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SUPPLEMENT TO "THE ELECTRICIAN," APRIL 27, 1906.

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

## VOLUME LVI.

(Second Series.)

FROM OCTOBER 20, 1905, TO APRIL 13, 1906.

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LONDON:
Printed and Published by GEORGE TUCKER, at the Offices of "THE ELECTRICIAN," Salisbury-court, Fleet-street.

1906.

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# VOL. LVI.

(Second Series.)

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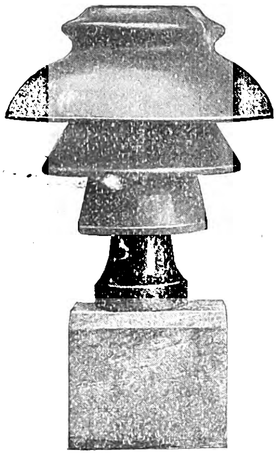

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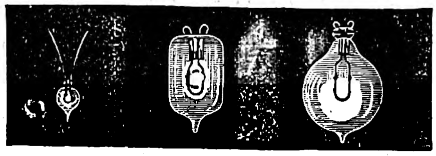

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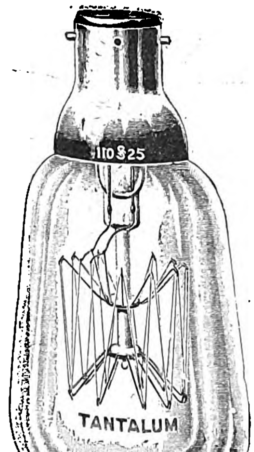

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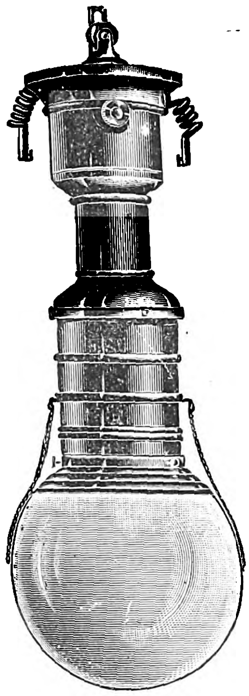

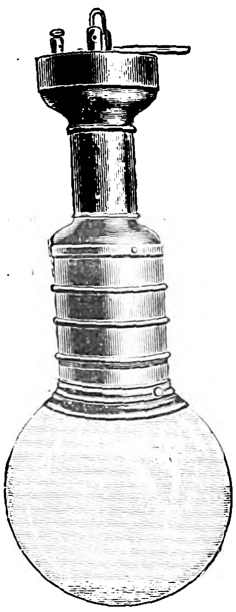

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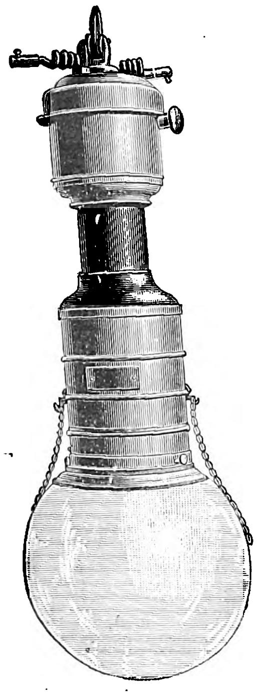

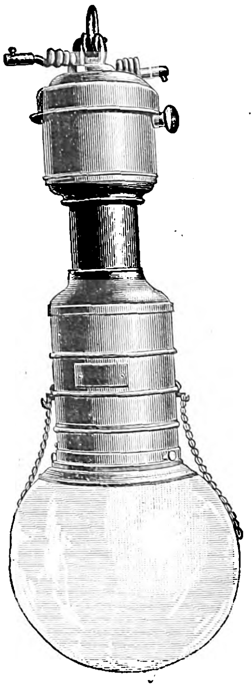

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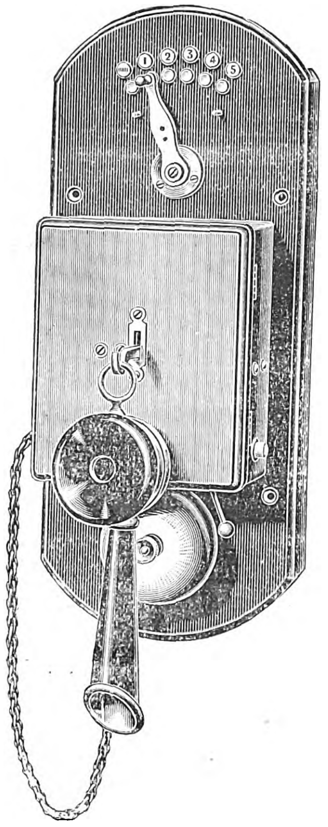

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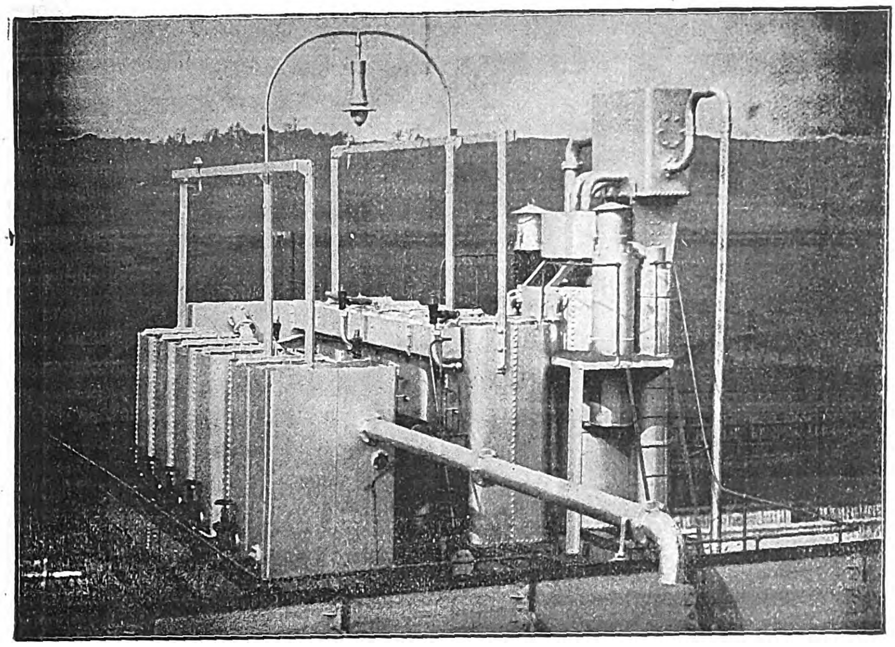

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**The Times** ENGINEERING SUPPLEMENT.

## ELECTRICAL EXHIBITION AT OLYMPIA.

. . . It is to be observed that this competitive war, which in other industries might easily have led to shoddy work, has brought no such result to British electrical engineering. There is no shoddy at Olympia. . . . Rules and specifications . . . have undoubtedly added to the force of these inherent protective influences; but supporting everything is the array of modern electrical instruments, whose accuracy and scope are at once the safeguard and pride of the electrical profession. Olympia to-day is testifying to a fact which many older industries may observe with advantage—the progress which results from the application of exact methods of defining, testing and designing the *materiel*. . . .

INSTRUMENTS.

Of new instruments, the most comprehensive exhibit is probably that of Messrs. Everett, Edgcumbe & Co. (No. 8). Attention may be called to their direct-reading watt-photometer, which by a single adjustment measures candle-power, watts and the efficiency of a glow-lamp in watts per candle-power. Their street photometer is designed on the "Flicker" principle. The "inkless" synchronised recorder is likely to be one of the most useful developments in this class of instrument. Friction between the moving paper and the stylus is obviated by supporting the stylus clear of the paper; at recurring short intervals the stylus is tapped into contact and makes a mark by means of an inked ribbon. The principle is somewhat similar to that of the vibrator of a siphon recorder; the vibrations are, however, timed and actuated by an electrically-driven clock.

**EVERETT, EDGCUMBE & CO., LIMITED,**
HENDON and VICTORIA STREET.

# THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING. INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,431. [No. 1. Vol. LVI.] FRIDAY, OCTOBER 20, 1905. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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## NOTES.

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WE publish on another page the Regulations prescribed by the Board of Trade for the use of overhead wires for electric light and power under ordinary conditions. Under No. A 13 of the Board of Trade Regulations under the Electric Lighting Acts (*The Electrician*, Vol. LV., p. 180), the Board intimates that it will issue regulations for each case in which it is desired to use overhead wires. The regulations which we publish are those which have been prescribed recently in a number of cases, and as no objection has been made to them by those interested, it may be taken that they represent a model set which will be made to apply in all ordinary circumstances. They practically describe the best modern practice for overhead lines of this character, but we are in a position to state that the Board would be unlikely to raise any serious obstacle should variations be desired in order to fit special cases.

◆

PARTICULAR attention, and possibly some criticism, will doubtless be directed to Nos. 5 and 6 of the new rules. Under No. 5 it will be seen that the neutral wire of a three-wire system is to be erected as a simple kind of guard net beneath the two outer wires. It may be objected that the voltages in this case are no greater than those of an ordinary trolley wire, and that in consequence no additional precautions should be necessary. On the other hand, the conductors will be of heavier section in most cases, so that the effects of a short-circuit would be greater, and a slight additional expense is well justified in order to ensure that in the event of breakage the short-circuit is immediate and takes place well above the ground. In order to comply with Regulation 6—namely, that the conductors of a two-wire system with earthed negative are to be placed so that the positive falls on the negative before it can reach the ground—all that it is necessary to do is to place the insulators on alternate sides of the poles and to zig-zag the wires. We trust that these precautions will satisfy the Post Office in the case of conductors carrying alternating currents. Inductive action will not be neutralised quite as effectively as with an actual revolution of the wires, but as the telephone wires themselves are revolved when any disturbance is probable, this should in itself be sufficient.

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ONE of the noteworthy features of the dynamos and motors at the Electrical Exhibition at Olympia is the extensive adoption of auxiliary poles for reducing sparking in continuous-current machines. It is fairly long ago since commutating poles were first proposed, but the present exhibition is the first, we believe, which has witnessed a number of commercial machines fitted with them. The same result as obtained by the means mentioned may also be achieved by a distributed winding, resembling that of an induction motor, and the effect of such compensating devices is well known. They produce, in the direction of the brushes, a flux, which not only compensates the armature's own flux, but, furthermore, induces in the coils undergoing commutation a voltage partly neutralising the reactance voltage, and thus smoothing the way for the reversal of current. Since the output of many of our present-day generators and motors is limited by considerations of sparking, it follows that more, sometimes much more, could be got out of them if equipped with a compensating device. Such is notably the case with motors whose speed is required to vary, by shunt control, within very wide limits, and for turbo-generators. Of course, these advantages are not pure gain, for the compensating devices consume a certain amount of energy themselves, besides increasing the cost of the machine. For these reasons the employment of auxiliary poles is inadvisable in the case of dynamos whose sparking can be suppressed by simply adopting suitable brushes. There is a tendency to elaborate in this direction in some of the machines exhibited at Olympia.

There are not many fresh facts disclosed in Lieut.-Col. Druitt's report on the Hall Road (Lancashire & Yorkshire Railway) accident, an abstract of which we publish in another column; but some of the opinions expressed therein are worthy of attention. Col. Druitt says that the collision would probably not have been so severe if the train had been hauled by a steam locomotive, as the acceleration, and therefore the speed at the time of impact, would not have been so great. A little further on, referring to the high rate of acceleration obtained by electric traction, he says " . . . . but this, and the quick stopping due to the very powerful brakes in use, form the great advantages of electric traction. . . . " This is apparently paradoxical, since the latter statement admits that the retardation or negative acceleration is great, as well as the positive acceleration. The explanation of the matter is, of course, that the motorman succeeded in getting his train up to full speed very soon after getting the flag signal, and that he could not appreciably reduce that speed when he saw that the road was not correctly set, as the end of the stationary train was too close to the points. Naturally, if the train had been steam-driven, the speed at this point would have been much slower. The accident was due to exceptional circumstances, whereas, in the ordinary course of events electric traction provides a far safer mode of haulage.

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One point that Col. Druitt might well have emphasised more forcibly is the great immunity from fire which a wrecked electric train enjoys. It is more than probable that a derailed train would at once short-circuit the live rails and throw out the feeder circuit-breakers, as actually happened at Hall Road. An arc might conceivably last for some seconds, but stout iron bars are provided on the trains for deliberately short-circuiting the live rails should necessity arise. There is no glowing coal to set fire to the coaches, and unfortunate drivers and firemen cannot get scalded to death by escaping steam. The absence of gas reservoirs under the coaches is an important point and an additional argument for the universal adoption of train lighting by electricity. We may be justly proud of the few fatal accidents on our steam railways, and there can be no doubt that the gradual adoption of electric traction will result in a still further decrease in the number of accidents and in their severity.

**Röntgen Society.**—An ordinary general meeting of the Röntgen Society will be held on Thursday, November 2nd, at 20, Hanover Square, London, W., at 8:15 p.m. A paper on "The Ruhmkorff Coil" will be read by Professor Wertheim-Salomonson.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Tarifa—Tangier | Jan. 18, 1904 |
| Jamaica—Colon | Jan. 10, 1905 |
| Cadiz—Teneriffe | July 20, 1905 |
| Kotonou—Grand Bassam | Oct. 4, 1905 |

**The Electric Furnace at the Electrical Exhibition.**—Messrs. Marryat & Place inform us that the 1,000 ampere electric furnace which they are exhibiting at the Olympia Exhibition has been purchased by the National Physical Laboratory.

**Hastings Tramways.**—In our article on the Hastings tramways last week, column 1, line 6, p. 1016, we incorrectly stated the name of the makers of the feed pumps. This should be Messrs. J. P. Hall & Sons of Peterborough, and not Messrs. J. P. Hall & Co. of Oldham.

**Junior Institution of Engineers.**—The annual general meeting of the Junior Institution of Engineers will be held at the Westminster Palace Hotel on Friday next, October 27th, at 8 p.m. This will be the first meeting of the Association since its incorporation.

**Breakdown at Battersea.**—A breakdown occurred at the Battersea Borough Council electricity works on Saturday night at 9:15. This was caused by the armature of a 750 kw. turbo-generator failing at a time when it was carrying three-quarters of the total load. The supply was resumed to the various sections of the network within periods varying from 10 to 45 minutes.

**Glasgow Technical College Scientific Society.**—The opening meeting of the 14th session of this Society will be held in the new buildings of the Glasgow and West of Scotland Technical College, George-street, Glasgow, on Saturday, October 21st, at 7:30 p.m., when Mr. Henry Dyer will deliver a lecture on "The Training and Work of Engineers in some of their Wider Aspects." The president of the society, Mr. R. D. Munro, will occupy the chair.

**Water Power Electric Supply Plants.**—Two small private water power electric supply plants have been opened during the past week, one in Scotland and another in Ireland. The former is at Fochabers, and is on the estate of the Duke of Richmond and Gordon. Water is taken from the River Spey, the turbines having been supplied by Messrs. Carrick & Ritchie, and the electrical installation by Messrs. Drake & Gorham. The plant will be used for lighting Fochabers as well as Gordon Castle. The second plant referred to is at the Irish watering place Buncrana, a village on the shores of Lough Swilly. A local mill owner has enterprisingly placed the plant on his premises, where there is a good fall of water, the installation having been carried out under the superintendence of Mr. L. J. Lawless, a Dublin electrical engineer.

**Tramways and Light Railways Association.**—The October issue of the Official Circular of the Tramways and Light Railways Association gives some particulars of the lectures that have been promised for the coming session and the visits that have been arranged. On Wednesday, October 25th, a lecture on "Roller Bearings," by T. W. How, will be read at the Society of Arts. The following is the provisional programme after October:—November—Lecture "On Paving of Roadways"; Visit to Holborn and Strand Subway, and inspection of all-steel car. December—Lecture on a technical subject; Visit to Lot's-road Power Station. January—Lecture "On Brakes," by A. L. C. Fell, Chief Officer, London County Council Tramways: Visit to Baker-street and Waterloo Railway. February—Visit to Neasden Power Station. March—Lecture "On the Up-keep of Tramway Electric Motors," by S. Sudworth; Visit to Great Northern, Piccadilly & Brompton Railway. April—Lecture on "All-Steel Cars." May—Lecture "On the Thermit System of Welding," by Dr. Goldschmidt.

**Electrification of the Vienna Railway System.**—It has been known for some time that experiments in electric traction were to be carried out on the Vienna railway system, at present worked by steam. We now learn from the *Elektrotechnischer Anzeiger* that a continuous-current three-wire system (the track rails forming the neutral conductor) is to be adopted with 3,000 volts between the outers, the latter being in form of overhead trolley wires, suspended by means of side poles and span wires. At present the line between Praterstern and Hauptzollamt (about 0·85 miles in length) is being electrically equipped, the Helenengasse sub-station for converting the three-phase 5,000-volt current from the municipal electricity works to continuous current is being built, while the 800 H.P. experimental locomotives have already been supplied by the contracting firm, Fr. Krizik of Prague. Each locomotive has four 200 H.P. motors. The controllers permit of all four motors being connected in series across the outers, or in two groups of two motors each. The trolley wires are of the 8 section, the sectional area being 115 sq. mm. (0·178 sq. in.). They are suspended by double insulation from the span wires, which, in their turn, are doubly insulated from the poles. In a few cases the poles are replaced by rosettes fixed to houses. The trolley wire is 17ft. above the top of the rails.

**Opening of Kingsway.**—In connection with the opening of the new Strand to Holborn thoroughfare by His Majesty the King, on Wednesday, an ingenious electrical contrivance was made use of for opening the gates which were placed across Kingsway. The gates were attached by means of ropes to electric winches, one on each side of the roadway. These winches consisted of $2\frac{1}{2}$ B.H.P. motors, directly-coupled to worm gears provided with drums for hauling in the ropes. The gold key inserted by His Majesty into the pedestal on the daïs closed an electric circuit, which, in turn, brought automatic solenoid self-starting switches into circuit, thus starting the motors and gradually opening the gates. When the gates were fully opened they automatically disconnected the circuit by means of trip switches, thus bringing the winches to rest. The solenoid self-starting switches were of the Sturtevant Company's make, and the whole of the apparatus controlling the gates was furnished by Messrs. Electromotors Limited, of Manchester, to the instructions of the Chief Engineer of the London County Council. The apparatus will be on view at the Electrical Exhibition, Olympia, to-day and to-morrow.

**New Graving Dock at Southampton.**—The Marquess of Winchester is to open, to-morrow, the magnificent graving dock just completed at Southampton by the London & South Western Railway Co. The principal dimensions of the new dock are: Length, from point of cill to dock head, $875\frac{1}{4}$ ft.; length occupied by keel blocks, 839 ft.; width of entrance, 90 ft.; width of dock at floor level, 90 ft.; width of dock at cope level, 125 ft.; depth of dock from cope to floor, 43 ft.; depth of water over cill at high water of spring tides, 33 ft.; depth of water over cill at high water of neap tides, $29\frac{1}{2}$ ft. Since they took possession of the dock property in 1892, the South Western Railway Co. have reclaimed an area of nearly 100 acres, formerly known as the "Mudlands," and the new dock, approached directly from the estuary of the River Test, stands upon the northerly portion of this land, in an exceedingly convenient situation. It is built almost entirely of Portland cement concrete, 133,000 cubic yds. of which material have been used. The dock will hold 85,000 tons of water, and can be emptied by two centrifugal pumps in $2\frac{1}{2}$ hours. The plant provided for graving purposes includes a travelling electric crane—the largest in existence it is claimed—capable of lifting more than 50 tons at a radius of 87 ft., and supplied by Messrs. Stothert & Pitt.

**Wireless Telegraph Notes.**—We are informed by the American DeForest Wireless Telegraph Co. that, as a result of the test which Dr. Lee DeForest recently completed at the wireless telegraph station which the American DeForest Company has been equipping for the U.S. Navy, the Bureau of Equipment has accepted the Pensacola station, after a series of exhaustive and difficult tests between this and the Key West station, in which over 75 official messages were exchanged, many of them in the navy code. For a certain time while these tests were in progress the DeForest 2 kw. station at Key West was in communication with the Havana station, 90 miles away. Concerning this the Commandant at Key West, in the official report to the Bureau of Equipment, stated that "the connections of the DeForest syntoniser No. 3 were so adjusted that the wireless messages from Havana 90 miles distant were being received at the DeForest wireless station at La Brisa (three-quarters of a mile distant from the naval wireless station at Key West), while signals from Pensacola, 410 sea miles distant, were distinctly heard at this station. Havana signals were not heard at this station." Another illustration of tuning is found at Chicago, where the service between the station at Indiana Harbour and the City of Traverse goes on uninterruptedly, while the DeForest 20 kw. station at Chicago is communicating with St. Louis, 300 miles distant, or receiving messages from St. Louis.

A contract has recently been entered into between the Peruvian Government authorities and the Gesellschaft für Drahtlose Telegraphie for the construction of a wireless telegraph station to operate between Puerto Bermudez on the Pichios and Masisea on Ucayali, the ultimate objective being communication with Iquitos on the Amazon River.

**British Science Guild.**—The Lord Mayor has consented to preside at the inaugural meeting of the British Science Guild at the Mansion House, on Oct. 30, at 4:15 p.m, when the following officers will be proposed:—

*President.*—Rt. Hon. R. B. Haldane, M.P., K.C. *Vice-Presidents*—The Lord Mayor, Sir Lawrence Alma-Tadema, R.A., O.M., Lord Balcarres, M.P., Lord Berkeley, Sir William Broadbent, K.C.V.O., F.R.S., Sir Walter Buller, K.C.M.G., F.R.S., Sir J. Burdon-Sanderson, F.R.S., Major-General Sir Owen Tudor Burne, G.C.I.E., K.C.S.I., Rt. Hon. Joseph Chamberlain M.P., Sir William Church, Sir George Sydenham Clarke, K.C.M.G., F.R.S., Sir John Colomb, K.C.M.G., M.P., Lord Donoughmore, Lord Egerton of Tatton, Sir John Eliot, K.C.I.E., F.R.S., Sir Michael Foster, K.C.B., M.P., F.R.S., Sir Edward Fry, F.R.S., Sir Archibald Geikie, F.R.S., Mr. F. du Cane Godman, F.R.S., Sir John Gorst, K.C., M.P., F.R.S., Lord Haliburton, G.C.B., Sir Joseph Hooker, G.C.S.I., F.R.S., Sir Alfred Jones, K.C.M.G., Lord Knutsford, G.C.M.G., Prof. Ray Lankester, F.R.S., Dr. J. Larmor, F.R.S,, Lord Lister, F.R.S., O.M,, Sir Charles McLaren, K.C., M.P., Sir Horace Plunkett, K.C.V.O., Prof. Rhys, the Bishop of Ripon, Mr. E. Robertson, K.C., M.P., Lord Tennyson, G.C.M.G., the Duke of Wellington, K.G., G.C.V.O. *Chairman of Committees.*—Sir Norman Lockyer, K.C.B., F.R.S. *Vice-Chairmen.*—Sir William Abney, K.C.B., F.R.S., Sir Lauder Brunton, F.R.S., the Hon. Sir John Cockburn, K.C.M.G., Sir Gilbert Parker, M.P. *Trustees.*—Lord Strathcona, G.C.M.G., Sir Henry Roscoe, F.R.S. *Hon. Treasurer.*—Lord Avebury, F.R.S. *Hon. Assistant Treasurer.*—Lady Lockyer. *Hon. Secretary.*—Mr. C. Cuthbertson.

A large general committee will also be proposed for election. It will include the names of the present organizing committee. Since the first meeting of the guild, held at the rooms of the Royal Society in April, 1904, the labours of the organizing committee have been directed to securing the help of representatives of all sides of the nation's activities to secure the objects of the Guild, which are:—

(1) To bring together as members of the guild all those throughout the Empire interested in science and scientific method, in order, by joint action, to convince the people, by means of publications and meetings, of the necessity of applying the methods of science to all branches of human endeavour, and thus to further the progress and increase the welfare of the Empire. (2) To bring before the Government the scientific aspects of all matters affecting the national welfare. (3) To promote and extend the application of scientific principles to industrial and general purposes. (4) To promote scientific education throughout the Empire by encouraging the support of Universities and other institutions where the bounds of science are extended, or where new applications of science are devised.

The Science Guild, an official announcement states, is not identical in aim with any existing society. Its purpose is to stimulate, not so much the acquisition of scientific knowledge, as the appreciation of its value, and the advantage of employing the methods of scientific inquiry, the study of cause and effect, in affairs of every kind. Communications may be addressed to the hon. secretary of the British Science Guild, 16, Penywern-road, London, S.W.

**Opening of the Bournemouth-Christchurch Tramway Extension.**—At the invitation of Messrs. J. G. White & Co., a number of engineers and representatives of the technical Press were present at the inaugural ceremony of the through tramway service between Poole, Bournemouth and Christchurch. The party left Waterloo by a special train at 11 a.m. on Tuesday, and Bournemouth was reached in 2 hours 10 mins., after a non-stop run, luncheon being served en route. Immediately on arrival, the special cars were boarded and in a few minutes the Square was reached. Here cars were waiting, their passengers including the Mayors and Corporations of Bournemouth, Poole and Christchurch, and a start was at once made for Christchurch. The new line passes through most delightful country and is about 3·5 miles in length, nearly all of it being double track with occasional short lengths of single track and interlacing. Centre poles, side poles and span wires are employed for supporting the trolley wires, according to the locality, and this part of the work was carried out by the British Electric Equipment Co., as sub-contractors to Messrs. J. G. White & Co. Of course, the same gauge has been adopted as that at Bournemouth and Poole, where a mixed side-conduit and overhead system is employed. A complete illustrated description of the Bournemouth tramways appeared in *The Electrician*, Vol. L., p. 462. The journey from Bournemouth to Christchurch and back was successfully accomplished, the only untoward incident being a carriage accident, in which a restive horse caused two ladies to be thrown from a carriage and slightly injured. It appears that the animal shied at the bunting on one of the cars, and came into collision with another car travelling in the opposite direction. An interesting feature of the route is a new bridge which has been constructed entirely of ferro concrete, and has a very pleasing appearance. This bridge, we believe, is one of the first of its kind to be constructed in this country, and is remarkable for its low capital cost. On the return of the cars to Bournemouth the Mayor and Mayoress of that town held a reception in the Winter Gardens. Subsequently a banquet, presided over by Mr. J. G. White, was given at the Grand Hotel. Some 150 guests sat down, and a most enjoyable evening was spent. After the usual loyal toasts had been duly proposed and honoured, Mr. J. H. Rider, electrical engineer to the London County Council tramways, proposed the "County Borough of Bournemouth and the Tramways Undertaking." He said that Bournemouth was even before London in having the conduit system, and the town was therefore much to be congratulated. The through system which had been inaugurated that day had a great future, and he looked forward to the time when Bournemouth, Poole and Christchurch would be all one town. The Mayor of Bournemouth, Mr. Alderman G. J. Lawson (Chairman of the Tramways committee), and Mr. F. W. Lacey (borough engineer) responded. The Mayor of Bournemouth proposed "The Hosts," and spoke highly of Messrs. J. G. White's work in the town. Mr. J. G. White responded with an excellent speech, in which he said that it had been a pleasure to carry out the Bournemouth contract, since there had been an entire lack of the unpleasantness which was met with when dealing with some municipalities. There were borough officials who did all they could to harass contractors, but this was not the case at Bournemouth, and a superior system of tramways was the result. Other toasts were: "The Neighbouring Boroughs of Poole and Christchurch," proposed by Councillor J. Druitt, and responded to by the Mayors of Poole and Christchurch; and "The Other Contractors," proposed by Mr. A. N. Connett, and responded to by Mr. T. O. Callender. In confirmation of Mr. White's remarks, it may be mentioned that an unusual feature of the entire proceedings was the regard with which the contractors were held by "the purchasers." As a rule praise is bestowed very sparingly, and the grumbles made much of; at Bournemouth there were no grumbles and praise for the manner in which the work had been carried out was unstinted. The proceedings did not terminate until a late hour.

## ELECTRICITY v. GAS FOR STREET LIGHTING.

In response to our enquiries, we have received further figures relating to the comparative cost of electricity and gas for street lighting.

Mr. S. L. Pearce, Chief Engineer of the Manchester Corporation Electricity Works has sent us some valuable comparative figures as to the cost of gas and electricity and the relative amount of light obtained in a street in Gorton.

*Hyde road, Gorton, Manchester.*—Length, 700 yds. to 800 yds.; width, 45 ft.; number of lamps, 22; type, Gilbert single enclosure; maximum candle-power, 430; cost per lamp per annum = £8; number of hours per annum = 4,000. (14 hours per day for winter, six months; eight hours per day for summer, six months. Equated figure of 11 hours per day.) This should reasonably cover the efficient lighting from sundown to sunrise.

The above arc lighting has *displaced* the gas.

The original number of gas standards was 25—mostly of the two-burner "C" Welsbach type, using 4 ft. per hour and giving 150 c.p. with the mantles new. Therefore, total original effective lighting by gas = 3,750 c.p. approximately.

*Cost of lighting by gas* (figures furnished by the Gorton Council) = £6 per lamp per annum. (£3 per lamp per annum for actual gas consumed; £3 per lamp per annum for mantles, maintenance, &c.) *Total*, £150 per annum.

Present total effective lighting by electricity (taking 300 c.p. as the mean hemispherical candle-power of the arcs = 6,500 c.p. Total cost = £176. In short, 75 per cent. more illumination for 18 per cent. increase in price.

He has also made the following estimates for lighting Fleet-street by "flame" arcs.

1. *Short Hour Lamps* (16 *hours*).—No. of lamps, 12; wattage of lamps, 300; No. of hours of burning per annum, 4,000; cost of current, 1½d. per unit; total effective candle-power = 10,000.

*Cost per annum per Lamp.*

| | £ | s. | d. |
|---|---|---|---|
| Current | £7 | 10 | 0 |
| Carbons | 4 | 16 | 6 |
| Trimming and maintenance | 3 | 2 | 6 |
| Repairs and depreciation | | 15 | 0 |
| | £16 | 4 | 0 |

*Total cost per annum.*

| | £ | s. | d. |
|---|---|---|---|
| 12 lamps | £194 | 8 | 0 |
| Interest and sinking fund on capital charges | 33 | 0 | 0 |
| | £227 | 8 | 0 |

2. *Long Hour Lamps* (45 *hours*).—No. of lamps, 12; wattage of lamps, 300; hours of burning per annum, 4,000; cost of current, 1½d. per unit; total effective candle-power, 10,000.

*Cost per Annum per Lamp*:—

| | £ | s. | d. |
|---|---|---|---|
| Current | £7 | 10 | 0 |
| Carbons | 2 | 2 | 0 |
| Trimming and maintenance | 1 | 5 | 0 |
| Repairs and depreciation | 0 | 15 | 0 |
| | £11 | 12 | 0 |

*Total Cost per Annum*:—

| | £ | s. | d. |
|---|---|---|---|
| 12 lamps | £139 | 4 | 0 |
| Interest and sinking fund on capital charges | 35 | 0 | 0 |
| | £174 | 4 | 0 |

Mr. Pearce adds:—

I think the gas people are on the right lines in using lamps of smaller candle-powers and more of them. We have endeavoured to adopt this principle in Gorton by using the smallest arc lamp possible consistent with good working results. In making a comparison between "flame arcs" and the present Fleet-street "gas," better figures for the former could, no doubt, be shown by using fewer lamps of greater individual candle-power, but this course I believe to be on wrong lines for securing good diffusion of light.

He concludes with the following comparative figures:—

*Comparative Selling Costs of foregoing Different Systems of Illumination for 1,000 Effective Candle-power Hours per Annum with Electricity at 1½d. per Unit.*

| | |
|---|---|
| Flame arcs (long hour) | 1·025 |
| Flame arcs (short hour) | 1·35 |
| Ordinary carbons, single enclosure, long hour (Manchester) | 1·6 |
| Fleet-street (incandescent gas) | 2·4 |

We published last week an estimate from the engineer-in-chief of one of the London electricity supply companies, and we have now before us some figures relating to the street lighting experience of another London supply company. The whole of the capital expenditure in connection with the street lighting contract was borne by them, including lamps, poles and many miles of street mains which had to be laid for this purpose. The capital expenditure, interest at 5 per cent. and depreciation at 3·9 per cent., came to £5. 2s. per lamp per annum. These charges are based on a contract for about 30 years. Repairs, maintenance, wages, carbons and current at 1d. per unit come to £13. 4s. per annum, making £18·6 or £18. 12s. per lamp. Applying these figures to Fleet-street, and assuming 12 arc lamps, the total would be therefore £223, with a far better illumination than at present.

The Gilbert Arc Lamp Co. write us as follows:—

We are in receipt of your letter of the 4th inst. with reference to the question of street lighting by means of gas *v.* electricity. We quite agree with you that it is not difficult to obtain some comparative figures to show that the cost of street lighting is lower by means of arc lamps than with any system of gas lighting.

With regard to the special street you mention [Fleet-street] you say that has been lighted with 12 arc lamps of 10 amperes with inefficient lanterns. How much better lighting do the gas company propose to give? If only the same lighting, and the 12 arc lamps were replaced with 12 open-type lamps with light opalescent globes, or 12 enclosed lamps of our standard single-enclosure type, such as are used in Manchester for street lighting, according to the rate which Mr. Pearce says should be charged there, 1¼d. per unit, the cost of 12 such lamps would be £151. 10s., and even at a considerably higher price the cost of lighting would be well under the figure given by the gas company. The high-load factor of arc lamps for street lighting, especially with all-night lighting, makes it possible to supply current at a very low price and still make a profit.

The gas company do not state the minimum candle-feet which are to be allowed anywhere in the street at the beginning and the end of the life of the burners.

With reference to flame lamps, we have not sufficiently extended experience with regard to these, but there would doubtless be a reduction in cost, though the frequency of trimming is an undesirable feature.

We are just introducing a double-carbon convergent-flame lamp, burning about 35 hours, which we hope will meet this difficulty somewhat satisfactorily, with more reliability than a magazine lamp, which has some inherent difficulties, for instance, in getting the current satisfactorily conveyed to the carbon.

In conclusion, we would point out that it is a well-known fact that many gas companies and committees will supply gas for street lighting at cost price, or under, in order to keep this in their hands, and, in addition, the cost of up-keep of the mantles with high-pressure gas is not yet ascertained.

## THE NEW FERRANTI SWITCH GEAR.

Undoubtedly the most interesting exhibit to power-station engineers in the Electrical Exhibition at Olympia is that of Messrs. Ferranti Limited. The firm has remodelled almost the whole of its switch gear to meet the conditions now obtaining in modern generating stations.

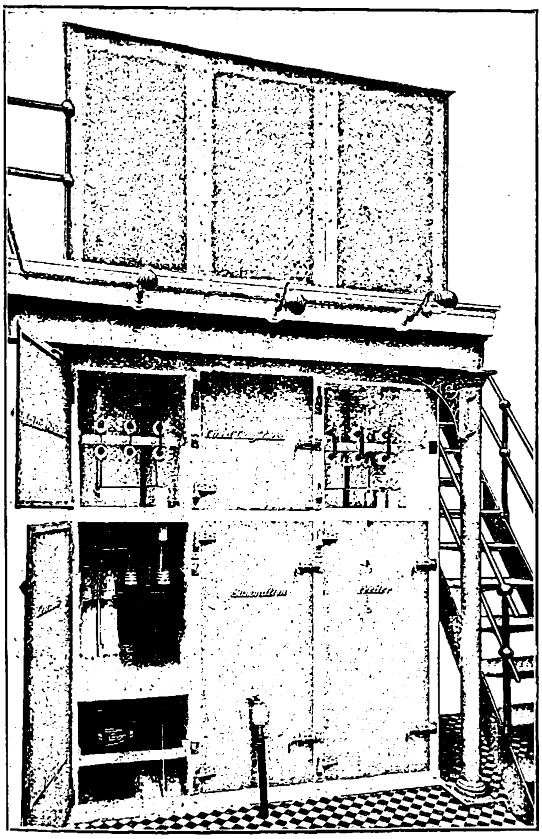


Fig. 1.—Typical Panels of E.H.T. Switchgear.

In fact, the most noticeable feature of Messrs. Ferranti's stand is a negative feature—viz., an absence of the Ferranti backless cellular board with oil-trough fuses and front-contact switches, which has done such good service in the past but is unsuited for the control of large units and heavy E.H.T. feeders.

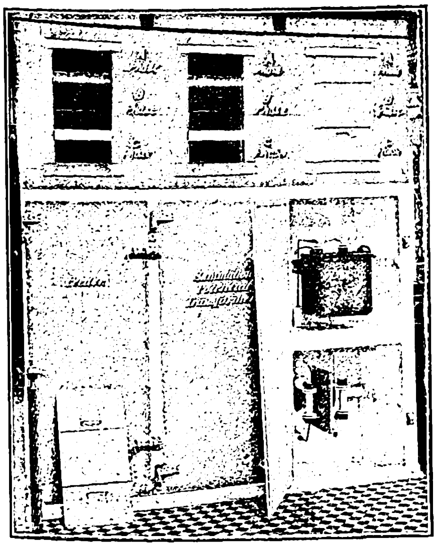


Fig. 2.—Ferranti Switchgear, 'Bus Bar and Potential Transformer Chambers.

The new board is cellular, it is true; this fundamental principle of construction, originally introduced by Mr. Ferranti, is almost an essential for high-pressure switchboards, but this and the high-class workmanship throughout are practically the only points of resemblance between the old and the new Ferranti switchboard. Fig. 1 shows the fine specimen of an E.H.T. switchboard which occupies a prominent position on Messrs. Ferranti's stand. It includes three typical panels of a 30 panel board which the firm has in hand for colliery work in the North of England. It should be mentioned, however, that these particular panels had to be made specially for the Exhibition, and that, as the organisers of the Exhibition limited the height to 12ft., the compartments containing the switch gear are somewhat lower than they would usually be in actual practice.

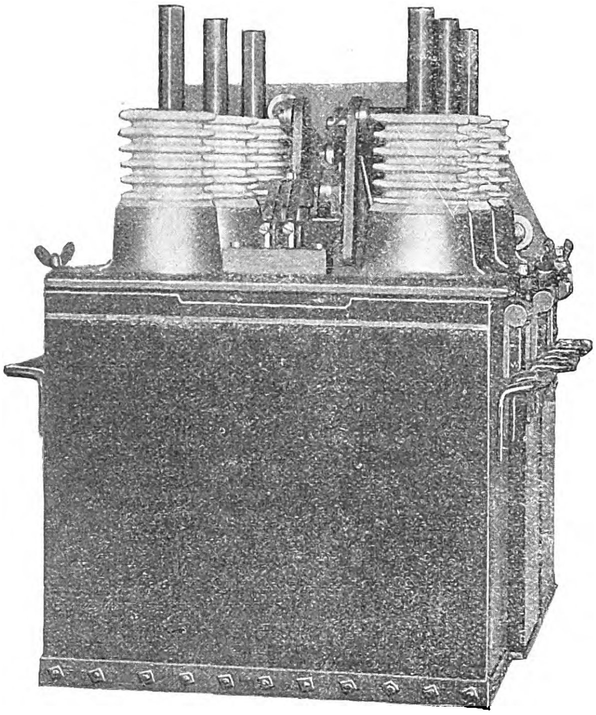


Fig. 3.—3-phase, 15,000 volt, Oil Switch.
(100 amps. per phase.) Back view.

The gear is controlled from a "bench board" on the gallery above, the back of the bench being seen in the illustration. Concrete reinforced with expanded metal is used for the cells, and these have iron doors. On the left of the figure is a generator panel, the door of which has been opened, in the middle the "summation" or "total output" panel, and to the right a feeder panel.

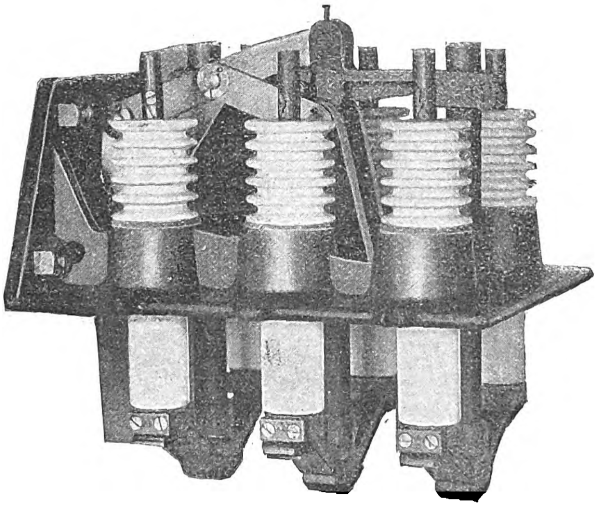


Fig. 4.—3-phase 15,000 volt Oil Switch.
(50 amps. per phase.) Side View, Tank off.

In the feeder panel the cables, coming up from the cable pit below, first pass through current transformers in the bottom compartment.

D

In the middle compartment is the main automatic switch controlled by an overload time-limit relay, which we shall describe presently, and in the top compartments are the isolating switches.

These isolating switches are, of course, solely for the purpose of cutting the particular panel off from the 'bus bars; thus, should it be desired to examine the state of the oil in the switch oil-tanks, or to examine the state of the contacts, the main switch is first opened to interrupt the circuit, the isolating switches are then withdrawn by means of the insulated hook seen in front of the figure, and this, of course, renders the rest of the panel entirely dead. There is another set of compartments backing those in the illustration, and accessible through similar doors on the other side. This side is shown in Fig. 2, and in this the doors of the generator panel are again open. The connections from the upper terminals of the isolating switches pass through the middle dividing wall into the 'bus-bar chambers, each 'bus bar being in a separate compartment. These compartments are seen at the top of Fig. 2. The space available below the 'bus bars is utilised for the potential transformer with its protecting fuses. The feeder panel is similar to the generator panel, with the exception that a potential transformer is not required, while in the summation panel merely current and potential transformers are necessary.

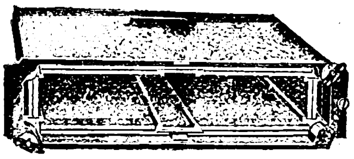


Fig. 5.—Tan of High-tension Switch, showing Wooden Lining.

The current transformers of the summation panel are situated in the topmost compartment on the side of the board seen in Fig. 1. By this arrangement of compartments all crossing of leads is avoided. Each individual item of apparatus, with the exception of the isolating switches, is immersed in oil in a cast-iron case, which is earthed, and this complete case is in a separate concrete compartment. The connections are bare, but are taken through porcelain insulators of substantial make where they pass through the concrete. As may be inferred, the whole system is flexible—*e.g.*, when laying out the concrete work it is easy to allow for, say, a duplicate set of 'bus bars, a ring-main system or other modifications that may be desired.

On the bench board are the handles operating the switches with their trip coils, reverse-power relays, time-limit relays, ammeters, voltmeters, integrating wattmeters, &c.

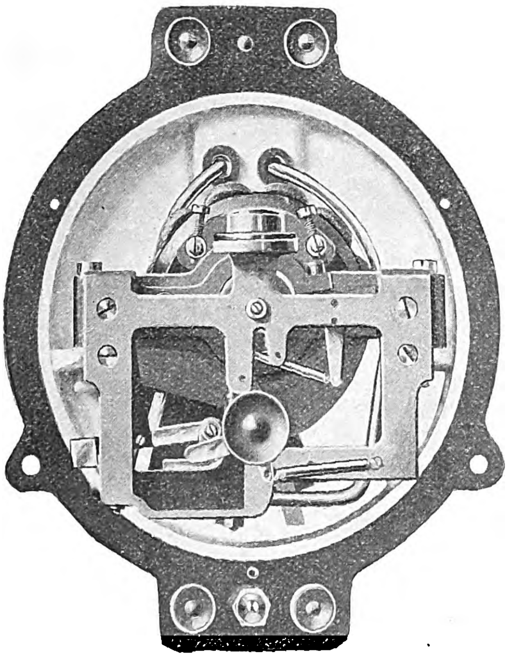
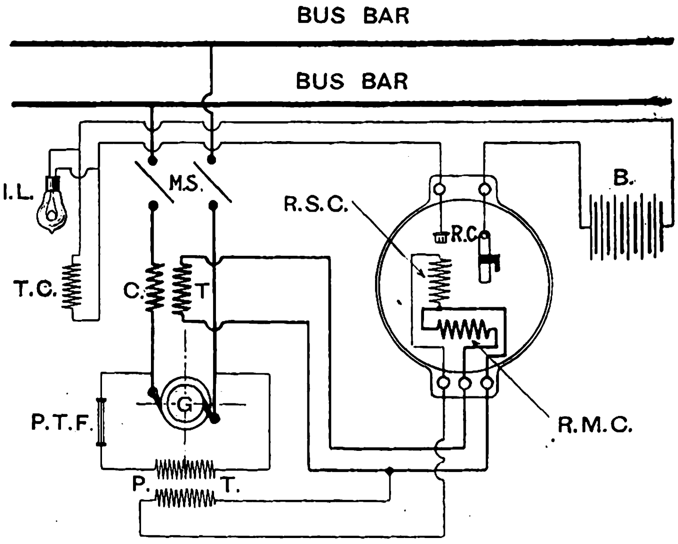


Fig. 6.—Reverse Power Relay.

Figs. 3 and 4 show, on a larger scale than in the preceding illustrations, the type of switch employed. In Fig. 4, the tank has been removed so that the shape and arrangement of the contacts is clearly visible.

The rods carrying the contacts are of teak impregnated in a vacuum tank. After the air is exhausted from the pores of the wood under vacuum, the compound is let into the tank, and then pressure is applied so that the wood is thoroughly impregnated. The handle and the metal work on the board are all earthed. Another interesting detail is the oil tank in which the switch contacts work. This is of iron, and has an impregnated wooden lining separated from the sides of the tank by corner-pieces so that there is oil between the lining and the iron of the tank. Thus if heavy sparking blows away the oil between the contacts and the lining, there is still a layer of oil between the lining and the iron tank. The construction is clearly visible from Fig. 5, which shows the tank removed from the switch.



M.S., Main Switch. T.C., Tripping Coil. R.S.C., Relay Main Coil. G., Generator. C.T., Current Transformer. P.T., Potential Transformer. P.T.F., Potential Transformer Fuse. R.C., Relay Contactor. B., Battery or other source of Low Tension Current, preferably quite indepondent of Main 'Bus Bars, for operating T.C. I.L, Indicating Lamp.

Fig. 7.—Diagram of Connections of Reverse Power Relay.

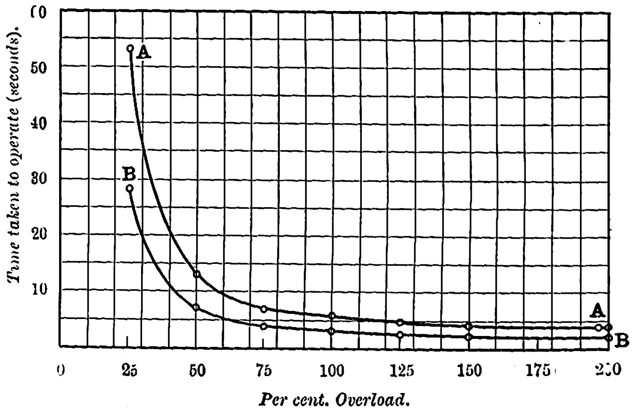


Fig. 8.—Curve Showing "Inverse Time Element" of Time Limit Relay.

The reverse-power relay, to which we have referred, is illustrated in Fig. 9. It consists mainly of the movement of a Ferranti alternating-current meter (see *The Electrician*, Vol. LIV., p. 621) placed on end, and it is arranged so that with power flowing in the right direction in the controlled circuit the rotating part of the relay impinges against one side of a pivoted weight. With power flowing in the right direction, the movable disc of the relay is stopped from rotating and presses against that side of the pivoted weight which prevents it falling over. It is thus seen that it is impossible for external vibration to cause the pivoted weight to fall over and complete the tripping circuit. On a reversal of power in the main circuit, to a predetermined extent (controlled by the hanging weight), the disc will begin to move in the opposite direction to that in which it is urged by a normal flow of power. Just before the disc has made one complete revolution it impinges, with a smart knock, on the other side of the pivoted weight, throwing it over and thus causing the main circuit-breaker to be automatically opened. The speed at which the disc makes this one revolution is determined, firstly, by the extent of the reversal of power, and, secondly, by the retarding action of a permanent magnet between the poles of which it travels. The longest time taken by the relay to close the tripping contactor after the occurrence of the reverse current is, we are informed, generally about 20 seconds, when the reverse power just exceeds that for which the relay is set. From the design of the relay it is apparent that there is an "inverse time element," the relay acting quicker the greater the power flowing in a reverse direction. These relays are also made to act instantaneously on reversal of power, if so desired.

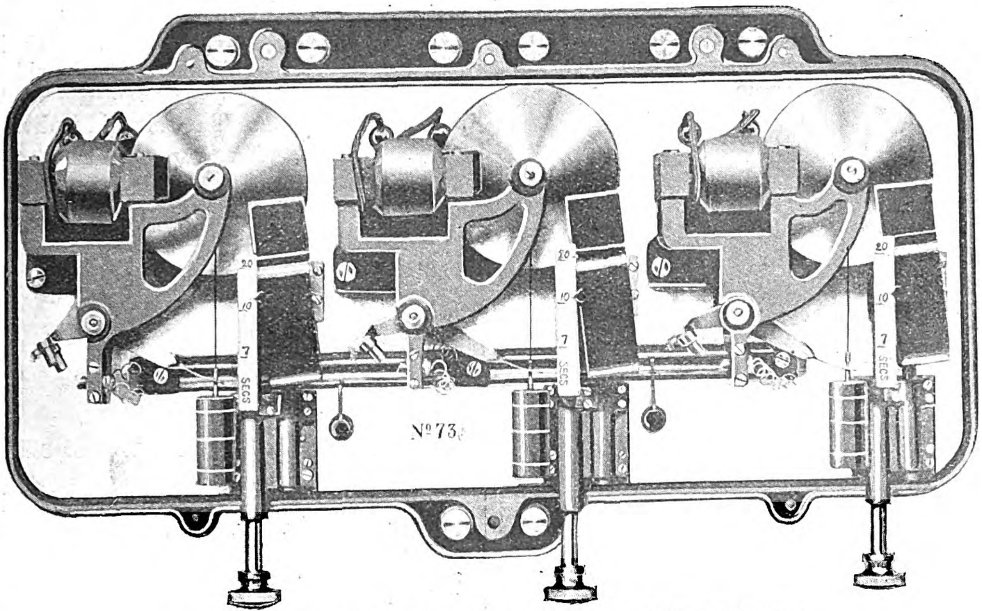


Fig. 9.—Set of Three Time-Limit Relays on 3-phase Circuit.

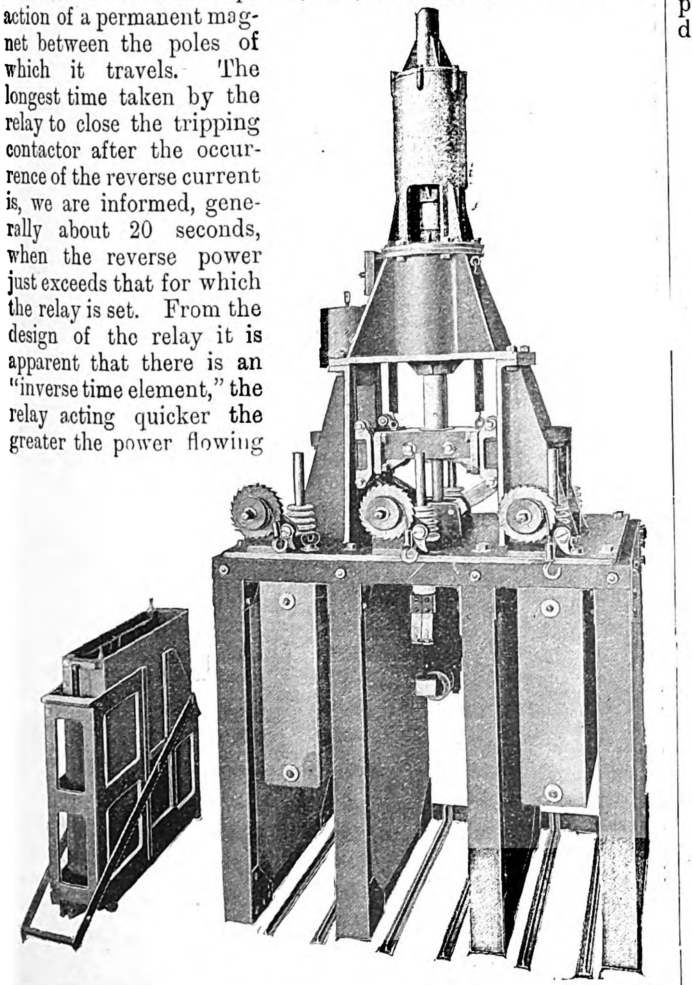


Fig. 10.—5,000 kw. Remote-control Switch, in Half-closed Position.

The ordinary maximum current time-limit relay for alternating-current feeder circuits, &c., is equally ingenious, and is adjustable within a wide range. A group of three, arranged for a three-phase circuit, is shown in Fig. 9. In this the meter principle is also introduced. On the left of each relay is a laminated electro magnet with "shaded" poles, that is to say, copper rings are placed on the poles, and the current induced in them reacts on the magnetic circuit, with the result that a torque is exerted in the pivoted copper disc, which is embraced by the poles as seen in the figure. The magnet is energised by current from a series transformer, the primary winding of which is in the main controlled circuit, and the pivoted copper disc is set into rotation when the primary current exceeds a certain value. When the disc turns, it winds up a hanging weight, also clearly seen in the figure, and its motion is retarded by means of a damping permanent magnet, seen on the right-hand side, similar to the damping magnet used in almost every type of motor meter

Attached to the hanging weight is a pivoted lever carrying a contact which, when impinging on the fixed contact, closes the circuit of the tripping coil on the main circuit-breaker. This tripping coil is fed by any low-tension current which may be available.

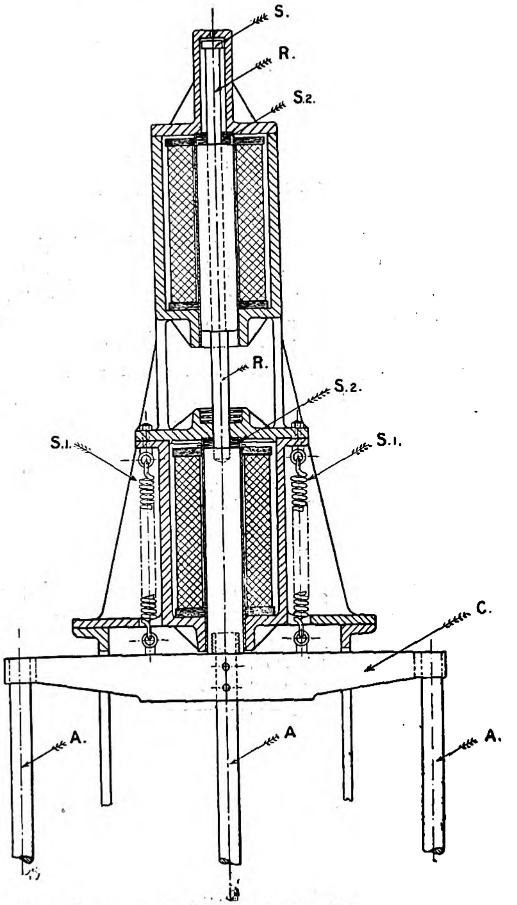


Fig. 11.—Diagram of Solenoid and Plunger Mechanism.

Before the two contacts are brought together, however, it is necessary for the disc to make a certain number of revolutions, and the speed at which these are made depends upon the value of the current in the controlled circuit. Thus, with a very bad short-circuit, the disc revolves very quickly, and the time interval before the circuit-breaker opens is proportionately short, from which it will be seen that the time element is inversely proportional to the degree of the overload.

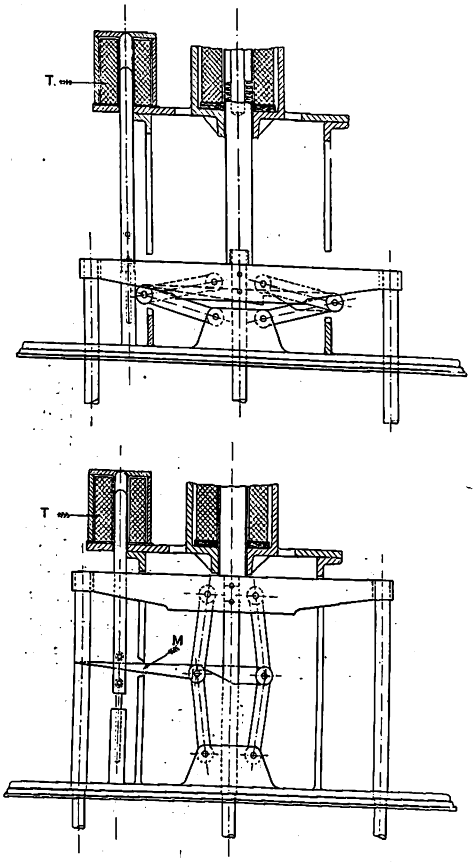


Fig. 12.—Trigger and Toggle Arrangement.

The time taken for the relay to close the tripping-coil circuit after the overload comes on can be predetermined by altering the position of the damping magnet by means of the screw projecting through the bottom of the case. A pointer fixed to the magnet shows on the scale the number of seconds which will elapse before a 25 per cent. overload will trip the circuit-breaker. The relay is adjusted for different currents by charging the hanging weight. The curves Fig. 8 (p. 6) show the time element with varying percentage overload. In the case of curve A, the relay was set so that with 25 per cent. overload it took about 50 seconds before the main circuit breaker opened. In curve B the relay was set with a time element of about 25 seconds with the same overload of 25 per cent.

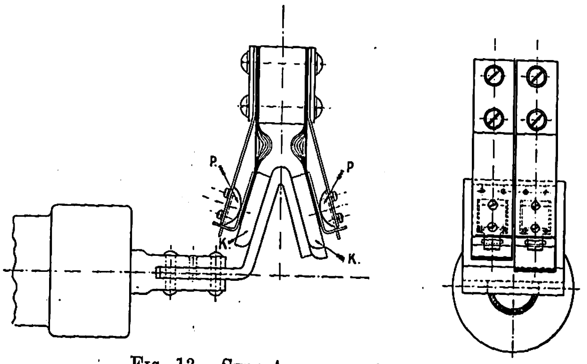


Fig. 13.—Self-Adjusting Contacts.

The relay can be used in conjunction with the ammeter current transformer, if desired, instead of by an independent current transformer, and this method of using instruments and relays is recommended, as it reduces the number of current-carrying parts, and thus also the cost and the risk of breakdown. The relay current is 10 amperes with full load in the main circuit.

In their remote-control E.H.T. switch, illustrated in Fig. 10, Messrs. Ferranti employ a direct solenoid control, an ingenious device being used to lengthen the stroke of the solenoid-plunger mechanism. The solenoid is divided into two portions, an upper and a lower, each being provided with a separate plunger (see Fig. 11). The lower plunger is rigidly attached to the carriage C carrying the vertical steel tubes A which support at their lower ends the moving contacts. The upper plunger is concentric with, but not directly attached to, the rod R, which forms virtually a prolongation of the lower plunger. The upper end of the rod R is provided with a collar, S, which rests upon the top surface of the upper plunger when the switch is in the full-open position. In these circumstances it will be observed that when the lower plunger is practically outside of its solenoid the upper plunger is in a favourable position to be acted upon by the upper solenoid. Both upper and lower solenoids are energised together, the first half of the stroke being effected mainly by the upper plunger being drawn within its solenoid to its full extent, and carrying the switch mechanism with it, in virtue of the collar S. By the time the first half of the stroke is completed the lower plunger has been brought into a favourable position to be acted upon by the lower solenoid, and the second half of the stroke is completed

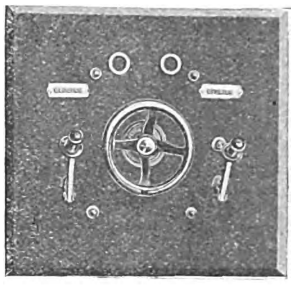
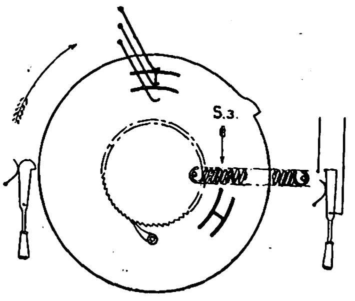
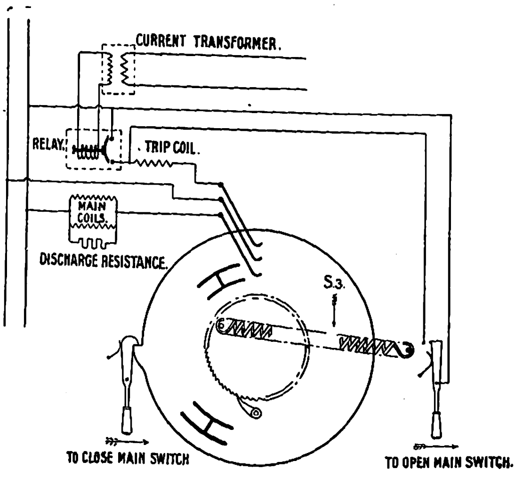


Fig. 14.—Front View of Controller



Off Position.

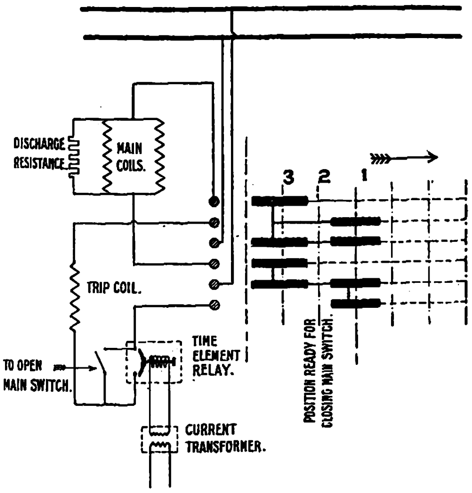


Position ready for Synchronising or Closing.

Fig. 15.—Diagram of Controller Gear.

by the lower plunger, the central rod R now passing freely through the upper plunger. By this device it is possible to obtain a very powerful long-pull electro-magnet, giving a stroke of 10 in. with a minimum pull of 180 lb., and a maximum pull at the end of the stroke of 400 lb. The two springs $S_1$, $S_1$ are attached to the carriage C, and are so designed that in the closed position they are unextended, while in the open position they exert a lifting force of about 75 per cent. of the weight to be raised. The effect of these springs is two-fold. Firstly, they greatly accelerate the closing motion of the switch, and secondly, being unextended in the closed position they do not retard the quickness of the break, but on the other hand take up the shock and jar when the mechanism has reached the full-open position. Further, two short and very stiff springs $S_2$, $S_2$ are introduced on the top side of the plungers. The effective force of the solenoids increases very rapidly during the last portion of the stroke, and this is utilised in compressing these springs, the object of which is to aid the initial acceleration during the opening motion, and particularly at that instant when the friction of the main-switch contacts has to be overcome.

The switch is held closed by means of the trigger and toggle arrangement depicted in Fig. 12. Eight links arranged diamond fashion are attached to the cast-iron top plate below and the moving carriage above, and a trigger, M, is pivoted on the right-hand hinge pin and catches on the left-hand hinge pin. The diamond pattern formed by the links opens out laterally when the switch opens, the trigger, however, always remaining in a nearly horizontal position. When the switch is closed, the links are nearly vertical, forming with the trigger practically a toggle joint. It will be observed that this arrangement of links obviates all sideway thrusts against the frame, so that no undue pressure is brought to bear upon the guide rollers. The plunger of the trip coil T acts upon the end of the trigger M, a certain amount of free movement being provided so that the trigger receives a hammer blow when the switch is tripped. The switch can obviously be tripped by hand by raising the end of the trigger. This can be arranged from the bench control board and forms an alternative method of tripping the switch.



"Off position" : Contact fingers lie in column 1.
Position ready for closing : Contact fingers lie in column 2.
On releasing controller, drum moves past contact fingers in direction indicated by arrow, passing through position 3 and coming to rest in position 1.

FIG. 16.—DIAGRAM OF CONNECTIONS OF CONTROLLER.

Referring back to Fig. 10, it will be seen that each phase is in a separate cubicle. There are two breaks per phase each 9 in. in length. The breaks occur under oil within an oil tank lined on the principle explained earlier in this article. Fig. 13 shows the self-adjusting and movable contacts. It will be noticed that the fixed contact pieces K have a certain limited motion in and out, and at the same time they can roll upon the steel stampings P so as to adjust themselves automatically to the taper of the movable contacts. Each fixed contact is divided into four independently controlled contact blocks, one being made somewhat longer than its neighbours to take up any sparking that may occur. The movable contact is supported on a porcelain insulator which is gripped about the middle by a gun-metal clamp, this being supported from the carriage by means of the vertical steel tubes marked A in Fig. 11.

As the switch opens, insulating slabs surrounding the rods A slide down into the tanks, each tank being thus divided into two separate compartments for the purpose of minimising the risk of under-oil arcing. A special tank carrier is shown on the left-hand side of Fig. 10. This runs into the complete cubicle on rollers and the tank is then raised into position by means of the winding gear seen in Fig. 10.

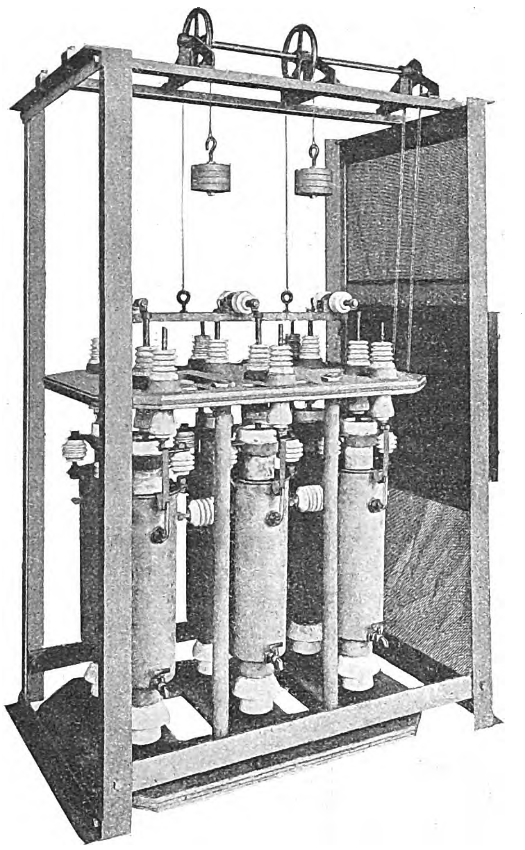


FIG. 17.—MAINS-CHARGING GEAR.

Fig. 14 shows the front view of the controller and Fig. 15 represents its functions diagrammatically. Two positions are shown, the "off" position and the position ready for synchronising or closing. The process of closing as follows : The hand-wheel, to which an ordinary controller drum is attached, is first turned through a little more than 180 deg., in which position it is arrested by a suitable catch, as seen in the lower figure. This motion has the sole object of extending the spring $S_3$, so that when the drum is released, the revolution, half-made, will be completed. The drum is released by means of the closing lever on the left-hand side, a small pressure on this being sufficient to release the catch which blocks the hand-wheel after the first motion has been completed. On pressing the left-hand lever the connection for energising the solenoid is made instantaneously by the drum passing under the controller fingers, and this connection is automatically maintained for a sufficient time interval to ensure that the switch completes its motion and that the trigger engages. This operation, of course, takes place in an extremely short space of time. By the time the hand-wheel has returned to its original position after completing one revolution, the solenoid circuit has been interrupted and the switch is now ready for automatic tripping in the event of an overload. The switch may furthermore be tripped by the operator by pressing the right-hand lever, the effect of which is to energise the trip coil. The controller is provided with a ratchet so that it can only move in one direction and cannot be turned back. A second ratchet is introduced between the hand-wheel and the drum similar to the winding arrangement of a keyless watch, so that the drum itself cannot be arrested during the second portion of the revolution by the operator holding the hand-wheel stationary. Thus while the switch cannot be held closed on a short-circuit, it is also impossible for it to close more than once, even though the closing lever be held in the "on" position, for in order that the switch may be closed a second time, the hand-wheel requires to be set afresh. Signal lamps are provided on the operating panel, to indicate whether the switch is in a closed or open position, these being operated electrically by suitable contacts on the switch itself.

Fig. 16 is a diagram of the controller connections, and is self-explanatory.

Fig. 17 is a new type of feeder-charging gear suitable for three-phase circuits up to 10,000 volts. It consists of six cast-iron circular tanks supported on heavy porcelain insulators; and inside each tank, and concentric with it, a porcelain pipe is fixed. Insulated copper rods, connected together, are gradually lowered into the cast-iron tanks. The tanks are filled with water, and at the bottom of each is a small cast-iron pan of mercury. The cast-iron tanks themselves form the terminals of the different phases, so that no flexible connections are required.

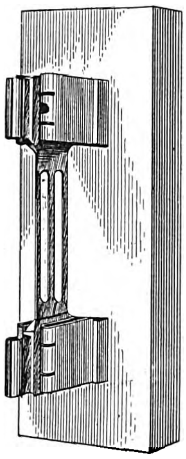


Fig. 18.—Open Type L.T. Fuse.

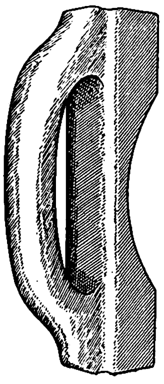


Fig. 19.—Detachable Handle for Replacing Fuse.

Before passing from the subject of the high-tension switch gear, mention may be made of the sub-station boards supplied to the Hammersmith Borough Council, some panels of which boards are on view at the Exhibition. Each panel includes nothing more than a direct hand-operated H.T. switch for 2,000 volts of the pattern illustrated in Figs. 3 and 4 (the lever and tripping coil only being to the front of the board, of course), and a time-limit overload relay such as has also been described in this article. As the board is for a sub-station, measuring instruments have been deemed an unnecessary refinement.

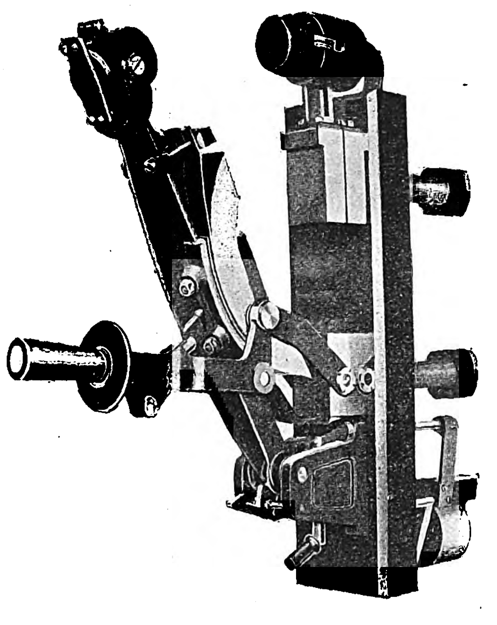


Fig. 20.—Continuous-current Carbon Break Circuit Breaker, Reverse Current Type.

A simple and ingenious low-tension fuse of the open type is shown in Fig. 18. It is made of a special "non-arcing" metal, and the ends are cast directly on to the fuse strip and provided with a special beading so that a detachable insulating handle (Fig. 19) can be fitted for the purpose of insertion and withdrawal of the fuse. This materially reduces the cost of the fuse, without impairing its practicability. A useful feature of this fuse is that the fuse strip is formed of three bands of different widths. In the particular instance shown in the illustration, for instance, the widths are $\frac{2}{32}$ in., $\frac{5}{32}$ in. and $\frac{9}{32}$ in. In "fusing" a circuit it is quite a simple matter to cut away one or two of these bands with a cutting pliers, and thus seven combinations are possible from $\frac{2}{32}$ in. to $\frac{16}{32}$ in. In this manner a single stock fuse will suffice over a range of, say, from 25 to 200 amperes, and this enormously reduces the amount of stock fuses which it is necessary to keep.

Fig. 20 shows Messrs. Ferranti's latest type of continuous-current circuit-breaker. The carbon on the movable arm is arranged to swivel, so as to give the best possible contact with the back carbon, and the latter is attached to a sliding sleeve pressed outwards by a strong spring. This spring serves the double purpose of providing a quick break, acting as it does at the maximum radius on the movable arm, and it also causes the carbon supported by the fixed portion of the circuit-breaker to follow the other sufficiently far during the opening motion to ensure that the final break occurs between the carbons and not between the main contacts. The breaker is closed by a very simple toggle joint arrangement, and the overload tripping mechanism is actuated without a solenoid.

The same type of toggle joint is employed on an isolating switch shown at the Exhibition. Although the switch is for closing a 3,000-ampere circuit, it can be put on or off quite easily with one hand without any effort, and is the most easily-worked switch of its capacity that we have seen.

## NEW SWITCHBOARD AT THE GUERNSEY TELEPHONE EXCHANGE.

As was recently announced in our columns, a new multiple switchboard has been taken into use at the Guernsey Telephone Exchange. The board has been made by the International Electric Co. to the specification of the consulting engineer (Mr. A. R. Bennett), and the resident engineer (Mr. Robert McLean) has supervised its erection.

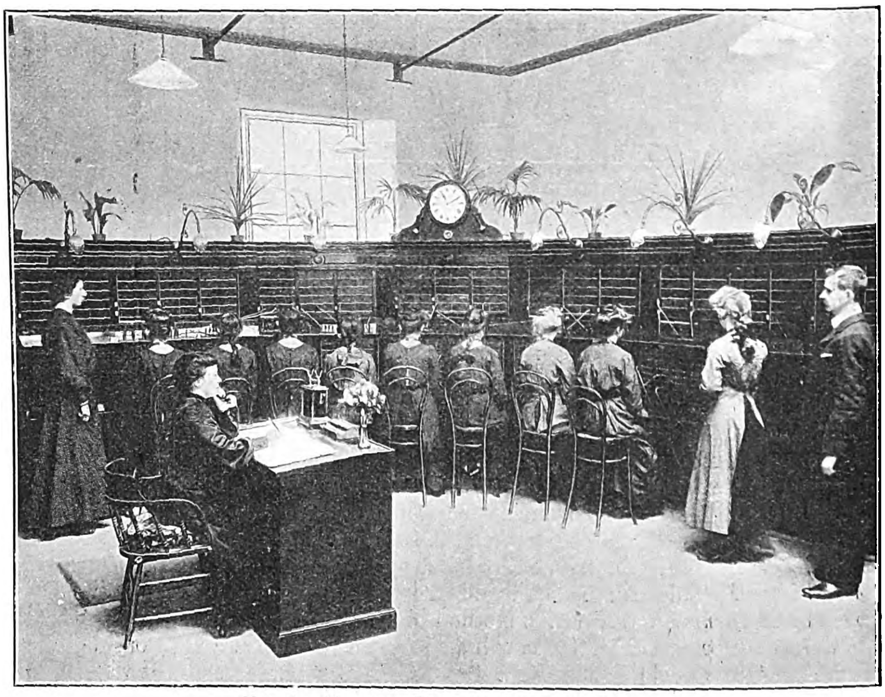


Fig. 1.—General View of Switchboard.

The general arrangements of the board are seen in Fig. 1. The chief feature is the arrangement of the operator's cords, the operating shelf being in two parts. The answering plugs are on the lower shelf, and the calling plugs on a shelf at a higher level (clearly seen in the figure), above the calling indicators and local jacks, and below the multiple jacks. At present the board accommodates 50 junction lines, 50 public call lines, and 900 subscribers, there being 11 operators' positions. There are 100 subscribers to each operator's position, and one operator serves 50 junctions, or 50 public call lines.

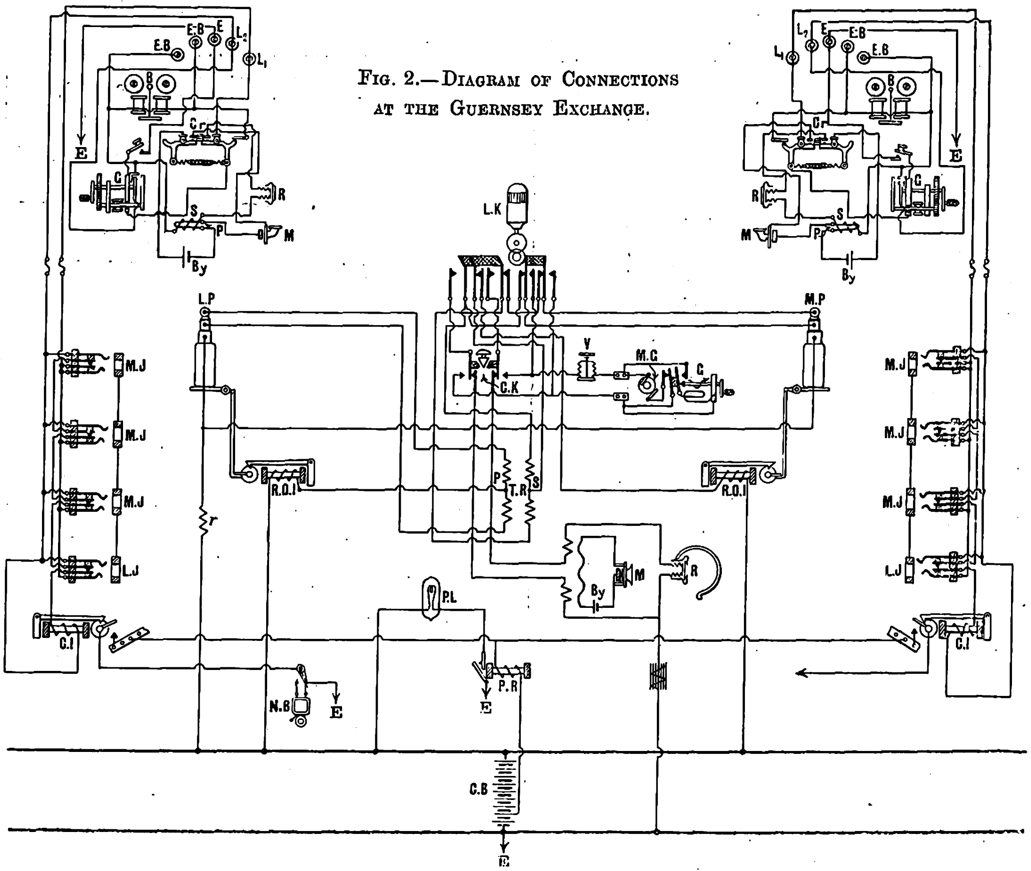


Fig. 2.—Diagram of Connections at the Guernsey Exchange.

The multiple of the board is capable of extension, however, to 3,000 subscribers. A type of calling indicator is employed which is automatically restored by the insertion of the answering plug. The mechanism is shown diagrammatically in Fig. 4, which represents the indicator after it has acted. The coil D is of the ordinary tubular pattern, and, when the armature is attracted, the hooked brass lever GG is lifted as usual. Instead of releasing a drop flap, however, it releases a spring-controlled semi-cylindrical brass piece, F, part of which is painted white and shows through a window above the answering jack. This revolves about the centre C, and at the same time the crank-pin A, which is fixed to an extension of the piece, revolves in an opposite direction and comes in front of the jack B. On inserting the plug into the jack through the hole E below the indicator window, this crank-pin is pushed back again to the left, and the whole piece F revolves with it, restoring the indicator, as now only the black part of the cylinder comes opposite the window. Provision is made for a double ring-off, in accordance with modern telephone work, and the arrangements are such that the withdrawal of the calling plug automatically replaces both ring-off indicators. The cord circuit is also so arranged that the operator, after having connected the two subscribers, cannot put her own instrument into circuit without disconnecting them. The ring-off indicators and pilot lamps are actuated by a common battery. Each operator's position has 12 pairs of plugs, the cords of each pair being connected together only through a translator, the centre of each winding of which is connected to the battery through the ring-off indicator corresponding to that side. Each pair of cords is controlled by a three-position combined ringing-and-listening key, and provision is made for the joining up of adjacent positions during the less busy hours of the service. Each operator has also a ringing-back key for use if necessary. The connections of all the circuits, including the cord circuit, are clearly indicated in Fig. 2, and Fig. 3 shows the external appearance of a strip of indicators.

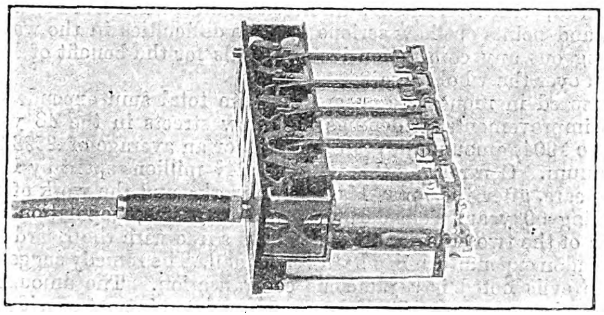


Fig. 3.—Strip of Indicators.

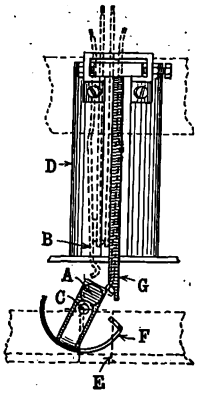


Fig. 4.—Diagram of Mechanical Replacement Indicator.

## THE RECENT STRIKE AND LOCK-OUT IN BERLIN.

BY H. S. MEYER.

All labour wars—strikes as well as lock-outs—embody sociological problems which are of considerable interest to the industry at large. Therefore, it might not be out of place to give a short review, on the basis of facts obtained on the spot, of the causes of the recent Berlin strike, with the engineering lock-out of about 40,000 workmen.

To understand the situation, one has to bear in mind that from a politico-economic point of view a considerable change has taken place in the German industry during the last decade. Most of the private firms have been turned into joint-stock companies, and these have amalgamated into huge trusts, which control the market to a certain extent, and whose leaders have great influence with the Government. On the other hand, the workmen, who in former days used to look at their employers more or less as their paternal friends, have formed strong labour associations, after the model of the British trades-unions, and although these associations are supposed to be non-political, they are *de facto* under the influence of the Labour party.

During the years of trade depression, when most of the factories worked with a reduced staff, matters ran fairly smoothly, but as soon as the electrical trade in Germany began to improve again and the firms had a large amount of orders on their books, the workmen began to bring up their grievances, resorting in most cases to strikes if their demands were not fulfilled. Their policy was to limit such strikes to specific classes of work, avoiding a general strike, so as to be in a better position to carry their points; since any partial strike, while paralysing to a great extent economical production, allowed the strikers to be supported by those who remained working.

At first the labour organisations fought chiefly for better wages and piece-work prices, but gradually they began to meddle with questions of shop discipline and changes in the organisation. Their deputations took it upon themselves to criticise the management for any move they made, and continual negotiations had to be carried on between employers and employés. Such a condition of affairs in a military country like Germany was unbearable, and therefore a fight, which would determine how differences of opinion between capital and labour were to be decided, was bound to come sooner or later. Although social politics accord in principle equal rights to both, in practice successful work is only possible if the former remains master in his own house.

In this strained atmosphere a comparatively trivial matter was sufficient to cause the explosion. The screw-makers of Messrs. Siemens & Halske and the labourers in one of the departments of the A.E.G. cable works—all told, a few hundred hands—thought their turn had come to demand a substantial improvement in their earning capacities. As usual, an ultimatum was sent to the respective managements with the threat of a strike in case the demands should be rejected. Both firms, probably in view of the prosperous times which exist just now in Germany, were willing to make some concessions to their workmen; but, blinded by previous successes, the men insisted on all of their demands, and without further pourparlers went out on strike, relying on the support of their fellow-workmen.

Under such conditions the two large firms decided to clear the situation by making this a test case of strength between capital and labour. In accordance with a mutual agreement, all their works in Berlin and surroundings were closed, which forced about 40,000 workmen out of employment and on to the limited funds of the labour organistions. On the other hand they asked for their capital of about 200 million marks a temporary reduction of its earning power. It was a foregone conclusion who would be the winner in this struggle, in which all the odds were against the workmen, even public opinion, which during the last great miners' strike in Westphalia had been strongly on their side and against the syndicate of pit-owners.

For a time the fight threatened to extend over a much larger area, as either side tried to obtain assistance from their affiliated interests; but while the employers were successful in forming a defensive and offensive alliance of all the metal works in Berlin, the workmen failed completely in their efforts to cripple the service of the Berlin tramways and the town lighting by a strike of sympathy of the employés in these services, which would have brought about the intervention of the authorities.

The struggle lasted about four weeks, when the labour organisations had to admit their defeat. Peace was concluded on the basis of the concessions which the firms offered before the strike.

To us in England this last event in the history of strikes must cause grave reflections. Is our electrical industry equally prepared to meet unreasonable demands of the labour unions? This question can hardly be answered in the affirmative, as long as there are such an excessive number of small and large firms, some with entirely American and others with entirely Continental organisations, and all without a common representation. Only if united, can capital defend its rights against labour, and therefore a similar process of amalgamation must begin in England, as has been witnessed in America and in Germany, the more so as the electrical industry requires also for successful competition on the world's market large capital and combined efforts.

In conclusion a Table giving a comparison of the average wages paid by the Berlin electrical works and by a large English firm in the Midlands may be of interest.

| Average wages per hour. | Berlin. | Midlands. |
|---|---|---|
| Skilled labourers ................ | 8d. | 8d.–9d. |
| Unskilled labourers .............. | 5d. | 5d.–6d. |
| Girls and boys ................... | 2d.–3d. | 2d.–3d. |
| Number of working hours per week. | 60 | 52 |

## ENGINEERS' ADVICE ON LONDON TRAFFIC.

The report of the Advisory Board of Engineers to the Royal Commission on London Traffic was published last week as Vol. VII. of the Commissioners' Report. The main results arrived at in the shape of recommendations were adopted by the Commission and published in the main report, Vol. I., which we summarised and commented upon in *The Electrician* of July 21st.

The volume just issued contains the detailed information gathered by the Advisory Board and the considerations leading to the various recommendations. The names of Sir John Wolfe-Barry and Sir Benjamin Baker are a sufficient guarantee of engineering competence, business experience and level-headedness, and that of Mr. William Barclay Parsons adds the special experience and study of traffic problems in a great city where they have been as pressing as in London.

The "reference" by the Commission to the Advisory Board covered the following matters: The best general directions of new thoroughfares from Central London outward, with surface or other tramways; how far the provision of secondary thoroughfares parallel or adjacent to existing main thoroughfares might relieve traffic congestion; the proposals of Mr. Fitzmaurice in regard to the construction of new streets; the means of obviating obstruction caused by crossings, and by the standing of vehicles in thoroughfares for unduly lengthy periods; as to the practicability of the construction of subway for pipes, cables, &c.; the preparation of plans of the best types of "shallow" subways for railways and tramways, including the approaches thereto; and generally any practical suggestions which the Board may think desirable to offer for dealing with the problems of locomotion and transport in London.

The report is divided into the main headings of "Preliminary," "Streets," "Tramways," and "Railways." The preliminary section sets out the present anomalous conditions which distribute the provision and care of highways in Greater London among 106 highway authorities, with no central authority to guide, advise or supervise them, and points out how serious are the difficulties in the way of carrying out any comprehensive proposals for the benefit of locomotion over the whole area.

Measured in money it appears that the total sum expended on street improvements, widenings and new streets in the 48 years (1856 to 1904) amounted to £18,879,573, or an average of £393,325 per annum. Contrasting this with the 24¾ millions spent by Paris in 30 years, after the great Hausmann works and the work of the preceding 60 years, considering the relative size, population and wealth of the two cities, most people will agree with the Board that the London expenditure has been very small. The remedy suggested for the evils noted is a judicious centralisation. The amount of goods and passenger traffic to be accommodated is next considered, the area being divided up into zones and sections for the better display of distribution of total and working population.

The Board rightly considers that street improvements are the root of the problem, and that very little having been done in that direction during the last 30 years deals with the matter at considerable length. It is pointed out that, in considering the problem of new and wider streets and their costs, many other urgent subjects would be determined. Among these are tramways, both on the surface and underground, and town railways below the street surface. Subways for pipes and cables, too, are included, so that no breaking up of road surfaces will be necessary.

The widths necessary for new or widened streets will depend upon their relative importance, and hence the Board classifies the thoroughfares into—

1. Main avenues, with a roadway of 94 ft. and a total width of 140 ft.
2. First-class arterial streets, with a roadway of 64 ft. and a total width of 100 ft.
3. Second-class streets, with a roadway of 48 ft. and a total width of 80 ft.
4. Third-class streets, with a roadway of 36 ft. and a total width of 60 ft.
5. Fourth-class streets (suburban only), a total width of 40 ft. to 50 ft.

The main avenues would accommodate four tramway tracks, the inner for fast cars, the outer for local cars; the other streets would each provide for a double tramway line. It is suggested that the width above defined for a third-class street should be the minimum permitted in the strictly urban districts, and 40 ft., or, better, 50 ft. the minimum in suburban districts. After providing for cellars and pipe subways, the main avenues and first-class streets could accommodate four railway tracks below the road surface, and the second-class streets a double line. In place of railways there might be subway tramways. So arranged, the station platforms would be only 14 ft. or 16 ft. from the street level. Where four tracks are run, the central pair should be for an express service, with stations at considerable distances, as in the New York subway.

A satisfactory plan must include: (1) A "main avenue" from east to west from Whitechapel to the Bayswater-road. (2) A "main avenue" from north to south, from Holloway to the "Elephant and Castle," and possibly further south, crossing the Thames by a new bridge near the western boundary of the City. (3) The widening in places of the width to "first" or "second-class streets" or the making of new streets of those dimensions on several of the trunk lines of thoroughfare. (4) Provision that no new streets for local purposes should be less in width than the width of "third" and "fourth-class streets." (5) The freeing of points of congestion where the tide of east and west traffic clashes with that from the north to south.

The west to east avenue is the most important work advocated. It provides for the greatest existing volume of traffic and will require the acquisition of much valuable property. But we are not at all sure that the north to south avenue will not be of superior benefit, especially if extended, as we think it should be, to Denmark Hill or Dulwich Village. North to south traffic is now less than east to west, but this is partly due to the inferior facilities. Equalising these will probably alter the distribution of population and reduce the relative pressure upon the east and west routes. Both "main avenues" should carry four lines of surface tramway and four lines of electric railway in their sub-structures, these lines joining up to existing or future tramways and railways at their termini, and so providing two great lines of communication the length and breadth of London, each with four transport services of graduated speeds. The expenditure on these two works might be in the neighbourhood of 30 millions, reduced by "recoupment" and "betterment" to perhaps 25 millions. It is difficult to assess the commercial value of the tramways and railways, and indeed it would be a very bold "traffic expert" who would pledge his reputation to an estimate within 50 per cent. either way of the actual results.

This project appears a very bold one, but reduced to its proper proportions it amounts to making 10 miles of new streets in a city which has several thousand miles of old ones, and providing those streets with carrying capacities somewhat commensurate with the population to be served; to quote the words of the report: "Formidable, therefore, as the figures of first cost of the 'main avenues' may seem, they appear to us such as should be faced in view of the advantages to be gained." Forcible reasons for cutting these avenues on a new alignment instead of widening out existing lines of thoroughfare are given, and, we think, might have been added to if necessary. A list of smaller and less costly improvements follow, which, the Board is careful to say is not exhaustive. It suggests that an Act of Parliament should be passed providing that on certain scheduled roads or streets no further building within 50 ft. of the centre line should be permitted. The list mentions the Euston and Marylebone-roads, with a new street cut through from Stafford-street to the Edgware-road, facing Harrow-road. Thus a "first-class arterial street" would connect the line of trunk railway termini from King's Cross to Paddington. The cutting through of the Mall to Charing Cross, the widening of Constitution-hill, and the construction of a street from Victoria-street across the Horse Guards' Parade to Waterloo-place, suppressing the Duke of York's steps (but not the column), and a new road from Berkeley-square to the Mall are improvements small in extent, but calculated to be of great benefit. Viaducts from Blackfriars Bridge to Farringdon-street and from the northern end of Waterloo Bridge to Wellington-street are suggested to get over the level crossing of the two streams of traffic. These viaducts would be of the "elevated railway" type, and in the Blackfriars case a tramway is proposed; widening of the bridge would be necessary.

These are put forward as typical cases and the most urgently needed, but not as exhaustive. The serious constriction of some of the main roads leading out of London is mentioned as requiring attention, especially the notorious case of High-street, Brentford. This matter, however, requires particular study, and is certain to be kept to the front by the increasing body of motorists.

The statistics of traffic taken in the main thoroughfares of the metropolis are set out in the report in a carefully analysed form, with coloured diagrams of some of the main crossings. One remark on the relation of street widening to tramways is worthy of the careful attention of local authorities generally and the London road authorities in particular. We quote it verbatim from page 47: "The widenings of streets should not in justice be considered or treated as incidental merely to tramways. They are necessary in all cases, as the widening of the Strand is necessary to accommodate street traffic, of which tramways under modern conditions form as much a part as cabs or other vehicles."

The Tramway section of the report contains few constructive recommendations beyond those adopted and set out in the main Commission Report. To general descriptions of the existing tramways, tabular and graphic traffic statistics are added. It will perhaps surprise some to find that more passengers use the Westminster tramway terminus than Charing Cross station. The principal extensions urgently required are: (1) the extension of the southern lines across the Thames; (2) the extension of the cross-bridge lines to reach "points of destination" and avoid terminals; (3) the joining of the terminals of the "northern section" where these are not extended through, to permit of continuous running with an increased number of cars, *i.e.*, the abolition of "dead-ends"; (4) the construction of lines between Putney, Hammersmith, Victoria and Knightsbridge, possibly combined with a subway to Aldgate; (5) tramway extension to all the great railway termini; (6) general and unrestricted through communication, so that cars can pass from outlying districts to the centre and vice versa, irrespective of ownership.

These recommendations are only the common sense of the position, and we think that any body of levelheaded men who were mainly concerned to improve the means of transport in London would agree to them.

Apart from the lines on the "main avenues," the most important new route suggested by the Board is one from Hammersmith to Aldgate. It is considered that over a large part of the area surface tramways are out of the question, and it is consequently proposed to construct in subway from the corner of Sloane-street and Knightsbridge to Aldgate. This proposal seems to us the one most open to criticism of all those made by the Board. That its authors are aware of the difficulties is quite clear from their remarks "that such a line will be extremely costly, and such an expense can be met only by arranging to bring to the system the largest possible amount of traffic." Radiating surface tramways at the western end are to assist in supplying the traffic needed to make this subway pay. The crossing of the bridges and consequent extensions to eliminate "dead-end" termini are insisted upon as of the utmost importance. Connection between the northern and southern systems via the Victoria Embankment and Kingsway, and by the Viaduct from Blackfriars Bridge to Farringdon-street are suggested as urgently needed and immediately practicable. The Aldersgate terminus presents the greatest difficulty; the Board considers street widening impracticably expensive and suggests a subway with a terminal station near Cheapside, or possibly an extension to Southwark Bridge or to a new bridge west of Southwark. An important general recommendation is that all the great railway termini should be served by tramways. The amount of widening work which will be necessary does not appear to be of alarming extent, and, moreover, the widening cost cannot properly be charged to tramways *per se.* Widening is needed to accommodate the traffic, however it is carried.

On the working of tramways the first recommendation is that variation of ownership should be eliminated in the working. The Board particularly points out that the universal running powers advocated should cover the whole of Greater London irrespective of company or municipal ownership, and makes the important suggestion that the required uniformity of working might be secured by the combination adopted in some foreign cities of municipal construction and company working under lease. The Board thinks it probable that the effect of a proper tramway system in London will result in the practical disappearance of the omnibus. The contention of various tramway authorities that a tramway lessens congestion is also supported by the Board, but it is pointed out that in London a good tramway system will increase the present traffic very greatly, so that eventually there may be as many passenger vehicles on the streets as at present, but they will carry a far larger number of passengers at a higher average speed. The Board naturally took into consideration the existence of the motor omnibus, and emits a non committal opinion as to its true position in a system of rapid transit relatively to the electric tramcar.

The railway section commences by an analytical description of the traffic handled by the existing railway companies, a statement of the districts served, termini, &c., of all the existing and authorised lines. The analysed and tabulated traffic statistics and diagrams are most instructive, especially the "load diagrams," which show that electric supply is not the only business in which maximum demand and load factor are of paramount importance. The disadvantages of termini for urban and suburban railway traffic, and the other disadvantages resulting from trunk line railways and termini designed and located to suit long distance traffic having catered for suburban traffic are discussed in some detail, and summarised in the opinion that the attempt to cater for two or three distinct classes of traffic has not been crowned with success. The long distance and suburban services interfere with each other, and the urban services are little superior in speed to good tramway services.

The practical absence of through running is justly charged with much of the suburban railway inconvenience. There are but three through routes north and south, the East London or Thames Tunnel, the Chatham and Dover via Snow Hill and Blackfriars, and the West London.

In every case there is divided ownership and administration, which militate against any general system of through services of such frequency as is necessary for efficient service and the relief of the various termini.

The City & South London railway, of course, affords a north and south communication, mainly of an urban character, and the increase in its traffic since the extension to Islington bears out the value of running through instead of only to a central terminus.

The Board considers that through running to termini outside "Greater London" for suburban, and outside the "Central Area" for urban traffic is the system best fitted for the needs of the metropolis, and mentions as examples the various east and west services on the Metropolitan and Metropolitan District Railways. It notes the comparative failure of circular running, as shown by the financial results of the "Inner Circle," but we are disposed to think that if the Inner "Circle" had been less elliptical, and the speeds 30 to 50 per cent. higher, these results would have been materially improved. However this may be, it is interesting to notice that all the later "Tube" promotions have been laid out to provide through services. An apparent exception is shown by the N. E. London Railway Act, passed last session, but the plans suggest that its engineers did not exclude from their thoughts a southern extension as a future contingency. The Board thinks that the decision which may be come to on new street and tramway proposals will sensibly affect future railway development in London.

If the new "main avenues" are formed it is reasonable to suppose that the opportunity of constructing railways in their subsoil will be taken, whilst where surface tramways are laid on existing streets adequately widened it will probably be found that the tramways will meet the necessities of the case, at least for strictly urban traffic. Experience shows that the construction of underground railways does not relieve street congestion and offers no alternative to street widenings The poor financial results of the existing underground lines leads the Board to consider whether assistance from the rates can be recommended. History of metropolitan railway finance commences in 1855, when the Metropolitan Railway obtained its act for a railway from Paddington to the Post Office. The public showed no eagerness to subscribe the capital, and it may fairly be said that the City of London and the Great Western Railway enabled that line to be built. The completion of the "Inner Circle" was also rendered possible only by the subscription of £800,000 by the City and the Metropolitan Board of Works.

The difficulty is purely financial and great hopes were based upon the cheaper construction made possible by the "tube" system, with its freedom from compensation claims and from the interference of various subsoil works. These hopes have not been altogether realised owing mainly to the costs of station accommodation and equipment, including large and rapid lifts, and the capitalised cost of working these. The Board considers that the total cost of any future "tube" railway fully equipped may be estimated at from £650,000 to £900,000 per mile. Allowing for present prices, the recorded construction costs of the Metropolitan and Metropolitan District lines work out about £1,000,000 per mile. But it is pointed out by the Board that the two amounts are not quite on all fours, nothing being allowed in the shallow lines for generating station and electrical equipment, whilst the stations for electrical working would be less costly than those necessary for steam.

However the comparison may work out in any particular case, result is that the public steadily refuses to find capital for either tube or shallow railways in London, the tubes now working and under construction being at the risk of a few financiers and contractors.

The Board has not seen its way to make plans for shallow railways or tramways, but it makes one suggestion for the cheapening of tube railways which seems worthy of consideration. It amounts to the combination of "shallow" stations with tube-line construction, the lines diving away from the stations below all subsoil works. But after all, "the question is one of detailed estimate under particular conditions, and no general law can be laid down."

The Board's main recommendation on the subject is that adopted in the Commission's report, that no extensions can be recommended until the effect of the lines now under construction is ascertained. But "they do not think that the results will modify the present experience, that underground railways do not relieve street congestion or save the cost of new streets and street widenings." Therefore street improvements have the first claim on the rates at present. We believe that this opinion will hold good for a very long time. Street congestion can only be cured by additional street accommodation. Even underground railway passengers eventually come into the streets, and must get to their "points of destination" by the use of streets. Experience shows that it is only for comparatively long journeys that people will descend, whether to shallow or deep lines.

It is noteworthy that although the traffic statistics show that in the central area the goods vehicles in the streets may equal or exceed the passenger vehicles in number, whilst their low speed makes them more obstructive, no possibility of banishing the bulk of the goods traffic to the nether darkness is even hinted at. This is the more remarkable in view of the recent completion of the Chicago tunnels, but it may be admitted that the subject is one of enormous complexity. We should mention that the pneumatic parcel scheme advocated by Sir John Wolfe-Barry and Colonel Crompton, and promoted unsuccessfully in the last session of Parliament receives a certain amount of approval. But on the whole the Board has devoted itself to the passenger problem, and has done so advisedly.

Our readers will see that the main physical remedies recommended for the present unsatisfactory conditions of London transport are: 1. New streets; 2. Wide streets; 3. Comprehensive tramway system; 4. Improved railway working. On the administrative side there are: unity of purpose as the guide of all street improvements and tramway extensions and single control of tramway working. The special interest of the report to our readers is the prospect of the greatly extended use of electric traction consequent on the adoption of these recommendations, and it will suggest itself to many that a great scheme of electric-power generation and distribution over the whole of "Greater London" under a single administration will be found a necessary corollary, essential to the most economical and efficient working of the various transport systems.

How these recommendations can be translated into actual fact rests primarily with Parliament, for the necessary administrative machinery does not yet exist. Upon the action of Parliament will depend the relative extent to which public and private promoters will be able to obtain the necessary powers of action; but whoever does the work will find a great mine of preliminary information, and a good deal of detailed suggestion, that will ease their labours very materially. It may be hoped, too, that Parliament will treat with a great deal of respect all responsible attempts to carry out the recommendations of the Royal Commission and its Advisory Board of Engineers.

## BOARD OF TRADE REGULATIONS FOR OVERHEAD WIRES.

The regulations for overhead lines, which we print below, have been prescribed recently by the Board of Trade in a number of instances. Under No. A13 of the regulations for securing the safety of the public, made by the Board under the Electric Lighting Acts, 1882 and 1888, it is prescribed that:

A 13. *Overhead Lines.*—Overhead lines shall not after the date of these regulations be erected or maintained except in accordance with plans approved by the Board of Trade and subject to such regulations as the Board may prescribe; provided that this regulation shall not apply to any electric lines which have been erected at the date of these regulations so long as those lines are maintained in accordance with any regulations of the Board of Trade which are in force and applicable thereto at that date and with any requirements of the Board made thereunder.

The following regulations apply to modern practice with ordinary pressures, but it is probable that no serious objection would be made by the Board to variations to suit special cases

### REGULATIONS FOR OVERHEAD WIRES.

1. *Maximum Intervals between Supports.*—The interval between any two wooden poles used singly as supports for an overhead line shall not exceed 200 ft.; provided that where the line makes an angle at any such pole the interval between that and the next pole shall not exceed 150 ft. In the case of supports other than single wooden poles the intervals between the supports shall be such as may be prescribed by the Board of Trade.

2 *Factors of Safety.*—Every support for an overhead line shall be of a durable material, and shall be properly stayed against forces due to wind pressure, change of direction of the line or unequal lengths of span. The factor of safety shall be for overhead lines at least 5, and for wooden poles at least 10, and for iron or steel structures at least 6, taking the maximum possible wind pressure at 50 lb. per square foot. No addition need be made for a possible accumulation of snow.

3. *Attachment of Overhead Lines.*—All overhead lines shall be attached to insulators, and shall be so guarded that they cannot fall away from the support.

4. *Height from Ground, &c.*—An overhead line, placed after the date of these regulations, shall not in any part thereof be at a less height from the ground than 22 ft., except with the consent of the Board of Trade, and shall not be accessible to any person without the use of a ladder or other special appliance; and, in the case of a high-pressure overhead line so placed, no part thereof which crosses a street shall be at a less height from the ground than 25 ft., except with the consent of the Board of Trade.

5. *Three-wire System.*—Where a supply is given by overhead lines on the three-wire sytem the positive and negative conductors shall be placed side by side above the intermediate conductor. The intermediate conductor shall consist of two wires placed side by side at a distance apart greater than that between the positive and negative conductors, and connected in each span by two cross wires placed in such a manner that in the event of either the positive or negative conductor breaking it shall fall on one at least of the cross wires.

6. *Supply from Two-wire System.*—Where a supply is given by overhead lines from a two-wire system, with the negative conductor connected with earth, the positive conductor shall be placed above the negative conductor in such a manner that in the event of breakage it must fall on the negative conductor.

7. *Service Lines from Overhead Lines.*—Service lines from overhead lines shall be led as directly as possible to insulators firmly attached to some portion of the consumer's premises which is not accessible to any person

without the use of a ladder or other special appliance. Every portion of any service line which is outside a building, and is within 7 ft. from the building, shall be efficiently protected by insulating material.

8. *Angle of Crossing Thoroughfares.*—Where an overhead line crosses a street, the angle between the line and the direction of the street at the place of crossing shall not be less than 60 deg., and the spans shall be as short as possible.

9. *Lines Crossing Metallic Substance.*—Where an overhead line crosses, or is in proximity to, any metallic substance, precautions shall be taken by the undertakers against the possibility of the line coming into contact with the metallic substance, or of the metallic substance coming into contact with the line by breakage or otherwise.

10. *Discharge of Pressure in Case of Fire.*—In the case of any high pressure overhead line exceeding one half-mile in total length, means shall be provided whereby in case of fire or other emergency the pressure may be discharged from any portion of the line erected over or alongside of any building or buildings.

11. *Maintenance.*—Every overhead line, including its supports and all the structural parts and electrical appliances and devices belonging to or connected with the line, shall be duly and efficiently supervised and maintained as regards both electrical and mechanical conditions.

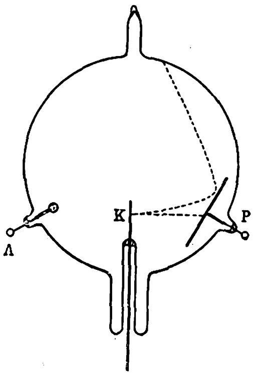
12. *Disused Overhead Lines to be Removed.* – The undertakers shall remove any overhead line upon ceasing to use it for the supply of energy unless upon so ceasing they satisfy the Board of Trade that they intend to bring it into use again within a reasonable time.

These regulations are made subject to the power of the Board of Trade to make such further or other regulations as they may think expedient.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

*Parabolic Path of Cathode Rays.*—A. Wehnelt describes an experiment for demonstrating the parabolic path of cathode rays under the influence of an electric field. In the ordinary experiment, the trajectory is so flat that its parabolic curvature is not at all evident. The author therefore employs the very soft and slow cathode rays obtained from cathodes consisting of metallic oxides. These rays have been employed for demonstrating the circular path of cathode rays in a magnetic field. The apparatus is shown in the figure. A is the anode, K the cathode, consisting of a piece of platinum foil heated by a separate battery, and bearing on its right-hand face a patch of metallic oxide the size of a pin's head. P is an aluminium plate which may be connected with K. If K is joined to the negative terminal of a 110 volt direct-current circuit and A with the positive terminal, with a resistance interposed, a pencil of cathode rays passes from K to P so long as the latter is insulated. On joining K and P, however, the latter exerts a repelling electrostatic action upon the rays, and these are deflected along a parabolic path. The field is not quite homogeneous, and therefore the parabola is not perfect, but it would be easy to make it so.



[A. Wehnelt, *Physikalische Zeitschrift*, October 1, 1905.]

*The Electric Wind.*—The electric wind is the product of three different factors—viz., the change of form of a fluid conductor under the influence of electrostatic force, the repulsion between similarly-charged ions, and the drag exerted by these ions upon the fluid. Chattock found that the air constituting the dragged portion possesses a velocity which is very small in comparison with that of the dragging ions, being 2 per cent. of the speed of the positive ions and 1·4 per cent. of the speed of the negative ions. V. Schaffers describes some experiments by which the three effects may be distinguished. If a positively-charged point is held near a flame, and a glass plate is interposed, the yellow part of the flame is repelled, while the blue part is attracted. This is the simple deformation. On substituting an earthed wire gauze for the glass plate, the whole flame is repelled by the air current, the ions being stopped by the gauze. On removing the latter, both effects are superposed, and the ordinary phenomenon of the electric wind is witnessed. The author describes an experiment in which the ionic repulsion may produce an effect stronger than the dragged air. He mounts six vanes of aluminium in a little mill wheel exposed to a charged point, and discharges them on the principle of the influence machine. In this way he succeeds in making the point drive the vanes in a direction contrary to the electric wind, thus showing the superior power of the ions.

[V. Schaffers, *Physikalische Zeitschrift*, October 1, 1905.]

*Atmospheric Electricity and the Eclipse.*—A. Gockel measured the potential gradient and the ionisation of the air before and during the total eclipse of August 30th at Vinaroz in Spain. The potential gradient rose in the course of the morning from 80 to 95. This maximum was reached at 1 p.m. Then there was a rapid fall, the value 68 being reached at 1:5 p.m., 12 minutes before totality. At 1:18, one minute after totality, the value rose suddenly to 90, but then fell again rapidly to 80, remaining constant at that value till 3 p.m. The ionisation showed a similar course.

[A. Gockel, *Physikalische Zeitschrift*, October 1, 1905.]

*Slow Beta-Rays from Radium.*—Miss J. M. W. Slater has made a special study of the slow electrons discovered by Thomson, whose ability to penetrate aluminium foil and other media is no greater than that of the $\alpha$-particles. Both polonium and radium give out quantities of these rays. Thomson has suggested that these rays may also be emitted by the emanations of radium and thorium, though these do not emit rapid electrons, in which case the deposition of excited activity on the negative electrode would be accounted for. The authoress's experiments decided this point. A gold-leaf electroscope mounted in a vacuum communicated with a side tube containing radium. The positive leak then considerably exceeded the negative leak, showing the emission of a negative radiation. That this did not consist of rapid electrons was shown by interposing a thick lead screen, which did not affect the leak. The question then remained as to whether the slow electrons were emitted by the emanation or by the excited radio-activity, and this was decided in favour of the emanation by showing that the leak commences at once, whereas the excited activity is slow in developing. The experiment consisted in introducing a sealed radium bulb into the branch tube, and breaking it by means of a piece of soft iron released by a magnetic contrivance and dropped upon the bulb. Thus the emanation is proved to give off both $\alpha$-rays and slow $\beta$-particles.

[Miss Slater, *Philosophical Magazine*, October, 1905.]

*Origin of Prismatic Colours.*—The fact that by the aid of a spectroscope interferences may be observed with light originally white used to be regarded as a proof of the existence of periodicities in the original radiation. This conclusion, as Lord Rayleigh points out, requires revision. When a pulse strikes a grating, it is obvious that the periodicity and its variation in different directions are the work of the grating. Even in a prism there is some generation of waves within the prism itself. The author connects this with the fact that a small obstacle, such as a fishing-line, when hanging in a stream, produces a wave pattern short in front and long behind, although it has no motion, periodic or otherwise, of its own. Now the resolving power of a prism is given by

$$\frac{\lambda}{d\lambda} = \mathrm{T}\frac{d\mu}{d\lambda},$$

where $\lambda$ is the wave-length in vacuo, T the "thickness" of the prism, $\mu$ the refractive index, and $d\lambda$ the smallest difference of wave-length that can be resolved. This formula also gives the number of waves ($\lambda$) which travel in the prescribed direction as the result of the action of the prism upon a single incident pulse. The author expresses this number in terms of the velocity V of the transverse pressure (corresponding to the velocity of the stream) and the "group velocity" U ($=\frac{1}{2}$ V in water), and obtains the value outside the prism

$$\mathrm{N} = \frac{\mathrm{V}-\mathrm{U}}{\mathrm{U}}\;\frac{t^1}{\tau},$$

when $\tau$ is the periodic time, and $t^1$ the time of action.

[Lord Rayleigh, *Philosophical Magazine*, October, 1905.]

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## STREET LIGHTING.

We publish this week further interesting figures, all based on actual results, showing that, in spite of the recent improvements in connection with the incandescent gas mantle, street lighting by electricity remains far cheaper than street lighting by gas. The difficulty of making comparisons is enhanced by the different methods of photometry employed by different investigators, so that many of the actual comparisons that are of value are those made by lighting committees whose estimates of relative illumination are made without reference to any measurements either of candle-powers or candle-feet. Another obstacle is the difficulty in obtaining reliable data as to cost, consumption and upkeep of the new high-pressure gas systems which are being put forward as rivals to electric arc lighting; and even the exact falling-off in the candle-power of gas mantles with age is still uncertain,—it is known to be great, but reliable figures are not published freely. In the data that have been circulated by the Gas Light & Coke Co., for instance, the only actual estimate of annual cost relates to the 34 pairs of burners in Fleet-street which displace 12 of the old arc lamps. These burners, it now appears, are not high-pressure burners at all, but are ordinary incandescent ones, rated at about 75 c.p. each. No wonder that the illumination of the street is poor, and were it not for the large number of private lamps—mostly electric—complaints would have been numerous. It appears probable that there is not much difference between these burners and the gas burners referred to by Mr. S. L. PEARCE in the interesting figures which we print on another page. These burners each consumed 2 ft. of gas per hour and gave 75 c.p. when the mantles were new, and if the observations recorded in Mr. FRANK BAILEY'S exhibition lecture are accurate, the show gas burners in Fleet-street are not allowed to get old. In Hyde Street, Gorton, where the tests were made, 25 pairs of these burners were displaced by 22 Gilbert single enclosed arc lamps, probably consuming 400 watts and with a measured maximum candle-power of 430 and a mean hemispherical candle-power of about 300. The enclosed arc lamps probably give as even a distribution of light over the lower hemisphere as the two-burner gas lamps in question, so that the assumption of 300 c.p. instead of 430 favours the gas lamps, for 150 c p. for a pair of gas-burners is their maximum and not their mean hemispherical candle-power. The cost of gas lighting was £150 per annum, half of this cost actually being due to new mantles and other items of maintenance, while that of the arc lighting was £176—an increase of 18 per cent. for at least 75 per cent. more light. The figures for gas lighting were obtained by the Gorton District Council, who decided on retaining the electric lighting, as customers of the Manchester electricity works, rather than pay £26 a year less for a system of gas lighting which was far less efficient. In Fleet-street if 12 of these comparatively small enclosed lamps were put in the same standards as the arcs which have just been displaced, the same illumination would probably be obtained as with the 34 pairs of incandescent gas burners. These would cost, according to Mr. PEARCE'S figures, a total of £96 a year, or less than half the cost of gas lamps. With the better illumination obtained by larger lamps, which would be many times greater than that under present conditions of gas lighting, it is seen that the majority of the estimates published last week and this week have come out at about the same price as gas with far greater light.

We should have liked to extend our comparison to high-pressure gas lighting, but as we have said, it is not easy to obtain satisfactory figures for the cost of this. A significant fact, however, is that the Westminster City Council, after using both electric and high-pressure gas lamps for a considerable period and having made comparative tests, called for tenders for street lighting for a prolonged period and have accepted tenders for electric lighting. The severe rivalry is a good tonic for the electricity supply engineer and the arc lamp maker, but we have no fear of the ultimate result of the competition.

## REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign book.)

◆

**Commercial Economy in Steam and other Thermal Power Plants.** By ROBERT H. SMITH, Professor Emeritus of Engineering in Birmingham University. (London: A. Constable & Co.) 24s.

The object of the author is to try and find some rational expression for obtaining the best dimensions of a power plant in order to obtain the maximum commercial efficiency. With this purpose in view one of the first things is to obtain some expression of the cost of the plant, and this is done by plotting the prices of engines, boilers, gas and oil engines, obtained from current catalogues, against the final volume of the working fluid—that is to say, in the case of a steam engine, the volume of the low-pressure cylinder. The author has taken a prodigious amount of trouble to obtain results for all classes of engines. The curves are plotted to give cost in £ in terms of the final volume expressed in cubic inches. Having plotted the curves for a large number of cases an empirical formula is constructed to express the results. In the particular class, for example, of simple single-acting steam engines with twin cylinders, and working with steam at an initial pressure of 80 lb. per square inch, and having a piston speed of from 475 ft. to 600 ft. per minute, the formula is

$$\text{Price in } £ = 86 + 0{\cdot}1S - \frac{21{,}000}{400 + S},$$

where S is the final volume of the steam in cubic inches. Again, in the case of gas engines of the usual type with one cylinder, the cost in £ is

$$170 + 0{\cdot}04S - \frac{200{,}000}{400 + S}.$$

The expressions for different types of engines are collected together in Table XXIII., p. 111.

There is an interesting table opposite page 118 giving similar information regarding boilers. Here the price is given in terms of the evaporative power of boilers. Thus, a Lancashire boiler costs in general $110 + (0{\cdot}016 + 0{\cdot}0003p)E$ pounds, where E is the evaporative power in pounds of water per hour and $p$ is the working pressure in pounds per square inch. This chapter on capital and working costs, in which these price formulæ are developed, contains a vast amount of useful information, expressed in ordinary language.

Chapter IV. is, in the main, devoted to dynamics, and contains at the end a set of diagrams showing the connection between pressure, velocity, acceleration, &c., in the case of a mass of gas 83⅓ ft. long, which is supposed to be moving in a straight line, the instantaneous pressure at every point in its length being given as an initial condition.

In dealing with the thermo-dynamic part of the subject, the author analyses the change which takes place when heat is added to the expanding fluid as an addition of heat at constant volume, and an adiabatic expansion of the fluid. Thus, if a fluid undergoes a small change of state the change may be conceived as taking place in two steps, first by the addition of an amount of heat, $hp$, where $h$ is the heat required to increase the pressure of 1 lb. of the substance by unity, the volume remaining constant (or, as the author defines it, $h$ = the specific heat per unit volume per unit change in $p$ when the stress alone changes without change in the strain) and then by an adiabatic expansion to the final state. The author goes on to define the dynothermic coefficient which is the ratio between the "resilience created and the heat transmitted." The term resilience is used to mean the energy which can be obtained from a fluid expanding adiabatically from a given state to zero pressure. The author, in fact, makes the pressure and volume the independent variables in the consideration of heat quantities, and develops the subject without specifically introducing temperature, and lays stress on the time element in connection with heat transference.

In Chapter VII. the first adjustment of the size of the plant to realise the maximum commercial economy is considered, the problem which Willans attacked in 1888 by plotting the theoretical amount of energy available per cubic foot of steam with various degrees of expansion, on a ratio of expansion base, in this way finding the particular ratio of expansion which gave the best commercial efficiency with a given back pressure and initial steam pressure. The author elaborates the problem to include the cost of the engine by means of the formulæ for cost developed in Chapter III. and further to include the effect of varying the ratio between the initial and the back pressure. A further elaboration takes place in the final chapters in connection with the furnace temperature and working speed.

The work is original, and suggests many instructive points of view; it is out of the beaten track, and aims at codifying and concentrating experience in a useful way, but the pleasure in reading the book is very much reduced by the mental struggles which have to be made with the nomenclature invented by the author in connection with the thermodynamic part of the subject. There are many diagrams in the book, drawn by Mr. H. M. Hodson, to whom the author gratefully acknowledges his indebtedness.

**Molecular Forces and Newtonian Laws.** By ALEX. CLARK. (Glasgow: W. and R. Holmes.) 3s.

The nature of the views expressed in this book may be inferred from the following extracts. They certainly "differ materially from the current theories on the subject," as the author says in his preface.

The force between two magnetic poles varies inversely as the square of the distance between them, "if the field consists of a perfectly non-magnetic substance; if it possesses any degree of the magnetic property, the force is greater" (p. 42).

In the neighbourhood of a straight magnet "the position of a fragment of iron or small magnetised needle is tangential to an ellipse of which the poles of the magnet are the foci" (p. 58). The *proof* of this is given on p. 227.

A solenoid conveying a current, behaves like a magnet, because the oxygen of the air is a magnetic substance. Two parallel currents in the same direction attract one another for the following reason: "The position of the weakest force is the space between the currents." But "diamagnetic substances when placed in a magnetic field, move from the position of stronger to the position of weaker force. Hence the two copper conductors move towards each other."

These illustrations are chosen at random and are quite typical of the whole book; surely it is unnecessary to criticise them.

**The Law and Practice relating to Patents, Trade Marks and Designs.** By DAVID FULTON, A.M.I.C.E. (London: Jordan & Sons.) 12s. 6d. net.

In addition to being brought up to date by the inclusion of the changes in Patent Law and Practice introduced by the Patents Act of 1902, the new edition of this work exhibits a decided improvement upon the preceding issues. The work of revision and excision has been carefully done; the various acts passed between 1883 and 1903 have been codified and consolidated; and nearly every legal decision of importance is referred to or commented upon, over 300 additional cases having been included in the present edition.

The book is divided into three sections. In the first the law and practice relating to patents for inventions is treated in a clear and systematic manner. After a brief historical introduction the author deals with the procedure in obtaining patents, the subject matter, the specifications, opposition to grant of patent, amendment of specification, the actions for infringement and restraint of threats, licences, assignment and prolongation of patents, &c. The Patent Rules, as amended in 1905, conclude this section. The law and practice relating to Trade Marks and Designs are dealt with in a somewhat similar manner in the two other sections. There are separate indexes, tables of contents and cases cited for each section, thus rendering the work easy of reference. To those engineers and manufacturers who wish to obtain a clear and accurate view of the law and practice relating to three such important branches of industrial property as Patents, Trade Marks and Designs the present work may be recommended, and we can safely say that inventors and those interested in inventions would save themselves much trouble and expense by perusing it.

## ELECTRICAL EXHIBITION AT OLYMPIA.

(FIFTH NOTICE.)

On Monday afternoon a general meeting of the National Electrical Manufacturers' Association was held at the Exhibition.

Mr. WALTER DAVENPORT, secretary to the Association, who was in the chair, said the object of calling the meeting was to report progress. It was hoped that the Exhibition would bring in many new members, as the Association had been working for the general good of manufacturers, and with that end in view a large number of exhibitors who were not members had been invited to the meeting. The Council of the Association wished to impress upon manufacturers that when the membership was increased considerably, the Association could be sectionalised, and in this way greater attention paid to lamp manufacturers, accumulator makers, and so on, than was possible at present. Each section could devote itself specially to its own manufactures. A number of matters for discussion would be brought forward by various members of the committee, and he would call upon Mr. Berry to raise the question of local exhibitions.

Mr. H. H. BERRY (Messrs. Berry. Skinner & Co.) said the committee felt that some steps should be taken to deal with the increased number of applications which manufacturers were receiving from different parts of the country to exhibit in minor exhibitions. In view of the enormous expense which these exhibitions entailed he thought they ought to put their foot down upon this sort of thing. On the other hand, it was felt that the progress of the industry might be retarded if some steps were not taken in order that suitable electrical exhibits might be shown in out-of-the-way places, and consequently it was suggested by the committee that in all cases where manufacturers were approached, the body so approaching should be asked to pay the carriage of the goods both ways and to guarantee the return of the exhibits in good condition. In fact, it was suggested that the members of the association should confine themselves to "loan" exhibits in the circumstances mentioned.

Mr. JUSTUS ECK (Union Electric Co.) said there were two classes of calls in this matter to which the manufacturer was subject. First of all there was a constant "cadging" from different central station engineers to send down stuff to fill their showrooms. If they agreed to do this for one man they were bound to do so for everybody, but there was no guarantee that the apparatus was properly exhibited or that the showrooms would be properly appreciated. The second class of exhibition which the manufacturer was asked to contribute to was the ordinary open show, and the success of the present Exhibition at Olympia might make it advisable for the Association to have local exhibitions in large centres of industry, say, at Manchester or Birmingham. By this means expense would be economised on the part of the manufacturer, a course which he was strongly in favour of.

Mr. BIRNBAUM (Sterling Telephone Co.) supported the suggestion of the Council, but wished to know in what way local authorities, for instance, could be made to pay the railway carriage on goods lent.

Mr. C. S. NORTHCOTE (Veritys Limited) said that the borough engineer of Exeter and his committee were at the Exhibition during the first week, and they had canvassed very hard with a view to getting support for an exhibition which they were promoting in Exeter. They had prepared a plan, and a schedule of rates for rent, current, &c. They visited the Exhibition committee, and were told that so far as the members of the Association were concerned they would get no support. As a consequence, on October 11 various firms were asked to exhibit goods free of charge, and the Exeter Corporation also agreed to pay carriage both ways. If the attitude adopted by the Exhibition committee was adopted by all manufacturers the object of the Council would soon be achieved.

Mr. H. BEVIS (General Electric Co.) did not wish it to go forth that the Association was desirous of stopping local exhibitions. They merely wished to avoid the heavy expenses incidental to such exhibitions as had been the case in the past. Manufacturers were quite willing to lend goods.

Mr. KENELM EDGCUMBE (Messrs. Everett, Edgcumbe & Co.) said the Association should do its best to prevail upon all manufacturers who were not members to do the same.

Mr. DAVENPORT then put it to the meeting that the action of the committee in this matter be endorsed (viz., that members of the Association should refuse to take space at local exhibitions, and should only send plant, &c., on loan if the promoters of the exhibition paid carriage both ways).

This was carried unanimously.

Mr. F. H. NALDER (Nalder Bros. & Thompson) raised the question of railway rates, and said it was proposed to form a committee to deal with this question. On a previous occasion they had succeeded in preventing the railway companies from increasing the rates by an appeal t the Board of Trade, and it was felt that the present inequality of railway rates all over the country needed serious attention.

The suggestion to form a committee was agreed to.

Mr. H. BEVIS (General Electric Co.), dealing with the rates for insurance which were charged for manufacturing premises, said that although these were more reasonable now than they had been in the past, he had found that with expert advice in this connection, great savings could be made. It very often happened that the presence of a certain class of machinery in a works raised the rates over the whole factory, of, course, unknown to the manufacturer. It was not the business of the insurance companies to point this out, but the assistance of an insurance expert might be of great value. His firm had made considerable reduction in its insurance premiums by the aid of such assistance, and he would propose that this gentleman be appointed officially to the Association for this purpose. Each firm availing themselves of his services would pay him nothing unless some reduction in the premium was secured. In answer to a question the speaker said that it would very often be possible, by isolating one particular portion of a works, to reduce greatly the rates over the remainder.

After a short discussion, it was decided "that an insurance expert be appointed" in the manner suggested.

A discussion was then opened on the question of whether all the members of the Association should agree to discontinue giving Christmas boxes, in the same way that it has already been decided to cease contributing to beanfeasts. There was some difference of opinion on this point, many of the members not being clear where to draw the line between friendly gifts to those deserving them and gifts given in response to applications from persons who claimed to be able to influence orders. Whilst some members were in favour of "doing the thing thoroughly" and stopping Christmas boxes in any form, others retained a conscientious feeling that in certain cases they should be given as a matter of duty, for services rendered. Ultimately it was arranged that the Secretary should draw up a circular, a number of copies of which should be sent to each member, for use as a reply to actual applications for Christmas boxes.

Mr. T. J. GRAINGER (Sunbeam Lamp Co.) then put before the meeting the views of the Council as to when another electrical exhibition should be held. He said there had been numerous suggestions and inquiries as to when another exhibition, on the lines of the present one, should be held, but the Council felt that it would be disastrous to be led away by the success of the present venture. Some people had suggested that another exhibition should be held next year. The committee, however, thought it unwise to do this; in fact, they did not think that at the present moment any definite time should be mentioned. The Olympia Exhibition was proposed in the first instance by the National Electrical Manufacturers' Association, and they felt that it should be left to them to decide when the time was ripe for another exhibition, and that the members should be bound by agreement not to support any exhibition other than one promoted by the Association. As he had mentioned, the Council felt that no time should be laid down, but in order to indicate their views on the matter he would say that it was felt that there should certainly not be another exhibition for three years.

It was finally agreed, by resolution, not to exhibit at any exhibition except under the auspices of the Association.

The members of the National Electrical Manufacturers' Association and a number of guests were assembled at dinner at Olympia on Monday evening, Mr. W. Davenport, secretary of the association, occupying the chair. After the loyal toasts had been duly honoured, Mr. J. E. Edgcome proposed "Success to the Association," pointing out the good work done by the association, notably in connection with the present Exhibition. This toast was responded to by Mr. C. S. Northcote, who sketched the career of the association from its formation 4½ years ago, and remarked that a better title for the toast would have been "Continued Success to the Association." Much had been accomplished, its usefulness had been gradually extended, but more remained to be done, and he appealed to the trade to assist them in making this association the true centre of commercial and trade interests of the electrical industry. In the absence of Mr. H. Hirst, "Success to the Exhibition" was proposed by Mr. David Smith. After the chairman had referred in complimentary terms to the invaluable service rendered by Messrs. A. T. Snell and S. G. C. Russell as consulting engineers, Mr. Snell rose to reply. He gave a *résumé* of the electrical exhibitions held in this country from the Crystal Palace exhibition of 1882 onward, mentioning the chief features of each. The present Exhibition overshadowed all previous ones in size as well as in importance. Its greatest feature was the attention given to details of construction, which were of cardinal value to consumers. Perhaps the most striking progress had been made in the lighting branch, the flame arc lamps, mercury vapour lamps, tantalum and osmium lamps representing achievements the value of which could hardly be overestimated. Other notable advances referred to electric furnaces and electric cooking. He believed that the number of visitors who passed the turnstiles last Saturday (21,000) constituted a record for Olympia. Mr. Russell also replied, briefly. Mr. H. H. Berry proposed "Guests and Visitors," to which toast Mr. S. W. Baynes replied, and the toast of "The Chairman," proposed by Mr. E. Cunliffe Owen concluded the proceedings.

On Friday evening last week Mr. A. Martin delivered a lecture on telegraphy.

Mr. Martin commenced by describing the principles of the Morse alphabet, and then dealt with various forms of telegraph instrument, from the old single needle to the most up-to-date Wheatstone. He then dealt with duplex and quadruplex working. After referring to capacity troubles in long underground mains, the lecturer concluded by stating that Morse working was gradually being displaced by the typewriter telegraph.

On Tuesday Mr. Frank Bailey, chief engineer to the City of London Electric Lighting Co., delivered a lecture on "Electric Arc Lighting," Mr. Sydney W. Baynes, electrical engineer to the St. Pancras Borough Council, being in the chair. Unfortunately many lantern slides and a few experiments which the lecturer had intended to show had to be omitted owing to the very short space of time in which the arrangements had been made. These omissions undoubtedly reduced the attractiveness of the lecture, but Mr. Bailey is to be congratulated in holding his audience in the manner he did in the circumstances, and his concluding remarks on the question of gas lighting in the City will be read with interest.

Mr. Bailey first directed himself to showing that arc lighting was no new thing, as might be inferred from various statements which werepublished from time to time. He said the electric arc originated with the experiments of Sir Humphrey Davy, and lamps were in actual use in 1867. Therefore, arc lighting was not modern by any means. The lecturer then explained what was meant by continuous and alternating currents, and also showed, by means of a model, the general principles of the internal mechanism of an arc lamp. Generally speaking, he said there was very little new in the modern arc lamp, for, if an examination were made of all the lamps in the Exhibition, each would be found to embody the old principles in some form or other, whilst many were a combination of the best features. It was impossible for him to go into the details of arc lamps at any length, and he thought he had better refer his audience to that remarkable and monumental work on the electric arc by Mrs. Ayrton, whose book on the subject was published by "The Electrician" Printing & Publishing Co. In describing the mercury vapour lamp Mr. Bailey said that its remarkable efficiency was not appreciated by the electric supply authorities, but it was a lamp which he believed had come to stay, and he could only hope, as one interested in the supply business, that they would be used in sufficiently large numbers to compensate for this extra efficiency. Dealing with the question of the relative cost of electric lighting and gas lighting, Mr. Bailey said that all his remarks upon this matter were made upon his own responsibility. If he were wrong, he alone would be responsible. This matter had reached rather a critical stage in the City of London. He was only mentioning what he saw in the papers now, and he wished to be very discreet, for the City Corporation had certain statutes locked away in cupboards, and if he were not discreet it might end in his being sent to the Tower. As a matter of fact, however, he should not much mind this, because the Tower of London would shortly be lighted from the mains of the City of London Electric Lighting Co., and he would sooner be in a prison with electric light than in a palace without it. But, so far as the streets in the City were concerned, every one had had an opportunity of admiring the gas lighting—for instance, in Fleet-street, where what was called "pressure gas" was not used. Pressure gas, however, was used in Queen Victoria-street. He rather thought this should be called "pushed" gas, for it was being pushed for all it was worth. With these gas lamps, however, the illumination was generally confined to the kerb; it was not street lighting, but merely indicated the route of the road by the lamps being placed low down. In order to obviate any danger, however, some flame electric arc lamps had been placed at Blackfriars to start pedestrians on their way, and if Queen Victoria-street was traversed safely, another series of flame arc lamps would be found at the Mansion House. The cost of lighting by incandescent gas mantles had been very erroneously stated by various people, but some time ago Mr. Bradley, engineer to the City of Westminster, made very careful tests, which were published. These results were beyond a shadow of dispute or doubt, and he understood that certain tests had been made in Fleet-street and Queen Victoria-street, which amply confirmed these results. These tests showed that electric arcs would give three times the light given by the gas lamps at the same cost. This was not all, for this merely dealt with candle-power. Candle-power was not necessarily illumination, but given certain facilities in the shape of reasonable-shaped lanterns, positions, reflections and so on, illumination followed from a certain stated candle-power. In Queen Victoria-street the gas mantles illuminated the pavement fairly well, but the buildings were not illuminated at all; first-floor windows were in the dark. Mr. Bradley's report, to which he had referred, showed that 30d. per candle-power per annum was the cost of a gas jet, the improved Sugg burner cost 10d., but the ordinary arc lamp was about 8d., under very bad conditions, for the lamps referred to were 15 years old, and with very poor lanterns. The modern arc lamp would come out at 5d. So far as the City experiments were concerned, all he had to say was that the Corporation were worthy of every praise for their endeavour to ascertain which was the best illuminant at the lowest cost. No one could grumble at them for doing this, or for giving the gas people the best facilities in their power for carrying out an admirable demonstration. The gas people had done their very best, changing the mantles even day by day. What did it matter to the gas people? Cost was nothing! What they had got to do was to show that a street in London could be lighted with incandescent gas, and from that they would build up records showing marvellous successes. He would ask, however, that, simply as reasonable Englishmen with an idea of justice, the Corporation should also ask the Electric Supply Co. to demonstrate and show what could be done with modern electric arc lamps. At present they were judging arc lighting on what was done 15 years ago. The electric lanterns in the City were designed 15 years ago by the Corporation engineer himself, and he had insisted upon that particular antiquated form being adopted. Yet with the round globe they could get reflection and there were no shadows. He hoped the City Corporation would soon give the Electric Lighting Co. an opportunity, and when this opportunity came he felt sure that Fleet-street and Queen Victoria-street would once more be lighted by arc lamps.

On Tuesday evening an exhibitors' dinner was held, Mr. John Verity occupying the chair. The healths of the Executive Committee, the Exhibitors, the Joint Managers, Consulting Engineers and Permanent Officials, and the Electrical Press were drunk with enthusiasm. In the course of the informal speeches after dinner it was announced that 104,000 people had visited the Exhibition up to the previous Saturday night. Mr. Walter Davenport, Secretary of the National Electrical Manufacturers' Association, and speaking in that capacity, urged those present not to support any exhibition that might be promoted in the near future unless the Association that had organised the present exhibition should consider the time appropriate for another exhibition of electrical manufacturers.

Mr. W. M. Mordey's lecture on "Electric Traction," delivered on Wednesday evening, attracted a larger audience than any of the previous ones, partly owing to the presence of a party of members of the Junior Institution of Engineers. Those members of the public who were present, however, found the lecture of extreme interest, and there was in consequence less of that coming and going and buzz of conversation at the back and sides of the hall that had been much to the detriment of previous lectures. As a history of electric traction from its very inception to the present day the lecture was as complete as it could be possible to make it, whilst the very large number of slides—many of them landscape views—and the completely popular character of the address, kept the lecturer well within the grasp of his audience for practically the whole of the time. A most hearty reception was accorded Mr. Mordey at the conclusion, on the motion of Mr. James Swinburne, who was in the chair.

Mr. Mordey said that the first application of electricity to traction purposes was upon a little line by Werner von Siemens, in 1879, at the

Berlin Exhibition, which was followed by other lines in Germany during the next few years. The first conduit system, that of Mr. Holroyd Smith, was laid down at Blackpool in 1885. In principle, and in many details, this was very like modern lines, but it was laid in a most unfortunate position—on the promenade—where the sand washed up by the high tides was too much for the conduit. Accumulator cars were then briefly explained, their failure being explained as due to the great weight, the low efficiency and the high depreciation of the accumulators, drawbacks which, in Mr. Mordey's opinion, were inherent, and, for physical reasons, probably incapable of removal. The surface contact system used for the Wolverhampton tramways was fully described and its position as intermediate in cost between the trolley and the conduit systems was explained. Electric omnibuses running on ordinary roads worked from trolley wires were described as holding out no prospect of competition with oil-propelled vehicles. In dealing with electric railways, the systems adopted upon all the electric railways in Great Britain were described; credit being claimed for this country as pioneers in the construction of the City and South London Railway. The experimental high-speed Berlin-Zossen line, on which a speed of 130 miles per hour has been attained, the Engelberg Mountain Railway, the Bergdorf-Thun railway in Switzerland and the Valtellina line in Northern Italy, which had now proved its success by being taken over by the authorities, were also referred to and illustrated by lantern slides. It was his belief, however, that the single-phase system, in which overhead wires could be used, gave the most promise of suitability for the general electrification of railways. The motors used under this system had the advantage of being suitable for use with low-tension direct currents as well as with high-tension alternate currents, so that the same trains could be run over railways equipped for either method. He believed that future development would rather be in the direction of high than of low tension, the dangers of high-tension overhead conductors being probably less, even in towns, than the low-tension third-rail systems, which had already been responsible for so many fatalities. In examining the question of consumption of energy on the railway trains, the high rate of acceleration on the Liverpool Overhead Railway was referred to, and it was pointed out that, of the total energy received by the train, only 25 per cent. was spent in driving the train, the other 75 per cent. being lost, mostly in braking. One partial cure for this was to put every station on the top of a little hill, as had been done with the Central London Railway, so that the trains all started down hill and stopped at the top of an incline. On this line the efficiency was nearly twice as high as on the Liverpool line but the acceleration was not nearly so good. There was great promise in the future, however, that the energy spent in braking might be largely recovered by making the trains when descending grades or when stopping, generate electricity and return it to the lines to help other trains. This method which had first been suggested by Sir William Siemens in 1881, was now being developed by Raworth and others with direct currents, and had for some years been made use of with alternate currents on the steep inclines of mountain railways in Switzerland. The lecture was concluded by showing a large number of lantern slides concerning traction matters.

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Messrs. Ferranti Limited (stand Nos. 112 and 131) have undoubtedly one of the finest exhibits in the Exhibition. The firm has entirely remodelled the design of its switch gear, and a specimen of practically every one of the new patterns is on view. We devote a special article to the new switch gear this week. Switchboard instruments of the firm's own manufacture are also shown (including an ammeter on the induction principle), together with current and potential transformers, consumers' meters, &c.

A trip was arranged for the employés of Messrs. Ferranti Limited to visit Olympia Electrical Exhibition on Saturday last. A party of 170 men assembled, leaving Manchester at midnight on Friday by the Great Central Railway. Messrs. Ferranti Limited contributed towards the general expenses of the trip, provided breakfast on arrival in London and a luncheon in the restaurant of the Exhibition, at which the directors of the company were present. Some of the party returned on Saturday evening, while others deferred their departure until the following day. The trip was eminently successful, and will, it is hoped, prove to be of educational advantage to the employés of the firm.

Another of the really new things at the Exhibition that bids fair to lead to an industrial development of some importance is the Oliver flame arc lamp, called by the trade name "Oriflamme." This is to be seen at Messrs. Oliver & Co.'s stands (Nos. 25 and 34). The chief difficulty with which makers and users of flame arc lamps have to contend is the rapid consumption of the carbon, so that the choice hitherto has been between comparatively short burning hours or the employment of abnormally long carbons, which add considerably to the cost of maintenance, as the cost of long straight arc lamp carbons is considerably greater than the equivalent length in shorter pieces. In the Oliver lamp this difficulty is overcome by the use of a "magazine." The lamp can thus hold eight or nine pairs of carbons, each 12 in. long. These are of exceptionally small diameter, but the proportion of the total section taken up by the core is greater than in ordinary flame lamps. It has been found that within certain limits the greater the relative size of the "flame"-producing core the greater the efficiency of the arc, but it is also an unfortunate fact that the greater the proportion of core the more rapid is the consumption of carbon. As he has a whole magazine to draw upon, however, Mr. Oliver can afford to burn his carbons at a high rate, and he thus supplies the arc with the requisite amount of potassium silicate and calcium fluoride (which produce "flame" and colour respectively). Since the carbons are of smaller size, it is possible to use carbon of comparatively poor quality without impairing the steadiness of the arc, and he is able to guarantee that the cost of carbons does not exceed 0·09d. per lamp-hour in a 9-ampere lamp. Each pair of carbons burns five hours.

Having indicated the advantages that may be gained by employing a magazine of small carbons in place of long carbons of larger diameter, we must describe briefly the mechanism which permits of this. The carbons are placed in two flat boxes inclined at an angle of 22 deg. They are put in at the back, and pressed forward by a pair of arms controlled by a spiral spring. Fig. 1 is a sketch of one of the magazines, the arms AA pressing against the carbons C. The front carbon emerges from the magazine as seen, and is pressed forward by the stud S, fixed on a chain B. It is this chain that feeds the lamp, being turned by the sprocket wheel D. There are two studs, S and T, on this chain. In the position seen in the sketch the stud S is pressing down the carbon as the lamp feeds by the travel of the chain. When this stud reaches the bottom the carbon is ejected and the next one takes its place, and the second stud T has at that moment reached the top of the carbon and presses it down as the chain travels. One of the magazines is pivoted on the crown of the lamp, and this is swung by the controlling electromagnet to strike the arc, and also serves to regulate the length of the arc. When it reaches its extreme position it closes an iridium contact and sets into operation a make-and-break mechanism which actuates the sprocket wheels and feeds the chains onwards. The chain and rocking lever are mounted on knife edges, so that there should be no trouble due to friction. Figs. 2 and 3, which are sketches showing elevations of the mechanism at right angles to one another, help to indicate the general arrangement. In these figures the reflector R is shown, which is designed to prevent the deposit of the products of combustion on the globe of the lamp. It is of porcelain in a copper spinning, and rests on the rim of the globe on three distance pieces. By this arrangement there is an upward draught of air through the hole in the reflector and the products of combustion are deposited above. An ash tray G catches the short ends of carbon.

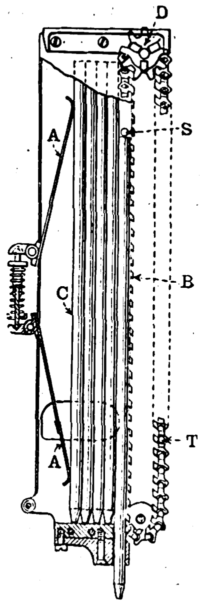


Fig. 1.

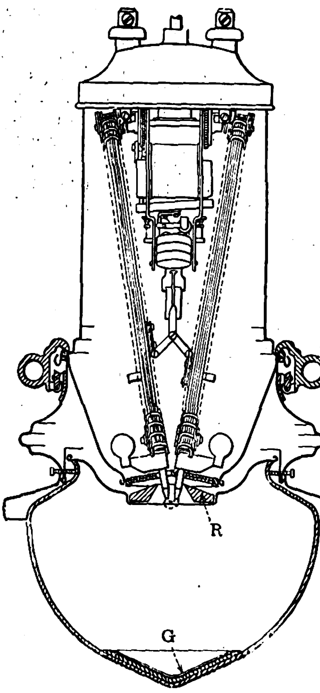


Fig. 2

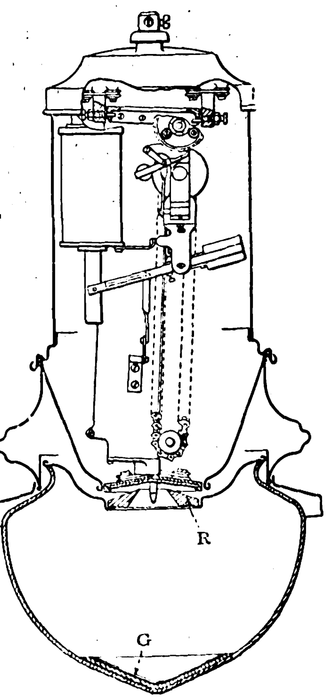
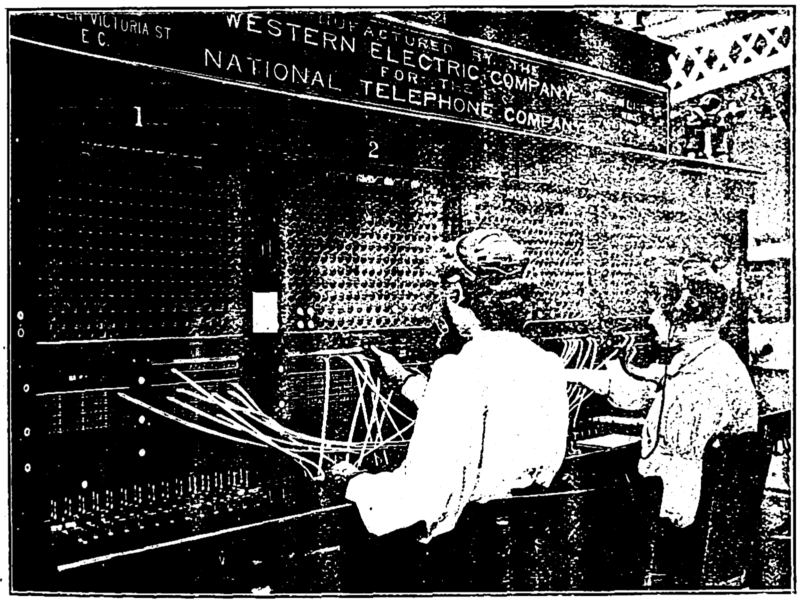


Fig. 3.

It is seen that the angle between the carbons is so small that no blow-out magnet is necessary. The voltage of the arc is 35, so that allowing five more volts for steadying resistance, &c., it is seen that five lamps may be burned in series across 200 volt mains. At nine amperes per lamp, the standard type, this represents 360 watts per lamp, and Messrs. Oliver & Co. claim that this will give far better illumination than the ordinary 500 watt arc.

Mention may also be made of the new pattern of globe introduced by Messrs. Oliver & Co., in which the sides of the globe facing along the street are broader than the sides facing across the street.

The National Telephone Co. have a large collection of standard telephone apparatus, fire alarms, metaphones, &c., but the chief feature of interest is undoubtedly the multiple switchboard used to serve as a telephone exchange for the Exhibition. The board is of a new pattern which the company have recently introduced for large private branch exchanges, *i.e.*, for such places as hotels, where the switchboard is operated by the subscribers' servants, but yet has a large number of lines connected to it. The switchboard is fitted with "eyeball" calling and clearing indicators to take the place of lamp signals used in larger exchanges. The name "eyeball" is used because the drop of the indicator is in the form of a section of a sphere, painted white, and actually resembles an eyeball. The board is on the central-battery system, but a local central battery is not employed, current being supplied from the nearest local exchange by special power leads. In addition to the continuous current used for working the transmitters and the signals, alternating current for ringing purposes is supplied by another pair of power leads.


VICTORIA ST
E.C.
WESTERN ELECTRIC COMPANY
NATIONAL TELEPHONE COMPANY
1
2

The National Telephone Co.'s Service Exchange.

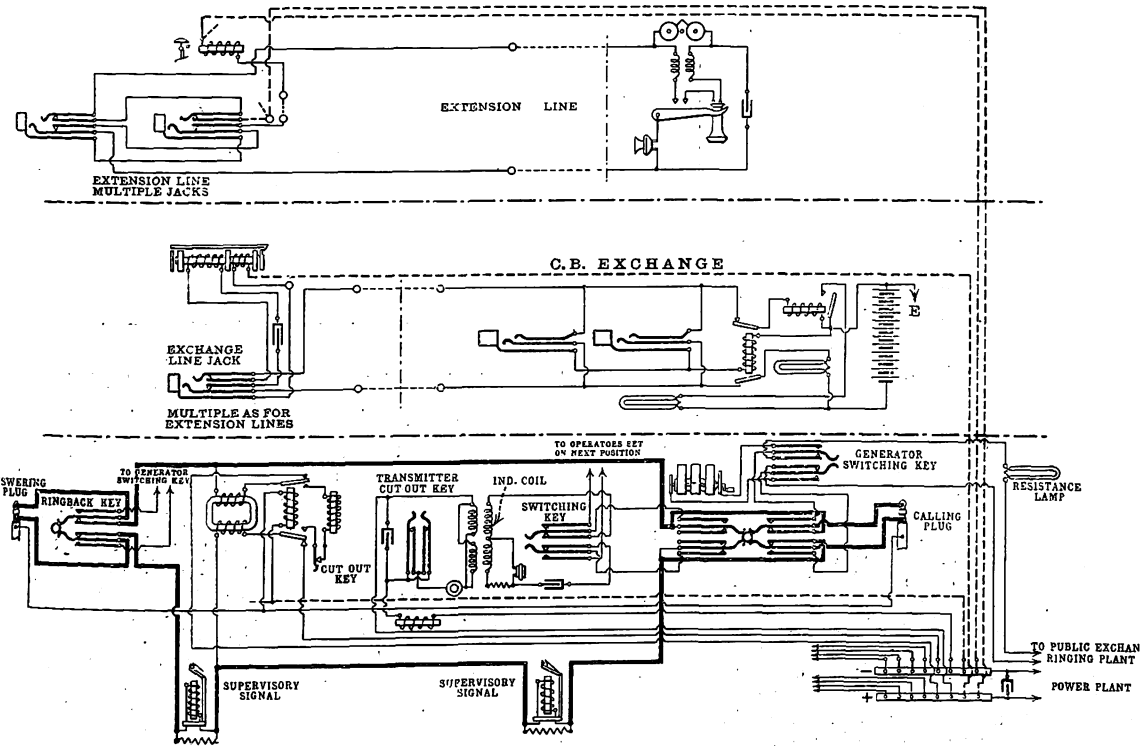

EXTENSION LINE
EXTENSION LINE MULTIPLE JACKS
C.B. EXCHANGE
E
EXCHANGE LINE JACK
MULTIPLE AS FOR EXTENSION LINES
TO OPERATORS SET ON NEXT POSITION
ANSWERING PLUG
TO GENERATOR SWITCHING KEY
RINGBACK KEY
TRANSMITTER CUT OUT KEY
IND. COIL
SWITCHING KEY
CUT OUT KEY
GENERATOR SWITCHING KEY
RESISTANCE LAMP
CALLING PLUG
TO PUBLIC EXCHANGE RINGING PLANT
POWER PLANT
SUPERVISORY SIGNAL
SUPERVISORY SIGNAL
−
+

Diagram of Exchange Switchboard.

The switchboard is of the one-operator-per-section type, faced with polished mahogany, the framework being of birch. It is absolutely self-contained, all relays, retardation coils, &c., being mounted within the sections at the rear. The 'bus bars for the power leads run the whole length of the board at the rear, and are made continuous by means of linking pieces when several boards are lined up, as is the case at Olympia. Thus each section has its own fuses on its own particular length of 'bus bar. There are also two connecting fields for distribution, as carried out on an intermediate distributing frame in a large exchange.

Each operator's keyboard is fitted with 15 pairs of plugs and cords with a combined listening and ringing key to each pair of cords. There is also a transmitter cut-out key for opening the microphone circuit for night work. A hand-ringing generator is provided on each section, but during the busy hours ringing current is taken from the special pair of ringing leads already referred to.

The subscribers' sets are of the standard common-battery type.

The switchboard has a capacity for 720 subscribers' gravity-restoring signals in strips of 20, and 40 self-restoring indicators for exchange lines. These latter are mounted above the subscribers' signals, as shown in the middle part of diagram. The board is divided into four sections, so that there are 180 subscribers per section. Below these are the junction multiple and the subscribers' multiple, so arranged that on each position the multiple jacks correspond to the signals on that position, thus becoming practically answering jacks. They are multipled on every fourth panel. The jacks are of the cut-off type, so connected that when current passes round the loop, on a subscriber removing his receiver, a calling signalis actuated, the white eyeball is brought into view and held magnetically until the act of plugging into the jack to answer breaks the circuit, when the eyeball or target disappears from sight by gravity. A few words are necessary to explain the nomenclature in the diagram. What would correspond to subscribers' lines in an ordinary exchange are referred to as "extension lines," as, from the telephone company's point of view, the hotel is the subscriber, as it were, with a certain number of "exchange lines" connecting it to the public exchange, and the individual lines and telephone stations in the hotel are "extensions." The upper part of the diagram refers to the extension line and its multiple jacks on the board. The middle part of the diagram shows a line from the exchange leading from a public common-battery exchange on the right (with branching jacks multipled on the various sections), and the corresponding jacks and self-restoring indicator of the hotel board on the left. The bottom part of the diagram is the cord-circuit, and the power 'bus bars are seen at the bottom right-hand corner.

The exchange lines are equipped at the public exchange like ordinary subscribers' lines, and all outgoing calls from the private branch exchange are treated at the former exchange in exactly the same manner as ordinary subscribers' calls, the private branch operator signalling by simply inserting a plug into the exchange-line jack. The cord circuit is so arranged that it can be indiscriminately used either for local connections or for exchange-line connections. When a local call is received by the subscriber's signal showing, the operator inserts an answering plug in the corresponding jack; the signal disappears and the supervisory signal shows instead, the battery being on the line through a retardation coil both for speaking and for actuating the supervisory signal. On ascertaining the number required, if it is another number in the hotel, the operator touches the bush of the required jack with the tip of the calling plug (the key shown being all this time in the listening position) so that her head set is connected to the line. If no click is heard she inserts the plug, and moves the key over to the ringing position, thus connecting alternating current to the calling plug, and so to the called line, and she rings the wanted subscriber's bell. Ringing is continued at short intervals until the supervisory signal in connection with the calling plug shows, when the operator knows the subscriber has answered. During the conversation both supervisory signals show, and only disappear when both subscribers hang up their receivers. Current for speaking, it will be seen, is fed to the line through retardation coils.

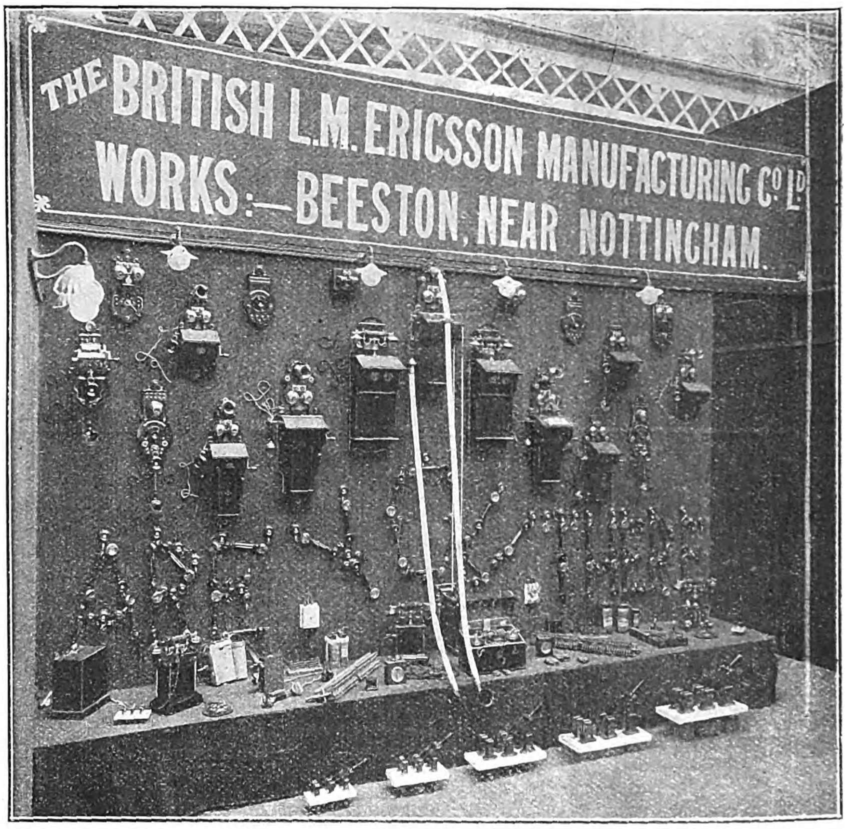
If the subscriber wants to make an exchange-line call, the operator answers and carries out the operation in exactly the same manner as for a local call, the connections being such that on the insertion of the calling plug in the exchange-line jack the cut-off relay in the sleeve circuit is actuated, current is cut off the cord circuit, and a retardation coil (termed a "holding coil") is introduced between the two windings of the permanently connected retardation coil. A bridge is thus formed across the exchange line, and the supervisory signal at the public exchange consequently remains inoperative so long as the plug is in the jack referred to. Speaking current is now supplied to the extension instrument over the exchange line from the public exchange, in the same way as to an ordinary subscriber on that exchange. During conversation, both supervisory signals at the private branch exchange are visible. When the private-branch-exchange subscriber replaces his receiver, the corresponding signal disappears, and the operator withdraws the plug. The holding coil is disconnected, the supervisory signal at the public exchange is consequently shown, and the operator there having already one supervisory signal from the called subscriber, withdraws her plug.

For incoming calls—viz., calls to the private branch exchange, from the public exchange, the operator at the latter exchange rings in the ordinary way on one of the exchange lines and actuates the corresponding self-restoring indicator at the private branch exchange. The insertion of the answering plug by the operator there connects battery to the restoring coil of the drop and the latter is restored to normal. In this case again, the wanted subscriber on the private branch exchange speaks with the current from the public exchange, the cut-off relay being actuated as before, disconnecting current from the cord circuit and introducing the "holding coil." "Clearing" is also carried out in the same way.

If it is required that an extension line on the private branch exchange be left connected to the public exchange after the operator at the former has finished duty for the day, the connection is made to an exchange line in the usual manner, but the holding coil is cut out by means of a special key, so that the act of taking the receiver from its rest will signal the public exchange direct.

On the board at the Exhibition, there are 10 incoming exchange lines from the Kensington exchange of the National Telephone Co. and 10 outgoing lines to the Holborn and Kensington exchanges respectively. As there is no object in economising space on the board, the jacks are fairly wide, viz., at ½-in. centres, so that it is easier for an inexperienced operator to work such a board than it would be for her to work an exchange board. The whole fitting of the board is extremely neat and compact, and although there are only about 40 or 50 subscribers' instruments in the Exhibition, it is evident that if the board were equipped to its fullest capacity, everything would be neat and easily accessible.

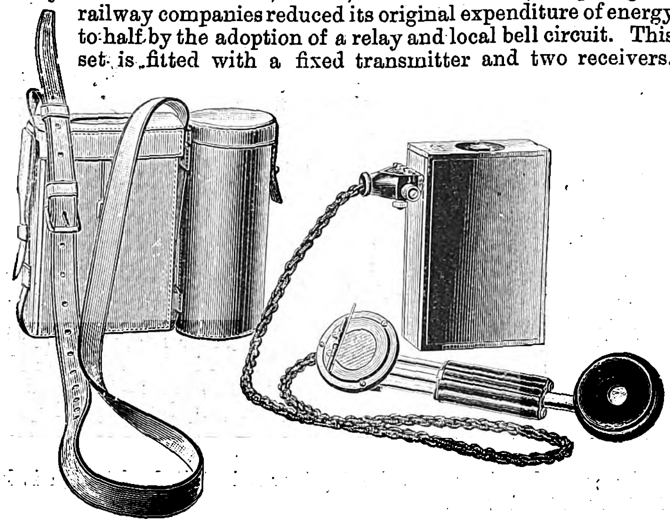
An exhibit which is attracting a considerable amount of attention is the Telautograph, which may be seen in actual operation between the stands of the National Telephone Co. and the Edison & Swan Co. This device is an exceedingly ingenious one and permits of handwriting or drawings being transmitted instantaneously and accurately over many miles of wire. The sending apparatus consists of a very large number of resistances arranged in two arms, over which two sliding contacts work. These contacts are actuated by means of levers to which the pencil is attached. The receiver consists of a pair of moving coil galvanometers in series with which are the above-mentioned resistances. Instead of each galvanometer being provided with a pointer it has a lever similar to that on the transmitter, and it is easy to see that, by arranging the galvanometers and levers suitably, the variations of current produced by varying the resistances in the transmitter cause the receiver to reproduce the writing or other characters produced at the transmitter. A complete description of the apparatus appeared in *The Electrician*, Vol. XLVI., p. 115. We understand that the National Telephone Co. are taking up the Telautograph with a view to letting it out to subscribers at a yearly rental.


THE BRITISH L.M. ERICSSON MANUFACTURING Co Ld
WORKS:—BEESTON, NEAR NOTTINGHAM.

The British L. M. Ericsson Co.'s Stand.

The British L. M. Ericsson Mfg. Co., at stands Nos. 146 and 153, exhibit a large assortment of well-finished and strongly-made telephone sets and accessories for many purposes. In the centre of stand No. 146 is a telephone set, the receiver and transmitter of which, being fitted at the ends of long indiarubber tubes, are frequently mistaken by the visitors of the Exhibition as being for use in bath rooms. They are intended, however, for use in telephone installations, the wires of which are strung from the same poles that carry high-tension transmission lines. Such installations are becoming numerous, especially in America, Italy, Spain and Switzerland, and we understand that the firm has sold a large number of these protected sets. The instrument is fixed high up on the wall, as near the ceiling as possible, and the indiarubber speaking and listening tubes protect the telephone user completely against high-tension currents but are said not to interfere with the distinctness of telephonic transmission. The switch hook is operated by a weight which hangs from the end of the switch by a long non-conducting cord, and is hung on a hook when the telephone is not in use. In order to ring the magneto from below, the usual magneto handle has been replaced by a pulley. A second pulley with a handle is placed at a safe distance beneath the first pulley, the transmission being by a cord. Combined telephone and telegraph instruments, constructed especially for cavalry scouts and largely used during the South African war, are also shown. These instruments weigh only about 5 lb. and are enclosed in a stout leather case which can be stored away in an overcoat pocket. They include a telescopic hand micro-telephone with cord, buzzer, a condenser for the line and two dry cells. For operating these instruments a single copper wire (laid bare on the ground) is used, the return being through the earth. Beyond a certain distance telephonic communication becomes indistinct, but telegraphic communication by means of the buzzer may be kept up for a considerably longer distance. Since the top of the leather case, just above the button of the buzzer, is of soft leather, it is possible to telegraph without opening the case. We were told that communication has repeatedly been kept up even in cases in which the bare copper wire was subsequently found to have been broken in several places. The design is such that the buzzer is ordinarily in circuit, but by pressing the button on the telephone handle the buzzer is cut out of circuit, the telephone being substituted. For more permanent installations (such as were represented during the war by installations between block houses) the firm supply portable sets with or without buzzer. Rods, made up of several parts, are generally used in connection with these sets for hooking up the wires on existing poles, trees, and so on. Such a rod is visible in the illustration. The portable sets are enclosed in strong oak boxes, containing a hand micro-telephone with waterproof cord, two dry cells, generator, bell, lightning protector and terminals for line and earth.

For use in tropical climates, the firm manufacture a rakish-looking telephone set enamelled in black and gold, the only wooden part of which is the teak board of the back. All the coils are soaked in paraffin so as to exclude moisture. Iron parts are only used where unavoidable, and are then heavily lacquered to prevent rusting. All other parts are of brass. Some robust railway telephone sets are also on view. In one pattern shown, the signal bell, which is powerful, is not operated directly from the set in the caller's cabin but by the intervention of a sensitive relay. Since the latter device requires much less current to operate than a large bell, it is apparent that its use conduces to a considerable saving of electric energy on long railway lines. We were told, in fact, that one of the leading English railway companies reduced its original expenditure of energy to half by the adoption of a relay and local bell circuit. This set is fitted with a fixed transmitter and two receivers.



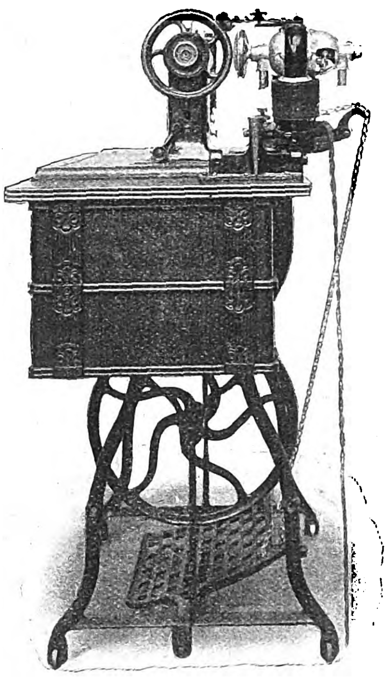
LIGHT TELEPHONE-TELEGRAPH SET FOR CAVALRY SCOUTS.
(As supplied to the War Office by the British L. M. Ericsson Mfg. Co.)

Another railway set, likewise mounted in a strong teak box, is fitted with a hooter for calling and may be heard where the sound of a bell would not penetrate. No relay is fitted to this instrument, which can be used on the same line as the block telegraphs. This is made possible by a suitable application of condensers. The buzzer to work the hooter is fitted to the instrument at the other end, and the hand micro-telephone is provided with a button which, when pressed, cuts the buzzer out of circuit. Lightning discharges are prevented from damaging the apparatus by plate lightning arresters. The firm is manufacturing a cheap telephone set for private use, called the "Converser." Although cheap, it is accurately made and well-finished, being provided with grain microphone and other features associated with high-class work. A series of battery-charging switches, ranging up to 1,000 amperes in capacity, are likewise shown and the remainder of this exhibit includes telegraph line selectors (as supplied to the War Office), test jacks and test plugs (made in accordance with the National Telephone Co.'s standard practice), Post Office lightning arresters, 10 to 30 line intercommunication boards for wall and table use, indicator boards, detectors, galvanometers in aluminium cases, window terminals, head receivers and breast transmitters for operators, extension bells and switches, dry batteries, &c.

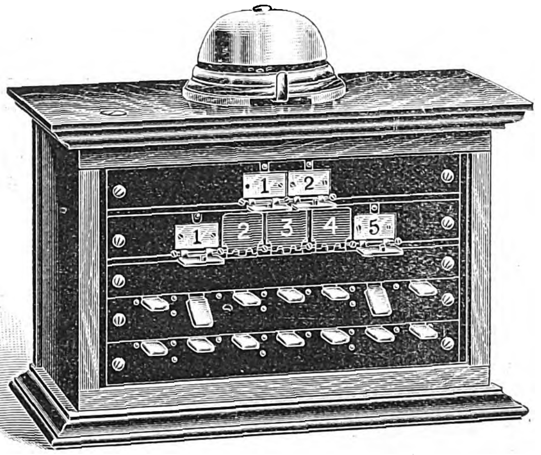
The object on the WESTERN ELECTRIC Co.'s stand (No. 89) which attracts most attention is the sewing machine, illustrated in the next column. It is put into operation by pressure of the foot on the treadle of the machine, the speed being also regulated by the same action. The machine has a friction-cone drive, and as the pressure of the foot upon the treadle is increased, the body of the motor is gradually turned round, so that the driving wheel of the sewing machine comes in contact with a larger periphery of the friction wheel, resulting in a corresponding increase in speed. To stop the machine it is only necessary to remove the foot from the treadle, when the motor assumes its normal position, and a brake which is fixed to the motor above the friction wheel comes in contact with the driving wheel and arrests its motion instantaneously.

The cordless switchboard which is shown opposite has keys in place of solid plugs. The boards for use in connection with magnetic exchanges are arranged with electromagnetic drops, and those for central-battery exchanges with electromagnetic self-replacing signals.

The latest type of interrupter attachments for ringing motor-generators at exchanges are shown. The following tests and signals are now considered a necessary part of the modern central-battery telephone-exchange equipment:—Busy test, tone test, trouble test, busy back, trouble back or "don't answer," and howler. The first three are placed upon the third wire of the subscriber's line inside the exchange and are intended to notify the testing operator only, who in turn notifies the local subscriber or the local operator at the distant exchange. The fourth and fifth are signals sent back over a junction line for the information of the local operator and sometimes over a subscriber's line to notify the subscriber. The sixth provides a means of calling a subscriber who has left his receiver off the hook by mistake. All these signals except the first are obtained by means of interrupters attached to the ringing machine. The current from the central battery is passed through a brush on to a slip ring which is in connection with the alternate segments of a commutator, the other segments being insulated. This commutator is run at a speed of 1,000 revs. per min., and the current obtained from its brush is therefore interrupted and when passed through a receiver gives a loud humming sound which is used for the tone test. A similar arrangement, but provided with a much larger number of teeth produces the "howler" current and the "trouble back" test. The busy-back and trouble-back currents are obtained by passing the tone-test current through other commutators running at a low speed provided with unevenly-spaced commutator sections so that the first gives a tone interrupted thus: - - - - - - - - -, and the second a tone interrupted thus —·—·—·—. The uses of these tones are practically described by their names: for instance, the busy test indicates to the operator by a click in the receiver that the subscriber is already engaged, which fact she conveys by inserting the other plug of her pair of cords into a jack connected to the "busy back" circuit thus transmitting the peculiar buzzing sound to the distant operator and subscriber. If a subscriber does not reply, or if his line is out of order so that a reply cannot be obtained, the "trouble back" is used. The "tone test" is used to indicate to other operators that a line is engaged in a "trunk" conversation and the "trouble test" indicates that a line is at presen out of order. The interrupters are made of hard brass insulated with micanite, the high-speed ones being mounted on an extension to the ringing dynamotor shaft, and the low-speed ones being driven by worm gearing from this shaft. Similar interrupters to the "busy back" and "Don't answer" ones are used to interrupt the ringing current used in connection with machine-ringing keys, so that once the key is depressed ringing current is sent out for a few seconds over the line at definite intervals until the subscriber answers,

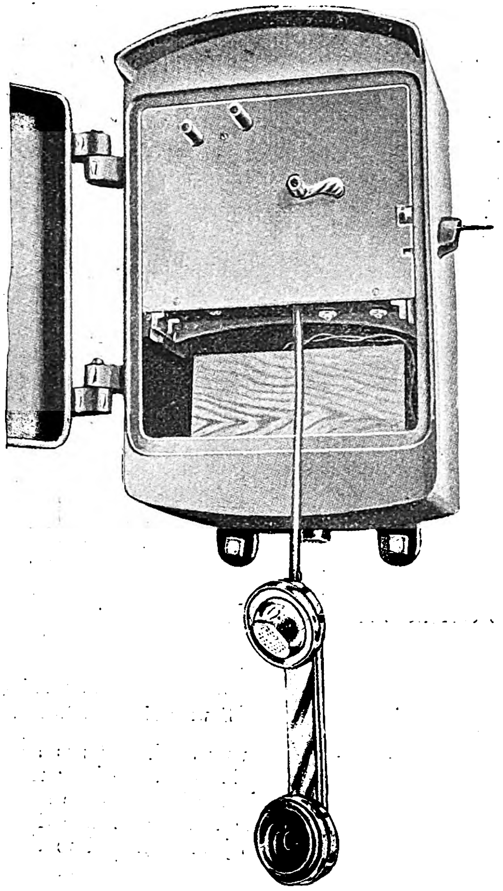


WESTERN ELECTRIC CO.'S SEWING MACHINE MOTOR.



WESTERN ELECTRIC CO.'S CORDLESS SWITCHBOARD.

A strong tramway telephone set is shown on p. 24. At the upper part of the set will be noticed two projecting rods; these engage with the anvils cast in the front of the outer door and operate switches, which, respectively, open the transmitter circuit and cut the apparatus entirely clear from the line when the door is closed. All the apparatus is mounted on a sliding base which runs in guides cast in the side of the set, this arrangement enabling the whole to be removed into a convenient position for inspection. Included in the circuit of the apparatus are line fuses so arranged that if abnormal currents are present on the line the fuses blow while the door is being opened, thus constituting a signal whereby the person desiring to use the instrument is apprised of the abnormal and dangerous condition of the lines. The fuses entirely disconnect the apparatus before the person has time to grasp the handle of the generator or micro-telephone. In addition to this, a lightning or high-voltage protector, of the open-space carbon cut-out type, is provided, which serves to earth the line in the event of connection with a circuit of over 300 volts P.D. This will cause the fuses previously mentioned to be operated and isolate the apparatus. Further protection is obtained by interposing a repeating coil between the telephone apparatus and the line.


Western Electric Co.'s Traction Telephone.

Some huge electro-mechanical bells give occasional recitals. When the hammer of the bell is released it makes a full revolution, passing under the gong to an inclined plane, when it is raised and strikes the gong with the great force gathered in the revolution; the recoil causes it to drop and be locked in its normal position under the gong. The locking and releasing is by means of an eccentric, which leaves the armature free from any pressure, so that one cell is said to be sufficient to operate even the largest bell on a short line. The force for moving the hammer is furnished by clockwork, and each winding is sufficient for 200 to 375 blows to each winding.

The Frictionless Engine Packing Co. show, at stand No. 178, several specimens of packings, beltings, &c. It is claimed for the "Karmal" packing that its lubricating qualities never cease so long as there is a fibre left, that it cannot char or become hard and that it will withstand any steam pressure or degree of superheat. The patent "Roko" belting shown at this stand is manufactured from camel-hair yarn. It has a special edge which prevents it from being affected by the action of guide forks, and thus fraying is prevented.

The D. P. Battery Co., who are manufacturers of plates for all kinds of accumulators from the smallest ignition C type cell to the largest type of central-station battery, show various specimens of their plates and cells at stand No. 12. They have divided their exhibits into four chief sections, showing complete cells and separate plates of their four types in various stages of manufacture—namely, the "Lumford Station," "Lumford Heavy," "Lumford Light" and "Strip" batteries. The two former types are suitable for heavy charge and discharge rates, such as are required at central stations, institutions, factories, &c., while the two latter types are largely used by contractors for private house work. They are easy to erect, and have a clearance varying from 4 in. to 6 in. between the bottoms of the plates and the bottom of the box, thus obviating the necessity of cleaning out any battery during its life. At this stand are also shown various specimens of completely connected up cells, both when bolted together either with one or more lugs or when burned up on site. A feature of special interest is a cell having a capacity of 11,000 ampere hours, or 5,500 ampere hours at the one-hour rate. This is the largest cell in the Exhibition. There is also a set of positive plates which has been in use for five years and now appears to be as good as it was on the day it was installed, although it has had much hard work.

THE D.P. BATTERY Co. Ltd
LUMFORD MILLS BAKEWELL DERBYSHIRE
LONDON OFFICE 11 VICTORIA ST. WESTMINSTER S.W
STORAGE BATTERIES
FOR
ALL PURPOSES
HIGH OR LOW RATES OF
CHARGE AND DISCHARGE
LONG LIFE LOW MAINTENANCE
BILITY
D.P.
POWER
BATTERIES
E BEST CELLS
OR ALL PURPOSES
12
D.P. ACCUMULATORS
D.P.
Capacity

The Tudor Accumulator Co. (stands 16 and 43) exhibit a large number of the various standard types of stationary cells made by them, in glass, lead-lined wood and lead boxes, ranging in capacity from 60 to 7,500 ampere-hours; the latter type is one of the largest cells in use in this country. All the cells are mounted on racks of the normal design adopted by this firm, and in two of the largest cells, from which the sides are removed, the details of the internal arrangements can be clearly seen. On two boards are shown samples of the plates, both formed and unformed, as well as sections of the positive plates, from which may be seen the form of structure that gives them so much strength. The new design of negative plates, recently introduced by the Tudor Company, has got over all the past difficulties, and a much longer life is anticipated than from any previous type. There is also to be seen on this stand an automatic regulating switch of the Trumpy pattern, for which the Tudor Accumulator Co. are sole agents in this country. The essential parts of the Trumpy switch are the contacts for each cell (several cells can also be connected between two adjacent contacts), the rings for collecting the current, the brushes, the mechanism, the commutator and the voltmeter. The two latter parts are the same for all sizes and types of the switch. Two patterns of switch, single and double, are made. The single switch is only provided with one arm, which is moved automatically, while the double switch has a second arm, moved by hand, which is used for cutting out cells at the end of the charge. In the smaller sizes, the contacts and collecting rings are mounted on the same slate, while the mechanism is mounted in a cast-iron frame, which serves at the same time as a support to the slate. The whole is fixed to a wooden board, on which are also mounted the commutator and voltmeter; these are enclosed in glass cases, and the mechanism is also enclosed in a wood case to protect it from dust. In the larger sizes, the contacts and collecting rings are attached directly to the cast-iron framework, from which they are insulated, the commutator and voltmeter being mounted separately. The brushes are claw-shaped, and rub on both sides of the contacts and collecting rings. Connections and the method of working are shown on the accompanying diagram. The voltmeter A is connected up to the circuit, which is to be kept at a constant potential. When the voltage is too low the core of the voltmeter drops and makes contact with the lower screw, and when the voltage is too high with the upper screw. Through these contact screws, the circuit of one of the electro-magnets *a* or *b* of the commutator B is completed; this draws down its armature and completes the circuit of the electromagnet E or $E_1$ of the moving mechanism, which, in turn, sucks in its core. The ratchet attached to this core engages in the ratchet wheel and turns the contact arm round through a distance equal to the space between two contacts. As soon as the core of the electromagnet E or $E_1$ is at the end of its course it breaks mechanically at *c* or *d* the circuit of the electro-magnet of the commutator, which comes back to its neutral position, and in doing so breaks in its turn the circuit of the principal magnet E or $E_1$. As the core of the principal electromagnet comes back to its original position it again completes the circuit of the magnet *a* or *b* at *c* or *d* automatically, and if the voltmeter core is still in contact with the screw, the cycle of operation described above is again gone through. When the arm reaches its end position on the switch, the circuit of the commutator magnet is broken at *e* and *f*. The commutator, at the same time that it closes the circuit of one of the principal magnets, shunts the voltmeter contact, so that if the voltmeter breaks contact while the operation is in progress the circuit is not broken, and it is thus impossible for the arm to remain halfway between two contacts of the switch. The switch moves with extreme rapidity, and thus keeps the voltage constant, even with large and rapid fluctuations of load. The commutator and magnets of the mechanism are worked off about six regulating cells, thus reducing the sparking at the mercury cups of the commutator.

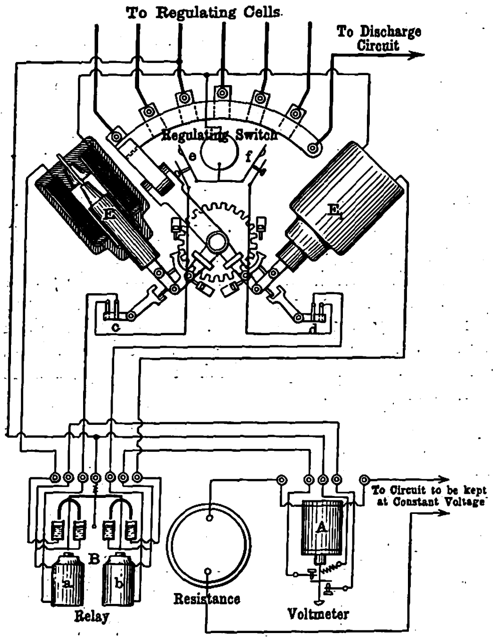
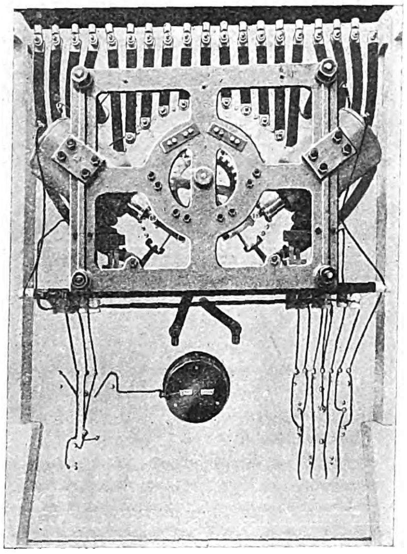
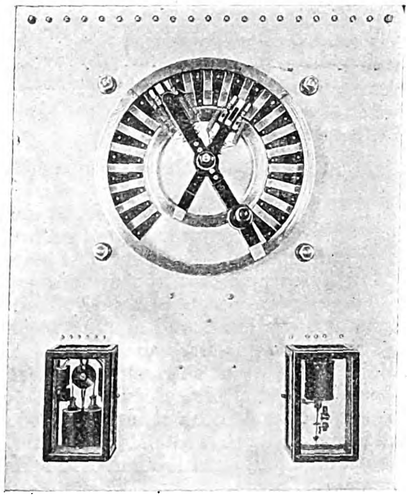


DIAGRAM OF CONNECTIONS FOR "TRUMPY" AUTOMATIC REGULATING SWITCH.



BACK VIEW OF "TRUMPY" SWITCH.



FRONT VIEW OF "TRUMPY" SWITCH.

One of the few exhibits of engines is that of Messrs. E. S. HINDLEY & SONS at stand No. 7. This firm shows several specimens of their steam engines, none of which, however, are in motion. One engine is of the open compound type, capable of developing 50 B.H.P. and having cylinders of 7 in. and 12 in. diameter by 7 in. stroke. A 30 B.H.P single-cylinder open-type high-speed engine has a cylinder measuring 7 in. by 7 in. The dimensions of the cylinder of a similar machine capable of developing 20 B.H.P. are 6 in. by 6 in. A third open-type engine of 14 B.H.P. has a single cylinder measuring 5 in. by 5 in., while an enclosed high-speed engine developing 12 B.H.P. has a 6 in. by 4½ in. cylinder.

Among the exhibits of the SUNBEAM LAMP CO. (stand Nos. 54 and 61) is a reducing lamp with two filaments. The third contact of the lamp is made on the collar and is protected by a ring of vulcanised fibre. When the lamp is full on, a filament of the ordinary size is connected across the mains, and when it is switched over to the reduced candle-power, this filament is connected in series with a smaller filament. The connections are shown in the accompanying diagram. The Sunbeam Co. have also a large-globe incandescent lamp which they call the "Outshine" lamp. It is a 60-watt lamp and is said to give 48 c.p. in the downward direction.

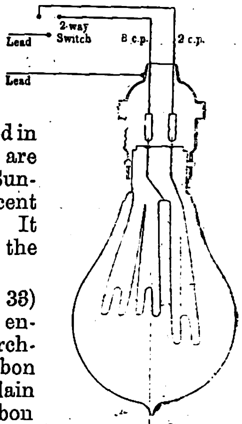
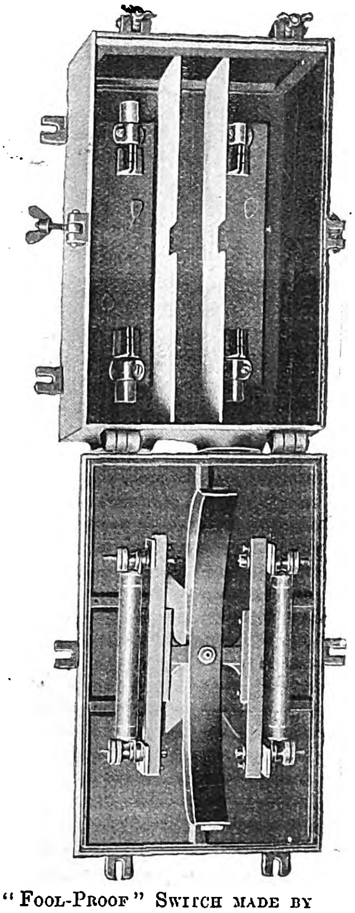


DIAGRAM OF CONNECTIONS FOR SUNBEAM REDUCING LAMP.

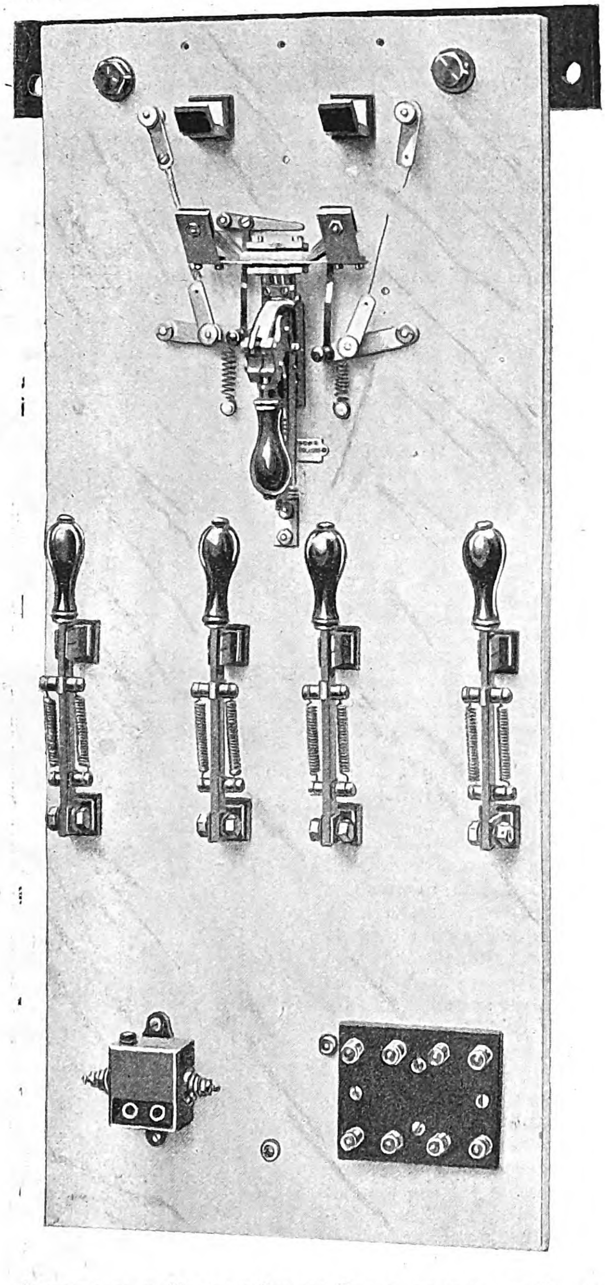
Messrs. SCHIFF & CO. (stands Nos. 26 and 33) exhibit a large assortment of carbons for open, enclosed and flame arc lamps, as also for searchlights, cinematographs, &c. The other carbon specialities to be seen here include brushes (plain and coppered) for electric machines and carbon blocks of almost any size for electrolytic purposes and for the manufacture of calcium carbide. The firm is also pushing a cheap line of house telephones.

One of the novelties to be seen at the stand (No. 59) of Messrs. BERRY, SKINNER & CO. is a D.P. "fool-proof" combined ironclad switch and fuse as shown in the accompanying illustration. The switch mechanism, which is of the simplest design, is enclosed in a water and dust-proof cast-iron box. A rod, having a knob of insulating material at its end, protrudes through the hinged front lid of the box, and the lid can only be opened to get at the switch and fuses by pulling this knob. The latter is connected by a rod to the springs of the switch, so that pulling the knob first causes the switch to cut out and then the front lid to open. Likewise, the lid can only be closed if the switch is in the "off" position—*i.e.*, if the knob has been pulled away from the lid to its fullest limit. If, now, the knob be pressed, the lid will first be closed, and, this done, a further pressure on the knob causes the switch to close. It may be mentioned that the switch springs are flat, and that both the make and the break are rapid. When the lid is open, the fuses and the switch gear are readily accessible, and the fuses and the blades of the switch, being mounted on the inner side of the lid, are "dead," and there is thus no likelihood of the operator making a short-circuit or getting a shock when replacing a fuse. These switches are designed for voltages up to 2,000 volts and for two or three poles. A model installation of Berry & Risch's automatic insulating device of trolley wires is also on view. This novelty has as object the opening of the switches at either end of the ordinary ½-mile tramway section, should the trolley wire in this section break or should a telephone or telegraph wire foul the overhead wire. It is claimed that the device is so sensitive that the main current will be cut off the section in question, while a 5 ampere fuse connected in the telephone or telegraph wire will remain intact. This result is achieved by running an insulated guard wire parallel to and above the ordinary trolley wires. At intervals the two overhead wires are bridged by pieces of galvanised-iron wire bent to form an inverted U. These bridge connections encircle the guard wire mentioned, and are stiffened against swaying by being connected together by wires. They do not interfere with the trolley. In cases where there is only a single overhead wire, loops of galvanised-iron wire are fixed to the top of



"FOOL-PROOF" SWITCH MADE BY BERRY, SKINNER & CO.

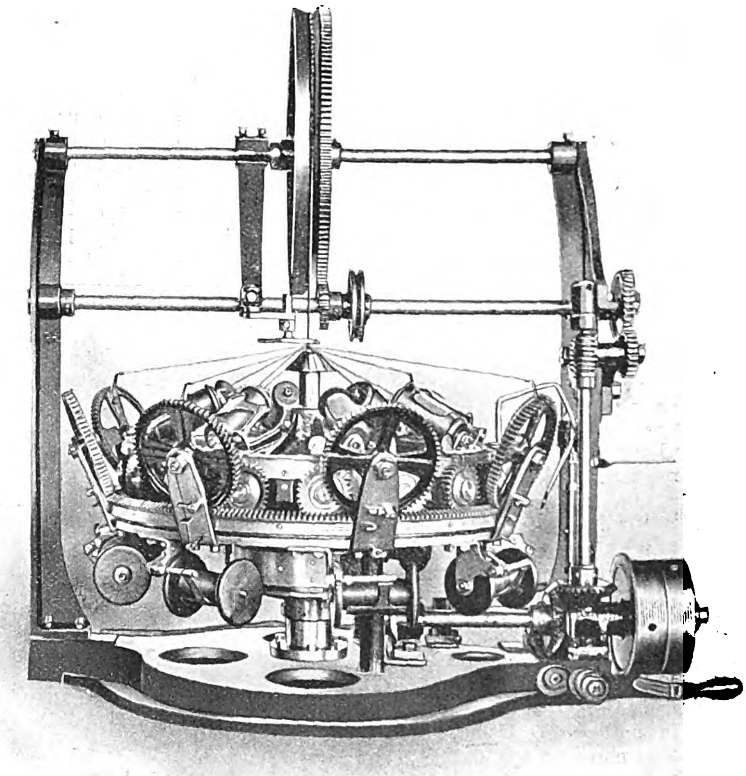
the trolley wire, and embrace the guard wire as above. At the section pillars the guard wire is connected to fuses which, when fused, cause the tripping mechanism of the section switches (see illustration) to operate. Of course, it is possible to switch in and switch out these section switches by hand at any time without disturbing the fuse device. As soon as the trolley wire breaks, or when a telephone or telegraph wire forms a metallic connection between the trolley wire and the guard wire, current flows from the overhead wire through the guard wire and the fuses at either side of the disturbance to earth. The fuses blow and the two section switches are tripped. No other section is affected. The whole of the Walthamstow light railways have been equipped with this device, and the apparatus is being manufactured for the Johannesburg light railways under the instructions of the consulting engineers, Messrs. Mordey & Dawbarn. In addition to the two apparatus just described the firm are exhibiting arc-lamp raising and lowering gear, ordinary switches and continuous concrete conduit.



Switchboard in Tramway Section Pillar, showing the Section Switch "Tripped" owing to the Melting of the Fuse.

For the first few days of the Exhibition Messrs. **Bruce Peebles & Co.** had no machinery on their stands (Nos. 79, 80, 81, and 82). This was due to the fact, we are informed, that the firm was so busy with contracts in hand that the necesary apparatus could not be spared. However, there are now a few single-phase traction motors shown, as well as a duplex continuous-current three-phase traction equipment. There are in process of manufacture at Messrs. Bruce Peebles' works 10 equipments of this type for the South-Western Traction Co. of Canada. These equipments have been specially designed to allow the cars of this traction company to work in the open country upon 1,100 volts three-phase current, and in the City of London, Ontario, on the existing 500-volt continuous-current overhead system. They have a distributed winding of the alternating-current type for the field or stators, and the armatures are of the continuous-current pattern, each being fitted both with a commutator and with four slip rings. When working on alternating current the control is obtained first by arranging the motors in cascade and afterwards cutting them into parallel, while intermediate steps are given by the insertion of resistance in the two-phase secondary circuit. When running on continuous current the motors are controlled in the ordinary series parallel manner. The characteristics of the motors in either case are eminently suited for traction work.

The exhibit of the **High-Speed Braiding Machine Co.** (stand No. 169) has been found interesting by many cable manufacturers. As is seen below, these machines make use of a thread-carrying arm fixed to the periphery of an outer revolving wheel, and this arm thus describes the necessary trochoid path. This mechanism appears to be simpler than that constructed on the usual principle, and it is claimed that it provides an equal tension at all points at any speed. The speed is very high.

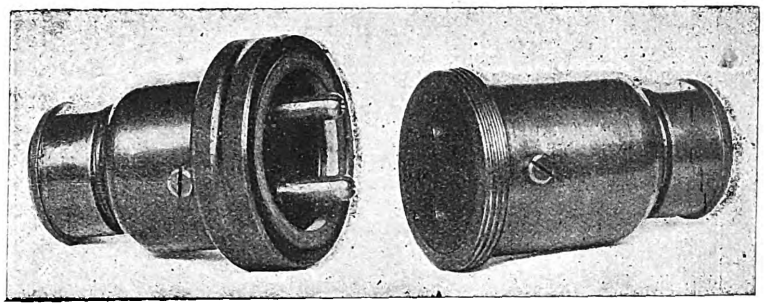


High Speed Braiding Machine.

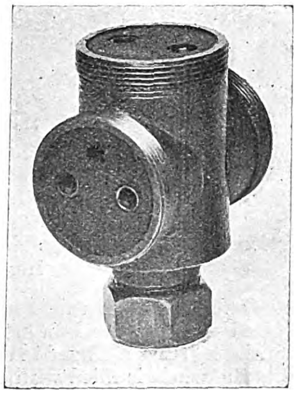
The 16-spindle machines on exhibit are running at 210 revs. per minute, and we were informed that a machine of this size will braid a mile of ordinary small electric light wire in a day. The machines are made in 8, 16 and 24-spindle sizes.

The **Reason Mfg. Co.** (stand Nos. 140 and 159) has a good collection of its specialities. As may be expected, the Wright electrolytic meter is much in evidence. It has recently undergone slight modification. A return has been made to the annular trough of mercury, as it was found that vibration sent the mercury over in the last pattern that had been adopted. This is now prevented by platinum gauze with a wide mesh. The prepayment meter, recently described in some detail in our columns, is also exhibited, and another piece of apparatus, of which several are shown, is the time switch. The company has evidently made a speciality of this, and an effective form of time switch has been evolved. The dials of the clock connected to it are set to the hours at which the current is to be cut off, and, as soon as this period is arrived at, the switch is automatically released and cannot be switched on again until the end of the period is over and another contact is closed on the clock. The clock used for this purpose is of the Dubois pattern, and this is also employed in conjunction with electrolytic meters fixed up as two-rate meters. Both the liquid and the electromagnetic types of demand indicator are on view, and also the company's various patterns of arc lamps, lanterns and fittings for incandescent lamps, fuses, &c.

A number of excellent couplings for temporary and permanent wiring work constitute the chief feature of Messrs. **Simmonds Bros.'** exhibit at stand No. 162. Some time ago Messrs. Simmonds Bros. designed a coupling for temporary work and this device was fully described in *The Electrician* of July 14. They have now improved the coupling by making the design of a heavier nature and adding screwed rings for holding the plugs in position.



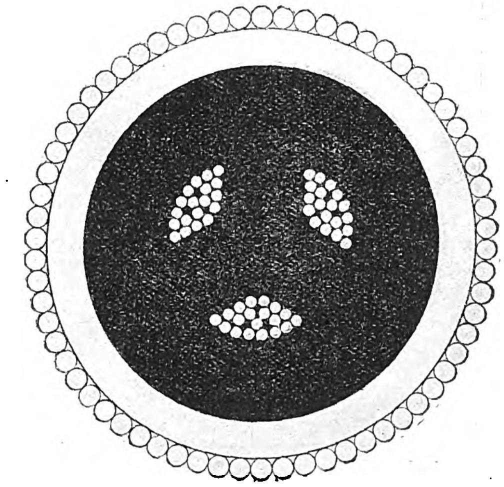
Simmonds Bros.' 50 ampere Plain Coupling, showing Plugs.



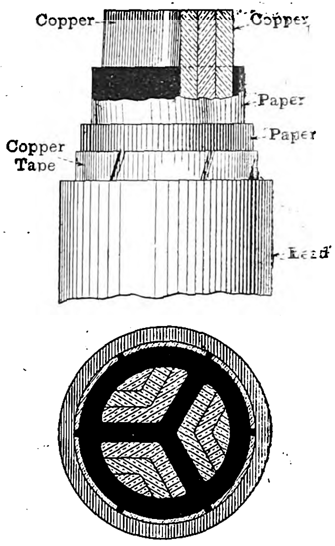
Simmonds Bros. 15 ampere Two-way Side Coupling for Tapping off.

Visitors are attracted to the **Diesel Engine Co.**'s stand (No. 208) by a 20 h.p. Diesel crude-oil engine, made by Messrs. Sulzer Bros., of Winterthur (Switzerland), and driving a generator by the Lancashire Dynamo & Motor Co. The guaranteed consumption of crude oil per brake-horse-power-hour is 0·41 lb. at full load and 0·47 at half-load, according to figures supplied us by the company. When we visited the stand the set was running very smoothly and silently. Of course this is a small engine compared with the 500 h.p. engine exhibited at Liège. We understand that the company is prepared to supply engines up to 1,000 h.p. in size. The engine, which has been described in our columns on a previous occasion, requires no vaporiser and no ignition device, the temperature attained by the compression in the cylinder being sufficient to ensure combustion of the charge. In the engine exhibited, the pressure reaches about 510 lb. per sq. in. Since compressed air is constantly required for working the engine, this agent is also used for starting purposes.

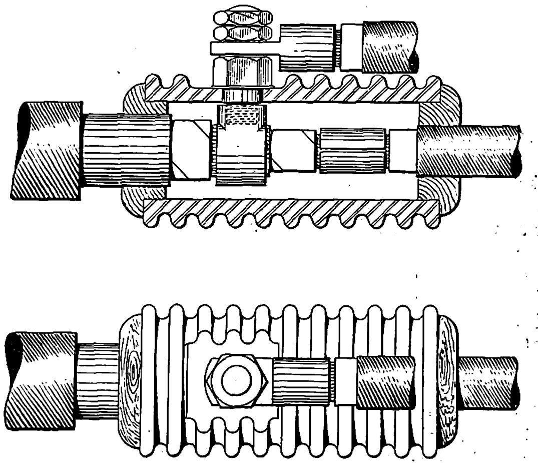
Messrs. **W. T. Henley's Telegraph Works Co. (Ltd.)** have an interesting display of cable at their stands Nos. 143 and 156. One of these is a very heavy 11,000 volt cable, 30 miles of which is being supplied for the London United Tramways extension to Wimbledon, the cable being used to convey the current from the Lot's-road generating station of the Underground Electric Railways Co. of London. We show a full-size section of it above. The cable is insulated with impregnated paper and lead-covered, the armouring being directly on the lead without an intermediate serving of jute or covering of tape, in order that the conductance of the lead may be enforced by that of the armouring. Another interesting cable is one with so-called "Laminæ" conductors, illustrated below, which, we understand, is employed to a considerable extent by the Newcastle-upon-Tyne Electric Supply Co. As is seen in the section and part section and elevation below the conductors are made up of copper strip bent into a **V**, instead of being ordinary wires stranded and subsequently stamped to sector shape. To increase the conductance of the sheathing, copper strip is inserted directly beneath the lead. A large multiple cable made for the Post Office for telegraph work is also exhibited, and in this the wires are paper insulated and have a lapping of copper tape over the paper, so as to screen the conductors and prevent external influence. A pretty sample also shown is a 1,212 wire paper-insulated telephone cable which has just been ordered by the Post Office for use in short lengths. The cable is very compact, each conductor weighing only 10 lb. per mile, so that the diameter outside the lead is no greater than 2¾ in. The ordinary 320 pair cable used by the Post Office with 0·036 in. conductors is also shown, and an interesting composite cable in which some of the wires are laid up in pairs for telephone work, and the others are single, shielded with copper tape, as in one of the cables mentioned above. On this stand is also an asbestos braided-rubber cable which presents a well-finished appearance. A new terminal end for concentric cable is also on view; the illustration of this below is self-explanatory. Messrs. Henley also show a pattern of house cut-out which they have recently placed on the market. In this the fuse is held in a removable carrier, the fuse wire being stretched along a grooved trough in the porcelain. The fixed part of the fuse which forms the base has a slightly wider groove, and the clips are so arranged that when the fuse is pushed in the fuse wire is encircled, as it were, by a tube.



Henley's 0·05 sq. in. Three-core Three-phase 11,000 Volt Cable (Steel Wire Sheathed). As supplied to the London United Tramways.



Henley's "Laminæ" Cable.



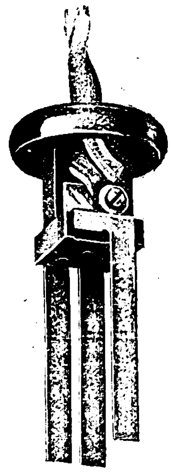
End Connection for Concentric Cable. (One-fourth full size.)

Stand No. 137 is occupied by Messrs. **Haines** & Co., who exhibit non-stretching belting, steam-pipe coverings, steam jointing and packing, lubricating oils and greases, engineers' tools, castings, &c. A novelty shown is the "asbestos" slate, which may be pressed into any shape. It is said to be entirely fireproof, an excellent electric insulator and impervious to water. It looks somewhat like glazed tile, but is not so brittle. As implied by the name, its chief component is asbestos.

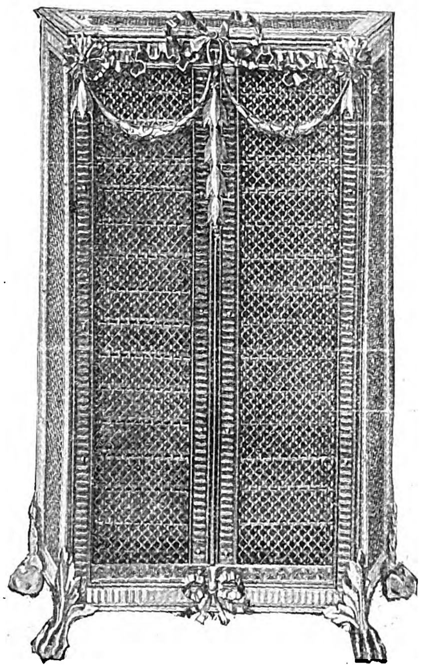
The **British Accumulator** Co. (stand No. 148) display a series of storage batteries ranging from the 4,400 ampere-hour type (at the 10 hour rate) downwards, as well as separate plates and sections of plates and accessories. The smaller types of cells are shown in glass boxes, while the larger types of plates are assembled in lead-lined wood and solid lead-alloy crate boxes. In the two last-named cases the plates are suspended from glass slabs, being separated by glass tubes. A further feature of the cells shown is the lead expansion feathers fixed between the side of the box and the negative end plates. These feathers are strips of lead bent to a wavy form and keep the plates firmly together. Being quite inside the cell, there is no creeping of acid outside the battery box. All the positive plates are of the large surface Planté type, the negatives consisting of a leaden net which, whilst offering a large surface, can hold a large quantity of active material.

The **British Prometheus** Co. (stands Nos. 146 and 153) employs a different system of electric heating to other firms making similar apparatus. The heating conductor is an extremely thin film of metal deposited on mica and covered with a mica sheet. These heating elements are of a uniform size, 6 in. long, and they fit into clips, so that if one burns out it may be replaced just as a lamp. Each takes the full pressure of the mains across its terminals, all the elements being connected in parallel. In many of the radiators exhibited, a few lamps are placed inside to give the comfortable glow which is appreciated by most users. The radiators or stoves are made in a multitude of artistic patterns, to which the small space occupied by the heating element adapts itself well. The illustration below is a stove in the Adams style. In the case of flat irons, the bottom surface of the interior of the iron is milled, and a sheet of asbestos or uralite is placed above the heating element, so that the pressure is uniform, and the heater is thus pressed tightly against the iron so that the distribution of heat is uniform. An alternative form of heating element which the company has recently introduced is ring-shaped, and is clamped tightly round the bottom of the pot to be heated. With this arrangement it is essential that the pot itself be spun absolutely true for the heating to be uniform. A practical form of regulating connecting plug for cooking appliances is shown above; the contacts are arranged so that four different grades of heat may be obtained by turning the plug. The electrical part of the apparatus is all made at the company's works at Kingston-upon-Thames, and the appliances also are mostly made in this country.

"Prometheus" Regulating Plug.

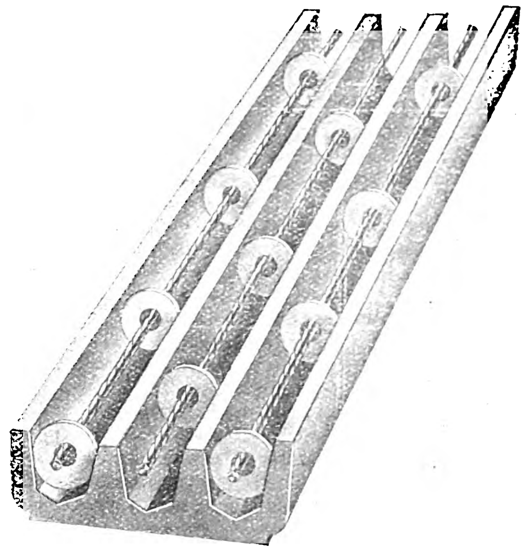


Regulating Connector.
Cover Removed.



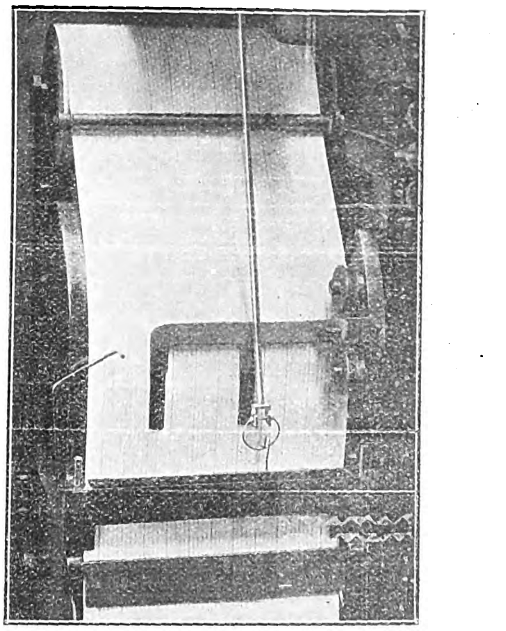
A "Prometheus" Radiator.

The **Steel Core Concrete** Co. (stand No. 195) exhibit specimens of their concrete ducts for electric light mains, reinforced with expanded steel. Several patterns of duct are shown, including the Post Office shape of hexagonal duct, and troughs for laying mains on the solid system, both in 6 ft. lengths, and flat conduits with circular ducts (in 4 ft. lengths) for use on the drawing-in system. The company's conduit is used by the Hammersmith Borough Council and on the North Metropolitan Tramways. A specimen of Messrs. Alexander Duckham & Co.'s "Imperishable" system is also exhibited. In this bare conductors are used, and rings of unglazed vitreous porcelain are threaded over them. These porcelain insulating rings are fixed in the "steel-core" trough as shown above, and the whole is filled with compound and protected by a cover.



"Imperishable" System. Trough Showing Conductor in Position Ready for Filling.

One of the best shows in the Exhibition is that of Messrs. **Elliott Bros.** (stand No. 145), who exhibit an entirely new series of indicating instruments of various types for continuous current in actual operation on a switchboard. They are of the moving-coil type and absolutely dead-beat. Some of the special features embodied in their manufacture are: They are made interchangeable, both electrically and mechanically; the special advantage of this being that new shunts or resistances can always be supplied without the instruments being returned. A zero device is provided in all types exterior to the case, thus enabling adjustment to be easily made. The moving coils are so wound that the resistance of the leads forms a much smaller proportion of the total instrument resistance than usual, and thus small variations in the length of the leads do not materially affect the instrument readings. They are adjusted to accuracies vary-

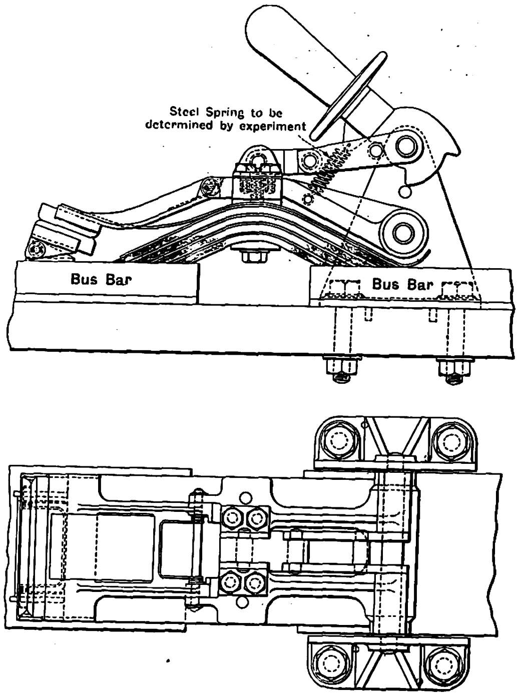


Elliott Bros.' New Inking Device for Recording Instruments.

ing from 2½ to ½ per cent., according to the type employed. All pointers are made of specially stiffened tube, thus considerably lessening the chance of bending. Different classes of finish are shown on one side of the board, and also copies of certificates from the National Physical Laboratory and Board of Trade for instruments actually supplied.

Several recording instruments are also shown in actual operation, a special feature of these being the new inking device, which will, no doubt, find favour for traction work especially. It consists of a long trough on the front of the instrument (see our first illustration), and this holds at least 100 times as much ink as the ordinary cup pen. The pen itself is very simple in form, being practically a piece of very fine bent tube, through which the ink flows by capillary attraction. We understand that this form of pen is very cheap. Enquiries at Messrs. Elliott Bros.' stall elicit the information that, although not on the market, they have designed a new form of recorder which enables fresh rolls of paper to be fitted without opening the case of the instrument. The paper spool is put into a small box on the top of the instrument, and is then fed down a specially-constructed chute into position. A section of the switchboard designed by Mr. Highfield for the extension of the Tower-street sub-station of the Metropolitan Electric Supply Co. is shown complete with instruments, switches, &c.

A new pattern of the well-known "Century" test set is shown, greater compactness being a special feature. Several samples of portable instruments for both continuous and alternating currents are exhibited, and several other test sets, amongst which may be noted the insulation test set and others to suit special requirements of the new Home Office regulations in connection with electricity in mines. A portable testing set is also shown in this exhibit, specially designed for the mains superintendent and cable engineer. This set can be used for the following tests: (1) Insulation resistance. (With 100 volt battery, insulation up to 200 megohms can be measured, and with 500 volt battery, 1,000 megohms.) (2) Copper resistance from 0·01 ohm to 11,000 ohms. (3) The localisation of a fault to earth in the insulation of a cable. (4) Measurement of voltage from about 0·0005 up to about 550 volts. (5) Can be used as a very sensitive milliammeter (for currents as low as 0·00000065 amperes). (6) The galvanometer can be used separately from the rest of the apparatus. The set consists primarily of a sensitive pivoted D'Arsonval galvanometer with shunts for varying the sensibility; a number of coils giving from 0 to 110 ohms by steps of 1 ohm, coupled up in conjunction with two ratio arms (each ratio arm consisting of three coils, 1,000, 100 and 10 ohms) to form a Wheatstone bridge. A resistance of 100,000 ohms and a three-way switch are provided for taking the "constant" of the galvanometer and making insulation tests. The switch and resistance are so arranged that it is practically impossible to damage the galvanometer in the event of the insulation resistance being very low, and a high-battery power being used. A universal shunt gives four sensibilities to the galvanometer. The scale of the galvanometer is even throughout its range, and the deflection is directly proportional to the current flowing. The zero is slightly set up, allowing deflections in either direction; this is very convenient for bridge work and fault localising at the same time it does not greatly reduce the length of scale when used as a voltmeter or milliammeter. The scale is provided with a mirror, and the pointer is in the form of a knife edge. The "insulation" portion of the apparatus is provided with a key, and a bridge part with a "double successive" key that breaks both galvanometer and battery circuit. There are no plugs to lose or work loose, all the necessary alteration in connections being made by means of self-cleaning lever switches. Substantial binding posts are provided, and everything is clearly labelled. The whole is mounted on ebonite in a varnished teak case with carrying handle, and a 3 ft. tripod is provided, on to which the set is fixed when in use.



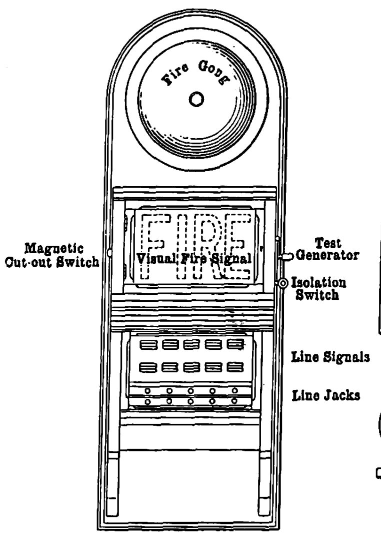
One-sixth full size.

ELLIOTT BROS.' 5,000-AMPERE SWITCH.

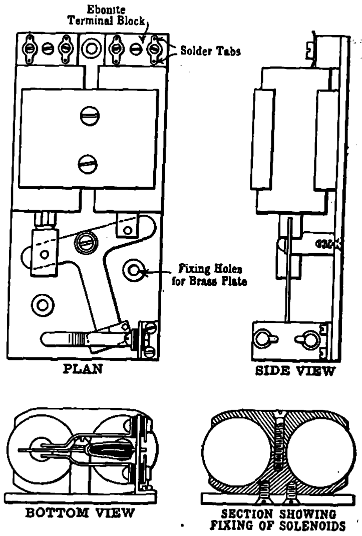
(In the Plan of the Switch the Handle has been omitted.)

Amongst the many switches exhibited there is a 5,000-ampere switch of the design shown in the accompanying drawing. A cheap D'Arsonval galvanometer, provided with both a pointer and a mirror, and chiefly intended for workshop use, is also on view. Mechanical and electrical speed indicators are shown, the latter consisting of a small dynamo and a voltmeter marked not only in volts but also in revs. per min., miles per hour, and so on, according to the use to which the instrument is to be put. These instruments are particularly adapted for indicating, at the switchboard or any other place, the speed of turbo-generators. A neat indicator, the "Simplex" indicator, has been improved in various ways, and is particularly recommended by Messrs. Elliott Bros. for taking indicator diagrams from gas engines, the instrument, it is said, giving perfect diagrams up to a speed of some 650 revs. per min. In order to prevent the indicator spring (which is of the flat type) from getting unduly hot, it is fixed externally. An arrangement is fitted so that the drum may be stopped or caused to oscillate at will. The remaining exhibits include "Sparklet" fuses, standard resistances, white-metal castings, &c.

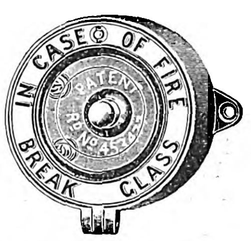
The STERLING TELEPHONE & ELECTRIC CO., stand Nos. 22 and 37, have a good selection of their apparatus, all of which display a finish and workmanship which will no doubt be retained by the company when it starts its projected works in this country. The "Hygienea" telephones, described in *The Electrician* for September 22, are very much in evidence and attract considerable attention. The company have a number of writing-table exchanges of practical construction, one of which we illustrate overleaf. The little switchboard on this is on the central-battery system with lamp signals, while on other specimens of writing tables grid visual signals are used. The relays (of the lamp signal exchange), weights and jacks are neatly disposed of at the back of the writing table. Being well cased in, they do not occupy too much space, so that the usual complement of drawers and cupboards, &c., are provided. On one of the writing-table exchange sets, a typewriting machine is provided, this being fitted on a "disappearing" platform which covers up the machine when not in use. This is intended as a stenographer's outfit, so that the clerk sitting at the table can wear a head gear telephone and take down letters which are dictated to her.



STERLING COMBINED PRIVATE EXCHANGE AND FIRE ALARM BOARD.

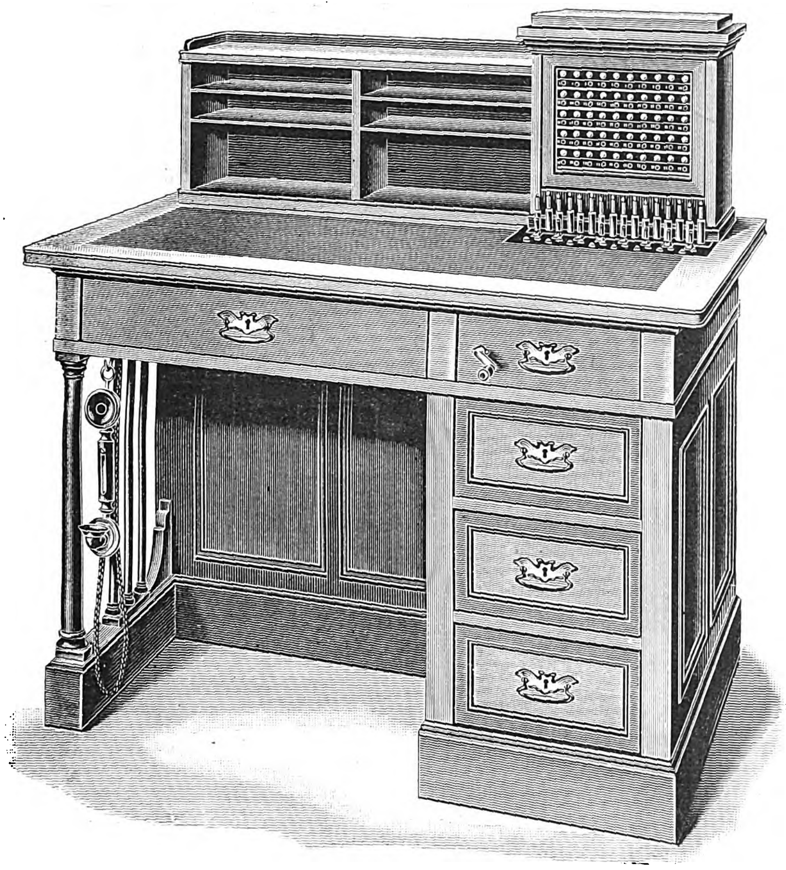

Ebonite Terminal Block
Solder Tabs
Fixing Holes for Brass Plate
PLAN
SIDE VIEW
BOTTOM VIEW
SECTION SHOWING FIXING OF SOLENOIDS

SOLENOID SWITCH WITH INDICATOR, used on the Bell Indicator Board for the Ritz Hotel. (Indicator flag not shown.)



"STERLING" FIRE ALARM BOX.

A new type of small private central-battery exchange board is shown, from five lines upwards. In these there are grid indicators, and the calling indicator acts also as clearing indicator. By an ingenious arrangement of circuits, however, this only gives the clearing signal when both the people who are conversing hang up their instruments, instead of the signal being received directly the caller has hung up. These sets require about 16 volts to work them and can either be used with secondary batteries or with the "Primax" battery supplied by the company, which is a caustic soda and copper oxide cell. Thirty cells of these would be required, or a smaller number of six-block agglomerate cells would also work the exchange. A fire-alarm system is shown combined with one of these small exchanges, the same wires being used, but with the addition of a common-return wire. We illustrate on p. 29 a switchboard and indicator board with the fire alarm above it. This consists of a sheet of red glass in which the letters "fire" appear when the glass of the fire-alarm is broken. Also on p. 29 is given an illustration of the fire alarm box, in which the plunger keeping the circuit open is held back by the glass. As soon as the glass is broken, this comes forward and closes the circuit as usual. An additional precaution is taken which prevents the reception of a fire alarm at the board if the case is opened with a key for ordinary inspection. There is a second contact under the iron cover, so that when the whole cover is open the circuit is broken there before it is made by the central plunger coming out. Another useful device in connection with the fire-alarm box is that the terminal screws are made as sockets to take a testing plug. The inspector simply plugs his testing set, which consists of a buzzer and a condenser, into the sockets and presses the push, say three times, as a test signal. If everything is in order the operator sends him back a signal by turning her magneto, which acts on the buzzer. The exchange board in connection with this system is provided with an isolation switch, so that, when the fire signal is received, the operator can cut off all the other lines from the indicator until she has ascertained the cause of the fire, and then she can make use of a common jack which connects her instrument to all the lines at the same time, and can inform them where the fire is. She has also a switch which disconnects the fire alarm in the case of a false alarm, and it is so arranged that when the glass of the call box is replaced the switch comes back to its normal position.

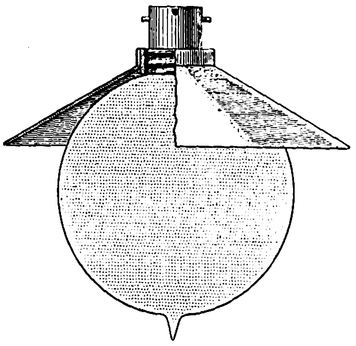


The Sterling Telephone and Electric Co.'s Writing-table Telephone Switchboard.

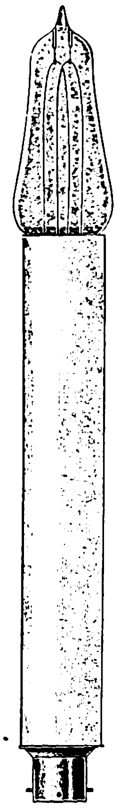
Another interesting exhibit is a section of the indicator board of the electric bell system which is to be installed in the new Ritz Hotel in Piccadilly. In addition to the ordinary service room indicator, in which a red bar appears when the bell is rung, there is a controller board in the manager's office, or general office, in which a luminous signal appears, showing the number of the floor. In addition to this a lamp lights up outside the room in which the bell has been rung, and it is only extinguished by depressing the push beneath it. The indicators of the service board act at the same time as relays, there being two ironclad solenoids, one of which closes the lamp circuits and the other re-opens them. The solenoids and contacts are seen in a figure on p. 29. The whole board is beautifully finished, and contains 490 movements. The luminous signal board used for the manager's office or the general office simply contains a lamp for each floor and a relay which can be connected to a single stroke bell if required. The company also exhibit a large fire alarm which they have made for the same hotel, one feature of which is the long rubbing contact made by the indicator flap when it drops.

One of the few exhibits of large machinery in motion is that of Messrs. Crossley Bros., who show three of their standard engines at stand No. 215. The firm's No. 2 suction gas plant is employed for supplying an "R.E." type high-speed gas engine. This engine is capable of giving 27·5 B.H.P. as a maximum with town gas, and 21·5 B.H.P. as a maximum with suction gas. It is coupled to a dynamo which supplies part of the current necessary for lighting the stand. Another feature of Messrs. Crossley's exhibit is an "O.E." type high-speed gas engine capable of developing 16 B.H.P. as a maximum with town gas, and 12·5 B.H.P. as a maximum with suction gas. This engine is also shown in actual operation, driven by town gas; it is coupled to a dynamo and effects part of the stand lighting. The third exhibit on this stand is an "L.L.E." type high-speed oil engine and dynamo combined. This engine has an output of 4·5 B.H.P. as a maximum.

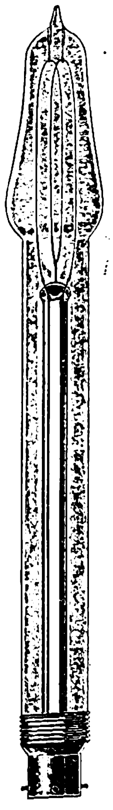
Pope's Electric Lamp Co. (stand No. 179) have a large exhibit of incandescent lamps made at their works near London. Like other lamp makers, they have introduced a large-globe lamp, the "Rilelite." This, they inform us, is run at an efficiency of 2·8 watts per candle and gives 25 c.p. in a downward direction. The reflector shade, instead of resting on the lamp merely, is screwed on to the lamp cap, as shown in the figure below. This company has also made a speciality of imitation candle lamps, in which the outer glass tube, representing the candle, is detachable, although the lamp cap is below, so that some of the light shines through the imitation candle. The construction is clear from the illustration. The arrangement enables the consumer to change the colour of the "candle" to suit dining-table decorations.



Pope "Rilelite" Lamp.

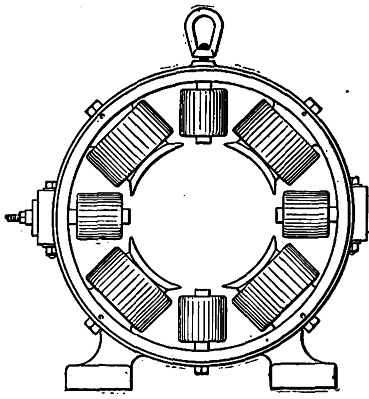


Pope Candle Lamp. Complete with Tube.

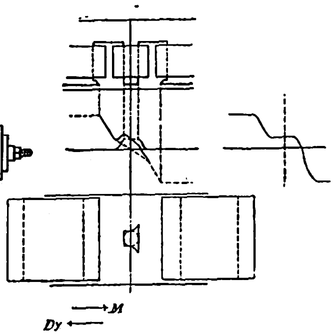


Pope Candle Lamp. Tube removed.

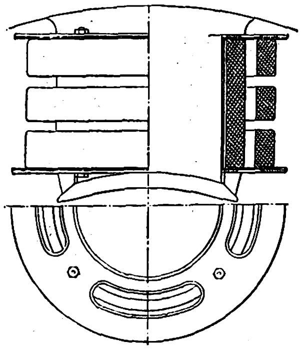
A stand which receives much attention is that of the Phœnix Dynamo Mfg. Co. (Nos. 117 and 126), who show some novelties in connection with generators and motors. Our first sketch illustrates the general arrangement of the auxiliary poles within the magnet frame, while the second diagram indicates the action of this compensating device. The construction is due to Dr. Pohl, the company's dynamo designer for continuous-current machinery, and we understand that dynamos aggregating 5,000 H.P. have already been supplied with this commutating device, the largest machine thus fitted being of 600 kw. capacity. It is now well recognised that the output of a given size of continuous-current generator is limited by two factors --the sparking at the commutator and the heat developed. In proportion as these can be suppressed, the weight and cost of a machine can be reduced for a given output; and as the efficiency of a modern dynamo is almost as high as it can possibly be, it is in the direction of diminished heating and improved commutating qualities that the efforts of designers are almost entirely directed. It is evident that during the time that any armature coil is passing under the brush, the current in it has to be reversed and rise to its full value in the opposite direction. This is facilitated if the coil enters a reverse field during that time. In an ordinary shunt machine, however, the line of demarcation between the positive and negative fields varies in position according to the load on the machine, on account of the distortion of the main field by the cross-field produced by the current in the armature. Hence the greater the load the more the brushes must be shifted towards the leading pole-piece. It will be seen that if the reverse field could be increased in strength proportionately to the armature load, the distorting effect of the latter might be neutralised and a fixed position of the brushes be secured. This desirable effect is obtained by providing auxiliary poles, the windings of which are in series with the armature. These poles create fluxes which link with the coils undergoing commutation, the direction and strength of these fluxes being such as to neutralise the reactance voltage and the voltage induced by the armature's own flux. Strictly speaking, the strength of the auxiliary flux does not increase quite in the same proportion as the motor load—owing to saturation—but the increase is sufficient to prevent sparking over a much wider range than would ordinarily be the case. The peculiarity of the poles as adopted by the Phœnix Dynamo Mfg. Co. is that their faces decrease in breadth in the direction of motion for the purpose of equalising the field in the manner invented by Dr. Pohl (see the second illustration). The commutating poles are as short as possible in the axial direction of the armature. The E.M.F. curve produced by the usual pattern of auxiliary poles is shown projected beneath the auxiliary pole in the second sketch, while the curve at the right-hand side of this sketch shows how the E.M.F. is maintained at constant value for a considerable period in the machine in question, and the commutating position correspondingly enlarged. In order to test the theoretical conclusions, the firm experimented with a machine originally built as a standard four-pole shunt dynamo for an output of 30 kw. at 550 volts at 525 revs. per min. With this output the machine did not commutate sparklessly, on account of the high reactance even with an air-gap of 4·5 mm. on each side. Auxiliary poles were fitted designed to give constant commutation conditions over about one-half the neutral zone, the air-gap was reduced to 2·5 mm. on each side, and the rated output increased to 33 kw. Running as a dynamo giving 60 amperes at 550 volts, the brushes could be shifted for more than 1 in. to each side of the central position without sparking. The machine was then loaded for a short time with 120 amperes, and even with 150 amperes, which is nearly thrice the normal full load current, without signs of sparking. At a load of 30 amperes only, if the winding of the commutating poles was short-circuited, excessive sparking occurred. All brushes were then lifted off the commutator save one positive and one negative brush, and even then no sparking occurred at full load, although the current density in the carbon was 93 amperes per square inch. The machine has also been tested as a dynamo at 1,000 revs. per min., and giving 1,000 volts, the fields being separately excited at 550 volts, showing that even under these conditions of voltage and speed the auxiliary poles gave sparkless commutation. When run as a motor, with 440 volts on the armature and 550 on the field, the speed at full load could be regulated from 350 to 900 revs. per min. At the highest speed only was there any sign of sparking.



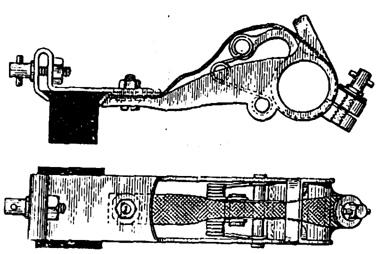
Sketch showing General Arrangement of "Phœnix–Pohl" Auxiliary Poles within Magnet Frame.



Details of Auxiliary Pole and Curves of E.M.F.



Field Coils of "Phœnix" Dynamos.



"Phœnix" Brush Holder. One-third full size.

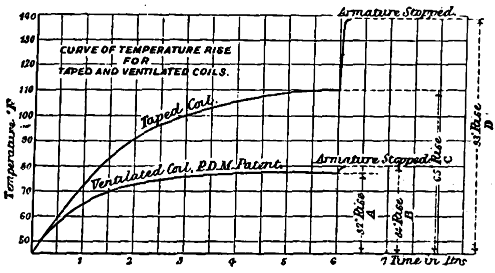


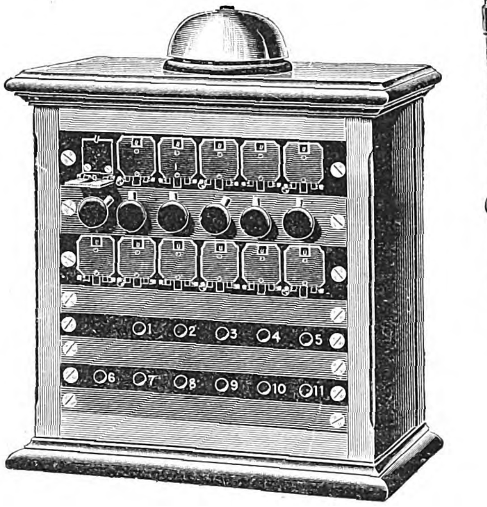
Diagram showing the Difference in Temperature Rise (measured externally) between an Ordinary Taped Coil and a "Phœnix" Ventilated Coil.

In order to improve the ventilation, the field coils are provided with ducts, as indicated by our third sketch. The effect of ventilation is clearly shown by the curves in the diagram. In the ordinary coil the external temperature rose to about double that of the ventilated coil on the same machine; while after the machine was stopped, and the air-blast consequently absent, the ordinary coil rose very much higher again, showing that its internal temperature was far greater than that of the other.

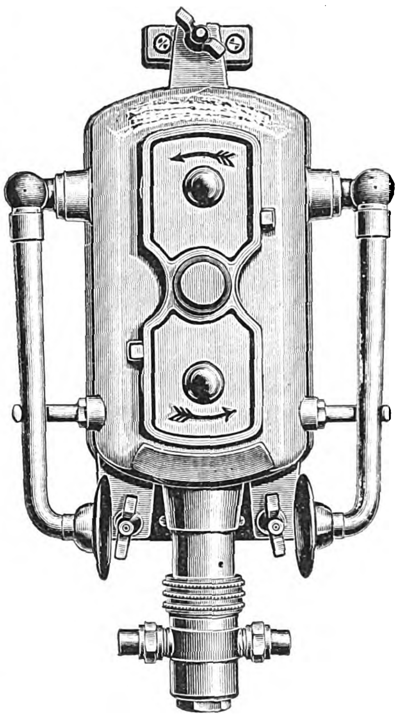
A 3½ H P. shunt motor, fitted with auxiliary poles, was varied in speed from 470 to 2,400 revs. per min. by shunt control in our presence. It was taking 22 amperes at 220 volts, and showed no signs of sparking at any speed. One of the generators with auxiliary poles is coupled to a 400 B.H.P. three-phase 5,000 volt 50 ∿ synchronous motor with rotating field excited from a 250 volt continuous-current supply. The generator is specified to supply 1,140 amperes at any voltage between 220 and 260 volts. This motor-generator (which is occasionally set running) is fitted with a 30 H.P. induction motor keyed to the shaft of the motor-generator and used for starting purposes. The set on show is one of four of the same output which have been made for the Sunderland Corporation. The other machines exhibited include three-phase alternators, induction and "squirrel-cage" motors, continuous-current motors and the "Phœnix" electric sensitive drill. This useful machine is fitted with ball bearings in the principal parts and is operated by a friction drive. The four pole series motor employed is capable of developing ¼ H.P. continuously and is fixed to an extension of the bracket. It carries on its extended shaft a small sliding friction wheel which entrains a friction disc keyed to the drill spindle. In order to vary the speed, the friction wheel may be fixed nearer to or further from the centre of the friction disc by a simple mechanism. An ordinary tumbler switch is used for switching the motor on and off, no starting resistance being necessary. Another illustration shows the company's brush-holder. Its parts are stamped out of sheet brass by special machinery, and it appears light and strong. The illustration is self-explanatory.

A new "flame" arc lamp is shown by Arc Lamps (Ltd.) (stands Nos. 169 and 170), but Mr. W. J. Davy, the patentee, has asked us to refrain from publishing any details concerning its construction, as the patents are still in the provisional stage. There are in all some 14 lamps of various patterns lighting the stand, the supply being from the Hammersmith mains at 220 volts alternating, 50 periods. The two flame lamps exhibited, we are told, are designed to run for some 26 to 30 hours without retrimming. Among others there is a photo-printing lamp and inverted reflecting lamp, a shop reflecting pattern and also miniature lamps. The company's self-contained compensator lamp is also on exhibition, a pattern designed to run off 200 to 220 volts alternating current with a single pair of carbons consuming only 300 watts. A twin carbon lamp, some 700 to 800 of which have been installed for street lighting in Cardiff and other towns, is also shown. The lamps are made in England.

The chief feature of the International Electric Co.'s exhibit (stand No. 88), if we except a loud-speaking telephone which asks visitors in a stentorian voice to stop at that stand, is a large central-battery switchboard, in conjunction with which a four-party line system is shown, with polarised bells. A similar board to this is, we understand, being supplied for the Cape Town telephone exchange. A 100-line exchange board is also shown, which is arranged so that it can be easily adapted for multiple working, up to a 2,000-subscriber multiple, if this should subsequently be desired. Telephone engineers will also be interested in the specimens of indicators which are mechanically replaced by the insertion of the answering plug, as described in our article on the Guernsey telephone exchange elsewhere n this issue. A neat little "cordless" switchboard, illustrated below, is also on view. The ship's telephone, which we also illustrate, is a strongly-made instrument. The transmitter is shielded by a revolving cover when not in use, and on the cover being turned, to open it, the bell at the other end rings automatically. The receiver ear pieces are mounted on arms which are fixed to the case through a universal joint so that they can be placed close to the ears. Some equally strong instruments for use in mines are also shown, and a military telephone which, in a modified form, has stood the test of the Russo-Japanese war. Considerable space is devoted to fire alarms. In a system of bells for calling up the firemen from the station, the generator is provided with two windings, one connected between the two ends of the series circuit passing through the bells and the other between the line and earth. Each bell has a second winding between line and earth, so that all the bells can be rung even when there is a short-circuit or a dead-earth on the line.



International Electric Co's Cordless Switchboard.



International Electric Co's Ship's Telephone.

Some fire alarms are exhibited similar to those supplied by the firm to the Great Northern Railway, the arrangement being that when the glass is broken the box can be opened and a telephone, which is inside, can be used. The company also exhibit their various types of motors.

In our description last week of Mr. A. P. Lundberg's exhibit at stand No. 106 we mentioned a method of controlling any number of lamps from any number of points. Mr. Lundberg calls our attention to the fact that the word "series-parallel," which appeared in a foot line to the diagram of connections, might be superseded by the word "intermediate" with advantage.

(*To be continued.*)

## THE LANCASHIRE & YORKSHIRE RAILWAY ACCIDENT.

This accident, which occurred on July 27th, forms the subject matter of a Report by Lt.-Col. E. Druitt, R.E., appointed by the Board of Trade to inquire into the causes of the collision between a passenger train and an empty passenger train at Hall Road on the Lancashire & Yorkshire Railway.

In this case the 6:30 p.m. express train from Liverpool to Southport ran into an empty passenger train standing in the middle siding at Hall Road station. Each train was electrically driven, and consisted of five cars—viz., a third-class motor car at either end, and two first-class and one third-class trailer cars between the motor cars, all fitted with Westinghouse automatic couplings. One motorman and one guard accompanied the express, in which were about 56 third-class and 20 first-class passengers. Twenty passengers were killed (all of whom were in the leading car), two severely injured (also in the leading car), and 45 other passengers complained of injuries, mostly suffering from shock. The motorman of the express was also severely injured. The collision was a very severe one, the leading car of the express and the first car of the standing train being telescoped one inside the other. The two bogies of the first standing car were driven back underneath the second standing car, so that there were four bogies under this car. The only wheels derailed of either train were the leading pair of the front bogie of the express. Each train was fitted with the automatic vacuum brake, working blocks on all wheels of the train, and the brakes on the express were stated to be in good order. There was practically no damage to the permanent way. The causes of this most unfortunate collision are clearly shown by the evidence of signalman Boote, on duty in the Hall Road signal-box at the time, and by that of motorman Rimmer, the driver of the express train. There is a 10 minutes' service of trains from Liverpool to Hall Road and a 20 minutes' service beyond Hall Road to Southport. Thus, approximately, half the trains arriving at Hall Road are turnback trains, and these, as soon as the station work is completed, are run direct through facing points either into the middle siding or into the down siding. From these sidings the empty trains can be brought out direct to the up platform ready for the return journey to Liverpool. On the evening in question the train leaving Liverpool at 6:20 p.m., due at Hall Road at 6:37, arrived at 6:39 p.m., and was sent into the middle siding at 6:40 p.m. Boote was offered, and accepted, the 6:30 p.m. express train Liverpool to Southport from the Crosby signal box at 6:41 p.m., and his account of what happened subsequently is, I believe, correct. When he had put the 6:20 p.m. into the middle siding he reversed the facing points leading to it, so that they were in the normal position—*i.e.*, right for the main down line—and bolted them. As soon as he accepted the 6:30 p.m. express he lowered his outer home signal, which requires the bolt locks of both the facing points to be home, and also the starting signal, but when he tried to lower his inner home signal he was unable to do so. Thinking the switch blades of the facing points leading to the middle siding were perhaps not absolutely in their true position, and that in consequence the inner home signal was being held at danger by the electrical detector, he placed his starting signal and outer home signal to danger, put back the levers working the locks and locking bars of both facing points and worked the facing points leading to the middle siding, three times more vigorously, intending to force the blades into their accurately true position.* Unfortunately, Boote finished up by pulling over the lever working these points, by which means they were set for the siding instead of for the main line. He then pulled over the levers working the locks and locking bars of both the facing points, and lowered his outer home and starting signals. Finding he still could not lower the inner home signal he went to the window of the signal box with a green flag and waved it to Rimmer, the driver of the express, intending thereby to signal the train past the inner signal at danger, which was 173 yds. in advance of the signal-box. Rimmer accepted this unauthorised signal. He was at the time running slowly as he was approaching the outer home signal at danger, but turning on the full current he rapidly accelerated the speed of the train and was running from 40 to 50 miles an hour before he saw, when too late, that the facing points lay for the siding and not for the main line. From the points to the standing train was a distance of 88 yds., and, judging by the terrible result of the collision, speed could not have been appreciably diminished before it occurred. I doubt very much if Rimmer cut off the current as he states, as the handle of the controller was found in the full "on" position. It is locked by a catch in each of its six or seven positions, and could not be turned a full circle by a succession of blows without being broken. What Rimmer probably did was to put on the vacuum brake as hard as possible when he found his train had entered the middle siding, and this has the effect of causing the circuit breakers to come out, and the sharp cracks caused by this were heard by Brereton, the motorman of the train standing in the down siding. I consider that the collision was due solely to inadvertence in leaving the siding points in the wrong position and then to disregard of rules on the part of Boote, and to disregard of rules and reckless driving on the part of Rimmer. This collision naturally attracted much attention owing to the great number of deaths resulting from it, and also owing to its occurring in a section of the railway worked by electric traction. It may be desirable, therefore, to refer to some of the many points raised in connection with the occurrence in the press and elsewhere. With regard to whether the open corridor type of car is more liable to be telescoped than the ordinary pattern with separate compartments, these open cars have very strong and heavy underframes, and the tops are light and independent of the frame, being secured to it by a few bolts. It may be pointed out that the open corridor carriage is coming into use on many railways where steam locomotives are used, and judging by the damage to the cars forming the express train behind the first motor car, which was very slight indeed, there would appear to be no extra danger with this type of car. It must be remembered that this collision was a very violent one, the express running at a high speed into a train weighing 170 tons standing with the brakes hard on. The rear end of the first car of the standing train jumped up and so the heavy underframe of the leading car of the express slid along under that of the first car of the standing train, and the top woodwork was all torn away and the two cars completely telescoped one inside the other. The standing train was driven back a distance of 50 yds. with the wheels not revolving but skidding, so that some telescoping was certain to occur whatever type of vehicle was in use.

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* These facing points being at the full limit of 200 yds. from the signal box would require a very smart movement of the lever working them to get them truly home, and so to make the electrical connection for the detector to work, owing to the friction of the long length of rodding on the rollers of the supports.

With regard to the danger from fire, it may be pointed out that on this occasion as soon as the collision occurred a short circuit was set up between the live rail and running rail, probably through a bar falling across them, and so a very large arc was formed at once, and this blew the section circuit breakers at the Formby sub-station but not those at the Seaforth sub-station, which were much further away from Hall Road, but the sub-station attendant at Seaforth records a heavy overload at the moment of the collision. This arcing caused by the short circuit soon ceased, either from the bar being fused through or something being moved, and then the current fed to the third rail from Seaforth was normal, showing that no short circuit existed. When the circuit breakers at Formby sub-station blew, the switchman on duty there telephoned to Seaforth sub-station and also to Formby signal-box to know if anything was wrong, and being informed all was well there, he, thinking the circuit breakers had blown through overload, restored them and found there was a load of 600 amperes (less than the normal load), and this shows that there was no longer a short circuit and therefore no arcing taking place. As soon as he had restored the circuit breakers the Hall Road stationmaster rang him up to cut off the current, which was done at once both at Formby and Seaforth sub-stations, and the third-rail rendered dead for that section of the line. About four minutes had then elapsed since the collision had occurred. On subsequent examination it was found that there were no signs of fire on any of the cars, except a slight charring of the woodwork underneath the first car of the standing train, and signs of short circuiting between the broken conductors and the ironwork under the car, which caused a certain amount of smoke, but there was no actual fire in any of the carriages, and no one in them could have received any electric shock. It may be mentioned that iron bars are supplied to stationmasters, and are also carried on the trains for setting up a short circuit and thereby blowing out the circuit breakers at the sub-stations in case of emergency. On the occasion in question the stationmaster should have telephoned at once to have the current cut off, as he saw the large flame of the arc, instead of first going to the scene of the collision. So far as can be gathered from the results of the first bad collision on a railway worked by electric traction in this country, there would appear to be no extra danger of fire occurring among derailed coaches than on a railway worked by steam. On electric *express* trains there is one guard with instructions as soon as the train starts to walk through the train from end to end, count the passengers, and then stand behind the motorman for the remainder of the journey. On electric stopping trains there are two guards, one of whom is always standing behind the motorman when the train is running. Looking at the facts connected with the collision, the two most striking results are: first, the absence of any fire among the derailed coaches, the danger from fire being one regarded as especially liable to occur on railways using electric traction; and, secondly, the very small amount of damage done to the cars, with the exception of the leading one of each train, due no doubt to the very heavy and stiff underframes. Probably the collision would not have been so severe if steam locomotives had been in use, as under the same conditions the acceleration of the express would not have been so rapid; that on the electric trains is stated to be such that a speed of 30 miles an hour can be obtained from rest in a period of 30 seconds, but this, and the quick stopping due to the very powerful brakes in use, form the great advantages of electric traction for a fast and frequent passenger service of trains, and no danger need result therefrom if the ordinary rules for working trains are adhered to.

## CORRESPONDENCE.

### TRAIN-WEIGHT AND ACCELERATION UNITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of September 1st, 1905, on p. 786, in the review of Messrs. Ashe and Keiley's book on "Electric Railways," the following words attracted my attention: "The American 'short' ton of 2,000 lb. is used in all weight measurements as well as the curious 'unit' of acceleration, miles per hour per second, which may be an American unit, although we should doubt it."

This paragraph prompts me to offer a few lines of explanation and comment, which may, possibly, serve to make some of your readers, even in England, change opinion, or, at least, suspend judgment, on the question whether these particular American "units" are entitled to the palm, as freaks or curiosities, in competition with the corresponding English units.

The writer of that book review is, apparently, unconscious, as are many Englishmen, of the fact that the English method of expressing weight is, indeed, a great curiosity, and, incidentally, at first, a source of perplexity to the "foreigner." The first experience with curious units in England is had when one finds his weight, as given by the penny-in-the-slot automatic weigher at the railway station, to be quite unintelligible, until one inquires of some "native" and ascertains that the blooming thing is calibrated in units called "stones," each of which is half a "quarter," and represents 14 lb.; this being the "standard" English unit for weighing cattle and persons. If his weight is still, say, 166 lb., as it was when he left home, he finds the index pointing to 11 stones 12; and on multiplying 11 by 14, and adding 12 he gets the whole, or 166 lb. He wonders, of course, why it is not just as well to express the whole of the weight in pounds, as is done in America, instead of partly in "stones" and the rest in pounds. But he shortly meets with other curious units or ways of using them, and he concludes that in some way there seems to be a sort of national preference for, and pride in, the complicated, involved, roundabout system of notation in England.

As for the American ton, it may need an explanation, but it requires no apology for its lack of consistency, as does the English ton. The American ton was, as is well known, "patterned" after the English ton, and, like it, consists of "twenty hundredweights." The "curiosity" in this case, is the fact that our "hundredweight" does weigh 100 lb., as its name indicates, whereas yours weighs 112 lb.! We consider your hundredweight a misnomer; we think it should have been termed a "hundred-and-twelve weight"! We not only find our American or "short" ton of 2,000 lb. more consistent with the definition of a ton (*i.e.*, as equal to 20 hundredweights), but, practically, we find it simpler to multiply by 100 than by 112, or to divide by 2,000 than 2,240. The latter advantage is, obviously, more appreciated in America than in England, where the system used for expressing monetary values has developed a fondness, habit or custom (I do not know exactly which) for other units involving more or less complicated multiplications or divisions. Thus (doubtless by analogy with pounds, shillings, pence and farthings) the weight of an English railway train has to be expressed in tons, hundredweights and quarters (with "stones" and "pounds" when great refinement and accuracy are desired). The following is a quotation from J. A. F. Aspinall's classical Paper on "Train Resistance" (Inst. C.E. *Proceedings*; Vol. CXLVII.): "Vehicles Nos. 1-5, with dynamometer car, formed the five-coach train; total length over bodies 284 ft. 10 in., weight 115 tons 4 cwt. 1 qr." Now, to get a real concrete idea of the whole of this weight, even when accustomed to the English multiphase unit system, it is necessary to bear in mind and to make certain conversions, thus: Since there are 20 cwt. per ton, then 4 cwt. $= \frac{4}{20} = 0{\cdot}20$ ton; the 1 qr. means 28 lb. $= \frac{1}{4}$ cwt. $= \frac{1}{4} \times \frac{1}{20} = \frac{1}{80}$ ton $= 0{\cdot}0125$ ton, and, then, finally, by summing up, we get $115 + 0{\cdot}20 + 0{\cdot}0125 = 115{\cdot}2125$ tons. The American engineer, not appreciating the beauties and the intellectual training or gymnastic qualities of this mental arithmetic, would have given this weight directly as 115·213 English tons, or, simply as 129·04 tons (American tons then being understood). If the total weight was originally obtained in pounds, as is most likely to be the case, the English system involves division, first by 2,240, then by 112, and then by 28; the American system (using the "short" ton unit) involves merely the relatively simple division by 2, and then pointing off three decimals.

Passing now from units of train weight to units of train acceleration, the writer is not in the least ashamed, but is rather proud to acknowledge that the mile-per-hour-per-second is the American unit of train acceleration; and although he was not the original "perpetrator" of this so-called "curious" unit, he pleads guilty to being an active "propagator" or "promulgator" of it, by using it and encouraging the students who attend his lectures to use it. The writer is not surprised, however, to learn that this unit is regarded as "curious" in England. It is much more simple, logical, consistent, direct and natural than the unit, which, in England, has been transplanted from the physical laboratory (namely, the foot-per-second-per-second); and, consequently, it may not be quite the proper thing. It is possibly "too easy" to use, and does not harmonise with systems wherein conversion factors appear to be necessary either to keep up the fashion or to keep the memory under training.

Nobody will deny, even in England, that the mile-per-hour is the recognised practical unit of railway-train speed or of railway-train velocity, and that it is the unit employed generally in all English-speaking countries. It is, as we know, derived from, and is directly related to, the mile, which is the general unit of railway distance, and the hour, which is the general unit of railway time. When referring to a mean value, railway men speak of a train-speed of so many miles per hour; when considering an instantaneous value, they speak of a train velocity of so many miles per hour. All railway engineers understand this unit, and many of them, as the result of more or less experience with it, can estimate and give the speed of a train in miles per hour quite accurately. The great majority of them do not know the unit of velocity of the physicist (the foot per second); and it has no meaning at all to them until it has been translated into miles-per-hour. Now, train-acceleration is the time-rate of change of train-velocity. If we take V to represent train-velocity in miles-per-hour (its standard practical unit), and if we take A to represent acceleration, $t$ being time in seconds, then the rate of change per second in the train-velocity is expressed naturally and directly by the following simple equation:—

$$\frac{dV}{dt}=A \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (A)$$

What does the symbol A represent here?

Miles-per-hour-per-second! It is the quotient of a quantity representing variation of velocity in miles-per-hour by a quantity representing a lapse of time in seconds. An acceleration at the rate of one mile-per-hour-per-second is simply an acceleration which occasions or results in a change of velocity equal to one mile per hour in the time interval of one second. This "curious" unit is readily understood, as the writer has found, by anybody who knows what is a mile-per-hour of velocity.

When we wish to ascertain the result of the action of a certain accelerating force during a certain time (usually a certain number of seconds), then, using the same notation, we write,

$$\int_{t_0}^{t_1} dV = A\int_{t_0}^{t_1} dt = A(t_1 - t_0) = At,$$

where $t=(t_1-t_0)$.

This equation enables us to obtain directly just what we are interested in knowing—namely, the effect produced on the miles-per-hour by the accelerating force A. If, for instance, we had $A=1{\cdot}85$ miles-per-hour-per-second, then, at the end of, say, 20 seconds, we would have a velocity equal to

$$At = 1{\cdot}85 \times 20 = 37 \text{ miles per hour.}$$

Again, if we had to attain a velocity of 25 miles-per-hour, in 15 seconds, we would need an acceleration equal

$$\frac{25}{15}=1{\cdot}67 \text{ miles-per-hour-per-second.}$$

There is no conversion factor involved or required in these computations, for the simple reason that the foot-per-second has not been unnecessarily brought in as a velocity unit.

The English method of expressing and dealing with train-acceleration involves, to begin with, the translation or conversion of "miles-per-hour" into "feet-per-second," by means of the conversion-factor

$$\frac{5{,}280}{3{,}600}=1{\cdot}467,$$

so that equation (A) takes the form

$$1{\cdot}467\frac{dV}{dt}=1{\cdot}467\ A=a. \quad . \quad . \quad . \quad (AA)$$

The resulting value $a$ is one devoid of physical concrete meaning to the great majority of practical railway men, just because it expresses the rate of change in velocity in a language which is "foreign" to them, feet-per-second, instead of miles-per-hour, which is perfectly familiar to them, as already stated. In order to find how long a time ($t$) will be required to attain or lose a certain train-velocity (which, as we know, is always expressed in miles-per-hour), the English system requires the preliminary conversion of the miles-per-hour into feet-per-second. Again, the conversion-factor! Again, the mental arithmetic, or the slide-rule, or the pencil and paper, to make the thing intelligible or palpable, when one is not a physicist or has not had special training in estimating velocity in terms of feet-per-second.

These remarks should suffice to show that, from the standpoint of a railway engineer, our American unit of train-acceleration, the mile-per-hour per second, is not, after all, as "curious" and at the same time, that it is not quite as absurd, as your English unit, the foot-per-second-per-second. It is both consistent and practical. The only possible excuse for the use of the English unit is the precedent of its adoption and use by physicists. If this argument had any force, then the railway engineer should also renounce several other "practical" units, which he has used, and he should study and adopt the standard units of the physical laboratory; and then freight would have to be measured in pounds instead of tons; distances travelled in feet, instead of miles; earthwork in cubic inches, instead of cubic yards, &c.

The fact is, that the more we look into it, the more we realise that this laboratory unit is quite out of its sphere in the field of railway engineering.

The countries using the metric system have also, in most cases, adopted a laboratory unit, which is the metre-per-second-per-second, as the unit of train-acceleration. The following quotation from the Paper on "Speed-time Curves" presented by the writer before the American Institute of Electrical Engineers, in June, 1902 (*Transactions*, Vol. XIX., p. 1,129), is of interest in this connection:—

"The usual practice, in all countries where the metric system is in use, is to measure train speed or car speed—*i.e.*, 'amount of velocity'—in 'kilometres per hour,' a term of measure analogous to our term 'miles per hour.' The logical terms for unit of measure for acceleration—*i.e.*, rate of velocity—or for the quantity termed the 'acceleration coefficient' in the Paper, would be 'kilometres per hour' per second, which would be analogous to our term 'miles per hour' per second. For some reason, however, this unit does not seem to be much used, if at all. The unit of acceleration generally used by European engineers is the 'metre-per-second-per-second.' It certainly would be more logical and less confusing to express both amount and rate of velocity in like terms, using either kilometres per hour only, or metres per second only, for the amount, and the same unit per second for the rate of velocity (acceleration coefficient)."

The only change which the writer would make to-day in the preceding statements is in reference to the principal "reason" for this difference in train-acceleration units. The writer believes this reason to be related to the fact that in America the individuals who have done the most to develop or to give publicity to our knowledge of the theory of train movement, are engineers rather than physicists, while the conditions are apparently more nearly reversed in England and on the Continent.—Yours, &c., C. O. MAILLOUX.

New York, Oct. 3.

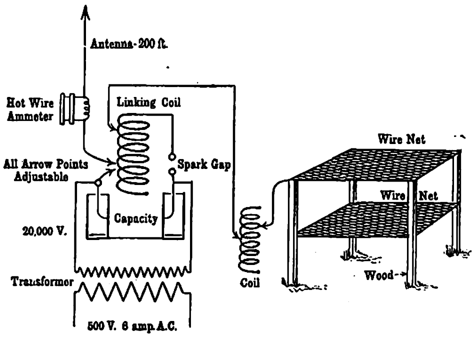
[No criticism of the American short ton was either expressed or intended in our review of Messrs. Ashe and Keiley's book. Its use was noted as a warning to casual readers. Our feeling about the weights and measures used in the United States is one of surprise that so much of the complicated English system has been retained. The unit question is quite a different matter. For railway purposes, "miles per hour per second" may have all the conveniences claimed by Mr. Mailloux, but the quantity is a practical or commercial measure, and not a unit. The term unit should be confined to the base or fundamental quantities which arise from the first principles adopted in any particular system of measurement. To call "miles per hour per second" a "unit of acceleration" is as much a misuse of language as to call "pounds per ton" (of tractive effort) a "unit of force." They are convenient measures—nothing more.—THE REVIEWER.]

## WIRELESS TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to *The Electrician* of September 15th, and the article therein, by Mr. C. C. F. Monckton, on the earthing of wireless telegraph aerials, I would say that I have recently had some experience in this direction, which may be of interest. In August, 1904, I erected two stations in Alaska at latitude 64. One of these was at St. Michael and the other at Safety Harbour. It was found necessary to build the station at St. Michael upon a glacial formation, with a slight covering of tundra. For 10 months in the year this tundra itself is completely frozen. A substitute for the electrical ground was, therefore, necessary for both the sending and the receiving circuits. The accompanying diagram shows the method used.

These stations, 107 miles apart, have been in continuous service since August 4, 1904, without a single interruption from any cause. A total of about 1,000,000 words has been transmitted, many of which were in cipher. There have been no errors checked against either station during this time. The temperature has varied between 80°F. and − 51°F. No trouble has been experienced in cutting out static or atmospheric disturbances, although the electric storms in that region are frequent and severe. Neither the aurora borealis nor the currents caused by grinding ice have interfered with the transmission of messages.



Arrangement of Ground Capacity in Wireless Telegraph Station at St. Michael, Alaska (lat. 64°). (Distance 107 miles.)

Designed and erected by Captain L. D. Wildman, U.S. Army (August 6, 1904), under the direction of Brigadier-General A. W. Greely, Chief Signal Officer U.S.A.

The sending power is derived from a 3 kw. 500 volt 60 cycle single-phase alternating-current generator, which is transformed to 20,000 volts. The closed condenser circuit is connected with the open aerial circuit, through my linking coil, patented in the United States. Complete resonance between the two circuits is obtained by altering the inductance on this common coil, which is indicated upon a hot-wire ammeter, placed in series with the antenna. The antenna is 200 ft. high, having but two wires, and is made from insulated cable core. It is probable that no larger number of wires could be suspended on account of the great wind velocity experienced at times and the great weight of accumulated ice.—Yours, &c.,

LEONARD D. WILDMAN,
Captain Signal Corps, U.S.A., Chief Signal Officer D. of Cal.
San Francisco, Cal., Sept. 30.

## LEGAL INTELLIGENCE.

### Hammersmith Borough Council v. Mulholland.

At Brompton (London) County Court on Friday last, before Sir W. Selfe, plaintiffs sought to recover £52. 17s. 3d. for electricity supplied to defendant as proprietor of the King's Theatre.

Plaintiffs' counsel said the amount had been reduced by mutual agreement from £80. 10s. 6d. to the sum claimed. The reduction had been made necessary by the fact that the first amount was arrived at from the reading of a faulty meter.

Mr. MUNROE, for the defence, said Mr. Mulholland was counterclaiming for £152 odd in respect of his loss of receipts by reason of plaintiffs' failure to provide a continuous supply of electric current in respect of extra limelight which had to be provided, and of additional work which had to be done on account of plaintiffs' failure to instal their motor generator at the time promised.

Mr. G. BELL, borough electrical engineer, said that the Council agreed to supply electric current to Mr. Mulholland when the theatre was in course of erection. The Council only supplied alternating current, but they agreed to have a motor generator installed, whereby alternating current could be converted into continuous current. Defendant had continued to use the Council's electric current ever since, but he had not paid the account in which the mistake had been made.

On the counterclaim Mr. HILL (for plaintiffs) submitted that there was no contract to supply continuous current before Dec. 1, 1903, and that, therefore, there had been no breach, and defendant had suffered no loss at the Council's hands; and, secondly, that the case came under the Public Authorities' Protection Act, and, in consequence, any redress that defendant had should have been sought in the police court directly the Council had failed to carry out their public duty. Mr. Hill further submitted that the Court had no jurisdiction to deal with a counterclaim of over £50, considering the date of the act he had quoted.

The JUDGE suggested that since a point had been raised concerning his jurisdiction, the parties might possibly come to some arrangement. A consultation was held, and counsel announced that an agreement had been come to. The claim and counterclaim would be withdrawn, and the parties would pay their own costs.

### Roche & Co. v. Electromotor & Dynamo Co.

At the Lord Mayor's Court (City of London) before the Recorder (Sir F. Fulton, K.C.) last week, plaintiffs sued defendants for £23. 1s. 6d. for electrical work done. Mr. Roche said that in March he was asked to give an estimate for re-winding six field coils for an electric motor. He gave an approximate price, and the work was given to them. Upon stripping the motor the price was altered. No particulars were given, but the work was done with wire of an English standard of the nearest gauge to that which had been used on the machine, which was of American make. Some three months after the account was sent in and payment pressed for, and then for the first time a complaint was made that the coils had not been properly re-wound.

For the defence, Mr. E. B. HAERTEL, sole member of defendant firm, said the coils were now as bad as before plaintiffs were given the work of re-winding. Another motor had to be placed in the customer's premises, and they counterclaimed for expenses to which they had in consequence been put.

Judgment for plaintiffs on both claim and counterclaim.

### Moser v. Scott.

At Westminster (London) County Court, on Monday, plaintiff claimed damages for trespass against defendant, who is a builder and electric wiring contractor. It appeared that the tenant of the first floor of a house in Maddox-street, W., ordered certain electrical work to be done and stated that the landlord had given permission to use any of the existing fittings. The wiring and fitting work was completed and the tenant had a separate meter, necessitating a temporary disconnection of supply, and it was this that formed the alleged trespass.

His HONOUR held that the tenant who gave the order (if anyone) was liable, and non-suited plaintiff, with costs.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT AND FILLED.

*Birmingham* Corporation require a resident engineer at the new Corporation electricity station (commencing salary £300, rising to £400 per annum); also a sub-station superintendent (£250, rising to £350), and a shift engineer (£120, rising to £250). Further particulars from the city electrical engineer (Mr. R. A. Chattock, M.I.E.E.), 14, Dale end, Birmingham, to whom applications by 30th inst. See also an advertisement.

Two postal and telegraph inspectors and one mechanician are required for the postal and telegraph department of Northern Nigeria. Salary £250 a year, rising by annual increments of £10 to £300, with free single quarters and second-class passage. Applications to the Crown Agents for the Colonies, Whitehall-gardens, London, S.W., until Nov. 1. See an advertisement.

Portsmouth Corporation require a switchboard attendant. Applications to the Engineer by 28th inst.

South Shields Corporation require a general manager for their electric tramways. Salary £250 per annum. Applications by 27th inst.

A professor of natural philosophy and physics is required for the Transvaal Technical Institute, Johannesburg. Applications by Nov. 1, to Mr. A. R. Golding, 202, Salisbury House, London, E.C.

Mr. H. N. Newcomb, of the South London Electric Supply Corpn., has been appointed engineer-in-charge at Wimbledon Electricity Works.

Mr. David Heron, M.A., has been appointed instructor in mathematics for the engineering day courses at Northampton Technical Institute, Clerkenwell, London, E.C.

Ilford Council have appointed Mr. S. A. Lovick, of Battersea, as canvasser for the electricity department at £2 a week and 2d. for every 8 c.p. lamp ordered.

**Alleged Frauds on Electrical Firms.**—On Friday Wm. Leslie, Alice Frances Cheesman, George Webber and Richard Thos. Rosenberg were again charged on remand at Guildhall (London) Police Court with conspiring to defraud various electrical firms of large sums of money. Further evidence having been given, the case was again adjourned.

**Argentina.**—The "Review of the River Plate" states that Messrs. Quesada Hermanos have transferred to the Cia. Tramways Electricos del Sud their concession for an electric railway from Buenos Ayres to Androgue.

**Australasia.**—An important legal decision has been recently given at Adelaide in connection with the purchase by the S. Australian Government of the tramways in Adelaide, with a view to having the whole system electrified. The Adelaide & Suburban Tramway Co. asked £235,950 for their undertaking, but the Government refused the offer, and the matter was referred to arbitration.

The arbitrators, Mr. H. Rymill (for company) and Chief Mechanical Engineer, Mr. T. Roberts (for the Government), asked the Supreme Court to settle the principle upon which the purchase-money in respect of the purchase was to be estimated. The company contended that the arbitrators were to determine the price of the whole of the lines and undertakings as a going and profit-making concern, including their statutory powers, privileges and revenue-earning rights. The Government claimed that all the company was entitled to was the value of what they had to sell.

The court upheld the contention of the company, and decided that the Government must also pay the profits which the company would have earned, until the terms of the current periods expire in 1909, 1910 and 1911.

**Barnes.**—The Council decided last week to give discounts off their charges for current for power and heating of 20 per cent. if consumption is between 6,000 and 8,000 units per month, and of 25 per cent. for 8,000 and beyond.

**Bermondsey.**—The Council on Tuesday resolved to apply to the London County Council for sanction to a loan of £5,390 for extensions of plant at the electricity works.

The borough electrical engineer (Mr. W. E. J. Heenan) recommended the provision of a 500 kw. steam dynamo and a boiler of the same evaporative capacity as the existing marine boilers, with switchboard extensions, steam pipe and exhaust connections, &c., at an estimated cost of £5,390. The Electric Lighting committee endorsed the electrical engineer's views and recommended that, subject to estimate being submitted to the Finance committee, Mr. Heenan be instructed to prepare the necessary specification and that advertisements be issued.

**Birmingham.**—The Electric Supply committee recommend the City Council to make the following reductions in the charge for current:—

For private lighting: From 6d. to 5d. per unit up to 300 units per quarter, and from 4d. to 3½d. for quantities in excess of 300 units. For power: From 3d. to 2d. for first 300 units, 2d. to 1½d. up to 3,000 units, and from 1½d. to 1¼d. for over 3,000 units. All-day lighting supply will continue to be charged at 3d. per unit for first 300 units per quarter and 2d. after, with a discount of 5 per cent. for prompt payment. The charge for current for the Corporation tramways will be 1½d. per unit net for 4,000,000 units per annum, 1¼d. for second 4,000,000, and 1d. for all current over 8,000,000 units.

The committee are considering the subject of letting out motors on hire.

**Bridgewater House Fire.**—As usual in the case of a fire whose origin it is not easy to determine, a statement has been circulated that at Bridgewater House the electric wires were the probable cause. With the concurrence of the Commercial Union Fire Office a conference was held at Bridgewater House yesterday, attended by Lord Ellesmere's secretary (Mr. Phipps), the consulting electrical engineers (Messrs. O'Gorman & Cozens-Hardy, represented by Mr. O'Gorman), and Messrs. Hancock & Rixon, to whom the electrical wiring had been entrusted. It was found that internally insulated screwed steel conduit had been used, that there was absolutely no damage to the steel conduit, that there had been no arcing and no wires melted inside the conduit, and that the roasting given to the rubber had been caused by external heat. It was therefore agreed that electricity could not have been the cause. On the other hand, a lead gas pipe which was found in a partially melted condition near the fireplace is thought to have been the probable offender.

**Bristol.**—On Tuesday the Electrical committee authorised an extension of the electric light mains.

**British Imports of Foreign Telephone Apparatus.**—According to a parliamentary return relating to the imports of foreign goods and materials during the year ended March last, the Post Office imported telephonic apparatus to the value of £220,054 and materials for telephone and telegraph work to the amount of £8,417.

**Brixham.**—Owing to the Board of Trade's refusal to sanction the laying by the Urban Electric Supply Co. of high-tension electric cables along the road to Kingswear, the company have not been able to carry out their scheme for the supply of electricity in Brixham and consequently their tender for public lighting at £500 per annum (conditionally accepted in September) has been withdrawn.

**City of London.**—The Charing Cross, West End and City Electricity Supply Co. appealed to the Board of Trade against the conditions imposed by the City authorities in March with respect to a proposed change of pressure from 100 to 200 volts in the western area of the city.

The Board of Trade have consented to the change subject to conditions (1) for the establishment of means of testing; (2) that consumers be repaid the reasonable costs incidental to the change; (3) that disputes arising under No. 2 be referred to an abitrator appointed by the Board.

An agreement has been entered into by the City Council with the London Electric Supply Corp. for the supply of current at 1½d. per unit for lighting the Foreign Cattle Market, Deptford.

Instructions were given yesterday (Thursday) for the installation of the electric light at the Eastcheap underground convenience. It was stated that electricity was better suited than gas for the illumination of such conveniences.

**Cleethorpes.**—On Wednesday the Council resolved to defer the purchase of the power station of the Grimsby Street Tramways Co. for five years. At the end of this period they undertake to purchase the station for £15,400, less £640 depreciation.

**Clacton.**—The Council have resolved to proceed with their electricity supply scheme at an estimated cost of £9,000.

**Commercial Intelligence.**—The first meeting of the reconstituted Advisory committee of the Board of Trade on Commercial Intelligence was held on Tuesday, the Marquis of Salisbury in the chair. A list of the members of the reconstituted committee was given in our issue for Sept. 1 last.

The Chairman thanked the members for consenting to place their services at the disposal of the Board of Trade. He anticipated that the reconstituted committee, enlarged as it was by an increase in the members directly representing the commercial world and by the additional representation of colonial interests, would be of great assistance to the Board, and would be able to render useful service in connection with the commercial interests of the country. Valuable results were expected from the expert assistance which the committee would be able to render to the department on questions affecting foreign customs tariffs and their bearing upon British trade, and also in developing the work already undertaken in collecting commercial intelligence and in disseminating it for the use of the manufacturing and trading classes.

After a discussion upon questions which were likely to engage the attention of the committee, the meeting adjourned.

**Croydon.**—At a public meeting on Monday resolutions were unanimously passed in favour of the Council taking over the control of the tramways at the expiration of the British Electric Traction Co.'s lease next year. The terms of the company's revised offer for a renewal of the lease were given in a recent issue.

**Dublin.**—At the meeting of the Corporation last week a letter was read from the city electrical engineer (Mr. Mark Ruddle) disclaiming responsibility for any breakdown or undue wear and tear which might occur to the machinery under his charge as a result of the use of the oils which the Council had directed him to use.

Mr. Ruddle pointed out that the tests which he had adopted were sufficient tests, and denied emphatically that the English firm (whose tender was recommended for acceptance) had in any way been favoured by him.

The Town Clerk read a letter from the Greenmount Oil Co. stating that, as regards the engine oil supplied, they were not prepared to accept the report of the analyst, as, on ascertaining unofficially the figures given by him, they re-tested the portion of the sample retained by them in their laboratory, and found a difference of 156 seconds between their tests and the analyst's tests of the oil at 70°F. That difference would bring the oil above standard. They would be pleased to have their samples submitted to Sir Charles Cameron or any other analytical chemist. With reference to the cylinder oil, they were aware that their sample was not up to specification. They obtained a sample of the oil used at the Pigeon House, which did not at all agree with the specification, and accordingly they made their sample to match the one supplied, as they understood it to be suitable.

After discussion it was agreed to insert the letter in the minutes.

The Four Courts have been wired and fitted for the electric light by Egan & Tatlow, and it is expected that current will be available for the opening of the Michaelmas sittings on 25th inst. There are about 500 lights, varying from 16 c.p. to 50 c.p.

**Dunfermline.**—The Council have refused to sanction the Scottish Electric Traction Co.'s tramways proposals, though it is probable that a modified scheme would be acceptable to members of the Council.

Permission has been given to the National Telephone Co. to reconstruct their telephone system in Dunfermline, and to place their cables underground, subject to the cables being laid along other than principal streets, and that 2s. 6d. per subscriber be allowed for wayleave.

At the meeting of the Council on Monday Provost Macbeth said there seemed to be a misunderstanding regarding the Council's negotiations with the Fife Electric Power Co.

They were not bound to come to an agreement with that or any other company. All the Council had to do was to give notice to the Fife Co., which had Parliamentary powers in the burgh, that they (the Council) were to apply for a provisional order. Meantime he (the Provost) was continuing negotiations with the company, whose directors would meet shortly and adjust final terms. Within the last few days he had received a communication from a Manchester firm, who offered to erect electricity works, pay interest on capital, depreciation and sinking fund, and supply current for public lighting at a cost which was less than that of the Fife Co.

**Edinburgh-Queensferry Tramway.**—The application of the National Electric Construction Co. for consent to the construction of the Edinburgh-Queensferry electric tramway was last week remitted back by Midlothian County Council to the Suburban committee with full powers.

**Electric Swing Bridge.**—The mayoress of Hull (Mrs. Larard) opened on Monday an electrically-operated swing bridge over the River Humber and connecting Stoneferry and Newland.

**Electric Traction in British Columbia.**—The Canadian Pacific Railroad Co. have approved an agreement between the company and the British Columbia Electric Railway Co. for the operation by electricity of the Vancouver and Lulu Island railway between Vancouver and Steveston.

**Electrical Association for Victoria (Australia).**—At a gathering of engineers and others engaged in the electrical industries held in August, to further the proposal (referred to in a recent issue of *The Electrician*) to form a Victorian Electrical Association, the Hon. W. Knox moved and Mr. T. L. Coleman (Messrs. Edmiston & O'Neill) seconded a resolution in favour of the promotion of such an association, and this was carried with acclamation. Messrs. F. W. Clements, J. O'Neill, G. Weymouth, H. Noyes, W. Nimmo, and J. A. Newton were appointed as a provisional committee, with Mr. T. L. Coleman as secretary.

**Electrical Developments in Italy.**—The Società Metallurgica Italiana, founded at Leghorn in 1887 for the manufacture of all kinds of worked copper, is perhaps the most important institution of the kind in Italy. The capital of the society has been raised from 7,600,000 to 10,000,000 lire, and it possesses two other foundries—one at Limestre and the other at Mammiano, both situated in the district of Pistora. The company employs over 1,300 workmen—800 at Leghorn and 500 in the two smaller foundries. About 15,000 tons of combustibles are consumed each year, and about 20,000 tons of copper ore are smelted. Some of the ore used is native, but much of it comes from the United Kingdom, America, Spain, &c.

The station for generating electricity is equipped with five dynamos of 1,000 amps. each at 50 volts (two Savigliano, two Siemens, one Alioth) for electrolysis. There are besides four dynamos (two Savigliano and two Bergmann) of 1,600 amps. at 500 volts for generating energy for motive power and light. In this department there is also a chemical laboratory for analysing electrolytic products, a shop for testing the strength of the materials, and a dark room furnished with a Thomson galvanometer and a Wheatstone bridge for measuring large and small electric resistances. The main shops contain all the plant necessary for working copper and its alloys, such as rolling mills, tube hammers, drawing plate benches, cutting machines, saws, milling, planing and turning machinery, wire rolling and wire rope machines, &c., the whole being driven by one motor of 500 H.P. and two of 120 H.P. each. The principal products of the Società Metallurgica are copper plates for locomotive fire boxes, brass plates, plates for Muntz metal, weldless copper and brass tubes, uncovered and tinned copper wire and phosphor-bronze, and bars and wires of brass, pinchbeck, German silver, &c. The company paid a dividend of 7½ per cent. in 1904.

**Electricity in Dockyards.**—The London & South-Western Railway Co. have just completed the construction at Southampton of what is claimed to be the largest graving dock at present existent. The dock has a total length of 875¼ ft. and is capacious enough to accommodate the largest vessel of any kind now afloat or building. The equipment of the new dock includes an electric crane (also said to be the largest in the world) capable of lifting more than 50 tons at a radius of 87 ft.

**Electricity in Gold Mining**.—The report of the directors of the El Oro (Mexico) Mining & Railway Co. states that the substitution of electric power for steam will be completed by the end of the year. It is estimated that the cost of the installation will be recouped in two years by the reduction effected in the cost of operating the company's mines and mills.

**Falkirk.**—The electrical equipment of the tramway was officially inspected on Wednesday.

**Falmouth.**—Electric lighting mains are now being laid by the Electric Supply Corp.

**Fulham (London.)**—The borough electrical engineer (Mr. Arthur J. Fuller) has drawn up and is circulating among householders in this district an illustrated pamphlet pointing out the many advantages of electricity for lighting, power, heating, cooking and other domestic purposes. The charge for current for lighting in the borough is 3½d. per unit, with discounts, and for power 1d., with a minimum charge of £1 per annum. A number of apposite illustrations of electric-light fittings, motors, heating and cooking appliances are given in the pamphlet.

After considering the report of the auditor on the electric lighting and refuse destructor accounts the Council are recommended to keep separate accounts for the electric lighting and destructor undertakings. The charge to be made for steam supplied to the electricity undertaking from the destructor is to be subsequently decided upon. A further point raised by the auditor was the cost of providing and maintaining the electric lamps and pillars for public lighting, which was treated in the accounts as a charge upon electricity revenue. The auditor held that there is no authority for this charge upon the electricity revenue, and the cost of providing the lamps should be transferred to the general fund, and the charge for the supply of current based upon this fact. The charge for arc lamps is £25, out of which all capital charges, maintenance, &c., are provided. The committee recommended that the electricity revenue be credited with £25 per arc lamp (large) per annum for street lighting, and that a deduction be made from this amount (the actual amount to be subsequently ascertained) at the end of each quarter and transferred to the general rate to cover capital charges, interest, &c. This was approved.

**Glasgow and West of Scotland Technical College.**—The report adopted at the recent annual meeting of governors is to hand. During the past year there were 5,671 students, against 5,333 in the previous year, while the class enrolments were 9,084, compared with 7,848. The first section of the handsome new building of the college will be formally opened at a later period of the present session. The total expenditure to date on the site, building and equipment has been £163,060. The building and equipment fund now stands at £209,763, of which £198,845 has been received. The report contains particulars of the changes in the staff, the honours gained by students of the college during the year, &c. The Sir John Pender Bursary (£40) and Gold Medal in electrical engineering were awarded to Mr. Geo. H. Stevenson.

**Greenock.**—On the advice of the burgh electrical engineer (Mr. Robertson) the Council have decided not to entertain the request to extend the electric lighting cables to the new cottage hospital to be erected in Port Glasgow, owing to the heavy cost (£2,000), but in the event of Port Glasgow Corporation taking a supply the subject will be re-considered.

Application is to be made to the Secretary for Scotland for further borrowing powers for the electricity department.

**Grimsby.**—The Lighting committee have decided to give a supply of electric energy to a consumer for a motor generator at the power rate.

**Hampstead (London).**—The Council have adopted a recommendation of the Lighting committee to give private consumers the option of the maximum demand system or a flat rate after December. During the half-year October–March, the charge will be at 6d. per unit for the first two hours' maximum demand per day, and 1½d. per unit after, but current consumed from April to September will be charged at the uniform rate of 1½d. per unit. On the flat rate system the charge will be 4d. per unit throughout the year.

**Hindley.**—The Council are negotiating with the Lancashire Electric Power Co. for the supply of electricity in bulk and for the transfer of the Council's provisional order.

**Hornsey (London).**—The charge for electric current for power and heating has been reduced to 2d. a unit.

**Huddersfield.**—For the half-year ended Sept. 30 the total income of the tramways department was £38,298; working expenses were £19,010; and after paying £12,257 for interest and redemption fund charges, the surplus was £7,030.

**Kalgoorlie (W. Australia).**—The Kalgoorlie Electric Power & Lighting Corp. have obtained permission to erect poles and overhead mains for lighting South Kalgoorlie.

**Keighley.**—The receipts of the municipal tramways for the past year were £4,648, and the expenses £4,008, leaving £640. After paying interest and sinking fund there was a deficit of £1,612. The number of passengers carried was 1,091,409.

**Leith.**—The formal opening of the municipal tramways has been fixed for Nov. 3.

**Light Railways.**—The Board of Trade have confirmed the Bere Alston and Calstock Light Railway (Amendment) Order and the Padstow Bedruthan and Mawgan Light Railway (Extension of Time) Order.

The Board of Trade have issued the North Devon Light Railway Order, which authorises the construction of light railways in Northam and Bideford, in extension of the Bideford, Westward Ho! and Appledore Railway.

At the Board of Trade on Wednesday Sir Herbert Jekyll heard the objections to the confirmation of the Newark and District Light Railways Order.

The local gas company asked for the insertion of a special clause protecting the company against electrolysis, but Sir Herbert held out no hope that the Board would insert such a clause. He considered sufficient protection was already given by the joint committee clause. In deference to the views of the Board's inspecting officer the promoters decided to construct a double line around two sharp curves.

**London County Council.**—At Tuesday's meeting the Finance committee reported an application from Woolwich Council for a loan of £16,275 for the cost of laying electric lighting mains over a route of 10 miles, and asking that the repayment be spread over 42 years, with three years' postponement of the commencement of repayment. The committee did not consider this postponement could be justified, as mains should produce income within a short time of their being laid. It was proposed that the loan be granted on the usual terms, and this was agreed to.

*Tramways.*—The Highways committee again brought up their recommendation for the construction of new tramways of a total length of about 8 miles at a cost of about £414,160. (Details of the proposals have already been given in *The Electrician.*)

Mr. Phillimore suggested that the Finance committee might alter the present method of dealing with the cost of renewals, and should charge less in the earlier years of the tramway than in the latter. If this were done it would do away with the hesitation to embark on new schemes which in the first year or two showed an estimated deficiency.

Lord Welby said he could hold out no hope of any such change as that suggested by Mr. Phillimore.

The Highways committee recommended that expenditure of £5,300 be sanctioned for additional high-tension feeder cables for the Elephant and Castle sub-station.—Postponed.

*Wiring of Consumers' Premises.*—The Highways committee reported that representations had been made to the Council by several metropolitan councils to revive the proposals giving borough councils which have power to supply electrical energy the further power to wire and fit up consumers' premises and to obtain loans for this purpose. The committee recommended that the Council should again seek such power in the forthcoming session.

**London United Tramways.**—At the last meeting of Ealing Council it was stated that, with regard to the alleged excessive noise made by the company's cars on the Ealing section, the managing director of the company (Sir J. Clifton Robinson) had written to the Board of Trade admitting that in Ealing the types of rail and truck had militated against smooth running.

The exceptional corrugations of the rails were due, possibly, to the fact that they did not contain sufficient carbon. He was advising the directors to discontinue the use of the type of truck at present in use and to equip the 60 Ealing, Acton and Hanwell cars with Brill trucks. With respect to the corrugation of the rails, he had equipped a motor truck with a form of travelling plane, which had (on the Middlesbrough, Stockton and Thornaby lines) proved eminently satisfactory in removing all grounds for complaint. He suggested that the inquiry intended to be held should be postponed until the end of the year, by which time he undertook to make the improvements indicated.

The Council resolved by 12 votes to 5 to inform the Board that they did not consider the promises of Sir Clifton Robinson sufficiently binding on the company to abate the nuisance, and asked the Board to insist upon a compulsory arrangement being effected.

**Nelson.**—The borough electrical engineer (Mr. W. A. Fraser) has, it is reported, tendered his resignation, which the Electricity committee recommend the Council to accept.

**North Carolina.**—The "Financial Times" gives particlars of a scheme under which the Whitney Co, with $10,000,000 capital, has been formed to control the Yadkin Land Co. and the Yadkin River Power Co. The last-mentioned company is to construct and run hydro-electric works, the initial cost of which is estimated at $2,500,000. The complete scheme includes the extension of the cotton manufacturing industry in the district, and the provision of new electric railways for the carriage of material and goods.

**Obituary.**—We regret to record the death of Mr. Alfred Morcom, chairman of Belliss & Morcom (Ltd.), which took place on Monday at his residence at Edgbaston, after a short illness.

Mr. Morcom, who was born in the Isle of Man, was only 57 years of age. He was educated at Tavistock Grammar School and at Keyham. He left Keyham in 1871 first of his year, with first-class fellowship and honours in mathematics and several other subjects. In the same year he was appointed first assistant engineer on H.M.S. "Bellerophon," and after a few years' ship experience he was appointed (in 1874) assistant to the engineer-in-chief of the navy and lecturer on marine engine design at the Royal Naval College, Greenwich. Three years afterwards he became assistant to the chief engineer at Portsmouth Dockyard, and on the death of the chief engineer was promoted to that position for a year to complete the arrangements in connection with the transport and warships for the Egyptian expedition and the bombardment of Alexandria. Then he was sent in the same capacity to the dockyard at Sheerness, where he rendered conspicuous service. It was during his official connection with the Government at Portsmouth and Sheerness that Mr. Morcom became interested in the work of Mr. G. E. Belliss, the founder of the well-known firm of engine builders in Ledsam-street, Birmingham. At that time Mr. Belliss was chiefly engaged in the construction of steam pinnaces and launches for the navy, and after remaining at Sheerness five or six years Mr. Morcom, in 1884, decided to leave the Government service and join Mr. Belliss in partnership. From that time the business of the firm of Belliss & Morcom was largely developed. In 1890 practically a new industry was commenced, consisting of the manufacture of high-speed engines for electricity generating purposes. The firm in 1893 was converted into a private company, Mr. Belliss becoming chairman and Mr. Morcom managing director. In 1904 when Mr. Belliss retired from business life, Mr. Morcom succeeded him as the head of the concern. The success of the firm has been due to a gradually built-up reputation for thoughtful and able design and perfect workmanship, and the credit of this achievement has been largely the result of the inventive energy and ability shown by Mr. Morcom in the management of the works and in the training of the staff. Mr. Morcom was a member of the Institutions of Naval Architects, Civil Engineers and Mechanical Engineers, and he was also a member of the Council of the Birmingham University. He leaves a widow and family. His eldest son, Mr. R. K. Morcom, is a member of the Institution of Civil Engineers and occupies a prominent position in the management of the firm.

**Over-bridge Tramways.**—The Bridge House Estates committee, having considered the proposals recently submitted by the Highways committee of the L.C.C. in regard to the Embankment tramway scheme, recommended the Court of Common Council yesterday (Thursday) to seek Parliamentary powers to widen Blackfriars Bridge or to erect a new bridge. The committee have been advised in the matter by Sir B. Baker. This recommendation was adopted.

**Persia.**—It is stated that the Shah has asked the French Government to select for him an engineer to manage the electric generating plant and general installation for lighting, &c., at the Palace at Teheran. The salary is to be £320 per annum, with house, travelling expenses, &c. Several candidates for the post have come forward—apparently undeterred by any fear of the consequences.

**Perth.**—The Corporation's electric tramways were officially inspected on Tuesday.

**Peru.**—Electric tramways between Lima and Callao and between Callao and La Punta, as well as in the town of Callao itself, have now been completed. The Lima horse tramways are also being converted to electric traction, and a company has recently been formed for the construction of an electric tramway between Lima and Chorrillos.

The railway from Guaqui and Lake Titicaca to the Alto of La Paz is connected with the city of La Paz by an electric railway now just completed.

**Ramsgate Tramway Inquiry.**—The adjourned Board of Trade inquiry into the tramway accident which occurred on Aug. 3, was resumed at Ramsgate last week by Col. von Donop. The proceedings at the first sitting were reported in our issue of Aug. 25.

The motorman (L. W. Lloyd) was now present, and said that he went on duty on the morning of Aug. 3 at 11:15 and took charge of the car from motorman Jones at Broadstairs Station terminus. Jones said when he handed it over everything was all right. Witness started away from the station, and had no difficutly with the car until he reached Wellington-crescent, near the top of Madeira Walk. He had had no trouble in descending the hill at Belle Vue-road from Thanet-road, and came to a standstill at the stopping-place at the intersection of the Plains of Waterloo and Wellington-crescent. He received a signal from the conductor to go on, and proceeded along Wellington-crescent. After turning the corner he had worked his car up to the fourth notch of power, there being eight notches altogether. He got about half-way between Wellington-crescent and the next stopping place and threw off all the power, and gradually worked the power brake up to the third notch. By that time the car was just commencing the descent at Madeira Walk, and after he had gone a few yards further the wheels, without any warning, started skidding. He released his power brake, as that was of no use when the wheels were skidding, and worked the sand pedal, but, although he jumped upon it with all his weight, he could not get a particle of sand out of it. By that time he was going round the corner and approaching the Board of Trade stopping place. Recognising that he was going too fast he looked to see if the trolley arm was off, and saw that it was and was swinging backwards and forwards. That gave him to understand that he had no chance whatever of reversing. He continued to work the sand pedal, as there was nothing else to do, but no sand came. The car was then just on the point of leaving the rails. He firmly believed that if the car had only gone for a few yards further on the rails he should have had it under control. He never thought the car was going to leave the rails at that point. The bottom part of the hill was always kept well sanded, but he had never seen the upper part well sanded. He remembered crossing the road, but nothing beyond. He did not know the car went over the cliff until he was told so afterwards. He merely remembered the car leaving the rails and going a little way. The statement of the engineer and manager (Mr. Humphries) that witness applied his brake too suddenly he did not agree with. He had no reason for applying his brakes. He already had three notches of his power brake on. He had been up and down that road since Easter and had never seen the upper part properly sanded. Witness had an old rule book which gave the maximum rate as 8 miles an hour in Wellington-crescent, but on this occasion the car was travelling about 4 miles an hour. The car commenced to skid some distance before the Board of Trade stopping place. Witness knew the slipper brake was applied then. He seldom used his hand brake going downhill. He had no occasion to use it, and on that occasion he was only using it to keep the slack of his chain in. From beginning to end he did not apply his hand brake. At the time he looked at the trolley arm the car was travelling at the rate of from 6 to 8 miles an hour. On the incline the car might have been going at 10 miles an hour. At the last moment the car seemed to slow down a little. As soon as the car started skidding he knew he was powerless to stop it. When he took the car over from Jones the sand bunkers were full, and going down Belle Vue-road the sand-box acted properly. He could not explain what prevented its acting properly at Madeira Walk, nor could he tell the cause of the wheels skidding. He commenced regular driving on July 29. He did not agree with the evidence of Mr. Humphries, who thought that the driver did not make sufficient allowance for the wet condition of the rails. Witness also considered the sanding arrangement on the main line cars from Ramsgate to Margate was much more efficient than on the loop line cars running from Broadstairs to Ramsgate.

Alfred Bullock, motorman in charge of a car ascending the hill at the time of the accident, said he saw Lloyd working the sanding pedal. Witness shouted to his conductor to put sand on the line as soon as he saw the car running away.

Ralph Allsworth, a passenger in Lloyd's car, said he jumped off just as the car went over the cliff. He did not think the speed of the car slackened at all up to the time of derailment.

Conductor Woodward said he examined the line after the car had disappeared over the cliff and found it clear of sand. He had never seen anyone sand the line above a certain distance on the incline, but at the bottom he had noticed the line sanded.

The Town Clerk inquired as to the scope of the Inspector's report to the Board, and was informed that nothing beyond the actual facts relating to the accident which formed the ground of the present inquiry would be included. The inquiry then terminated.

**Shoreditch (London).**—The Council decided on Tuesday to obtain two further turbo-generators at an estimated cost of £18,000.

**Smoke Abatement.**—The question of finding some practical means for abating the nuisance caused by smoke will be discussed by members of the Royal Sanitary Institute and the Coal Smoke Abatement Society at a conference to be held in December at the Royal Horticultural Society's Hall, St. Vincent-square, Westminster, under the presidency of Sir Oliver Lodge. The sections of the conference to consider Domestic Smoke Abatement, Factory and Trade Smoke Abatement, and the Administration, Legislation and Necessary Reforms, will be presided over by Sir George Livesay, Sir William Preece and Sir William Richmond. Municipal authorities throughout the kingdom have been invited to send delegates. In connection with the conference, the Royal Sanitary Institute are arranging an exhibition of smoke abatement appliances, and the classification of exhibits includes heating and cooking appliances by gas or electricity; grates, stoves, mechanical stokers and fuel economisers, and other appliances for the prevention of smoke. Further particulars and forms of application for space from the offices of the Institute, 72, Margaret-street, London, W.

**Spain.**—A concession has been granted to the Sociedad los Tranvias de Zazagoza for the construction and working of an electric tramway in the City of Zaragoza.

**Switzerland.**—The Alioth Electric Co., of Basle, and Vallière & Simon, of Lausanne, have been granted a concession for the construction and working of an electric railway from Sépey to Ormont–Dessus.

**Telegrams to Japan.**—The Great Northern Telegraph Co. notify that they have been advised by the Japanese Telegraph Administration that all restrictions imposed upon telegrams exchanged with Japan, Korea and Formosa, as well as the military censorship at Nagasaki, have been withdrawn.

**The New Post Office Buildings.**—In the course of his speech when laying the foundation stone of the new General Post Office buildings, His Majesty the King said—

"I have observed with great interest the establishment and rapid growth of the telephone. I feel confident that this wonderful invention, which has been already proved so useful for economising time and facilitating commercial intercourse, will be found capable in the future of more greatly extended use and development.

**Todmorden.**—The opening of the Corporation's electricity works and refuse destructor took place last week.

Mr. Handley, chairman of the Electricity committee, started the engines and the mayoress (Miss Jackson) turned on the current. The electricity works, designed by Mr. H. Waring, have cost £18,000. Bruce Peebles & Co. supplied the two steam dynamos (of 150 and 75 kw. respectively) and W. T. Glover & Co. the cables. The charge to private consumers has been fixed at 5d. per unit, and 1s. per quarter meter rentals. The refuse destructor and the destructor buildings cost between £5,000 and £6,000.

**Tramway Transfer Tickets.**—At Sunderland Police Court on Tuesday a person named Joyce was charged with having travelled on a tramcar without having paid his fare and with intent to avoid payment.

Mr. A. R. Dayson, tramways manager, said defendant travelled on a car and when asked for his fare he tendered a transfer ticket that had been issued to another man. This practice was becoming common and he was endeavouring to stop it. Defendant said he did not know he was doing wrong in accepting and using the ticket.

A fine of 5s. and costs was imposed.

**Wireless Telegraphy.**—The Gesellschaft für Drahtlose Telegraphie (m.b.H), Berlin, have recently received the following orders:

(1) The Deutsche Kaiserliche Marine has given an order for the erection of two coast stations on the Baltic Sea coast. (2) Two complete overland stations have been ordered for Rost and Soervagen, Norway. (3) The experiments of transportable stations employing balloons and kites have been concluded in Sweden, and new trials with transportable masts will now take place. (4) The proprietors of the "Diaro Ferrolano" have installed a wireless telegraphic service between La Coruna and Ferrol (Spain), which, according to Spanish reports, continues in perfect working order. The Spanish Government, we are informed, intend to work both stations on their own account, and the stations are now operated by Government officials. The construction of the stations for the fortresses Almeria and Melilla will soon be commenced. (5) The Dutch navy has ordered three stations of 500 km. range. The War Department of Holland is at present engaged in experimenting with the company's transportable stations, and one of their engineers is initiating Dutch officers in the operation of these stations. Two of the company's staff are also engaged in erecting two experimental stations in Batavia (Dutch E. Indes). One station will be built in Batavia, the second either on the island of Noerdwachter or in Cheribon (distance from Batavia about 190 km. across country). Cheribon is a port on the north coast of Java where men-of-war as well as the steamers of the Koninklyke Pakketvaart Maatschappy call. The last-named company has ordered an installation of wireless telegraphy for the ss. "De Carpentier" as an experiment. (6) The Danish navy is in communication with the company relative to the building of installations on warships and pilot boats. A cruiser looking after the interest of the fishing trade in Iceland will next month be installed with the company's apparatus. (7) In Finland the authorities of the pilot and lifeboat service have instructed the company to equip the lighthouses at Marieham and Bogoker with "Telefunken" stations. (8) The Argentine navy has already installed four warships with the company's wireless telegraph apparatus—viz., the "Julio," "Patria," "Libertad" and "Independencia." On Aug. 25 an Argentine squadron, which included the above ships, paid a visit to the Brazilian Republic, on which occasion the President of Brazil sent the cruiser "Barozo," also provided with the "Telefunken" apparatus, to meet the squadron with instructions to greet the guests by wireless telegraphy.

**Electro-Harmonic Society.**—The first smoking concert of the season takes place this (Friday) evening in the King's Hall, Holborn Restaurant, London, W.C., at eight o'clock, Mr. W. Worby Beaumont in the chair.

## TRADE NOTES AND NOTICES.

### TENDERS INVITED.

*Barrow-in-Furness* Corporation invite tenders for supply and erection of one 500 kw. combined steam engine and generator, one balancer booster, switchboard panels and connections for generator and booster, one water-tube boiler with superheater, one mechanical stoker, steam and exhaust pipes, valves, &c., one economiser, ironwork, one 15 ton travelling crane and one cooling tower. Specifications after 23rd inst. from the borough electrical engineer (Mr. H. R. Burnett), Electricity Works, Barrow-in-Furness, and specifications and drawings may also be seen at the electricity works. Tenders (addressed to Chairman of Electricity committee) to the town clerk (Mr. C. F. Preston), Town Hall, Barrow-in-Furness, by noon Nov. 13. See also an advertisement.

*Clacton-on-Sea* Urban District Council invite tenders for the supply and erection of gas engines and dynamos, switchboard, underground mains, accumulators, meters, crane and buildings. Specification, &c., from the consulting engineer (Mr. W. H. Trentham), 39, Victoria-street, Westminster, S.W., after 23rd inst. Tenders, addressed to the clerk of the Council (Mr. G. T. Lewis), before 3 p.m. of Nov. 6. See also an advertisement.

*Edinburgh* Corporation invite tenders for arc lamps and arc lamp posts. Specifications, &c., after 16th inst. from the chief electrical engineer (Mr. F. A. Newington), Dewar-place, Edinburgh. Tenders to the town clerk (Mr. Thos. Hunter, W.S.), City-chambers, Edinburgh, by Oct. 23.

*Tynemouth* Corporation invite tenders for supply and erection at their electricity works, Tanner's Bank, North Shields, of one 165 kw. traction dynamo. Specifications, &c., from the borough electrical engineer (Mr. C. Turnbull), and tenders to the town clerk (Mr. E. B. Sharpley) by first post Nov. 2.

*London County Council* invite tenders for electric lighting of bandstand in Villiers-street section of Victoria Embankment Gardens. Tenders to the clerk (Mr. G. L. Gomme), County Hall, by 10 a.m. Oct 25.

*London County Council* require tenders by 10 a.m. 30th inst. for 12 months' supply of electric fittings, cables, &c., engineers' goods, oils, &c.

*Metropolitan Asylums Board* want tenders by 10 a.m. Oct. 31 for an electric motor, engineers' tools, &c., for Western Fever Hospital, Fulham.

*Dundee* Harbour trustees require tenders by 25th inst. for supply and erection of three arc lamps and three incandescent cluster lights, with wiring, &c., at Craig Pier.

The Zuid-Hollandsche Electrische Spoorweg Maatchappij (South Holland Electric Railway Co.), *Amsterdam*, invite tenders for making of permanent way, engineering and additional works (in connection with contract No. 14), laying of rails and switches, and supply and use of gravel ballast, as well as some works in connection with the railway (in accordance with contract No. 17). The estimated cost of the work is fl.936,000 (£78,000). Specifications from Messrs. Bevensen & Van Hoorn, Heenengracht, 38, The Hague, at cost of fl.12.20 (£1. 0s. 4d.). Tenders by 1:15 p.m. Nov. 2.

Tenders for a concession for the construction and working of an electric tramway in the east of *Madrid* may be sent to the Director of Public Works, Madrid, by Dec. 13. Particulars are given in the "Madrid Gazette" for Oct. 10, where it is intimated that local representation on tenderers' behalf is essential, as is also a deposit of about £60 to qualify tenders.

### TENDERS RECEIVED AND ACCEPTED.

The Metropolitan Asylums Board have received the following tenders for electric lighting installation, fire alarms, telephones, &c., at the South-Eastern Hospital and ambulance station :—

| | | | | | |
|---|---|---|---|---|---|
| Bromley, Batstone & Kirk (*accepted*) | £4,894 | 0 | Alliance Electrical Co. | £6,026 | 12 |
| Belshaw & Co. | 6,894 | 0 | Wenham & Waters | 5,974 | 0 |
| Drake & Gorham | 6,590 | 0 | Foote & Milne | 5,535 | 0 |
| F. A. Glover & Co. | 6,500 | 0 | Buchanan & Curwen | 5,495 | 0 |

Engineer-in-chief's estimate £5,100.

The Great Western & Metropolitan Railway Co.'s have awarded contracts to the Metropolitan Amalgamated Railway Carriage & Wagon Co. for the new rolling stock required for the Hammersmith & City Railway, which is now being converted to electric traction.

The electric motors and equipment will be supplied by the British Thomson-Houston Co. There will be 20 new trains, 10 for the G.W.R. and 10 for the Metropolitan Co., each train consisting of six coaches.

The following tenders have also been accepted by the Works committee of the Board:—

Pritchetts & Gold, repairs and renewals to electric storage battery at Grove Hospital (at £25), also replacing negative plates in storage battery at Grove Hospital (at £42); Julius Sax & Co., rearranging internal telephones at head office (at £42. 15s.); and for rectification of electric light and bell installations at Western ambulance station (at £19. 10s.).

City of London Corporation have accepted the tender of Lund Bros. & Co., at £4,190. 8s., for an electric lighting installation at the Foreign Cattle Market, Deptford; and that of the British Thomson-Houston Co. for 1,000 incandescent electric lamps at £40.

Stoke Newington (London) Council have placed orders with Bruce Peebles & Co., Ferranti Limited, and the Electrical Power Sotrage Co. for sub station plant, switchboards, and storage battery respectively

Islington (London) Council have accepted the following tenders for bituminous nutty slack coal: Phillips & Co., 10,000 tons, 2s. 6d. at pit's mouth, 9s. 3d. delivered; Charrington, Sells, Dale & Co., 3,000 tons, 2s. 5d. at pit's mouth, 9s. 1d. delivered.

Wolverhampton Electricity committee have accepted the tender of the Anglo Russian Oil Co. for supply of lubricating oil to the electricity works for two years.

Hammersmith (London) Council have accepted (out of 13) the tender of J. & A. Law at £57. 10s. for extension of handrail round switchboard.

The tender of Barlow & Young for wiring and for the supply of fittings at Wapping Fire Station for £130 has been accepted by London County Council.

Shoreditch (London) Council have accepted the tender of Willans & Robinson for two Willans-Parsons turbines with Siemens generators, with condensers, &c., at £18,475.

Chiswick District Council have accepted the tender of Bromley, Batstone & Kirk for wiring the refuse destructor and other buildings, &c., at £120. 2s. 6d.

Ashton-under-Lyne Council have accepted the following tenders: Dick, Kerr & Co., steam dynamo (Belliss engine); Babcock & Wilcox, water-tube boiler.

Taunton Council have accepted the tender of Allin & Son for the supply of a tank for the electricity works at £72. 5s.

Dewsbury Joint Hospital Board have accepted the tender of G. J. Hood for electric wall plugs and hand lamps.

Bexley Council have accepted the tender of the British Westinghouse Co. for a 50 kw. transformer at £65. 10s.

Exeter Council have accepted the tender of Hubber & Son for wiring the higher and lower markets at £130. 10s.

The Westinghouse Co. (U.S.A.) have recently secured an important contract from the New York, Newhaven & Hartford Railway Co. for the supply of 25 single-phase electric locomotives for service on the company's main line, which is being converted to electric traction.

The single-phase overhead system has been adopted, but the locomotives (by the Baldwin Locomotive Co.) will also use direct current where they traverse the line of the New York Central, which serves the suburbs of New York. Each locomotive will be equipped with four 400 H.P. Westinghouse single-phase motors of the straight series gearless type, and the unit switch system of multiple control will be used. The weight of the locomotives is approximately 78 tons, and with a 200-ton train making stops every 2·2 miles and attaining a maximum speed of 45 miles an hour, the schedule speed will be 26 miles per hour. Express trains of 250 tons will be propelled at from 60 to 70 miles an hour by one locomotive, but heavier trains will be run by two or more locomotives coupled together and controlled from the forward cab. The motors are to be spring-supported and connected by flexible drive in such manner that all dead weight will be taken off the axles. They will be permanently connected too in series, and on direct current the pairs will be operated on the series parallel system, and on alternating current by means of voltage control. It is stated that much interest attaches to the new electric railway, which is the first to adopt electricity over the whole line.

## BUSINESS NOTICES.

Mr. A. Eckstein, who has for the past 18 years been connected with the General Electric Co., and since the formation of the public company in 1900 has held the post of managing director and head of the Manchester factories and supply house at Victoria Bridge, terminated his association with the company this week. We learn that Mr. Eckstein has not yet finally decided upon his future course, but after a lifelong association with the manufacturing branch of the electrical industry he will doubtless shortly re-enter the field of his past activity.

Mr. N. Gunz has resigned his position of secretary to the General Electric Co. (Ltd.), and has decided to commence business as manufacturers' agent at 46, Queen Victoria-street, London, E.C.

Messrs Clarke, Chapman & Co., Victoria Works, Gateshead-on-Tyne, and London, Liverpool, Glasgow, Manchester and Sunderland, have decided to open an office at 21, Mountstuart-square, Cardiff, to deal with the whole of the South Wales district. The office has been opened owing to the extension of the company's electrical business in the district, and also on account of the phenomenal success of their Woodeson water-tube boiler and Woodeson pumps on the North-East and West Coasts. Mr. George Winn, who has been at the Gateshead works for about 12 years, will take charge of the Cardiff office on and after Nov. 1.

The Glasgow office of the Union Electric Co. (Ltd.) has been transferred to 12, Waterloo-street, which is in charge of Mr. Alexander Morrison, the company's representative for Scotland. Mr. Morrison has had considerable electrical engineering experience, having served his time with Mavor & Coulson, and subsequently being in the employ of Haddow & Co. and Glasgow Corporation tramways department.

Mr. C. C. F. Monckton, M.I.E.E., consulting electrical engineer, informs us that his business address in the future will be 53, Victoria-street, Westminster, S.W. Mr. Monckton has had considerable electrical engineering experience in the East and West Indies, and is electrical engineer to the Government of Trinidad.

Percy Joseph Driscoll and Chas. Balbiani (P. J. Driscoll & Co.), electrical engineers, 33, Portland-street, London, W., have dissolved partnership.

In addition to the office recently opened at Newcastle-on-Tyne at K, Exchange-buildings, Quayside, the Eastern Telegraph Co. has opened an office at Cardiff at 33, Merchants' Exchange, Bute Docks, where telegrams are accepted for all stations on the Eastern and Associated Companies' systems, including all parts of Australia, New Zealand, China, Japan, Straits Settlements, Dutch Indies, Philippines, India, the Red Sea, Africa, the Mediterranean, Greece, Turkey, Spain, Portugal, South America, &c.

The Direct Spanish Telegraph Co. has opened a Cardiff office at 33, Merchants' Exchange, Bute Docks, which is in direct communication with the company's cable system between England and Spain, via Bilbao.

## BANKRUPTCIES, LIQUIDATIONS, &c.

At Birmingham County Court on Wednesday Wm. Bannister, Frederick-road, Stechford, was examined. Liabilities £147; deficiency £143.

Debtor said he was an electrical engineer. He attributed his failure to lack of employment and excessive interest charged by money-lenders. He admitted having made mis-statements on an application form for a loan. He alleged that his wife's name had been added to a promissory note for £35 signed by him since the note was posted. It was stated that Mrs. Bannister had made an affidavit that the signature was not hers. Examination was adjourned until Nov. 22.

In the failure of Ernst Emil Donat, mechanical engineer and agent (trading as Donat & Co.), 21, Spring-gardens, Manchester, the first meeting of creditors will take place on 30th inst., at Byrom-street, and the public examination on Nov. 27, at the Court House, Quay-street, Manchester.

Thos. Hill, electrical engineer, 24, Vicarage-road, Wolverhampton formerly of Stafford-street, Willenhall, has been adjudicated bankrupt.

A first and final dividend of 1s. 4¾d. will be payable on 26th inst. at Trinity House-lane, Hull, in the failure of John Morley, electrician, &c., 7, North-street, Hull.

Claims against Fred Shaw, electrical contractor, 258, Hessle-road, Hull, to Mr. C. H. King, Trinity House-lane, Hull, by Nov. 2.

A meeting will be held on Nov. 14 at 79, Mark-lane, London, E.C., to receive an account of the winding-up of the Crypto Works Co. (Ltd.) The Crypto Electrical Co. carry on the electrical branch of the company.

A meeting will be held on Nov. 20, at 1, Oxford-court, Cannon-street, London, E.C., to receive an account of the winding-up of the Electrical Supplies, Rubber & Ebonite Co. (Ltd.).

A meeting will be held on Nov. 14 at 79, Mark-lane, London, E.C., to receive an account of the winding up of the Electric Light Insurance & Maintenance Co., Ltd.

**Old Post Office Stores Sale.**—Tenders are invited by the Postmaster-General for the purchase of about 52 tons of gutta percha, 100 tons of copper, a quantity of other metals, indiarubber, covered wire, incandescent lamp tops, tools, &c. Forms of tender can be obtained from the Controller, Stores Department, G.P.O., 17-19, Bedford-street, London, W.C. Tenders will be received until 10 a.m. Nov. 1. See also an advertisement.

**Apparatus for Sale.**—Messrs. Price & Co., 32, Clerkenwell-road, London, E C., advertise for sale six arc lamps, and some brackets and pendants.

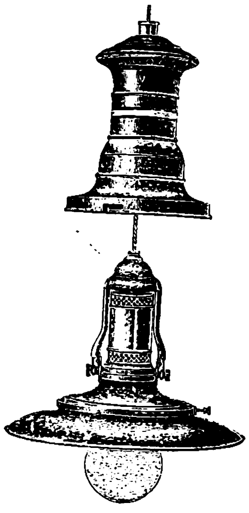
Mr. R. Archer, Horsforth, Leeds, advertises for sale Evershed testing sets.

**Premises to Let, &c.**—Messrs. Marshall & Co., Campbell Works, Stoke Newington, London, N., have to let premises suitable for electrical works or light engineering trades. See an advertisement.

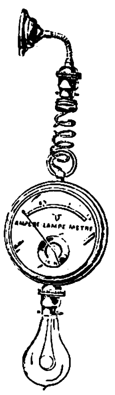
Mr. G. F. Francis, 50, Buckingham Palace-road, London, S.W, has extensive factory premises near Victoria Station to let on lease. See advertisement.

Messrs. Faraday & Rodgers, 77, Chancery-lane, London, W.C., have for sale, or for letting on lease for 99 years, some freehold land in Middlesex. Conveniently situated and suitable for immediate erection of factory. See advertisement.

**Nernst Lamps.**—A new price list (No. 188) of Nernst lamps has been issued by the Electrical Co., 121-125, Charing Cross-road, London, W.C., which includes all the types shown in previous lists, explains fully the special advantages claimed for the Nernst lamp, and compares the cost of current used with that of ordinary incandescent lamps. A considerable reduction has recently been made in the price of the "Multiple" type of Nernst lamp, which provides means for regulating the amount of light required. The makers claim that this type of Nernst lamp is capable of competing with the enclosed arc lamp. The list also illustrates and describes a number of Nernst lamp accessories, and a number of water-tight fittings for shop and street lighting have now been added. Among the latter is the accompanying illustration, which shows how Nernst lamps are fixed into lanterns by means of three screws on the lantern plate which fit into the inlets as shown. Fig. 2 shows a small ammeter fitted with B.C. adapter and B.C. holder, which is used for comparing the current consumption of Nernst lamps with that of other lamps.

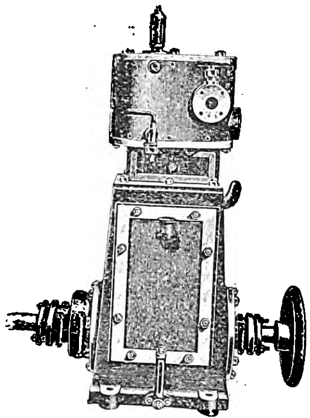


WATERTIGHT FITTING FOR NERNST LAMPS.



AMMETER FOR COMPARING CURRENT CONSUMPTION OF NERNST WITH OTHER LAMPS.

**Catalogues, &c.**—E. Reader & Sons, Phœnix Works, Nottingham and London, have ready a new steam engine list containing particulars and illustrations of engines manufactured by the company for varied classes of work, including a special type of engine designed for driving dynamos, fans and other high-speed machinery. The illustration shows a simple single-acting vertical steam engine (Class S), which is a compact form of engine adapted for constant running at high speeds. This type of machine is supplied fitted with governor and fly-wheel for dynamo driving. Other designs for this special work are also illustrated in the list, copies of which can be obtained on application to the company.



SIMPLE SINGLE-ACTING VERTICAL STEAM ENGINE.

The Chas. Cohen Tool Co., 34, Barbican, London, E.C., have prepared a catalogue of tools and materials for electricians, engineers, machinists, watch and clock makers, &c., embracing all the light mechanical trades. The list contains about 2,000 illustrations.

A new type of suction gas producer is illustrated and described in a circular list being sent out by James Watt & Co., Soho Foundry, Birmingham.

For the purpose of advertising the merits of the Robertson "Wytelite" lamps a whist marker has been issued by the General Electric Co.

W. T. Glover & Co. have prepared a new joint box list in handy pocket form. In this list a number of neat illustrations show some of the single conductor, concentric and multicore types of patent joint boxes which Messrs. Glover & Co. supply. Instructions are printed in the list for jointing Glover cables in Glover boxes, bonding, &c.

"**City Diary.**"—For the 43rd consecutive year the "City Diary" has been issued by W. H. & L. Collingridge, of the "City Press" Offices, Aldersgate-street, London, E.C. Like its predecessors, the "City Diary and Almanac for 1906" is crammed full of information useful to men having business relations with the City authorities, the City companies, the City charities, or, in fact, any of the public bodies whose business is conducted within the area administered by the Corporation of the City of London. There is, in addition, the usual three-day-to-a-page diary, interleaved blotting. At the price of 1s. this diary is both cheap and useful.

**Electric Mining Rules and Data.**—A booklet has been prepared by W. T. Glover & Co. intended to combine in a handy form some regulations and data that may be useful to those interested in the application of electricity to mining work. Most of the matter contained in the booklet is copied from previously published sources, but some specially compiled items have been added

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified (from Oct. 11 to 17 with the ports of destination :—

*Africa*—Cape Town, £298; Durban, £1,349 (including £762 telegraph material); East London, £361; Port Elizabeth, £150. *Argentina*—Buenos Ayres, £1,257 (including £60 telegraph material). *Australasia*—Adelaide, £21; Auckland, £168; Christchurch, £30; Hobart, £120; Lyttelton, £23; Melbourne, £74; Otago, £234; Perth, £596; Rockhampton, £54; Sydney, £444; Wellington, £163. *British Guiana*—Demerara, £5. *Canada*—Halifax, £26; Montreal, £141. *Ceylon*—Colombo, £421. *China*—Shanghai, £214; Tientsin, £86. *France*—Paris, £44. *Germany*—Hamburg, £38. *Gibraltar*—£67 (including £14 telegraph material). *Holland*—Amsterdam, £115; Rotterdam, £22 (telegraph material). *India*—Bombay, £153; Calcutta, £3,724; Karachi, £77; Madras, £547; Marmagoa, £140. *Italy*—Genoa, £21. *Japan*—Nagasaki, £52; Yokohama, £275. *Mauritius*, £80 (including £14 telegraph material). *Mexico*—Salina Cruz, £25. *Portugal*—Biera, £295 (including £240 telegraph material). *Russia*—Batoum, £90 (telegraph instruments); St. Petersburg, £180. *Siam*—Bangkok, £19. *Spain*—Bilbao, £188; Grenada, £148. *Straits Settlements*—Penang, £49; Singapore, £162 (including £122 telegraph material). *Sweden*—Gothenburg, £83. *United States*—Boston, £250. *West Indies*—Trinidad, £17. *Zanzibar*, £700. Total, £13,796, against £54,357 in the corresponding week last year (Oct. 12 to 18).

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.

"Radio-Activity." By Prof. E. Rutherford, F.R.S. 2nd edition. (Cambridge: The University Press.) 12s. 6d.

"Physikalische Grundlagen der Gleich ünd Wechselstromtechnik. By A. Königswerther. No. 1. (Hanover: Dr. Max Jänecke.) 3.20m.

"Traité Pratique d'Electrochimie." By Richard Lorenz. (Paris: Gauthier-Villars.) 9fr.

"A Guide to the Electrical Examinations." By Frederick H. Taylor. (London: Percival Marshall & Co.) 1s. net.

"Lecons d'Electrotechnique Générale." By Paul Janet. 2nd edition. Vol. II. (Paris: Gauthier-Villars.) 5fr.

"Die Elektrochemie der Organischen Verbindungen." By Dr. Walter Löb. (Halle-a-S.: Wilhelm Knapp.) 9m.

"Die Elektrolyse Geschmolzener Salze." Vol. I. Verbindungen und Elemente. By Richard Lorenz. No. XX. Monographien über angewandte Elektrochemie. (Halle-a-S.: Wilhelm Knapp.) 8m.

"Die Erwärmung der Elektrischen Leitungen." By Prof. Dr. J. Teichmüller. Vol. VII. "Sammlung Elektrotechnischer Vorträge." Edited by Prof. Dr. Ernst Voit. (Stuttgart: Ferdin and Enke.) 1·20m.

## COMPANIES' MEETINGS AND REPORTS.

◆

### Cuba Submarine Telegraph Co. (Ltd.)

The sixty-eighth ordinary general meeting was held on Wednesday, Mr. CHARLES W. PARISH presiding.

The SECRETARY (Mr. James Scott) read the notice convening the meeting and the auditors' report.

The CHAIRMAN said: Gentlemen, the report deals with six months' working of a very ordinary nature. The last time I had the honour of addressing you I had to explain that we had been working under considerable difficulties with two of our cables down, but I was able then to report that our new main cable from Cienfuegos to Santiago had been laid and the Manzanillo-Santiago cable had been repaired. These were completed last January and February and since then, I am glad to say, our business has been running its normal course, and we have been able to deal in a satisfactory and rapid manner with all our traffic. If we compare the statement of traffic for the first six months of 1904 and the first six months of the present year we find 1904 produced £16,526, while this year we only received £14,811. But I wish to explain to you that this difference in-favour of last year was due to the French cable having been down part of the time; practically, it was not working for three and a-half out of the six months, and this brought us extra traffic, which does not usually come our way, and we may take it that our earnings for this half-year represent the usual business of our Company. Generally speaking, the Island of Cuba has prospered, more so than the West Indies, but on the whole, I think we have done fairly well. Our total receipts are £14,811, to which we have to add interest on investments, &c., of £1,461 giving a total of £16,272. Our expenses amounted to £6,334, and the preference dividend for the half-year comes to £3,000, making together £9,334, and we are able to recommend to you a dividend on the ordinary shares at the rate of 5 per cent. per annum and add £2,938 on to the balance carried forward to the current half-year. Our reserve fund now stands at £85,181, and I hope opportunities may arise in the future to enable us to gradually build it up to £100,000 again. I cannot too often repeat that no cable company can be in a safe position which has not a good reserve fund. The appeal to the law courts of Cuba for the subsidy due us for the coast cables has not yet come up for judgment, but I hope it may do so before long and that we shall obtain a favourable result. During the three and a-half months which have already run of the present half-year, I am glad to say we are holding our own very well, and I hope that when the next account is laid before you it will prove to be of a satisfactory nature. I now move the adoption of the report and accounts.

The motion was seconded by Mr. George Keith and carried unanimously.

Resolutions approving the dividends at the rate of 10 per cent. on the preference (less tax) and 5 per cent. on the ordinary shares (tax free) were then approved; as were motions for the re-election of Mr. George Keith as a director, and Messrs. Gane, Jackson, Jefferys, Wells & Co. as auditors. A cordial vote of thanks to the chairman and his colleagues and the staff of the company terminated the proceedings.

**BRITISH COLUMBIA ELECTRIC RAILWAY CO.**—At the meeting on Monday Mr. R. M. Horne Payne said that during the past year £107,445. 16s. 8d. had been spent in extending and improving the company's property. An arrangement had been made between the company and the Canadian Pacific Railway Co. by which the company electrified and worked the Canadian Pacific line to the centre of the salmon fishery industry on Fraser River, and the arrangement was proving a great success.

**ELECTRICITY IN MINING.**—At the recent meeting of the Cassilis Gold Mining Co. (Victoria, Australia) the manager (Mr. F. J. Coote) said he had found that a hydro-electric plant would be the cheapest means of supplying energy, and that about 4,000 H.P. was available at Victoria and Cobungra rivers. He estimated that the company would save £3,000 a year in fuel, and increased convenience and economy of time in working would probably be worth a further £3,000 a year. The chairman (Mr. T. C. Plant) said the cost of the works was estimated at £11,000. They might find it advisable to reduce the number of dividends next year from twelve to six, as it would then only be necessary to borrow half the sum required for the electrical installation.

**INDIAN ELECTRIC SUPPLY & TRACTION CO. (LTD.)**—At the first ordinary meeting last week Sir W. R. Lawrence, who presided, said the company was the first to introduce electric supply and traction into the interior of India. The first shipment of cables had been made, and the contractors expected to be able to supply current in March. The canvassing in Cawnpore indicated that the number of customers would be very numerous. In addition to Cawnpore, the directors contemplated developing electric traction in other large towns in India, though they would not extend their operations until the success of their initial experiment was assured.

**MONTEVIDEO TELEPHONE CO. (LTD.)**—The directors' report for the year ended July 31 states that the net profit was £15,473. 4s. 6d. after providing for all working expenses in Montevideo and London. To this amount should be added £1,805. 15s. 1d. from last year, leaving £17,278. 19s. 7d. After transferring £5,000 to reserve, and £3,000 to reserve for renewal of plant, the directors recommend payment of full dividend at rate of 5 per cent. per annum upon the preference share capital, and of a dividend at the rate of 4 per cent. per annum upon the ordinary share capital, leaving £2,047. 3s. 7d. to be carried forward. There has been a marked increase in the number of subscribers, and a proportionate increase in the receipts for the year.

**SWANSEA IMPROVEMENTS & TRAMWAYS CO.**—The report to June 30 states that gross receipts were £16,751, increase £2,920. Expenses amounted to £12,542, increase £2,557. The net profit was £4,293, and after paying preference dividends and taking into account £1,987 brought forward, £3,986 is to be carried forward and £1,000 placed to reserve.

## NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

### NEW COMPANIES.

**CAR TRUST REALISATION CO. (LTD.)** (86,106.)—Reg. Oct. 11, capital £25,000 in 5s. shares, to acquire assets of the Car Trust Investment Co. (Ltd.), to adopt a certain agreement and to act as financiers, railway and tramway proprietors, &c. First directors: R. D. Balfour, R. H. Glyn, L. G. Mortimer, A. Shepherd and C. O. Scott Murray.

**HOPPER & CO. (LTD.)** (86,118.)—Reg. Oct. 12, capital £8,000 in £1 shares, to adopt an agreement with P. Hopper and H. Wilson, and to carry on the business of electricians, electrical and general engineers, ironmongers, builders of electric tramcars and other vehicles, manufacturers, importers and exporters of and dealers in dynamos, motors, telephones, bells, batteries, and electrical apparatus, &c. First directors, P. Hopper and H. Wilson. Reg. office, Elmsdale-road, Walthamstow.

### STATUTORY RETURNS.

**CHLORIDE ELECTRICAL STORAGE CO. (LTD.)**—In return to Sept. 6 capital is £135,250 in 62,000 preference, 33,250 ordinary and 40,000 unclassified shares of £1 each, of which all the preference and ordinary have been taken up. £1 per share has been called up on 48,750 preference and 16,250 ordinary, and £65,000 has been received. 13,250 preference and 17,000 ordinary are considered as fully paid. Mortgages and charges, £20,000.

**EASTERN & SOUTH AFRICAN TELEGRAPH CO. (LTD.)**—The return to Aug. 10 gives capital as £600,000 in 60,000 shares of £10 each, all of which have been taken up and paid for in full. Mortgages and charges, £500,000.

**ELECTRIC OIL REFINING CO. (LTD.)**—The return to Aug. 2 gives capital as £5,000 in £1 shares, of which 4,375 have been taken up. £1 per share has been called up on 882 and £882 has been received. £3,493 is considered as paid on remainder. Mortgages and charges, nil.

**EXCHANGE TELEGRAPH CO. (LTD.)**—In return to Aug. 10 capital is £246,250 in 8,125 A and 16,500 B shares of £10 each, of which 8,023 A and 16,200 B have been taken up (exclusive of forfeited shares). £9 per share has been called up on £6,000 A and £1 per share on 2,023 A shares and £56,023 has been received, in addition to £816 paid in respect of forfeited shares. £179,000 is considered as paid, being £10 per share on £16,200 B and £8 per share on 2,125 A (of which 102 have been forfeited). Mortgages and charges, nil.

**FIFE ELECTRIC POWER CO. (LTD.)**—Return to Aug. 29 gives capital as £30,000 in 3,000 shares of £10 each, all of which have been taken up and paid for in full. Mortgages and charges, £15,000.

**GENERAL ELECTRIC CO. (LTD.)**—According to return to Aug. 7 capital is £800,000 in 40,000 preference and 40,000 ordinary shares of £10 each, of which 25,000 preference and 31,750 ordinary have been taken up. £10 per share has been called up on 18,000 preference and 6,750 ordinary and £247,500 has been received. £320,000 is considered as paid on 7,000 preference and 25,000 ordinary. Mortgages and charges, £200,000.

**HALIFAX & BERMUDAS CABLE CO. (LTD.)**—Return to Oct. 5, 1905, gives capital as £50,000 in 10,000 shares of £5 each, all of which have been taken up. £50,000 is considered as paid. Mortgages and charges, £46,500.

**HENLEY'S (SOUTH AFRICA) TELEGRAPH WORKS (LTD.)**—In return to Aug. 4 capital is £2,000 in £1 shares, all of which have been taken up and paid for in full. Mortgages and charges, nil.

**YALE ELECTRIC POWER CO. (LTD.)**—According to return to Oct. 6 capital is £20,000 in 800 shares of £25 each, of which 629 have been taken up. £25 per share has been called up on 561 and £13,780 has been received, leaving £245 in arrears. £1,700 is considered as paid on 68 shares. Mortgages and charges, nil.

### MORTGAGES AND CHARGES.

**IMPROVED ELECTRIC SUPPLIES (LTD.)**—A mortgage debenture dated Oct. 6, 1905, to secure £4,000, charged on company's undertaking and property, present and future, including uncalled capital, has been registered. Holder, H. Muff.

## CITY NOTES.

**MEMORANDA** (Oct. 19).—Bank rate 4 per cent. (since Sept. 28, 1905) Price of silver 28¾d. per oz. Consols $88\frac{9}{16}$—$88\frac{11}{16}$ for money, $88\frac{11}{16}$—$88\frac{13}{16}$ for account; 2½ per cent. annuities $87\frac{5}{8}$—$87\frac{7}{8}$. Consols Pay Day, Nov. 2; Stocks and Shares Continuation Day, Oct. 25; Ticket Day, Oct. 26; Pay Day, Oct. 27; Mining Share Carry-over Day, Oct. 24.

**BRUNNER, MOND & CO.**—An interim dividend is announced at the rate of 35 per cent. on the ordinary shares.

**CALLENDER'S CABLE & CONSTRUCTION CO. (LTD.)**—An interim ordinary dividend of 5s. per share is announced.

**CONSOLIDATED ELECTRICAL CO. (LTD.)**—A circular letter has reached us which states that the negotiations referred to by the chairman of this company at the last meeting of shareholders for the sale of the company's works at Canonbury and of the manufacturing business carried on there have been brought to a successful issue, and that a new company (the Consolidated Supply Co., Ltd.) has acquired the said works and business as from March 31 last. (Particulars of the registration of the new company were given in *The Electrician* for Sept. 22, 1905.) A circular has been issued stating that in consequence of the great improvement recently effected in the financial position of this company, and the reasonable assurance of a net profit for the current year more than sufficient to meet the preference dividend in arrear, as well as that now accruing, the directors feel justified in paying off the whole of these arrears, covering the period from Nov. 30, 1903, to May 31, 1905.

**CRAIGPARK ELECTRIC CABLE CO. (LTD.)**—The interim dividend on the preference shares at the rate of 6 per cent. per annum for the half-year ended Sept. 30 is announced.

**ELECTRICAL ENTERPRISE IN HOLLAND.**—It is stated that an American company (entitled the Holland-American Construction Co.) has been formed with a capital of $1,000,000, to construct light electric railways

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. No. of weeks. | Aggregate. Amount. | Aggregate. Inc. or Dec. (a) |
|---|---|---|---|---|---|---|
| | | £ | £ | | £ | £ |
| Aberdeen Corporation | Oct. 14 | 1,309 | + 19 | 20 | 30,525 | - 1,591 |
| Airdrie | ,, 6 | 217 | + 2 | 40 | 8,209 | + 117 |
| Anglo-Argentine | ,, 14 | 14,231 | + 1,478 | 41 | 544,148 | + 35,059 |
| Ayr Corporation | ,, 14 | 217 | + 20 | 21 | 8,512 | - 118 |
| Barcelona Trams Co. | ... | ... | ... | ... | ... | ... |
| Barcelona, Ensanche, Gracia | ... | ... | ... | ... | ... | ... |
| Barnsley | ,, 6 | 159 | - 5 | 40 | 6,480 | - 276 |
| *Barrow | ,, 6 | 260 | + 69 | 40 | 9,910 | + 2,080 |
| Bath Electric Trams, Ltd. | ,, 11 | 725 | + 84 | 41 | 28,419 | + 1,737 |
| Birkenhead | ,, 15 | 972 | - 44 | 2 | 1,973 | - 75 |
| Birmingham Corporation | ,, 14 | 367 | + 39 | 21 | 10,085 | + 1,153 |
| *Birmingham & Mid. | ,, 6 | 1,429 | - 176 | 40 | 64,856 | + 894 |
| Blackpool Corporation | ,, 12 | 662 | - 6 | 28 | 41,752 | + 2,069 |
| Blackpool and Fleetwood | ,, 14 | 335 | - 5 | 15 | 18,114 | - 810 |
| Blackp'l, St. Anne's & Lytham | ... | ... | ... | ... | ... | ... |
| Bolton Corporation | ,, 15 | 1,805 | + 100 | 29 | 56,727 | + 1,975 |
| Bournemouth Corporation | ,, 11 | 1,312 | + 303 | †27 | 41,219 | + 6,987 |
| Bradford Corporation | ,, 14 | 4,249 | - 187 | 28 | 127,659 | - 6,672 |
| Brighton Corporation | ,, 15 | 887 | - 52 | 29 | 32,104 | + 714 |
| Bristol Trams & Carriage | ,, 13 | 5,025 | + 208 | 10 | 51,607 | + 1,461 |
| Buenos Ayres & Belgrano | ,, 15 | 3,341 | + 345 | 41 | 135,010 | + 7,278 |
| Buenos Ayres Elec. Trams | Sept. 16 | 1,146 | ... | 37 | 42,374 | ... |
| Burnley Corporation | Oct. 14 | 1,086 | + 43 | 28 | 41,934 | + 1,891 |
| Burton Corporation | ,, 15 | 287 | - 37 | §28 | 9,308 | - 1,168 |
| Bury Corporation | ,, 8 | 670 | ... | §27 | 20,553 | ... |
| Calcutta Tramways Co. | ,, 14 | R35,570 | - R7,979 | 15 | R644,158 | + R85,776 |
| Camborne-Redruth | ,, 14 | 115 | + 7 | 24 | 2,848 | ... |
| Cardiff Corporation | ,, 7 | 1,945 | + 21 | 28 | 60,517 | + 320 |
| | ,, 14 | 1,988 | + 66 | | | |
| Carlisle Tramways Co. | ,, 14 | 181 | ... | 41 | 7,707 | - 609 |
| Central London Railway | ,, 14 | 6,731 | - 50 | 15 | 88,642 | - 1,909 |
| Chatham & Dist. Lt. Rys. | ,, 12 | 623 | + 46 | 41 | 27,559 | + 3,037 |
| *City of Birm'gh'm Tram Co. | ,, 6 | 5,256 | - 264 | 40 | 216,699 | + 2,436 |
| City & South London Rly. | ,, 15 | 2,578 | + 42 | 15 | 35,701 | - 531 |
| Colchester Corporation | ,, 12 | 174 | - 50 | 11 | 2,602 | - 1,023 |
| Cork Electric Trams Co. | ,, 12 | 472 | - 7 | 41 | 20,297 | + 791 |
| Devonport & Dist. Trams | ,, 6 | 473 | - 47 | 40 | 18,745 | - 2,803 |
| Dover Corporation | ,, 14 | 241 | + 39 | 28 | 6,925 | - 143 |
| Dublin & Lucan Railway | ,, 13 | 124 | - 8 | 15 | 2,168 | + 23 |
| Dublin Southern District | ,, 13 | 948 | + 16 | 15 | 80,802 | - 629 |
| Dublin United | ,, 13 | 4,061 | + 46 | | | |
| Dudley—Stourbridge | ,, 6 | 866 | + 16 | 40 | 36,622 | + 1,267 |
| Dundee Corporation | ,, 11 | 1,094 | + 172 | §21 | 19,615 | + 856 |
| East Ham Council | ,, 14 | 773 | + 128 | 29 | 24,223 | + 2,497 |
| Gateshead & Dist. Trams | ,, 6 | 969 | + 23 | 40 | 36,856 | + 650 |
| Glasgow Corporation | ,, 14 | 15,914 | + 1,350 | 20 | 303,248 | + 15,774 |
| Glossop | ,, 14 | 129 | + 18 | 41 | 5,089 | + 474 |
| Gloucester Corporation | ,, 11 | 269 | - 12 | 28 | 9,050 | ... |
| Gravesend—Northfleet | ,, 6 | 234 | + 6 | 40 | 9,482 | - 918 |
| Gt. Northern & City Rly. | ,, 14 | 1,603 | + 323 | 15 | 22,016 | + 5,641 |
| Greenock & Port Glasgow | ,, 6 | 638 | + 73 | 40 | 26,093 | + 2,810 |
| Halifax Corporation | ,, 4 | 1,501 | + 101 | 27 | 45,102 | + 2,010 |
| Hartlepool Tramways | ,, 6 | 281 | + 1 | 40 | 10,825 | - 1,150 |
| Hastings Elec. Trams Co. | ,, 12 | 474 | ... | 10 | 6,808 | ... |
| Huddersfield | ,, 14 | 1,318 | + 79 | 28 | 39,060 | + 1,077 |
| Hull Corporation | ,, 14 | 3,317 | - 27 | 28 | 63,863 | + 1,575 |
| Ilford Dist. Coun. | ,, 14 | 418 | + 29 | 29 | 14,297 | + 216 |
| Ipswich Corporation | ,, 14 | 338 | - 49 | 28 | 13,473 | - 1,616 |
| Isle of Thanet Co. | ,, 14 | 358 | - 76 | 2 | 760 | - 225 |
| Kidderminster & District | ,, 6 | 113 | - 4 | 40 | 5,061 | - 279 |
| Kilmarnock Corporation | ... | ... | ... | ... | ... | ... |
| Kirkcaldy Corporation | ,, 11 | 201 | - 14 | 6 | 1,291 | - 15 |
| Lanarkshire Trams Co. | ... | ... | ... | ... | ... | ... |
| Leamington | ,, 6 | 148 | + 37 | 12 | 2,659 | + 1,082 |
| Leeds Corporation | ,, 14 | 5,832 | + 219 | 28 | 175,301 | + 3,547 |
| Leicester Corporation | ,, 14 | 2,296 | ... | 41 | 85,880 | ... |
| Liverpool Corporation | ,, 7 | 10,629 | - 95 | 40 | 421,939 | + 8,811 |
| Liverpool Overhead Rly. | ,, 15 | 1,444 | - 9 | 15 | 25,206 | - 863 |
| *London County Council | ... | ... | ... | ... | ... | ... |
| Lowestoft | ,, 14 | 183 | + 7 | 2 | 362 | + 12 |
| Maidstone Corporation | ,, 12 | 118 | - 13 | 28 | 3,919 | ... |
| Manchester Corporation | ,, 14 | 12,564 | + 415 | 28 | 369,030 | + 15,495 |
| Mersey Railway | ,, 14 | 11,605 | + 87 | 15 | 23,355 | + 1,454 |
| Merthyr | ,, 6 | 191 | - 14 | 40 | 7,661 | - 425 |
| *Metropolitan Elec. Trams | ,, 6 | 2,854 | + 1,050 | 40 | 107,396 | + 47,671 |
| Middleton | ,, 6 | 323 | + 25 | 40 | 13,916 | + 604 |
| Musselburgh | ,, 5 | 247 | ... | 42 | 9,873 | ... |
| Nelson Corporation | ,, 14 | 129 | + 11 | 29 | 3,904 | + 357 |
| Newcastle-on-Tyne Corp. | ,, 14 | 8,698 | + 65 | 28 | 108,576 | + 3,045 |
| Newport (Mon.) | ,, 14 | 553 | + 66 | 2 | 1,114 | + 129 |
| Northampton Corporation | ,, 13 | 389 | - 17 | 27 | 12,168 | + 4,828 |
| Oldham, Ashton & Hyde | ,, 6 | 587 | + 44 | 40 | 22,411 | + 893 |
| Oldham Corporation | ,, 15 | 1,662 | + 467 | 29 | 48,268 | + 13,065 |
| Perth (W. A.) Elec. Trams | ,, 13 | 1,881 | + 154 | 41 | 56,168 | + 3,289 |
| Peterborough | ,, 6 | 173 | - 35 | 40 | 5,687 | - 512 |
| Pontypridd Dist. Council | ,, 14 | 148 | ... | 28 | 4,777 | ... |
| Portsmouth Corporation | ,, 14 | 1,628 | - 112 | 28 | 62,794 | + 1,385 |
| Potteries | ,, 6 | 1,804 | + 56 | 40 | 67,873 | + 406 |
| Reading Corporation | ,, 12 | 687 | - 40 | 2 | 1,225 | - 40 |
| Rotherham Corporation | ,, 12 | 472 | + 28 | 28 | 12,908 | - 737 |
| Rothesay | ,, 6 | 90 | + 26 | 40 | 9,119 | + 2,609 |
| Salford Corporation | ,, 16 | 4,005 | - 3 | 29 | 125,775 | + 6,684 |
| Sheerness | ,, 4 | 67 | - 3 | 40 | 2,921 | + 304 |
| Sheffield Corporation | ,, 15 | 4,734 | + 163 | 29 | 144,462 | + 6,624 |
| Southampton Corporation | ,, 11 | 916 | - 31 | †2 | 1,418 | - 348 |
| Southend Corporation | ... | ... | ... | ... | ... | ... |
| Southport Tramways | ,, 6 | 302 | - 6 | 40 | 13,075 | - 422 |
| S. Staffordshire Trams. | ,, 6 | 844 | + 109 | 40 | 29,154 | + 746 |
| Stockport Corporation | ,, 13 | 780 | + 291 | 28 | 21,704 | + 4,494 |
| Sunderland Corporation | ... | ... | ... | ... | ... | ... |
| Swansea Trams | ,, 6 | 811 | + 255 | 40 | 28,741 | + 6,744 |
| Swindon Corporation | ,, 11 | 186 | ... | 28 | 5,761 | ... |
| Taunton Trams | ... | ... | ... | ... | ... | ... |
| Tynemouth and District | ,, 6 | 217 | - 13 | 40 | 10,950 | - 1,495 |
| Tyneside Trams Co. | ,, 11 | 378 | + 12 | 41 | 17,215 | + 1,007 |
| Wallasey District Council | ,, 14 | 715 | + 5 | 28 | 23,190 | + 656 |
| Walsall | ,, 14 | 510 | + 45 | 40 | 20,180 | + 212 |
| Warrington Corporation | ... | ... | ... | ... | ... | ... |
| West Ham Corporation | ,, 12 | 2,023 | + 940 | 28 | 50,295 | + 21,012 |
| Weston-super-Mare | ,, 4 | 90 | - 4 | 40 | 6,458 | + 624 |
| Wolverhampton Corpn. | ,, 11 | 773 | ... | 2 | 1,602 | ... |
| Wolverhampton District | ,, 6 | 420 | + 7 | 40 | 15,888 | + 114 |
| *Worcester | ,, 6 | 297 | - 10 | 40 | 12,532 | + 591 |
| Wrexham | ,, 6 | 95 | - 8 | 40 | 4,115 | - 378 |
| Yorkshire Woollen District | ,, 6 | 654 | + 116 | 40 | 26,280 | + 2,453 |

(a) These comparisons are with the corresponding period last year. † Minus 8 days. § Plus 2 days. * Partly electrical.

in Holland of an aggregate length of 115 miles. Mr. J. G. Kaelber, the founder of the company, has obtained a concession for the undertaking, and Mr. J. H. Lukach, of London (a director of the British Westinghouse Co.) is said to be interested in the scheme.

**GLOBE TELEGRAPH & TRUST CO.**—The directors announce a quarterly interim dividend of 3s. per share on the preference and 2s. per share on the ordinary shares.

**ORIENTAL TELEPHONE & ELECTRIC CO. (LTD.)**—The directors have declared the following interim dividends: 3 per cent. on the 6 per cent. cumulative preference shares for current year (less tax) and 3 per cent. on the ordinary shares (tax free).

**SOUTH LONDON ELECTRIC SUPPLY CORPN. (LTD.)**—Sales of electric current for the Michaelmas quarter amounted to £17,577 against £16,755 for the corresponding quarter of last year.

**STOCK EXCHANGE NOTICE.**—A renewed special application has been made to the Stock Exchange Committee to grant quotations to 500,000 £1 fully-paid ordinary shares, 425,553 £1 fully-paid 6 per cent. cumulative preference shares and £500,000 5 per cent. mortgage debentures (reg.) of the *Lisbon Electric Tramways (Ltd.)*.

**WESTERN TELEGRAPH CO. (LTD.)**—The directors, after transferring £60,000 to general reserve and £5,000 to maintenance ship's reserve, have decided to recommend a final dividend of 3s. per share, making a total dividend of 6 per cent. for the year ended June 30, and also the payment of a bonus of 2s. per share (both tax free). The balance is carried forward. The register of transfers will be closed from 24th inst. to Nov. 1, inclusive, preparatory to payment of dividends and bonus on Nov. 2.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Oct. 18. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Oct. 18. Highest. | Business, Week to Oct. 18. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | £ s. d. | | | |
| 5 | 3/0 | Anglo-Argentine Ord. Shares | 8 5/16–8 9/16 | 4 11 0 | Ap, Oct | 8 9/16 | 8 3/8 |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞–6⅛ | 4 9 8 | — | 6 3/32 | 6 1/32 |
| St. | 6% | Do. Permanent 6% Deb. Stock | 141 –144 | 4 3 3 | — | .. | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 104 –106 | 4 14 4 | — | 106 | 105¾ |
| 10 | 12/0 | Barcelona Tramways Ord. | 13¾–14½ | 4 4 0 | — | .. | .. |
| 10 | 5/0 | Do. 5% Cum. Pref. | 9½ –10 | 5 0 0 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock (red.) | 97 –102 | 4 8 8 | — | .. | .. |
| 100 | 5% | Do. 5 per Cent. Debs. | 93 –101 | 4 19 0 | — | .. | .. |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1 –1½ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 3¾ - 4¼ | 5 17 8 | — | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 95 –98 | 4 12 0 | — | .. | .. |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 126 –129 | 4 13 0 | — | .. | .. |
| St. | 5% | Do. Pref. Ord. Stock | 109 –112 | 4 9 3 | — | .. | .. |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock. | 105 –108 | 4 12 6 | — | .. | .. |
| 40 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 101½–103½ | 4 7 5 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 100 –103 | 4 8 8 | — | 101¾ | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | 3 1/16–3 5/16 | 5 1 6 | — | 3⅜ | 3 1/16 |
| 5 | 3/0 | † Do. 6 per Cent. "A" Cm. Pref | 5⅝ - 5⅞ | 5 2 2 | — | .. | .. |
| 5 | 3/0 | † Do. "B" | 5 –5½ | 5 9 1 | — | 5 3/32 | 5 1/32 |
| St. | 5% | Do. 5 per Cent. Debs. | 106 –108 | 4 12 6 | — | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102 –105 | 4 15 3 | — | 104½ | 104 |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 98 –100 | 5 0 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 101 –105 | 5 4 9 | .. | — | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 101 –105 | 5 14 4 | .. | .. | — |
| 5 | 3/6 | Calcutta Tramways (Nos. 1 to 105) | 9 –9½ | 4 9 6 | — | 9 7/16 | .. |
| 5 | 0/3 | Do. Nos. 105,001 to 137,610 | 8½–9 | .. | .. | 9¼ | 8¾ |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 107 –109 | 4 2 7 | — | 103¼ | 107¾ |
| 1 | 0/6 | Cape Electric Tram Shares | 1⅛ –1⅜ | 3 12 9 | — | 1 5/16 | 1 3/16 |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 103 –105 | 4 15 3 | — | .. | .. |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 98 –100% | .. | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 103 –105 | 4 15 3 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort Debs. (1908) | 101 –104 | 4 16 2 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102 –104 | 4 6 7 | — | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 104 –107 | 4 13 5 | .. | .. | — |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 145 – 148 | 5 8 1 | .. | 147½ | 147¼ |
| .. | .. | Do. 5% 1st Mt. $500 Dbs. | 100 –102 | .. | .. | 101½ | .. |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | 5/0 | Calcutta Elec (1-60,000) ex new. | 8¾ 9¼ | 4 6 6 | — | .. | .. |
| 5 | 2/1½ | Do. (60,001-80,000) Do. | 8½ 9 | 5 0 0 | .. | 9 7/16 | .. |
| 100 | 5% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50 –52 | 4 16 1 | .. | 51¼ | .. |
| .. | .. | Cordoba Lt. and Power Co. 1st Mt. Stk. £100 000 5% Bds. | 96 –98 | .. | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½ - 3 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Debs. | 86 –90 | 5 11 1 | — | .. | — |
| 10 | .. | Havana Electricity Co. Shares | 9½–10½ | — | — | .. | .. |
| 100 | 15/6 | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 94 –96 | 5 4 2 | .. | .. | .. |
| 1 | 5·38d | †Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | 15/16 -1 | 6 0 0 | — | 1 | — |
| 1 | 1/0 | Rand Electric | 1 5/16–1 7/16 | .. | — | .. | — |
| 1 | .. | River Plate Electricity Co. Ord. | ⅝ - ¾ | .. | .. | [illegible] | .. |
| 1 | .. | Do. 6% Non. Cum. Pref | 1 - 1⅛ | .. | .. | .. | .. |
| St. | .. | Do. 5% Deb. Stock | 101 – 103 | .. | .. | 103 | 102¾ |
| 5 | 3/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5⅛–5⅜ | 5 6 8 | .. | .. | — |
| 5 | [illegible]3d | Do. (12,001-20,000) | 5 –5½ | 3 8 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100 –103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 10/9 | Shawinigan Water and Power 5% Bds., Scrip | 99 –101 | 4 19 0 | .. | 99⅝ | .. |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Share. | Last Dividend | Name. | Price Wed., Oct. 18. | Rate per Cent. Yielded. | Dividend Due | Business, Week to Oct. 18 | |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | £ s. d. | | Highest. | Lowest. |
| 1 | .. | Bath Elec. Trams Pref. Ord. | ⅞ —1 | .. | .. | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16—1 1/16 | 4 14 9 | .. | 1 | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) .. | 101 —103 | 4 7 5 | .. | 101¼ | 101½ |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 102 —104 | 4 6 7 | .. | 103½ | .. |
| 10 | 9% | Bristol Tramways and Carriage Ord. ... | 17 —17½ | 5 2 11 | Feb, Aug | .. | .. |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10 —10½ | 8 18 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Debs. | 105 —107 | 8 14 10 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 9½—10 | 6 0 0 | .. | 9⅞ | 9½ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 11 —11½ | 5 4 4 | Feb, Aug | 11 1/16 | 11 |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 121 —123 | 4 1 4 | .. | 122½ | 122 |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 99 —101 | 4 9 1 | .. | 100 | 99¾ |
| St. | 4% | Central London Ordinary Stock | 91 —93 | 4 6 0 | June, Dec | 91⅞ | .. |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 101 —103 | 8 17 8 | .. | .. | .. |
| St. | 4% | Do. Deferred Stock | 88 —86 | 4 13 1 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs.. | 110 —112 | 8 11 5 | .. | 111 | 110½ |
| 5 | 2/6 | †City of Birmingham Trams. 5% Cm. Prf. | 4⅞—5⅛ | 4 17 6 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 100 —103 | 3 17 8 | .. | .. | .. |
| St. | 2% | City and South London Rly. Con. Ord. | 40 —42 | 5 7 2 | Feb, Aug | 41⅜ | 40 |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) ... | 118 —121 | 4 2 8 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 117 —120 | 4 8 4 | .. | .. | .. |
| St. | 5% | Do. (1901) | 118 —116 | 4 6 8 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Perp(etual Debs | 107 —110 | 8 12 9 | May, Nov | 110 | .. |
| 10 | 6/0 | Dublin United Trams. 1896) Ltd., Ord. | 18½—14½ | 4 2 8 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 15 —16 | 8 5 0 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5 —5½ | 7 5 5 | .. | 5⅝ | .. |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8 —9 | 4 8 11 | .. | 8½ | .. |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 100 —102 | 4 8 3 | .. | .. | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 17 —18 | 5 0 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 18¾—14¼ | 4 4 2 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 108 —110 | 4 1 10 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼—2¾ | 9 8 6 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 83 —88 | 4 10 11 | — | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8 1/16—8 3/16 | 8 13 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾—10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99 —102 | 8 19 3 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9¾—10¼ | 4 17 6 | — | 10⅛ | 9 13/16 |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 100 —103 | 8 17 8 | — | 102 | .. |
| St. | .. | Mersey Con. Ord. Stock | 4 —7 | .. | — | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8 —11 | .. | — | .. | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32—9/32 | .. | — | 7/32 | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1 —1 1/16 | 4 14 1 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 105 —107 | 4 4 1 | — | .. | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½—1½ | .. | May | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾—9¼ | 5 5 8 | .. | .. | .. |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9 —9½ | 5 5 3 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 101 —104 | 4 6 7 | — | .. | .. |
| 1 | .. | South Lancs. Elec. Trac. & Power Ord. | .. | .. | .. | .. | .. |
| 1 | .. | Do. 6% Pref. (£1 paid) | .. | .. | April, Oct | .. | .. |
| St. | .. | Do. 4½% Deb. Stock (100% paid) | .. | .. | Jan, July | .. | .. |
| 100 | .. | Sunderland Dist. Elec. Trams. 5% 1st Mort. Debs. | 95 —99 | .. | .. | .. | .. |
| .. | 5% | Underground Elec. Rys. Co. of London | 99½—100½ | 4 19 6 | .. | .. | .. |
| St. | 3% | Waterloo and City Ord. | 88 —90 | 8 6 8 | June, Dec | .. | .. |
| St. | 12/11 | Yorkshire W. R. Elec. Trams Co. 4% 1st Debs. | 92 —95 | 4 14 6 | .. | .. | .. |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | * African Direct Tel. 4% Mrt. Deb. (red.) | 99 —102 | 8 13 5 | Jan, July | .. | .. |
| 10 | .. | Amazon Telegraph | 3 —3½ | .. | Jn, Dec | 3⅜ | .. |
| 100 | .. | Do. 5% Debs. (red.) | 82 —87 | 5 14 11 | .. | .. | .. |
| St. | 15/0 | †Anglo-American | 60 —62 | 4 16 9 | F,My,Ag,N | .. | .. |
| St. | 30/0 | † Do. Preferred | 108 —109 | 5 8 0 | F,My,Ag,N | 109¾ | 108 |
| St. | 2/0 | Do. Deferred | 16¼—16½ | .. | F,My,Ag,N | 16½ | 16¼ |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 97 —99 | 4 0 10 | Jn,Ap,Jy,O | 98¾ | 97½ |
| 10 | 5/0 | Cuba Submarine Ord. | 9 —9½ | 5 5 8 | Feb, Aug | .. | .. |
| 10 | 10/0 | Do. Preference 10 per Cent | 17½—18½ | 5 8 1 | Feb, Aug | .. | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅝—3⅞ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 9¼—9¾ | 5 2 6 | April, Oct | 9⅜ | .. |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 100%—103% | 4 7 5 | Jan, July | .. | .. |
| 20 | 8/0 | †Direct United States Cable. | 12¼—12¾ | 5 2 0 | Ja,Ap,Jy,O | 12⅝ | 11 13/16 |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 100 —102 | 4 8 8 | Jn, Dec | .. | .. |
| St. | 25/0 | †Eastern Ordinary | 142 —145 | 4 16 6 | Ja,Ap,Jy,O | 144½ | 142¼ |
| St. | 17/6 | † Do. 3½ per Cent. Pref. Stock | 89 —91 | 8 16 11 | Ja,Ap,Jy,O | 90 | 89 |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 108 —110 | 8 12 9 | May, Nov | 109 | .. |
| 10 | 2/6 | †Eastern Extension | 18¾—14¼ | 4 18 8 | Ja,Ap,Jy,O | 14⅛ | 13⅞ |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 106 —108 | 8 14 1 | Feb, Aug | 107¼ | .. |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 99½—101½ | 8 18 9 | Feb, Aug | 100 | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101½%—103½% | 8 17 4 | May, Nov | .. | .. |
| 10 | 5/0 | G. N. (of Copenhagen) | 85½—86½ | 6 16 11 | Jan, July | .. | .. |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 100 —102 | 4 8 3 | June, Dec | .. | .. |
| 25 | 52/6 | Indo-European | 54½—56½ | 5 15 0 | May, Nov | 56⅛ | 54½ |
| 100 | $1 | Mackay Companies Common | 47 | 4 5 1 | Jan, July | .. | .. |
| 100 | 4% | Do. Preference | 75¾ | 5 5 7 | Ja,Ap,Jy,O | .. | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1⅜—1½ | .. | .. | .. | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 100 —103 | 3 17 8 | June, Dec | .. | .. |
| 10 | 5/0 | West African Telegraph Shares | 10 —10½ | 4 15 3 | .. | 10⅛ | .. |
| 2½ | .. | West Coast of America | ⅝—¾ | .. | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100 —102 | 3 18 5 | Jan, July | .. | .. |
| 10 | .. | West India and Panama | 1⅛—1⅜ | .. | May, Nov | — | .. |
| 10 | 5/0 | Do. 6% 1st Pref. | 8½—9 | 6 13 4 | May, Nov | .. | .. |
| 10 | — | Do. 6 per Cent. 2nd Pref. | 7¾—8¼ | .. | May, Nov | 7¾ | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 101 —104 | 4 16 2 | Jan, July | 102 | .. |
| 10 | 8/0 | Western Telegraph | 14 —14½ | 4 16 6 | Mr,Jn,O,D | 14 5/16 | 14 |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 101 —103 | 4 17 1 | June, Dec | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 102½—104½ | 3 16 5 | .. | .. | .. |
| | | **TELEPHONES.** | | | | | |
| 5 | 5/0 | Chili Telephone (fully paid) | 7½—7¾ | 5 3 8 | August | 7¾ | 7⅝ |
| 1 | 0/7½ | Monte Video Telephone Ord. | ¾—⅞ | 3 8 7 | — | .. | .. |
| St. | 6% | National Co. Pref. Stock | 112 —113 | 5 6 2 | — | 113 | 112½ |
| St. | 5% | Do. Def. Stock | 107 —109 | 4 11 9 | .. | 108 | 107 |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 18 —15 | 4 0 0 | Feb, Aug | 14 | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 12 —18 | 4 12 4 | Feb, Aug | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅝—5⅞ | 4 5 2 | Feb, Aug | 5 23/32 | 5 11/16 |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 98 —100 | 3 10 0 | June, Dec | 98½ | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 104 —106 | 3 15 6 | .. | 104½ | 104¾ |
| 1 | 0/8¾ | Oriental | 1¼—1⅜ | 3 12 9 | April, Oct | .. | .. |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1 3/16—1 5/16 | 4 11 6 | — | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 102 —105 | 4 5 9 | .. | .. | .. |
| 5 | 5/0 | United River Plate | 7 —7½ | 5 6 8 | July | 7½ | 7¼ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5¼—5½ | 4 10 11 | June, Dec | .. | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) .. | 110 —112 | 4 10 8 | June, Dec | — | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 4¾—5¼ | 5 14 4 | .. | .. | .. |
| 10 | 2/0 | Globe Telegraph and Trust | 10¾—11 | 5 0 0 | Ja,Ap,Jy,O | 10⅞ | 10¾ |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14¼—14½ | 4 2 8 | Ja,Ap,Jy,O | 14 7/16 | 14¼ |
| 10 | 6% | †Submarine Cables Trust (Cert.) | 125 —128 | 4 13 9 | April, Oct | .. | .. |

| Share. | Last Dividend | Name | Price Wed., Oct. 18. | Rate per Cent. Yielded. | Dividend Due. | Business Week to Oct. 18. | |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | £ s. d. | | Highest. | Lowest |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12½—12⅝ | 5 10 9 | .. | 12½ | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10 —10½ | 4 5 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11 —12 | 5 0 0 | .. | 11⅝ | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) ... | 106 —108 | 4 3 4 | .. | 107¾ | 107¼ |
| 5 | 2 0 | †Bromley (Kent) El. Lt. & Power Shares | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 104 —107 | 4 4 1 | — | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 9¾—10¼ | 4 17 6 | .. | .. | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 9½—10 | 8 10 0 | Mar, Sept | 9⅝ | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 105 —108 | 8 14 1 | — | 105¼ | .. |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 7⅞—8⅜ | 3 17 6 | Feb, Aug | 8 3/16 | 7⅞ |
| 5 | 2/8 | Do. 4½ per Cent. Pref. | 5¼—5¾ | 3 18 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 103 —105 | 8 16 2 | — | .. | .. |
| 5 | 2/8 | Do. City Undertaking 4½% Cm. Pref. | 4¾ —5 | 4 10 0 | — | .. | .. |
| 5 | 2/8 | Do. Do. (1903) | 4⅞—5⅛ | 4 7 10 | .. | 4 31/32 | .. |
| 5 | 2 8 | Chelsea Electric Supply Ord. | 5¾—6¼ | 4 16 0 | March | 6 1/16 | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) ... | 109 —111 | 4 1 8 | Jn, Dec | .. | .. |
| 10 | 8/0 | City of London Electric Lighting Ord. | 12½—13¼ | 4 10 7 | Feb, Aug | 13 3/16 | 12 15/16 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13½—14½ | 4 2 8 | Jan, July | .. | — |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 124 —128 | 8 18 1 | Jn, Dec | 126 | 125¼ |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 104 —106 | 4 4 10 | .. | .. | .. |
| 5 | .. | County of Durham Elec. P.D. Ord. £2pd. | 2 3/16—2¼ | .. | April, Oct | 2¼ | 2 3/16 |
| 5 | 1¾d. | † Do. Do. 5% non cum. pref. | ⅝—[illegible] | .. | April, Oct | ⅝ | .. |
| 10 | 4 0 | County of London Elec. Supply Ord. | 10 —10½ | 4 5 9 | — | 10 3/16 | 9½ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅜—12⅞ | 4 13 2 | Mar, Sept | 12½ | 12⅜ |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 111 —114 | 8 18 11 | .. | 113½ | 113 |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 104 —106 | 4 4 11 | .. | .. | .. |
| 5 | 2 0 | Folkestone Electricity Supply Co. Ord. | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5 —5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 99 —102 | 4 8 8 | .. | .. | .. |
| 5 | 4 0 | †Hove Electric Lighting Ord. | 8 —8½ | 5 0 0 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100 —103 | 4 7 5 | .. | .. | .. |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 12 —12¾ | 4 14 1½ | .. | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½—7 | 4 5 9 | Jan, July | — | — |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) .. | 97 —100 | 4 0 0 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101 —103 | 8 17 8 | .. | .. | .. |
| 8 | 1/9⅜ | London Electric Supply Ord. | 2 —2½ | 3 12 0 | .. | 2⅛ | 2 1/32 |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5⅜—[illegible] | 5 6 8 | .. | 5¼ | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 99 —102 | 8 18 5 | Mr,Jn,S,D | — | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 10 —10½ | 5 4 9 | April, Oct | 10⅝ | 10⅛ |
| 5 | 2/8 | Do. 4½ per Cent. Cum. Pref. | 5⅝—5⅞ | 3 16 8 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 109 —113 | 8 19 7 | Jn, Dec | 109 | — |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 98 —100 | 8 10 0 | — | .. | .. |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 102 —104% | 4 6 7 | .. | .. | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 12⅝—12⅞ | 5 8 9 | Feb, Aug | .. | .. |
| 100 | .. | Do. 4½% Deb. | 105 —106 | .. | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8¾—9¼ | 4 18 2 | Feb, Aug | 8 3/16 | .. |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6 1/16—6 3/16 | 3 16 11 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99 —100 | 4 0 0 | Jan, July | .. | .. |
| 1 | 3% | Northern Counties Elec. Sup. 17/- paid | 27/32—⅞ | 2 15 7 | Mar, Aug | 27/32 | .. |
| 100 | .. | Do. 4½% Deb. £5 paid | 51 —52 | .. | Jan, July | .. | .. |
| 10 | 6/0 | Notting Hill Electric Ord. | 14 —15 | 4 0 0 | March | .. | — |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98 —100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅜—6⅞ | 5 1 6 | March | .. | .. |
| St. | 4% | Do. 4% Deb. Stock | 100 —102 | 3 18 5 | .. | .. | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 14¾—15¼ | 4 15 1 | Feb, Aug | 14⅞ | 14⅝ |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 8 —9 | 3 17 9 | Feb, Aug | .. | — |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) ... | 98 —100 | 3 10 0 | — | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2 —2½ | 8 0 0 | .. | 2 1/32 | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76 —80 | 5 0 0 | — | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 8⅝—4⅛ | 4 17 0 | .. | — | .. |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | 1⅜—1⅝ | .. | .. | .. | — |
| 1 | 0/8¾ | Do. 7% Cum. Pref. | 1 5/16—1 7/16 | 4 17 2 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105 —108 | 4 3 8 | .. | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4⅝—4⅞ | 5 2 6 | — | 4¾ | .. |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5 —5¼ | 4 15 3 | — | .. | .. |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 103 —105 | 4 5 9 | .. | — | .. |
| 5 | 6/6 | Westminster Electric Supply Ord. | 12⅞—13⅜ | 5 4 6 | Mar, Sept | 13¼ | 13 1/16 |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 6⅛—6⅝ | 3 15 6 | .. | 6¼ | .. |
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝—⅞ | 5 6 6 | — | — | .. |
| 1 | 6d. | Aron Elec. Meter 6% Cum. Pref. | [illegible] | .. | .. | .. | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3¾—4 | 5 0 0 | .. | 3 15/16 | 3 29/32 |
| 1 | 7½d. | Do. Pref | 1 7/16—1 9/16 | 3 16 10 | .. | .. | .. |
| 5 | 8/0 | British Insulated & Helsby Cables Ord. | 6½—7 | 5 14 3 | July, Feb | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾—6¼ | 4 16 0 | Jan, July | .. | — |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103 —106 | 4 4 11 | .. | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98 —100 | 4 10 0 | .. | .. | .. |
| 5 | 3/0 | British Westinghouse 6% Pref. | 2⅝—2⅞ | 11 4 6 | .. | 2 9/16 | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock ... | 85 —89 | 4 9 11 | .. | .. | — |
| 2 | — | Brush Electrical Engineering | ½—¾ | .. | March | .. | .. |
| 2 | 2/4½ | Do. 6 per Cent. Pref. Non-Cum. | 1½—1¾ | 6 17 2 | Mar, Sept | 1 9/16 | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 93 —97 | 4 12 10 | Mar, Sept | .. | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 78 —81 | 5 12 6 | Jan, July | .. | .. |
| 5 | 7/6 | Callender's Cable Con. Ord. | 10½—11½ | 5 4 4 | Jan, July | 11¼ | 10⅝ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝—5⅞ | 4 5 2 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 109 —111 | 4 1 1 | Nov, May | — | — |
| 1 | 9⅜d. | Castner-Kellner Alkali Co. | 1⅛—1 3/16 | 3 15 4 | .. | 1 | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 96 —101 | 4 9 1 | — | 99 | .. |
| 1 | 9⅜d. | Chadburn's (Ship) Telegraph Ord. | 1 3/16—1 5/16 | 4 10 6 | .. | — | — |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1 1/16—1 3/16 | 5 2 7 | .. | .. | — |
| 8 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) ... | 1⅜—1⅝ | 8 16 9 | Jan, July | .. | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 95 —100 | 5 0 0 | Jan, July | .. | .. |
| 5 | 10/0 | †Dick, Kerr & Co. Ord | 8½—9 | 5 11 1 | Sept | .. | .. |
| 5 | 8/0 | Do. 6% Cum. Pref. | 6⅛—6⅝ | 4 10 7 | Sept | 6½ | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106—108 | 4 4 1 | .. | .. | .. |
| 5 | 1/6 | †Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅜—1⅝ | .. | Feb, Aug | 1½ | 1 7/16 |
| 5 | 2/6 | † Do. (£5 paid) | 2 —2½ | .. | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 85 —90 | 4 8 11 | June, Dec | .. | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92 —97 | 5 8 1 | .. | .. | .. |
| 5 | 4/6 | Edmundson's Elec. Corp. Ord. | 5¾—6¼ | 5 12 0 | H'lf-yearly | 6 | 5 13/16 |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 6⅛—6⅝ | 4 14 1 | .. | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 108 —110 | 4 1 10 | .. | .. | .. |
| 2 | 1/7½ | Electric Construction Co. | ⅝—⅞ | 8 0 0 | July | .. | .. |
| 2 | 2/9⅜ | Do. 7 per Cent. Cum. Pref | 1⅞—2⅜ | 5 18 8 | July | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 92 —96 | 4 4 2 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9½—10 | 5 0 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96 —100 | 4 0 0 | .. | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 12 —13 | 5 15 5 | Feb, Aug | 12½ | 12¼ |
| 5 | 2/8 | Do. 4½ per Cent. Pref. | 5⅛—5⅝ | 4 8 7 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | 109 —111 | 4 1 1 | Feb, Aug | .. | .. |
| 10 | 5/0 | India Rubber, Gutta Percha, &c., Wrks. | 15½—16½ | 8 0 7½ | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99 —102 | 3 18 5 | Mar, Sept | .. | .. |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¼—11¾ | 4 5 1 | Mar, Sept | .. | .. |
| 12 | 12/0 | Telegraph Construction & Mainten'ce. | 32½—33½ | 5 2 0 | Mar, July | 34½ | 34 |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 .. | 102 —104 | 3 16 11 | Jan, July | .. | .. |
| 5 | — | Willans and Robinson Ord. | 1½—2 | — | Apr, Oct | .. | .. |
| 5 | — | Do. 6 per Cent. Cum. Pref. | 2½—3½ | — | Apr, Oct | — | .. |
| .. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 74 —79 | 5 1 3 | May Nov | .. | — |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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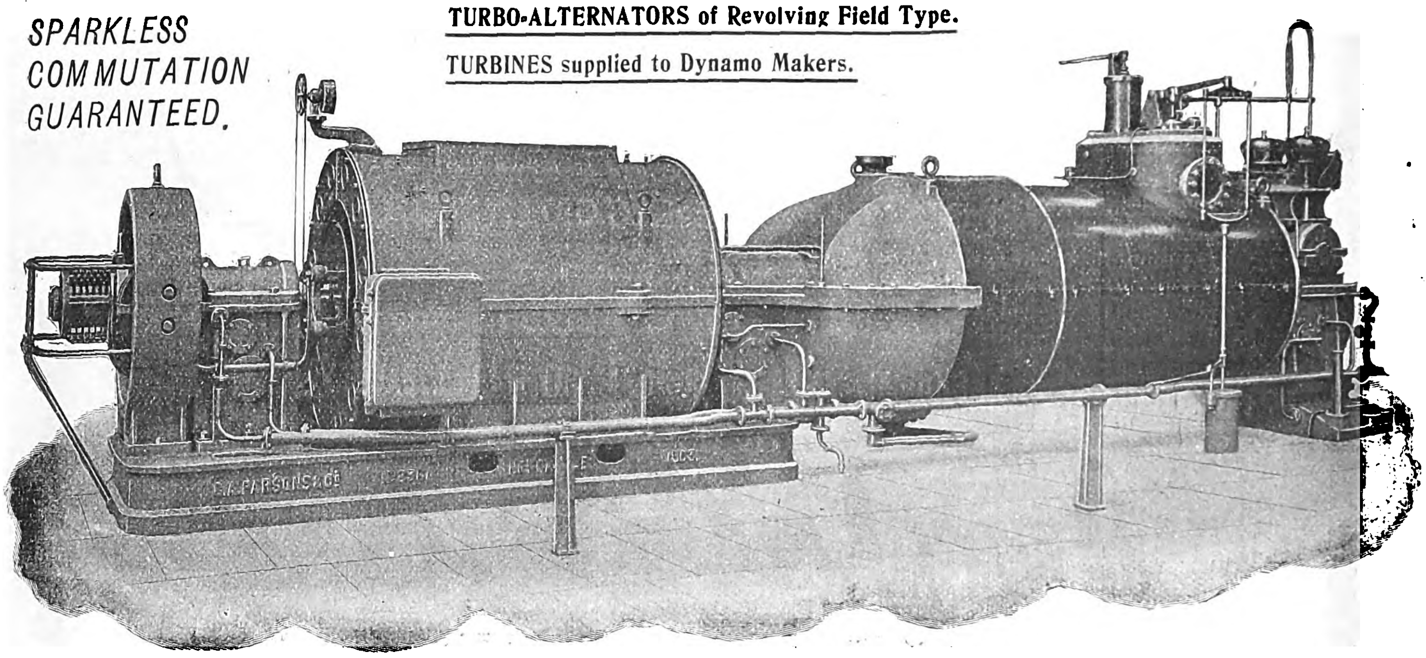

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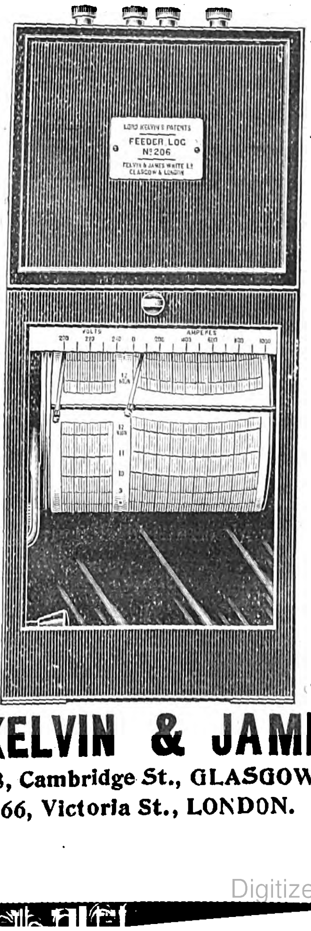

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Where answers to any of the above Advertisements are to be sent to the Publishing Offices to be forwarded, the sum of 3d. must be sent with the order to pay for postage of these replies. Six Words must be allowed for the address of the Publishing Offices.

## THE EASTERN TELEGRAPH COMPANY, LIMITED.

NOTICE is Hereby Given that the TRANSFER BOOKS of the FOUR PER CENT. MORTGAGE DEBENTURE STOCK of this Company will be CLOSED from the 27th October to the 31st October, both days inclusive.

By Order.
A. R. HARDIE, Secretary.

Electra House, Finsbury Pavement,
London, E.C.

## THE EASTERN EXTENSION AUSTRALASIA AND CHINA TELEGRAPH COMPANY, LIMITED.

NOTICE is Hereby Given that the SIXTY-FOURTH HALF-YEARLY ORDINARY GENERAL MEETING of this Company will be held on WEDNESDAY, the 1st November, 1905, at 3:30 o'clock in the afternoon, at RIVER PLATE HOUSE, Finsbury Circus, London, when the Report and Accounts for the half-year ended 30th June, 1905, will be submitted, and the ordinary business of the Company transacted.

Dated this 23rd October, 1905.

By order of the Board,
F. E. HESSE, General Manager and Secretary.

Electra House, Finsbury Pavement, London, E.C.

## THE EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY, LIMITED.

NOTICE is Hereby Given that the TRANSFER BOOKS of the FOUR PER CENT. REGISTERED MORTGAGE DEBENTURES (Mauritius Subsidy) of this Company will be CLOSED from the 27th October to the 31st October, both days inclusive.

By Order,
A. R. HARDIE, Secretary.

Electra House, Finsbury Pavement,
London, E.C.

## THE WESTERN TELEGRAPH COMPANY, LIMITED.

NOTICE is Hereby Given that the SIXTY-FOURTH ORDINARY GENERAL MEETING of the Shareholders of the Western Telegraph Company, Limited, will be held at RIVER PLATE HOUSE, Finsbury-circus, London, E.C., on WEDNESDAY, the 1st day of November, 1905, at 2 p.m., when the Report of the Directors and the Accounts to 30th June, 1905, will be presented, and the ordinary business of the Company transacted.

NOTICE is also given that the REGISTER OF TRANSFERS will be CLOSED from the 24th October to the 1st November, both days inclusive.

By order.
E. STEER HODSON, Secretary.

Electra House, Finsbury Pavement,
London, E.C., 24th October, 1905.

## C. PASS & SON, LTD.,

**Bedminster Smelting Works, BRISTOL.**

SELLERS OF

***ANTIMONIAL LEAD OF ALL GRADES.***

BUYERS OF

**LEAD ASHES AND LEAD RESIDUES FROM ACCUMULATORS.**

Telegrams: PASS BRISTOL. Telephone, 475.

# NO MORE COLLAPSED FURNACES OR BUCKLED TUBES

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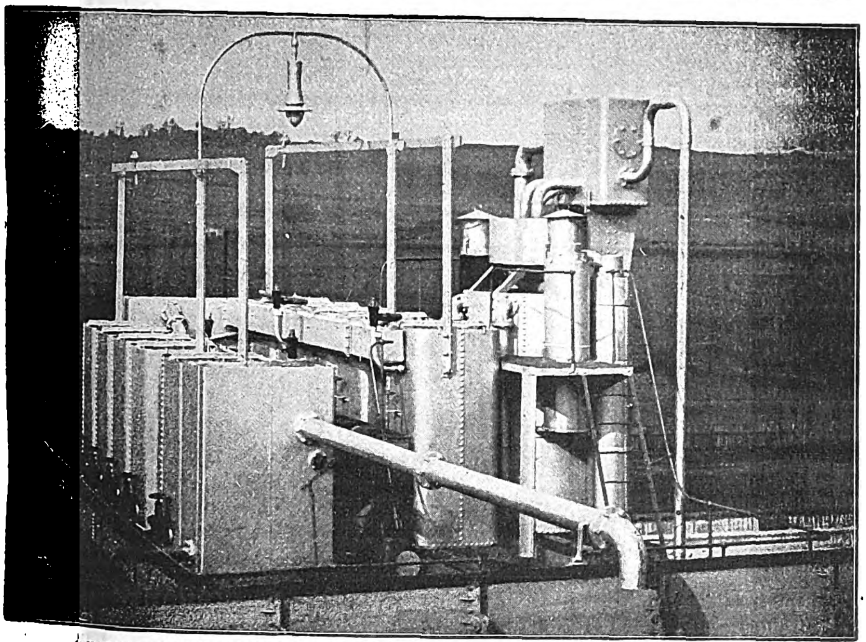
IF YOU **PURIFY** THE **CONDENSED WATER**

WITH THE **"HARRIS-ANDERSON" PURIFIER.**



"HARRIS-ANDERSON" PURIFIER, Cardiff Electric Generating Station.
Capacity, 10,000 gallons per hour.

Grease Absolutely Removed.

No Objectionable Matter introduced

Automatic and Simple Action.

Minimum Waste of Water.

Numerous Plants now at work in Electric Light & Power Stations, &c.

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Nat. Tel.: 876 WESTMINSTER.
26, St. Thomas Street, SUNDERLAND.
Telegrams: WINDTIGHT SUNDERLAND. Telephone 569
2, Hamilton Street, GREENOCK.
Telegrams: WINDTIGHT GREENOCK. Telephone 137.

◆

# VICKERS, SONS & MAXIM, Ltd.

TELEGRAMS:
VICKERS SHEFFIELD.

## SHEFFIELD.

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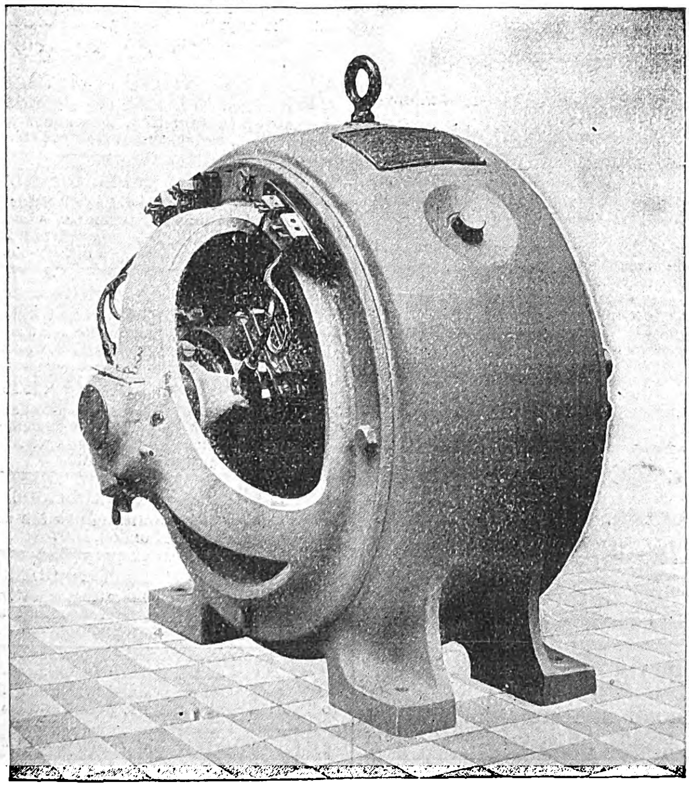

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SPEED RANGE,
UP TO 6 : 1.

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REGULATION ONLY

FULL POWER at
ALL SPEEDS.

# FESSENDEN Wireless Telegraph System

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**EIGHTH and WATER STREETS.**

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## THE ROYAL SANITARY INSTITUTE.

# SMOKE ABATEMENT EXHIBITION,

***December 12th to 15th, 1905,***

In the Royal Horticultural Society's New Hall,

VINCENT SQUARE, WESTMINSTER.

Heating and Cooking Appliances, Solid Fuels, Oil Fuels, Hot Water and Steam, Gas, Electricity, Testing Appliances, Domestic Destructors and Refuse Consumers, Boilers, Radiators, &c., &c.

Further Particulars and Application Forms for Space from the Offices of the Institute, 72, Margaret Street, London, W.

## PARTNERSHIPS, AGENCIES, &c.

ESTABLISHED CONSULTING ENGINEER, Westminster, wishes to meet Electrical Engineer with good connections among municipal bodies, collieries and ironworks with a view to PARTNERSHIP.—Letters, 5,892, *Electrician* Office, Salisbury-court, Fleet-street, London.

WANTED, first-class REPRESENTATIVE for South Wales district, for the sale of direct and alternating motors.—Apply, C. N. P., *Electrician* Office, Salisbury-court, Fleet-street, London.

WESTMINSTER CONSULTING ENGINEER desires JUNIOR PARTNERSHIP in firm of well-known Consulting Engineers. Good financial connections and extensive experience in tramways, large gas engine and electric mining work.—Letters, C. M. P., *Electrician* Office, Salisbury-court, Fleet-street, London.

## APPOINTMENTS VACANT.

### EAST INDIAN RAILWAY COMPANY.

**ELECTRICAL FOREMAN.**

The Directors of the East Indian Railway Company are prepared to receive APPLICATIONS, by letter only, for an appointment as Electrical Foreman in the Locomotive Department of the Company in India.

Candidates should be about 35 years of age, have had a good general education, and must possess a thorough knowledge and experience of high and low-tension three-phase power plant, and must also have had special experience with "Willans" engines.

*Terms.* A four years' agreement, with second-class free passage to India, and home again on satisfactory completion of engagement.

*Salary.* Rupees 300, rising to Rupees 400 per calendar month

The selected candidate will be required to pass a satisfactory medical examination by the Company's Consulting Physician before appointment.

Applications, accompanied by particulars of the candidate's career, together with copies (not originals) of testimonials, must be addressed to the undersigned not later than WEDNESDAY, the 8th November, 1905.

By Order,
C. W. YOUNG, Secretary.

East Indian Railway Company,
28-30, Nicholas-lane, London, E.C.,
16th October, 1905.

### NEWCASTLE-UNDER-LYME CORPORATION.

**SHIFT ENGINEER.**

Newcastle-under-Lyme Corporation Electricity Supply require Shift Engineer at once. To be capable of taking full charge on evening shift of continuous-current gas-driven station.

Write, stating age, experience, and send copies of recent testimonials. Salary to commence at 32s. weekly.

Endorse letters "Shift Engineer," Electricity Works, Newcastle, Staffs.

### THE UNIVERSITY OF LEEDS.

DEPARTMENT OF ELECTRICAL ENGINEERING.

The Council of the University invite APPLICATIONS for the appointment of **ASSISTANT LECTURER AND DEMONSTRATOR** in Electrical Engineering, to be made up to NOVEMBER 18th. Salary £175 a year. Further particulars may be obtained from the REGISTRAR.

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## John E. Raworth,

*Queen Anne's Chambers,*
*The Broadway, Westminster, London, S.W.*
**Patent Agent.**

## CHEAP PREPAID ADVERTISEMENTS.

**SITUATIONS VACANT**

*Three Lines and under (Minimum)* ... — — **1s. 6d.**
*Per Line after* ... ... ... — — — **6d.**

**Ten Words to the Line.**

**SITUATIONS WANTED.**

***Sixpence per Line of Ten Words, minimum One Shilling.***

Where answers to any of the above Advertisements are to be sent to the Publishing Offices to be forwarded, the sum of 3d. must be sent with the order to pay for postage of these replies. Six Words must be allowed for the address of the Publishing Offices.

## SITUATIONS, &c., VACANT.

REPRESENTATIVE WANTED for firm of Electrical Engineers in the North of England. Must be a gentleman capable of introducing and pushing business, with thorough technical training and experience in the manipulation of large contracts. Good position for suitable man.—Reply to C. O. D., *Electrician* Office, Salisbury-court, Fleet-street, London.

WANTED.—An EXPERIENCED ELECTRICAL ENGINEER, thoroughly familiar with the electrical and mechanical design of Induction Motors. Must be a technical graduate.—Write fully, giving age, qualifications, experience and salary expected, to C. N. D., *Electrician* Office, Salisbury-court, Fleet-street, London.

WANTED, immediately, an ENGINEER, fully qualified to take charge of electric light installation, pumping and sawing plant, &c., at large country house in Hertfordshire. Assistance given. Married man preferred. Good personal character essential. Cottage, with garden, rent free, fuel and light supplied.—Apply, stating wages, enclosing copies of testimonials as to experience and character, to E. S. H., Poles, Ware, Herts.

EXPERIENCED Tramway Constructional ENGINEER required for the Far East. Must be thoroughly accustomed to every detail of tramway construction, permanent way and overhead.—Apply, C. N. W., *Electrician* Office, Salisbury-court, Fleet-street, London.

WANTED at once, for North of England Manufacturing Firm, TWO YOUNG MEN for Experimental and Testing Work. Those who have just finished technical school training preferred. Salary 15s. to 25s., according to ability.—Apply, giving full particulars of training, age, &c., to C. N. S., *Electrician* Office, Salisbury-court, Fleet-street, London.

WANTED, for Straits Settlements, young ASSISTANT ELECTRICAL ENGINEER, well acquainted with general electrical and installation work, to supervise contracts.—State age, experience and salary required, C. N. T., *Electrician* Office, Salisbury-court, Fleet-street, London.

ASSISTANT DESIGNER WANTED for direct-current dynamos and motors. Up-to-date experience essential. Preference given to applicants with knowledge of turbo-generator design.—Apply by letter, stating age, salary required and earliest date at liberty, to VICKERS, SONS & MAXIM, LTD., Electrical Department, Sheffield.

WANTED, an experienced DRAUGHTSMAN accustomed to controller and switch work.—Address replies to H. H. LYDE, Esq., 32, Great St. Helens, London, E.C.

DRAUGHTSMAN required for about a month, drawing office, electric generating, traction and wiring experience necessary.—Reply, giving age, experience, references and salary required, to 5,931, *Electrician* Office, Salisbury-court, Fleet-street, London.

WANTED, first-class DRAUGHTSMAN, accustomed to electric cranes and lifting machinery. Permanency for good man.—Apply to THOMAS SMITH & SONS, Steam and Electric Crane Works, Rodley, near Leeds.

ELECTRICIAN.—WANTED, experienced Meter Tester.—Address, giving full particulars, to C. O. E., *Electrician* Office, Salisbury-court, Fleet-street, London.

# THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF
ELECTRICAL ENGINEERING. INDUSTRY, SCIENCE AND FINANCE.
ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,432. [No. 2. Vol. LVI.] FRIDAY, OCTOBER 27, 1905. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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## NOTES.

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It is seldom that an exhibition which has been opened during four of the dullest and quietest weeks of the year has the good fortune to gain more than that expression of faint approval which implies sympathy for a wasted effort. The Electrical Exhibition that has just been closed, however, has been voted a success by exhibitors and visitors alike, and the receipts have exceeded the expenses by an amount that will enable the Executive Committee to refund the exhibitors a large proportion of the sums paid for space. The interest taken in the Exhibition by members of the electrical industry, and also by the general public, was maintained to the closing day, when, in spite of the attractions in the centre of London in celebration of the Nelson Centenary, Olympia was as crowded as it had been on the three previous Saturdays.

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The Exhibition had even a modest little demonstration of its own in celebration of the day, and this was as successful as everything else at Olympia during the past four weeks, for the enthusiasm of the dense crowd at Olympia on Saturday was as thorough as that of any equal number of persons gathered together elsewhere. The demonstration served, too, as a fitting conclusion to an enterprise which proved one of the most popular attractions ever offered to London sightseers, for the general public, as distinct from the purely electrical section, undoubtedly supplied the bulk of the visitors. A noticeable feature was the very large number of lady visitors, who were doubtless attracted by the numerous and excellent displays of domestic apparatus to which the electric current can be successfully applied in every-day use.

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As our detailed descriptions of the exhibits have shown, the branches of the electrical manufacturing industry that were represented have been making firm and steady progress. It is typical of the present-day methods of electrical engineers, however, that there is in most cases a tendency to emphasise the stability of the progress and to discount its amount. Some of those who made the largest displays indignantly resented the suggestion that there had been room for improvement in their wares during the past few years, so perfect had been the degree of excellence already obtained; while others would blushingly acknowledge the indiscretion of having perpetrated an improvement or even a new invention which it had not yet been possible to standardise and to manufacture in quantities, and would demur to removing the cover from novelties which had not yet received that certificate of merit acknowledged proverbially to be the sincerest flattery. But those visitors who have been privileged, as ourselves, to examine the exhibits thoroughly and to study their details, will agree with us that standardisation has by no means led to crystallisation, and that improvement is proceeding on the correct lines. If any visitors came away from the Exhibition with the report that there was "nothing new," they must have been but casual observers or themselves inventors; and if any exhibitor came away dissatisfied with the results of his venture the blame must rest, not on the organisation of the Exhibition, but on the man's own show or on his showman.

◆

The competition of electric cooking utensils, the awards in connection with which we announce this week, was a happy idea on the part of the Executive Committee of the Exhibition. Occurring simultaneously with the reduction made by a number of London electric supply undertakers in the price charged for electricity used for cooking, it re-awakened the interest in this application of electricity that has lain too long dormant. With supply at 1d. per unit, electric cooking must become popular in many quarters, if only the apparatus can be supplied at a reasonable price and can be proved to be durable. The meetings of the judges and the tests they made were held *in camerâ* but we think that we may suggest, without fear of contradiction, that the points to which the greatest attention was directed were perfection in design and construction, efficiency and possibly price, rather than the actual edible products of the cooking trials. Although the employment of electric cooking utensils is not yet widespread, the manufacture of them may be deemed to have reached such a point that a good cook can cook a good dinner with those of A's manufacture just as well as with B's or C's. Our recent remarks as to the unduly high cost of the apparatus have been widely quoted, and we do not doubt that they will have effect. If, therefore, the construction of the apparatus is so improved that durability may be vouched for, and repairs are cheap and easy, we may expect that in the end cooking ranges in which the heat is obtained by direct combustion will be as old-fashioned as is the horse tramcar to-day.

WE publish this week a short article, written at our request by Dr. W. H. ECCLES, on "The Effect of Earthing the Radiator in Wireless Telegraphy." Much misconception exists with regard to this question and much remains to be determined both by theory and experiment before the subject is clear. Dr. ECCLES' article places before us exactly what is known on the subject and indicates also what must be known in addition before the practician and the man of theory can work together on a common basis. The question is one of considerable practical importance, and it is to be regretted that more information has not been forthcoming from those who are in a position to obtain it. A Paper, or even a letter from Sir OLIVER LODGE, pointing out the precise reasons for his abandonment of the earth connection in his wireless telegraph system, would be valuable at the present juncture.

IN the course of a somewhat amusing action heard at Shoreditch (London) County Court on Tuesday, the defendant maintained that he could have houses wired in the Leyton district for five shillings a point. It seems that the supply authority refused to connect an installation owing to the fact that the insulation resistance was not up to the standard specified by the Board of Trade. An electrician was called in, and after testing with an ohmmeter he discovered that the lead covering of a wire was in contact with the conductor itself. He thereupon made the fault good and sent in his bill. This bill was not paid, and the electrician had recourse to the County Court. The defence set up was that the charge for finding the fault was exorbitant, and that it was greater than the original cost of wiring the entire house. In fact, the defendant asserted that it would have been cheaper to re-wire the premises. Now, although this case has its humorous side, it has also a serious moral. Five shillings per point is an exceptional price in most places, but it is fairly common in some of the poorer districts in London. It is quite certain, however, that the work cannot be done properly at this figure, and quotations of the kind should be discouraged by every possible means.

THE interesting Paper on "The Thermodynamics of Electric Lamps," by Dr. E. F. ROEBER, which we print elsewhere, draws attention to the important rôle which electro-chemistry seems destined to play in the future development of electric lighting. Although in the earlier part of the article the author lays stress upon the fact that even in lighting by incandescent bodies it is possible to look for improvement by the use of substances possessing selective radiating powers, there seems at present little likelihood of any very startling developments on these lines. What advances have been made have all been by finding bodies capable of withstanding continuous running at extremely high temperatures; it seems, moreover, that a filament which has to be run at a very high temperature must be manufactured at a temperature as high or higher. In no case is this more strongly exemplified than in that of the improved carbon filament recently described by Mr. HOWELL in which the whole superiority seems to be produced by the preliminary high-temperature treatment. The Nernst, osmium and tantalum filaments also all require very high temperatures at some stage or other of their manufacture. The development of electric furnace work and electric heating which has made these temperatures commercially available has put into our hands methods which have already led to most promising results, and seem destined in the near future to produce considerable improvements in electric incandescent lamps.

**Institution of Electrical Engineers.**—The opening meeting of the 1905-1906 session of the Institution has been fixed for Thursday, November 9th, at 8 p.m., when the premiums awarded for Papers read or published during the session 1904-1905 will be presented, and the President, Mr. John Gavey, C.B., will deliver his inaugural address.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Tarifa—Tangier | Jan. 18, 1904 |
| Jamaica—Colon | Jan. 10, 1905 |
| Cadiz—Teneriffe | July 20, 1905 |
| Kotonou—Grand Bassam | Oct. 4, 1905 |

**Great Western and Metropolitan Railways.**—We are informed that the contract for the equipment of the trains on the Hammersmith and City line of the Great Western and Metropolitan Railway Companies has been awarded to the British Thomson-Houston Co. The contract is for 20 trains, the number of coaches per train being six. The equipment will consist of the B.T.-H. type G.E. 76 motor and the Sprague Thomson-Houston system of control.

**Obituary.**—*The Times* of Wednesday announced the sudden death from heart failure, at Barrow, of Mr. H. J. Brown, of the De Forest Wireless Telegraph Co. During that period of the war in the Far East when *The Times* despatch boat Haimun was cruising in the Yellow Sea, Mr. Brown was the operator in charge of the wireless installation on board the steamer. For five trying months he remained at his post, in all weathers and seasons, and was not even daunted when he read off the messages which informed *The Times* special correspondent on the despatch boat that the Russian Government promised to treat both correspondents and operators as spies if they fell into Russian hands. Mr. Brown was an American citizen.

The death is announced of Johann Heinrich Meidinger, chiefly known as the inventor of the Meidinger cell which has been extensively used by the German postal authorities for telegraph purposes. Born in 1829 at Frankfort-on-the-Maine, the deceased studied at the University of Giessen, and, after taking his degree of doctor, travelled for several years in Europe. In 1869 he was elected Professor of Physics at the Carlsruhe Polytechnicum.

**A Curious Shock Fatality.**—Two employés of the North-Western Telephone Exchange Co. of Minneapolis, U.S.A., were recently killed by an electric shock in a peculiar manner. The accident occurred at the junction of the telephone line and the 30,000-volt power line of the Apple River Power Co. With a small linen tape-line in his hand, one man climbed the telephone pole to measure the distance between cross-arms. He tossed the end of the tape-line over the transmission wires, and when he again took hold of the tape death resulted almost instantly. His companion, who stood on the ground and held the other end of the tape-line, was also killed. The hands of both men were scorched, and the feet of the man on the ground were pierced as if from small shot. In searching for the cause of the accident, fellow workmen discovered that, extending longitudinally through the tape line were small steel wires which served to keep the line from stretching, and no doubt conducted the current.

**St. Louis International Electrical Congress, 1904.**—We have received from the American Institute of Electrical Engineers a series of 10 handbooks dealing with the various stopping places on the circular tour organised by the Institute for the reception and entertainment of its foreign guests who visited the United States in connection with the International Electrical Congress, at St. Louis, September 12 to 17, 1904. The books referred to deal with Boston, New York, Schenectady, Montreal, Niagara Falls, Chicago, St. Louis, Pittsburg, Washington and Philadelphia, and were prepared by the local reception committees of the American Institute of Electrical Engineers in those centres. The object of this series was to present to the delegates short historical sketches of the cities visited and a "rapid" survey of the power plants and important electrical industries along the route. There is also an additional volume entitled "Edisonia," being a catalogue of the principal objects of interest in the "Collection of Edisonia" at the Exhibition by the Association of Edison Illuminating Companies. The whole of the 11 volumes are uniformly bound in boards, and each contains on the average some 150 pages of reading matter well illustrated with numerous photographs and drawings. From a knowledge of the contents of these volumes we should say that many electrical engineers in this country would like to possess them.

**Wireless Telegraph Notes.**—The *Electrical World* of New York announces that the European and colonial rights of the American De Forest Wireless Telegraph Co. have recently been sold to an English syndicate. Lord Armstrong, it is further stated, is the chairman of the new company, and it is understood that a number of other prominent financial men are connected with the enterprise. The patents of Mr. Nevil Maskelyne are included in the purchase, and the capitalisation of the new company is £120,000.

Owing to a recent agitation in some of the Opposition papers of the Italian press against the contract between the Italian Government and Mr. Marconi, which grants an exclusive licence to the Marconi wireless telegraph system for 14 years, Mr. Marconi wrote to the Italian Minister of Posts and Telegraphs offering to consider the agreement as cancelled. The reply of Minister Morelli Gualtierotti begged Mr. Marconi not to concern himself about any discordant opinion, which certainly did not reflect either the feeling of the country or that of the Government. This reply confirms the policy of the Italian Government in adopting the Marconi system and refusing to permit compulsory exchange of messages between it and other systems. Compulsory intercommunication was the main point raised during the preliminary wireless telegraph conference held in Berlin two years ago. It is rumoured that the next conference will be held in Paris.

**The United States Patent Office.**—The annual report of the United States Commissioner of Patents shows that the 12 months ended June 30th last was a record year in the history of the United States Patent Office. The receipts of the office were more than a million and a half dollars and the expenditures were a quarter of a million less. The report states that there were received in the last fiscal year 52,323 applications for mechanical patents, 749 applications for designs, 174 applications for re-issues, 1,846 caveats, 11,298 applications for trade marks, 1,236 applications for labels and 448 applications for prints. There were 30,266 patents granted, including re-issues and designs, and 1,426 trade marks, 1,028 labels and 345 prints were registered. The number of patents that expired was 19,567. Allowed applications which were by operation of law forfeited for non-payment of the final fees numbered 5,154. The total receipts of the office were $1,737,334; the total expenditures, $1,472,467, and the surplus of receipts over expenditures, being the amount handed over to the treasury, was $264,667. The most important event which has occurred in the operation of the Patent Office during the last year has been the new trade mark law, which took effect on April 1st. This new law, in extending the registration of trade marks to those employed in interstate commerce and in its reduction of the Government fee from $25 to $10, has stimulated an enormous increase in the trade mark work of the office. The statute also provides for oppositions to the registration of trade marks, which is a new subject of litigation in the business of this office.

**Static Electricity in Ore Dressing.**—In an article in *The Engineering and Mining Journal* of New York Mr. W. G. Swart states that after nearly five years of successful operation, it seems to be generally conceded that the electrostatic ore separator can be counted as being past the experimental stage. This is true, at least, of the Blake-Morscher machine, of which more than 40 are in operation. When a stream of ore particles is dropped through the field between two poles highly charged with electricity of opposite sign, but not necessarily of the same potential, the particles are urged out of their original path and into different directions, with varying degrees of force; the several minerals fall, each into its own receptacle at the bottom. With such an apparatus, our contemporary states, it is possible to separate substances independently of their conductivity. For example, to take materials of approximately equal conductivity, fluorite may be separated from quartz or barite; barite from blende; feldspar from corundum, &c. It must be evident that this enormously widens the field of the electrostatic process; and, when taken in connection with conductivity separations (where the conductivity is either natural or produced artificially), it gives a range covering almost all known minerals. The electrostatic generator has also been made closely to approximate the dynamo in reliability. The machine of the laboratory, running uncertainly a few moments at a time, has given place to mechanically-strong and powerful mica-plate generators, running continuously night and day, in damp and dusty mills. As now used by the Blake Company, all brushes and other moving contacts are abandoned, the field plates being self-exciting. The ozone and nitrogen compounds which are continuously formed are removed as fast as generated by a forced draught of hot, dry air, which also prevents all moisture deposits, so that the machines are now independent of atmosphere or altitude.

**Electric Railway Development in Holland.**—According to the *Electrical World* of New York, the Holland-American Construction Co., incorporated under the laws of the State of New York and backed by Westinghouse interests, has for its object the construction of the most extensive electric railway system ever projected by Americans in Continental Europe. The scheme provides first for the building of a railway from the German frontier to the North Sea. Later on it is proposed to build several branches. The western terminus of the proposed line is Wykan Zee, on the shore of the North Sea, about 3 miles north of the west end of the Amsterdam Canal. The main line is to cross Holland in a south-east direction to Arnheim, about a dozen miles from the German frontier. From Wykan Zee it will run to Zaandam, and thence into Amsterdam. Continuing in approximately the same southerly direction, the main line will cross the canal that connects the Rhine with the Zuyder Zee to Utrecht. From Utrecht the road will cross the lower Rhine Valley to Rhenen, a small town some 5 miles north of the Rhine, where it will turn slightly north of due east to its terminus in Arnheim. It is said that the system may be extended by the construction of branches, so that ultimately the entire lines to be built by the Holland-American Company may aggregate some 250 miles. Wykan Zee, the proposed western terminus of the line to be first constructed, is not now in direct land communication with Amsterdam, but from Zaandam to Arnheim the railway will practically parallel steam lines already in operation. Both goods and passengers will be carried by the proposed railway on its main line and branches. The ballasting of the lines will be in accordance with the best American practice, and the rails will be heavy to permit of high speed. The average speed to be maintained between towns is expected to exceed 50 miles an hour. The road will be constructed on a private right of way, as is necessary under the Dutch laws. It is estimated that the enterprise will involve an expenditure not far short of $5,000,000.

**Measuring the Flow of Water in Rivers.**—In a Paper read before the Boston Society of Civil Engineers, Mr. H. K. Barrows described an electric meter for determining the flow of water in rivers as used by the Hydrographic Branch of the United States Geological Survey. There have been many forms of flow meters used by the Survey in one way or another, but it has been found that the Price electrical meter gives, in general, the best results for river work. This meter is made in two sizes, the smaller size for use at ordinary and low-water stages, and the larger size, which is built stronger, for use when the velocity is high and the number of revolutions of the smaller meter would become too great for counting. The meter is suspended by a double-conductor cable which is heavily insulated. When this cable is new and in good condition it will safely carry a dead weight of 35 lb. or 40 lb. for holding the meter in place. The meter proper consists of cups of peculiar shape, mounted upon a shaft which revolves with a speed proportioned to the velocity of the water. In the Price meter, the shaft is vertical, and the greater part of the weight of the moving parts comes on the lower bearing, which is adjustable by means of screws. The top end of the shaft of the meter is bent slightly so as to give it an eccentric motion as the cups revolve, thus making and breaking an electric circuit as each revolution is made. The primary cell consists of a hard rubber cell with a cylindrically shaped carbon which is connected with a platinum wire extending through the bottom of the cell. The other pole is of zinc extending through a rubber stopper which closes the cell. This cell fits in a case, and is connected in circuit with a buzzer through the contact device of the flow meter. Experiments have shown that with the smaller Price meter, measurements of velocities of less than about 4 ft. per second are not reliable, the chief reason being that the friction of the meter on its bearings grows relatively greater as the velocity decreases. Two important improvements which are now being considered are the use of ball bearings, which should make the low velocity readings much more reliable, and the use of some device whereby, when desirable, only every fifth (or tenth) revolution of the meter will be recorded. This latter improvement will enable the small meter to be used for high velocities, and will result in a greater field of usefulness for it.

**Roller Bearings.**—Mr. F. W. How read a Paper on "Roller Bearings" before the Tramways and Light Railways Association last Wednesday, Mr. A. L. C. Fell being in the chair. Much of the Paper was a repetition of the author's Paper on the same subject before the British Association in South Africa (see *The Electrician*, Vol. LV., pp. 862 and 866), but some new tests and additional information were also given. At Wolverhampton a test was made with a track-cleaning and watering car on the surface-contact system. The energy consumption was carefully measured by means of a Thomson wattmeter, carried on the car both before and after it was fitted with roller bearings, the respective average results being 2·7 units per car-mile with plain bearings and 2·3 units per car-mile with roller bearings. On the Croydon Corporation tramways the tests were made on October 8th and 9th, upon two cars, one being fitted with roller bearings and the other with ordinary phosphor-bronze bearings, the weather and track conditions being precisely the same. The two cars selected were those of the double-deck Brill maximum traction truck type, identical in general construction, and weighing, when empty, 10 tons. During the tests both cars were loaded (inside) with 3 tons dead weight, equal to, say, 53 passengers. For the purpose of measuring accurately the current and energy consumed, a recording ammeter in series with a wattmeter was used, and the route covered in each case was 11 miles. In the case of the car fitted with ordinary bearings 47 stops were made, and the energy consumed was equivalent to ·90 units per mile run. In the case of the car fitted with Empire roller bearings 44 stops were made, the energy consumed being ·75 units per car mile. Records have been kept of the runs of these cars from the start, and between October 1st, 1904, and September 30th, 1905, 14 of the bogie cars on the Croydon system, fitted with roller bearings, travelled 545,898 miles, and one car, fitted with ordinary bearings, ran during the same period 30,988 miles, the total mileage run by the 15 bogie cars being 576,886 miles. Assuming that the 14 bogie cars had not been fitted with roller bearings, the extra energy consumed, based on the difference as obtained from the two tests, would have amounted to 79,155 units, and, at the price paid for the same—namely, 2d. per unit—would have cost £659. 12s. 6d., or £47. 2s. 4d. per car. Taking the cost of renewals at 10 per cent. per annum, which is a liberal allowance, and a further 10 per cent. for depreciation, there still remains a saving of £37. 14s. per car per annum, due to the employment of roller bearings. As regards the cost of roller bearings, Mr. How stated that it had been considerably reduced of late, owing to the possibility of casting the "floating cage" so accurately that the expensive machining and fitting, formerly imperative, could be dispensed with.

In the discussion on the Paper, Prof. Carus Wilson remarked that the journal friction proper varied from 1 lb. to 2 lb. per ton, the figure usually adopted by him being 1·3 lb. per ton. He agreed with Mr. How that the application of rollers reduced this friction in the ratio of about 6 : 1, so that the roller bearings saved about 1 lb. per ton in tractive effort. The saving at starting was small, because the time required to start a car was so short. Hence the percentage of saving due to roller bearings was larger the longer the run. At high speeds the air resistance was considerable, and for this reason the saving that could be effected by employing roller bearings formed only a small percentage of the total energy of propulsion. He calculated that the saving of energy in a car running at 35 miles an hour was 13 per cent., while the corresponding figure in the case of a car running at 10 miles an hour was 33 per cent. He concluded that roller bearings showed to best advantage on long and low-speed trains running on a good track. Mr. John Rider questioned whether the saving obtainable on high-speed tramways was worth the extra expenditure involved. He asked if roller bearings with a split cage were made. Mr. C. Watson mentioned that good results had been obtained in Birmingham with roller bearings. Mr. E. W. Dickinson mentioned that he had run a car at Peterborough, similar to one at Southport, but fitted with plain bearings. The consumption at Southport was found to be 0·562 unit per car mile, while the figure at Peterborough came to 0·565 unit per car mile, showing a very small saving indeed in favour of roller bearings. For railways, however, the bearing stood a better chance. He considered Mr. How's estimate of 2d. per unit far too high. Mr. A. L. C. Fell remarked that the roller bearings which were fitted seven years ago to some cars in Sheffield were still running, and had not cost a penny in repairs. Roller bearings were of special advantage for the shafting of workshops. He was surprised at the extraordinary high consumption figures on the Wolverhampton tramways, due, no doubt, to the system adopted. Mr. How, in reply, said that he considered Prof. Carus Wilson's figure for the journal friction too low. 6 lb. to 7 lb. per ton being nearer the mark. The best results were obtained with roller bearings on level track, and where the gradients were very severe plain bearings might possibly be preferable. Split cages were not supplied, although a number had been made for the Liverpool Corporation tramways, and had given satisfactory results in connection with the motor suspension bearings. In defence of the cost figure of 2d. per kilowatt-hour, he mentioned that this figure was not exceptional, the London County Council, for instance, paying more than this at present.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-day) **FRIDAY, October 27th.**

PHYSICAL SOCIETY.

*5 p.m.* Meeting at the Royal College of Science, South Kensington. Agenda: (1) "The Theory of Phasemeters," by Dr. W. E. Sumpner. (2) "Apparatus Designed for measuring the Coronal Radiation during an Eclipse," by Prof. H. L. Callendar, F.R.S.

JUNIOR INSTITUTION OF ENGINEERS.

*8 p.m.* Annual General Meeting at the Westminster Palace Hotel.

**THURSDAY, November 2nd.**

RÖNTGEN SOCIETY.

*8:15 p.m.* Ordinary General Meeting at 20, Hanover-square. Paper to be read: "The Ruhmkorff Coil," by Prof. Wertheim-Salomonson.

**FRIDAY, November 3rd.**

JUNIOR INSTITUTION OF ENGINEERS.

*8 p.m.* Meeting at the Westminster Palace Hotel. The President, Mr. Dugald Clerk, will deliver his Inaugural Address on "The Problems of the Gas Turbine."

**SATURDAY, November 4th.**

GLASGOW TECHNICAL COLLEGE SCIENTIFIC SOCIETY.

*7:30 p.m.* Meeting at Glasgow and West of Scotland Technical College, George-street, Glasgow, Paper to be read: "Electric Power Plant Design," by P. D. Ionides.

## STREET LIGHTING IN LONDON.

At our request Mr. Frank Bailey has sent us complete particulars of the photometric tests which have been made on the old and new street lamps in the City of London. They are set out in the Table below.

From these tests Mr. Bailey deduces the following comparative figures, the cost of the gas lighting being taken from the *Journal of Gas Lighting* :—

| | Average total cost per c.p. per annum. |
|---|---|
| *Gas.*—Double burner, ordinary low pressure incandescent (mean of six tests) | 11·1d. |
| Single burner, high-pressure gas | 9d. |
| Double burner, „ „ | 11·7d. |
| *Arc Lamp.*—Old lantern | 8d. |
| Flame arc | 5d. |

It must be noted, however, that whereas the cost of the electric arc is quoted including all charges of maintenance and interest and redemption of capital, in the case of the gas lamp the cost is solely for maintenance charges—that is to say, the supply of gas and mantles only, and it does not include any portion of the capital cost of providing posts, mains or fittings; and further, the hours per annum for the use of electric arcs are fixed at 4,473, but the hours of burning adopted for the gas lighting have been observed to be less.

These tests were made on a clear night under normal conditions. The candle-power measurements were in each case taken at a horizontal distance from the light equal to twice the height from the ground level, thus enabling positions to be taken, whereby the lamp measured was the only light in line with the photometer screen. Photometer measurements were made with a Flicker photometer mounted in a van with an aperture in the end. An incandescent electric lamp controlled by an adjustable rheostat, voltmeter and ammeter was used as the standard, and this lamp was standardised immediately before tests by means of the pentane and the Fleming standards. Heights and distances were directly measured by steel tape; angles were read off the photometer head by the focussed light rays from the light tested. Readings were taken by three observers, and every precaution was taken to ensure accuracy.

From these tests of candle-power Mr. Bailey has estimated the illumination at a distance of 100 ft. from the source as follows :—

| | Candle-feet. | Ratio. |
|---|---|---|
| Double ordinary incandescent gas-lamp illumination | 0·013 .. | =1·0 |
| Single H.P. „ „ „ | 0·016 .. | =1·24 |
| Double H.P. „ „ „ | 0·027 .. | =2·10 |
| Ordinary arc lamp | 0·060 .. | =4·50 |
| Flame arc lamp | 0·120 .. | =9·0 |

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The photometric tests sent us by Mr. Frank Bailey, and published in the above article, show once more what little credence can be given to estimates of candle-power made by parties whose interest in the matter must of necessity unconsciously influence their judgment. Statements circulated by the gas companies with regard to the candle-powers of the gas and electric lamps in the City of London are proved to be most inaccurate by these measurements. For instance, the figures circulated by the company gave the average candle-power of the new Fleet-street gas lamps as 5,000÷34=147; the test of one of the lamps with a new mantle gave 129 c.p. On the other hand the old electric lamps in the City are said to have an average candle-power of 6,000÷12=500, whereas actual measurement shows 659. Multiplying the candle-power by the number of lamps, the total for Fleet-street with gas is 4,390 and with the old electric lamps 7,910. No wonder the present lighting is dim in comparison. These figures for electric light refer to the old arcs in the old lanterns, so that open or enclosed arcs in efficient lanterns would give far better results, and flame lamps would be still more brilliant.

The cost, light for light, works out enormously in favour of the electric lamp, and some electrical engineers will be of the opinion that a still cheaper price for electricity might have been assumed. We have already given estimates of what should be the cost of 10-ampere lamps maintained in a street such as Fleet-street, and, as we write, yet another comes to hand confirming previous estimates, although from a different source :

Production and management costs :—

| | | £ | s. | d. |
|---|---|---|---|---|
| 500 watts × 4,400 hours = 2,200 units at 0·6d. | = | £5 | 10 | 0 |
| Carbons, trimming and cleaning | = | 4 | 8 | 0 |
| Depreciation on buildings, plant, mains, switchgear, pillars and lamps (viz., 2¾ per cent. on £85 per lamp) | = | 2 | 7 | 0 |
| | | £12 | 5 | 0 |
| Profit = 5 per cent on £85 | = | 4 | 5 | 0 |
| Total | | £16 | 10 | 0 |

The load factor of the supply would be about 50 per cent., so that low production costs would be assured.

On this basis the total cost of electric lighting in Fleet-street would therefore be = 12 × £16. 10s. = £198 for 8,100 c.p. of illumination, as against gas at £207 for 5,100 c.p. of illumination.

In addition to the small success in the City, which will evidently only be short-lived, as the gas lighting is only an experiment, the gas interests have secured a more glorious victory in the contract for the lighting of Aldwych and Kingsway. It has been given as a reason for the adoption of the poorer lighting by gas instead of electric lighting, that the tenders of the electric lighting companies were too high. Certainly they were high, and we are of opinion that if they had been made now instead of 18 months ago the figure would have been much lower. Yet it must not be forgotten that the contract was to be only for five years, and that an expensive standard of special design was asked for in the specification given to the electric lighting companies. The tenders asked for from the two electric lighting companies were for 1,000 c.p. lamps, and the two companies specified 10 and 12 ampere arcs respectively. We do not know whether, in deciding the award of the contract, the Westminster City Council assumed that the same number of electric lamps would be required as the number of gas lamps chosen. This would not have been right, for a high-pressure gas lamp guaranteed to give 700 c.p. is far less effective for illuminating a wide street than a 10 ampere arc. Here again, flame lamps would have carried the day almost without a contest. Possibly they will be adopted eventually in the new thoroughfare, for the lighting will not be any too bright when the present lamps are old.

*Photometric Tests on Street Lamps in the City of London.*

| Lamp. | Position. | Height from centre of light to ground surface. | Horizontal distance of photometer from lamp. | Slant distance from photometer to light. | Height of photometer screen above ground level. | Angle of light rays to horizontal plane. | Angle of incidence of light rays to ground. | No. of tests made. | Mean candle power. |
|---|---|---|---|---|---|---|---|---|---|
| * Gas. Double burner. Ordinary low pressure gas (incand.) .. | Nos. 121–122, Fleet-street | 10 ft. 10 in. | 21 ft. 8 in. | 22 ft. 2½ in. | 6 ft. 2 in. | 11·5° | 78·5° | 6 | 129·1 |
| * Gas. Single burner. High pressure gas (incand.) | N.E. corner, Monument-sq. | 11 ft. 10 in. | 23 ft. 8 in. | 24 ft. 4 in. | 6 ft. 2 in. | 12·0° | 78·0° | 6 | 150·4 |
| * Gas. Double burner. High pressure gas (incand.) | No. 97, Queen Victoria-street | 14 ft. 0 in. | 28 ft. 0 in. | 29 ft. 1 in. | 6 ft. 2 in. | 15·0° | 75·0° | 3 | 244·5 |
| † Electric arc. Old type lamp, lantern and glass | Upper Thames-st. Lamp No. B. 44. | 18 ft. 6 in. | 37 ft. 2 in. | 39 ft. 2 in. | 6 ft. 2 in. | 18·0° | 72·0° | 8 | 659·4 |
| ‡ Electric arc. Flame lamp. .... | Blackfriars Bridge approach | 18 ft. 6 in. | 37 ft. 2 in. | 39 ft. 2 in. | 6 ft. 2 in. | 18·0° | 72·0° | 6 | 1,317·0 |

* Mantle in good condition, evidently new. † Arc normal and similar to all other arcs in the street.

‡ Arc in fairly good order, but not the best of the set of four lamps. The other three lamps were difficult to test owing to their mutual influence.

NOTE.—The candle-power of the arc lamps is, of course, much greater at an angle of about 45°.

## EARTHED AND UNEARTHED RADIATORS IN WIRELESS TELEGRAPHY.

BY W. H. ECCLES, D.Sc.

Recent commendations of certain new Lodge-Muirhead wireless telegraph stations equipped with insulated oscillators and resonators of the 1897 English patent, make the moment opportune for a brief review of the reasons and facts that have made the use of the earthed radiator almost universal and the use of one unearthed rather exceptional. A plain statement of the present position of the rival cults—the earthed and the unearthed—in the light of widely-accepted theory, can be made and is best made without recourse to mathematics.

In the early days of Hertzian space telegraphy (say 10 years ago) the solution of the signalling problem was expected in the employment of straight beams of electrical radiation. The electric rays used, produced of course in the Hertzian manner, were to be projected in any desired direction and were to be capable of penetrating all obstacles between sender and receiver. Hence it was that radiation of short wave length generated at the focus of a parabolic mirror was the vogue among the "wireless" experimenters of that day. It was probably in an endeavour to get a bigger output of radiation per spark that Marconi in 1895 connected large insulated conductors—storehouses—to one side of his oscillator. Contrary, perhaps, to what he had expected, signals were better when these insulated conductors were lifted to a distance from the earth (and their capacity thus reduced), and better still when the far side of the spark-gap was earthed. In fact, capacity in itself seemed of so little account that the large elevated conductor could be removed and the connecting wire left supported alone in the air without greatly diminishing the strength of signals. Thus Marconi followed Popoff, without copying him, to the use of the plain earthed air-wire, originally designed, it seems, by Popoff for other purposes than wireless telegraphy.

The scientific basis, as we understand it, of these rapid successes of Marconi has been given numberless times. We see clearly enough now that it supports Marconi's own opinion that his success was largely due to the use of the earthed air-wire. It is necessary here to write down once again the virtues, as oscillator and radiator, of the long vertical earthed air-wire. Put shortly, its merits are: First, its great length ensures slow vibrations, and therefore long waves; second, it sets the waves up so that the electric force in a wave front is, from the very beginning, in a vertical plane; third, what is partly implied in the last, it attaches to the surface of the earth the free ends of the moving lines of force; fourth, it is a good radiator (and absorber). Long waves are advantageous, largely for reasons connected with diffraction; the setting vertically of the electric force near the earth avoids losses such as would otherwise occur from the generation of profitless currents in the earth's substance; and the attachment of the waves to the earth's surface prevents them straying wholly into space and gives them such guidance (similar to that given by a wire to the current it carries) as enables ranges of hills to be surmounted without suggestion of penetration. But the air-wire's power as a good radiator, valuable at a time when the object was to "get there," has become in this era of syntonic ambition its chiefest fault if it is in itself the whole oscillator; for, as has often been explained, rapid radiation shortens enormously the train of effective waves, if, as must be in the case of the simple air-wire, the energy stored electrostatically, just before each spark, is small. There is no need to do more here than mention that by using a closed (non-radiating) oscillator of great energy-capacity to feed a simple air-wire, sustained trains of waves can be emitted, and the earthed air-wire thus retained in its old post of honour.

At a very early stage of this story, Lodge seems to have perceived this inadequacy of the simple air-wire for syntonic working; and, at least as early as 1897, was using in preference a symmetrical Hertzian wave-maker. Forms of this apparatus in successful work to-day have been described recently in *The Electrician.* The one at Heysham, for example, consists of two horizontal conducting plane areas about 80 ft. square, one vertically above the other and connected to it by a vertical central wire about 80 ft. long. The lower square is about 3 ft. from the ground, and, like the upper, is insulated. The vertical wire is interrupted at its middle by a spark-gap. This structure is, from its geometrical configuration, a slower radiator than a simple air-wire, and gathers before each spark a much greater charge. For both reasons it produces trains of waves more sustained than those of an air-wire. Moreover, it possesses most of the merits of the plain air-wire: It makes very long waves, and it sets them up with their moving lines of force in vertical planes. But it fails in this—that it does not attach the waves to the earth's surface. The waves have to do that for themselves, as they may do, when free later on. To compensate for this, however, there stands the complete freedom from earth connection. What this means can only be appreciated by recalling *one*, let us say, of the difficulties that beset the radiator that is earthed—namely, the variability in the goodness of the "earth."

This variation of quality of "earth" did not matter so much in untuned working, but in tuned telegraphy it is more important; and when making comparisons with the Lodge-Muirhead wavemaker we must look to tuned systems. Suppose, then, that in a syntonic transmitter the radiator is tuned to the closed feeding circuit when there is a good earth, and that by some means the earth goes bad—*i.e.*, acquires an unwonted resistance. Then, inevitably, foreign overtones, of kind and strength depending on the badness of the earth, are introduced into the vibration. These overtones are produced at the expense of the fundamental by reflection, at the resistance, of the pulses descending the air-wire. There is, besides, absorption of energy in the resistance; indeed, it has been shown both theoretically and experimentally that with a certain critical resistance the absorption of the vibrations in the resistance may be extremely rapid. If this last condition is ever happened upon in practice, it must be of serious import even where forced vibrations of the correct period (namely, that of the distant receiver) can be maintained upon the transmitter air-wire by a heavy feeding system behind it. All these considerations apply with equal or even greater force to the earthed absorbing wire of the receiving system. Hence, it will be seen, to be earth-free is something worth striving for. Thus the question is, Does the attainment of this desideratum by the Lodge-Muirhead wavemaker compensate fully for the fact that the waves as at first emitted are free, that is, unattached to the earth's surface?

If one traces in imagination the movements of the lines of electric force near the Lodge-Muirhead radiator when in action, one concludes that the lines which detach themselves from the conductor to form waves appear as rings situated in vertical planes passing through the vertical central wire, moving outward horizontally with the speed of light and expanding as they go. They will resemble, in fact, the rings familiar to us in diagrams of the ordinary Hertzian oscillator, but will probably be more distorted than those in the pictures and will include a smaller proportion of the whole number of lines of force initially present in the fully-charged oscillator. As each ring moves forward and expands, its lower bend strikes the earth and is reflected or absorbed there. If the earth's surface were of very good conducting material, the lower half of each ring would ultimately be folded up towards coincidence with the upper half. Now, in this process of reflection, the direction of the horizontal component of electric force is reversed. Thus high reflection at the earth's surface would involve considerable strengthening of the waves near the earth—just where strength is wanted. As a matter of working experience, this strengthening by reflection seems not to be experienced at the earth's surface in any degree so completely as has just been indicated; but it is well admitted that the earth's surface cannot be supposed a perfect conductor. The folding up of the lower half of each looped line of force is probably very incomplete. Allowing for this, it seems possible that perhaps one-half of the whole wave energy—the half carried in the lower portion of each ring of force—may be wasted ohmically in the earth comparatively near the radiator. On the other hand, the earthed radiator, placed normally over a conducting sheet (the earth to which it is connected) detaches, in the popular theory, half-rings, which move outwards in vertical radial planes, with their cut ends sliding perpendicularly over the conducting plane. This arrangement seems ideally perfect. But here, again, the earth's surface is, in reality, not a good conductor. Therefore, in the very act of electrical vibration—which may be interpreted, as is well known, in terms of positive and negative reflections of electricity at the top *and bottom* of the earthed air-wire—great wastage may occur before the detachment of the waves. In both cases lines of force travelling over a bad conductor must acquire a forward slope which will involve the propagation of energy into the earth, or, to put it in another way, will involve the creation of currents in the earth's substance with consequent ohmic losses. Taking all this into account, however, as well as may be done by these descriptive methods of examining the question, the advantage, on the whole, seems to lie with the earthed radiator. The conclusions we are driven to amount, in fact, to these: That in the case of the Lodge-Muirhead radiator working over the badly-conducting earth a 50 per cent. ohmic loss of the whole output of radiation is possible; whereas with the earthed radiator there are losses in vibrational energy, amounting probably to a smaller figure.

Data are so difficult to obtain, are, perhaps, to-day, so impossible of obtainment, that calculation promises at present no trustworthy answer to these questions. The only appeal is to experiment. Up to now no experiments of value on the Lodge-Muirhead apparatus under notice have been published. The results of a few tests were given recently by Lieut. Evans in *The Electrician*, but he disclosed no details of the methods he had used for measuring currents, for instance, in transmitter and receiver. Now a great deal depends on how and where the measurements of current and potential are taken. But even were his methods of measuring shown justifiable, no conclusion of any kind can be drawn from his experiment of earthing (badly or otherwise!) the lower half of a Lodge-Muirhead oscillator and noting the results on current in it or in a resonator. Any experiments that are to afford valid data must be planned and executed with great judgment. And since the mere introduction into an oscillating circuit of measuring instruments possessing high resistance, capacity, or inductance may cause nodes to move and may encourage undesirable overtones, the description of methods and apparatus must be very careful and complete if discussion is to be profitable.

## ELECTRICITY METERS.*

BY C. H. W. GERHARDI.

(*Continued from page 1032, Vol. LV.*)

*Testing Stands.*—Where plain tables are provided, some form of testing stand will be necessary. A very useful form of stand for holding meters when being tested is shown in Fig. 134 in front and side view. A stand somewhat similar to the one illustrated was used some years ago by the British Thomson-Houston Co. for the Thomson meter, and the one illustrated is also used for that type. This meter in the old type is a rather awkward one to erect temporarily unless it is screwed up to a batten fixed to a wall, in which case the continual insertion of screws would soon make it necessary to have a new batten. On the stands, however, it is easily fixed. The weight of the meter is taken by the two brass brackets on which the terminal box rests, whilst the milled-head screw in the brass angle-piece to the left clamps one of the top lugs of the meter. To make the meter firmer on the stand, the right-hand lug is also clamped by means of the loose clamp shown. To the back of the stand a batten is fixed vertically by means of sash screws, so that it is easily detachable. On this batten at a suitable height is a headless nail slightly bent up, upon which "hanging" meters are hung.

The stands are made of teak, the base being 1½ in. thick, 12 in. deep and 12 in. wide, the back 1 in. thick, 13 in. high from the top of the base; the batten is 2 in. deep by 2½ in. wide by 19 in. long, and stands 12 in. above the top of the back.

The stand—resting on three points, two in front and one in the centre behind—is always firm on the table, and can be levelled by means of the milled-head screw at the back. If countersinks are let in flush in the table top, the stands are kept in a line, and the weight of the stand and meter prevents side slipping if any slight adjustment of the meter is required.

These stands will hold most types of meter. They have been found equally suitable, without any special fixing for meters of the following types:—Aron, Bat, Bastian, Brush-Gutman, Eclipse (all types) Electrical Companies (all types), O.K. (including prepayment), Scheeffer, Shallenberger, Shuckert, Stanley, Thomson (all types), Vulcan, Westinghouse, Wright, &c.

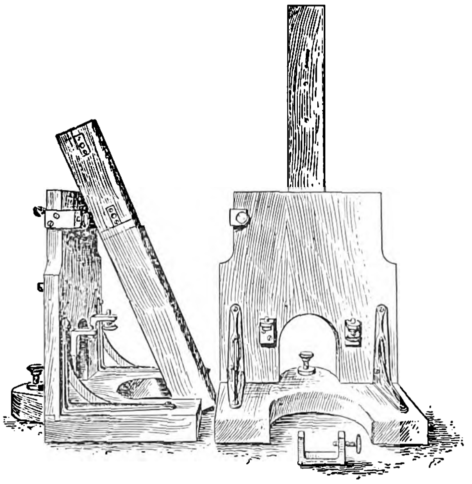

FIG. 134.—STANDS FOR SUPPORTING METERS WHEN TESTING.

A further advantage possessed by such stands is that they enable a set of meters of different types to be erected in series if required for the purpose of comparison under absolutely similar conditions of current.

Fig. 135 shows a table and set of stands, each holding a different type of meter. This view also shows the shunt leads already referred to in use; also the position of the Kelvin balance at the end of the table with magnifying glass for reading the index from any point along the table. Fig 136 is another view of the same table, the stands being removed and a set of "standing" meters connected up for a "long run" test.

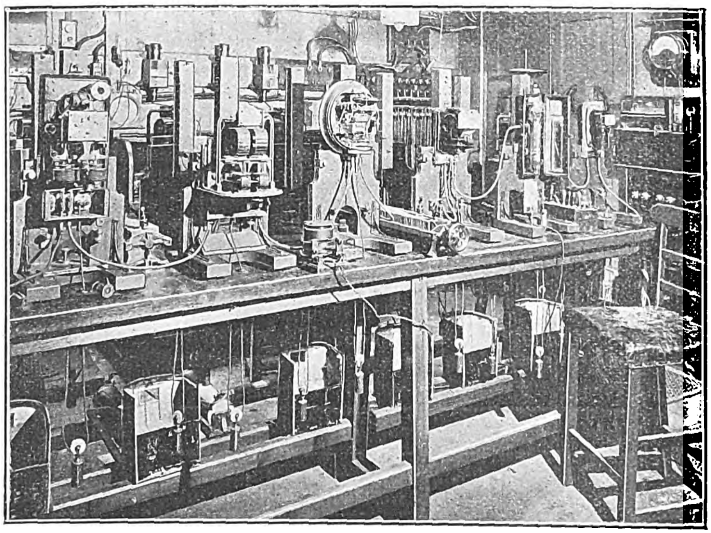

FIG. 135.

TEST TABLE WITH STANDS, SHOWING THE ADAPTABILITY OF THE STANDS TO DIFFERENT TYPES OF METERS; ALSO THE POSITION OF KELVIN-WATT BALANCE AND REGULATING RHEOSTATS.

These stands may also be used for ammeters and voltmeters, making a most convenient support for such instruments. The ordinary switchboard ammeters which are provided with back connections in the shape of rods are somewhat awkward to fix, but with the stand the rods either go through the hole in the stand back, or, if too wide apart for that, they most probably clear the batten and can thus be fixed to it.

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*Meter Store.*—As with the test tables and supports for meters in the test room it is important to provide suitable appliances for use with many and varied types of meters, so it is equally important in the store to provide racks for storing meters of many shapes.

Hanging meters—*i.e.*, those which have a central top lug, may be conveniently stored by simply having horizontal battens fixed to upright ones firmly fixed to the walls and fixing screws (round-headed for preference) at certain distances apart on the horizontal battens, the screws being screwed "half-home." For the centre of the store frames running the length of the room and carrying similar battens could be used. There are, however, several objections to such an arrangement. In the first place many meters are not provided with the central lug, and even with those which have it, the spacing sideways and the vertical distance apart of the battens becomes a difficult matter to settle owing to the varying sizes of the meters. To make matters worse, it would be found that the lugs of the meters would have varying-sized holes, so that it would be impossible to choose a screw which would suit all, if indeed one could be found to suit any two.

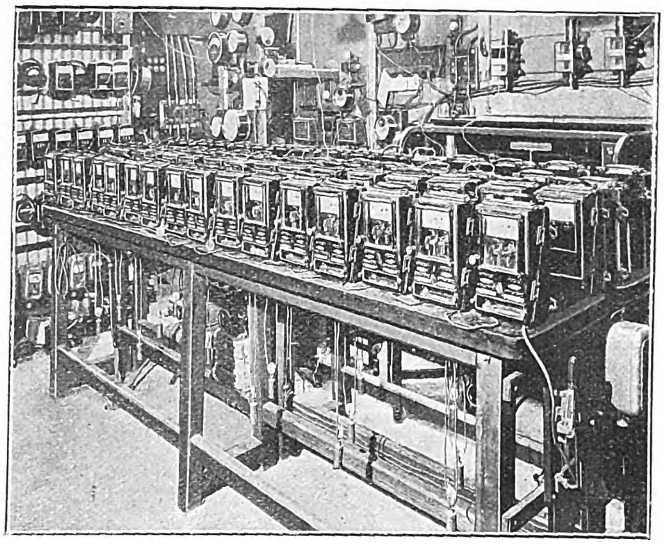


FIG. 136.

TEST TABLE WITH STANDS REMOVED FOR A SET OF "STANDING" METERS ON A "LONG RUN" TEST.

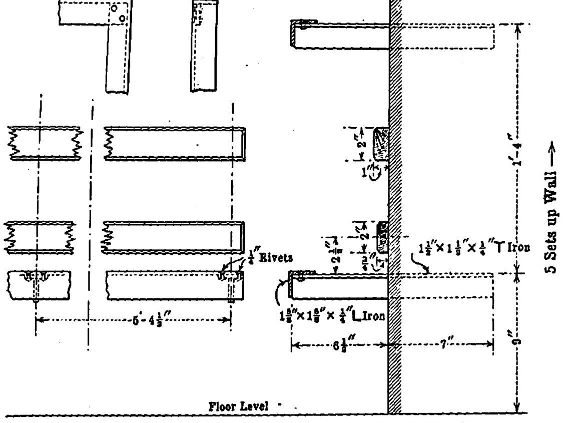


FIG. 137.—WALL RACKS.

For storing on battens as above, it is necessary for the meters to be provided with a ⚲ shaped hole, as otherwise the lug would not slip over the head of the screw. Such a system, therefore, is only suitable for very few types. It is, however, a convenient one to use with Bastian and Wright electrolytic meters, and Wright demand indicators. If, instead of using wood, iron be employed, the system becomes far preferable from a fire point of view.

Shelves are not altogether convenient for the storing of meters, owing to the fact that so many types do not stand, and would require to be laid on their backs. The storing of meters on their backs is a thing to be avoided, as when so laid it becomes very difficult to see the dials, numbers, &c.

A modified form of shelf rack, which has been found universal, is shown in Figs. 137 and 138. These racks were designed by the writer some years ago, and have been found to answer the purpose well.

The wall racks (Fig. 137) are extremely simple. A tee iron, 1½ in. by 1½ in. by ¼ in., is let into the walls at intervals of 5 ft. 4½ in., and an angle iron 1⅝ in. by 1⅝ in. by ¼ in. is laid along on the ends of the tee irons, and flush riveted to them. Along the wall, as shown in the drawing, are fixed battens of wood to protect the wall from being chipped by the meters when placed on the racks.

The centre double racks (Fig. 138) are very similar as to dimensions, but, instead of tee iron, flat iron is used for the supports of the angle irons, which are of the same size as in the wall racks. H-iron girders, 2 in. by 2 in. by ¼ in., extend from floor to ceiling 5 ft. 5 in. apart, and are, if possible, bolted by angle pieces to the floor girders top and bottom. To these are riveted the brackets formed by the flat-iron strips. Flat strips braced at intervals are riveted to the H-iron supports and take the place of the wooden battens in the wall racks. A distance of 1 ft. 4 in. has been found convenient between tiers; this makes the top tier of five, 6 ft. 1 in. from the ground, if the lowest rack is 9 in. above the floor level; it is, therefore, possible for an average-sized man to put meters on the top rack without the aid of steps.

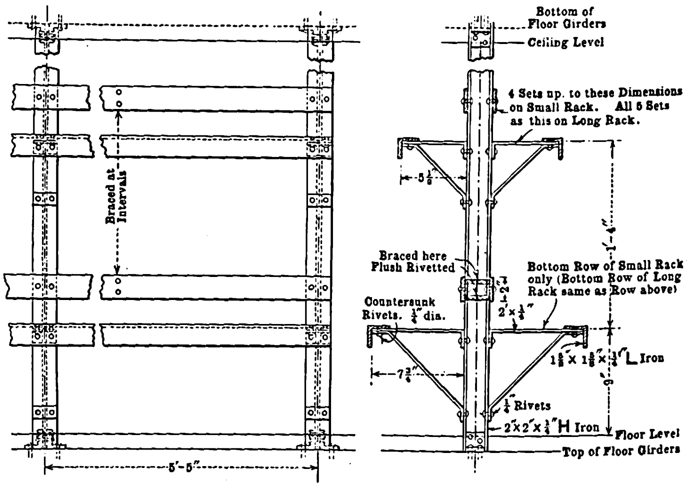

Braced at Intervals
5'-5"
Bottom of Floor Girders
Ceiling Level
4 Sets up to these Dimensions on Small Rack. All 5 Sets as this on Long Rack.
5½"
1'-4"
Braced here Flush Rivetted
2¾"
Bottom Row of Small Rack only (Bottom Row of Long Rack same as Row above)
Countersunk Rivets. ¼" dia.
2"×¼"
1⅝"×1⅝"×¼"L Iron
7¾"
9"
¼" Rivets
2"×2"×¼"H Iron
Floor Level
Top of Floor Girders

FIG. 138.—DOUBLE RACKS.

*Small Store.*—For the storing of spare parts of meters, wire, backing boards, and other sundries, it is very necessary to provide a small room, or a large cupboard fitted with wide shelves. This apartment should be adjoining the office, as it then becomes quite easy both to keep the costs of repairs, and a check on the stock of these sundries. This store should be provided with as many shelves as it is convenient to place in it.

(*To be continued.*)

**The Power of Niagara Falls.**—In a recent ruling in favour of the right of the Niagara, Lockport & Ontario Power Co. to acquire certain lands, the referee made some interesting statements about the effect of power development on the cataract. He said that the development of 200,000 H.P. at Lockport would not endanger the Niagara River. The diversion of 4,500 cubic ft. of water every second by the Lockport Company, at the point where it proposes to divert the water, would not lower the level over the American falls more than 1 in.; and that the diversion of 9,000 cubic ft. every second would not lower the level over the American falls more than 3⅒ in. He added that the lessening of the depth of the Niagara River from 3 in. to 6 in. would have no injurious effect upon its navigation, as the shifting winds often produce equally as great, if not greater, diminution of its depth.

## ELECTRICAL EXHIBITION AT OLYMPIA.

(SIXTH NOTICE.)

The Exhibition was closed on Saturday last. On Friday evening the awards in the Cookery Appliances Competition were announced as follows :—

I. For the best apparatus to fit up a complete kitchen :

*A First Prize of £50* to Messrs. VERITYS LIMITED, of King-street, Covent Garden, London, W.C., for the "Aston Electra" apparatus.

*A Second Prize of £20* to the BRITISH PROMETHEUS CO. (LTD.), of 18, London-road, Kingston-upon-Thames.

II. For the best single piece of apparatus :

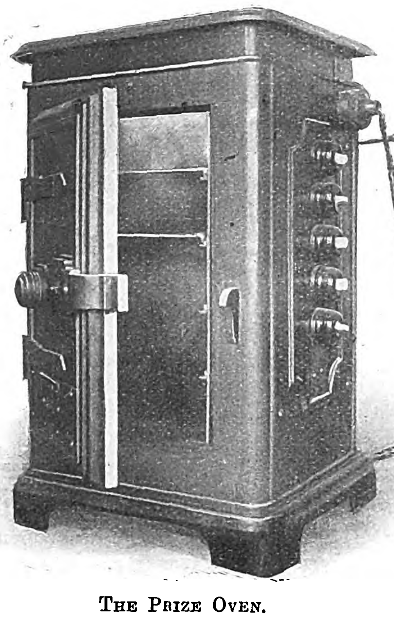
*A First Prize of £20* to the DOWSING RADIANT HEAT CO. (LTD.), of 24, Budge-row, Cannon-street, E.C., for an electric oven containing three different methods of heating.

*A Second Prize of £10* to the BRITISH PROMETHEUS CO. (LTD.), of 18, London-road, Kingston-upon-Thames, for an electric oven.

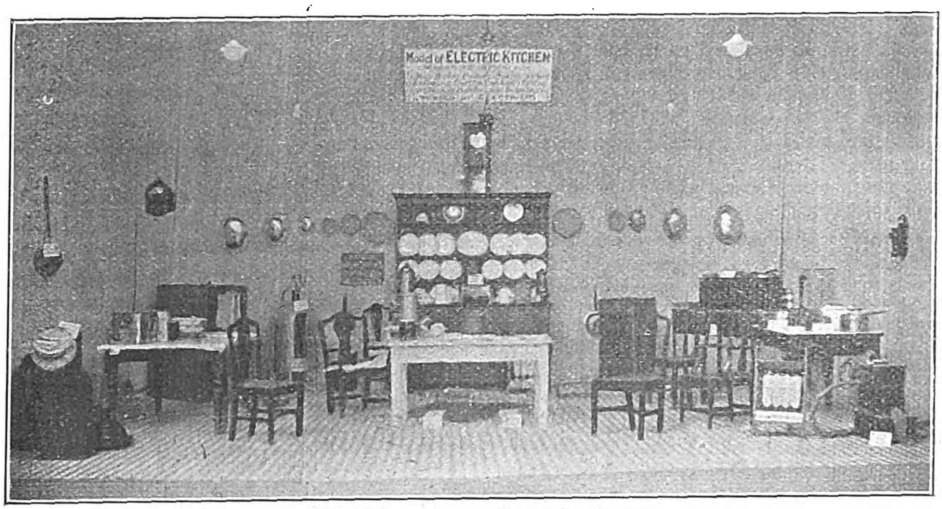
The judges further recommend to the executive committee that a Special Extra Prize be awarded to Mr. H. J. DOWSING for his design of a completely equipped kitchen.

(Signed) W. H. PREECE.
SYDNEY W. BAYNES.
SYDNEY T. DOBSON.
J. E. EDGCOME.
C. O. GRIMSHAW.
H. W. MILLER.

The apparatus gaining the first prize was similar to that used in the Cookery Lectures and described on pp. 987 and 988 of our issue of October 6th. The Prometheus apparatus was referred to on p. 28 of our last issue; the same type of heating elements, consisting of films of metals between mica sheets, is used for the cooking appliances as well as for the radiators. Some patterns of the Dowsing Company's cooking stoves and utensils were described in our issue of October 13th, p. 1028, and the complete kitchen which Mr. Dowsing opened in the annexe last week is illustrated below. It contained a large variety of electrical cooking apparatus, and was in active work during the last days of the Exhibition. The oven which gained the first prize for the best single piece of apparatus is one in which both flat heating elements and heating lamps are made use of. The flat heating elements are made up of thin sheet metal stamped in the shape shown in our third illustration below, and placed between strips of mica. Owing to its zig-zag shape the metal can expand and contract freely, and there is no enamel around it to crack. These strips are connected in groups in series, and are fixed to metal sheets which form the lining of the sides and bottom of the oven, the "top heat" being furnished by the long-shaped lamps with reflectors behind them.



THE PRIZE OVEN.



MR. DOWSING'S MODEL ELECTRIC KITCHEN.

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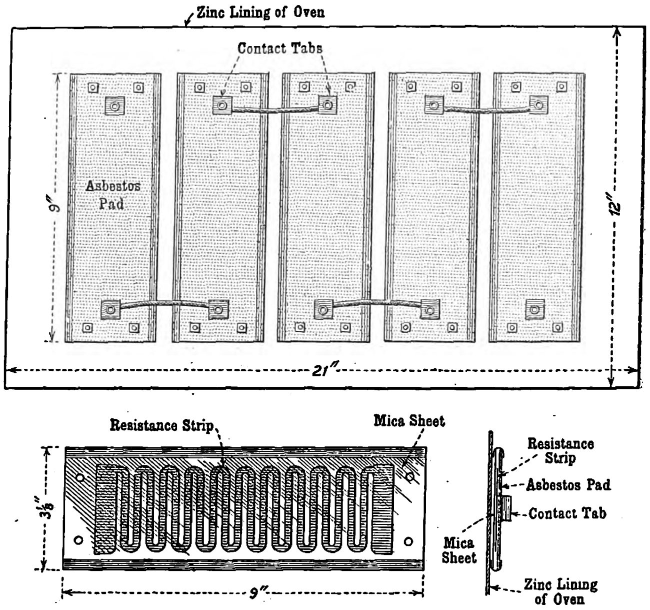
On Friday evening Mr. F. Gill gave a lecture on telephony.

Omitting the usual historical sketch, the lecturer proceeded at once to explain the action and mechanism of modern telephones. The formation of a magnetic field around an electromagnet, the attraction of iron bodies by such magnets, the vibrations set up in an iron diaphragm close to the poles of the receiver magnet by the telephone currents, the action of loose contacts in the way of increasing and decreasing the contact resistance when compressed by the sound waves emanating from the caller's mouth and other fundamental principles were explained with the aid of working models thrown on the screen. A number of oscillograms of the current ripples corresponding to a few simple sounds were also projected on the screen, the oscillograms having been taken by Mr. Duddell's well-known apparatus. Another set of oscillograms demonstrated to the audience how the original current impulses decreased in strength and became distorted along the



GENERAL ARRANGEMENT OF SIDE OF DOWSING OVEN, AND EXAGGERATED SECTION SHOWING DETAILED PLAN OF HEATING ELEMENT.

line. The construction of a telephone cable was then gone into, after which the lecturer showed, with the aid of a number of diagrams, the manner in which a telephone system works. By means of a series of photographs he next traced the successive movements of a telephone operator connecting subscribers, and he also showed views of street work, photographs of the interior of telephone exchanges and other illustrations. Turning, finally, to the more commercial aspect of telephony, he remarked that many a busy subscriber was satisfied with a single telephone, and was loth to have another added, although he might be turning business away and giving the exchange much useless work as a result. As an instance, he cited a case in which more than 400 calls for a certain subscriber had to be answered by "engaged" during one day.

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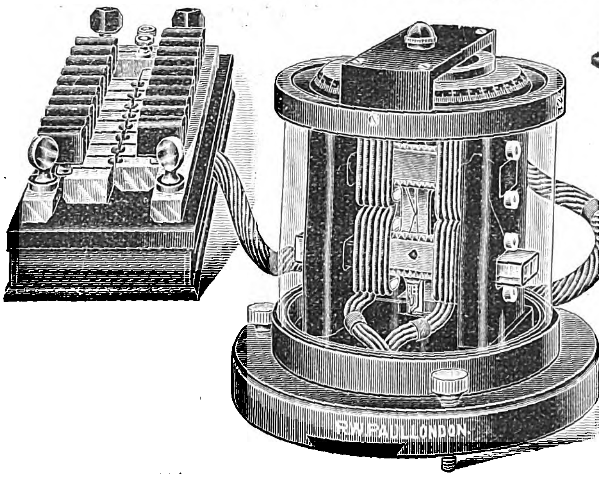
Mr. R W. Paul had a small stand upon which was a fine collection of measuring instruments. Of these the Duddell-Mather standard wattmeter deserves first mention. Two patterns of instrument are made, one suitable for use on circuits between 100 and 2,500 volts, and the other for extra high pressures of 11,000 volts. Both are illustrated herewith. In the extra high-tension type the whole instrument is enclosed in a glazed case and supported on porcelain insulators about 5 in. high, and an ebonite rod projecting through an earthed guard tube in the end of the case enables the wattmeter to be operated with safety. The instrument is of the electro-dynamometer type, having a set of fixed coils marked C, C, C, C in the elevation, and movable coils *c*, *c* (set astatically) which are brought into the same relative position by a torsion head, F, on which the reading is taken. The frame and supports are constructed entirely of insulating materials, chiefly ebonite and ivory, the only metal used in the instrument being in the coils and controlling spring. The coils are built up of strands of fine wires, and the spring is of high-resistance material. By these means eddy currents, which vitiate the readings of so many wattmeters on alternate-current circuits, are eliminated.



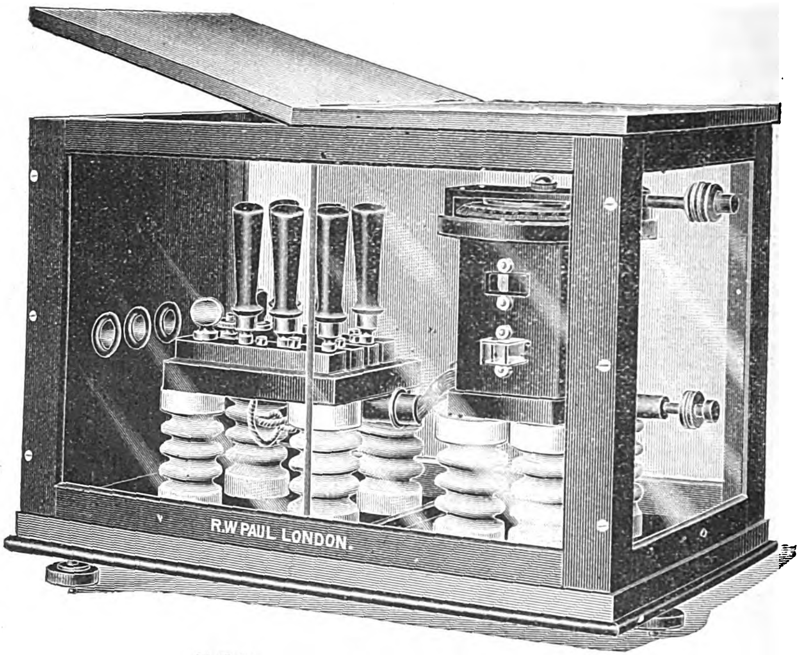
Duddell-Mather Wattmeter for 100 to 2,500 volts.

Subdivision of the windings enables the sections of the fixed coils, of which there are usually 10, to be connected in series or parallel, or partly series and partly parallel, thus giving the instrument a number of sensibilities in known ratios. By the fixed coils and torsion head a useful range of 1 to 100 is obtained without using deflections less than 50 divisions of the head. A further set of sensibilities may be got by putting different non-inductive resistances in series with the moving, or pressure coil, the resistances being supplied suitable for any voltage between 100 and 10,000. A total range of 1 to 10,000 is therefore possible. No terminals are put on the instrument itself, but the various sections of the fixed coils, as well as the ends of the moving coil, are connected by flexible wires several feet long stranded together to a plug board on which the various arrangements of coils can be quickly made. This device has the advantage of removing the terminals, plugs and blocks to a safe distance from the coils, so that eddy currents in the metal work cannot affect the readings, and also of ensuring that the leads near the instrument are properly stranded.

The sensitiveness is such that with $\frac{1}{10}$th ampere through the pressure coil and maximum current through the fixed coils a complete turn of the torsion head (100 divisions, sub-divided in fifths) is required to bring the pointer back to zero when the power factor is 0·1; it will thus be seen that for power factors as low as 0·01 quite a large reading (about 45 mm.) can be obtained on the instrument. As, however, the pressure circuit of all the wattmeters will safely carry 0·125 amperes, the reading of the instruments may be further increased by 25 per cent. by using $\frac{1}{8}$th ampere in the pressure coils, thereby making it possible to obtain a deflection of 56 mm. (62 subdivisions on the torsion head) on a circuit whose power factor is 1 per cent. This is a matter of increasing importance in the measurement of losses in dielectrics and in small quantities of iron cables, and is rendered possible by the high sensitiveness of the instrument and the relatively large cooling surface of the coils.

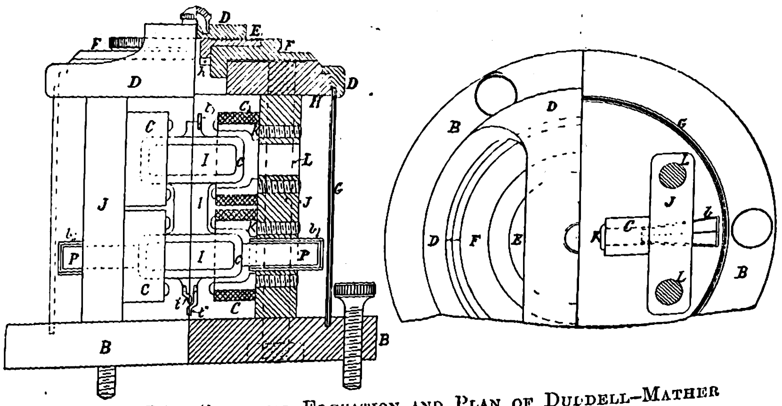
For ease in reading the instrument the figures are engraved in white on the black ground of the torsion head; a fixed index is employed, thus keeping the reading point always in a convenient position.

The strength of the controlling spring is adjusted, so that with 1,000 ohms, or convenient multiples of 1,000 ohms, in the pressure circuit, the scale is direct-reading with the principal arrangements of the current coils. Efficient damping of the moving system is obtained by air friction, projections from the plate of insulating material, II, which carries the pressure coils *cc*, passing into brass boxes, *bb*, and thus serving both as damping vanes and pointers, PP. By this means the movements are made practically aperiodic.



E.H.T. type of Duddell-Mather Wattmeter.

Resistances for the pressure circuits are made in two forms—one form for measurements where the power factor is high and the other where the power factor is low, the former being designed to carry $\frac{1}{80}$th ampere and the latter $\frac{1}{8}$th ampere continuously. For pressures below 125 volts, the resistance of the pressure circuit, in measurements where the power is below 0·1, is made 1,000 ohms, and for high-power factor (0·8 to 1·0) this is increased to 10,000 ohms, whilst for pressures between 125 and 250 the above resistances are doubled. For still higher pressures the resistances have to be increased in proportion.



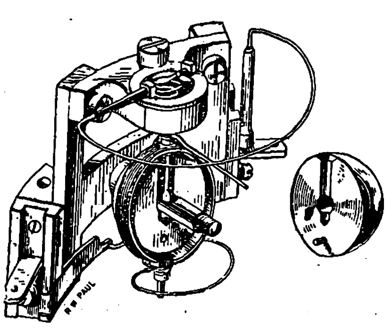
Part Sectional Elevation and Plan of Duddell-Mather Wattmeter.

All the resistances used in the pressure circuits of these wattmeters are of the "anti-capacity" type and are made of manganin wire (silk covered) woven into a fabric with silk threads as warp. They take the form of a ribbon 7 in. to 10 in. wide and of length sufficient to give the required resistance. The ribbon is wound in a zig zag fashion round porcelain insulators supported from the ebonite top of a box.

The wattmeters are made in three sizes, intended for maximum currents of 1, 10 and 100 amperes respectively, but by putting all the sections of the current coils in series, the instruments are suitable for currents of 0·1, 1·0 and 10 amperes, with corresponding increase in sensibility.

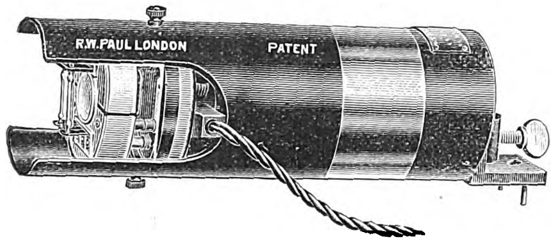
The constants of the instruments depend, of course, on the arrangement of the current coils, and on the resistance in the pressure circuits, and the controlling springs are adjusted to make these constants simple and convenient numbers. For example, in any size of wattmeter, the constant W (watts per large division of torsion head) is given by the expression $W = kR/S$, where R is the total resistance of the pressure circuit, S is the number of fixed coils in series, and $k$ has the values 0·0001, 0·001 and 0·01 for the 1 ampere, 10 ampere and 100 ampere instruments respectively. Thus by making R decimal multiples of S, the constant can be made unity multiplied by some power of 10, and, therefore, direct reading.

The instruments being of the dynamometer type it is evident that under certain conditions they may be used as ammeters for currents not exceeding $\frac{1}{8}$th ampere, and as voltmeters for any ordinary pressure, either direct or alternating. As the inductance of the 10 ampere instrument, when arranged as above mentioned, only amounts to 11 millihenries, it may be used as a voltmeter on alternating-current circuits without appreciable error for any P.D. above 20 volts at ordinary frequencies. By adding non-inductive resistance to the instrument to give a total resistance of 200 ohms, 20 volts will give one complete turn of the torsion head, and the error due to inductance on a circuit of frequency 100, will not exceed $\frac{1}{10}$th per cent. For higher voltages, higher non-inductive resistances must be used, and this reduces the inductance error still further. It will, therefore, be evident that one and the same instrument, with suitable non-inductive or anti-capacity resistances can be used to measure power, current or pressure to a high order of accuracy.



Arrangement of Moving Coil.

A useful direct-reading insulation-testing set was also on view on the stand. The galvanometer scale gives direct readings in megohms when a testing pressure of 100 volts is used, but there is a comparative resistance in addition. The galvanometer has a wide range of shunts, and is provided with separate terminals also, so that it may be independently utilised for other purposes than measuring insulation resistances. It is a moving coil instrument of Mr. Paul's single-pivot type The perspective sketch illustrates the method of supporting the circular coil at its centre, on a pivot at the centre of its spherical core. This construction admits of the automatic raising of the coil from its pivot on closing the lid of the set. In addition to the megohm scale, the scale is evenly divided into 55 divisions on each side of the zero, each division corresponding to 1 micro-ampere.

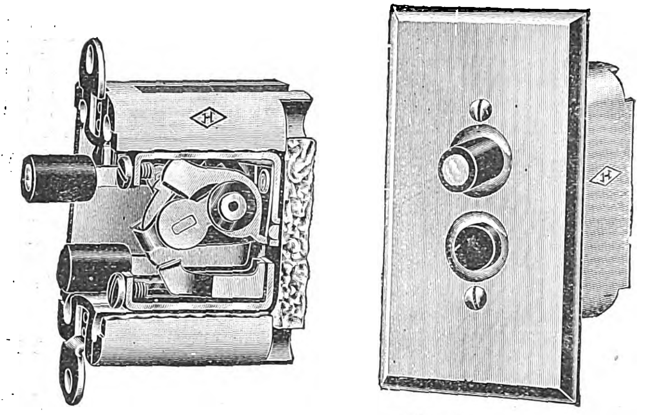


Nernst-Paul High Power Projector Lamp.

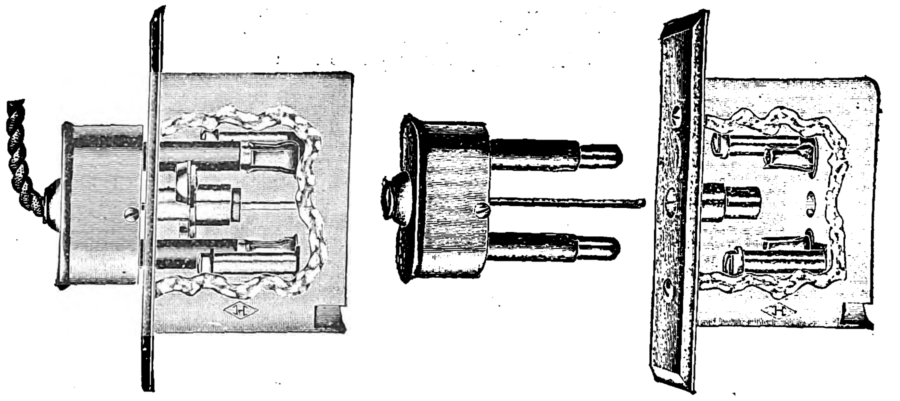
Mr. Paul makes use of Nernst lamps in place of ordinary incandescent lamps for the scales of mirror galvanometers, and has perfected a convenient method of mounting. A vivid Nernst projector lamp, illustrated above, was also shown.

The Pyrophone Co. had their "Autopyrophone" fire alarm system on view. This system was described fully in our issues for May 26th and September 15th. Since then, however, two improvements have been made in the system, one being directed towards preventing the apparatus being tampered with and so giving a false alarm, and the other towards making the system more efficient for night service. The former modification is in the shape of an additional contact which is put into operation when the case of the instrument is opened, and immediately gives the "trouble" call. As the system is now arranged, the "danger" signal is eliminated for night service, the fire alarm being given immediately. This can be effected by a switch which short circuits the "danger" signal, but as shown at the Exhibition this was brought about by hanging up a card, upon which were painted the words "night service," by metal hooks to the terminals.

The accompanying illustrations represent two specialities of the Hart Mfg. Co., who displayed a variety of switches and accessories. Our first two illustrations show the exterior and the inside of the "Diamond H" switch, designed for 5 amperes and 500 volts. The outside of these switches is flush with the wall. One of the two buttons shown serves for switching on, the other for switching off. All working parts are made of case-hardened and tempered steel, the contacts being of phosphor bronze. The break is long and rapid, and the action is positive. In order to suit all purposes, these switches are made in single-pole, two-way, two-circuit, three-circuit and multiple-series, and the finish is in gold, silver, bronze, copper, &c. Another novelty which the firm is introducing from the United States is the automatically-closing flush wall plug, represented in the last two sketches. When not in use the plug holes are covered by well-fitting caps flush with the front face of the switch. When the plug is to be inserted (which may be done with one hand) the metal tongue between the plugs is inserted into the narrow slit in the centre of the switch plate. This causes the caps first to recede and then (by a simple screw action) to rotate about one-quarter of a turn, leaving the way clear for the plugs, which are pushed home into the contacts shown. The switches are strongly made and well finished.



Hart Mfg. Co.'s "Diamond H" Switch.

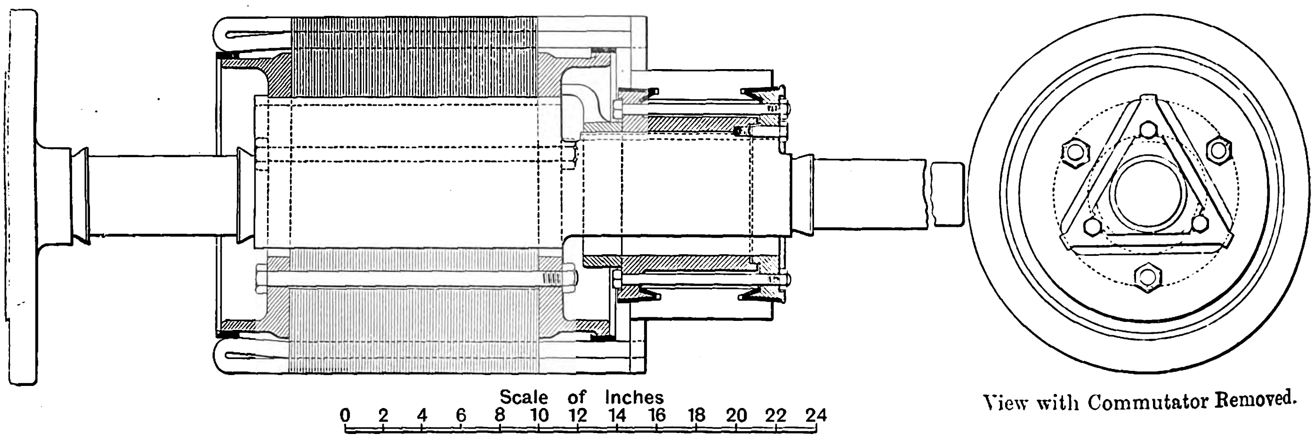


Hart Mfg. Co.'s Automatic Wall Plug.

Messrs. Joseph Kaye & Sons, in addition to their patent serrated, seamless oil cans, now so well known, showed several interesting pieces of apparatus. The chief of these was "K's" patent electric fire-alarm lock, by which all the doors in a building may be opened simultaneously by the person in charge pressing a button. The mechanism is extremely simple. The striking plate of the lock is so constructed that the catch is removable, being drawn away from the lock of the door by the action of an electromagnet. By this system, of course, any series of doors can be opened on completing the circuit. The special application of the lock is intended for lunatic asylums and similar institutions.

One of the largest stands at the Exhibition was that of Messrs. Veritys, who showed a great variety of appliances, from bell pushes up to fairly large-sized motors. Apparatus for heating and cooking formed a not inconsiderable part of the display, while lamps and fittings were prominent. It may be mentioned that the arc lamps which were employed for lighting the interior of Olympia were supplied by Messrs. Veritys, and it is hardly necessary to expatiate on the very excellent result which was obtained. The award to Messrs. Veritys in the Cooking Appliances Competition is mentioned on p. 53.

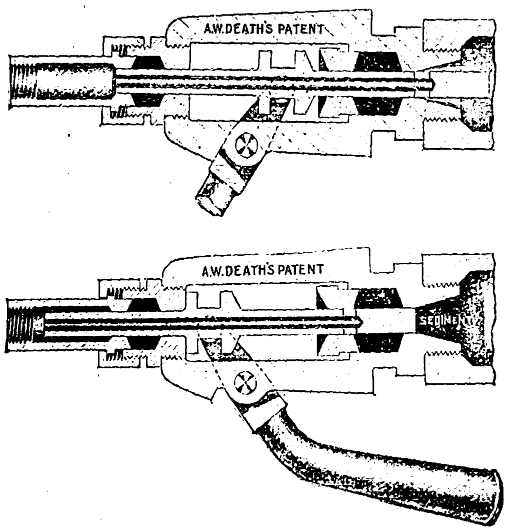
In addition to the large electrically-driven planing machine shown by Messrs. **Vickers, Sons & Maxim**, and described in *The Electrician* of September 29th, they also exhibited a motor armature of a new pattern. This motor was rated at 150 H.P. and was built to the order of the Admiralty. Its special feature was that the core body was not keyed to the shaft in the ordinary manner. As shown in the accompanying illustration, a considerable portion of the shaft is of triangular section, the altitude of the equilateral triangle being greatly in excess of the diameter of the shaft proper. It should be understood that the entire shaft consists of a single forging. Each apex of the triangle is rounded off and forms a key which fits into a groove cut in the stampings. Thus the moment of the couple tending to shear the key, when the motor has to start against a heavy load, is considerably less than when the keyway is cut in the surface of an ordinary circular shaft. For this reason the motor is peculiarly suitable for driving rolling mills and other purposes where a large starting torque is met with.



View with Commutator Removed.

Vickers, Sons & Maxim's New Type Armature.

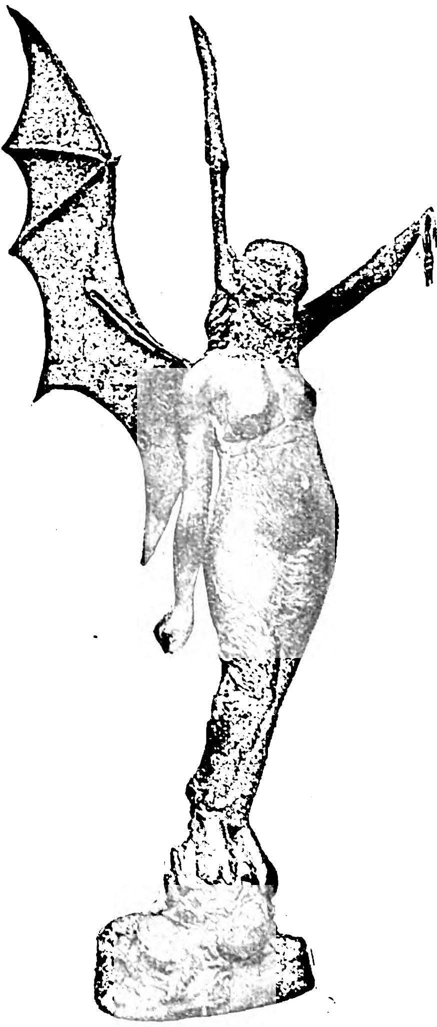
The **United Asbestos** Co. showed several samples of asbestos tubes and sheets, which have been specially treated to be used in connection with resistance frames, &c., for electrical purposes. This company also showed a new type of water-gauge cock. The opening and shutting of this cock is effected by the means of a central rod valve which keeps the seatings entirely free from sediment, and there is also a rod attachment which unseats the top valve simultaneously. A new material called "Uacolite" was also shown. This is a new asbestos material suitable for fireproof partitions, and when specially treated and enamelled is a substitute for slate, &c., for switchboard work. It can be easily moulded into any shape, drilled and screwed, and also takes a good surface finish.



United Asbestos Co.'s New Water-gauge Cock.

Messrs. **Santoni**, in addition to some small accessories of foreign make, showed a flame arc lamp, one of whose merits is its cheapness. Like many other makers of this new type of lamp, they were loth to furnish us with particulars of its construction. We may mention, however, that the mechanism is of the brake-controlled type.

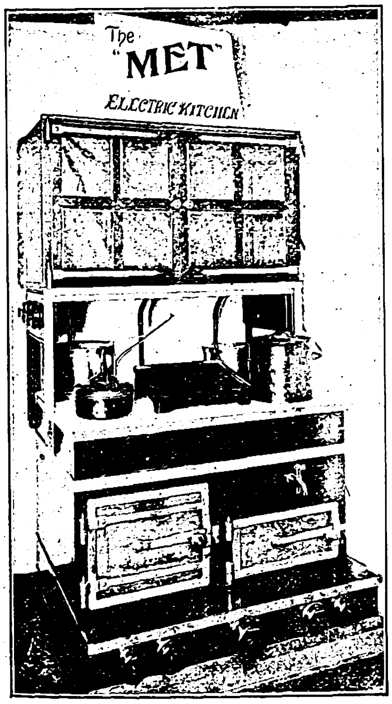
Much attention was deservedly bestowed by visitors on the exhibit of Messrs. B. **Dellagana** & Co., who showed a large assortment of articles manufactured by their new "Kupron" system. These articles varied in size from a small "flush" switch cover to an entire shop front, and were uniformly excellent. The process of manufacture is an exceedingly simple one, and it is only the development of it in this particular direction that is at all novel. First of all the electric light fitting, or whatever it may be, is modelled in clay and the clay is then covered with a thin film of blacklead. By immersing the latter in a copper bath, a layer of copper of any desired thickness is electrolytically deposited on the mould. The finish in bronze, silver, gold or any other style is easily accomplished and the amount of labour entailed by the process is very small. Of course, the deposit may consist of metals other than copper, if required. The chief advantage of the process is the low cost of the finished article, electric light fittings and other things of a similar kind costing not more than half what they would have cost if produced in the ordinary way. As an illustration of the facility with which the process may be applied to different purposes, we were shown ivy leaves which had been blackleaded and covered with a deposit of copper. Every vein in the leaf was perfectly distinct and all details were faithfully reproduced, in spite of the fact that no work whatever had been expended on the leaf after it had left the electrolytic bath. We are assured that entire shop fronts and fascias are being manufactured in the same way, the thickness of the copper, which may be varied to suit requirments, tending to considerable economy.



Bronze Figure
made by Messrs. B. Dellagana's
"Kupron" Process.

The **Chameleon Signs** Co.'s exhibit attracted a good deal of attention. These signs derive their name from the fact that they are constantly changing colour. Inside the box bearing the sign is an incandescent electric lamp, or more than one if necessary, fixed vertically, and surrounded by a cylinder of transparent material. This cylinder is capable of revolution about its axis and the transparent material, of which it is composed, is striped with various colours. Fixed to the top end of the cylinder, above the lamp, is a hot-air fan, and the small amount of heat generated by the lamp is sufficient to effect continuous motion. These signs possess the advantage of having no clockwork or other mechanism to get out of order or require attention.

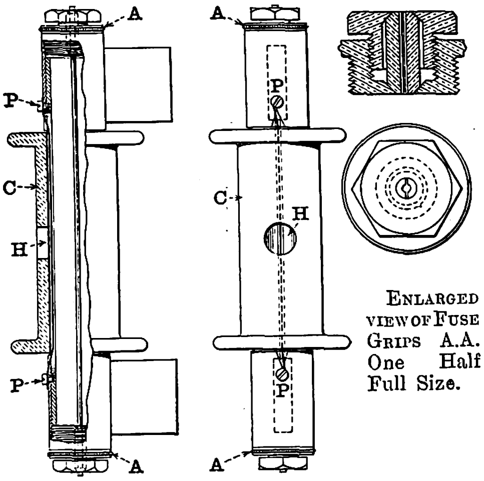
The popularity of the cooking lectures and experiments which were held throughout the period of the Exhibition at Olympia was sufficient to induce several of the exhibitors to do their utmost to extend their exhibits of appliances and apparatus suitable for employment in this branch of electrical work. In this connection Mr. H. J. Dowsing, as already mentioned, towards the close of the Exhibition presented a fully-equipped electrically-operated kitchen, and other exhibitors who were showing electrically-operated heating and cooking appliances added various items to their exhibits. Amongst these exhibitors may be mentioned the Metropolitan Electric Supply Co., whose double-fronted stand was throughout the period of the Exhibition the resort of a large number of spectators interested in the cooking operations there going on. The interest taken by the visitors in the display thus made induced the company's chief engineer (Mr. J. S. Highfield) to design a complete electric "range," and we present our readers with an excellent illustration of this complete cooking equipment. The upper part of the range forms a hot closet where plates and other articles, as well as cooked food, can be kept hot while subsequent cooking operations are proceeding below. Each utensil and each section of the range is provided with a separate plug, so that only those portions of the stove or those utensils which are immediately required for use need be electrically connected. In this way the grill can be used without connecting up any other portion of the range, or the water in the boiler can be separately heated, or the roasting oven, or, in fact, any other portion can be separately switched into circuit. As a means of economising current, switches are provided, as shown in the illustration, for switching on a quarter, half, three-quarters or a full supply of current. The "Met" range, or kitchen, as it is called, is a well-made and very serviceable piece of apparatus, and was the centre of much keen attention from lady visitors to the Exhibition. We understand that the Metropolitan Company contemplate extending their already large displays of domestic apparatus and appliances for electrical operation.



Mr. J. S. Highfield's Electric "Range."

The Pearson Fire Alarm Co. had their system in operation. The general principles of this system are now well known. Briefly, the main working part is a thermostat, the alarm being given by the heat acting on a metal strip, causing expansion, and thus closing the circuit. There is a Fahrenheit scale attached to the thermostat, which is so constructed that the distance between the pointer of the scale and the metal strip of the thermostat is regulated by setting the needle of the pointer at the required temperature, and immediately this temperature is reached the alarm is automatically given. The instrument, after operation, resets itself, and is at once ready for service. A recent improvement is the provision of a closed thermostat for use where excessive moisture, steam, corrosives, acids and gases are constantly present. This merely consists of a metal shield placed around a thermostat of the ordinary type, but it has the effect of completely preventing deterioration of the expanding strip, and, the company affirms, enables it to undertake dangerous risks which hitherto could not be accepted by any automatic fire alarm company.

The Simplified Underground Conductor Co. showed the method of laying bare underground mains on the solid system, which was described in detail in *The Electrician* of Aug. 19, 1904. They have found that this system answers admirably, practically without modification, the only alteration since the date of our former description being the substitution of a flat porcelain wedge across the duct, over the conductors, half way between the bridges, instead of the wooden wedge on the bridge itself, which they have formerly used. At their stand they also showed a specimen of a 0·75, 0·4, 0·75 sq. in. main and duct, which is now being laid at Reading. A novelty which the company is introducing is the fuse shown in the accompanying figure. The fuse wire passes through the nut at the end, and is gripped by two brass segments, similar in shape to the wooden cheeks of a cord grip in an ordinary pendant fitting. We show this part of the fuse on a larger scale in our drawing. Another interesting point in the fuse is the pilot fuse, PP, on the drawing, which is placed in an open slot cut in the vulcanised fibre lining. This fuse is in parallel with the main fuse. An insulating collar, C, can be turned round, so that normally the hole H in it is to the inside, and the pilot fuse is covered up, but if the attendant desires to see if the fuse has blown, he turns the collar round to the position shown in the drawing and can then see whether the pilot fuse is intact or not.



Enlarged view of Fuse Grips A.A. One Half Full Size.

One Quarter Full Size.

A model of an impoved water-cooling tower for electricity works was on view at the stand of the Regina Bogenlampenfabrik, but the attention of the numerous visitors was chiefly centred around the Regina and Reginula arc lamps. In the Regina arc lamp both arc and regulation gear are enclosed in one airtight space. A syphon and a safety valve are put in action should the pressure on the globe become too high. A length of $1\frac{1}{2}$ in. to $1\frac{1}{3}$ in. of the carbons glows with a white light. One consequence of the airtight arrangement is the long life of carbons, which is claimed to be between 300 and 400 hours. After that time it is only necessary to replace the upper carbon, as the remaining part of the upper carbon is used as the lower carbon The overall length of the lamp is 2 ft. 2 in., its weight, complete, being 19 lb. The inner globe is protected by a wire net, and this arrangement makes a dirt-catching wire net on the outer globe unnecessary. The carbon-catch consists of two cheeks, which pinch the carbon, lifting it up when the magnet is lifted by the coil, an arc between the carbons resulting thereby. These two cheeks are fixed to a hollow plunger, which is sucked up or let down in the regulating solenoid. The carbon slides in the hollow plunger. When the carbon is so far consumed that the cheeks touch a ring it is released and drops down easily. The resistance in the arc diminishes, the magnetic field grows stronger and the carbon is again lifted by the magnet. If there is no current on the mains the top carbon rests on the lower carbon. The Regina lamp is made for voltages and currents ranging from 100 to 250 volts and 2·5 to 8 amperes respectively, the available pressure across the arc being, it is stated, from 68 to 72 per cent. When used for alternating current a choking coil (with $\cos \phi = 0{\cdot}9$) is used. Alternating-current lamps are made for 40 to 60 ~ per second and for voltages between 110 and 220 volts, the voltage across the arc being as high as 85 to 90 per cent. The continuous-current type will burn in series of two, three, four or five lamps. It is claimed that the light given off by a 200 volt lamp is quite white with no bluish tints. The Reginula lamps are similar in construction to the Regina lamps, but are smaller in size and designed for currents from 1 ampere upwards and for 110 or 220 volts. It is stated that a Reginula lamp with 5 mm. carbons will burn for 40 hours when fed with continuous current and from 15 to 20 hours when supplied with alternating current.

Messrs. W. & T. Avery showed their patent weighing machines, one of which automatically adds up the net weight of trucks of coal, and another which weighs the coal delivered to boilers.

(*To be continued.*)

## USES OF ELECTRICITY IN MINES.*

BY HENRY WILLOCK RAVENSHAW.

### LECTURE I.

When your Council honoured me with an invitation to give a series of Cantor Lectures on the "Uses of Electricity in Mines," I thought that I appreciated the extent of the task I was asked to undertake. I very soon found, however, that the subject is of such a wide character, that, to do ample justice in every direction, would require a great many more than the two lectures that I have undertaken to deliver. In these lectures, therefore, I propose to confine myself within certain limits. On the one hand, I do not propose to go into the theory of the electrical transmission of power. The use of electricity is now so extensive, and the electric motor is so generally employed, that I feel safe in assuming that my audience has an elementary knowledge of the subject. On the other hand, time will not allow me to go very far into the mechanical side of the question. Having set certain limits to my subject, I propose to describe as far as possible the various applications of electricity in general use in mines and to give you some data that have been obtained from actual practice.

I find that to the average Londoner a coal mine is represented by a deep hole, at the bottom of which grimy men dig out the coal under dangerous and uncomfortable conditions, and that there is a general feeling of surprise when I describe the discipline and the wonderful machinery that is to be found underground. Some idea, however, may be obtained of the magnitude of the work done, when I say that a large colliery may have an output of over 2,500 tons a day, representing six or seven of the immense coal trains that we constantly see on our main lines, and that in some cases, the whole of this coal is brought up one shaft 500 yds. deep in 10 or 12 hours.

Taking an average thickness of 4 ft., this represents an area of 1½ acres of coal removed per week, or, say, 75 acres per annum. The result of so large an output is, that the distance from the shaft to the coal face (the place where the coal is actually obtained), becomes greater every year, and in many mines the coal has to be hauled, underground, at least a mile before it reaches the shaft. To obtain these vast outputs machinery has to be used wherever possible, and a large amount of power is required both underground and on the surface. Although power is sometimes produced in the mine by means of steam boilers and oil engines, it is usual to generate it on the surface and to carry it down the shaft by one of the following methods: Steam is carried down in pipes; compressed air is carried down in pipes; continuous ropes are carried down from an engine on the surface; spear rods are alternately raised and lowered to pump water; electricity is carried down through insulated conductors.

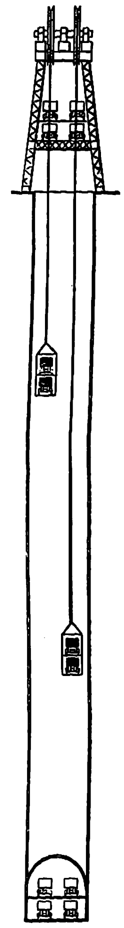


FIG. 1.—ROPES UNBALANCED.

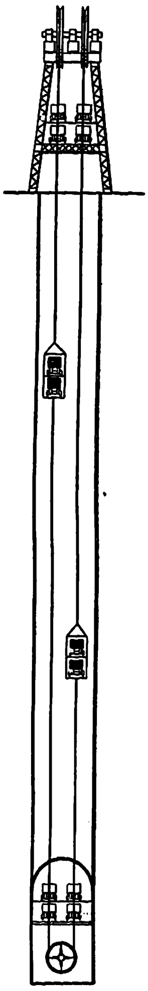


FIG. 2.—ROPES BALANCED.

To the average engineer the idea of a steam pipe 400 yds. long is out of the question, yet, in a great many collieries there are pipes of that length carried down deep shafts to supply haulage engines. It is usual for steam to be turned on in these pipes night and day, as the joints would be broken if the pipes were allowed to cool down. The loss from condensation is enormous.

Compressed air is very largely used, and although the losses in the pipes are not so great as where steam is employed, the practical impossibility of warming the air before it reaches the engines, prevents a satisfactory economy from being obtained. Electrical transmission presents many advantages for this class of work, as the efficiency of transmission is high, the cables are easily carried down the shaft, and through roadways, and the motors have been brought to such a state of perfection that breakdowns are infrequent. It is, of course, understood that where there is electrical energy there is some chance of a spark being obtained that would ignite inflammable gas. Large numbers of motors are, however, in use in fiery collieries, and where adequate precautions are taken there is little or no danger. This is borne out by the fact that there are hardly any cases on record where a serious fire or an explosion has been traced to the use of electricity.

I propose to take each application of electrical driving separately, and to give you, in some cases, actual load curves that have been taken from the machines themselves. The following table shows the various classes of machinery that are in general use, with the type of load and the range of sizes that are usually met with.

| — | Usual sizes. B.H.P. | Type of load. |
|---|---|---|
| Winding | 50 to 2,000 | Intermittent with frequent short stops. |
| Single rope haulage | 5 to 200 | Intermittent with long stops. |
| Continuous haulage | 15 to 500 | Steady load. |
| Main & tail haulage | 15 to 100 | Intermittent with fairly long stops. |
| Locomotives | 15 to 100 | Intermittent with variable stops. |
| Creepers | 10 to 30 | Continuous variable load. |
| Coal cutters | 20 to 50 | Intermittent with variable stops. |
| Pumping | 5 to 500 | Steady load. |
| Air compressors | 20 to 100 | Intermittent. |
| Fans | 20 to 200 | Steady. |
| Screens | 20 to 50 | Steady load. |
| Coal washing | 20 to 100 | Fairly steady. |
| Stamps | 15 to 100 | Steady. |
| Crushers | 20 to 100 | Very variable. |

*Winding*.—Steam engines are at present almost universally used for winding, many of them being of large size, and capable of raising heavy loads at a high speed. The character of the load requires rapid acceleration and retardation with extreme accuracy of control. The importance of accurate control is shown in a diagram that I will presently explain, where an engine raises nearly 5 tons of coal in 42 seconds, from a depth of 544 yds. The load attains a speed of 45 miles an hour, and yet it only takes 12 seconds to bring it from full speed to rest. This is done 500 times a day all the year round with a remarkable freedom from accident. Some electrically-driven winding engines of large size have been erected on the Continent, and are giving satisfaction; a good many are also being erected in this country. For small pits and staples (shafts connecting one underground level with another) electrical-winding engines have been in use for a good many years, and I know of one which was put down in 1891, and has been in use ever since. Owing to the large amount of power required, and the extreme variations of the demand, the large electrical-winding engine presents one of the most difficult problems that the electrical engineer has to deal with.

The problem is that the engine has to start a heavy weight of, say, 5 tons, from rest, raise it 500 yds. in 40 seconds, stop for 15 seconds, and repeat the operation in the reverse direction. This means that the engine must give an enormous starting effort, and develop from 1,500 H.P. to 2,000 H.P. for 30 seconds. It must also be capable of absorbing a large proportion of the energy that has been put into the load so as to enable an accurate stop to be made at the end of its travel. It must be remembered that the moving parts are of great weight, and move at a high velocity, thereby increasing the difficulties in acceleration and retardation. This subject has been discussed to some extent by the members of the Institute of Mining Engineers and other societies, but I do not think that any diagrams have been published showing the actual work done by really large engines. Where rapid and economical winding is necessary, it is important that the load should be as uniform as possible and this requirement is not obtained when the cages are unbalanced.

Fig. 1 shows the ordinary unbalanced system where the two cages are suspended from the same drum, one falling and the other rising. Owing to the great weight of the rope the load on the engine is constantly varying; for instance, the unbalanced load at starting is the weight of coal to be raised plus the weight of rope. When the cages are passing the ropes balance each other, and the load unbalanced is equal to the coal being raised. Towards the end of the wind the weight of the descending rope predominates and actually overbalances the weight of coal. To give an instance in a particular case, the coal weighed 3 tons and the rope 4 tons. As a result, the load against the engine at starting was 7 tons, at the middle of the wind 3 tons and at the end of the wind an overbalance of 1 ton was tending to drive the engine. This means an extremely variable load and a tendency to run away at the end of the wind. A number of different methods have been employed for giving a better balance, and to illustrate my point I have shown on Fig. 2 a method which has many advantages—namely, a balance rope. This, you will see, consists of a rope passing round a pulley at the bottom of the shaft and one end fastened to each cage. By this method the weight of the rope is balanced and the load is constant—namely, the coal to be raised. By the use of a heavy balance rope the stresses due to inertia can also be partly balanced. This method of balancing is frequently used in this country, and it is doubtful if really fast winding can be economically carried out without this or some similar arrangement.

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* Cantor Lectures delivered at the Society of Arts.

I have designed an apparatus for taking continuous records, and have shown on Figs. 3 and 4 the result of tests taken from two large steam winding engines of modern design under actual working conditions. The engines are of very similar size, but in one case the weight of the ropes is balanced and in the other it is unbalanced.

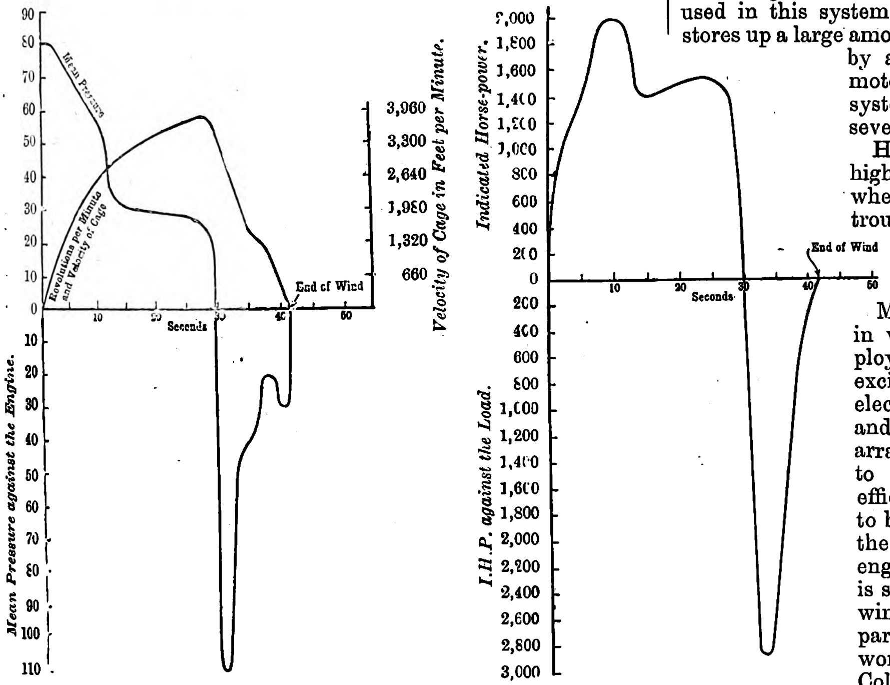

FIG. 3.—WINDING ENGINE WITH ROPES BALANCED. Results obtained from Time-pressure Diagrams taken April 7, 1905. Weight of Coal raised, 4 tons 15 cwt.

Fig. 3 shows that with the balanced arrangement a much higher rate of acceleration is obtained, steam is on the pistons for two-thirds of the running time and the cages are very promptly brought to rest. In the unbalanced arrangement, although the maximum horse-power developed per ton of coal raised is greater, the speed of wind is less, the acceleration and retardation are less rapid and steam is only applied to the pistons for one-half of the running time. It is an interesting fact that in neither case were the brakes used for retarding, and the large amount of energy required to stop should be noted. The peculiar shape of the power curve is due to the fact that in each case when the engine attained a speed of about 40 revs. per min. an automatic cut-off came into play. To illustrate the tremendous variations of load on the cylinders I would point out that in Fig. 3 steam was admitted during the whole of the stroke for six revolutions, it was cut off at one-fourth of the stroke for 14 revolutions, and the valves were reversed with steam against the load for five revolutions. The engine was moving again in the opposite direction in 12 seconds from the time it came to rest.

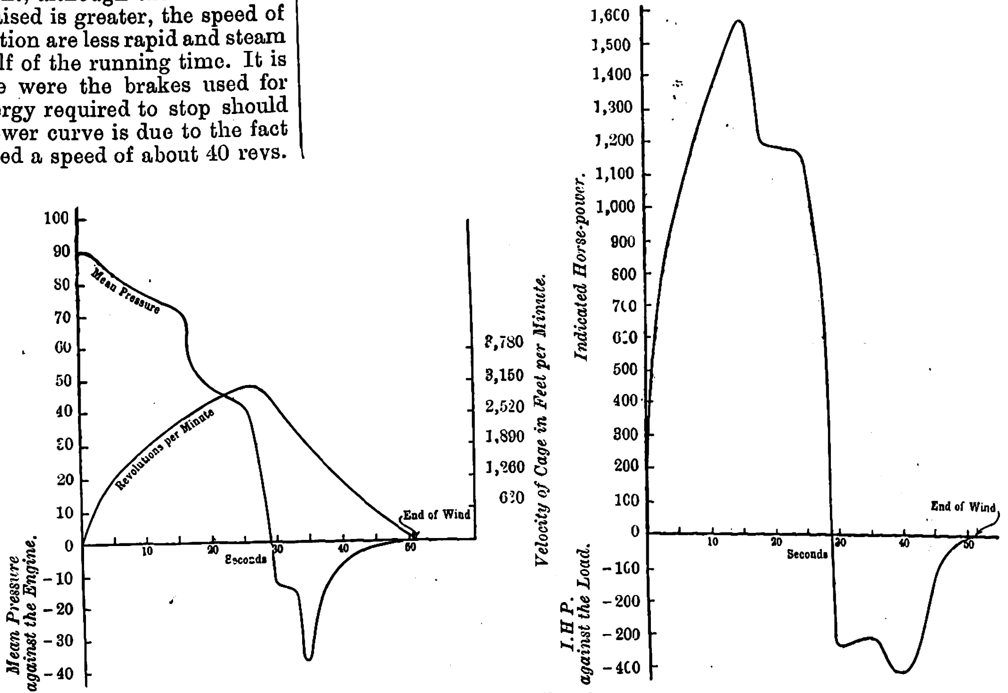

FIG. 4.—WINDING ENGINES WITH ROPES UNBALANCED. Results obtained from Time-pressure Diagrams taken April 7, 1905. Weight of Coal raised, 3 tons.

Although these diagrams do not bear directly on the question of electric driving, they are of the greatest importance as showing the kind of load that must be dealt with if rapid winding has to be carried out electrically. It will be seen that to apply electrical driving to so variable a load presents considerable difficulties, and that if the demand on the supply is to be free from sudden fluctuations, some method must be adopted for storing up energy during the period of no load. Accumulators can of course be used, but the heavy first cost and upkeep are unfavourable to their general adoption. For small plants it is probable that a motor having the speed regulated between, say, a third and full speed by means of shunt resistance, would give a simple solution, in conjunction with a motor carrying a heavy flywheel running free and connected across the mains. For large plants a more elaborate system has in some cases been adopted. The most characteristic of these is that adopted by Messrs. Siemens & Halske, and known as the Ilgner system (Fig. 5). This system includes a Ward Leonard motor transformer, consisting of a motor connected across the source of supply; this machine drives a very heavy flywheel and also a continuous-current separately-excited generator. The winding motor is also separately excited, and any speed can be obtained up to the maximum by varying the strength of fields of the two latter machines. This arrangement gives very accurate regulation, and has the advantage that the winding motor circuit need never be broken and that a considerable part of the energy given off during retardation is given back into the flywheel. The flywheel used in this system is very heavy, and, running at a high speed, stores up a large amount of energy which can be given off as required by automatically causing the speed of the primary motor to be varied. A good many plants on this system are in successful use on the Continent and several are under construction in this country.

Heavy steel flywheels are used running at a very high peripheral speed, and the result of a burst wheel or a broken shaft might be extremely disastrous. It is of the utmost importance that they should not be placed in the winding-engine room, and that they should be so arranged that, in case of accident, the damage would be localised.

Mr. Georgi has advocated a simple arrangement in which a high-speed steam or gas engine is employed driving a heavy flywheel and a separately-excited dynamo. The dynamo would be connected electrically to the separately-excited winding motor, and the speed controlled as in the Ward Leonard arrangement (Fig. 6). At first sight this appears to be a useless complication, but given highly efficient steam or gas engines there is a great deal to be said for the arrangement. With the advent of the steam turbine, and the still more economical gas engine producing electrical energy at a cheap rate, it is safe to prophesy that in the near electrical future winding will be very largely adopted. The following particulars of electrical-winding plants, which are working in Germany, are of interest: Zollern II. Colliery (Siemens & Halske Ilgner system).—Supply 520 volts direct current. Flywheel, 12½ ft. diameter; weight, 45 tons; maximum peripheral speed, 13,600 ft. per minute; revs. per min., 300 to 345. The motor-generator takes 600 amperes to start, and after 10 minutes takes 100 amperes light. When winding, the primary current varies between 250 and 450 amperes. Five tons of coal are raised per wind, the lift of 330 yds. being made in 43 seconds; the maximum speed is 1,980 ft. per minute. The periods of rest are as long as 45 seconds, against 12 to 15 seconds occupied in some of our best collieries.

At the Preussen II. Colliery there is a large winding engine driven by a three-phase motor. Pressure about 2,300 volts 25 cycles per second. No arrangement is fitted for storing energy between the winds. Three tons of coal are raised per wind, the lift of 600 yds. being made at an average speed of 1,800 ft. per minute. The maxi mum speed is 3,200 ft. per minute. This is a successful plant, but there have been difficulties owing to the low-power factor of the motor at starting causing great variations of supply pressure.

*Underground Haulage.*—Underground haulage comes next in importance to winding, as with modern developments of large collieries the coal has very often to be hauled underground for a distance of 2 or even 3 miles. In this country most of the coal seams lie on a slope, and consequently, although the coal that is obtained from the higher level will descend by gravity to the bottom of the shaft, the remainder has either to be brought along the level or up hill. Wire-rope haulage is almost always employed. Where the slope is not less than 1 in 20 the empty corves will descend, taking the rope with them, and either single or double roads are employed. In the case of double-road haulage the system is very similar to that adopted in winding, and the load is of the same character. With a single rope the motor runs in one direction, as, in lowering, the drum is set free, the empty corves unwinding the rope as they run down the incline. The load on the motor is consequently intermittent, the motor not being in use for more than half the time.

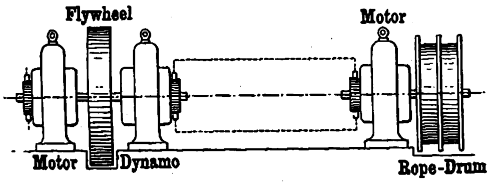

Fig. 5.

Fig. 7 shows a load curve taken from a 25 H.P. single-rope haulage motor, from which you will see that there were excessive variations of load, owing to curves and steep places on the incline. This demand on the supply was repeated every half-hour. Where the roads are flat or undulating main and tail haulage is frequently used, a second rope being carried on pulleys to the end of the roadway, round a large pulley, and back to the tail end of the train. There is, therefore, a rope attached to each end of the train, and it can be hauled in either direction. In this case the motor does not usually reverse, two drums being fitted connected to the shaft by clutches. The motor generally starts with the load, and owing to the trains having to be hauled in both directions the demand for current occurs twice as frequently as with the single-rope haulage. Continuous-rope haulage is very largely adopted and has many advantages. There are two roads, main and return, and the corves are either attached to the rope singly or in sets, the speed being about 4 miles per hour. The advantages of this system are regular supply, slow speed, and consequently fewer accidents. The load on the motor is an excellent one, as the demand is usually practically constant while the motor is running. Fig. 8 shows a record taken from a 25 H.P. single-rope haulage plant, which is only intermittently used, there being 20 runs of about five minutes' duration in eight hours. Where several roads are served, and separate ropes used for each road, all the rope pulleys are driven from one motor, and the demand is remarkably steady. I have frequently seen the ammeter connected to a 200 H.P. motor remain steady to within 5 per cent. for long periods. Some very large continuous-haulage motors are at work in this country.

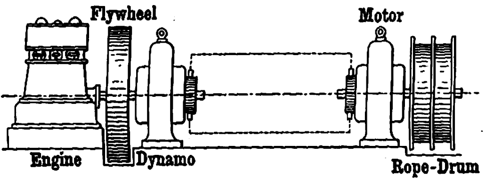

Fig. 6.

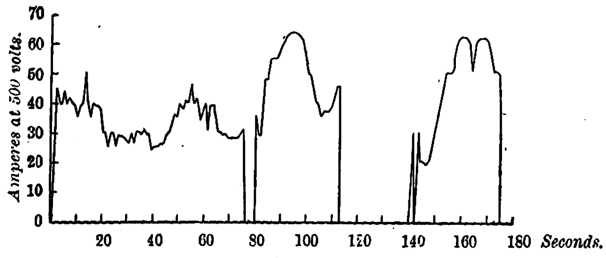

Fig. 7.—25 H.P. Gradient Haulage.

Electric locomotives are very little used in this country, the only one with which I am acquainted being in the Greenside Mines, under Helvellyn, in Westmorland. In the United States they are largely used, the coal being more free from faults than in this country, and the roads consequently more level. In many of their collieries the coal outcrops and the locomotives are able to bring trains out of the hillside without the intervention of a winding shaft. Electric locomotives are capable of working up an incline of 1 in 20. A trolley wire or live rail cannot, of course, be used in fiery mines. A creeper is a form of conveyor to bring trucks from one level to another. They are frequently used at pit bottoms and on the surface. The load is somewhat intermittent, but the power required is small. Electrical transmission is extremely convenient for these small applications.

*Pumping.*—This is a most important application. In some cases the weight of water raised exceeds the output of coal. The extreme flexibility of electrical transmission makes it particularly useful in the case of shaft sinking and for following drifts and workings that are on a downward slope. In many cases very little power is required, as a very small pump will deal with 20 gallons a minute, but unless dealt with that flow of water will very soon flood out a large district. In one of the collieries with which I am connected two pumps, absorbing together not more than 10 H.P., have entirely cleared a flooded district, the water-level being reduced by 150 ft. The ordinary three-throw pump is a most useful type, and is very largely used. Dip pumps are mounted on a truck, and are moved down the falling roadway as the water is pumped out. Some very large pumps are in use on the Continent coupled direct to slow-speed motors.

Electrical driving is particularly applicable to centrifugal pumps, and it is on record that a pump of this kind is working against a head of 1,850 ft. and raising 1,750 gallons per minute. A pump load is an extremely good one from the supply point of view, as the demand is practically steady. Electrical pumps are frequently placed in out-of-the-way places, and receive attention, perhaps, twice a day. A very convenient and economical arrangement can be obtained where the generating station supplies current for haulage during the day and for pumping at night. The capital expenditure is kept down in this way to a minimum.

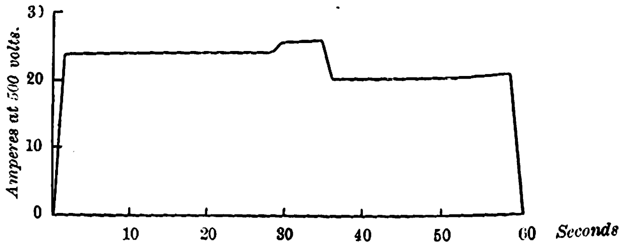

Fig. 8.—Continuous Haulage. Single Rope.

*Coal Cutting.*—This is an extremely important application of power to mining, and a large number of electrically-driven machines are at work. They can be divided into three classes—namely, disc, chain and bar cutters. Special merits are claimed by the makers for each type of machine, the disc machine being most largely used in this country. The system of getting the coal known as long wall is generally employed where coal cutters are used, the machine usually making a horizontal cut from 4 ft. to 6 ft. deep underneath the coal. As the cut proceeds the machine hauls itself along the face of the coal, being supported either on rails or on a sledge. Series motors are generally used with direct currents. The Diamond Coal Cutter Co. use two motors coupled in series. Multiphase motors are also successfully used for this work, but the great starting effort that a series motor will develop makes the continuous-current machines more popular with the men, especially where deep holing can be carried out. The current is conveyed to coal-cutter motors by means of long trailing cables well protected from injury, and arranged so that they can be readily disconnected. The main cables are generally brought to switch boxes in the gateways at several points along the face so that a long face can be worked without using cables of excessive length.

Electrically-driven air compressors are being extensively used, and where rock drills are employed advantage is taken of the cheapness and flexibility of electrical transmission to drive the air compressors underground. Compressed air can be more safely used than electricity for coal cutting in very fiery mines, and electrically-driven air compressors fixed some distance in-bye are also being used. There is good reason to believe that this combination of two methods of transmission is likely to be largely employed. There are numbers of other applications of electrical driving in mines, and it is interesting to note that a considerable discussion has been lately going on among engineers in the Rand as to the relative advantages of driving large numbers of stamps by one motor or dividing them into sections. It is likely that the latter system will survive, as the experience of engineers points directly to the great advantages to be obtained in sub-dividing the plant into sections of a reasonable size.

*Generating Stations.*—As I have already pointed out, the load on many classes of mining machinery is of a very variable character, and as a result the demand on the generating stations is not always a satisfactory one. In some cases where the haulage is continuous and there is a good deal of pumping, a steady load is maintained for long periods; but to show that this is not always the case, I have a diagram (Fig. 9) showing readings which were taken for three minutes from a dynamo supplying three haulage engines varying in size from 7½ to 25 H.P. You will see that at times there was no demand whatever. A dynamo running alongside and supplying screens and washing plant had a practically-constant load of 90 amperes.

I should like to point out how important it is for effective governors to be used on the engine. I have known a case where the governors failed on a large proportion of the load being thrown off, the pressure rose from 500 to 1,200 volts, and a great deal of damage was done. Reliability, good running, and a minimum cost in repairs and attendance are always required in a mine, but extreme economy in steam consumption is not often attempted. The steam pressures available are seldom more than 100 lb. per square inch at the older collieries, and there is often a remarkable disregard for the fact that every ton of coal burnt costs quite a large percentage of its actual selling value in labour, boiler repairs and depreciation.

In spite of the above facts, in many cases a remarkably low cost per unit generated is frequently obtained when there is a steady load extending over long hours. Capital costs, and consequently interest and depreciation, are kept down to a minimum. Attendance costs very little; for instance, an engine giving a steady output of perhaps 100 kw. for 12 hours a day may be looked after by the fan engineman. In some of the more modern plants the output is quite large, and high-pressure steam and condensing are available. Gas engines supplied by coke-oven gas will probably be very largely used in the near future, the reliability and economy of the modern gas engine placing it quite in the front rank among prime movers.

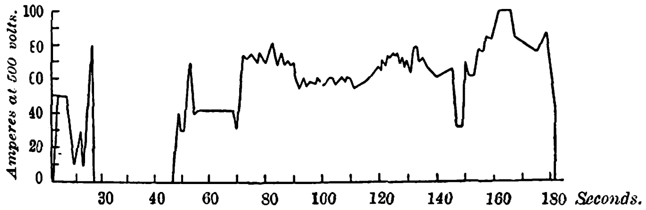

FIG. 9.—POWER HOUSE LOAD SUPPLYING HAULAGE MOTORS.

*Cables and Distribution.*—Owing to the fact that comparatively large powers are required at a considerable distance from the source of supply, and that in fiery mines a pressure of more than 500 volts is not available, the conductors have to be of ample section, and in many cases, in order to avoid an excessive drop of pressure, the density does not exceed 300 to 400 amperes per square inch. In the shaft it is necessary to support the weight of the cables, and this is usually done by fixing them in a tight-fitting casing or by cramping them between stout wooden cleats which are securely fastened to the walls of the shaft. Armoured cables are generally preferred for shaft work, the armouring helping to support the weight of the cable, and taking the stress off the insulation and the conductors.

In the mine the cables have to be carried in various ways, according to circumstances, but the most usual method is to hang them by means of cleats or leather thongs from the timbering. Armoured cables hung in this manner are remarkably free from serious injury, but where there is a danger of damage owing to trains running away on the inclines, or to falls of roof, they have either to be buried in the floor or specially protected.

The shaft cables are generally brought to a distributing point at the pit bottom, from which the cables to the various districts radiate. It is the best practice to build this distributing room of brick entirely fireproof, switchboards or pillars similar to those used for tramway work being arranged so that the cables can be conveniently coupled up. Where possible the engine planes, where trains are continually passing, should be avoided, the cables being carried along the travelling roads that are used by the men. Branches are made in suitable jointing boxes or in brickwork distributing rooms, similar in a smaller scale to that at the pit bottom. For coal cutters and portable motors, such as dip pumps, the cables are brought to a fixed switch-box, and flexible cables carried on to the motors. The efficient earthing of all armouring and of the cases of switches and motors is an extremely important matter, and I am glad to say that this is required by the Home Office to be efficiently maintained. In my own practice I always employ separate cramps and conductors to make efficient contact between the outer coverings where junction boxes are fitted.

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**The Reichsanstalt Standards.**—In January 1904, the four standard manganin resistances were checked against the mercury resistance standards, and the average resistance measured was 1·001739 ohms at 18°C. as compared with 1·001741 ohms, the mean of the measurements of the previous 10 years. A number of experiments were (and are still being) made to determine the exact relation between the thermal and electric units, and it is stated provisionally that the grammecalorie at 15°C. corresponds to 4·19 watt-seconds.

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# THE INFLUENCE OF ELECTRICITY ON POWER ENGINEERING.*

BY W. B. ESSON, M.INST.C.E.

*(Concluded from page 1040, Vol. LV.)*

It would be folly to assert that there are no greater risks with the higher pressures, for as a matter of fact, with pressures of 40,000 to 60,000 volts "the highest intelligence, vigilance and excellence must be employed to avoid accident and insure success." These pressures are not to be used indiscriminately or when they can be avoided. A large number of plants are operating at pressures between 10,000 and 20,000 volts and of these it may be said that the overhead lines give very little trouble. The latter figure represents a voltage which can be produced in the armatures of machines of moderate size without difficulty, so this pressure may be considered a limit below which step-up transformers may be dispensed with. When we get much above this we enter a zone where we begin to experience the line troubles which very high pressures bring without obtaining all the corresponding advantages they confer. It is very questionable therefore, whether there should be any halting place between 20,000 and 40,000 volts. At 33,000 volts Dr. Perrine tells us that the special difficulties due to capacity, insulator size, erratic lightning arrester effects, and switching begin to make themselves seriously felt, and it is just as well, if we have to re-design the apparatus with special reference to these difficulties, that we carry the pressure to the other extreme of the zone referred to and so get the full return for our trouble. If high pressures are ever standardised, the figures for the standards will be probably 20, 40, 60 and 80 kilovolts.

With pressures of the order of 40,000 volts quite a new set of phenomena is brought to our notice. In the first place the insulators, in order to prevent flashing over to the supports, must be very much larger and an increase of pressure from 20,000 to 40,000 volts necessitates their diameter being increased by 50 per cent. or more. A usual size of insulator for the former pressure is 6 in. diameter, while the latter should not be less than from 9 in. to 10 in. with the addition of at least one intermediate bell between the outside dome and the inside cup. When these high pressures are used the phenomenon of brush discharge has to be provided against. This results from the breakdown of the air at an insulator owing to electrostatic strain set up in the space between the wires, and it was very thoroughly investigated by several leading engineers in America in 1893. Their experiments showed that while the loss of power due to this cause at 40,000 to 50,000 volts was, with the usual line construction, inconsiderable, after the higher figure was reached the loss increased rapidly. Prof. Ayrton has lately worked out the distance wires of different diameters have to be placed apart to ensure that with certain pressures there shall be no brush discharge. The cure of the evil is of course to keep the wires far enough apart and keep them large enough in diameter, for it is common knowledge that in the vicinity of a sharp point or a sharp edge less pressure is required to break the air down than in the vicinity of a knob or well rounded edge. A thin wire presents along its whole length a comparatively sharp edge, and while with wires of $\frac{1}{10}$ in. diameter 40,000 volts will discharge through about 10 ft., if the wire is $\frac{1}{5}$ in. diameter discharge will only take place when the distance between the wires has been reduced to 15 in. As it is usual to space the wires on a 40,000 volt line about 48 in. apart and as in no lines requiring such high transmission voltage are wires likely to be less than ¼ in. in diameter, it will be seen that there need be no loss from this cause. But there is enough trouble with switches, lightning arresters and higher pressure surges in the line without brush discharge.

It is not the high pressure that makes the trouble last mentioned, indeed raising the pressure reduces surging since the current is reduced with the increased pressure. Experience has shown that if a large amount of power is transmitted it is easier to operate lines at a pressure of 60,000 volts than at a pressure of 30,000 volts, because in the former case the current flowing is only about half. Suppose we are transmitting 5,000 H.P. to a distance of 50 miles at 30,000 volts. Roughly, the current in each wire will be 80 amperes, and it is possible that if this be suddenly interrupted the surge pressure would rise to 20,000 volts. If it happened that the line was momentarily short-circuited by a lightning discharge, and that during the short four times the working current passed, the surge voltage on the removal of this short-circuit might rise to 60,000 volts, which pressure would be superposed to the working pressure. With 30,000 volts between the conductors, the pressure between any conductor and earth is 17,300 volts, so in this case the surge voltage makes the possible nearly four and a-half times the working pressure. If we worked at 60,000 volts, however, the rise on breaking the short would only be 30,000 volts, and this superposed to the working voltage gives a possible pressure of rather less than twice the working pressure. The momentary strain which insulators, transformers and other apparatus should be capable of standing is, in the case of the 30,000 volt transmission, 77,300 volts, while in the 60,000 volt transmission it is 64,400 volts. The higher working pressure has, therefore, the advantage, and if the power transmitted were increased the advantage would be more pronounced. It is probable that on account of this rise in pressure, due to circumstances, the occurrence of which the greatest precaution will not always prevent, the current to be transmitted through each wire of long distance transmission lines will not, as a general rule, exceed 100 amperes.

There is no hard-and-fast rule for pressures to be used but 1,000 volts per mile is recognised as good practice. This is subject to limitation, on the one hand, by the highest pressures of which we have commercial experience, and on the other hand, by the condition that the current in any wire shall not be excessive, a point which has just been dealt with. According to Mr. C. F. Scott a distance in miles equal to three times the number of thousands of volts may be covered without incurring an excessive annual charge per horse-power for copper. This means that 5,000 volts would cover 15 miles, 10,000 volts 30 miles, and 20,000 volts 60 miles. That 10,000 volts has reached 28 miles and 30,000 volts 92 miles is shown by the installations at work. But the solution to all engineering problems lies in compromising and the pressure is eventually settled by striking a balance between the cost and the risks undertaken. In this country the necessity for a higher pressure than 20,000 volts is unlikely to arise, at least for some considerable time.

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* Abstract of the Presidential Address to the Civil and Mechanical Engineers' Society. Delivered October 5th.

Up to the present I have referred to hydro-electric plants only. The water power utilised in the hydro-electric stations must lie somewhere between a million and a-half and two millions of horse-power.

All these schemes cannot be placed in the same category. The work in the immediate neighbourhood of Niagara use about 60,000 H.P., the greater portion of the power being used for metallurgical and electrochemical processes in the form in which it is received. The Niagara industries present the case of Mahomet going to the mountain, but amongst the cases of the mountain taking itself to Mahomet the transmission to the Kolar goldfield at Mysore already referred to furnishes a very good example. For years prior to 1899 the project of utilising the falls was discussed, but as often was it abandoned because of there being no local market for the power, and no prospect of any industries being tempted to the district. But the falls were there with their huge power running to waste, and the Kolar goldfield was but 92 miles distant. Fuel in the mines was excessively dear, while the possibility of transmitting the power economically to great distances had been demonstrated in the case of other undertakings. The problem of utilising the power was in 1900 again taken up, with all the knowledge which had been gained elsewhere brought to bear on it, and an enterprise is in full swing to-day by which 4,000 H.P. is delivered to ten mining companies in the Kolar fields, the revenues from which are sufficient to recoup the Mysore Government for the whole of its capital outlay in six years.

It is difficult to realise what electricity has done for the mining industry. I am not thinking of its use for power distribution in and about coal mines, though, on the Continent, this has now attained gigantic proportions, but of the reduction in operating costs effected by the utilisation of distant water power through the medium of electricity. Mines which, under the old regime, could not have been made to pay, have been opened up, while those that previously had just been clearing expenses have been enabled to pay dividends. It is estimated that the Sheba mine saved £10,000 per annum by introducing electric transmission, owing to the ore being then crushed in the mine instead of transported by aerial rope-way to a mill on the bank of a river 2¾ miles away. At the Burma ruby mines before the installation of the electrical transmission plant, the cost of fuel for power and lighting was £500 per month. The hydro-electric plant saved all this—£6,000 per annum—and enabled the company to begin paying dividends. By the installation of their three-phase plant, the first in the Rocky Mountain regions, the Silver Lake group of mines looked to save £7,200 per annum. These are a few instances out of many. The same tale is told in all cases.

The construction of the pole line often presents much difficulty though many points of interest. Until recently wooden poles only had been used, but it is evident that iron and steel, being many times stronger than wood and capable of economical disposition with regard to the strains, properly designed structures of this material would enable spans to be greatly increased. Such structures have been used in special cases, and where long spans are necessary for crossing rivers and spanning ravines, but there is a growing tendency to employ for high pressures a steel-pole construction with the spans made intentionally long so as to reduce the number of points of support and the number of insulators. Though the bulk of the work may be still carried out in wood, it is probable that for main lines, whenever the magnitude of the enterprise will justify the larger investment, the more solid and permanent construction will be employed. With proper care steel poles should last at least four times as long as wooden ones, so that the sum to be set aside for renewal is much reduced while the maintenance is also less. But against this there may, in many cases, have to be set the cost of freight and haulage to an almost inaccessible region where timber may be obtained for the cost of felling. We shall very likely use steel poles for power lines in this country because we produce not wood but steel and have a preference for things solid and lasting.

A good example of steel construction is presented by the line of the Guanajuato Power & Electric Co., in Mexico. There steel towers about 12 to the mile, are used instead of wood poles, which are generally spaced 40 to the mile. In Italy iron-pole work has been developed to a considerable extent. After Paderno, which was the first line to adopt an all-iron construction, the Cenischia line was erected with a similar design of pole and with spans up to 260 ft. Then came the Brembo line with specially-constructed spans up to 920 ft. to transmit the power over the mountains. Mr. Semenza, who has done a large amount of important work in connection with this subject, informs me that amongst others at present under construction are two new lines with spans of 360 ft., one of them to carry six wires, the other to carry 12. The first iron poles were unnecessarily heavy and had equal stiffness across the line and parallel to the line. Mr. Semenza has quite rightly contended that as in a straight line with equal spans the only strain to be borne by the line is exerted by the wind, it is unnecessary to employ poles of equal resistance in all directions, and he has accordingly designed a pole which presents great resistance in the direction of the wind, but low resistance in the direction of the line. This pole is elastic and can deflect over 16 in. without exceeding the limit of elasticity, the consequence being that if one or two of the wires break, the two nearest poles will bend, which will relieve the strain on the spans following, so that as a whole the line will stand and no damage be done to the supports. The two new lines mentioned above as under construction have poles of this kind as well as the Brembo line.

Several important undertakings depend only on one transmission circuit, amongst which may be mentioned the Electra–San Francisco transmission 154 miles long, the Shawinigan Falls–Montreal transmission 85 miles long, and the Welland Canal–Hamilton transmission 30 miles long. When two circuits are employed the individual conductors are smaller so that there is not necessarily a greater total weight of copper, but for high pressures a pole line for each circuit is advisable, and this with its complement of cross-arms and insulators considerably increases the outlay. Only when the pressure does not exceed 25,000 volts, and where, in consequence, the risk of shut-down is immeasurably less than when pressures of 40,000 to 60,000 volts are used, is it wise to adopt a construction whereby two circuits are carried on one set of poles.

Needless to say, turbine construction has been influenced to a very large extent by electric power development. Apart from the enormous amount of hydraulic engineering work represented by the utilisation of something between one and a half and two million horse-power, the improvement in the efficiency of the turbine from the date of Francis' wheel must be credited directly to the great stimulus electric-power work gave to turbine manufacture. While in 1870 the average power of each wheel made by one of the leading turbine firms was 70 H.P., in 1903 it was over 700 H.P., and the annual output in horse-power had increased from 10,000 to 130,000. Twenty-five years ago the construction of a turbine giving 500 H.P. was something of an achievement; to-day turbines are at work at 10,000 H.P. In all modern installations the electric generators are coupled direct to the turbine shafts. When it is possible, a horizontal shaft arrangement is chosen, though it is noteworthy that up to the present, owing to the special conditions to be met, the largest turbines have had vertical shafts. Generally the full-load turbine efficiency is about 80 per cent., though higher figures have been obtained, but the power of the wheel, the speed and the fall all influence the useful return. The design of turbines has not received such study in this country, possibly because here the sphere of their usefulness is comparatively narrow. On the other hand, the subject has been studied exhaustively on the Continent, and it is to books written in another language that we must go for our information.

But if we are backward with respect to water turbines, we make up for this as regards the steam turbine, for if Britain is not exactly the birthplace of the latter, it is the country which has seen its greatest development. The Parsons turbine was first designed in conjunction with a dynamo to form a complete generating unit and, born in 1884, in the present year the turbo-generator attains its majority. At the time of its advent but little attention was paid to it and it was regarded mostly as an interesting scientific toy. To-day there are 600,000 H.P. of turbines of the Parsons type at work, and in 21 years the machine has grown from a 10 H.P. infant to a 10,000 H.P. giant. The turbine is gradually being recognised as the simplest and best form of steam engine for alternator driving, and to be preferred to reciprocating engines in every case when the generator output is over 1,000 kw. and there is available plenty of condensing water.

The influence of electricity on the design of steam engines other than the turbine is undoubted. When the dynamo first made its appearance there was no high-speed engine in the market, and it was the persistent call of electrical engineers for an engine to which their machines could be coupled direct, thus dispensing with belts or ropes and the loss of power inseparable from them, that led the late Mr. Willans to persevere and achieve such remarkable results. The dynamo gave the engineer an appliance which enabled him to ascertain to a nicety the efficiency of his engine, and the researches in this direction described in the classical Papers of Willans are a standing tribute to his ability as an engineer and his patience as an investigator. Many have followed in Willans' footsteps with the result that high-speed engine design has about reached its highest level.

Dowson, by his introduction of a heat gas, did much in the early eighties to encourage the use of gas engines, and considerable progress resulted from his work. On account of the demand for engines to drive dynamos a large number of competitive designs came into the market, and improvement was greatly stimulated thereby, but it was not till 1896 that blast-furnace gas was used in a gas engine, an experiment being made in that year on a very small scale at the Wishaw Works of the Glasgow Iron & Steel Co. When the possibility of burning blast-furnace gas direct in the cylinder of an engine and the economy resulting therefrom were realised, a great impetus was given to gas-engine construction. But alas, from this date the sphere of the greatest activity was shifted to the Continent, and it is there that the business in large gas engines has been done. It was left for the newer iron and steel works on the Continent to take advantage of the opportunities which the working with blast-furnace gas afforded. In such works the blowing, of course, comes first, and engines of 1,200 H.P. have been constructed for this. Nevertheless, a large number of engines are coupled direct to electric generators which serve to operate motors for cranes, rail straighteners, shears, pumps and all the auxiliary machinery to be found in an iron and steel works. At the present time there are probably not less than a hundred engines of over 500 H.P. working with cheap power gas to drive electric generators, and more large engines are made for this purpose than for any other. Already engines of 2,500 H.P. have been constructed for electrical work, and I understand that the designs are completed for the 5,000 H.P. size. Undoubtedly engines using gas produced from cheap bituminous coal will figure largely in the electric power stations of the future.

On the Continent a number of installations have been erected in which the bye-product gas from coke ovens is utilised to drive gas engines. In the Ruhr coke-making district in Germany there is an aggregate of no less than 6,000 H.P. produced by the utilisation of waste gases from ovens, There are coked in this country annually about 50,000,000 tons of coal and the gas from the coke ovens is capable of yielding in gas engines 1,000,000 H.P. continuously. In Germany and Sweden there are several works in operation producing power gas from peat. For the production of this gas the peat can contain as much as 45 to 50 per cent. of water, and it is not unlikely that there may be an opening here for the establishment of power stations near peat moors remote from coal fields. I have heard of a peat moor about 1¾ miles square, capable of supplying enough gas to generate 10,000 H.P. for 60 years. This may or may not be an exaggeration, but it is certain that there is enormous industrial waste in this country, and that true co-operation in the widest sense of the term between different industries would result in large savings.

I have not touched upon that department of power engineering which concerns itself with railways. The influence of electricity has wrought revolutionary changes here, but I have already occupied your attention too long, and in dealing with a subject so vast something has to go. It is only 24 years since the first commercial electric railway was laid down, and to-day the capital invested in street railway undertakings is something in the vicinity of 200,000,000 sterling. In this country there are about 1,800 miles of electric tramways and about 280 miles of electric railways, of which in London alone 150 miles are opened or under construction. These figures indicate great progress, but there are many fields of enterprise as yet untilled, and in closing I feel that I have but touched the fringe of a great subject. In the application of electricity to power work, engineering finds its mission of civilisation as well as its greatest triumph; while the power lines disappearing in the jungle, climbing to the mountain tops, spanning the torrent and descending to the fertile valleys, bear to distant points, no less than telegraph and telephone, a message of peace and progress.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. FOURNIER D'ALBE.]

*The Spinthariscope.*—The scintillations of phosphorescent zinc sulphide, when subjected to the bombardment of the radium corpuscles, has not yet been satisfactorily explained. Crookes regards each flash as due to the impact of a single positive ion or α-particle, while Becquerel regards the production of light as a secondary effect resulting from cleavages of the crystals brought about by the action of the rays. These two views are not entirely incompatible, but R. W. Wood has obtained some data which, though not very conclusive, make it probable that Becquerel's tribo-luminescence is not the process actually in operation. He judges by the duration of the flashes. When zinc sulphide is mounted on the rim of a rapidly revolving disc, exposed to radium, and viewed through a small lens, the flashes are not drawn out until the disc is made to revolve at a very great rate. Their duration is hardly more than $\frac{1}{20000}$th of a second. When the sulphide is touched with the point of a glass rod, thus producing cleavages, the flashes apparently extend half-way round the disc. The author also tried photographic records of the scintillations, and found after an exposure of several days that only certain points of the sulphide screen were affected. He believes the flashes are conditional upon the presence of some impurity, and that only a small proportion of the sulphide crystals contain this impurity. In any case, the flash is not instantaneous, and its wave-train is several miles in length.

[R. W. WOOD, *Philosophical Magazine*, October, 1905.]

*Theory of Magnetism.*—P. Langevin works out the electron theory of magnetism. He starts from the conception of electrons revolving in orbits about atoms, and constituting amperian molecular currents or Ewing's elementary magnets. He shows mathematically that the establishment of a magnetic field modifies the molecular currents, as Weber supposed 50 years ago, and as is known to take place in the Zeeman effect. This modification or change of period is very slight, as is also the Zeeman effect, but it is always in the diamagnetic sense, and independent of the temperature or state of aggregation of the body. Diamagnetism is thus fully explained, and is the fundamental phenomenon. All matter is essentially diamagnetic, and paramagnetism and ferromagnetism are only superposed effects, the first being due to the orientation of the molecular magnets in accordance with the external field, and the second being due to the mutual influences of the molecular magnets. As soon as paramagnetism appears, it is large compared with diamagnetism, and completely masks it. It can be shown by the equations of Maxwell and Hertz that the magnetic moment of a molecular current is increased by a field H normal to its orbit by the amount

$$-\frac{He^2S}{4nm},$$

where S is the area of the orbit. But the strongest field we can produce is less than $10^5$ units, and we are therefore unable to change the molecular magnetic moment by more than $\frac{1}{100}$ of 1 per cent. Hence the smallness of diamagnetic polarity and of the Zeeman effect. The author further shows that the molecular current will accurately represent Weber's circuit of zero resistance if the inertia of the electron is entirely electromagnetic. Since the diamagnetic modification is very slight, the molecular currents may be considered as indeformable and as constant in strength. This implies that a complete representation of the facts of paramagnetism and of the exchange of energy between magnets and currents is obtained on the hypothesis that the magnets consist of similar currents rigidly obeying the ordinary laws of electrodynamics. As regards paramagnetism, Curie has shown that paramagnetic susceptibility is inversely proportional to the absolute temperature. The author fully explains this law. The molecules whose magnetic axis is parallel to the field acquire a greater kinetic energy than the others, leading to an increase of temperature proportional to the increase of moment. To reduce this a quantity of heat $dQ = H\,dM$ must be abstracted. Since $\frac{dQ}{T}$ is an exact differential, we have Curie's law

$$M = k\frac{H}{T},$$

if the magnetisation is proportional to the field.

[P. LANGEVIN, *Journal de Physique*, Oct., 1905.]

*Anti-Vibration Suspension.*—W. H. Julius, the inventor of the anti-vibration suspension which bears his name, points out that its principles are not yet sufficiently grasped by manufacturers. It must fulfil five conditions to be effective. The three wires of the suspension must be of equal length, equally loaded and perceptibly stretched. The centre of gravity of the whole suspended body must be in the horizontal plane containing the bearing ends of the wires. Those parts of the apparatus whose freedom from disturbance is most important must be near the centre of gravity. Vertical shocks must be eliminated by introducing a short length of spiral spring into each wire. And, lastly, the proper vibrations of the suspended body must be damped by liquid immersion or cotton wool, mounted in the plane containing the centre of gravity. If the apparatus on the suspension must be frequently handled it is best to have a clamping device. This consists of a triangular frame mounted on a table and surrounding the triangular plate of the suspension on all sides within 1 cm. A screw projects through each side of the frame, and when one of the screws is driven home it urges the suspension against the two others. The three screws then hold it until the manipulation is over.

[W. H. JULIUS, *Annalen der Physik*, No. 11, 1905.]

*Rare Atmospheric Gases.*—Dewar has shown that charcoal at the temperature of liquid air possesses an extraordinarily high absorbing power for atmospheric gases, and used this property for discovering hydrogen, helium and neon in comparatively small quantities of air. S. Valentiner and R. Schmidt have now employed this same property for manufacturing neon, krypton and xenon for spectrum tubes. To obtain the neon, they collected a quantity of argon, which contains neon, and led it over cocoanut charcoal kept at the temperature of liquid air. In this manner they liberated the neon, and avoided any admixture of nitrogen. The pressure had to be low, not exceeding a few millimetres. To free the neon from traces of helium, they occluded it in pure charcoal at a somewhat higher pressure and drove it out again. They thus obtained spectroscopically pure neon. To obtain krypton and xenon, they used charcoal at – 120 deg., which absorbs krypton and xenon completely, but only a little argon. They again eliminated the argon by connecting with a tube of charcoal in liquid air. Heating to – 80 deg. liberated pure krypton. A similar differential method enabled the authors to eliminate the krypton and to obtain spectroscopically pure xenon at – 15 deg.

[VALENTINER and SCHMIDT, *Annalen der Physik*, No. 11, 1905.]

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## THE NATIONAL PHYSICAL LABORATORY.

In 1897 the Treasury nominated a committee "To consider and report upon the desirability of establishing a National Physical Laboratory for the testing and verification of instruments for physical investigation: for the construction and preservation of standards of measurement: and for the systematic determination of physical constants and numerical data useful for scientific and industrial purposes—and to report whether the work of such an institution, if established, could be associated with any testing or standardising work already performed wholly or partly at the public cost." This committee duly proceeded to the consideration of these matters, and issued a report eleven months after its formation. The report was in favour of the establishment of a National Physical Laboratory for reasons which are now quite familiar, but it was specifically pointed out that "it would neither be necessary nor desirable to compete with or interfere with the testing of materials of various kinds as now carried out in private or other laboratories. . . ." Nevertheless, it was considered that such a laboratory would be of "great practical use to the commercial community in testing the various forms of measuring instruments which cannot at present be tested under any legal authority."

Considerable interest is now being taken in this matter, as it is felt in some quarters that the National Physical Laboratory is undertaking work for which it was never intended. For many years there have been experts in various branches of industry who have devoted the greater portion of their life, and have spent considerable sums of money, in acquiring experience in the execution of industrial tests. Manufacturers have become acquainted with these experts, and have come to regard them with great confidence. They know that their results can be relied upon to the utmost detail, and that all the work entrusted to them will be treated with the strictest confidence. Now, however, it is asserted that there is a danger of the National Physical Laboratory usurping the position of independent experts and undermining their practice. While this danger may become very real in the future if it is not nipped in the bud, there is really little to fear if the Laboratory is made to conform to the original intentions which resulted in its establishment. In the first place, although the staff at Teddington is possessed of most excellent scientific qualifications, their industrial experience is necessarily very limited. This is patent from the Director's last annual report, in which an appeal was made for higher remuneration, and it is obvious that men of ripe experience will not work for little money, however good the cause may be. Naturally, therefore, manufacturers will feel a certain amount of diffidence in entrusting important work to men of limited experience, and they will probably object to those men gaining experience at their (the manufacturers') expense. Moreover, the Committee referred to above concluded their report by stating that "the results of investigations undertaken at the request of private individuals should, except in special cases approved beforehand by the Governing Body, be published or be accessible to the public, even when the cost of the investigations is fully defrayed by the persons in question." Now, it is hardly likely that manufacturers will sanction the publication of the results of investigations on special subjects, so as to be of benefit to the industry at large. We repeat, therefore, that so long as the Laboratory is conducted according to original intentions, private practitioners need have little fear. There is one point, however, that is open to serious comment, and that is the publication of documents by the Laboratory setting forth scales of charges which are often far below those made by independent experts. Many technical societies and institutions forbid their members to issue scales of charges, and these members are, therefore, placed at a disadvantage with regard to the Laboratory.

So far it is probable that little harm has been done to electrical experts, for it would not be easy to point to specific cases in which private practices, established before the National Physical Laboratory, have been affected. As a matter of fact, there are, at the present day, remarkably few private laboratories where electrical investigations of industrial importance are being carried out by experienced men. It is true that there is the Board of Trade Electrical Laboratory, which performs a function of quite a special nature, and it is to be feared that the National Physical Laboratory is quite unnecessarily endeavouring to compete with this excellent institution. This is most regrettable, as the functions of the two laboratories differ widely. The Board of Trade is guardian of the standards, and its electrical laboratory exists essentially for standardising purposes—that is to say, for verifying and checking secondary standards against primaries. This work, it may be mentioned, the Board of Trade Laboratory can perform with greater accuracy than the National Physical Laboratory, owing to its special equipment.

The whole matter is one that will doubtless be forced upon the attention of the Government next session. On the one hand, the Laboratory is endeavouring to secure a larger grant from the State, while, on the other hand, the management of the Laboratory and the nature of the work done there has recently been criticised with some vigour in a weekly publication issued by *The Times*. If this additional State aid be granted a pledge may perhaps be exacted from the Government that the money is to be devoted to work performed for the public good and not in opposition to private enterprise. It is obvious, in fact, that no institution should be subsidised in order to compete with the very taxpayers who contribute towards the subsidy. Some time ago Mr. JOSEPH CHAMBERLAIN said that much of the work done at Teddington was being done equally well in college and university laboratories, but he might have added that certain work which the Laboratory attempts could be done better by independent experts. There is a work, and a very great work, for which it is admirably adapted, and to the execution of which all the energies of the staff, as well as public money, should be devoted. Scientific research, pure and simple, should be its primary aim, and is most certainly deserving of the support of any Government. Naturally enough, instrument makers are anxious to secure for their instruments certificates of accuracy granted by some well-recognised authority; and if the Board of Trade is not in a position to grant certificates, except for actual sub-standards, the National Physical Laboratory may continue to extend its sphere of utility in this direction, and this class of work could be made self-supporting.

Much more benefit will accrue to industry if progress is sought along the right lines than if attempts are made to undertake work when the proper material is lacking. Manufacturers throughout the Kingdom have observed with pleasure the establishment and growth of the National Physical Laboratory, and there is no doubt that their hearty support will be available in the future if the powers that be are only willing to take advice when it is offered in a sincere and friendly spirit. While wishing in no way to retard the progress of the true work of the Laboratory, we cannot but think that the note of warning that has been sounded is opportune, and we trust that it may prevent the disaster which would be bound to occur if the management developed their trading instincts to the detriment of the scientific pursuits which are their true vocation.

## REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign book.)

**Transactions of the American Electrochemical Society.** Vol. VII., 1905. (Philadelphia: The Society.) $3.00.

This is the epoch of the amateur. He is peculiarly rampant across the water. 339 pages are devoted in these "Transactions" to electrochemical dissertations; the major fraction is filled with material (we will not call it stuff) of the quality proper to graduating theses. It is right that the student should be encouraged to set down his experiments and to draw suitable deductions, but need they be printed for the consumption of the public? That pleasing optimism which is the privilege of ignorance, though delightful as a spectacle, is not to be taken too seriously, and should be excluded from the pages of a body devoted to the truth. The Paper on the reduction of titaniferous ores may be cited as an awful example, but there are others. As a contrast may be given the suggestive note by Mr. D. Bancroft on the rotating diaphragm, in which it is shown that if the diaphragm (say, of graphite) is rotated with sufficient speed, its sides are opposed alternately to anode and cathode often enough to act as an intermediate reversible electrode and to transmit current without the drop of voltage necessary for the continued separation of the anion and cation and without the resistance due to the diaphragm *quâ* diaphragm.

There is in the "Transactions" a great mass of useful material, illumined by cogent comments. There are also many pages wasted by ink; no doubt the ink is good, but it has been misapplied. Seeing that it is not only desirable but positively necessary that a record of useful work in the science and art of electrochemistry should be produced, and seeing that there is no country where opportunities for this work are so wide as in the United States, cannot the directing spirits of a notable society apply some styptic to obvious nonsense, and present in a clear well-edited shape those valuable researches which are essential for the advancement of the industry?

**Engineers' Turning.** By JOSEPH HORNER. (London: Crosby Lockwood & Son.) 1905. 9s.

The book contains in clear language a critical description of the various kinds of engineers' lathes and their accessories, besides giving much sound advice and many hints regarding the choice of apparatus, and the art of turning itself. High-speed tool steel and its treatment is considered at length, and altogether the book is up-to-date and covers the subject in its various aspects so exhaustively as to leave little to be desired. Something might have been said, however, of the driving of lathes by variable-speed electric motors, which is now gaining so rapidly in favour, and to the description of the magnetic chuck fitted with electro-magnets might have been added a description of a magnetic chuck provided with permanent magnets, which, although suitable only for very light work, possesses the advantage of requiring no electric supply. A reference to the hardening and tempering of tools by the electric current might also have been made. The book is well illustrated and we are confident that it will be an accurate guide to the amateur and a help even to the experienced turner.

## ELECTRIC SIGNALLING ON THE GREAT NORTHERN & CITY RAILWAY.

The safety of the travelling public and the frequency of trains on busy lines depend so much on the signalling system adopted that improvements and simplications of such systems and apparatus are not only of great value to railway men and electricians, but also of much interest to the general public. It was recognised long ago that electricity was the ideal power for operating signals, and a number of electric signalling systems have been invented in the past. As time went on such of those inventions as had been found worthy of practical application were perfected, and we have to-day a number of electric signalling systems which appear to answer their purpose satisfactorily.

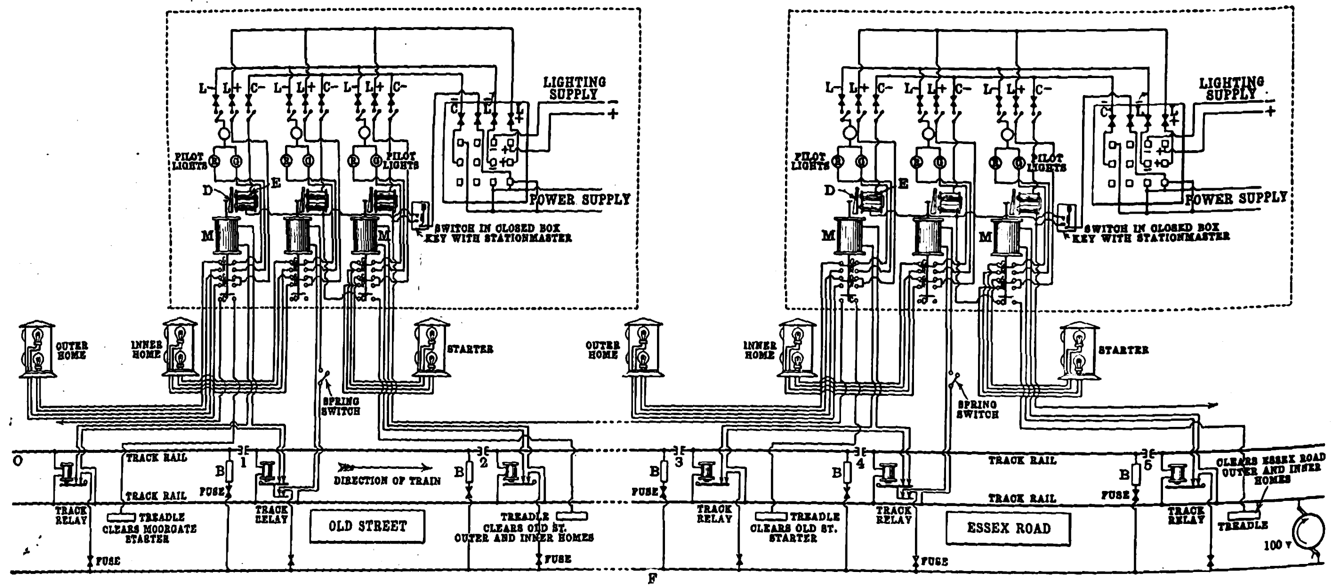
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Diagram of Connections of the Signalling System employed on the Great Northern and City Railway.

One such system has recently been installed on the Great Northern & City Railway by Messrs. J. E. Spagnoletti & Co. under the patents of J. E. Spagnoletti, R. P. Brousson and A. H. Binyon. The installation of the plant was supervised by the Engineer and Traffic manager of the railway, Mr. R. P. Brousson, whose former experience on the Central London Railway, combined with a special aptitude for problems of this character, has been of great value. Previous to this installation Messrs. Spagnoletti & Co. manufactured and fitted the electric locking gear of the Metropolitan Railway, the City & South London Railway and the Central London Railway, the patents covering the apparatus being held by Mr. C. E. Spagnoletti. The patents of the Great Northern & City system are now to be taken up by a new company, the Automatic Block Electric Signalling Company.

It may be remembered from our description of the Great Northern & City Railway (*The Electrician*, Vol. LII., pp. 490 and 558) that there are two conductor rails, the running rails not being used for conveying traction current. The track rails are, therefore, now employed for signalling purposes. Altogether the railway consists of 3½ miles of double track, this length being divided up into 40 block sections.

The accompanying figure represents the diagram of connections of the signalling plant between Old-street and Essex-road stations. For clearness, the two insulated conductor rails are not shown. The general idea of this signalling system is to actuate the signal lamps by the train itself in such a manner that the signals, which consist of electric lamps in the tunnels and semaphores in the open, are constantly set at "danger" behind a train but cleared again after the train has proceeded a certain distance beyond. Signals in the previous section or sections cannot be cleared until the signal immediately behind the train has gone to danger. Moreover, the arrangement is such that any irregularity in the current supply or any breakage in the wires, &c., is automatically indicated by putting the signals to danger. What is most noticeable with this signalling system is that all the controlling mechanism of the signals is placed in the signal cabins and therefore accessible, there being no mechanism in the tunnels between stations which requires adjustment.

The direction in which the trains run is indicated in the diagram of connections by an arrow. One of the track rails is bonded so as to form a continuous conductor throughout its length, the other running rail being divided into block sections. In order to ensure a fair insulation the fishplates at the junction of sections are of oak, and the rail ends are separated from each other by a piece of vulcanised fibre. The rails of each section are also bonded, of course. The dotted line in the diagram embraces the apparatus installed in the signalling cabins, the remainder being in the tunnel. Two voltages are made use of in connection with the signalling—viz., 100 and 500 volts. The 100 volt circuit is fed from one or two motor generators at Highbury station, near the centre of the traction system. Current for the motors of these sets is obtained from the 500 volt lighting supply, and the current at 100 volts is conveyed from the generator along the tunnels by the insulated wire F, returning back through the continuous-track rail. In the tunnels these feeders, F, are carried along the walls by porcelain insulators. All other wires relating to the signalling system are likewise insulated and carried on insulators in the tunnels, being protected at the entrance to and exit from the signalling cabins by iron tubes and other suitable protection. The 500 volt supply for the signalling is obtained from the regular traction supply.

At the end of every block section current is fed from the cable F through a number of incandescent lamps in parallel (forming an adjustable resistance, B) to the section, the current then flowing through the simple direct-working track relay (which is connected across the track rails at the front end of each section), and returning back to the 100 volt generator at Highbury through the continuous-track rail, as indicated in the diagram. The track relay, which is well protected, is fixed on the wall of the tunnel well out of reach. Matters are so adjusted that the voltage across the track rails is kept constant at about 3 to 4 volts, but in any case this can easily be regulated by the resistance B. When energised the track relay attracts its armature, and when this occurs the two contacts shown are connected and current is enabled to flow from the 100-volt cable F by way of the contacts of the track relay and the main solenoid M, returning through the continuous-track rail to the generator at Highbury. In the case of the "outer home" relay (see diagram) the current, before returning to the continuous rail, has to pass the "inner home" relay also.

Although the main solenoid is thus energised, its plunger armature is prevented from rising at once by the stop D, which is only drawn back when the train has advanced a certain distance, as will be explained later. Hence the plunger armature remains at present in its lowest position (in the diagram the plunger is shown at its highest position) and the three pairs of contacts marked R, R and C, respectively, are metallically connected. This stop, D, makes it impossible for the signal to assume the "clear" position behind the train should there be sufficient rise in the track voltage to cause the track relay to energise again before the train is properly out of the respective section through leakage due to a short-circuit on the collector rail or derailment of a train. Considering first the circuit corresponding to the set of contacts marked C, it will be noted that this circuit includes the electromagnet E and ends in a treadle at the side of the track. Thus this circuit is not complete. It is closed, however, when a train passes the corresponding treadle in the section following the one to which the signals refer. To this end a metallic brush is fixed at the back end of the train, this brush rubbing against the treadle whenever it passes it. The contact between brush and treadle lasts only a moment, and the current thus sent through E is at 500 volts. The circuit corresponding to the middle and upper sets of contacts marked R includes the red lamp of the signal in the tunnel and the red lamp repeater in the cabin in series, so that both show "red" simultaneously when the plunger of the solenoid M has dropped to its lowest position. Current for these lamps is obtained from the lighting supply of the railway system as shown in the diagram.

When the stop D is drawn back by the train passing over a treadle, the plunger (providing current is flowing through the respective solenoid M) is drawn upwards and closes the two sets of contact marked G. It is easy to see that this causes the two "green" lamps in series (one in the tunnel, the other in the cabin), to light up.

So as to explain the order of the various movements and the interaction of the signals we will now assume a train to be entering the line represented in the diagram from the left. All the signals are supposed to be at "green." As soon as the train enters the block section 0-1, the first track relay, being short-circuited by the wheels and axles of the train, drops its armature. Current ceases to flow through the first main solenoid M, and the latter's plunger drops by gravity and sets the signals (both in the tunnel and in the cabin) of the outer home of Old-street station to danger. When the train enters section 1-2, the second relay is short-circuited. This causes a second break to be made in the circuit of the first main solenoid, at the same time interrupting the current to the second main solenoid. The plunger of the latter now drops so that the "inner" home signals in the tunnel and in the cabin are also set at danger. Whenever the plunger falls the stop D locks the plunger in its lowest position, so that the plunger could not rise even if its solenoid were energised. When the whole train is at the station, within section 1-2, the first track relay is again energised and attracts its armature. However, no current can yet flow through the first solenoid M because its circuit is still interrupted by the second track relay. The "starter" at Old-street station, at the entrance to the tunnel towards Essex-road station and consequently just in front of the motorman's cab, is still at "green" and the train continues its journey. When the first wheels of the train enter section 2-3, the third track relay is short-circuited, the plunger of the third main solenoid M drops, the "starter" at Old-street is set to "red," and the two contacts marked C are metallically connected. After a while the train has left section 1-2 entirely and the second track relay becomes energised. In consequence current is caused to flow through the first and the second main solenoids, but their plungers are as yet prevented from being sucked up by the stops D. Hence the outer and the inner homes of Old-street station are still at danger. An instant later, however, the brush contact at the rear of the train rubs against the first treadle between Old-street and Essex-road stations (the very first treadle shown in the diagram has not been referred to in our description, as it operates a signal outside the diagram), and current, at 500 volts, flows from one of the "third" rails through a special switch on the last coach of the train, the rear brush, the treadle, the first two solenoids E (which are connected in parallel as shown), returning to the other pole of the traction supply by way of the power mains indicated. Although this current is only momentary, the impulse suffices to attract the first two stops D, and the two respective armatures are attracted. The plungers of the first two main solenoids fly up immediately, and at the same time clear the Old-street outer and inner homes. The third main solenoid does not rise because it is not energised. Hence the "starter" at Old-street still shows a red light. When the train enters the section 3-4, the plunger of the fourth solenoid M drops, the outer home of Essex-road station goes to "red" and after a while the brush at the rear of the train comes into contact with the second treadle between the two stations; the third electromagnet E is energised, the plunger of the third solenoid M rises and the "starter" at Old-street goes to "green." The subsequent operations are a repetition of what has just been described. To provide the necessary overlap the treadles are placed in advance of each of the sections they control, so that a train must have passed at least a train length into the section ahead before the block (stop D) on the rear signal is removed. The circle above the "red" and "green" lamps in the cabin represents an ordinary lamp inserted for steadying purposes. Each cabin contains six sets of instruments, three for the "up" and three for the "down" line. The mechanism of each set is contained in a neat glazed case, measuring 18 in. by 9 in. by 6 in. We understand that the motor-generator at Highbury station has to supply an average of 100 amperes during the time the railway is in operation. This corresponds to an output of about 10 kw., which is not an excessive amount for so large a system.

The terminal junctions are semi-automatic stations with hand-worked points and crossings. The control of the signals from the track is effected in the same way as in the case of the simple automatic stations. The 100 volt solenoid coils governing the position of the red and green signals are also similar in principle, but have, in addition, hand-worked plungers and the necessary interlocking between the mechanical portion of the signal work and the electrical to ensure that the points and the signals agree. The apparatus to obtain this locking consists of: Electrical contact-making devices on the point blades, electrical contact-making devices on the facing point locks, electrical contact-making devices on the levers for points, and facing point locks in the signal cabins, plungers for clearing signals at junctions and electric locks on levers for controlling signals. In addition, block instruments worked off the 100 volt circuit are provided for controlling the platforms and portions of the line which are governed by two or more signals. These block instruments are provided with a permissive treadle control, worked from the 500 volt circuit on the trains, similar to that provided for the purely automatic stations.

Our thanks are due to Mr. R. P. Brousson and to Mr. H. M. Bayly, of Messrs. Spagnoletti's, for conducting our representative over the system and placing at his disposal the information embodied in this article.

**Combined Electric and Steam Traction in Hungary.**—According to *Elektrische Bahnen ünd Betriebe*, the railway which is at present being built between Miskolez and Diósgyör will normally be operated electrically, but the traction peaks (which are very pronounced) will be dealt with by three steam motor cars besides. This arrangement has been adopted to reduce the cost of electrical plant, especially in connection with the distributing system. Messrs. Ganz & Co., who are the contractors for the electrical portion, will also supply the three 80 H.P. steam motor cars, which are to haul a number of trailers.

## WATERSIDE STATION No. 2 OF THE NEW YORK EDISON COMPANY.*

*(Concluded from page 999, Vol. LV.)*

The boiler arrangement adopted is upon the cross-fire room plan, which has become typical of the more recent large turbine stations in this country. In the majority of cases, however, it has been found preferable to concentrate the firing rooms as much as possible, with the result of a less convenient arrangement of chimneys, whereas in this plant a division of fire rooms was selected which, as may be noted in the accompanying plan, is more advantageous for the flue, chimney and coal-bunker arrangements. There are upon each boiler floor three main firing rooms, each having a row of three batteries of two boilers each upon either side, and at either end of the building a half-firing room with a single row of six boilers; this arrangement permits of the use of only four chimneys, which will be symmetrical in design, each chimney thus operating 12 boilers upon either floor, or 24 each. The objection that might be offered to this arrangement for a smaller plant resulting in half-fire rooms will here not prove serious, as owing to the magnitude of the plant it will be an easy matter at all times to divide the work between boilers to the best advantage for the firemen.

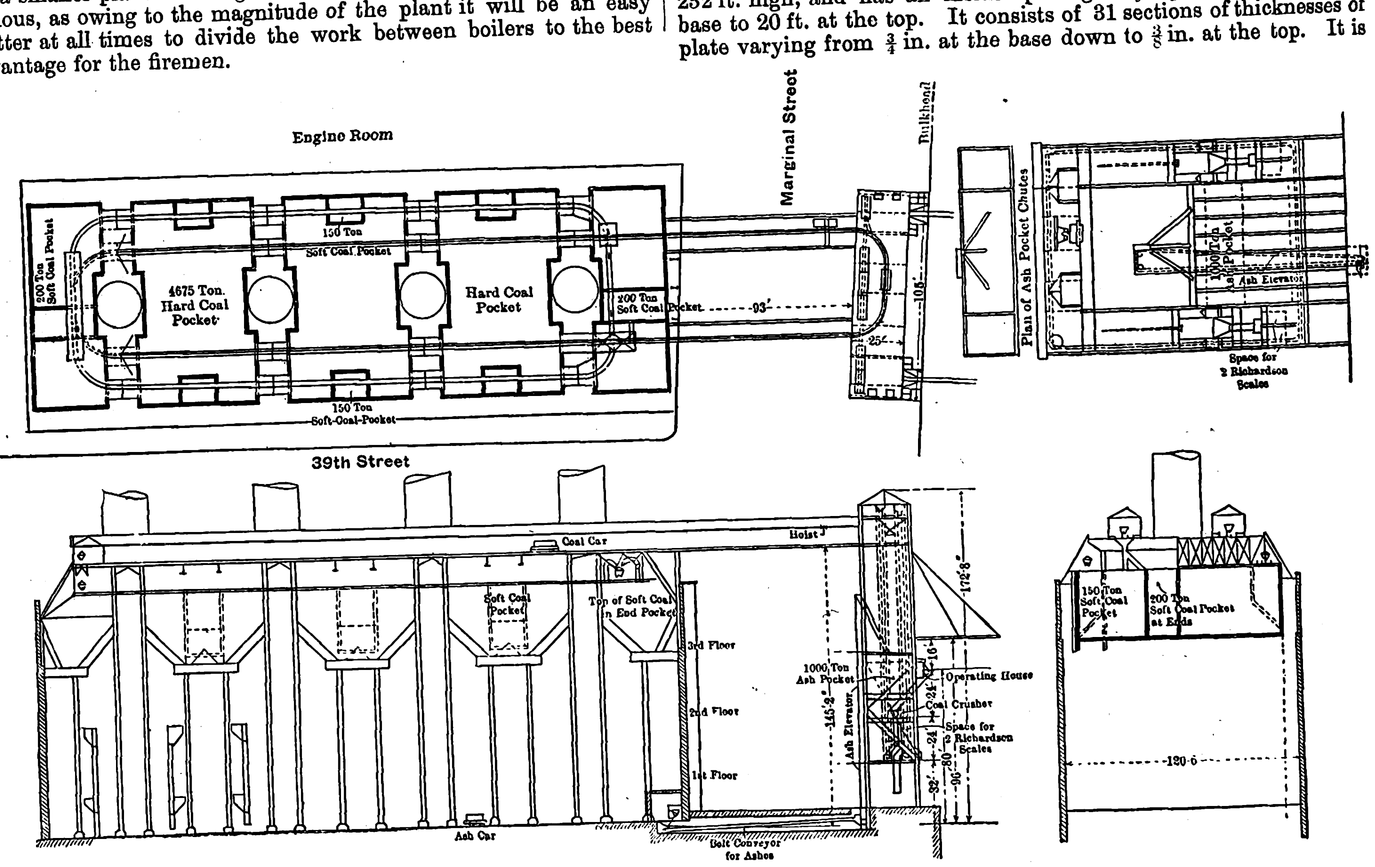

FIG. 3.—PLAN OF STEAM PIPING, COAL DISTRIBUTION, &C.

The boilers selected for the new station will be of the well-known inclined water-tube type of the Babcock & Wilcox Co. and will be equipped with the new Babcock & Wilcox single superheaters. Space is provided for 48 boilers upon each boiler floor, or 96 in all. Each boiler unit will be of 650 H.P. capacity, designed to deliver steam at 200 lb. pressure, and with a superheat of from 100° F. to 150° F., above saturation temperature. Each boiler consists of three 42 in. steam drums and has 294 tubes, 4 in. in diameter by 18 ft. long, arranged 21 tubes wide and 14 tubes high, thus presenting a total heating surface of about 6,500 sq. ft. The vertical rows of 14 tubes each deliver into a continuous wrought-steel header of a new design, which materially simplifies the construction. The trimmings and fittings for each boiler are of extra-heavy design for the purpose of securing a maximum of reliability in service. The boilers will all be fitted with flat grates for hand firing.

Both natural and forced draught will be provided, the latter permitting an advantageous flexibility in the burning of low grades of fuel. For the forced-draught supply there will be installed two blowers of 90,000 cubic ft. capacity per minute for each row of six boilers. These fans, which will be fitted with cases and driving engines by the B. F. Sturtevant Co., are of the Sirocco type, and are to be located upon elevated platforms at the sides of the boiler room, from which position the delivery will be through ducts leading down to cross flues beneath the ash pockets. Dampers are to be provided at each opening, so that the blast may be regulated at will. Sufficient capacity is provided in each blower to operate the entire six boilers to their maximum if at any time this is found necessary.

The products of combustion are discharged from the boiler furnaces through four large self-supporting steel chimneys, which rise to a height of 300 ft. above the first-floor level of the boiler-room. Each chimey will provide for 24 boilers, consisting of one-quarter of the equipment. Connection is made to each chimney through an interesting design of flue and uptake, which rise in the space between the rear ends of the double row of boilers up into the base of the chimney. The flue structure is built up of $\frac{3}{8}$ in. plate, and $2\frac{1}{2}$ in. by $2\frac{1}{2}$ in. by $\frac{5}{16}$ in. angles, having openings 3 ft. 9 in. by 9 ft. in section at the rear of each of the 24 boilers served. In the main uptake from the first to the second floors, which is $8\frac{1}{2}$ ft. by 24 ft. in section, there is a baffle plate to prevent interference of draft when one side is idle. At the second boiler-floor level the flue opens out to an area of $12\frac{1}{2}$ ft. by 31 ft., changing section above that to 21 ft. square at the opening beneath the chimney. The entire flue and uptake structure will be enclosed in a non-conducting covering for preventing radiation of heat into the boiler room.

The chimney, which thus commences at the third-storey level, is 232 ft. high, and has an inside opening varying from $21\frac{1}{2}$ ft. at the base to 20 ft. at the top. It consists of 31 sections of thicknesses of plate varying from $\frac{3}{4}$ in. at the base down to $\frac{3}{8}$ in. at the top. It is lined with 4 in. hard, common red brick backed up to the shell with 1 in. of concrete. This lining will be supported by an angle framework throughout the interior of the chimney with horizontal members at every third plate of the shell; this permits any section to be renewed without disturbing any of the remainder.

While there is no intention of installing economisers at the present, it will, however, be noticed that with the arrangement of uptake and flue adopted, there is ample space provided for economisers for use in connection with boilers toward the sides of the boiler room. Additional connections for such a purpose could easily be made from the boiler setting to the economiser, from which the outlet connection could be joined to the uptake with ease. The middle boilers of each group are inaccessible for such a connection owing to the presence of the main uptake at their rears.

A typical piping arrangement for one of the standard groups of 12 boilers is shown in Fig. 3. From the main steam-header at the turbine-room division wall a branch steam pipe extends up and over the rears of six of the boilers, looping back from thence over the rears of the other six and down to the header again. As the loop is equipped with intercepting gate-valves each battery may thus be seen to have two separate and distinct outlets to the main header. The loop header or branch is located about 5 ft. above the boiler settings, and connections to it from the boilers are made by heavy return bends of 8 in. pipe of 5 ft. 7 in. radius. Each bend has two valves, that next to the boiler a plain gate-valve and the other a non-return stop-valve.

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* A description of Waterside Station No. 1 appeared in *The Electrician* Vol. XLIX., pp. 741, 819 and 899.

The main steam header will be of 14 in. pipe, and is to be located in the area way alongside the division wall on the first floor, where the branch loop connections may easily be made to the boilers upon either floor. The branches to the turbines will be carried from the header through the basement, so that no piping will be visible in the turbine room, although the control of valves will be readily accessible at the machines. All of the high-pressure piping will be of wrought steel with Van Stone joints and sheet-steel gaskets. The flanges used for these joints will be of rolled steel and of a special design with bevelled or recessed edges, permitting of easy inspection of the joint at all times. A new schedule of flange sizes will also be used.

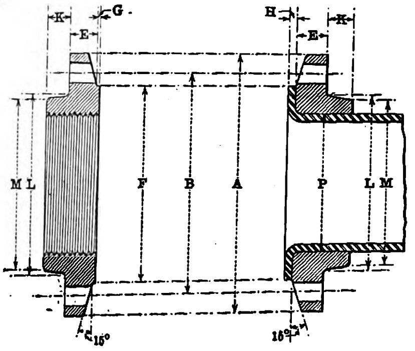

Fig. 4.—Details of Special Piping-Joint Flanges.

A novel feature of the feed-water piping for the new station will be the use of steel pipe with Van Stone joints upon the mains and larger branches, using 5 in. and 6 in. pipe, the 3 in. individual branches to each of the boilers being also of steel. The feed-water piping system will consist of a ring main of the 6 in. steel pipe encircling the entire boiler room, with 6 in. cross headers connected across from the two sides in front of each row of boilers. From the cross headers a branch is carried to each boiler, consisting of a 5-in branch between

ing through a tee to the 3 in. brass boiler
tem will thus, by virtue of the ring main
thereto, be thoroughly reliable, each
d supply and any section of the
luty without affecting the
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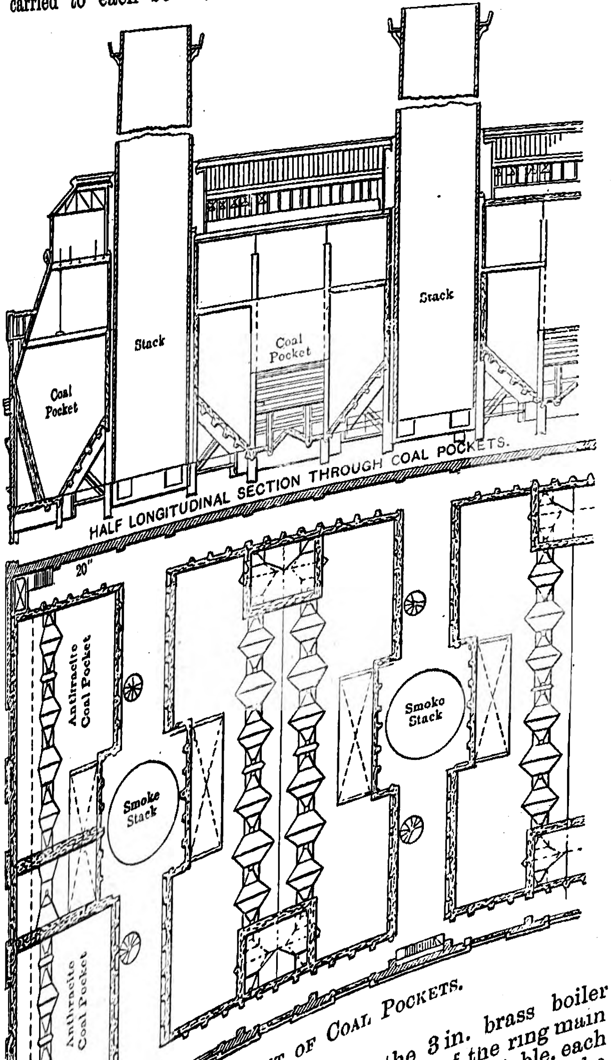

Fig. 5.—Arrangement of Coal Pockets.

The blow-off piping will consist of a single header of 4 in. pipe at the rear of each row of boilers, into which every boiler will deliver through two 2½ in. brass blow-off connections. The two headers at the rear of boilers in every chimney flue space discharge downward through 6 in. connections to a tee leading to a common 8 in. discharge pipe to the condenser-overflow tunnel beneath the turbine room, making thus short, simple and direct outlets for each group of boilers independently. The piping is all of wrought iron with screw-flange joints, except the branches leading from the boiler mud drums, which are of extra-heavy brass pipe. This pipe system is all fitted with flange joints, the flanges agreeing in design with those upon the high-pressure piping. Each blow-off connection will be provided with two valves for protection from leakage.

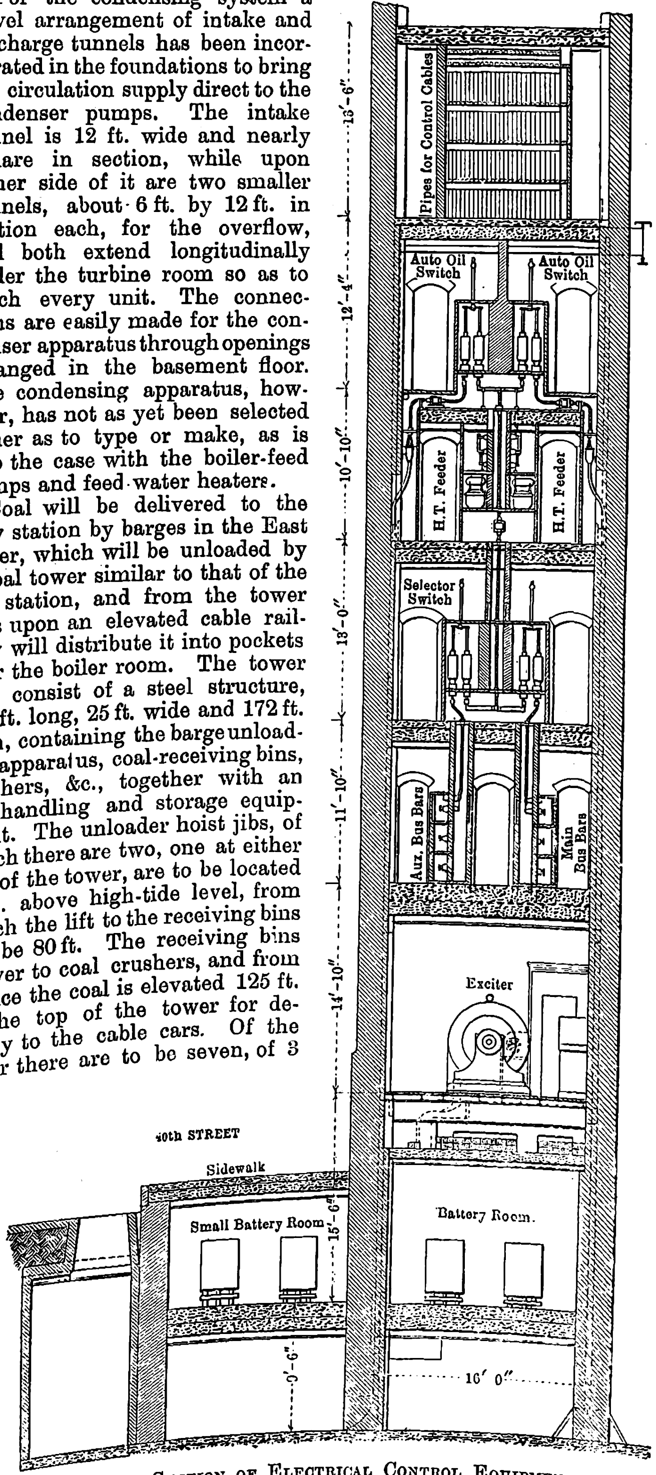

Fig. 6.—Cross Section of Electrical Control Equipment.

For the condensing system a novel arrangement of intake and discharge tunnels has been incorporated in the foundations to bring the circulation supply direct to the condenser pumps. The intake tunnel is 12 ft. wide and nearly square in section, while upon either side of it are two smaller tunnels, about 6 ft. by 12 ft. in section each, for the overflow, and both extend longitudinally under the turbine room so as to reach every unit. The connections are easily made for the condenser apparatus through openings arranged in the basement floor. The condensing apparatus, however, has not as yet been selected either as to type or make, as is also the case with the boiler-feed pumps and feed-water heaters.

Coal will be delivered to the new station by barges in the East River, which will be unloaded by a coal tower similar to that of the old station, and from the tower cars upon an elevated cable railway will distribute it into pockets over the boiler room. The tower will consist of a steel structure, 105 ft. long, 25 ft. wide and 172 ft. high, containing the barge unloading apparatus, coal-receiving bins, crushers, &c., together with an ash-handling and storage equipment. The unloader hoist jibs, of which there are two, one at either end of the tower, are to be located 96 ft. above high-tide level, from which the lift to the receiving bins will be 80 ft. The receiving bins deliver to coal crushers, and from thence the coal is elevated 125 ft. to the top of the tower for delivery to the cable cars. Of the latter there are to be seven, of 3 tons' capacity each, which will be loaded at a rate of about two per minute, giving thus a total capacity of 357 tons per hour. The cable railway makes a complete circuit of the coal pockets above the boiler room, embracing 835 ft. of track; the cars when in operation will be spaced 133 ft. apart, and will travel 265 ft. per minute.

The coal pockets (Fig. 5) in the boiler house consist of five large bins, as indicated in the plan, with an aggregate capacity of over 18,000 tons. The large bins are intended for anthracite only, while for other classes of fuel eight smaller bins of 150 and 200 tons' capacity are incorporated within the large bins, as indicated, so as to deliver to each of the five firing aisles. The large bins are designed to deliver without pocketing to all points of their respective firing aisles, while the small individual bins will deliver at the ends, from which the bituminous or other fuel will have to be distributed in barrows. The small bins will be used for bituminous coal, sometimes used in combination with the anthracite, in proportions of one part to five of the anthracite, during times of heavy-peak overloads.

The ashes from the boiler furnaces will be handled from the boiler-house basement by a system of small cars operating upon narrow-gauge tracks, to the ash pocket in the coal tower. This ash pocket is of large proportions, holding 1,000 tons, and is elevated so that the outlet spout is 32 ft. above high-tide level. Ashes are delivered from the cars to the pocket by an elevating conveyor, and outlet spouts are provided for delivery either to waggons or boats.

The electrical-control equipment for the new plant will be very similar to that in the original station, the only feature of departure being in minor detail where practice has indicated improvements. The high-tension system, including oil switches and control and switching apparatus, will be controlled the same as in Waterside No. 1, it being intended, in fact, to so tie the two stations together by 'bus-tie connections that the two plants may be operated as one unit. The oil switches and other high-tension apparatus, instead of being arranged at one end, will be located in the mezzanine galleries, of which there are six, extending along the entire Fortieth-street side of the turbine room. The control boards will, as in the original Waterside, be located on an upper-storey level (third mezzanine) at the First-avenue end of the room, and will be in the form of an open balcony overlooking the entire turbine section. The control boards are to be arranged in two rows of semi-circular shape in the gallery, the feeder panels at the rear and the generator panels at the front. The equipment of the panels will be in general similar to that of the control panels in the old station, which has been referred to in considerable detail in these columns.

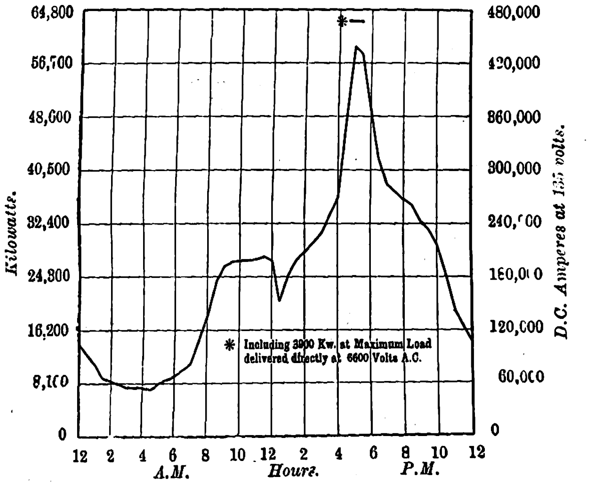

Fig. 7.—Load Curve of System. Day of Maximum Load, Dec. 22, 1904.

The arrangement of the electrical galleries adopted, as shown in Fig. 6, introduces novelties worthy of note. On the first-floor level adjacent to the turbine room will be located the exciter units and associated-control apparatus, a booster, compensator and two end-cell switches for the storage batteries. On the first mezzanine will be the main and auxiliary 'buses, encased in cells of brick wall and alberene partition construction; the 'buses will have wired-glass doors in front and at the rear, where the connecting cables are attached through disconnecting switches. The second mezzanine gallery is to contain the selector oil switches by which the feeders or generator leads are connected to either set of 'buses as desired. The individual-feeder oil switches are, however, located upon the fourth mezzanine, from which the high-tension feeders lead out through series transformers under the floor to the underground mains. The third mezzanine gallery will carry the potential transformer equipment, the connections to which are brought down from the gallery above through disconnecting switches, as shown. In the fifth gallery the greater portion of the space is devoted to racks to carry the control wires to the operating boards, this detail alone proving to be one of great magnitude, as well as of importance.

It will be noticed in the above arrangement, however, that each feeder will have only one automatic oil switch in it in addition to the selector or group oil switch, which is similar to the present arrangement in the original Waterside station. The new arrangement also permits of locating the generator oil switches in the same manner as, and alongside of, the feeder oil switches, thus materially simplifying the whole arrangement, and at the same time largely reducing the length of the generator leads. The generators with this arrangement feed directly through the selector switches to the 'bus bars at points opposite their locations. The arrangement of the potential transformers, series transformers, &c., on the third mezzanine by themselves is also a distinct advantage in concentration and simplification of arrangement.

While much of the detail of the electrical equipment is not as yet decided upon, and cannot be definitely referred to, still there are several interesting features which have been definitely determined. Among the latter may be mentioned the exciter system, which will consist of four 150 kw. motor-generators, delivering direct current at from 200 to 280 volts, supplemented by a storage battery. The storage battery will float upon the system constantly, but not so much in the sense of reserve capacity as in security from interruptions, which it is arranged to prevent absolutely. There will be two batteries installed in the basement of this station, one of 140 and the other of 150 cells, one of which will be kept on the exciter system and the other thus available for the local-distribution system. A novel form of direct-current reverse relay, or circuit-breaker, will be used in this connection on all the motor-generator leads to prevent a destructive return flow from the battery to a motor-generator in case it becomes inoperative; this relay is designed to open the circuit on any reverse flow from the 'bus to the machine equal to or above one-half its full-load capacity, although it is entirely inactive when current is flowing properly from the machine to the 'bus, even at heavy overloads. This interesting device, which is supplied by the General Electric Co., has been in use for some time in the original Waterside station.

General Electric Co. oil switches will probably be used throughout the new station. These will be automatically controlled by the General Electric diaphragm-type inverse-time-element over-load relay, which is designed to open the circuit more quickly in proportion as the overload is heavier or more severe, in contra-distinction to the type of overload relay involving a clockwork-operated time element, which is not influenced by the overload. This type of relay was installed on all feeders in the original Waterside station about two years ago and was the first complete equipment of a large system with this relay.

In this connection data as to the remarkable growth of the Edison lighting system in New York City will be of interest. In the article descriptive of the original Waterside station, in *The Electrician*, Vol. XLIX., p. 903, a total load curve was presented showing a maximum output of the stations for that winter of 35,000 kw., which occurred at about 5 p.m., December 23, 1901; Fig. 7 gives the curve of maximum load for the past winter of 59,000 kw. on the sub-station direct-current 'bus bars, which occurred at about 5 p.m. on December 22, 1904. This represents an increase in maximum-peak load of 24,000 kw. in the past three years, and from present indications of the company's output the maximum-peak load for next December will be from 60,000 to 62,000 kw.

There are in all at present 19 sub-stations from which the low-tension service is distributed, and of these three were installed within the past year or so. Nearly all the others have been added to also, so that the distribution equipment has experienced as radical a change as that under way at the generating station. The accompanying table, showing new rotary converter and battery equipment, added recently, and the present totals, will be of interest. It is to be noted, by way of explanation, that the standard battery of the company consists of 150 cells, 75 on each side of the three-wire distribution system, having a capacity of 2,000 amperes for one hour on each side.

The installation connected to the company's mains on August 1, 1905, was as follows :—

| | |
|---|---|
| Incandescent lamps, 16 c.p. equivalent ............ | 1,651,917 |
| Arc lamps .................................... | 22,093 |
| Storage batteries and heating appliances in kw....... | 2,539 |
| Horse-power in motors ......................... | 99,258 |
| Total installation (16 c.p. equivalent) .......... | 3,425,106 |

# THERMODYNAMICS OF THE ELECTRIC INCANDESCENT LAMP.*

Dr. E. F. Roeber recently presented a Paper on this subject before the American Electrochemical Society.

The subject was treated with relation to the thermodynamics of radiation from an incandescent body. A lamp consisting of a conductor of the first class—that is, a filament conducting as a metal—enclosed in an absolute vacuum, was assumed. The following equation connecting the supply of electrical energy to the lamp, with the total radiation was then established, on the assumption of a black radiating body :—

$$\frac{e^2\gamma}{2}\cdot\frac{r}{l^2}=K(T^4-T_0^4), \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where $e$=volts at terminals, $\gamma$=condnctivity, $r$=radius of filament, $l$=length of filament, Tp absolute temperature of filament, $T_0$= surrounding absolute temperature, K=Stefan-Boltzmann radiating constant. This equation enables the temperature of the filament to be calculated if $e$ is known, and if the filament behaves as a black body.

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* From the *Electrical World* of New York.

The total radiation consists of electromagnetic waves of an infinite series of different wave lengths, but the physiological effect of light is produced on the normal eye only by those waves the length of which is between $8 \times 10^{-5}$ and $4 \times 10^{-5}$ cm., corresponding to a frequency between $39 \times 10^{13}$ and $76 \times 10^{13}$ periods per second. The desideratum is such a spectrum of incandescent filament radiation that as much as possible of its area falls within the limits of the wave lengths of visible light. It is shown that a first indication of the degree to which this desideratum is fulfilled is given by Wien's displacement law, according to which the product of the wave length, $\lambda m$, of maximum energy and the absolute temperature, T, of the radiating source is constant.

$$\lambda m T = \text{constant.} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

If the wave length $\lambda m$ is measured in centimeters, the constant is 0·2940 for a black body. If, therefore, the temperature of the incandescent filament increases, the maximum of energy is shifted toward shorter wave lengths. In order to get the maximum energy within the visible spectrum, for instance at the wave length $6 \times 10^{-5}$ cm. not far from the D line of sodium, the absolute temperature of the black body filament must be 4,900 deg. absolute, or over 4,600°C. This is far beyond anything we can ever hope to reach in incandescent lamps.

The spectral distribution of energy in the radiation of a black body is given by another Wien's law, which, as modified by Planck, is given below, where J is the energy corresponding to the wave length λ in the spectrum, T is the absolute temperature of the radiating black body, ε is the base of the natural system of logarithms, and $C_1$ and $C_2$ are constants.

$$J = C_1 \lambda^{-5} \frac{1}{\varepsilon - 1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where

$$\varepsilon = C_2/\lambda T.$$

This equation has been found to represent in a most remarkable way the facts throughout the extreme ranges in which it has been tested. These formulæ represent the fundamental laws of the radiation of a black body.

It would, of course, be possible to calculate from Planck's law the exact distribution of the energy in the spectrum of a black body at any given temperature, or to calculate from this law the temperature at which the energy within the visible spectrum becomes a maximum. This would give the temperature for which we would get the highest possible efficiency of a black-body filament incandescent lamp. However, no attempt was made to give this calculation, for two reasons: First, from Wien's displacement law it has been found approximately above that this temperature is very high, beyond anything we can hope to reach in practice. Secondly, it will be seen later on that a black-body filament is really not the goal to strive at in incandescent lighting.

In practice the efficiency of a lamp is not given as the ratio of the energy of radiation within the visible spectrum to the total radiation, but is given by the candle-power which is produced by one watt, or what is the more general, although improper usage, by the reverse ratio—*i.e.*, the number of watts consumed per candle. The rays within the visible spectrum form what we call the flux of light and their energy is sometimes assumed to be measured by spherical candle-power.

The underlying idea is that the spherical candle-power is proportional to the energy of the light emitted. Now, as long as we have to do with light of one single wave length this supposition is correct. But if we compare two composite sources of light, the element of the physiological effect enters into the measurement of the candle-power, since the intensity of the physiological effect depends on the wave length. On the other hand, the energy of light has a distinct value independent of whether it produces any physiological effect or not.

It is, therefore, strictly correct only with monochromatic light to assume the candle-power to be a measure of the energy of visible radiation; and for this reason it is proper only for single wave lengths to try to find a numerical relation between spherical candle-power and the usual units of power—or as we may say, the mechanical equivalent of light.

Since the physiological effect on the normal eye is a function of the wave length, the relation between candle-power and other units of power must also be a function of the wave length. Nevertheless, in practice we compare different sources of light—of different spectral composition—by their candle-power. In such cases we average the physiological effects of the energies of the different wave lengths.

The results obtained by experimental determinations of the mechanical equivalent of light must, therefore, if not limited to a single wave-length, be taken *cum grano salis*, although they undoubtedly are interesting as giving a first approximation to the truth.

Experimental researches on this problem seem to have been made first by Julius Thomsen and O. Tumlirz. The result of Tumlirz was 0·188 watt per spherical hefner candle-power. However, his method of measurement was open to objections, since he separated the visible spectrum from the other rays by trying to absorb the latter in a layer of water. This must lead to too high a numerical value of the watts per candle, as was more recently pointed out by Angström, who made another determination of the mechanical equivalent of light. In order to separate the visible spectrum from the balance of the spectrum, he decomposed by refraction the total radiation into the rays of different wave lengths, cut off all rays except those within the visible spectrum and recombined the latter by means of a lens. His result appears to be the best available at present.

Angström found that the equivalent of the light radiation of 1 hefner candle per square centimetre at a distance of 1 meter (1 candle-meter) is 8·1 ergs per second. This gives as the equivalent of 1 spherical hefner candle 0·102 watt. This is only about one-half the equivalent of Tumlirz.

Now 1 spherical hefner = 0·88 spherical (British) candle-power. We, therefore, get as the result of Angström's determination, for 100 per cent. efficiency, 1 spherical candle-power = 0·115 watt; or 1 watt = 8·63 spherical candle-power.

One of the most efficient new types of incandescent lamps, the tantalum lamp, consumes initially 1·99 watts per mean horizontal candle-power, and 2·78 watts per mean spherical candle-power; while the average value throughout life was found as 2·19 and 2·70 watts respectively, according to recent tests made in a testing laboratory in this country. For the efficiency calculation the watts per spherical candle-power must be chosen, and if we base this calculation on 2·70 watts and on Angström's equivalent, it follows that the tantalum lamp has an efficiency of 4·3 per cent. An ordinary carbon filament incandescent lamp, if consuming 3·1 watts per mean horizontal candle-power and 3·9 watts per mean spherical candle-power, has an efficiency of only 3·0 per cent.

The author referred in this connection to the question of mean horizontal *versus* mean spherical candle-power. It is still a general rule in this country to rate incandescent lamps (with the exception of the Nernst lamp) by mean horizontal candle-power, although the impropriety of this method is clearly recognised. The American Institute of Electrical Engineers has already formally declared itself in favour of rating on the basis of mean spherical candle-power. This is obviously the only proper method of comparing the light given out by different types of lamps with each other.

But even in the test of a single lamp the curve giving the change of horizontal candle-power during life does not represent a true indication of the performance of the lamp. In testing the horizontal candle-power one unconsciously makes the supposition that the reduction factor (by which the mean horizontal candle-power must be multiplied to get the mean spherical candle-power) remains the same during the whole life. But, as a matter of fact, this is not the case. The distribution of light in a vertical plane changes during life, and with it changes the reduction factor.

This was very clearly shown in the tests of the tantalum lamp above referred to. In this case a black band formed during life on the globe around the sides of the bulb and about an inch wide, which materially decreased the horizontal candle-power.

As to the problem: What can be done to make incandescent lamps more efficient? One obvious conclusion from the above discussion is, that if we are confined to a black-body filament we must increase the temperature of the glowing filament very materially.

The carbon filament of the old ordinary incandescent lamp has often been assumed to come pretty near a black body. Now, it will at once be seen that we can easily increase the voltage temperature, T, of the filament by increasing the voltage $e$; equation (1) gives the exact variation of T with $e$. If we do this, the maximum of energy in the spectrum will be shifted towards shorter wave lengths according to (2), *i.e.*, the light gets better, whiter, more like sunlight in spectral composition. As a necessary concomitant, the area of the energy curve, which falls within the visible spectrum, increases; in other words, the efficiency increases.

It can be laid down as a general rule that the colour effect of the light of an incandescent lamp enables one to judge approximately the efficiency at which it burns. The reason is, that according to the above theory, both the colour effect and the efficiency are functions of the temperature. Dr. Louis Bell gives the following colour scale of efficiencies of ordinary carbon filament incandescent lamps. Naturally, these are only approximations, since one's judgment is so liable to be warped by the bluish tint of ordinary daylight, owing to reflected sky light, that the colour values of artificial light are very difficult to judge.

| Watts per c.p. | Colour. |
|---|---|
| 1·5 .............. | Clear white. |
| 2·0 to 2·5 ........ | White, very faintly tinged with yellow. |
| 3·0 .............. | Yellowish white. |
| 3·5 .............. | Yellowish. |
| 4·0 .............. | Yellowish, tinged with orange. |
| 4·5 .............. | Orange yellow. |
| 5·0 .............. | Distinctly orange red. |

Lummer refers to a test of a lamp of 16 spherical candle-power which, when burned at 45 volts, gave 16 c.p., thus consuming 3·5 watts per spherical candle power; the voltage was raised, and with it the electrical energy supplied to the lamp to 285 watts; simultaneously, the candle-power increased to 2,000 c.p., representing a consumption of 0·13 watt per spherical candle-power (which is almost the theoretical limit, according to Angström's equivalent). Thus an increase of energy in the ratio from 1 to 5 corresponds to an increase of candle-power from 1 to 130, and to an increase of efficiency from 1 to 26.

But, of course, the highly efficient state lasts only a moment. This brings us to the point of life. We must make, in practice, a compromise between a reasonably long life and a reasonably high efficiency. There must be an economic relation between life of lamp, cost of lamp and cost of energy.

Moreover, a very important forward step in the manufacture of the carbon filament lamp was the recognition of the importance of differentiating useful life from actual life. This is due to the continual decrease of candle-power of the lamp, setting in shortly after starting, accompanied by an increase in the consumption of watts per candle-power. It is now considered proper to "oslerize" a lamp when its candle-power has decreased to 80 per cent. of its initial value.

The decrease of candle-power at constant voltage which determines the useful life of the carbon filament lamp is known to be mainly due to three causes: First, an increase of resistance, resulting in a diminution of watts; second, a change in the surface activity of the filament, resulting in a diminution of emissivity; third, diminished translucency of the globe, due to the well-known black deposit which forms on the globe. A possible explanation of the second effect will be discussed later. Concerning the third effect, it may be said that it is usual to speak of evaporation of carbon. The speaker doubted whether it has ever been proven that such evaporation really takes place. It is quite possible that minute small solid particles of carbon are thrown off from the filament. It is a fact that the carbon is mainly given off near the negative extremity of the filament. Chemical analysis of the black deposit in the case of lamps with flashed filament have shown that the deposit consists partly of carbon and partly of hydrocarbons.

According to Marshall, 16-c.p. carbon filament lamps can be made according to the following table:—

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Useful life in hours | 28 .. | 132 .. | 412 .. | 1,000 .. | 2,005 .. | 3,570 .. | 6,125 |
| Watts .......... | 32 .. | 40 .. | 48 .. | 56 .. | 64 .. | 72 .. | 80 |
| Watts per cp. .... | 2 .. | 2·5 .. | 3·0 .. | 3·5 .. | 4·0 .. | 4·5 .. | 5·0 |

What type to select depends on the relative cost of the lamps and of the electrical energy.

The author then returned to a discussion of possibilities of improving the efficiency. If a black body filament is to be used, the progress must be looked for in an increase of its temperature. This is the reason of experiments with metals of very high melting points for filaments, such as osmium in Dr. Auer von Welsbach's osmium lamp, since osmium has the highest melting point of any known metal. The same principle was followed in the systematic development of the Siemens & Halske tantalum lamp by Dr. von Bolton, who tried the following metals one after the other: Vanadium, niobium, tantalum. Their melting points are 1,680°C., 1,950°C. and 2,250°C. to 2,300°C., respectively, and on account of its highest melting point tantalum was finally chosen. The underlying idea is that a filament made from a material of very high melting point will stand without injury a high temperature during a reasonably long life. In this connection it is important to use pure materials, since any small addition of a foreign material lowers the melting point. Thermodynamically this is the same effect as the lowering of the freezing point of water when salt is added. The necessity of using both high temperatures and pure materials indicates the need of employing electro-chemical methods.

However, by simply increasing the temperature we cannot get very far towards the realisation of the ideal if a black-body filament is used. We saw before, that according to Wien's displacement law, we would need to use a temperature of more than 4,600°C., *i.e.*, more than 8,000°F. to get the maximum of energy at 0·6 $\mu$. There is no hope of coming near such a temperature in present practice.

But, fortunately, there is no necessity whatever to use a black-body filament. A black body is an ideal case in thermodynamics; it is nowhere strictly realised in practice, but it is now absolutely within the grasp of the mathematical physicist. But the black body is not at all the ideal thing for the lighting engineer. On the contrary, we will see the further we can get away from the black body, the better for us.

The above discussion was based on the consideration of the black body filament because on this matter we can speak with certainty and without vagueness. The discussion of filaments departing from black-body radiation can be carried out only in special cases with similar mathematical exactness. In general, we must be satisfied to indicate the direction in which the results will vary from black-body radiation.

At a given temperature the total radiation from a non-black body is less than from a black body. Hence, if we substitute a non-black-body filament for the black-body filament, leaving everything else unchanged, the fundamental equation (1) will no longer be valid. The stationary condition, represented by the quality of radiation energy and electrical energy supply, necessitates now a higher temperature, T, than with a black-body filament.

Of greater importance, however, that the total radiation is the distribution of the energy of radiation over the whole spectrum. Non-black-body radiation is essentially selective radiation. The real ideal thing about the black body is that, according to definition, its radiation is not selective, since it absorbs all rays of any wave-length, and, therefore, according to Kirchhoff's law of the parallelism between radiation and absorption, it also radiates all of them.

The ideal filament for the lighting engineer must be one which absorbs only rays within the visible spectrum, while it either perfectly reflects all other rays or is perfectly transparent for the same. Such a body would then emit a radiation completely within the visible spectrum.

It serves no useful purpose to speculate whether we have any prospects to realise such an ideal filament body. Instead, the author briefly stated what we know concerning polished platinum, which is one of the bodies which of all those tested show the greatest departure from a black body.

In Wien's displacement law (2) $\lambda_m T = \text{constant}$, the constant is 0·2940 for the black body and 0·2626 for polished platinum (Lummer and Pringsheim), when the wave length is measured in centimetres. Hence the absolute temperature, T, at which the maximum of energy lies at a certain wave length, is less by about 10 per cent. with polished platinum than with the black body. This means that heated to the same temperature, a polished platinum filament will have a spectrum with its maximum of energy nearer to the visible spectrum than a black-body filament. Nevertheless, polished platinum is still very far from the ideal material which the lighting engineer must aim at.

No rule can be laid down how to select or devise such an ideal material, except to determine empirically the absorption of all possible substances for all different wave lengths. However, the degree of departure of a body from black-body radiation does not depend solely on its material, but also depends to a certain degree on the condition and the configuration of its surface. The more porous the surface the more will it behave like a black body.

The realisation of the black body in practice is based upon Kirchhoff's fundamental rule that the radiation inside an enclosure all points of which are kept on uniform temperature is absolute black-body radiation. The black body with which the laws of radiation have been experimentally established is such a hollow enclosure, the walls of which are kept on uniform temperature but contain a small opening through which the ratiation is observed. The presence of the opening represents a negligible departure from absolute black-body radiation. Further, in pyrometric practice, "If a porcelain tube with closed bottom be immersed into a lead-hardening bath, the radiation coming from the bottom of this tube will be a close approximation to that of a black body, especially if the inside of the tube is blackened with iron or nickel oxide, for example" (Waidner and Burgess).

Now it is evident that any pore in the surface of an incandescent filament, whatever it is made of, will cause a behaviour more or less like black-body radiation. Hence, we get the important result that the ideal filament must have a polished surface without pores. Blau has called attention to this point in connection with the osmium lamp.

In the case of the osmium lamp, it has been noticed that the initial increase of candle-power after the current is turned on, which is observed with almost every filament, continues for an unusually long period, somewhat like 200 hours. This is said to be due to a continuation of the formation of the filament, the particles being better fused together and the surface getting more polished. It is quite possible that in the case of the new graphitised carbon filament of the General Electric Co. something similar goes on, since the treatment is essentially an external surface treatment, although the material of the filament itself is changed.

While speaking of the ordinary carbon filament it was noticed above that two of the reasons of the ageing of the lamp were decrease of surface emissivity and a throwing off of carbon particles from the filament with a resulting blackening of the globe. These two effects have generally been considered to be independent of each other, although in the light of the above discussion it may be that the decrease of emissivity is due to the formation of pores or minute holes in the surface of the filament, as a result of the throwing off of small carbon particles. If this is true, the negative terminal of the filament (from which the carbon particles are mainly thrown off) should lose more in emissivity than the other terminal. To test this suggestion it would be necessary, of course, to separate carefully the effect of change of emissivity from the effect of blackening of the globe. For this reason the globe would have first to be uniformly cleaned, before the emissivity of the two ends of the filament should be compared.

Dr. Roeber then showed, connected in circuit, the several new types of incandescent lamps—the tantalum and osmium lamps and the graphitised carbon filament lamp made by the General Electric Co. and invented in its research laboratory under the direction of Dr. W. R. Whitney.

Concerning the manufacture of the tantalum lamp Dr. von Bolton gives the following information: He first mentions the experiments of Berzelius and Rose. They produced tantalum by heating the potassium and tantalum fluoride ($K_2TaF_7$) with potassium, and extracting the potassium fluoride with water; this method, however, does not yield pure metallic tantalum, but a product containing only about 5 per cent. of the pure metal. Moissan described in 1902 the production of tantalum in the electric furnace by reducing the oxide with carbon; but the product contained about 0·5 per cent. carbon, and was, therefore, either a carbide (0·5 per cent. C being a pretty large quantity in view of the high atomic weight of tantalum) or it was an alloy of the metal with carbide. Von Bolton describes briefly two methods of producing pure metallic tantalum.

The first method is electrolytic reduction of one of the oxides in the incandescent state in a vacuum. He formed filaments of brown tantalum tetroxide and placed them in vacuum. By passing the electric current through, they were caused to glow slightly, whereby much air was driven out of the porous filaments. Evacuation was then continued and the temperature of the glowing filament was increased until, at beginning white heat, several points of the filament showed strong incandescence. These points gradually extended to longer and longer lines, until the filament was incandescent uniformly along its whole length. During this reaction much gas was given off, which was identified as pure oxygen. The brown colour of the original oxide had changed into pure metallic grey, and the wire had become flexible after several hours of strongest white incandescence, like a wire of copper.

The second method, which is the most practical one, is to produce tantalum by the method of Berzelius and Rose, mentioned above, and then to purify and refine the metal in the vacuum under the action of the electric arc. This method is based on the fact that the oxides of tantalum melt more easily than the tantalum itself, and on the other fact, that they are much more easily volatilised in a vacuum than the metal, so that the metal can be completely separated from the oxide.

Concerning the manufacture of the filament of the osmium lamp the latest information is given by Blau. The raw material is very finely divided osmium, which is mixed with organic binding materials so as to form a thick, tough paste, which is pressed under very high pressure through an aperture. A thread is thereby obtained which is formed unto loops. The threads are then dried and are heated in the absence of air in order to carburise the binding material, and then subjected to the most important process, which is called formation. The threads which now consist of porous rough osmium with a high content of carbon are heated for a long time by means of an electric current gradually to a higher and higher temperature up to white heat in an atmosphere which contains very much steam and smaller or larger quantities of reducing gases. The carbon is removed by the same reaction which takes place in the production of water gas, and the filament thus becomes pure porous osmium of a far greater density than the former rough thread. During the first period of the use of the lamp the osmium surface becomes gradually smoother and more polished; this accounts for an increase of the light given out by a lamp during this period.

Concerning the manufacture of graphitised carbon filament of the General Electric Co., the fullest information is contained in the Paper of John W. Howell (*Electrical World and Engineer*, June 24, 1905). The main point is an external-surface treatment of the filament in an electric-tube furnace.

It will thus be seen that in the development of all three new lamps electro-chemical methods have proven of enormous importance. The speaker pointed out that it would be extremely interesting to know how far the progress achieved by the new lamps is due to the increased temperature and how far to a greater departure from black-body radiation. We know of all three lamps that their filaments are at higher temperature than the ordinary carbon filament. Concerning the question, however, how far the three new filaments (in comparison with the ordinary carbon filament) depart from the black body, no information of an exact nature has apparently been published.

A complete investigation of these problems would involve not only a determination of the actual temperatures and of the "black-body temperatures" of the filaments, but the actual distribution of the energy within the spectrum.

This would give us directly the absolute efficiency of the three lamps as the ratio of the area within the visible spectrum to the area of the total spectrum of the energy curve. It is quite possible that the numerical value of the efficiency, thus determined, may differ essentially from the efficiency, as determined from the candle-power per watt on the basis of the mechanical equivalent of light.

The first definition is absolutely physical and leaves the physiological aspect of the problem out of consideration; in this definition each watt corresponding to one wave-length within the visible spectrum is considered as perfectly equivalent to 1 watt corresponding to any other wave-length within the visible spectrum, although the physiological effects may be very different. The second definition of efficiency, on the other hand, is essentially based on the physiological effect. According to the second definition, the efficiency of the osmium lamp is about twice that of the ordinary carbon lamp; but this does not necessarily mean that the efficiency according to the first definition has also been doubled. For the actual efficiency the loss of heat by conduction through the leading-in wires is also a factor; this has not been considered in the above discussion.

The speaker concluded that, in spite of what has already been accomplished, we are still far from finality, and he expressed the hope that the progress made in electro-chemical methods during the last decade will continue to react on the invention of incandescent lamps in an encouraging and helpful manner, as has already been the case with the osmium, tantalum and graphitised filament lamps.

## NOTES ON ALTERNATE-CURRENT INDUCTION MOTORS.*

BY T. HARDING CHURTON.

In this Paper the author proposes: To compare the performance and characteristics of motors of the induction type when provided with short-circuited and with wound rotors respectively; to compare the performances of such motors on single-phase and polyphase circuits respectively; and to indicate, by comparisons, the extent to which the working of such motors is affected by the frequency of alternations. For the purpose of illustrating these comparisons, the performance of a particular size of machine with short-circuited and with wound rotor, for single-phase and for polyphase working, and on circuits of various periodicities, will be shown, the particulars given being the results obtained from actual tests on a number of machines of the same size. The windings were, in each case, appropriate, of course, to the circuit upon which the motor was to operate. It is not suggested that the comparative results here shown necessarily apply in all cases, but they may at least be taken as fairly representative.

When an induction motor is started up, the field of the stator starts at once to revolve at the full speed of the motor and the rate at which it cuts the rotor conductors falls from a maximum when the rotor is at rest to a minimum when the highest speed of rotation is attained. The currents thereby induced in the rotor conductors lag behind the stator field, the difference in phase depending upon the strength of the currents, which will depend, of course, upon the resistance of the circuits. And the field due to the rotor currents, reacting upon the stator field, which it consequently weakens, is also, of course, dependent upon the resistance of the rotor circuits. But the torque exerted by the rotor, being proportional to the strength of the stator field and rotor currents, and inversely proportional to the phase difference between them, the maximum torque of the motor at a particular speed depends, therefore, upon a certain value being given to the rotor resistance, which value decreases as the speed of the motor increases up to synchronism. For this reason, a motor provided with a rotor, into the circuits of which (either through slip-rings or other device) external resistance may be inserted and gradually cut out as the motor gains speed, starts up better than one having permanent connections. This may be expressed by the formula—

$$R_0 = R_2 \times \frac{n_1}{(n_1 - n_2)}$$

where $R_0$ = total resistance of rotor circuits, $R_2$ = ohmic resistance of rotor winding, $n_1$ = frequency of stator currents (or speed of stator field), $n_2$ = frequency of rotor currents (or slip of rotor).

In the case of two-phase or three-phase motors a considerable starting torque may be obtained with short-circuited rotors having conductors of comparatively high resistance. But such resistance seriously affects the efficiency, as well as the slip, of the motor when running on load, and motors so constructed are usually employed therefore only for intermittent work, such as, for example, operating cranes. When an induction motor is required to combine relatively high starting torque and high efficiency on load, it should have a wound rotor and variable starting resistance. If, however, so high a starting torque is not required, the short-circuited rotor, with low resistance conductors, is preferred on account of mechanical superiority, greater electrical efficiency and overload capacity. In a short-circuited rotor the currents and field are much more evenly distributed than in a wound rotor and the former is consequently less liable to have "dead" points at starting. And though, owing to the more definite polar winding of the wound rotor, the average torque is greater than that of the short-circuit rotor, yet, when the coils of the rotor are exactly opposite the coils of the stator, the torque is less than that of the short-circuited rotor. Again, with the wound rotor, the number of slots in the stator and rotor must have a common factor which conduces to a cogging effect. But a further desideratum in the choice of the type of motor, particularly when of large size, is the maximum current that may be drawn from the mains at the moment of starting and will not interfere with the pressure regulation of the supply. As before mentioned, the field due to the rotor currents reacts upon the stator field, which it more or less wipes out, and thus, by reducing the self-induction of the stator coils, allows an increase of current to flow through them from the mains. Now, when a motor with an ordinary short-circuited rotor is started, the currents induced in the rotor are very great and the current drawn from the mains must also, therefore, be considerable. If a polyphase motor of high efficiency with short-circuited rotor is switched directly on to the mains, with a periodicity of, say, 50 cycles, there will be a momentary rush of current equal to about three to five times full-load current, while the resulting starting torque will be about two and a-half to four times full-load torque. If the pressure of the supply current is reduced by a transformer starter, the current from the mains may be reduced to, say, about full-load current, when the torque will be equal to about one-half to three-quarters full-load torque. With a wound rotor a similar machine would give full-load torque with full-load current, and this current could be switched on gradually.

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* Abstract of a Paper read before the Leeds Local Section of the Institution of Electrical Engineers on Wednesday.

The type of transformer usually employed for starting polyphase motors with short-circuit rotors is that known as the auto-transformer, which consists, for each phase, of a single coil wound upon an iron core forming a closed magnetic circuit. By tapping the coil at a point intermediate between the two ends the voltage may be readily obtained that limits the current drawn from the mains to the permissible value, while allowing a considerably greater current to flow into the stator windings. With regard to the starters for motors with wound rotors, as the rotors are invariably provided with a three-phase winding, the regulating resistance is always in three divisions. Liquid resistances are sometimes used, but more frequently wire or metal strip multiple-contact rheostats are employed.

The curves shown in Fig. 1 are from tests taken upon two motors, one having a short-circuited rotor and the other a wound rotor, but in other respects identical machines. It will be noticed that both the efficiency and power factor are higher in the case of the machine with the short-circuited rotor. Both machines were constructed to give 5 B H.P. at about 1,420 revolutions on single-phase 200 volt 50 cycle circuit. The starting torque obtained with the short-circuited rotor machine was 0·45 full-load torque with 1·25 times full-load current, while the wound rotor machine gave 0·75 full-load torque with full-load current. The slip is somewhat greater with the wound rotor, which would, moreover, pull out of step rather sooner than the short-circuited rotor. The difference between the results obtained with the short circuited and wound rotors on polyphase working is practically the same as that on single phase, though with the polyphase system the results themselves are much better, as will be shown later.

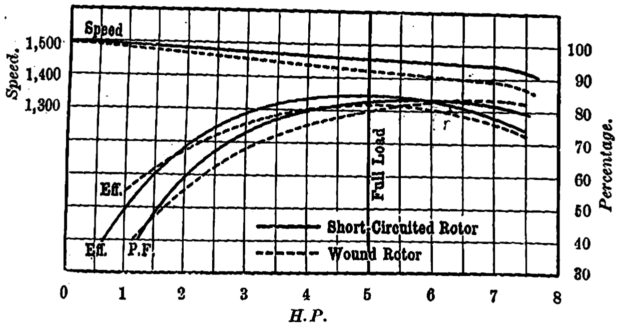

Fig. 1.

Speed regulation has been so far, perhaps, the least satisfactory feature of the induction motor. The usual methods adopted are, firstly, the insertion of non-inductive resistance in the rotor circuits; secondly, alteration of the number of poles of the stator, and, in the case of wound rotors, those of the rotor also; and thirdly, varying the voltage on the stator either by the insertion of resistance in the mains, or by transformer. With regard to the first of these methods, the one mostly in use, though possessing the advantage of simplicity, has the disadvantage of being uneconomical, being analogous, in fact, to the insertion of resistance in circuit with the armature of a direct-current shunt-wound motor. A further objection—one which also applies in the direct-current example—is the instability of the speed with varying load. If any considerable reduction in speed is attempted in this manner, it may become so susceptible to variations in the load as to render certain operations difficult or impossible. For many purposes, however, this method answers sufficiently well, and where the work is of an intermittent character, the question of economy is not, of course, of much consequence. The second method, that of altering the number of poles, is not only complicated, involving many connections, particularly in the case of the wound-rotor machine, and low efficiency and power factor, but is open to the further objections that the number of steps thus practicable is very limited, and that the system is too costly for general use. The third method, that of reducing the voltage on the stator windings, is the most wasteful of energy and the least effective. For the purpose of speed regulation, then, the wound-rotor motor is the more satisfactory, though for some purposes, such as operating cranes, the short-circuited rotor with conductors of relatively high resistance, combined with graduated transformers for varying the voltage on the stator windings, is sometimes preferred for polyphase motors.

To compare, now, the performance of the motor on single-phase and on polyphase working, it must be remembered that the field produced in the single phase motor is not a uniformly rotating field as it is in the case of a polyphase motor. When the rotor is at rest, a simple alternating current in the stator winding would produce only an oscillating field which would not cause the rotor to move at all. To start up the motor, therefore, a second winding is placed at 90 deg. to the main winding, and by causing the current to lag in one winding and giving a lead to the current in the other winding a phase difference is produced which creates a rotating field. But whereas the currents in a regular two-phase stator differ in phase by 90 deg., those in the single-phase motor cannot be made in the above manner to differ by anything like so much, and the resulting field is, in consequence, very irregular. As the rotor gains speed the field due to the combined action of the stator and rotor currents becomes more uniformly rotating, but never attains to the uniformity of the field produced by polyphase currents. For the above reason, motors of this type have not nearly so good a starting torque on single-phase as on polyphase circuits. And, for the same reason, the maximum running torque and brake horse power of the motor is less when working single-phase than polyphase, and the single-phase motor will, moreover, pull out of step and stop with less overload than the polyphase motor will carry.

**Table I.**

| | Single-phase. | | Polyphase. | |
|---|---|---|---|---|
| | Starting current. | Starting torque. | Starting current. | Starting torque. |
| Short-circuited rotor.... | 1·25 | 0·45 | 1·25 | 0·75 |
| Wound rotor .......... | 1·0 | 0·75 | 1·0 | 1·0 |

Note.—The figures refer to the normal full-load values.

Table I. shows the performance of the motor with regard to starting torque and current on single and two-phase circuits of 50 cycles 200 volts, and with short-circuited and wound rotors respectively. The superiority of the polyphase motor in this respect is clearly shown.

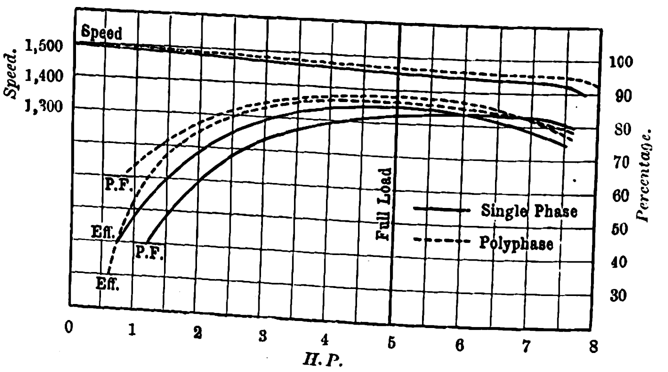

Fig. 2.

The curves in Fig. 2 show also that the efficiency and power factor are higher in the case of the polyphase motor, and that the slip is greater in the single-phase motor. The lower efficiency of the single-phase motor is accounted for by the greater iron losses due to the irregular flux and to the torque being lower on account of the irregularity of the field. And the power factor is also lower because the greater slip of the rotor retards the rotor field, which consequently becomes more out of phase with, and thus opposes the stator field. The leakage coefficient and self-induction of the stator winding are thus increased, and the power factor is therefore reduced.

A great deal of attention has been paid to the methods of starting the single-phase motor, the principal object being generally to obtain as great a phase difference as possible between the currents in the main and starting coils. Condensers, which were formerly extensively used in this connection, have been abandoned on account of the trouble they gave through heating, varying in capacity with varying temperature, and by breaking down. Choking coils were also much more used than at present, the required self-induction now being usually obtained by suitably winding the auxiliary coils. The method of starting adopted by the author is to connect the main and starting coils in series and a non-inductive resistance across the starting coils, that is, in series with the main winding to which it gives a lead, while the self-induction of the starting coil gives the current flowing in it a considerable lag. The auxiliary winding occupies about one quarter of the stator winding space and is wound in the centre of the main poles where the main winding could not be usefully employed. It is usually wound with either one-half or twice the number of turns of the main winding. The author prefers the fewer number of turns on account of the otherwise high induced voltage continually on the windings tending to break down the insulation. In some makes of motors this risk of failure of insulation is still further increased by one end of the auxiliary coil being left connected to one end of the main winding, in which case, the voltages of the two windings are in series. Thus, in a 200 volt motor, the voltage on the windings may be about 550 volts, depending upon the phase difference of the voltage in the windings.

There are several means by which the starting torque of the single-phase motor may be somewhat improved, but which involve lower efficiency on load. And, as in most other problems in engineering, the question as to how far the running efficiency shall be sacrificed to improved starting performance is a matter of compromise. The results actually obtained depend, of course, upon the details of design, particularly with regard to the flux densities, shape of the stator and rotor teeth and length of air gap, as well as upon the materials employed, particularly the quality of the iron in the stator. While the single-phase motor cannot upon equal terms compete with the polyphase motor, it is, nevertheless, in its better forms, an excellent machine.

The question of frequency is a very important matter with regard to induction motors. In the first place, the torque exerted by the motor is inversely proportional to the frequency of the supply current, and a given size of motor will, therefore, be capable of giving twice the horse-power on, say, 50 cycles that it can give at the same speed on 100 cycles. In order, therefore, that the motor may give the same maximum horse-power on 100 cycles as on 50 cycles, the speed must be doubled. The loss due to hysteresis is directly proportional to the frequency. If, therefore, the frequency is greatly increased, the induction—and, therefore, the torque—must be much reduced to prevent heating of the iron and noise. But the magnetisation curve not being straight, the watts spent in magnetising are not diminished in the same ratio as the induction is reduced. Thus the iron loss is greater at the higher frequency, and, other things being equal, the efficiency of the motor is, therefore, lower. And the leakage coefficient being greater at the higher frequency, the power factor is, therefore, lower. This again, by increasing the currents, increases the $C^2R$ losses, which, therefore, further reduce the efficiency. The hysteresis loss and leakage coefficient increase much more rapidly on the higher range of frequencies than on the lower. For example, the difference is much greater between 50 cycles and 100 cycles than between 25 and 50 cycles.

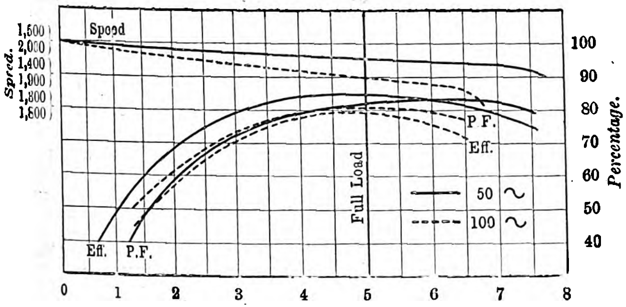

FIG. 3.

The curves in Fig. 3 show the difference in the efficiency, power factor, and slip of the same size of motor as before referred to when giving 5 B.H.P. on 50 cycles at about 1,430 revs. per min., and the same horse-power on 100 cycles at 1,880 revs. per min. It will be here observed that the speed on 100 cycles is not, for the same horse-power, double that on 50 cycles as would have been expected from the statement above. But it may be explained that this was due merely to the exigencies of manufacture, the same standard stampings having been utilised in each case and the windings varied to obtain the required output with the best results. While this arrangement occasionally necessitates the use of a machine somewhat larger than actually required, economies in manufacture are effected which repay the extra cost of material involved. When it is remembered that there are in the United Kingdom alone over 100 alternating supply systems, of which about 86 are single-phase, working at no less than 17 different frequencies, besides two-phase and three-phase, each with their own variety of frequencies, it will be understood that a manufacturer could not profitably make so great a variety of special patterns as would be required to obtain the greatest possible effect from a given size and weight of machine in every case.

High frequency is not only prejudicial to efficiency, power-factor, and torque, but is particularly detrimental to good starting performance. This will be seen from Table II., which gives the starting torque and current of the 5 H.P. motor on 50 cycles and 100 cycles respectively. It may be remarked that on circuits of 100 cycles about twice the full load current is usually taken for starting short-circuited rotor motors, whereas on 50 cycles the starting current does not usually much exceed the normal full-load current.

**Table II.**

Starting torque and current on 50 cycles and 100 cycles of 5 H.P. motor (short-circuited rotor)—200 volts.

| Cycles per sec. | Starting current. | Starting torque. | Revs. per min. |
|---|---|---|---|
| 50 | 1·25 | 0·45 | 1,430 |
| 100 | 2 | 0·43 | 1,880 |

High periodicity, then, to the motor user implies (1) higher cost of motors and (2) higher cost of working, and to the electricity supply undertaking it means (*a*) lower day load (because of the less inducements to power users to adopt the supply), and (*b*) greater proportional loss on mains, &c., on account of lower power-factor of motors.

Most of the systems having frequencies above 50 or 60 cycles were established before induction motors were practically thought of. Some of these are, happily, being gradually changed over to 50 or 60 cycles, and it would be well if a frequency of 50 cycles were adopted whenever possible. Standardisation in such matters greatly promotes economy and excellence in manufacture, promptitude of delivery, and is, from every point of view, a consummation devoutly to be wished.

## IS MACHINE STOKING ECONOMICAL ?*

BY ALFRED W. BENNIS.

The most careful and elaborate tests made by the manufacturers of mechanical stokers, and the engineers representing the companies who use these stokers, have indisputably demonstrated that mechanical stoking is in every way more economical than manual stoking. To crowd on as much coal at a time as the furnace will hold—the bigger the lumps the better—to shut the door and then trust to luck has already been laid down as "the main object in life of the average human stoker," and all who have practical acquaintance with the type will agree as to the accuracy of this description. It is a recognised fact that, in the actual manipulation of fires, the efficiency of the individual fireman, even of the most expert, varies widely. In order to illustrate the personal element introduced in good and bad stoking we may quote the competition which was carried out at Messrs. Davy Bros., of Sheffield. Five stokers were made to fire the same boiler with the same coal and with the steam pressure about the same. The best stoker was able to obtain an evaporation of 9 lb. of water per pound of coal, the worst evaporation being 7·4 lb. per pound of coal; the difference is here 22 per cent. The opportunities afforded for increasing the efficiency of the boilers were, in this instance, limited. A well-laid fire which by constant attention is prevented from burning into holes is one of the chief items in securing a high evaporation. Keeping the fire-bars clean, and regulating the dampers for a maximum quantity of air just after firing, contributes greatly to high efficiency. Beyond these points there is little opportunity for exercising skill in stoking, and yet these tests show clearly how very important the simple operations involved in firing a boiler become. The very simplicity is the one cause for neglect.

In a Paper read before the Ohio Society of Mechanical, Electrical and Steam Engineers, for the purpose of showing the relative cost of hand-firing in large plants, when compared with modern coal-handling equipment, combined with mechanical stokers, the following particulars were given. These were obtained from actual records in a large establishment, containing about 7,500 boiler horse-power. The plant was operated for some time after construction without coal-handling machinery of any kind except small hand cars, which were loaded by hand from railway cars outside the building, and then hauled up a slight incline to the boilers. The cost is given for the month of May, 1900, and for May, 1901. In the first instance no mechanical means were employed. In the second, mechanical stokers and conveying machinery were used. The only handling necessary was shovelling into the conveyor, and that might have been greatly cheapened by using a track hopper, but existing conditions made this impracticable. The cost of hand firing compared with mechanical stoking is given as follows:—May, 1900, 16 firemen and one helper, wages £196. 7s. 2d., tons burned 4,292, cost per ton 10·9d. Eleven coal and ash men, wages £126. 18s. 8d., cost per ton 7·0d. May, 1901, three firemen and two helpers, wages £57. 11s., tons burned 6,975, cost per ton 1·9802d. Eleven coal and ash men, £130. 18s., cost per ton 4·504d. The saving in wages per ton handled is thus shown to be 11·5935d., which, estimating 6,975 tons per month, is a saving of over £4,000 per year.

An item of great importance in deciding upon the methods of handling coal in steam-power plants is the cost of boiler room labour. An estimate which is probably not far from accuracy is that which puts the cost of moving coal by hand or wheel-barrow at 6d. per ton for short distances. One man, besides one night man, can run an engine and fire about 10 tons of coal per week. One man, besides an engineer and night man, can fire about 35 tons per week. These figures do not admit of the night man refusing such work as banking, cleaning and starting, and are for average conditions. When the coal has to be wheeled for long distances a fair allowance should, of course, be made. When boiler houses are small, or by reason of their arrangement, an elevating and conveying plant cannot be conveniently put down, the use of small elevators is advocated—either one elevator to each boiler, or one to every two boilers. Many firms are going in for this kind of plant, including Messrs. Rowntree, of York, who are making a saving of over £2,000 per annum on an outlay of less than £1,200 for stokers and elevators, on five Lancashire boilers.

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* Abstract of a Paper read before the Keighley Association of Engineers.

Let us now take some of the objections advanced to the use of machine-firing. Among these may be mentioned the following: (1) There is no economy. (2) The lower grade coal is not worth burning, and in any case it smokes. (3) The cost of upkeep is excessive. (4) Where the load varies machine firing has to be supplemented by hand-firing. (5) The machine is frequently out of order. (6) Machine stokers reduce the capacity of the boiler.

Dealing with objection 1, it is customary now, with all manufacturers of first-class machinery of the kind, to instal it with a guarantee of saving. The economy effected varies between 25 and 200 per cent. on the outlay—*i.e.*, on the initial cost of the machinery.

2. With regard to this objection very many practical tests have established the claim that the work done, whether with low or high-grade coals, is practically the same. The Glamorgan Coal Co. owning one of the largest collieries in South Wales, recently made some elaborate trials of stokers and hand firing. Hand firing evaporated about 6,000 lb. of water per hour. The stoker on the same boiler gave, with colliery small 9,469 lb., unwashed peas 11,142 lb., washed peas 11,335 lb., washed nuts and beans 10,160 lb., unwashed beans 9,720 lb., unwashed nuts 10,390 lb., washed colliery small 10,684 lb., and dry duff 8,301 lb.; so that the variation in evaporation obtained on the same boiler with these different fuels was never very great, though the price varies many shillings per ton between the best and worst of the lot, and curiously enough, the coal which gave the best economical efficiency—the washed nuts and beans mixed—did not give the highest evaporation.

3. In answer to the third objection, it may be said that if stokers are reasonably looked after the cost of upkeep does not amount to 10 per cent. on the saving made by the machines. The Leeds electric lighting station has some 40 machines, and their average upkeep cost comes to less than £1 per boiler per annum. The stokers at work at the lighting station in Keighley have only cost 7s. 9d. per annum per boiler for repairs; they have been at work five years.

4. This objection may be answered by an emphatic denial that there is need for hand firing if the man in charge knows what he is doing. In this connection it may be pointed out that machine-stoked dye houses work without hand firing, and the dye-house load is admittedly more variable than even the electric power-station load.

5. Against this objection we have the fact that many mills, with but one or two boilers, employ these stokers, which they could not do if constant breakdowns were the order of the day.

6. Machine firing does not reduce boiler capacity, but increases it. In a series of tests carried out on marine boilers with hot air at the Sheffield Corporation (Sheaf-street) electricity works, by Mr. S. E. Fedden, the following facts, which are not without significance, were established: The rated capacity of the boilers with hand firing was 9,000 lb. to 10,000 lb. of water per hour; with mechanical firing and hot air 17,652 lb. of water were evaporated per hour with an efficiency of 79·9 per cent. These tests brought out most clearly the high attainable efficiency, with an increased evaporation of about 80 per cent., and this with small slack coal as against through and through by hand firing.

Mr. J. A. Jeckell has given figures showing the results of working at the Corporation electricity works, Coventry. In 1901 the station costs in pence per unit were 3·05. In May two boilers were fitted with the Bennis stokers, and in October, 1902, two more boilers were fitted. In 1902 the costs went down to 2·43d. In 1903, when the costs were affected by the change in the stoking, the station costs went down to 1·51d.; in 1904 they went down to 1·16d.; in 1904 two more boilers were fitted with these machines, and in 1905 the Coventry cost stands at 0·85d. which is a world's record.

A most important point, which up to now has been entirely lost sight of, accounts for high efficiencies having been obtained by what I might term high-speed stokers burning a lot of coal and doing heavy evaporations. The rate of transmission of heat varies as the square of the difference of temperature between the water and the furnace temperature, and so it happens that, other things being equal, the hotter the furnace the more efficient the boiler. It is, therefore, advisable to work with as little excess of air as possible, but not a fraction too little, or down comes the temperature. It is important if good results are to be obtained to see that the air supply is properly distributed over the furnace. A self-cleaning furnace is essential, and one in which a controllable supply of air is arranged for is imperative; otherwise it becomes impossible to adjust the conditions to he best advantage.

# CORRESPONDENCE.

## THE GUERNSEY MULTIPLE SWITCHBOARD.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The brief description of the new multiple switchboard at Guernsey which appears in *The Electrician* for October 20th hardly does justice to this remarkable achievement in telephone equipment. Perhaps you will permit me, for the benefit of those interested in modern telephone practice and in switchboard design, to point out some of the peculiarly effective results arrived at by the apparatus and circuits described. The article makes no mention of the traffic which the switchboard is to carry, but the oft-published Guernsey telephone statistics show that the Guernsey subscriber has an average daily traffic of as many as two calls. On this basis, the 900 subscribers' lines, which the new switchboard serves by means of nine operators' positions, would therefore give about 1,800 calls daily —a fair day's work in a modern exchange for one operator's position.

The operating of the 50 junction lines and of the 50 public station lines makes some addition to the daily load, and the operators have to record all calls, so that, taking all conditions into account, there should be a moderate day's work for, perhaps, three subscriber positions and one junction position. To distribute the work of, at the most, four positions among 11 seems to require some of the startling features of multiple switchboard design which have been adopted. These are: Mechanically-restored indicators, which occupy much valuable space and incidentally bar effective team work; the placing of one cord of a pair on one shelf and one on another, which is highly conducive to errors at each end of the operation of a connection; and the use of two clearing indicators, each to be operated by the corresponding subscriber before an effective disconnection signal is obtained. Even with all these eccentricities of equipment the operators at Guernsey will hardly be overworked, as with an average load of 200 calls a day, on the above basis of two calls per subscriber, each operator will not be required to deal with more than about two calls in five minutes, even in the busiest hour of the day.

This sort of telephone work simply goes to show how very dark it can be in places where the occupants deliberately refuse to see the light, and I suppose no real telephone man would be so lacking in sense of humour as to want to criticise it seriously. What could be more humorous, for example, than to adopt from modern telephone work a "double ring-off," and so to arrange it as to require both subscribers to press a button in order to produce a complete disconnection signal! Why deliberately cut in half the chances of getting a disconnection signal?

The most conspicuous feature of the Guernsey telephone service is the extremely small traffic. Sufficient experience has been had to demonstrate that the conditions are not likely to change. When the necessity arose for abandoning the old transfer boards and rebuilding the exchange, one would have thought that the reasonable course would be to take advantage of modern telephone practice (in the true sense of the words) and procure a switchboard having some relation to the traffic. A lamp signal board would do the work of the Guernsey exchange vastly more efficiently and economically than the erratic equipment adopted, but even an ordinary bridging magneto board would be appreciably more efficient and economical.—Yours, &c.,

HERBERT LAWS WEBB.

35, Old Queen Street, Westminster, S.W., Oct. 21.

**Factory Act Regulations for Locomotives and Waggons on Lines and Sidings.**—The Home Secretary, in pursuance of sec. 81 of the Factory and Workshop Act, 1901, has appointed Mr. Chester Jones, barrister-at-law, to hold an inquiry with regard to the draft regulations for the use of locomotives and waggons on lines and sidings under the Factory Act. The inquiry, which will be public, will be opened at the Caxton Hall, Westminster, S.W., on Nov. 22, and any person who has objected to the draft regulations, and any other person who, in the opinion of Mr. Chester Jones, is affected by them, may appear (either in person or by counsel, solicitor, or agent).

# LEGAL INTELLIGENCE.

### Lloyds v. Marconi International Marine Communication Co. (Ltd)

In the Chancery Division on Wednesday, on the application of Mr. P. O. Lawrence, K.C. (who stated that important witnesses would have to be brought from all parts of the country), Mr. Justice Kekewich fixed Nov. 21 for hearing this action. It was stated that the Admiralty had intervened in the case, and that the Attorney-General would appear.

### Defective Gas Meters.

At Lambeth (London) County Court on Wednesday, Vogan & Co. sued the South Metropolitan Gas Co. for £70 odd overpaid in consequence of three gas meters registering too fast.

It appeared that one of the meters complained of was put up in 1898 and the others in 1901. Early in the present year plaintiffs had them tested by London County Council, with the result that they were found registering too fast to the extent of from 5 to 7 per cent. The company had refunded £16, which they calculated had been overpaid on the previous quarter, and also the testing fees. Plaintiffs now contended that it was probable that the meters had been registering too fast before the quarter for which allowance had been made.

On behalf of the gas company, it was argued that it was the duty of the consumer to take the initiative in having the meters tested.

Judge EMDEN held that it was the duty of defendant company to keep their meters registered correctly. There was a strong inference that the meters were going too fast before the time for which an allowance had been made. He would not, however, be warranted in deciding that the meters went too fast from the time they were put up, and judgment would be for plaintiffs for £15, with costs on the higher scale.

### Osment v. Jenner.

In the Shoreditch (London) County Court, on Tuesday, before Judge Smyly, K.C., plaintiff sued Mr. E. Jenner, a builder, to recover £3 for electrical work done.

Mr. CHAMPION, for plaintiff, said the claim was for testing an electric wiring installation, replacing wiring, making work satisfactory to Leyton electricity supply department, &c.

PLAINTIFF said there were about 80 houses on defendant's estate, all of which were wired for the electric light. He was called in to put in the fittings in a house, which he did, the wiring having already been done by the electrician who had wired all the other houses. Subsequently plaintiff was called in by the tenant, who said that the Council had refused a supply of current as there was a leak, and asked him to find it and put it right and defendant would pay.

DEFENDANT said he disputed the whole matter. Why should he be called upon to pay such a monstrous charge? There were 70 to 80 houses on the estate and it was a curious thing that this was the only house where anything of the kind had occurred.

His HONOUR (to plaintiff): Well, what was the matter, and why is the charge so heavy? How many hours did this work take?

PLAINTIFF: The current was going to earth. There were an electrician and an apprentice for 20 hours, besides which I had to borrow an ohmmeter, which was worth £25, and pay 10s. for the hire. I do not consider I have charged too much, and I only make about 15s. out of the whole transaction and give in the time of the apprentice.

HARRY BAGGS, electrician, who went to do the work, said the lead covering was touching the wires which caused the earth. The leak was only in one place, but it was very difficult to locate.

DEFENDANT: I have built 200 houses in this district and am willing to pay any reasonable charge, but for just finding a leak I am charged more than for wiring a whole house. There are only 10 points in a house and 5s. a point is the charge. That is the regulation price in the district of Leyton. I can get any house done at that rate.

His HONOUR gave judgment for plaintiff for £2. 5s., considering that this price should leave him a good profit.

# MUNICIPAL, FOREIGN & GENERAL NOTES.

## APPOINTMENTS VACANT AND FILLED.

The Council of the University of Leeds require an assistant lecturer and demonstrator in electrical engineering. Salary £175. Particulars from the Registrar. Applications by Nov. 18. See an advertisement.

Newcastle under-Lyme Corporation require a shift engineer for their electricity works. Applications to the Electricity Works, Newcastle, Staffs. See advertisement.

Thomas Smith & Sons, Steam and Electric Crane Works, Rodley, near Leeds, require a first-class draughtsman, accustomed to electric cranes and lifting machinery. See advertisement.

An assistant engineer is wanted for direct-current dynamos and motors. Applications to Messrs. Vickers, Sons & Maxim (Electrical Department), Sheffield. See an advertisement.

Senior and junior canvassers are required for an electric supply company. See an advertisement.

The directors of the East Indian Railway Co. require an electrical foreman in the locomotive department of the company in India. The terms are four years' agreement with second-class free passage to India and home on satisfactory completion of engagement. Salary 300 rupees, rising to 400 rupees, per calendar month. Further particulars are given in an advertisement, and applications must be sent to the secretary (Mr. C. W. Young), 28-30, Nicholas-lane, London, E.C., by Wednesday, Nov. 8.

A fully-qualified engineer is wanted to take charge of electric lighting installation, pumping and sawing plant, &c., at a large country house in Hertfordshire. Applications to E. S. H., Poles, Ware, Herts.

Birmingham Corporation require a resident engineer at the new Corporation electricity station (commencing salary £300, rising to £400 per annum); also a sub-station superintendent (£250, rising to £350), and a shift engineer (£120, rising to £250). Further particulars from the city electrical engineer (Mr. R. A. Chattock), 14, Dale-end, Birmingham, to whom applications by 30th inst.

Two postal and telegraph inspectors and one mechanician are required for the postal and telegraph department of Northern Nigeria. Salary £250 a year, rising to £300, with free single quarters and second-class passage. Applications to Crown Agents for the Colonies, Whitehall-gardens, London, S.W., until Nov. 1.

A lecturer in applied mathematics is required for Armstrong College, Newcastle-upon-Tyne. Applications to Secretary by Nov. 1.

Mr. E. S. Atkinson Smith, of Bridlington, has been appointed, by Battersea (London) Council, canvasser for the electricity department at £2 a week and commission. There were 71 candidates for the post.

Dr. Alex. McKenzie, lecturer and senior demonstrator at the University of Birmingham, has been appointed head of the chemical department at Birkbeck College, in succession to Dr. J. E. Mackenzie.

## EDUCATIONAL NOTICES.

**City and Guilds Institute.**—In the annual report of the City and Guilds of London Institute it is stated that, during the past year, in the 440 centres in the United Kingdom, the number of subjects of examination was 69, increases of 21 and 3 respectively over the previous year. There was a decrease of 107 in the number of classes, the total being 2,601; but the number of students in attendance increased from 41,089 to 41,618, the number of candidates' papers from 19,041 to 19,782, and the number of passes from 11,293 to 11,838.

In mechanical engineering there were 1,742 students, against 1,479 in 1904, and 839 passes, against 743. In boilermaker's work 73 candidates were examined, against 53. In electrical engineering there were 5,775 students in 250 classes, against 4,911 and 218. In the examination for honours and the ordinary grade the largest percentage of failures was in electric wiremen's work. It would seem either that the teaching in this subject is very imperfect, or that candidates vainly suppose that they can become expert wiremen, fit to be entrusted with the wiring of a building after receiving a few months' instruction, without the continuous practice necessary to make efficient workmen. The percentage of failures in nearly all the preliminary examinations is still unduly high, illustrating the complaints of so many of the examiners that the elementary education of a large number of the students who enter technical classes is defective.

**Robert Gordon's College, Aberdeen.**—The Governors of this college have asked the Education Department for £50,000 for the extension of the technical department of the college.

**Aberdare.**—The Parliamentary committee recommend the Council to withdraw their support of the scheme prepared by a London syndicate for the construction of a system of tramways in the district.

**Alleged Frauds on Electrical Firms.**—William Leslie, Richard T. Rosenberg, George Webber and Frances Cheeseman were again charged at Guildhall (London) yesterday with fraudulently obtaining money from various electrical manufacturers. Further evidence was given and the case again adjourned.

**Asylum Lighting.**—The electric lighting of the new infirmary annexe at Macclesfield county asylum has been completed. The plant consists of three steam dynamos, switchboard, wiring, &c. The entire installation has been carried out to the engineer's specifications, and the work has been done at about 2 per cent. less than the amount of the accepted tenders. The contractors for the wiring, fitting and outside lighting were D. Firth & Sons, Manchester, and for the plant J. H. Holmes & Co. The consulting engineers were Messrs. Lacey, Sillar & Leigh, of Westminster and King-street, Manchester, who have worked in association with the county architect of Chester, Mr. H. Beswick.

Swindon Joint Hospital Board have decided to adopt electric lighting at the isolation hospital. The estimated cost of current is £71 on the present maximum demand system, whereas last year gas lighting cost £172.

**Award.**—In connection with the arbitration proceedings between the Marquis of Salisbury and the Charing Cross, Euston & Hampstead Railway Co. for compensation for the premises required by the company for their new station at the corner of Charing Cross-road and Cranbourn-street, the arbitrator has awarded £11,070. The claim was for £15,000.

**Bath.**—In regard to the Council's recent application for permission to borrow £19,000 for the electricity department, sanction has been given for the loan with the exception of £797 for items which the L.G.B. did not regard as suitable subjects for a loan. Dissatisfaction was expressed that the estimate on which a previous loan of £30,000 was sanctioned had been largely exceeded. Of the amount now sanctioned, £17,203 is for 15 years and £1,000 for five years.

**Battersea (London).**—The Law and Parliamentary committee reported at the Council meeting on Wednesday having considered a joint letter from the Chairmen of Poplar, Shoreditch and Stepney Electric Lighting committees asking that Battersea should send delegates to a conference convened by these three Councils for the purpose of considering the question of municipal supply of electricity in bulk and, if thought fit, to promote legislation thereon in the ensuing session.

The circular convening the conference pointed out that "only those boroughs who really mean business" should send delegates. Taking part in the conference would therefore (according to the Battersea committee) practically amount to a pledge to join in the cost of giving effect to its decisions, and that might involve a large expenditure. Battersea Council had already asked the London County Council to convene a conference of local authorities and such other bodies as they might think fit for considering the advisability of erecting large generating stations and supplying electricity in bulk. As the Highways committee of the London County Council were going very fully into the question of the bulk supply of electricity in London, the committee were of opinion that Battersea should not take part in the movement originated by Poplar, Shoreditch and Stepney.

The Council endorsed this view.

**Bethnal Green (London)**—At the last meeting of the Council, Mr. Hall, chairman of the Lighting committee, said they were considering tenders for the supply of electricity in bulk from the surrounding authorities. These tenders were of a very complicated character, and he asked the Council to give them time to make a complete report.

**Brighton.**—The Lighting committee have been informed by the consulting engineer (Mr. Arthur Wright) that at the very careful test made by him on the 20th inst., it was proved to his satisfaction that the plant supplied by the British Westinghouse Co. for the Southwick electricity supply scheme is capable of carrying out the guaranteed performances specified in the contract, consequently he was able to certify that the company were entitled to payment of £60,221. 2s., made up as follows:—Section 1—Turbine and condensing plant £31,748. 10s.; section 2—motor generator and converting plant at North-road, £20,556; section 3—switchboards, &c., at North-road and Southwick, £7,916. 12s. The total amount of the contract was £81,246, leaving £21,024. 18s. due to the company.

**Camberwell (London).**—The Borough Council have received an intimation from the Highways committee of London County Council that they cannot recommend that any of the schemes suggested by the Borough Council for the construction of tramways to the Crystal Palace merit submission to Parliament next session. The committee state, however, that they are prepared to consider any such scheme for the session of 1907.

**Chesterfield.**—On the recommendation of the Electricity committee the Council have decided to purchase additional plant at an estimated cost of £500, and to lay cables for lighting Whittington Moor.

**Croydon.**—At Monday's Council the Tramways committee reported on the proposed tramway extension to the borough boundary at Penge.

Owing to the objection of property owners and the objection of the Board of Trade to the laying of a double line, the committee had given instructions for its construction as a single line, with passing places.

The British Electric Traction Co. have notified in regard to the lines authorised by the Mitcham Light Railway Order that an agreement had been entered into with Croydon Rural Council, and a contract had been let for the construction of the tramways.

The report was adopted.

Councillor Stapleton said they were unable to proceed further at present with an application to Parliament for powers for tramways to the Crystal Palace, as the committee's hands would be full in regard to tramway matters for some time to come.

Penge-road is to be lighted by arc lamps at an estimated cost of £417.

The borough electrical engineer (Mr. A. C. Cramb) recently prepared an estimate for the electric lighting of the tramway route along Mitcham-road with 32 flame arc lamps at a cost of £882. Ald. Miller said these lamps would be charged to the town at £12 per annum while the high pressure gas lamps in London were £15. The Lighting and Electricity committee recommended that the work be carried out. This extension will also enable the borough hospital to be lighted electrically.—The proposal was adopted.

**Customs Decisions.**—The French Customs authorities have decided that glass bulbs for incandescent lighting, made of glass or crystal rendered opalescent, are dutiable as "table glass decorated" under No. 350 of the French tariff, which fixes a duty of 28fr. per 100 kilogs.

**Dundee.**—The Tramways committee have decided to construct the Arbroath-road electric tramway line at a cost of £4,000.

**Durban Harbour Electric Cranes.**—An electrically-operated crane capable of lifting 20 tons and having a span of 135 ft. 8 in. has been supplied by Stothert & Pitt for Durban Harbour.

The main girders are placed sufficiently far apart to allow of concrete blocks being lifted between them. They are 8 ft. deep, fish-bellied in form and built up of plate and angle, and each girder is braced to a subsidiary platform girder to give it the necessary lateral stiffness, the main girders being single web, so as to be more easily painted, as the traveller is intended for working on the seashore, and is therefore liable to corrosion. The traveller is mounted on eight double-flanged wheels, each pair arranged in a bogie. The traveller has the motions of lifting and cross traversing operated by separate motors, and the longitudinal travel is actuated by two motors arranged with series-parallel control. The speeds of lifting are 10 ft. and 20 ft. per minute, the cross traverse 120 ft. per minute, and travel 300 ft. per minute. Magnetic brakes are fitted to the lifting and travelling motions. Lifting is supplied by one electric motor, cross traversing by another, and longitudinal travel by two motors. Electric energy is supplied by the Harbour Department's power station.

The electrical equipment was supplied by Bruce Peebles & Co., and the gantry (which is 15,500 ft. in length and 22 ft. in height) was built by Mr. A. Short. The cost of the whole work was £13,500. The trials which followed the inaugural ceremony were very satisfactory, a 20-ton block of concrete being handled in a few minutes. This is an operation which would, it was stated, have occupied 3¾ hours under the system formerly in vogue at Durban, and as the electric crane can be worked by one man (compared with 15 required under the old system), the cost of lifting, transporting and depositing loads by the new crane will, it is estimated, effect a large saving, the average cost of this work with the electric crane being only about ½d. per ton.

**East Ham.**—Delegates have been appointed by the Council to open up negotiations with the North Metropolitan Tramways Co. to discuss a proposal of the Council to take over certain of the company's lines, &c.

**Edinburgh.**—A sub-committee of the Electric Lighting committee recommend that in future stair lighting be undertaken at £1 per lamp per annum where the wires are already installed.

**Electric Lighting Notice.**—Wembley District Council give official notice of intention to apply for a provisional electric lighting order, which will (inter alia) authorise the council to take a supply of electricity in bulk from any company or corporation.

**Exeter.**—The City Council have decided to light the tramway routes by arc lamps.

**Falkirk.**—The Falkirk and district electric tramways system was opened for traffic on Saturday.

**Fochabers.**—Elgin County Council has approved the action of the Fochabers local committee in accepting a tender (referred to in another column) for the erection of posts for electric lamps in the streets, and for the supply of electricity, which is to be taken from the installation put down by the Duke of Richmond and Gordon. It was resolved to raise a loan locally to carry out the work.

**Grimsby.**—The Council have approved the draft of an agreement with the Great Central Railway Co. for a supply of electricity in bulk.

The agreement provides for the taking of a supply of electrical energy by the company from the Corporation for use on the docks for three years, and then from year to year, the agreement to be terminable by 12 months' notice from either side. The company is to provide and lay all necessary feeder cables, the company to pay for the necessary connecting cables laid on their property between the Corporation distributors and the sub-station, the Corporation providing the connecting feeder cables. The energy supplied is to be charged for on the maximum-demand system at a fixed charge of £4 per annum per kilowatt of maximum demand, required at any one time, and in addition a charge of ¾d. per unit for all current consumed. The company will take all current required by them at Grimsby from the Corporation during the continuance of the agreement, except in the case of a small supply on the fish pontoon and in the transit sheds.

**Hackney (London).**—The Finance committee have approved an expenditure of £4,000 for work in connection with the scheme for taking condensing water from the river Lea for the electricity department.

**Hammersmith (London).**—The accounts of the electricity department for the year ended March show capital expenditure £210,994. 8s. 8d., an increase of £16,515. 5s. 10d.

Receipts were £35,769. 18s. 11d., including £30,329. 8s. 10d. net for private and £4,498. 7s. 10d. for public lighting. Working expenses were £18,913. 6s. 7d. Gross profit was £16,856. 12s. 4d. and net profit £5,282. 16s. 2d., after meeting interest and capital charges (£11,505. 19s. 10d.), &c. 3,456,570 units were generated, 472,906 supplied to public lamps and 2,475,727 to private consumers. The maximum supply was 2,426 kw., compared with 1,596 kw. in previous year. There are 1,518 private consumers with the equivalent of 92,552 8 c.p. lamps (for lighting), compared with 1,469 consumers and 85,693 lamps in the previous year. There are 180 motors (=1,207 H.P.) connected (against 98 motors and 938 H.P.). The average price obtained from private consumers was 2·94d. (against 3·43d.) and for public lighting 2·28d. (against 2·99d.)

**Haslingden.**—The Council are promoting an omnibus bill for reconstruction, extension and electrification of the tramways and for the supply of electricity thereto.

**Hayward's Heath.**—The Council have signified their willingness to meet representatives of a company to discuss the question of electricity supply.

**Horsforth.**—The Council recently decided to open negotiations with the Yorkshire Electric Power Co. for the transfer of the Council's electric lighting order.

**Huddersfield** —The chairman of the Electricity committee (Councillor Chatterton) and the borough electrical engineer (Mr. A. B. Mountain) have been commissioned to draw up a scale of charges for electric current for power.

In connection with the supply of electricity to Golcar, the Council have asked the Board of Trade to sanction the erection of an overhead line from Golcar to Crimble.

**Liverpool.**—At the last meeting of the Electric Power and Lighting committee for the municipal year, the chairman (Mr. R. Dart) was heartily thanked for his services.

Mr. Dart stated that during the year the equivalent of 16 c.p. lamps connected to the mains had increased from 277,767 to 310,562, and the number of consumers from 5,345 to 5,821. The amount of electrical energy supplied for lighting and power showed an increase of about 6 per cent. and 5·75 per cent. increase in electrical energy supplied for tramways.

**Liverpool to Manchester by Tramway.**—Salford Tramways committee are taking steps to construct a new tramway from their line at Pendlebury through Clifton and Unity Brook to the terminus of the Farnworth tramway system. When this is complete, tramcars will run from Manchester, through Bolton and on to Liverpool.

**London County Council**—At Tuesday's meeting loans for electric lighting were made: Stepney £3,770 and Woolwich £5,111.

*Tramways.*—The Highways committee brought up an adjourned report recommending that expenditure of £5,300 be sanctioned for the provision of additional high-tension feeder cables for the "Elephant and Castle" sub-station.—Agreed.

The same committee recommended that application be made to Parliament for power to acquire certain short lengths of tramway in or on the boundary of the County of London to be connected with the Council's northern tramway system.—Postponed.

*Electric Power for London.*—A joint report from the Highways and Parliamentary committees recommended that the two committees be authorised to arrange a conference with representatives of the City Corporation and borough councils to consider the whole question of the supply of electrical energy in London. The committees suggested that the conference, if decided upon, should be held on Nov. 20 next.—Agreed to, on the understanding that the supply companies should be invited to send their views to the Council on the subject.

**Manchester.**—An inquiry will be held here to-day into the Council's application for sanction to borrow £60,000 for extensions of the electricity undertaking.

**Manchester and Salford Tramways.**—The Trafford Park Estates Co. are claiming £10,000 damages from Manchester and Salford Corporations for alleged breach of contract in not running electric tramcars into Trafford Park by an agreed date. It is urged by the Corporations that considerable difficulties have been encountered in carrying out the scheme. A as swing bridge had to be constructed over the Ship Canal, and the tramway wires had to be erected in such manner as not to interfere with the working of the bridge. This work has been successfully accomplished, and very little now remains to be done in connection with the scheme. Signals have been erected 150 yds. away on each side of the bridge.

**Marylebone (London).**—The total number of consumers changed over to the increased pressure of supply was on 17th inst. 1,047.

Certain consumers had made claims for loss of business and on other grounds in consequence of the change over, and the Council's engineer is negotiating with a view to early settlements.

The Finance committee reports having drawn cheques during the recess to the sum of £54,000 on account for works in connection with the electricity undertaking. In addition, the committee had passed accounts for payment during the past fortnight totalling £23,968.

**Melbourne (Australia).**—The city electrical engineer (Mr. H. R. Harper) has been authorised to spend £6,900 during the next two years on two boilers, with mechanical stokers, economiser, motor-driven pump, switch gear, motor-balancer, extension of switchboard, foundation work, &c.

**Newport (Mon.)**—The Electricity committee recommend that from Jan. 1 next the charge for current for public buildings, shops, &c., be reduced from 5½d. to 4d. per unit and 3d. per unit in excess of 6,000 units per annum, for office lighting from 5½d. to 4½d. and for places of worship and private houses from 5d. to 4½d. For heating and cooking it is proposed to reduce the charge from 2d. to 1d. per unit.

**Personal.**—Mr. E. Trenam, Comptroller of the Central Telegraph Office at the G.P.O., St. Martin's-le-Grand, London, is about to retire under the age limit. Mr. Trenam was appointed to the position in 1902.

**Pontypridd.**—The Council have granted the contractors (Krauss & Co.) a six months' extension of time for laying the Council's tramways on the condition that only local stone is used.

**Slot System of Issuing Tickets.**—The Mersey Railway Co. have adopted the penny-in-the slot principle of issuing tickets at James-street station, Liverpool, with the object of relieving pressure at the booking office. By inserting a penny into the machine a penny journey ticket is secured.

**Solomon Islands (British).**—Even in the far away, isolated British Solomon Islands electrical work is progressing, if we may accept as evidence the imports into these islands, which included for 1904-5 three dynamo electric machines and four cases of electrical goods. The year 1903-4 was the first when any goods of this character were imported.

**Speed of Tramcars in South London.**—Lieut.-Col. Yorke, in his report to the Board of Trade on the application of the London County Council for an increase in the speed limit for electric tramcars, recommends that on certain sections the rate of speed may be increased from 10 to 12 miles, and on others from 12 to 16 miles. Under the dangerous Clapham and Balham railway bridges the present limit of four miles per hour is to be retained.

**Stalybridge, Hyde, Mossley and Dukinfield Tramways.**—The formal opening of these tramways took place on Monday. The scheme has cost £430,000; the total length of the line is about 19¾ miles. For two years past tramcars have been running, and the electric lighting and power supply portion of the scheme is being gradually developed.

**Stepney (London)**—An arrangement has been come to by the Council whereby Cloke Bros. will pay 9d. per ton of clinker and ashes drawn from the refuse destructor works and passed through the clinker-crushing plant of the department. The borough electricity undertaking will pay the Works committee 7d. per ton in respect thereof. Cloke Bros. are to remove the flue dust and rubbish from the electricity works on a payment by the Council of 1s. and 2s. per ton. respectively. These arrangements are to be for 12 months.

**Torquay.**—An inquiry will be held on Tuesday into the Council's application for sanction to borrow £9,500 for additional electric generating plant.

The Electric Lighting committee have engaged Messrs. Kincaid, Waller & Manville, as consulting engineers, to watch the tramway construction works on behalf of the Corporation at a fee equal to 3 per cent. on the total outlay. The Dolter Co. have intimated that they will assert their rights to the utmost, owing to the decision of the Corporation not to pass their plans except on the condition that the company relieve the Corporation of liability for damages in the event of the Corporation being unable to supply current when the company are ready to take it. The construction of the tramway track was commenced by the company on Monday.

**Walthamstow.**—The electrical engineer (Mr. J. H. Fooks Bale) has been instructed to obtain tenders for the following: Automatic switches, an extra panel for the traction board, alterations to the gas generators, re-arranging the old lighting switchboard (estimated cost between £600 and £700), motors for hire purchase and spare parts.

**Watford.**—The Council have agreed to supply electric current for power to G. W. Jones (Ltd.) for their new printing works on the Cassiobridge estate at 1d. per unit.

The firm have decided to adopt electric driving throughout their works; the contract will be for five years, the minimum payment by the firm to be £400 per annum after the first 12 months' working; lighting other than by arc lamps not to exceed 20 per cent. of the supply. The Council will lay a cable and erect a transformer station, &c., at a cost of £2,500.

**Wednesbury.**—The Council decided, on Wednesday, to give statutory notice to South Staffordshire Tramways Co. requiring them to sell to the council the Wednesbury and Walsall section of their undertaking.

**West Ham.**—On Tuesday the Corporation decided that for the half-year ended March, electrical energy supplied to the tramways department by the electricity department should be charged at 1·6d. per unit; for the half-year ended 30th ult. 1·5d. per unit; and after that date 1d. per unit.

**Wimbledon.**—The Surveyor has been instructed by the Council to obtain tenders for two centrifugal electric pumps for Raynes Park. The 12 Nernst lamps and the "Excello" flame arc lamp, which were recently put up in the streets as an experiment, are to be purchased. 1,819 consumers are now connected with the mains, representing 86,267 8 c.p. lamps. There are in addition street lamps equivalent to 5,162 8 c.p. lamps.

**Wisbech.**—The Corporation have decided to apply for another provisional electric lighting order, and to open negotiations with a company for the supply of electricity.

**Workhouse Lighting.**—At their last meeting Yarmouth guardians decided to adopt electric lighting for the lodge and the avenue leading to the workhouse, including two 500 c.p. lamps at the entrance.

**Football.**—The annual match between the Robertson Electric Lamp and General Electric teams took place on Saturday last on the lamp-makers' ground at Acton, the home team securing a good win by 7 to 1. The lamp makers have thus started their second season well, having won both their League matches.

# TRADE NOTES AND NOTICES.

## TENDERS INVITED.

*Barrow-in-Furness* Corporation invite tenders for supply and erection of one 500 kw. combined steam engine and generator, one balancer booster, switchboard panels and connections for generator and booster, one water-tube boiler with superheater, one mechanical stoker, steam and exhaust pipes, valves, &c., one economiser, ironwork, one 15-ton travelling crane and one cooling tower. Tenders (addressed to Chairman of Electricity committee) to the town clerk (Mr. C. F. Preston), Town Hall, Barrow-in-Furness, by noon Nov. 13. See also an advertisement.

*Shoreditch* (London) Council invite tenders for three water-tube boilers, superheater, &c., steam, feed and drain pipes, valves, &c., and overhead steel flue for Whiston-street generating station. Tenders by noon, Nov. 7.

*Clacton-on-Sea* District Council invite tenders for supply and erection of gas engines and dynamos, switchboard, underground mains, accumulators, meters, crane and buildings. Tenders, to the clerk of the Council (Mr. G. T. Lewis), before 3 p.m. Nov. 6.

*Tynemouth* Corporation invite tenders for supply and erection at their electricity works, Tanner's Bank, North Shields, of one 165 kw. traction dynamo. Tenders to the town clerk (Mr. E. B. Sharpley) by first post Nov. 2.

*London* County Council want tenders by 10 a.m., Nov. 7, for about 1,000 tons of steel conductor tee rails. Forms of tender from the engineer's department, Spring-gardens, S.W.

*Metropolitan Asylums Board* want tenders by 10 a.m. Oct. 31 for an electric motor, engineers' tools, &c., for Western Fever Hospital, Fulham.

Tenders are invited for wiring the Stamford Park new Council schools, *Altrincham*. Tenders to Mr. J. Howarth, Education Offices, Altrincham, by Nov. 3.

The Posts and Telegraph Department of *Cape of Good Hope* require tenders for telegraph and electric light material, as set out in the Cape Government "Gazette" of Oct. 3. Tenders have to be sent to the chairman of the Tenders Board, Parliament-street, Cape Town, by noon, Nov. 22. Samples can be inspected and all further information obtained of the Controller of Stores, General Post Office, Cape Town.

## TENDERS RECEIVED AND ACCEPTED.

London County Council have accepted the following tenders:—

*Low-tension Cables for Strand to "Angel," Islington, Tramway Route.*

| | | | |
|---|---|---|---|
| Callender's Co. (*accepted*) | £4,025 | 4 | 4 |
| Anchor Cable Co. | 4,141 | 5 | 4 |
| Siemens Bros. & Co. | 4,093 | 12 | 4 |
| British Insulated & Helsby Cables | 4,068 | 10 | 0 |

*Laying of Stoneware Cable Ducts.*

| | | | |
|---|---|---|---|
| J. A. Ewart (*accepted*) | £2,813 | 14 | 0 |
| John Mowlem & Co. | 4,435 | 0 | 0 |
| British Insulated & Helsby Cables | 2,992 | 0 | 0 |
| Reid Bros. | 2,974 | 8 | 0 |

The Council on July 25 accepted the tender of Evered & Co. for supply, delivery and erection of low-tension switchboards for the Battersea and Wandsworth tramways sub-stations. This switch gear being similar to that required for the Aldwych and Islington tramways, it appeared to be of advantage to arrange for Messrs. Evered's contract to be extended. Messrs. Evered were prepared to agree to this course, subject to an increase for the additional work of £26 on schedule rates in the original contract. The total price of the switch gear will not exceed £275.

West Ham Corporation have accepted the tender of the British Insulated & Helsby Cables for 1,720 yds. 0·034 low-tension cable at £73. 2s. Johnson & Phillips (Ltd.) tendered at £84. 6s. and W. T. Glover & Co. at £78. 5s. 6d. The tender of the British Insulated & Helsby Co. for 1,640 yds. 0·017 low-tension single cable has also been accepted at £47. 15s.; Johnson & Phillips' tender was £61. 10s. and W. T. Glover & Co.'s £53. 18s.

Wimbledon Council has accepted the following tenders: General Electric Co., 10-way street lighting fuseboard at £6. 17s. 6d.; British Thomson-Houston Co., electrically-driven plant at pumping station, £1,740.

Sydney (N.S.W.) City Council have placed an order with the Allgemeine Electricitäts Gesellschaft (through their agents, Staerker & Fisher) for 600 electricity meters.

Battersea Borough Council have accepted the tender of West Bros., at £43. 15s. 6d., to supply 10,000 tiles in connection with the Nine Elms lighting scheme.

Pontypridd Council have accepted the tender of the Brush Co. for the electrical equipment of the tramway to Hafod at £3,603, and that of W. T. Henley's Co. for cables at £2,585.

Southend Council have accepted the tender of Callender's Co. for cable for repairs to the tramway overhead equipment.

The tender of Hugh Douglas, Elgin, for the erection of 31 lamp-posts for street lighting in Fochabers at £109. 5s. 6d. has been accepted by Elgin County Council.

Walthamstow Council have accepted the tender of the British Thomson-Houston Co. for supply of electric motors for the tramway car shed.

Walthamstow Council have also placed an order with Frank Mortimer & Co. for a 10 H.P. motor and with W. H. Baughan & Co. for a 5 H.P. motor.

Southwark Council have accepted the tender of Spenser Whatley & Co. for 4,000 tons of West Hallam and Manners coal at 12s. 7d. and 12s. 9d. per ton respectively.

Chelmsford Education committee have accepted the tender of Christy Bros. & Middleton for wiring the Friars school at £38. 7s. 6d.

The tender of E. Dewhurst at £595 has been accepted for wiring and fitting up the Isolation Hospital, Preston, for the electric light.

Chorley Guardians have accepted the tender of H. Brindle for telephone installation at their hospital.

Worksop Council are recommended to accept the tender of Thomas Parker (Ltd.) for steam balancers for the electricity works at £477.

Clydebank Town Council have accepted the tender of Heenan & Froude for refuse destructor works at £7,142. 2s. 11d.

Leeds City Council have placed an order with the Romapac Tramway Construction Co. for tramway rails.

**Steam Turbine Orders.**—The successful setting to work of a number of steam turbines built by Willans & Robinson, of Rugby, has resulted in a large number of orders for this make of turbine, and those departments of the Victoria Works, Rugby, dealing with the manufacture of steam turbines, are working day and night. Among recent contracts for Willans & Robinson's turbines may be mentioned: Four turbines of 1,000 kw. each for the Cleveland & Durham Electric Power Co.'s new station at Middlesbrorough; three turbines of 1,000 kw. each for Bruce Peebles & Co.'s scheme for supplying power to a number of Durham collieries; two turbines of 1,000 kw. each for Bruce Peebles & Co.'s Fife scheme; one turbine of 1,500 kw. capacity for Islington (London) Council; one turbine of 1,000 kw. capacity for Messrs. Drake & Gorham; and two turbines of 1,500 kw. capacity, each for Shoreditch (London) Council.

## BUSINESS NOTICES.

Mr. W. Clark Fisher, Gordon Works, Gordon-road, West Ealing, London, W., has recently taken into partnership Mr. T. Wadsworth, who graduated (Honours) B.Sc. at Owen's College, Manchester, served his time with the General Electric Co., Manchester, and was until recently assistant lecturer at the Chelsea (London) Polytechnic. The title of the firm is now "Clark Fisher & Wadsworth."

Herbert Jas. Swift and Geo. Hy. Herrod (trading as H. J. Swift & Co.), electric appliance fitters and dealers, &c., Earlestown, Lancs., have dissolved partnership. Debts by Mr. Swift.

Mr. Robert MacGregor, for many years partner in W. Dunn & Co., Durban, Natal, has been admitted a partner with Messrs. Rowland Carr & Co., ironfounders and contractors, 6 and 8, Lime-street-square, London, E.C., and at Glasgow, Sheffield and Worcester. The business will be carried on as hitherto under the style of Rowland Carr & Co. Mr. J. C. Brown, who is well known among electrical engineers, will now devote the whole of his attention to the firm's outside work.

The Cambridge Scientific Instrument Co. (Ltd.), Carlyle-road, Cambridge, having discontinued their London office, all correspondence should be addressed to Cambridge.

Edwin Lansing and Thos. Fredk. Griggs (trading as Lansing, Griggs & Co.), electricians and electrical engineers, 19, Victoria-buildings, and Golden Gate Works, Old Trafford, Manchester, have dissolved partnership. Debts by Mr. Lansing.

## BANKRUPTCIES, LIQUIDATIONS, &c.

At Bradford Bankruptcy Court on Wednesday the public examination took place of Walter Binns, railway contractor, Stanhope House, Frizinghall, and 25, Cheapside, Bradford.

In 1902 debtor projected the Mexborough and Swinton and the Saddleworth and Springhead tramways, and obtained the necessary parliamentary powers. He entered into an agreement with the New General Traction Co. to take over his rights and powers in the Mexborough and Swinton scheme for £20,000, half to be paid in cash and half in fully-paid shares in the company to be formed for constructing and working the tramways. The promotion of the company, however, fell through, and the whole business was suspended until 1904, when the debtor entered into negotiations with others. About a year ago he approached a Mr. Godfrey C. Isaacs, with whom he ultimately agreed that the latter should take over the concessions and form a syndicate to construct and work the tramways, the debtor to receive £15,000 in cash and £10,000 in shares in the new company. Debtor executed a power of attorney to Mr. Isaacs to act for him in connection with promotion of the company, and hand over the balance remaining of the purchase money. The tramways were in course of construction by the National Electric Construction Co., acting under instructions from Mr. Isaacs, and it was hoped that some of them would be working this year. Debtor had not yet received any portion of the cash and shares, or any statement regarding the liabilities from Mr. Isaacs, who had been abroad. The construction of the Saddleworth and Springhead tramways, in which he had a half-share, had not yet begun. In fact, it had been necessary to obtain no fewer than three Acts of Parliament. Ultimately, the debtor sold his share to his partner for £2,000. He estimated that there was a surplus of assets over liabilities of £3,480. Examination adjourned.

William Jefferson, electrical engineer, 3, Grainger-street, Darlington, was examined last week at Stockton. Liabilities £254. 1s. 9d., estimated deficiency £211. 8s. Failure attributed to creditors of a firm in which he was formerly a partner pressing him. Examination adjourned.

In the failure of Thos. Hill, electrical engineer, 24, Vicarage-road, Wolverhampton (formerly of Stafford-street, Willenhall), the first meeting of creditors will take place on Nov. 3 at 45, Copenhagen-street, and the public examination on Nov. 7, at the Guildhall, Worcester.

Robert Herbert Scotter, civil engineer, late of Cambridge-road, Southend, and 36, Emperor's-gate, London, S.W., has been adjudicated bankrupt.

Geo. and John Samson Robson, electrical engineers, trading as Robson, Robson & Co., Empire-buildings, Newcastle-on-Tyne, have been adjudicated bankrupt. Mr. T. Leman, St. Peter's Church-walk, Nottingham, is trustee. J. S. Robson was examined at the local bankruptcy court on Oct. 19. The case was adjourned to Nov. 9.

Claims against the National Electric Traction Co. (Ltd.) to Mr. L. Morse, 79, Queen-street, London, E.C., by Dec. 7.

The Delafon Batteries Synd. (Ltd.) is being wound up voluntarily. Mr. E. Williams, Norfolk-street, and Mr. Chas. B. Hahn, Bloom-street, Manchester, are liquidators.

The British Electric Signs Co. (Ltd.) is being wound up voluntarily. Mr. G. E. Mount, Dashwood House, London, E.C., is liquidator.

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**Old Post Office Stores Sale.**—Tenders are invited by the Postmaster-General for the purchase of about 52 tons of gutta percha, 100 tons of copper, a quantity of other metals, indiarubber, covered wire, incandescent lamp tops, tools, &c. Forms of tender can be obtained from the Controller, Stores Department, G.P.O., 17-19, Bedford-street, London, W.C. Tenders will be received until 10 a.m. Nov. 1.

**Apparatus, &c., for Sale.**—Messrs. Price & Co , 32, Clerkenwell-road, London, E.C., advertise for sale six arc lamps, and some brackets and pendants.

Mr. R. Archer, Horsforth, Leeds, advertises for sale Evershed testing sets.

White Bros. & Co., Princes Wharf, High-street, Stratford, advertise for sale two 100 kw. Mather & Platt-Belliss sets, with surface condensers, air pumps, &c.

Messrs. Bourne & Hollingsworth, 116, Oxford-street, London, W., advertise 19 flame arc lamps for sale.

Cambridge Scientific Instrument Co., Cambridge, advertise for sale a 19 H.P. Stockport gas engine, suitable for driving electric lighting plant.

Messrs. Wild & Collins, 31, Lawrence-lane, London, E.C., have for sale 52 milligrammes of radium bromide. See an advertisement.

**Works for Sale.**—Extensive slate, slab and enamelling works, conveniently situated for railway and shipping wharves (with plentiful supply of best slate, suitable for electrical purposes) are advertised for sale by Mr. John Pritchard, auctioneer, Bangor.

**Premises to Let, &c.**—Messrs Marshall & Co., Campbell Works, Stoke Newington, London, N., have to let premises suitable for electrical works or light engineering trades. See an advertisement.

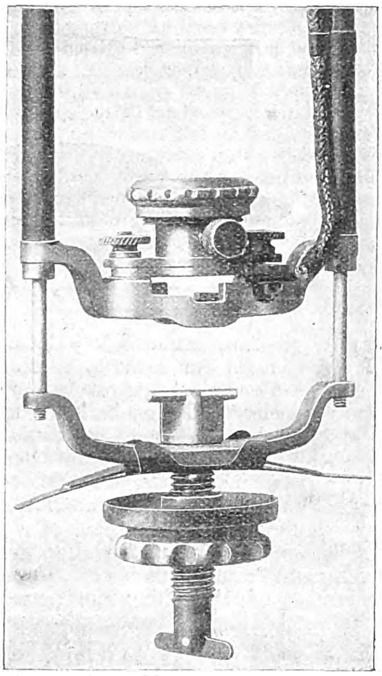
Mr. Adams, Chichester House, Chancery-lane, London, W.C., has some factory premises in Clerkenwell and Shoreditch to let. See an advertisement.

**Week-End Holidays.**—The subject of week-end holidays is an interesting one for all workers, and we may therefore call attention to the winter edition of a popular guide to places where the week-end hours can be spent to most advantage, either for rest or recreation. Mr. W. T. Perkins has compiled a very useful list of such places, which includes a complete list of golf links. The booklet is distributed gratuitously by the London & South-Western, the Great Eastern, the London, Brighton & South Coast, and the South-Eastern & Chatham Railway Companies, and can be obtained, price 1d., at the various railway bookstalls.

**Watertight-tube System of Wiring.**—Messrs. Rawlings Bros. (Ltd.), 82, Gloucester-road, South Kensington, London, S.W., write as follows:

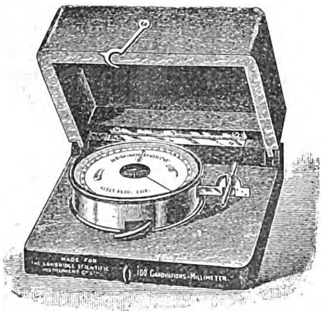
It has been brought to our notice that a circular which we issued at the recent Electrical Exhibition at Olympia may lead to the misapprehension that Messrs. Handcock & Dykes, consulting engineers, have some interest in the watertight-tube system of wiring which we have been exhibiting there. We, therefore, wish to explain that some time ago we tendered successfully to a specification of Messrs. Handcock & Dykes which called for the use of this system, which they had devised and used for some years past to meet certain difficulties in wiring work. Since then we have carried out similar installations under the direction of the same firm, and found the system possess so many advantages that we proceeded to stock the necessary parts. We have modified the boxes in one or two directions and in other ways altered the system to suit our own purposes. Our only object in mentioning Messrs. Handcock & Dykes' name was to make it clear that the credit for the invention was theirs, but we wish to make it equally clear that they have not patented the system and have no financial interest in it.

**Catalogues, &c.**—A new pamphlet (No. 184) on the subject of enclosed arc lamps has been issued by the British Thomson-Houston Co. In this pamphlet the different types of B.T.-H. enclosed arc lamps are illustrated and their mechanical construction described. There are two forms of these lamps, the Drop Frame and the Fixed Frame. These differ in the lower frame construction and in the method of supporting the lower carbon and the inner and outer globes. Our illustration shows the lower lamp mechanism for the drop frame lamp with globe holders. In this type of lamp the lower carbon and enclosing globe are held in a removable holder, and the outer globe is carried on a telescopic lowering device as shown in the figure. This form of lamp is specially designed for the use of double-enclosing globes and greatly facilitates trimming. It is a form of lamp recommended for use where lamps are required to be so placed as to render trimming difficult. The outer globe when lowered is rigidly held by the sliding rods and cannot swing. This feature is an important one where lamps have to be trimmed in positions exposed to high winds. It is further claimed for the drop frame type of lamp that it is well adapted for street and other lighting where large numbers of lamps are installed. The lower carbon and enclosing globe being clamped in the same holder, the labour of trimming is reduced to a minimum. The lamp is entirely weather-proof and is supplied with either spring or hook suspension.



Lower Lamp Mechanism for B.T.-H. Drop Frame Lamp.

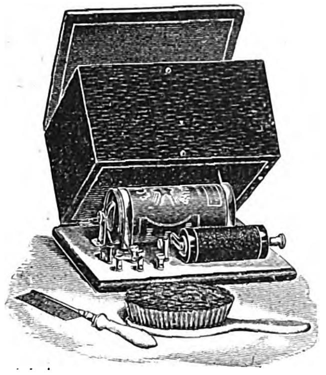
The Cambridge Scientific Instrument Co. are placing upon the market Weicholdt's instantaneous dial micrometers. Model I. (metric measure) of this instrument is shown in the accompanying illustration. The instruments are essentially sliding calipers, in which the displacement of the movable jaw is greatly magnified upon a divided dial. The jaws are opened positively, in some patterns, by a gentle pressure of the thumb upon a lever release, the closing of the jaws being effected, except in one of the three models, by a spring. The effort of this spring is so applied that no back lash or loss of motion can affect the readings. It is claimed that, notwithstanding their great sensitiveness and accuracy, these micrometers are well adapted for general laboratory use.

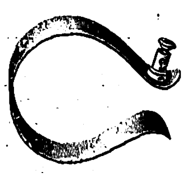

MADE FOR THE CAMBRIDGE SCIENTIFIC INSTRUMENT Co.
100 GRADUATIONS = MILLIMETER

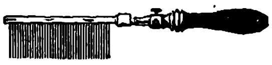
Model I. of Instantaneous Dial Micrometer.

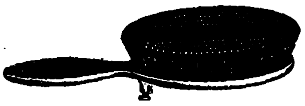
A comprehensive catalogue and price list of pipes and accessories which have been made up to illustrate the company's method of supplying complete piping installations for electric power stations, factories, &c., has been issued by John Wilson & Co , of 49, Lime-street-square, London, E.C. The list includes an illustration of one of these plants supplied by the firm, assembled together at the company's works for inspection before being shipped for an electric power station in India. A good assortment of stocks and dies, tube cutters, screwing machines, &c., is also listed.

The General Electric Co. have ready a pamphlet containing particulars of electro-medical apparatus for hairdressers, chiropodists, manicurists, &c. The pamphlet describes and illustrates a number of articles which will doubtless in due time come into general use. Our illustrations show (Fig. 1) a tonsorial outfit specially designed to supply the demand for a compact and high-class article for hair treatment. A double-pole brush, metal comb and wristlet are shown in the smaller illustration (Fig. 2). These electrodes can be employed in connection with any of the outfits supplied on this system. The wristlet is intended to be so arranged that it will allow the operator's hand to be used as part of the circuit.


G.E. Electrical Tonsorial Outfit.


Polished G.S. Wristlet.


Metal Comb.


Double-pole Brush.

Electrodes for G.E. Tonsorial Outfit.

A copy of the new catalogue of the Amalgamated Dry Batteries (Ltd.), Devonshire-square, London, E.C., has come to hand. It contains illustrations and all necessary technical data relating to the firm's dry cells, wet cells, the "Reeplen" sparking battery (representing a combination of a wet and dry cell), small accumulators and sparking coils for gas and petrol motors. The "Reeplen" sparking battery, recommended especially for motor cars, petrol launches, &c., may be made ready for use at any time by adding water. It is essentially a primary battery. Following is an abstract of a test made with a battery of four cells, weighing 14 lb. altogether, by the Electrical Standardising, Testing and Training Institution, Faraday House, London: In order to imitate actual working conditions, the battery was discharged through a rotating contact breaker and a choking coil, the contact breaker being driven by a motor at 800 revs. per min. Two contacts were made at every revolution of the motor, each contact lasting for ⅛ of a revolution. The current flowing was equivalent to a steady current of 0·25 amperes. As a rule three tests of two hours' duration each were made each day, the discharge being stopped for 30 minutes between the tests. The number of two-hours tests totalled 115, and the average P.D. during the whole test (measured whilst the current was flowing) was 4·2 volts. There were no signs of corrosion at the terminals of the battery at the conclusion of the tests. All the company's goods (we are informed) are manufactured in London.

J. G. Ingram & Son, of the London India Rubber Works, Hackney Wick, London, N.E., have ready a new price list of indiarubber gloves and gauntlets for handling acids and chemicals and for electrical purposes. The list is accompanied by a report from the Electrical Standardising, Testing and Training Institution upon the insulating resistance of a pair of indiarubber gloves of this firm's manufacture.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Oct. 18 to 24 with the ports of destination:—

*Africa.*—Alexandria, £1,025 (including £179 telegraph material); Bonny, £16; Cape Town, £257; Durban, £2,906 (including £307 telegraph material); East London, £1,607; Port Said, £45; Suez, £93 (telegraph material). *Argentina*—Buenos Ayres, £1,734 (including £1,223 telegraph material); Rosario, £423 (including £312 telegraph material). *Australasia*—Hobart, £23; Lyttelton, £42; Melbourne, £831 (including £170 telegraph material); Perth, £171; Sydney, £1,823 (including £580 telegraph material); Wellington, £246. *Belgium*—Ostend, £231. *Brazil*—Pernambuco, £145. *Canada*—Halifax, £25 (telegraph material); Montreal, £32. *China*—Shanghai, £230 (including £92 telegraph material); Tientsin, £485. *Denmark*—Copenhagen, £1,571 (including £630 telegraph cable). *France*—Bordeaux, £23; La Treport, £22. *Germany*—Hamburg, £426. *Gibraltar*—£279. *Holland*—Amsterdam, £194; Flushing, £100; Rotterdam, £14. *India*—Bombay, £4,850; Calcutta, £1,569; Madras, £30 (telegraph material). *Japan*—Kobe, £42; Moji, £200; Osaka, £52; Yokohama, £1,977. *Malta*, £8. *North Sea*, £2,835 (telegraph cable). *Peru*—Callao, £3,775 (submarine cable). *Russia*—Libau, £18; Odessa, £5; St. Petersburg, £605 (including £295 telegraph material). *Spain*—Seville, £15. *Straits Settlements*—Singapore, £159. *Sweden*—Gothenburg, £63; Stockholm, £95. *Uruguay*—Montevideo, £109 (telegraph material). *United States*—Philadelphia, £100. Total, £31,526, against £13,103 in the corresponding week last year (Oct. 19 to 25).

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"The Use and Care of Chains for Lifting and Hauling." 2nd edition of a Paper read before the Civil and Mechanical Engineers Society on April 27, 1887. By Prof. Henry Adams. (London: The Author.)

"Fowler's Electrical Engineers' Year Book and Directory of Light, Power and Traction Stations for 1906." (Manchester: Scientific Publishing Co.) 1s. 6d.

"High Tension Power Transmission: A Series of Papers and Discussions presented at Meetings of the American Institute of Electrical Engineers, under the Auspices of the Committee on High Tension Transmission." (New York: McGraw Publishing Co.)

"Transactions of the Civil and Mechanical Engineers Society." 1904-1905 session. Edited by A. S. E. Ackermann. (London: The Society.)

"Elementary Electrical Calculations." By W. H. N. James and D. L. Sands. (London: Longmans, Green & Co.) 3s. 6d.

"Elektromagnetische Theorie der Strahlung." By Dr. M. Abraham. (Liepzig: B. G. Teubener.) 10m.

"Berechnung und Ausfuhrung der Hochspannungs-Fernleitungen." By Carl Fred. Holmboe. (Berlin: Julius Springer.) 3m.

"Die Zweckmässigste Betriebskraft." Vol. I. Die mit Dampf betriebenen Motoren. Vol. II. Verschiedene Motoren. By Friedrich Barth. (Leipzig: G. J. Göschen.) 80 pf. each.

"Die Gleichstrommaschine." By C. Kinzbrunner. (Leipzig: G. J. Göschen) 80 pf.

## COMPANIES' MEETINGS AND REPORTS.

### Montevideo Telephone Co. (Ltd.).

The annual general meeting was held yesterday (Thursday) under the presidency of Mr. F. Williams Jones.

The SECRETARY (Mr. David Smith) read the notice convening the meeting and the auditors' report.

The CHAIRMAN then said: Since the re-arrangement of the capital of the company in 1898 our business has steadily improved. In 1898 our net profits were £6,826, and in 1905 these had reached £15,473. The past year has especially surpassed all others, but a considerable portion of the excess is owing to the recovery of indebtedness in arrear through the general disturbance of business by the late civil war. Notwithstanding the general injury to business, we did not suffer any falling off, except for a brief period, either of our subscribers or of our revenue. It is also an important fact that the whole of the capital expenditure required in the past eight years has been derived entirely from revenue. The company has no debenture debt, its principal office buildings in Montevideo are freehold and unencumbered. It has no indebtedness that it cannot pay practically at a moment's notice, and it has in hand, at present Stock Exchange values, over £12,000 in securities. It does not, however, follow that we can go on meeting capital expenditure from revenue for an unlimited period. Large expenditure is to be anticipated when we renovate and modernise our system, and I had hoped to be able to announce that work in this direction was already in progress. For several years the company had been in negotiation with Uruguay Congress and with Montevideo Municipality in regard to an extension of their system beyond its present territory, to connect up with Buenos Ayres, and for an underground plant in the city of Montevideo, but the civil war had delayed consideration of these proposals, but it was hoped that it would not be long before the work was carried through, as the proposal to establish telephonic communication between the two cities of Buenos Ayres and Montevideo had been strongly supported by leading banks and business houses. In view of the importance of this work the directors had continued the policy of preparation by limiting dividends and increasing reserves, thus assuring as far as possible the stability of the company's reserves and its future. From 1889 to 1899 they paid no cash dividends on the ordinary shares, in 1899 2½ per cent. was paid, in 1903 and 1904 3 per cent.; and it was now proposed to pay 4 per cent. In the meantime their real estate and other investments had increased to £24,000, the reserve fund to £54,500, and the capital expenditure to upwards of £30,000 had been entirely met out of revenue. They did not intend to depart from that conservation policy of the past, which had given a needed assurance to investors that shares in telephone companies working in distant countries were desirable investments. The general rise in price in those shares during the past year had been an indication that such a feeling existed. Turning to the accounts, he considered they presented very satisfactory figures. While their general expenses had increased about 10 per cent., it would be seen from the profit and loss account that their receipts had increased 12½ per cent. The appropriation of their net profits would, he hoped, be considered gratifying. £5,000 had been carried to general reserve, the same as last year, and £3,000 to the special reserve for renewal of plant. This was £1,000 more than last year. The regular 5 per cent. dividend on the preference shares was provided for, as was also the 4 per cent. on the ordinary shares, while an increased amount was carried forward. Before concluding he desired to express the regret of the board at the loss of their late secretary, Mr. E. M. Reiss, who had been an efficient and valuable assistant to the board for upwards of 13 years. Fortunately for them, they had been able to replace Mr. Reiss with their present secretary, Mr. David Smith, but they would always remember the thoughtful and comprehensive labours of Mr. Reiss, and his considerate and courteous conduct to all with whom he was associated. He would also like to refer to their manager, Mr. Powers, of Montevideo. Few of those interested in the company in this country had any idea of the responsibilities and labours of their manager in Montevideo. Their business was one which demanded unremitting patience and labour on the part of their manager, as every detail of the business called for his personal supervision. He was able to say that Mr. Powers brought to bear upon his position tact, ability, discretion and judgment, and this was reflected in the satisfactory business which resulted. He then moved the adoption of the report and accounts.

Mr. CHARLES LOCK seconded the motion, which was carried unanimously.

Resolutions approving the declaration of the preference and ordinary dividends and re-electing Mr. Le Marchant as a director and Messrs. Van de Linde & Son as auditors were approved.

The CHAIRMAN then proposed a vote of thanks to the manager and staff in Montevideo, and this was seconded by Mr. WILLIAMS (a shareholder, and carried unanimously.

On the motion of Mr. KINGSBURY, a hearty vote of thanks to the chairman and directors was carried unanimously and the proceedings terminated.

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**BUENOS AYRES GRAND NATIONAL TRAMWAYS CO. (LTD.)**—The directors' report for the year ended March 31 states that the gross receipts of the Grand National lines in Buenos Ayres amounted to £176,896. 19s., compared with £172,653. 16s. 2d. for the previous year. Working expenses were £130,997. 8s. 2d., compared with £128,140. 7s. 2d. The Grand National Co.'s share of the profits under the agreement was £40,385. 19s. 5d., compared with £40,117. 9s. 6d. After payment of London administration expenses and interest, there remains £10,652. 9s. 4d., from which £3,739. 2s. 9d. has been transferred to debenture reserve and £3,726. 3s. to income bondholders' interest account, leaving £3,187. 3s. 7d. to be carried to a contingency fund. It is proposed to pay 5 per cent. interest for the year on the income bonds, absorbing £3,726. 3s., and to pay 2 per cent. on these bonds out of £1,563. 7s. 4d. transferred from suspense account, absorbing £1,490. 9s. 2d., leaving £103. 15s. 11d. to be carried forward. 20,026,548 passengers were carried, against 19,360,747. Satisfactory progress has been made with the work of converting for electric operation the joint system consisting of the lines of the company and those of the Buenos Ayres New Tramways Co. Certain sections have been opened to public service by electricity, making the total length so operated at Sept. 24 30 miles.

**CAPE ELECTRIC TRAMWAYS (LTD.)**—At an extraordinary general meeting on Wednesday, the directors were authorised to raise £200,000 by the issue of new debentures. Sir C. Euan-Smith, who presided, said the Cape electric tramways had been running in Cape Town since 1896, and the nine years' heavy and continuous traffic on the badly-constructed roadways of Cape Town had rendered the renewal of the rails and the relaying of the track absolutely necessary, notwithstanding the sums yearly expended on the ordinary maintenance and upkeep of the lines and of the rolling stock. Other extensions and improvements had also been found requisite to bring the whole system into a thoroughly efficient condition.

**EASTERN EXTENSION AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.)**—The report of the directors for the half-year ended June 30 last states that the gross receipts amounted to £348,849. 19s. 6d., against £300,057. 18s. 7d. for the corresponding half-year of 1904. Working expenses, including £21,457. 2s. 8d. for maintenance of cables, absorb £135,950. 3s. 6d. against £141,707. 4s. 9d., leaving £212,899. 16s. From this is deducted £3,383. 16s. 8d. for income tax, and £14,615. 14s. 2d. for interest, &c., on debenture stock, leaving £194,900. 5s. 2d. as net profit for the half-year. Adding £22,181. 0s. 8d. brought forward, there is an available balance of £217,081. 5s. 10d. Two quarterly interim dividends of 1¼ per cent. each, amounting to £75,000, have been paid for the half-year, leaving £142,881. 5s. 10d., of which £100,000 has been transferred to general reserve, and the balance (£42,081. 5s. 10d.) is carried forward. The tariff for telegrams transmitted between Japan and Europe by this company's route was reduced on July 1 last from 5s. 8d. to 4s. 10d. per word, making the rate the same as by the Great Northern Company's route via Russia.

**METALLIC SEAMLESS TUBE CO. (LTD.)**—At the meeting on Friday, the chairman (Mr. W. Neale) congratulated the shareholders on the improvement in the company's position and the satisfactory prospects. The business was increasing largely and they had to introduce fresh capital. The directors' report with the dividend recommended was adopted.

**RICHARDSONS, WESTGARTH & CO. (LTD.)**—The report of the directors for the year ended Aug. 25 states that the profits, after maintaining buildings and machinery in thorough repair at a cost of £18,384, amount to £75,372, added to £16,635 brought forward, making £92,007. A dividend of 6 per cent. is declared on the ordinary shares for the year, and £6,757 is carried forward.

**ROSARIO ELECTRIC CO. (LTD.)**—The report for the year ended June 30 states that the balance profit is £11,293, added to £913 from 1904, making £12,206. A dividend of 3s. per share is declared on the ordinary shares and £2,667 is carried forward. The number of 8 c.p. lamps connected, including theatres (about 11,300 lamps) at June 30 was 67,994. In view of the continued demand, the directors have ordered a fifth steam dynamo (of 500 kw.) and boilers and accessories. The old station plant is still partially in use for street lighting. It will be necessary to increase the capital very shortly to meet the general expansion of the company's business.

**UNDERGROUND ELECTRIC RAILWAYS CO. OF LONDON (LTD.)**—The directors' report states that the works which are being carried out by the company on (1) the Metropolitan District, (2) the Baker Street & Waterloo, (3) the Great Northern, Piccadilly & Brompton, and (4) the Charing Cross, Euston & Hampstead Railways, and the power house, have made satisfactory progress. Electricity has been supplied from the power house at Chelsea to Earl's Court, and thence through the District Co.'s own cables, for the past six months, for the operation of that company's electric railway system. Five turbo-generators have been installed at the power house. The sub-stations for the operation of the District Railway are all completed and operating. The sub-stations for the Baker Street & Waterloo Railway are nearing completion and the machinery is being installed. The sub-stations for the Great Northern, Piccadilly & Brompton and the Charing Cross, Euston & Hampstead Railways are in course of erection, and the machinery is being manufactured. All the work of construction on the District line has been finished, and all the lines have been opened for public traffic with electric trains. A few steam trains still continue to run during the rush hours, but they will be replaced by electrical trains before Nov. 1. A serious delay occurred in the delivery of the rolling stock which was contracted to be delivered during November and December of last year. The balance of cars will, however, be delivered this month. All electrical equipments for the cars have been received. The new car shops at Mill Hill Park, which have been equipped with the most modern and up-to-date appliances, are in full service, and it is expected that a very large saving in expenditure will result. The replacing of the old wooden station platforms with concrete platforms is a substantial improvement. All stations are now lighted electrically. On the Baker Street & Waterloo lifts are being installed, the permanent way is completed, and the conductor rails are being bonded. The car and repair shops at St. George's-circus are finished and completely equipped. The electrical apparatus for all the trains has been delivered and is ready to be installed on the cars. A delay has occurred in the delivery of the rolling stock, which has to some extent retarded the opening of the line; but it is hoped that the line will be opened for traffic during March next. The tunnelling for the Great Northern, Piccadilly & Brompton Railway has been completed between Finsbury Park and West Kensington, where the line comes to the surface, with the exception of the station tunnel at Holborn. The lift and stair shafts have been sunk at all but two of the stations, the permanent way is being laid in the greater part of the tunnels, the rolling stock has been ordered and no delay in delivery is anticipated. It is hoped that this line will be opened for public traffic before the end of 1906. The tunnelling is nearly completed on the Charing Cross, Euston and Hampstead Railway. The lifts and stair shafts have been sunk at nearly all the stations. An inter-change station has been arranged with the L. & N.W. and the City & South London Companies at Euston. The rolling stock has all been ordered and it is hoped this line will be opened for public traffic early in 1907. For the London United Tramways (1901) Ltd., good progress is being made by the company's contractors in the construction of the authorised tramways in Kingston, Surbiton, the Maldens and between Brentford and Hanwell. These lines are expected to be completed during the present year, and will link up important centres of population and connect with the company's main system of electric tramways in Middlesex and the London central area. At the meeting on Tuesday Mr. C. T. Yerkes stated that since the report was drawn up they had been making rapid progress, much more so than previously, and several matters had nearly reached the concluding point. The directors were pleased that their estimates would not be exceeded, a circumstance not often met with in connection with the construction of important railways. All the machinery was working well, and the receipts of the District Co. were increasing. Wherever electricity was in full operation splendid results were being shown, and he felt sure that their most sanguine expectations would be fully realised.

**WESTERN TELEGRAPH CO. (LTD.)**—The report of the directors for the half-year ended June 30, announces that the revenue for this period amounted to £283,360. 2s. 9d., and the working expenses to £116,665. 6s. 4d. After providing £14,146. 3s. 3d. for debenture stock and debenture interest and sinking fund, and £5,136. 18s. 1d. for income tax, there remains £147,411. 15s. 1d. To this is added £3,891. 16s. 6d. brought forward, making £151,303. 11s. 7d. A quarterly interim dividend (amounting to £31,189. 10s.) has been paid, £60,000 transferred to the general reserve and £5,000 to maintenance ships' reserve. The directors now recommend a final dividend of 3s. per share, making 6 per cent. for the year, and also the payment of a bonus of 2s. per share (both tax free) which together will amount to £51,982. 10s., leaving £3,131. 11s. 7d. to be carried forward. The dividend and bonus will be payable Nov. 2. It is with much regret that the directors announce the retirement of their esteemed colleague, Mr. W. S. Andrews, through ill-health. The Right Hon. Lord Balfour of Burleigh, K.T., has been elected a director to fill the vacancy thus occasioned on the board.

**WESTMINSTER ELECTRIC SUPPLY CORPN. (LTD.)**—An extraordinary general meeting will be held on Tuesday to discuss resolutions for the increase of the capital of the company from £800,000 to £2,000,000 by the creation of 240,000 new shares of £5 each, of which 90,000 share shall be issued as ordinary and 150,000 as 4½ per cent. cumulative preference shares, ranking with the 50,000 preference shares already authorised. Any preference shares previously authorised and remaining unissued to be issued upon the terms of a 4½ per cent. instead of a 5 per cent. basis. A resolution will also be submitted authorising the directors, out of the balance of the reserve fund for the time being and the balance of revenue carried to the general balance-sheet of Dec. 31 last, to divide between the holders of preference shares issued prior to this meeting (ratably in proportion to the amount paid on the preference shares so held) the sum of £15,640, tax free. If the preference shareholders consent to the reduction of the dividend thereon, 3,128 preference shares are to be offered to the existing preference shareholders for subscription ratably in proportion to the number of such shares now held by them, the amount to be paid up in full on allotment, such shares to carry 4½ per cent. cumulative preference dividend instead of 5 per cent. If these resolutions are approved the confirmatory meeting is to be held on Nov. 15.

A circular has been issued to the shareholders setting out that in view of the continued increase of the company's business the directors consider it desirable that arrangements should be made for providing the further capital needed from time to time in the company's business. It is pointed out that the directors have power to issue debentures or debenture stock, but that they do not consider it would be in the interests of the shareholders to exercise these powers. They, therefore, recommend the increase in the capital of the company in the terms of the special resolution to be submitted to the meeting as above-mentioned. If the resolutions above set out are carried and confirmed, the directors propose to at once issue £250,000 preference share capital (50,000 shares of £5 each), to be allotted to existing shareholders (ordinary and preferred) pro rata to their present holdings, at 7s. 6d. premium per share. This premium will be placed to reserve and will be applied to the cost of conversion of existing preference shares from 5 per cent. to 4½ per cent. and other expenses. The balance of the proposed increased capital is to be retained and issued as occasion requires.

## NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

### NEW COMPANIES.

**DIAMOND ELECTRIC LAMP (LTD.)** (86,201.)—Reg. Oct. 20, capital £20,000 in 12,000 15 per cent. cumulative preference shares of £1 each and 32,000 deferred shares of 5s. each, to adopt an agreement with H. Diamant and A. Chiesa, and to carry on the business of manufacturers of and dealers in arc lamps, electricians, mechanical and electrical engineers, manufacturers and suppliers of electricity, &c.

**ELECTRICAL INSTRUMENT MANUFACTURERS (LTD.)** (86,187.)—Reg. Oct. 19, capital £5,000 in £1 shares (100 founders'), to carry on business of electrical engineers, contractors, tool and instrument makers, cable manufacturers and layers, electricians, &c.

**INTERNATIONAL ELECTRIC RAILWAYS & WATER POWER SYND. (LTD.)** (86,215.)—Reg. Oct. 21, capital £120,000 in £20 shares, to acquire concessions, rights, powers or privileges relating to construction of and to construct, maintain, work and use railways or tramways adapted to electric or other traction, in any part of the world, to acquire rights of water power, and to turn the same to account for (inter alia) the generation of electric power, and to carry on any business incidental or auxiliary to any of the above objects.

**JUNIOR INSTITUTION OF ENGINEERS (INCORPORATED).**—Reg. Oct. 10, with an unlimited number of members each liable for £1 in event of winding up, to take over the unincorporated association (established in 1884) known since 1903 as the Junior Institution of Engineers. The word "limited" is omitted from the title by licence of the Board of Trade. The management is vested in a council. Reg. office, 39, Victoria-street, Westminster, London, S.W.

**LIGHT RAILWAYS CO. OF SICILY (LTD.)** (86,207.)—Reg. Oct. 20, capital £12,000 in £1 shares, to acquire any railways or tramways, electric lighting works, plant and machinery in Sicily or other part of Italy or elsewhere, and to carry on the business of railway and tramway proprietors, carriers of passengers and goods, electrical, mechanical and hydraulic engineers, electricians, manufacturers of and dealers in railway, tramway, electric and other apparatus, suppliers of light, power, &c.

**LONDON OUTER CIRCLE RAILWAY SYND. (LTD.)** (86,165.)—Reg. Oct. 17, capital £20,125 in 20,000 A shares of £1 each, and 2,500 B shares of 1s. each, to promote a company for the construction and working in the counties of London, Middlesex, Hertfordshire and Essex, or elsewhere, of a railway or railways for the carrying of passengers, minerals and goods, by electric traction or otherwise, and to apply for a special act of Parliament relating thereto. First directors H. K. Rutherford, the Hon. A. C. Ponsonby, R. H. Cox, W. B. Cownie and C. Rozenraad. Reg. office, 266 and 267, Salisbury House, London Wall, E.C.

**A. W. PENROSE & CO. (LTD.)** (86,209.)—Reg. Oct. 21, capital £40,000 in £1 shares (10,000 6 per cent. cumulative preference) to acquire business carried on by A. W. Penrose & Co., and to carry on the business of manufacturers of and dealers in all machinery, apparatus, material and appliances used in connection with photography, etching, engraving, drawing, painting, printing or other graphic arts, electrical and general engineers, makers of arc and incandescent lights, manufacturers of electric cranes and hoists, makers of printing machine motors and gears and electrotyping and electroplating plant, &c. First directors are A. W. Penrose (governing director), W. Gamble, and D. Munro (nominated by the Law Guarantee and Trust Society). Reg. office 109, Farringdon-road, London, E.C

### STATUTORY RETURNS.

**MATHER & PLATT (LTD.)**—Return to Sep. 2 gives capital as £1,000,000, in 50,000 preference and 50,000 ordinary shares of £10 each, of which 40,000 preference and 40,000 ordinary have been taken up. £10 per share has been called up on 29,200 preference and 2,500 ordinary, and £317,000 has been received. £483,000 is considered as paid on 10,800 preference and 37,500 ordinary. Mortgages and charges, nil.

**NEW PHONOPORE TELEPHONE CO. (LTD.)**—A list of allotments made up to Oct. 9 shows a further 100 ordinary shares taken up (10s. called up on each) in addition to 5,111 ordinary and 1,000 founders' shares shown by return of Oct. 7, 1904, to have been issued (10s. per share being called up and paid on ordinary, and £1 per share considered as paid on founders') out of a nominal capital of £10,000, in 9,000 ordinary and 1,000 founders' shares of £1 each. Mortgages and charges, nil.

### MORTGAGES AND CHARGES.

**CRYSELCO LIMITED.**—Issue on Oct. 9 of £500 first debentures, part of series created June 26, 1905, to secure £10,000, charged on company's undertaking and property, present and future, including uncalled capital and land and buildings known as Kempston Works, Kempston, Beds. Trustees, A. Baker and H. S. Deacon. Previously issued of same series, £8,200.

**ELECTRIC SAFETY APPLIANCES CO. (LTD.)**—A mortgage debenture dated Oct. 14, 1905, to secure £100, charged on company's undertaking and property, present and future, has been registered. Holder, R. J. Bott.

**ELECTRIC CONVERSION SYND. (LTD.)**—An equitable charge dated Oct. 13, 1905, to secure £16,500 has been registered. Property charged: Uncalled capital to extent of 7s. 6d. per share on 32,350 £1 preference shares in syndicate, £47,500 first mortgage debenture stock of South Lancashire Electric Traction & Power Co., 20,638 £1 fully-paid preference shares in Sunderland District Electric Tramways, 18,441 £1 ordinary shares in Durham Collieries Electric Power Co., 1,585 £5 preference shares in North Wales Power & Traction Co., and 14,500 £1 shares in Canadian Electric Traction Co. (Ltd.) Holders, Messrs. Herbert Wagg & Russell.

**ELECTROMOBILE CO. (LTD.)**—A memorandum of satisfaction to extent of £10,000 of a mortgage dated Aug. 10, 1904, securing £3,500 and further advances of an indefinite amount (now stamped to cover up to £20,000) has been filed.

**IMPROVED ELECTRIC SUPPLIES (LTD.)**—£2,500 second mortgage debentures, created Oct. 4 and dated Oct. 13, 1905, charged on company's undertaking and property, present and future, including uncalled capital, have been registered. No trustees. Holder, W. Chamberlain.

**NEWCASTLE & DISTRICT ELECTRIC LIGHTING CO. (LTD.)**—A memorandum of satisfaction in full of mortgage debentures dated Sept. 9, 1903, securing £11,085, has been filed.

## CITY NOTES.

**MEMORANDA** (Oct. 26).—Bank rate 4 per cent. (since Sept. 28, 1905). Price of silver 28¾d. per oz. Consols $88\frac{5}{16}$—$88\frac{7}{16}$ for money, $88\frac{3}{8}$—$88\frac{1}{2}$ for account; 2½ per cent. annuities $87\frac{5}{8}$—$87\frac{7}{8}$. Consols Pay Day, Nov. 2; Stocks and Shares Continuation Day, Nov. 13; Ticket Days, Nov. 14 and 29; Pay Days, Oct. 27 and Nov. 15; Mining Share Carry-over Day, Nov. 10.

**AMALGAMATED DRY BATTERIES (LTD.)**—Mr. B. Sherman has resigned his directorship of this company, and Mr. F. Heron Rogers has been elected to the vacancy.

**ANGLO-PORTUGUESE TELEPHONE CO. (LTD.)**—In a circular to the share and debenture stockholders it is stated that the managing director (Mr. F. W. Kerr) has just returned from Portugal, and reports that the condition of the company's affairs generally is very satisfactory. Since the installation of the common-battery system in Lisbon a great improvement in the service has taken place, and Mr. Kerr received assurances from all sides that the service now leaves nothing to be desired. The number of subscribers continues to increase. Three new exchanges (Coxias, Queluz and Cintra) have recently been established; the work of installing exchanges in Almada and Barreiro, on the other side of the river, has been commenced, the necessary permissions for laying the cable under the River Tagus to connect these places with the central office having been obtained. In Oporto the reconstruction of the system has been followed by a steady increase in the number of subscribers. The issue of £50,000 5 per cent. debenture stock (sold to the Consolidated Electrical Co. in April last for £45,500) was (the circular states) all subsequently paid for on the due dates, and the proceeds have been applied in the redemption of all outstanding debentures of earlier date. The debt due to the contractors has also been discharged.

**BUENOS AYRES GRAND NATIONAL TRAMWAYS CO.**—The gross receipts for the three months ended June 30 were $623,600, a decrease of $34,400 compared with corresponding period of 1904. The gross receipts for the three months ended Sept. 30 were $653,500, an increase of $31,600.

**DEVONPORT AND DISTRICT TRAMWAYS CO.**—For the half-year ended June 30 the total revenue was £12,005. 13s. 3d. After deducting expenses (including interest) the profit is £1,044. 10s. 9d. Adding £80. 14s. 5d. from previous account, the available balance is £1,125. 5s. 2d., which the directors propose to carry forward. The total capital expenditure to June 30 amounted to £160,321. 8s. 5d,

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. | | |
|---|---|---|---|---|---|---|
| | | | | No. of weeks. | Amount. | Inc. or Dec. (a) |
| | | £ | £ | | £ | £ |
| Aberdeen Corporation | Oct. 21 | 1,180 | - 51 | 21 | 31,705 | - 1,646 |
| Airdrie | " 13 | 219 | + 16 | 41 | 8,428 | + 133 |
| Anglo-Argentine | " 21 | 13,878 | + 580 | 42 | 558,021 | + 35,639 |
| Ayr Corporation | " 21 | 195 | - 19 | 22 | 8,925 | - 117 |
| Barcelona Trams Co. | ... | ... | ... | ... | ... | ... |
| Barcelona, Ensanche, Gracia | ... | ... | ... | ... | ... | ... |
| Barnsley | " 13 | 164 | - 19 | 41 | 6,644 | - 295 |
| *Barrow | " 13 | 207 | + 34 | 41 | 10,117 | + 2,114 |
| Bath Electric Trams, Ltd. | " 18 | 661 | + 26 | 42 | 29,080 | + 1,762 |
| Birkenhead | " 22 | 957 | + 45 | 3 | 2,930 | - 120 |
| Birmingham Corporation | " 21 | 882 | + 66 | 29 | 10,465 | + 1,216 |
| *Birmingham & Mid. | " 13 | 1,392 | - 145 | 41 | 66,248 | + 749 |
| Blackpool Corporation | " 19 | 463 | - 119 | 29 | 42,215 | + 1,934 |
| Blackpool and Fleetwood | " 21 | 257 | - 21 | 16 | 18,871 | - 830 |
| Bolton Corporation | " 22 | 1,875 | + 460 | 30 | 58,602 | + 2,035 |
| Bournemouth Corporation | " 18 | 1,224 | - 28 | †28 | 42,413 | + 6,959 |
| Bradford Corporation | " 21 | 4,080 | - 334 | 29 | 181,740 | - 7,006 |
| Brighton Corporation | " 22 | 818 | - 87 | 30 | 32,917 | + 626 |
| Bristol Trams & Carriage | " 20 | 4,562 | - 275 | 11 | 56,169 | + 1,186 |
| Buenos Ayres & Belgrano | " 22 | 8,579 | + 271 | 42 | 145,867 | + 7,444 |
| Buenos Ayres Elec. Trams | Sept. 23 | 1,294 | ... | 38 | 43,668 | ... |
| Burnley Corporation | Oct. 21 | 1,032 | + 16 | 29 | 42,966 | + 1,957 |
| Burton Corporation | " 22 | 269 | - 65 | §29 | 9,578 | - 1,233 |
| Bury Corporation | " 15 | 696 | ... | §28 | 21,249 | ... |
| Calcutta Tramways Co. | " 21 | R39,916 | - R1,141 | 16 | R684,074 | + R84,635 |
| Camborne-Redruth | " 21 | 102 | - 9 | 25 | 2,945 | ... |
| Cardiff Corporation | " 21 | 1,776 | - 188 | 29 | 62,098 | + 132 |
| Carlisle Tramways Co. | " 21 | 156 | - 22 | 42 | 7,863 | - 631 |
| Central London Railway | " 21 | 7,116 | + 407 | 16 | 95,748 | - 1,502 |
| Chatham & Dist. Lt. Rys. | " 19 | 586 | ... | 42 | 28,145 | + 3,887 |
| *City of Birm'gh'm Tram Co. | " 13 | 5,125 | - 410 | 41 | 221,824 | + 2,026 |
| City & South London Rly. | " 22 | 2,909 | + 103 | 16 | 88,613 | - 428 |
| Colchester Corporation | " 19 | 154 | - 72 | 12 | 3,852 | - 1,123 |
| Cork Electric Trams Co. | " 19 | 451 | - 26 | 42 | 20,748 | + 765 |
| Devonport & Dist. Trams | " 13 | 458 | - 76 | 41 | 19,203 | - 2,879 |
| Dover Corporation | " 21 | 204 | + 7 | 29 | 7,130 | - 135 |
| Dublin & Lucan Railway | " 20 | 92 | - 17 | 16 | 2,260 | + 6 |
| Dublin Southern District | " 20 | 797 | - 100 | 16 | 65,152 | - 846 |
| Dublin United | " 20 | 3,553 | - 269 | | | |
| Dudley—Stourbridge | " 13 | 834 | + 15 | 41 | 37,456 | + 1,382 |
| Dundee Corporation | " 18 | 894 | + 75 | §22 | 20,509 | + 932 |
| East Ham Council | " 21 | 713 | + 58 | 29 | 24,936 | + 2,556 |
| Gateshead & Dist. Trams | " 13 | 950 | + 49 | 41 | 37,806 | + 699 |
| Glasgow Corporation | " 21 | 14,948 | + 26 | 21 | 317,196 | + 15,799 |
| Glossop | " 21 | 115 | - 18 | 42 | 5,154 | + 456 |
| Gloucester Corporation | " 18 | 238 | - 81 | 29 | 9,287 | ... |
| Gravesend—Northfleet | " 13 | 218 | - 3 | 41 | 9,700 | - 920 |
| Gt. Northern & City Rly. | " 21 | 1,662 | + 304 | 16 | 23,678 | + 5,945 |
| Greenock & Port Glasgow | " 13 | 666 | + 98 | 41 | 26,758 | + 2,918 |
| Halifax Corporation | ... | ... | ... | ... | ... | ... |
| Hartlepool Tramways | " 13 | 286 | - 1 | 41 | 11,111 | - 1,151 |
| Hastings Elec. Trams Co. | " 20 | 402 | ... | 11 | 7,205 | ... |
| Huddersfield | " 21 | 1,253 | + 42 | 29 | 40,855 | + 1,119 |
| Hull Corporation | " 21 | 2,166 | - 1 | 29 | 65,530 | + 574 |
| Ilford Dist. Coun. | " 21 | 392 | + 6 | 30 | 14,689 | + 222 |
| Ipswich Corporation | " 21 | 336 | - 79 | 29 | 13,809 | - 1,696 |
| Isle of Thanet Co. | " 21 | 301 | - 76 | 3 | 12,406 | - 155 |
| Kidderminster & District | " 13 | 102 | - 6 | 41 | 5,163 | - 285 |
| Kilmarnock Corporation | ... | ... | ... | ... | ... | ... |
| Kirkcaldy Corporation | " 18 | 185 | - 22 | 7 | 1,476 | - 57 |
| Lanarkshire Trams Co. | " 12 | 840 | + 72 | 42 | 31,011 | + 3,681 |
| | " 19 | 792 | + 113 | | | |
| Leamington | " 13 | 163 | + 48 | 13 | 2,822 | + 1,150 |
| Leeds Corporation | " 21 | 5,463 | - 17 | 29 | 180,764 | + 8,563 |
| Leicester Corporation | " 21 | 1,976 | + 163 | 42 | 87,857 | + 28,034 |
| Liverpool Corporation | " 14 | 10,649 | + 116 | 41 | 435,579 | + 8,840 |
| Liverpool Overhead Rly. | " 22 | 1,386 | - 109 | 16 | 26,592 | - 972 |
| *London County Council | " 7 | 14,624 | + 1,576 | 28 | 427,318 | + 63,571 |
| | " 14 | 14,484 | + 1,339 | | | |
| Lowestoft | " 21 | 152 | - 18 | 8 | 515 | - 38 |
| Maidstone Corporation | " 19 | 114 | - 27 | 29 | 4,031 | ... |
| Manchester Corporation | " 21 | 12,109 | - 132 | 29 | 381,159 | + 15,422 |
| Mersey Railway | " 21 | 1,576 | + 116 | 16 | 24,931 | + 1,570 |
| Merthyr | " 13 | 186 | - 7 | 41 | 7,857 | - 432 |
| *Metropolitan Elec. Trams | " 13 | 2,769 | + 1,005 | 41 | 110,195 | + 48,677 |
| Middleton | " 13 | 804 | + 7 | 41 | 14,220 | + 611 |
| Musselburgh | " 12 | 241 | ... | 43 | 10,117 | ... |
| Nelson Corporation | " 21 | 120 | + 3 | 80 | 4,024 | + 861 |
| Newcastle-on-Tyne Corp. | " 21 | 8,666 | - 208 | 29 | 112,242 | + 2,984 |
| Newport (Mon.) | " 21 | 509 | + 8 | 8 | 1,628 | + 136 |
| Northampton Corporation | " 20 | 362 | - 28 | 28 | 12,629 | + 4,801 |
| Oldham, Ashton & Hyde | " 13 | 572 | + 30 | 41 | 22,983 | + 427 |
| Oldham Corporation | " 22 | 1,632 | + 1,249 | 30 | 49,900 | + 13,448 |
| Perth (W. A.) Elec. Trams | " 20 | 1,800 | + 44 | 42 | 57,468 | + 3,538 |
| Peterborough | " 13 | 109 | - 14 | 41 | 5,795 | - 567 |
| Pontypridd Dist. Council | " 21 | 139 | ... | 29 | 4,916 | ... |
| Portsmouth Corporation | " 21 | 1,506 | - 163 | 29 | 64,800 | + 1,222 |
| Potteries | " 13 | 1,837 | + 83 | 41 | 69,710 | + 489 |
| Reading Corporation | " 19 | 549 | - 61 | 8 | 1,774 | - 101 |
| Rotherham Corporation | " 19 | 426 | - 10 | 29 | 13,884 | - 748 |
| Rothesay | " 13 | 77 | + 23 | 41 | 9,195 | + 2,632 |
| Salford Corporation | " 23 | 8,991 | - 118 | 30 | 129,766 | + 6,666 |
| Sheerness | " 11 | 62 | + 1 | 41 | 2,983 | + 305 |
| Sheffield Corporation | " 22 | 4,742 | + 53 | 30 | 149,205 | + 6,677 |
| Southampton Corporation | " 18 | 868 | - 45 | †3 | 2,286 | - 893 |
| Southend Corporation | ... | ... | ... | ... | ... | ... |
| Southport Tramways | " 13 | 271 | - 11 | 41 | 13,846 | - 433 |
| S. Staffordshire Trams. | " 13 | 832 | + 70 | 41 | 29,985 | + 816 |
| Stockport Corporation | " 20 | 752 | + 179 | 29 | 22,427 | + 4,644 |
| Sunderland Corporation | " 23 | 1,198 | - 40 | 29 | 40,003 | + 980 |
| Swansea Trams | " 13 | 794 | + 299 | 41 | 29,633 | + 7,043 |
| Swindon Corporation | " 18 | 175 | ... | 29 | 5,989 | ... |
| Taunton Trams | ... | ... | ... | ... | ... | ... |
| Tynemouth and District | " 13 | 209 | - 30 | 41 | 11,159 | - 1,526 |
| Tyneside Trams Co. | " 18 | 253 | - 125 | 42 | 17,567 | + 883 |
| Wallasey District Council | " 21 | 663 | - 15 | 29 | 23,853 | + 641 |
| Walsall | " 21 | 479 | - 2 | 41 | 20,659 | + 211 |
| Warrington Corporation | " 19 | 828 | + 11 | 29 | 9,988 | + 490 |
| West Ham Corporation | " 19 | 1,896 | + 836 | 29 | 52,192 | + 21,816 |
| Weston-super-Mare | " 11 | 68 | + 6 | 41 | 6,526 | + 629 |
| Wolverhampton Corpn. | " 18 | 726 | ... | 3 | 2,328 | ... |
| Wolverhampton District | " 13 | 433 | + 39 | 41 | 16,821 | + 153 |
| *Worcester | " 13 | 285 | - 22 | 41 | 12,817 | + 562 |
| Wrexham | " 13 | 98 | + 4 | 41 | 4,218 | - 374 |
| Yorkshire Woollen District | " 18 | 707 | + 174 | 41 | 26,987 | + 2,628 |

(a) These comparisons are with the corresponding period last year. † Minus 8 days. § Plus 2 days. * Partly electrical.

**EASTERN TELEGRAPH CO. (LTD.)**—Payment will be made by warrants on Nov. 1 of interest for the half-year ending Oct, 31 on the company's 4 per cent. mortgage debenture stock. The transfer books will be closed from Oct. 27 to 31 inclusive.

**EASTERN & SOUTH AFRICAN TELEGRAPH CO. (LTD.)**—Payment will be made by warrants on Nov. 1 of interest on this company's 4 per cent. Mauritius Subsidy debentures. The transfer books will be closed from Oct. 27 to 31 inclusive.

**PARSONS MARINE STEAM TURBINE CO. (LTD.)**—The accounts for year ended June 30 show a profit on manufacturing and from royalties, after providing for depreciation and for experimental work (but including £2,059 brought forward) of £27,572. It is proposed to pay a final dividend of 7½ per cent., making 10 per cent. for the year, and to carry forward £6,772.

**STOCK EXCHANGE NOTICES.**—The Stock Exchange committee have granted quotations to 20,000 £5, fully-paid, 5 per cent. preference shares of the *County of Durham Electrical Power Distribution Co. (Ltd.)*; 500,000 £1, fully-paid, 6 per cent. cumulative preference shares and £500,000 5 per cent. mortgage debentures of the *Lisbon Electric Tramways (Ltd.)* and 170,000 £100, fully-paid, shares of the capital stock (Montreal certificates) of the *Montreal Light, Heat & Power Co.* The Committee have been asked to appoint a special settling day in 6,635 £1 fully-paid ordinary shares and £116,667 5 per cent. first mortgage debenture stock of *Johnson & Phillips (Ltd.)*, and to grant quotations to 20,000 £10 (£9 paid) and 10,000 £10 (£5 paid) shares of the *Newcastle & District Electric Lighting Co. (Ltd.)*, and £100,000 4 per cent. redeemable debenture stock of the *Oriental Telephone & Electric Co. (Ltd.)*.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend. | Name. | Price Wed., Oct. 25. | Rate per Cent. Yielded. | | | Dividend Due. | Business, Week to Oct. 25. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | £ | s. | d. | | Highest. | Lowest. |
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | | | | | | |
| 5 | 8/0 | Anglo-Argentine Ord. Shares | $8\frac{11}{16}$–$8\frac{15}{16}$ | 4 | 9 | 0 | Ap, Oct | $8\frac{13}{16}$ | $8\frac{7}{16}$ |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞–6⅛ | 4 | 9 | 8 | – | $6\frac{3}{32}$ | .. |
| St. | 6% | Do. Permanent 6% Deb. Stock | 141 –144 | 4 | 3 | 3 | – | .. | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 104 –106 | 4 | 14 | 4 | – | .. | .. |
| 10 | 12/0 | Barcelona Tramways Ord. | 13¾–14¼ | 4 | 4 | 0 | – | 105¾ | 105 |
| 10 | 5/0 | Do. 5% Cum. Pref. | 9½–10 | 5 | 0 | 0 | – | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock (red.) | 97 –102 | 4 | 8 | 8 | – | .. | .. |
| 100 | 5% | Do. 5 per Cent. Debs. | 93 –101 | 4 | 19 | 0 | – | .. | .. |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1 –1½ | .. | | | – | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 3¾–4¼ | 5 | 17 | 8 | .. | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 95 –98 | 4 | 12 | 0 | – | .. | .. |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 126 –129 | 4 | 13 | 0 | – | 128¼ | 126½ |
| St. | 5% | Do. Pref. Ord. Stock | 109 –112 | 4 | 9 | 3 | – | 111½ | .. |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock. | 105 –108 | 4 | 12 | 6 | – | 108 | 107¾ |
| 40 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%–105% | 4 | 5 | 9 | – | .. | – |
| 100 | 4½% | Do. Vancouver Power Debs. | 100 –103 | 4 | 8 | 8 | – | 101¾ | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | $8\frac{11}{16}$–$8\frac{15}{16}$ | 5 | 1 | 6 | – | 8⅜ | 3¾ |
| 5 | 8/0 | † Do. 6 per Cent. "A" Cm. Pref | $5\frac{1}{16}$–$5\frac{13}{16}$ | 5 | 2 | 6 | – | $5\frac{11}{16}$ | 5¾ |
| 5 | 8/0 | † Do. "B" | 5 –5½ | 5 | 9 | 1 | – | $5\frac{1}{16}$ | $5\frac{3}{32}$ |
| St. | 5% | Do. 5 per Cent. Debs. | 106 –108 | 4 | 12 | 6 | – | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102 –105 | 4 | 15 | 3 | – | 106¾ | 104½ |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 98 –100 | 5 | 0 | 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 101 –105 | 5 | 4 | 9 | .. | .. | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 102 –106 | 5 | 13 | 8 | .. | 104½ | .. |
| 5 | 8/6 | Calcutta Tramways (Nos. 1 to 105) | 9 –9½ | 4 | 9 | 6 | – | $9\frac{5}{16}$ | 9¼ |
| 5 | 0/3 | Do. Nos. 105,001 to 137,610 | 8½–9 | .. | | | – | 8⅝ | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 107 –109 | 4 | 2 | 7 | .. | .. | .. |
| 1 | 0/6 | Cape Electric Tram Shares | 1 –1¼ | 4 | 0 | 0 | – | $1\frac{3}{16}$ | .. |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 103 –105 | 4 | 15 | 3 | – | .. | .. |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Pds. | 98 –100% | .. | | | .. | 99¾ | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 103 –105 | 4 | 15 | 3 | .. | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101 –104 | 4 | 16 | 2 | Ja, Jul | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102 –104 | 4 | 6 | 7 | – | 102½ | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 104 –107 | 4 | 13 | 5 | – | 104½ | – |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 145 –148 | 5 | 8 | 1 | .. | 147 | .. |
| .. | .. | Do. 5% 1st Mt. $.00 Dbs. | 100 –102 | .. | | | .. | 101 | .. |
| | | **ELECTRICITY SUPPLY.** | | | | | | | |
| 5 | 5/0 | Calcutta Elec. (1-90,000) ex new | 8⅞–9⅜ | 4 | 5 | 9 | | | |
| 5 | 2/1¾ | Do. (60,001-80,000) ex new | 8⅞–9⅜ | 4 | 13 | 0 | – | 9⅛ | .. |
| 10 | 5% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50 –52 | 4 | 16 | 1 | .. | .. | .. |
| .. | .. | Cordoba Lt. and Power Co. 1st Mt. Stk. £100 000 5% Bds. | 96 –98 | ... | | | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½–3 | .. | | | .. | .. | .. |
| St. | 5% | Do. 5% Debs. | 86 –90 | 5 | 11 | 1 | .. | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | 9½–10½ | – | | | – | .. | – |
| 100 | 15/6 | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 94 –96 | 5 | 4 | 2 | – | .. | .. |
| 1 | 5·38d | † Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | 3½–[illegible] | 5 | 16 | 6 | .. | .. | .. |
| 1 | 1/0 | Rand Electric | 1¼–1⅜ | .. | | | – | .. | – |
| 1 | .. | River Plate Electricity Co. Ord. | ⅝–¾ | .. | | | – | .. | – |
| 1 | .. | Do. 6% Non. Cum. Pref | 1 –1⅛ | .. | | | .. | $\frac{23}{32}$ | .. |
| St. | .. | Do. 5% Deb. Stock | 102 –104 | .. | | | .. | .. | .. |
| 5 | 8/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5⅞–6⅛ | 5 | 6 | 8 | .. | .. | .. |
| 5 | 9·73d | Do. (12,001-20,000) | 5 –5½ | 3 | 8 | 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100 –103 | 4 | 7 | 5 | Ap, Oct | .. | ... |
| .. | 10/9 | Shawinigan Water and Power 5% Bds., Scrip | 99 –101 | 4 | 19 | 0 | .. | 99⅞ | 99⅝ |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

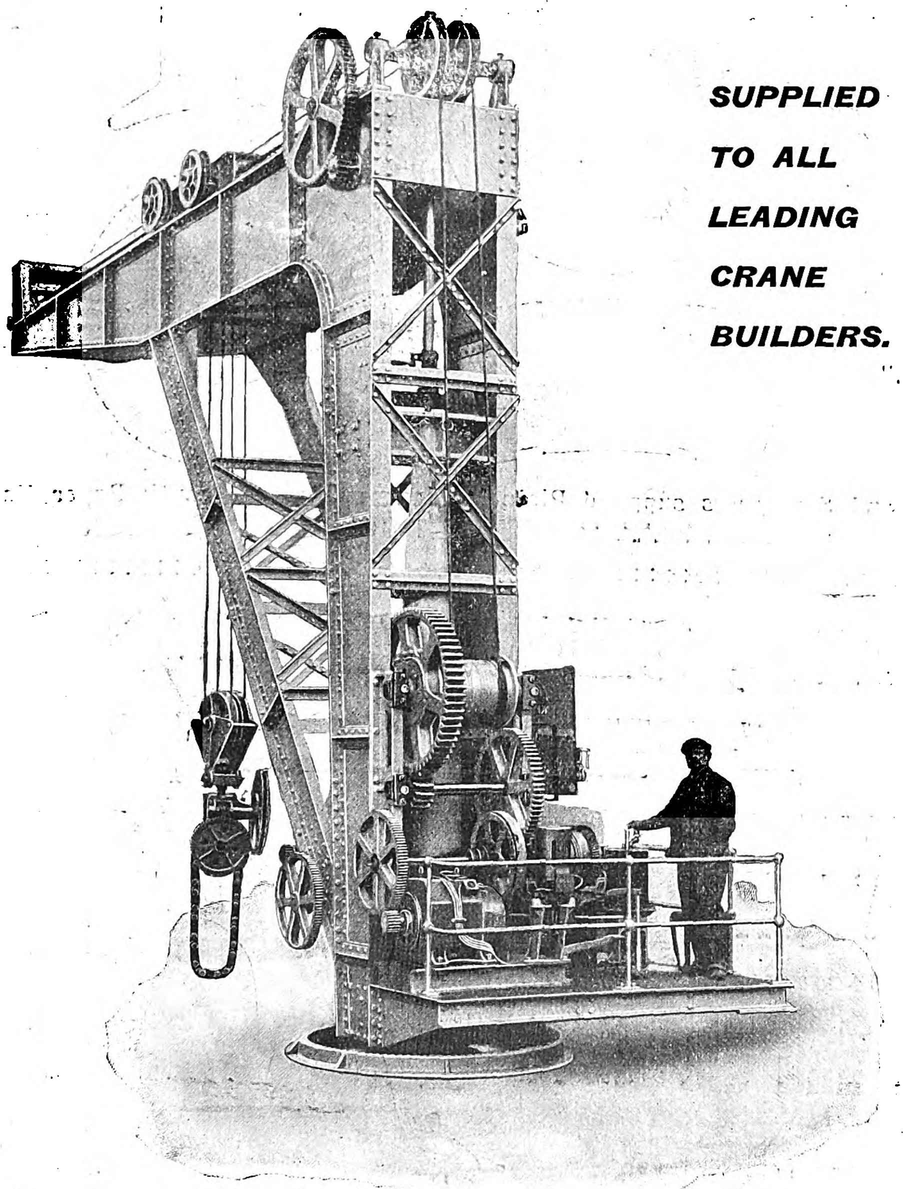
| Share. | Last Dividend | Name. | Price Wed., Oct. 25. | Rate per Cent. Yielded. | | | Dividend Due | Business, Week to Oct. 25. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | £ | s. | d. | | Highest. | Lowest. |
| | | **ELECTRIC RAILWAYS,TRAMWAYS,&c.** | | | | | | | |
| 1 | .. | Bath Elec. Trams Pref. Ord. | ⅞—1 | .. | | | .. | 15/16 | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1⅛—1 1/16 | 4 | 14 | 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) .. | 102—104 | 4 | 6 | 7 | .. | 103¼ | 102½ |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 103—105 | 4 | 5 | 9 | .. | 103¼ | .. |
| 10 | 9% | Bristol Tramways and Carriage Ord. ... | 17—17½ | 5 | 2 | 11 | Feb, Aug | .. | — |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10—10½ | 3 | 18 | 0 | .. | .. | — |
| St. | 4% | Do. 4 per Cent. Debs. | 105—107 | 3 | 14 | 10 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 9⅝—10⅛ | 5 | 18 | 6 | — | 9 15/16 | 9½ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 11—11½ | 5 | 4 | 4 | Feb, Aug | 11 5/16 | 11 |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 121—123 | 4 | 1 | 4 | .. | 122½ | 121 |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 99—101 | 4 | 9 | 1 | .. | 100¾ | 100¼ |
| St. | 4% | Central London Ordinary Stock | 91—93 | 4 | 6 | 0 | June, Dec | 91 | .. |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 101—103 | 3 | 17 | 8 | .. | .. | .. |
| St. | 4% | Do. Deferred Stock | 83—86 | 4 | 13 | 1 | .. | 85½ | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 110—112 | 3 | 11 | 5 | .. | 111½ | .. |
| 5 | 2/6 | †City of Birmingham Trams.5% Cm.Prf. | 4⅞—5⅛ | 4 | 17 | 6 | .. | .. | .. |
| 100 | 4% | † Do. 4 per Cent. 1st Mort. Debs. | 100—103 | 3 | 17 | 8 | .. | 101⅛ | .. |
| St. | 2% | City and South London Rly. Con. Ord. | 42—44 | 5 | 2 | 4 | Feb, Aug | 42½ | 42⅜ |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) ... | 118—121 | 4 | 2 | 8 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 117—120 | 4 | 3 | 4 | .. | .. | .. |
| St. | 5% | Do. (1901) | 113—116 | 4 | 6 | 3 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Perp(etual Debs | 107—110 | 3 | 12 | 9 | May, Nov | .. | .. |
| 10 | 6/0 | Dublin United Trams. 1896) Ltd., Ord. | 13½—14½ | 4 | 2 | 8 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 15—16 | 3 | 5 | 0 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5—5½ | 7 | 5 | 5 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8—9 | 4 | 8 | 11 | .. | .. | — |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 100—102 | 4 | 8 | 3 | .. | 101¼ | 101⅛ |
| 10 | 9% | ‡ Imperial Tramways Ord | 17—18 | 5 | 0 | 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 13¾—14¼ | 4 | 4 | 2 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 108—110 | 4 | 1 | 10 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼—2¾ | 9 | 8 | 6 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 83—88 | 4 | 10 | 11 | — | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8⅛—8⅜ | 3 | 13 | 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾—10¼ | 4 | 15 | 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99—102 | 3 | 19 | 3 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9¾—10¼ | 4 | 17 | 6 | — | 10⅛ | 10 |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 100—103 | 3 | 17 | 8 | — | 102 | .. |
| St. | .. | Mersey Con. Ord. Stock | 4—7 | — | | | — | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8—11 | — | | | — | .. | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32—9/32 | .. | | | — | 7/32 | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1—1 1/16 | 4 | 14 | 1 | — | 1 1/32 | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106—107 | 4 | 4 | 1 | — | 106½ | .. |
| 5 | .. | New Gen. Tract. 6 per Cent.Cum Pref. | ½—1½ | .. | | | May | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾—9¼ | 5 | 5 | 8 | .. | .. | — |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9¼—9¾ | 5 | 2 | 6 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 102—105 | 4 | 5 | 9 | — | 103½ | 103¼ |
| 1 | — | South Lancs. Elec. Trac. & Power Ord. | .. | .. | | | — | .. | .. |
| 1 | — | Do. 6% Pref. (£1 paid) | — | — | | | April, Oct | .. | — |
| St. | — | Do. 4½% Deb. Stock (100% paid) | .. | .. | | | Jan, July | — | — |
| 100 | .. | Sunderland Dist. Elec. Trams. 5% 1st Mort. Debs. | 95—99 | .. | | | .. | 97½ | .. |
| .. | 5% | Underground Elec. Rys. Co. of London | 99½—100½ | 4 | 19 | 6 | .. | 99⅞ | .. |
| St. | 3% | Waterloo and City Ord. | 88—90 | 3 | 6 | 8 | June, Dec | .. | .. |
| St. | 12/11 | Yorkshire W. R. Elec. Trams Co. 4% 1st Debs. | 92—95 | 4 | 14 | 6 | .. | .. | .. |
| | | **TELEGRAPHS.** | | | | | | | |
| 100 | 4% | * African Direct Tel. 4% Mrt. Deb. (red.) | 99—102 | 3 | 18 | 5 | Jan, July | .. | .. |
| 10 | — | Amazon Telegraph | 3—3½ | .. | | | Jn, Dec .. | 3 7/16 | 3⅜ |
| 100 | .. | Do. 5% Debs. (red.) | 82—87 | 5 | 14 | 11 | .. | — | .. |
| St. | 15/0 | †Anglo-American | 60—62 | 4 | 16 | 9 | F,My,Ag,N | .. | .. |
| St. | 30/0 | † Do. Preferred | 108—109 | 5 | 8 | 0 | F,My,Ag,N | 108¾ | 107½ |
| St. | 2/0 | Do. Deferred | 16¼—16½ | .. | | | F,My Ag,N | 16 9/16 | 16¾ |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 97—99 | 4 | 0 | 10 | Jn Ap,Jy,O | 98 | 97¾ |
| 10 | 5/0 | Cuba Submarine Ord. | 9—9½ | 5 | 5 | 8 | Feb, Aug | .. | .. |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17½—18½ | 5 | 8 | 1 | Feb, Aug | 17½ | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅝—3⅞ | 5 | 11 | 9 | April, Oct | .. | — |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 9¼—9¾ | 5 | 2 | 6 | April, Oct | .. | — |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 100%—103% | 4 | 7 | 5 | Jan, July | .. | .. |
| 20 | 8/0 | †Direct United States Cable. | 12¾—13¼ | 4 | 18 | 1 | Ja,Ap,Jy,O | 13¼ | 12⅞ |
| 100 | 4½% | Direct West India Cable 4½% Rg.Db.(rd.) | 100—102 | 4 | 8 | 8 | Jn, Dec .. | .. | .. |
| St. | 25/0 | †Eastern Ordinary | 143—146 | 4 | 15 | 10 | Ja,Ap,Jy,O | 144¾ | 143½ |
| St. | 17/6 | † Do. 3½ per Cent. Pref. Stock | 89—91 | 3 | 16 | 11 | Ja Ap,Jy,O | 90 | 89¼ |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 108—110 | 3 | 12 | 9 | May, Nov | 109¼ | .. |
| 10 | 2/6 | †Eastern Extension | 14¼—14¾ | 4 | 15 | 0 | Ja,Ap,Jy,O | 14⅝ | 14⅛ |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 106—108 | 3 | 14 | 1 | Feb, Aug | 106½ | .. |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 99½—101½ | 3 | 18 | 9 | Feb, Aug | 101¼ | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101½%—103½% | 3 | 17 | 4 | May, Nov | 101½ | .. |
| 10 | 5/0 | G. N. (of Copenhagen) | 35½—36½ | 6 | 16 | 11 | Jan, July | .. | .. |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 100—102 | 4 | 8 | 3 | June, Dec | .. | .. |
| 25 | 52/6 | Indo-European | 55—57 | 5 | 14 | 0 | May, Nov | 56¼ | .. |
| 100 | $1 | Mackay Companies Common | 47 3/16 | 4 | 5 | 1 | Jan, July | .. | .. |
| 100 | 4% | Do. Preference | 75 1/16 | 5 | 5 | 7 | Ja.Ap,Jy,O | .. | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1⅜—1½ | .. | | | .. | .. | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 100—103 | 3 | 17 | 8 | June, Dec | .. | .. |
| 10 | 5/0 | West African Telegraph Shares | 10—10½ | 4 | 15 | 3 | .. | .. | .. |
| 2½ | — | West Coast of America | ⅞—1⅛ | .. | | | — | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100—102 | 3 | 18 | 5 | Jan, July | .. | .. |
| 10 | — | West India and Panama | 1⅛—1⅜ | .. | | | May, Nov | .. | .. |
| 10 | 5/0 | Do. 6% 1st Pref. | 8½—9 | 6 | 13 | 4 | May, Nov | .. | .. |
| 10 | — | Do. 6 per Cent. 2nd Pref. | 7½—8 | .. | | | May, Nov | 7¾ | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 101—104 | 4 | 16 | 2 | Jan, July | .. | .. |
| 10 | 8/0 | Western Telegraph | 14¼—14¾ | 4 | 15 | 0 | Mr,Jn,O,D | 14 7/16 | 14 1/16 |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 101—103 | 4 | 17 | 1 | June, Dec | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 103½—104½ | 3 | 16 | 5 | .. | .. | .. |
| | | **TELEPHONES.** | | | | | | | |
| 5 | 5/0 | Chili Telephone (fully paid) | 7½—7¾ | 5 | 3 | 8 | August .. | .. | .. |
| 1 | 0/7½ | Monte Video Telephone Ord. | ¾—⅞ | 3 | 8 | 7 | — | ⅞ | .. |
| 1 | 1/0 | Do. 5% Pref. | ⅞—1 | 5 | 0 | 0 | .. | 1 | 31/32 |
| St. | 6% | National Co. Pref. Stock | 112—113 | 5 | 6 | 2 | — | 112⅞ | 112 |
| St. | 5% | Do. Def. Stock | 107—109 | 4 | 14 | 9 | — | 108 | 107 |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13—15 | 4 | 0 | 0 | Feb, Aug | 14¼ | 14 |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 12—13 | 4 | 12 | 4 | Feb, Aug | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref... | 5⅜—5⅞ | 4 | 5 | 2 | Feb, Aug | 5 11/16 | 5¾ |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) ... | 98—100 | 3 | 10 | 0 | June, Dec | 98¼ | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 104—106 | 3 | 15 | 6 | — | .. | .. |
| 1 | 0/8¾ | Oriental | 1¼—1⅜ | 3 | 12 | 9 | April, Oct | .. | .. |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1 3/16—1 5/16 | 4 | 11 | 6 | — | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 102—105 | 4 | 5 | 9 | .. | .. | .. |
| 5 | 5/0 | United River Plate | 7—7½ | 5 | 6 | 8 | July.. | 7½ | 7¼ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5¼—5½ | 4 | 10 | 11 | June, Dec | .. | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) .. | 110—112 | 4 | 10 | 8 | June, Dec | 112 | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 4¾—5¼ | 5 | 14 | 4 | .. | .. | .. |
| 10 | 2/0 | Globe Telegraph and Trust | 10¾—11 | 5 | 0 | 0 | Ja Ap.Jy O | 10 13/16 | 10¾ |
| 10 | 6/0 | Do. 6 per Cent. Pref | 14¼—14¾ | 4 | 2 | 8 | Ja Ap,Jy,O | 14 7/16 | — |
| 10 | 6% | †Submarine Cables Trust (Cert.) | 125—128 | 4 | 13 | 9 | April, Oct | 125½ | .. |

| Share. | Last Dividend | Name | Price Wed., Oct. 25. | Rate per Cent. Yielded. | | | Dividend Due. | Business Week to Oct. 25. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | £ | s. | d. | | Highest. | Lowest |
| | | **ELECTRICITY SUPPLY.** | | | | | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12¼—12¾ | 5 | 9 | 10 | .. | 12½ | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10—10½ | 4 | 5 | 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 12¼—12¾ | 4 | 18 | 0 | .. | — | — |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) ... | 107—109 | 4 | 2 | 6 | .. | .. | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼—5¾ | 4 | 15 | 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 104—107 | 4 | 4 | 1 | — | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec.Sup.Ord. | 9¾—10¼ | 4 | 17 | 6 | — | 9⅞ | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 9¼—9¾ | 3 | 11 | 9 | Mar, Sept | 9 5/16 | 9¼ |
| St. | 4% | Central Elec. Sup.Co. 4% Guar. Db. Stock | 105—108 | 3 | 14 | 1 | — | 105¾ | .. |
| 5 | 2/6 | Charing Cross (W.End & City) El. Sup. Co. | 7½—8 | 4 | 1 | 0 | Feb, Aug | 7 15/16 | 7⅞ |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼—5¾ | 3 | 18 | 3 | Feb, Aug | 5⅝ | 5⅝ |
| St. | 4% | Do. 4% Deb. Stock (red.) | 103—105 | 3 | 16 | 2 | — | 104½ | 104⅜ |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4¾—5 | 4 | 10 | 0 | — | .. | .. |
| 5 | 2/3 | Do. Do. (1903) | 4⅞—5⅛ | 4 | 7 | 10 | .. | 4 11/16 | .. |
| 5 | 2/3 | Chelsea Electric Supply Ord. | 5¾—6¼ | 4 | 6 | 0 | March .. | 6 7/16 | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) ... | 110—112 | 4 | 0 | 4 | Jn, Dec .. | 112 | 111¼ |
| 10 | 5/0 | City of London Electric Lighting Ord. | 12¾—13 | 4 | 12 | 4 | Feb, Aug | 12¾ | 12½ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13¾—14¼ | 4 | 4 | 0 | Jan, July | 13 15/16 | 13⅞ |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 124—126 | 3 | 18 | 1 | Jn, Dec .. | 126 | 125¼ |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 104—106 | 4 | 4 | 10 | .. | 104½ | .. |
| 5 | .. | County of Durham Elec. P.D. Ord. £2pd. | 2 3/16—2¼ | .. | | | April, Oct | 2¼ | .. |
| 5 | 6¾d. | Do. Do. 5% non cum. pref. | 5⅜—5½ | .. | | | April, Oct | 5 7/16 | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. .. | 9¾—10¼ | 4 | 7 | 10 | — | 10 | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅜—12⅞ | 4 | 13 | 2 | Mar, Sept | 12½ | 12⅛ |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 111—114 | 3 | 18 | 11 | .. | 114 | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 104—106 | 4 | 4 | 11 | .. | .. | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼—5¾ | 4 | 16 | 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5—5½ | 4 | 11 | 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 100—103 | 4 | 7 | 5 | .. | — | .. |
| 5 | 4/0 | †Hove Electric Lighting Ord. | 8⅛—8⅜ | 4 | 18 | 7 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 101—104 | 4 | 6 | 7 | — | .. | .. |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 12—12¾ | 4 | 14 | 1½ | .. | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½—7 | 4 | 5 | 9 | Jan, July | — | .. |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) .. | 98—101 | 3 | 19 | 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101—103 | 3 | 17 | 8 | .. | .. | .. |
| 3 | 1/9¾ | London Electric Supply Ord. | 1¾—2¼ | 4 | 0 | 0 | .. | 2⅛ | 2 |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5⅜—5⅝ | 5 | 6 | 8 | .. | 5¼ | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 99—102 | 3 | 18 | 5 | Mr,Jn,S,D | .. | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 10—10½ | 5 | 4 | 9 | April, Oct | 10 5/16 | 10 |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5⅝—5⅞ | 3 | 16 | 8 | Jan. July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 109—113 | 3 | 19 | 7 | Jn, Dec .. | 109 | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 98—100 | 3 | 10 | 0 | — | .. | .. |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 102—104% | 4 | 6 | 7 | — | 102 | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 12½—12¾ | 5 | 19 | 1 | Feb, Aug | .. | .. |
| 100 | .. | Do. 4½% Deb. | 104½—105½ | .. | | | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8¾—9¼ | 4 | 18 | 2 | Feb, Aug | 8 13/16 | .. |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6 7/16—6½ | 3 | 17 | 6 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99—100 | 4 | 0 | 0 | Jan, July | .. | .. |
| 1 | 8% | Northern Counties Elec. Sup. 17/- paid | ¾—⅞ | 2 | 15 | 7 | Mar, Aug | 25/32 | .. |
| 100 | .. | Do. 4½% Deb. | 100½—101½ | .. | | | Jan, July | .. | .. |
| 10 | 6/0 | Notting Hill Electric Ord. | 14—15 | 4 | 0 | 0 | March.. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98—100 | 4 | 0 | 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅜—6⅞ | 5 | 1 | 6 | March .. | 6⅝ | .. |
| St. | 4% | Do. 4% Deb. Stock | 100—102 | 3 | 18 | 5 | .. | .. | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 14—15 | 5 | 0 | 0 | Feb, Aug | 14¾ | 1 |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 8½—9½ | 3 | 13 | 8 | Feb, Aug | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) ... | 98—100 | 3 | 10 | 0 | — | 99½ | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord... | 2—2½ | 8 | 0 | 0 | .. | 2 1/32 | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76—80 | 5 | 0 | 0 | — | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord .. | 3½—4 | 5 | 0 | 0 | .. | 3 11/16 | .. |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | 1⅛—1⅝ | .. | | | .. | .. | .. |
| 1 | 0/8¾ | Do. 7% Cum. Pref. | 1 5/16—1 7/16 | 4 | 17 | 2 | .. | — | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105—108 | 4 | 3 | 8 | — | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4⅝—4⅞ | 5 | 2 | 6 | — | 4¾ | .. |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5—5¼ | 4 | 15 | 8 | — | .. | .. |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 103—105 | 4 | 5 | 9 | .. | 104 | .. |
| 5 | 6/6 | Westminster Electric Supply Ord. | 11¾—12¼ | 5 | 14 | 3 | Mar, Sept | 13 | 1 |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅞—6⅜ | 3 | 18 | 4 | .. | 5⅞ | .. |
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝—⅞ | 5 | 6 | 6 | — | .. | .. |
| 1 | 6d. | Aron Elec. Meter 6% Cum. Pref. | 7/16—9/16 | .. | | | .. | ½ | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 1¾—2 | 5 | 0 | 0 | .. | 1 31/32 | .. |
| 1 | 7½d. | Do. Pref | 1 1/16—1 3/16 | 3 | 18 | 10 | .. | .. | .. |
| 5 | 6/0 | British Insulated & Helsby Cables Ord. | 6¾—7¼ | 5 | 10 | 3 | July, Feb | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾—6¼ | 4 | 16 | 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 105—106 | 4 | 4 | 11 | .. | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98—100 | 4 | 10 | 0 | .. | .. | .. |
| 5 | 3/0 | British Westinghouse 6% Pref. | 2⅝—2⅞ | 11 | 4 | 6 | .. | 2 21/32 | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock ... | 85—89 | 4 | 9 | 11 | .. | 85 | .. |
| 2 | .. | Brush Electrical Engineering | ½—¾ | .. | | | March .. | ⅝ | .. |
| 2 | 2/4½ | Do. 6 per Cent. Pref. Non-Cum. | 1¼—1¾ | 6 | 17 | 2 | Mar, Sept | 1⅜ | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 93—97 | 4 | 12 | 10 | Mar, Sept | 95 | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 78—81 | 5 | 12 | 6 | Jan, July | 79¼ | .. |
| 5 | 7/6 | Callender's Cable Con. Ord. | 11—12 | 5 | 0 | 0 | Jan, July | 11½ | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅜—5⅞ | 4 | 5 | 2 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 109—111 | 4 | 1 | 1 | Nov, May | 110½ | 1 |
| 1 | 9¾d. | Castner-Kellner Alkali Co. | 1 1/16—1 3/16 | 3 | 15 | 4 | .. | 1 | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 97—102 | 4 | 8 | 8 | — | .. | .. |
| 1 | 9¾d. | Chadburn's (Ship) Telegraph Ord. | 1 3/16—1 5/16 | 4 | 10 | 6 | .. | — | .. |
| 1 | 7⅜d. | Do. 6% Cum. Pref. | 1 1/16—1 3/16 | 5 | 2 | 7 | .. | .. | .. |
| 3 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) ... | 1⅜—1⅞ | 3 | 16 | 9 | Jan, July | 1 15/32 | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 94—99 | 5 | 1 | 0 | Jan, July | 97 | .. |
| 5 | 10/0 | †Dick, Kerr & Co. Ord. | 8½—9 | 5 | 11 | 1 | Sept .. | 8 13/16 | .. |
| 5 | 3/0 | Do. 6% Cum. Pref. | 6—6½ | 4 | 16 | 0 | Sept .. | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106—108 | 4 | 4 | 1 | .. | .. | .. |
| 5 | 1/6 | †Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅜—1⅝ | .. | | | Feb, Aug | .. | .. |
| 5 | 2/6 | † Do. (£5 paid) | 2—2½ | .. | | | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 85—90 | 4 | 8 | 11 | June, Dec | 86½ | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92—97 | 5 | 3 | 1 | .. | .. | .. |
| 5 | 4/6 | Edmundson's Elec. Corp. Ord. | 5½—6 | 5 | 16 | 8 | H'lf-yearly | 5¾ | .. |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 6⅛—6⅜ | 4 | 14 | 1 | .. | 6 3/16 | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 109—111 | 4 | 1 | 1 | .. | 109½ | .. |
| 2 | 1/7½ | Electric Construction Co. | ⅝—⅞ | 8 | 0 | 0 | July .. | ⅝ | .. |
| 2 | 2/9¾ | Do. 7 per Cent. Cum. Pref | 1⅞—2⅜ | 5 | 18 | 8 | July .... | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 92—95 | 4 | 4 | 2 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref... | 9½—10 | 5 | 0 | 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96—100 | 4 | 0 | 0 | — | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 12—13 | 5 | 15 | 5 | Feb, Aug | 12 9/16 | .. |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5⅛—5⅜ | 4 | 3 | 7 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | 109—111 | 4 | 1 | 1 | Feb, Aug | .. | .. |
| 10 | 5/0 | India Rubber, Gutta Percha, &c., Wrks. | 15½—16½ | 3 | 0 | 7½ | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99—102 | 3 | 18 | 5 | Mar, Sept | .. | .. |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¼—11¾ | 4 | 5 | 1 | Mar, Sept | .. | .. |
| 12 | 12/0 | Telegraph Construction & Mainten'ce. | 33½—34½ | 5 | 2 | 0 | Mar, July | 34½ | .. |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 ... | 102—104 | 3 | 16 | 11 | Jan, July | .. | .. |
| 5 | — | Willans and Robinson Ord. | 1½—2 | — | | | Apr, Oct | .. | .. |
| 5 | — | Do. 6 per Cent. Cum. Pref. | 2½—3½ | — | | | Apr, Oct | 3 | .. |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 74—79 | 5 | 1 | 3 | May Nov | .. | .. |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote th

# P.P.P.

# CRANE MOTORS



*SUPPLIED*
*TO ALL*
*LEADING*
*CRANE*
*BUILDERS.*

P.P.P. Motor driving 15-ton Forge Crane.

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**Bruce Peebles**
**& Co., Ltd.**
Head Office and Works : EDINBURGH.
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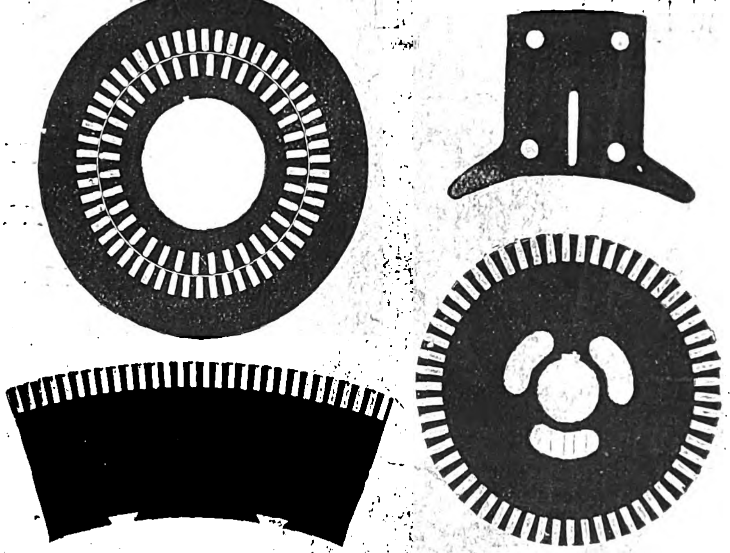

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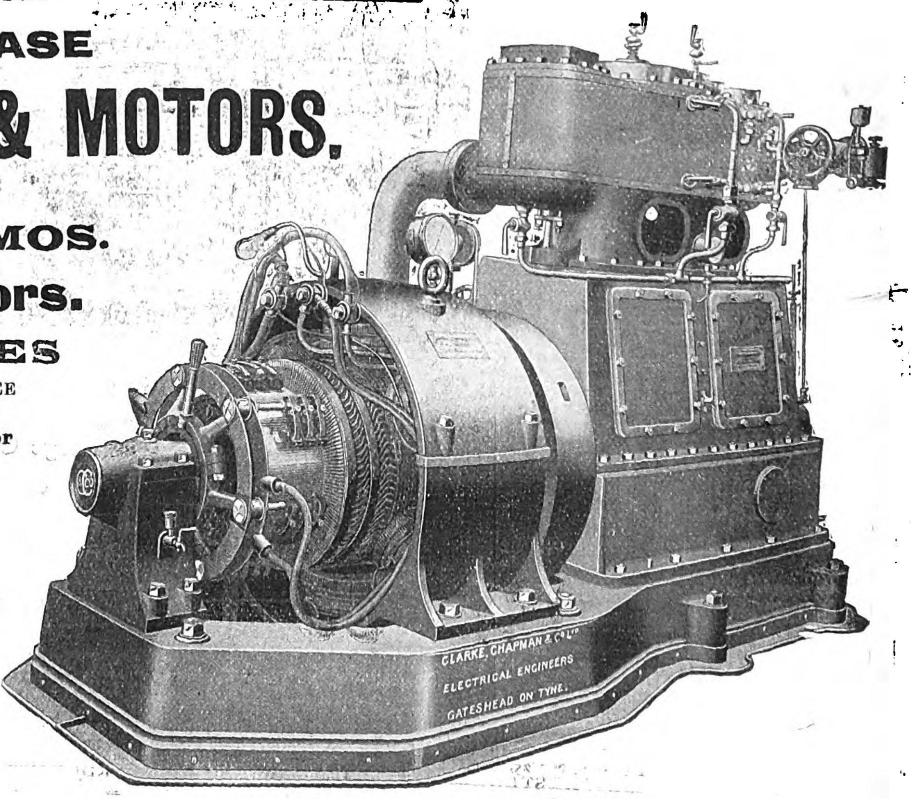

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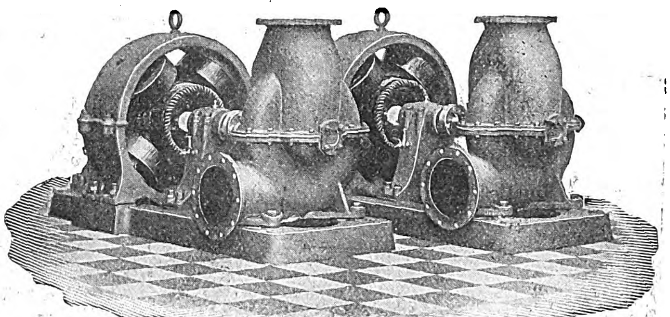

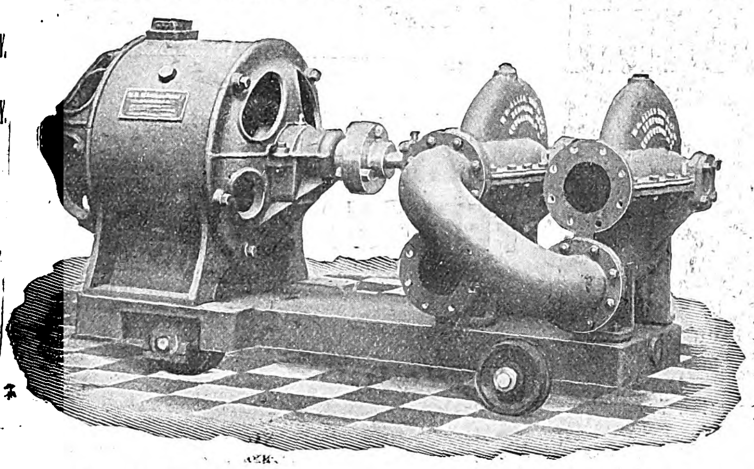

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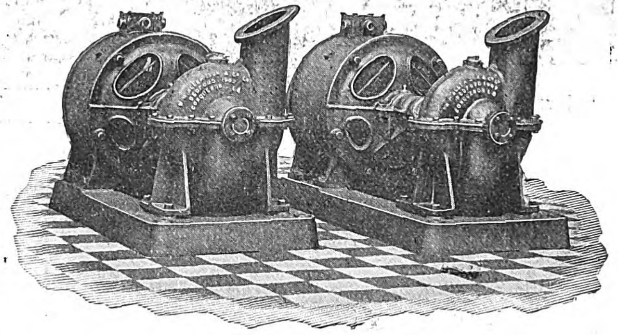

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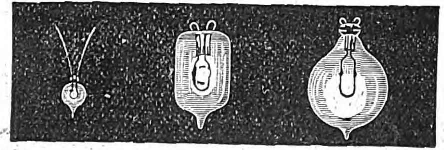

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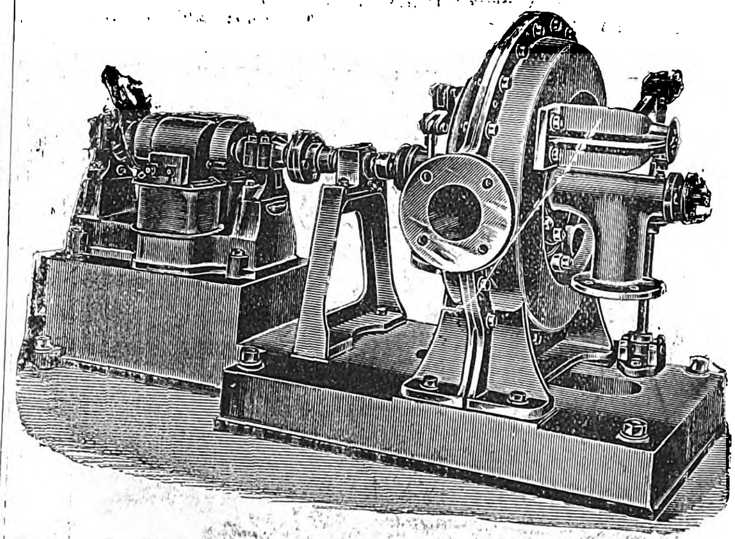

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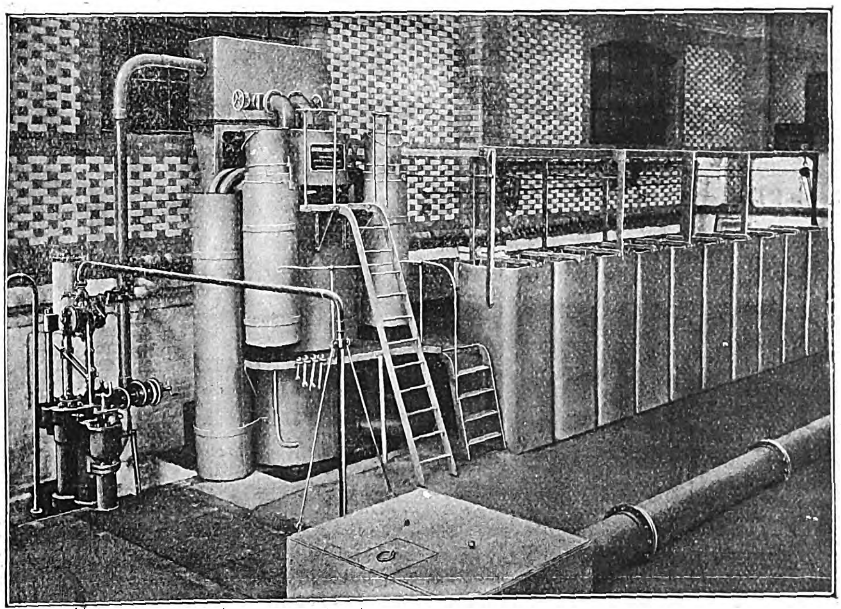

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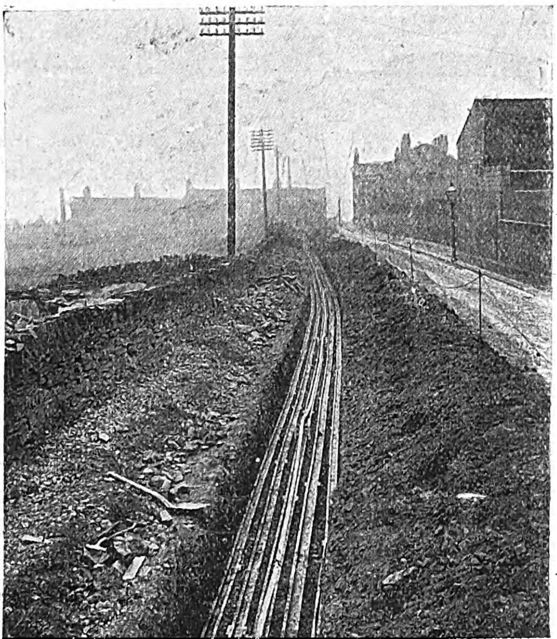

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## ELECTRICAL EXHIBITION AT OLYMPIA.

. . . It is to be observed that this competitive war, which in other industries might easily have led to shoddy work, has brought no such result to British electrical engineering. There is no shoddy at Olympia. . . . Rules and specifications . . . have undoubtedly added to the force of these inherent protective influences; but supporting everything is the array of modern electrical instruments, whose accuracy and scope are at once the safeguard and pride of the electrical profession. Olympia to-day is testifying to a fact which many older industries may observe with advantage—the progress which results from the application of exact methods of defining, testing and designing the *materiel*. . . .

INSTRUMENTS.

Of new instruments, the most comprehensive exhibit is probably that of Messrs Everett, Edgcumbe & Co. (No 8). Attention may be called to their direct-reading watt-photometer, which by a single adjustment measures candle-power, watts and the efficiency of a glow-lamp in watts per candle-power. Their street photometer is designed on the "Flicker" principle. The "inkless" synchronised recorder is likely to be one of the most useful developments in this class of instrument. Friction between the moving paper and the stylus is obviated by supporting the stylus clear of the paper; at recurring short intervals the stylus is tapped into contact and makes a mark by means of an inked ribbon. The principle is somewhat similar to that of the vibrator of a siphon recorder; the vibrations are, however, timed and actuated by an electrically-driven clock.

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THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING. INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,433. [No. 3. Vol. LVI.] FRIDAY, NOVEMBER 3, 1905. PRICE SIXPENCE (by post, 6½d.), *Abroad 9d., or 18 cents, or 90c., or 80pf.*

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## NOTES.

THE Institution of Electrical Engineers will commence its 1905-6 session next Thursday, when the President, Mr. JOHN GAVEY, C.B., will deliver his inaugural address. The Council has been rather late this year in issuing its general invitation to members to read Papers, for the customary circular with a list of the premiums offered was only sent out on October 26th with the time-table and announcement of the Presidential Address. This may be accounted for by the fact that some excellent Papers have already been received. Mr. W. H. PATCHELL has written a Paper on the Charing Cross Company's City of London works, and Lieut.-Col. H. C. L. HOLDEN, F.R.S., has sent in a contribution on the applications of electricity in the Royal Gun Factory, Woolwich Arsenal. One of these two Papers will be taken at the second meeting of the session. We learn that the Sectional Committees have also made several suggestions as to subjects of Papers, and some of our friends have received invitations from the Committees to send in Papers on chosen topics. Notwithstanding these preparations, we trust that accounts of practical work and investigations on electrical engineering matters will also be forthcoming from the general membership, for new talent will be welcome at the Institution debates.

AS has already been indicated in our columns, there will be no Institution visit abroad this year, but arrangements are being made for the entertainment in this country of members of the kindred institutions in Europe and America who have given such a kindly reception to members of our own Institution in previous years. Official invitations to visit Great Britain as guests of the Institution have been sent to the American Institute of Electrical Engineers, the Canadian Electrical Association, the Associazione Elettrotecnica Italiana, the Elektrotechnischer Verein, the Verband Deutscher Elektrotechniker, the Schweizerischer Elektrotechnischer Verein, and the Société Internationale des Electriciens. The date for the arrival of the foreign guests has been fixed for the last week in June, 1906, and the visit will probably extend over about a fortnight. It is not to be confined to London; it is anticipated that a week will afford sufficient time to inspect the electrical work in the neighbourhood of the metropolis, and that a tour will then be made through some of the principal industrial centres in the United Kingdom, where works will be visited and local entertainments provided for the guests. No more definite arrangements can yet be announced, but it is not unreasonable to expect that some time will be spent in the Manchester and Liverpool district, and that the party may even be tempted as far North as Glasgow, in which case Newcastle might well be visited on the return journey. The programme outlined above should receive the cordial support of all members of the Institution. We trust that the membership will not merely consider that they are returning the lavish hospitality shown them by our hosts abroad, but that they will do their utmost towards the success of the tour with a view to promoting the international "entente cordiale" that should prevail between engineers and scientific men of all nations irrespective of any trade rivalry that may exist between them.

◆

WE fully sympathise with the object of the British Science Guild "to bring home to all classes the necessity of applying scientific treatment to affairs of all kinds," but we are in doubt whether this object can be attained better by the formation of a new "guild" than by strengthening the hands of the many existing scientific and technical institutions which have this same aim in view. No detailed programme has yet been issued, but the prospectus promises to do nothing that is not already within the scope of the older institutions. The work of the British Association for the Advancement of Science, is almost identical with that which the new Guild proposes to undertake, and we need only mention, in addition, the Royal Society, the Royal Institution, the Society of Arts, the London Institution, the University Extension Lectures, the various large technical societies and the smaller ones in provincial centres. The modern universities themselves work in the same direction, and the number of technical schools and local science and art schools for the popularisation of science and to further the application of science to industry is already so great that many of them are not filled. If each of our popular daily papers could afford a small retaining fee for a scientific man and engineer to advise it on scientific and engineering matters, this would do more to benefit the cause of science than the most eloquent appeals by the distinguished men who occupied the platform of the meeting on Monday.

◆

At present, however, it is the higher education in applied science and engineering that requires most attention, and if the fresh energies of the British Science Guild are concentrated, as a first effort, on Mr. Haldane's recent scheme for the establishment of a well-organised college to educate men destined to be leaders in the engineering professions, it will justify its existence. Since the publication of the report of Mr. Haldane's Committee on this matter last July (*The Electrician* of July 7, 1905) nothing further has been heard of the project, and we trust that details have been worked out in the interval and that a college for the teaching of advanced engineering and science will soon be established in London under the management of practical engineers chosen from the highest ranks of the profession.

◆

Considerable progress in the adaptation of single-phase motors to traction work is indicated in the article we reprint from the New York *Electrical World*. Of the three lines there reported on, two have the General Electric and one the Westinghouse equipment; and some interest attaches to the differences mentioned in the construction of the motors. Both are series motors capable of use with the 500 volt continuous-current supply as well as the alternating. This necessity of the American "inter-urban" road leaves very little choice, and the series motor with forced compensation bids fair to be the standard type for such work. It does not entirely follow that for pure railway work in the English sense it will prove the most suitable, and the note as to the comparatively low acceleration at starting indicates that for conditions approximating to tramway service the continuous current retains supremacy.

◆

A peculiar feature of the Westinghouse motor is the use of "spark-preventing" leads between the coil terminals and the commutator segments. These leads wound into the coil slots must have some considerable self-induction as well as resistance, and presumably they are so arranged as to oppose the coil reactance. This recalls the well-known "commutating coil" of Mr. W. B. Sayers' armature winding, but how far the resemblance extends it is not possible to tell from the description given. The abandonment of series-parallel control in favour of voltage regulation through taps from the transformer is not surprising—it seems the obvious way.

Altogether the information given is encouraging, and it makes us desire more. It makes us desire, also, that there were greater facilities in our own country for these twelve inch to a foot scale experiments. Where is the British manufacturer, and where the British Railway Board that will venture so much in trying a new device? It is some consolation that our friends in the States publish their results so freely, and in this also they show their wisdom; for it is fairly certain that whenever a demand arises here for single-phase equipments, the first lots will come from Schenectady or Pittsburg, where they are already "standardised," listed, priced, and the characteristic curves plotted, traced and blue-printed.

◆

The municipal elections all over the country on Wednesday have resulted in an increased representation of the Labour party, and this is not good news for the municipal electrical engineer. In those boroughs where the Labour interest predominates there is too often a tendency on the part of individual members of the Council and the Electricity Committee to interfere between the engineer-in-chief and his staff and workmen. More than one borough electrical engineer has, on occasion, complained to us that he would be able to manage his works more efficiently and economically if he were left a free hand as to the number of men he employed, and if his absolute discretion with regard to the discharge of men were not interfered with to such an extent as to prevent proper discipline. It is to be hoped that such encroachments on the part of the Labour element on the councils will be firmly opposed, and that the few instances in which this kind of thing now occurs will remain the only ones.

◆

The Physical Society met for the first time this session on Friday last, at the Royal College of Science. There was a very good attendance, though only two Papers were down to be read. Dr. Sumpner's Paper on phase-meters possesses great practical interest. As may be seen from the abstract that appears on another page, the problem of the customary type of phase-meter for polyphase circuits is discussed mathematically and many of the conclusions reached are corroborated very closely by experiment. The results as a whole are, considering the dubious character of the instrument, unexpectedly optimistic; for with fairly large power-factors in circuits with reasonably-balanced loads a well-made instrument is now shown to be more trustworthy than has hitherto been thought possible. But, perhaps, the most important outcome of the Paper is the method proposed by the author for the calibration of phase-meters by continuous current. If this method proves as satisfactory in the testing room as it appears to have been in the laboratory, it should enable manufacturers to put on the market instruments of assured veracity.

◆

We give on another page the full text of a report which the Highways Committee of the London County Council has drafted on the question of the supply of electric power in London. The report advices the Council to provide a substitute for the scheme of the Administrative County of London and District Electric Power Co., whose Bill, although passed by Committees of both Houses of Parliament last session, did not pass the final stages through want of time. In the report no details of the County Council's proposals are given, although it is made abundantly clear that the present intentions are that the general principles of Mr. MERZ's scheme are to be adopted, with the difference that the Council itself should be the authority for the supply of electricity "in bulk" and for power purposes. How far public opinion will coincide with this latter proposition is problematical, for, in the first place, it is apparent that if the objects set forth in the report are to be achieved, trading outside the area over which the London County Council has at present jurisdiction must be involved. On this point Parliamentary Committees during the past few sessions have expressed very pronounced views.

◆

BUT we are not so much concerned with these matters at present as with the engineering aspect of the question. It is common knowledge that the Administrative County of London scheme occupied at least two years in its preparation. The County Council and all the borough councils argued last session that the basis of the estimates in connection with Mr. MERZ's scheme was wrong. This being so, a fresh start must be made, presumably, for a new scheme, such as is now suggested, and we feel sure that the able engineers who have the honour to conduct the engineering affairs of the Council will be the first to admit that the time now available for the formulation of such a power scheme for this session is all too short to enable a really effective and comprehensive proposal to be evolved. Printed copies of private Bills have to be deposited in the Private Bill Office of the Houses of Parliament by December 17th, and the statutory public notices have to be published by November 27th. Surely the Highways Committee of the London County Council cannot prepare in one month plans and estimates for the completion of which two years were necessary on a previous occasion. The fate of the proposal, however, will largely rest with the Borough Councils, with whom it is suggested that a conference should be held on November 20th.

◆

**The Finsen Memorial.**—It is announced that His Majesty the King has sent 50 guineas and the Queen 100 guineas to the fund for the monument to Prof. Finsen in Copenhagen.

**Obituary.**—The death was recently announced, at Fulham, London, of Mr. W. H. Akester, who was an early pioneer of electric lighting and patentee of numerous inventions in the eighties.

**New German Pacific Cable.**—The Deutsch-Niederlandische Telegraphengesellschaft has just completed the laying of a new submarine telegraph cable between Shanghai and Yap, in the Caroline Islands, and the cable is now open for traffic. The work of laying the cable was carried out by the c.s. "Stephan."

**Tiberius Cavallo.**—A fine portrait of Tiberius Cavallo, F.R.S., who died in 1809, has just been purchased by the trustees of the National Portrait Gallery. Cavallo was the author of several electrical Papers in the *Philosophical Transactions*, the inventor of many electrical instruments, including the pith-ball electroscope. He wrote a treatise on Electricity and one on Magnetism which went through three English and several Continental editions.

**Birmingham University.**—At a meeting of the Council of the University held on Wednesday it was announced by the Chancellor, Mr. Joseph Chamberlain, M.P., that a sum of £50,000 had been promised, by a person who wished to remain anonymous, towards the completion of the new University buildings.

**Association of Teachers in Technical Institutes.**—The annual general meeting of the Association of Teachers in Technical Institutes will be held at the Birkbeck College, London, to-morrow (Saturday) at 3 p.m., to discuss the annual report, proposed amendments to constitution and rules, to elect officers and council and other business.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Tarifa—Tangier | Jan. 18, 1904 |
| Jamaica – Colon | Jan. 10, 1905 |
| Cadiz—Teneriffe | July 20, 1905 |
| Kotonou—Grand Bassam | Oct. 4, 1905 |
| Medan—Plehleh | Oct. 26, 1905 |
| Oran—Tangier | Oct. 30, 1905 |
| Tangier—Cadiz | — |
| Falmouth – Bilbao | Oct. 31, 1905 |

**The Duddell-Mather Wattmeter.**—Mr. Duddell asks us to correct two errors in the description of the Duddell-Mather wattmeter published in our article on the Electrical Exhibition last week. At the top of the second column of page 54 the following sentence occurs: "This is a matter of increasing importance in the measurement of losses in dielectrics and in small quantities of iron cables." The last word should be omitted. Lower down, in the same column, the damping boxes *bb* are stated to be made of *brass*; they are actually made of *glass*, which enables the vanes PP to be seen so that they can be used as pointers as well as damping vanes.

**North London Tramways.**—An interesting visit was paid by the Tramways and Light Railways Association on Tuesday to the Brimsdown power station and sub-stations of the North Metropolitan Electric Power Supply Co. and the tramways and light railways system of the Metropolitan Electric Tramways Co. These have been fully described in *The Electrician*, with the exception of two short pieces of the light railway line which actually lie within the grounds of the Alexandra Palace. There is nothing of particular interest in connection with these, excepting that at some places the gradient is as severe as 1 in 10, and for this reason the Board of Trade will only allow single-deck cars to be used. For about half a mile the tracks are laid on a private right of way. The Metropolitan Electric Tramways Co.'s lines are being extended considerably in different directions, and the length of route is now over 20 miles.

**Breakdown on the North-Eastern Railway.**—An accident occurred on Saturday evening at the Wallsend sub-station of the Newcastle-upon-Tyne Electric Supply Co. It appears that the contractors to the railway company for the erection of the sub-stations were making preparations for some final tests on the machinery which they had supplied. In order to carry out these tests they erected some temporary cables, and during the progress of preliminary tests these temporary cables fused and set fire to several other cables which were used for feeding the railway. The actual damage by the fire was insignificant, and none of the machinery was burnt in any way. The train service would not have been delayed even for an hour had it not been for the fact that the telephone box was the chief thing that caught fire, and therefore could not be used. Soon after the accident occurred energy was supplied by other sub-stations, and the total time of failure of the train service was about an hour.

**Institution Local Sections.**—The first of the local sections of the Institution of Electrical Engineers to get to work is Leeds, whose chairman (Mr. A. B. Mountain) delivered his inaugural address on October 25th at the Leeds University. No meeting of this local section, however, has been announced for November. The opening dates of the remaining local sections are as follows: Dublin, at the Royal College of Science, Thursday, November 9th; Glasgow, Institution of Engineers and Shipbuilders at 207, Bath-street, Tuesday, November 14th; Manchester, at the University, Friday, November 17th; Newcastle, at the Armstrong College of Science, Monday, November 20th;

Birmingham, at the University, Wednesday, November 22nd. The Chairman's inaugural address will be delivered at the opening meetings. As already stated, Mr. A. B. Mountain is chairman at Leeds, and the following completes the list of chairmen : Prof. R. Threlfall, F.R.S. (Birmingham), Mr. P. S. Sheardown (Dublin), Mr. J. M. M. Munro (Glasgow), Mr. S. L. Pearce (Manchester), Dr. W. M. Thornton (Newcastle-on-Tyne).

**Opening of the Perth Tramway System.**—The Perth Corporation electric tramway system was put into operation on Tuesday. The tramways in Perth have for many years been worked by a company with horse traction, but the Corporation acquired the undertaking at a cost of between £20,000 and £30,000. The cost of the conversion to electric traction has been about £45,000, exclusive of £4,000 for the provision of the necessary additional generating plant at the power house, the Corporation having supplied electrical energy for lighting and power purposes since 1901. Messrs. Kincaid, Waller, Manville & Dawson have acted as consulting engineers to the tramway scheme. The total length of route opened is the equivalent of 6 miles of single track, the gauge being 3 ft. 6 in. The rails weigh 90 lb. to the yard, the maximum gradient is 1 in 16·2 and the sharpest curve is 35 ft. Messrs. R. W. Blackwell & Co. secured the complete contract, and sublet portions. The cables were supplied by the Callender's Cable & Construction Co., the car bodies by Messrs. Hurst, Nelson & Co. and the tramway motors by the British Westinghouse Co. Span wires and side brackets are employed in connection with the overhead equipment. Twelve single-truck double-deck cars have been provided. The necessary extensions to the electricity works were carried out by Mr. J. Lambert, the borough electrical engineer, who has also been appointed tramways manager.

**The c.s. "Grossherzog v. Oldenburg."**—An order was given to the Schichau Shipbuilding Co. last February by the Norddeutsche Seekabelwerke to build a new cable steamer, the "Grossherzog v. Oldenburg," to take the place of the old c.s. "v. Podbielski" recently sold to the Dutch Government and re-named "Telegraaf." According to the *Kölnische Zeitung*, this old steamer is at present conveying a cable made by the Norddeutsche Seekabelwerke to the Dutch East Indies. This cable is to be laid in November between Balikpapan (Borneo) and Macassar (Celebes). The new steamer was successfully launched on the 21st of last month in the presence of a distinguished assembly of official and civil dignitaries. It will be employed, our contemporary states, chiefly in connection with the maintenance of German cables both governmental and private. The following table gives the chief data of the cable steamers "Grossherzog v. Oldenburg," "Stephan" (also owned by the Norddeutsche Seekabelwerke) and "Telegraaf":—

| — | "Grossherzog v. Oldenburg." | "Stephan." | "Telegraaf." |
|---|---|---|---|
| Displacement (tons) ........ | 4,640 | 9,850 | 3,200 |
| I.H.P. of engines .......... | 2,000 | 2,400 | 1,600 |
| Cable storage capacity (tons) | 1,300 | 5,000 | 1,100 |
| Tank space (cubic feet) .... | 29,800 | 94,500 | 19,300 |
| Speed (knots) ............ | 12·5 | 12 | 10·5 |

**The Faraday Society: Alternating-current Electrolysis.**—At a meeting of the Faraday Society last Tuesday, four Papers of an electrochemical nature were presented and discussed, Lord Kelvin occupying the chair for the first time. The first Paper was by Prof. E. Wilson and dealt with "Alternate-current Electrolysis." As it had been previously published, Prof. Wilson contended himself with giving a *résumé* of the laboratory work carried out, the chief conclusions being that electrolytic action also occurred with alternating current, that electrolytic action decreased with the frequency and increased rapidly with the current density. An abstract of this Paper appeared in *The Electrician*, Vol. LV., p. 826. In the discussion, Mr. A. P. Trotter remarked that the laboratory conditions differed widely from actual conditions. He had made tests with two lead pipes buried in the ground 4 in. apart, and had maintained a current of 1 ampere between them for several months. After a while the current tended to drop and he attributed this to the formation of salts which acted like a resistance. It was curious to observe that the corrosion only extended for a certain distance on the surface of the lead pipe, the line of demarcation being most pronounced. This was observed by the audience itself on the pipes handed round by the speaker. It was an unsettled question whether electrolytic action stopped at a certain low voltage drop or at a certain small current density. He inclined to the latter view. Where the Board of Trade regulations had been observed, no electrolytic troubles had, so far, been experienced. Mr. J. Swinburne thought that in this country the salt formed by electrolysis on lead pipes was chiefly lead chloride, which would not prevent the pipes from being eaten right through. The second Paper was by Mr. W. R. Cooper on "Alternate-current Electrolysis as shown by oscillograph records." The electrodes consisted of platinum wires, 0·18 mm. in diameter, projecting 2 cm. out of glass tubes into which they were sealed. They were placed 3·2 cm. apart in an electrolyte consisting of dilute sulphuric acid of 1·130 specific gravity. As a result of capacity and polarisation effects, the current flowing (even when a pure sine wave of E.M.F. was impressed) was of an irregular shape. The phase difference between current and voltage diminished steadily as the applied pressure was increased. Prof. A. K. Huntington read the third Paper, his subject being, "Note on the Crystalline Structure of Electro-deposited Copper." When the mandril on which copper is to be deposited is provided with a spiral groove, it is very easy to pull off the deposited copper after formation in form of a long ribbon. This peculiar property, the lecturer explained, was due to the fact that the crystals formed at right angles to the surface on which the deposit was made. It followed that when the crystals which formed on surfaces more or less at an angle to one another met, there would be a want of continuity in the two sets of crystals and a line of weakness would result. This explanation was verified by some splendid photo-micrographs of electro-deposited copper thrown on the screen. The last Paper, which had to be taken as read owing to the advanced hour, was by Mr. W. P. Digby, on "Some Observations respecting the Relation of Stability to Electrochemical Efficiency in Hypochlorite Production."

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**(To-day) FRIDAY, November 3rd.**

Junior Institution of Engineers.

*8 p.m.* Meeting at the Westminster Palace Hotel. The President, Mr. Dugald Clerk, will deliver his Inaugural Address on "The Problems of the Gas Turbine."

**SATURDAY, November 4th.**

Glasgow Technical College Scientific Society.

*7:30 p.m.* Meeting at Glasgow and West of Scotland Technical College, George-street, Glasgow, Paper to be read: "Electric Power Plant Design," by P. D. Ionides.

Birmingham and District Electric Club.

*7:30 p.m.* Meeting at the Municipal Technical School, Suffolk-street, Birmingham. Paper to be read: "Electric Furnaces," by J. H. Stansbie.

**MONDAY, November 6th.**

Society of Engineers.

*7:30 p.m.* Ordinary Meeting at the Royal United Service Institution, Whitehall, London, S.W. Paper to be read: "The Metallic Preservation and Ornamentation of Iron and Steel," by Sherard Cowper-Coles.

**TUESDAY, November 7th.**

Institution of Civil Engineers.

*8 p.m.* Ordinary Meeting, when Sir Alexander R. Binnie will deliver his Address, and afterwards present the medals and prizes awarded by the Council.

**THURSDAY, November 9th.**

Institution of Electrical Engineers.

*8 p.m.* Ordinary General Meeting. Mr. J. Gavey, President, will deliver his Inaugural Address, and distribute the prizes awarded during last session.

Institution of Electrical Engineers: Dublin Local Section.

*8 p.m.* Ordinary Meeting at Royal College of Science. Mr. P. S. Sheardown, Chairman, will deliver his Opening Address.

**FRIDAY, November 10th.**

Physical Society.

*8 p.m.* Meeting at Royal College of Science, Exhibition-road, South Kensington. Agenda.—(1) The question of Temperature and Efficiency of Thermal Radiation, by James Swinburne. (2) Note on Constant-deviation Prisms, by T. H. Blakesley.

## SOME TESTS ON LAMP GLOBES.

BY MAURICE SOLOMON.

In the course of some experiments made nearly three years ago in the laboratory of the Nernst Electric Light (Ltd.) on the mean spherical candle-power and distribution of light with Nernst lamps, the writer obtained some results which seemed to throw doubt on the figures generally accepted for the absorbing powers of different classes of globes. Unfortunately, as will be pointed out later, the Nernst lamp is not very well suited for an investigation having the determination of these values as its special object, and it was in the hope of being able to confirm the results obtained by means of some other illuminant that the figures have not hitherto been published. But as the point is one of considerable importance, and as, moreover, the results are of interest in themselves, it is hoped that the present article may not be considered premature.

The investigation also led the writer to devise a method for obtaining graphically with a fair degree of accuracy the mean spherical candle-power for a light source which is not even approximately symmetrical about the vertical axis: it is believed that this method is new, and, in view of the fact that several modern illuminants are far from being axially symmetrical, its publication may be of use. To the best of the writer's knowledge, all published methods for determining mean spherical candle-power, graphically or otherwise, assume a source which is at least approximately symmetrical, and do not give more than a reference to the increased difficulty of the problem with a light source which does not fulfil this condition. In Palaz' "Treatise on Photometry" a method of approximation is given which, as the translators point out in the appendix, is obviously incorrect: they do not, however, suggest an alternative method.

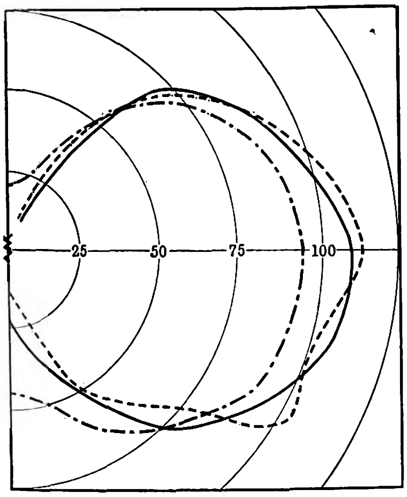


Fig. 1.—Vertical Light Distribution Curves for 200 volt 1·0 ampere Nernst Lamp.

——— Without globe.
- - - - - With clear globe.
—·—·— „ frosted „

The lamps investigated were all of the Allgemeine Elektricitäts Gesellschaft's make, and were the standard patterns in use at that date (December, 1902). The candle-power measurements were made on a Kruss photometer with a Lummer-Brodhun head, an incandescent electric lamp being used as standard for comparison. The standard was a secondary (or rather a tertiary) one, being compared from time to time with another incandescent lamp which had been standardised by the writer against the pentane standard and also independently at Faraday House. This secondary standard was a 100 volt lamp, and was run on a 200 volt circuit: it was found that by using a large resistance in series in this way the candle-power of the standard could be maintained very steady. Very high accuracy is not claimed for the results, nor are the absolute values of the candle-powers necessarily exact, it being only of importance that they shall be consistent in themselves. The lamp under test was mounted on a specially-constructed frame, by means of which it could be easily rotated and the candle-power at any desired angle measured. Measurements were made for every 15 deg., or where the light varied rapidly every 10 deg. or 5 deg.

**Table I.**—*Nernst Lamp. Model A. 200 Volts. 0·96 Amperes.*

| — | No globe. | Clear globe. | Frosted globe. | Holo-phane. Class A. | Holo-phane. Class B. |
|---|---|---|---|---|---|
| Mean horizontal candle-power .. | 109·5 | 113·5 | 95·5 | 57 | 91·5 |
| Candle-power vertically downwards | 20·0 | 13·5 | 44·5 | 177 | 91·5 |
| Mean hemispherical c.p. (upper).. | 77·0 | 78·0 | 74·5 | 50 | 41·0 |
| „ „ „ (lower).. | 85·0 | 86·0 | 82·5 | 96 | 100·0 |
| Mean spherical candle power .... | 81·0 | 82·0 | 78·5 | 73 | 70·5 |

The curves in Figs. 1 and 2 are for a 200 volt 1 ampere lamp (Model A) with four different sorts of globe and in that any globe. In this lamp the glower is mounted vertically and the distribution in the horizontal plane is practically uniform. There is very little error in this case in assuming the source to be symmetrical about the vertical axis. The mean horizontal candle-power was determined in each case and the measurements made in a plane through the filament, for which the horizontal candle-power had the mean value both in the plane and a little way on either side of it. From the vertical distribution curves the Rousseau figures were drawn in the usual way, and the areas measured with a planimeter in order to obtain the mean spherical and the mean hemispherical candle-powers. The results are given in Table I.

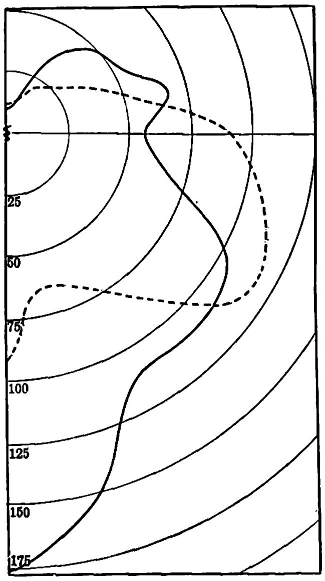


Fig. 2.—Vertical Light Distribution Curves for 200 volt 1·0 ampere Nernst Lamp.

——— With Class A (pointed) holophane globe.
- - - - „ „ B (round) „ „

The curves in Fig. 3 are for a 200 volt 0·5 ampere lamp. This lamp was the same pattern as the 1·0 ampere lamp and the same remarks therefore apply with reference to the horizontal distribution. The lamp was not tested without the globe, but was tested with a clear globe and with two different frosted globes one 18 cm. and the other 15 cm. in diameter. The results of the tests are summarised in Table II.

**Table II.**—*Nernst Lamp. Model A. 200 Volts. 0·52 Amperes.*

| — | Clear globe. | 18 cm. frosted globe. | 15 cm. frosted globe. |
|---|---|---|---|
| Mean horizontal candle-power .... | 68·0 | 60·0 | 58·5 |
| Candle-power vertically downwards | 7·5 | 31·0 | 25·0 |
| Mean hemispherical c.p. (upper) .. | 43·5 | 42·5 | 46·5 |
| „ „ „ (lower) .. | 53·5 | 54·5 | 50·5 |
| Mean spherical candle-power .... | 48·5 | 48·5 | 48·5 |

In Fig. 4 are given the curves of vertical distribution for a 200 volt 0·25 ampere lamp (Model B). In this lamp the glower is mounted horizontally, and the horizontal distribution is very far from being symmetrical, the curve being butterfly-shaped, wide in the plane at right angles to the filament, and very much constricted in the plane of the filament. The curves given in Fig. 4 are, however, for the mean vertical distribution: the method of obtaining them will be explained later; for the present it may be assumed that by rotation about the vertical axis they would sweep out surfaces enclosing the same volumes as the actual candle-power surfaces, and hence the Rousseau figures can be plotted from these curves, and the mean spherical candle-power obtained in the usual way. The results are summarised below in Table III.

**Table III.**—*Nernst Lamp. Model B. 200 Volts. 0·24 Amperes.*

| —— | No globe. | Clear globe. | Frosted globe. |
|---|---|---|---|
| Mean horizontal candle-power.... | 12·0 | 13·0 | 13·1 |
| Maximum „ „ .... | 19·8 | 20·0 | 17·4 |
| Minimum „ „ .... | 1·7 | 2·2 | 6·6 |
| Candle-power vertically downwards | 24·0 | 23·8 | 24·3 |
| Mean hemispherical c.p. (upper).. | 9·0 | 9·3 | 9·2 |
| „ „ „ (lower).. | 17·8 | 18·5 | 18·2 |
| Mean spherical candle-power .... | 13·4 | 13·9 | 13·7 |

If the distribution curves in Figs. 1-4 be examined carefully, several points of interest may be noted. It will be seen that there is a slight tendency even with a clear globe for the distribution to be improved, but the effect is somewhat marred by an increased irregularity in the curve due, probably, to reflection from the inner surface of the globe. With the frosted globes the distribution is improved rather more, but the effect is not so great as might be expected. The most remarkable curves are those for the two holophane globes. The class A globe is designed to concentrate the light below the lamp and the class B globe to give good general distribution with a concentration of the light below the horizontal. The Nernst filament being a small light source concentrated at the centre of the globe is probably particularly well suited to give the best results: in any case both globes perform the work for which they are designed with remarkable efficiency as is shown by the curves and tables.

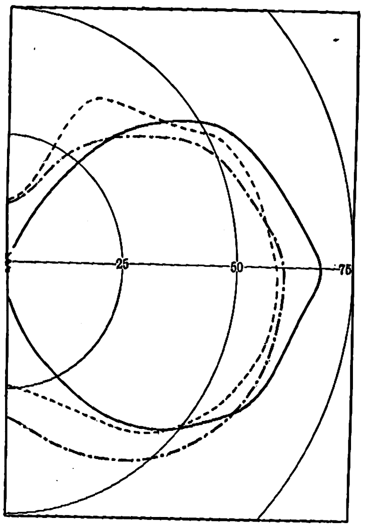


Fig. 3.—Vertical Light Distribution Curves for 200 volt 0·5 ampere Nernst Lamp.

——— With 18 cm. diameter, clear globe.
······ „ „ „ frosted globe.
—·—· „ 15 „ „ „ „

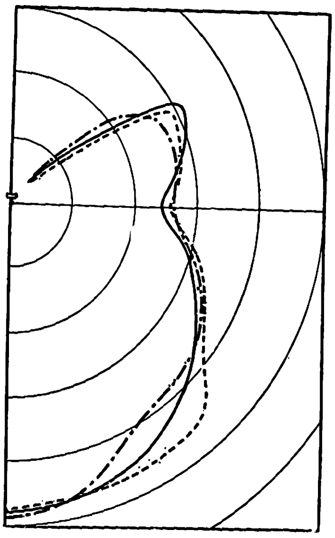


Fig. 4.—Mean Vertical Light Distribution Curves for 200 volt 0·25 ampere Nernst Lamp.

——— Without globe.
– – – – With clear globe.
—·—· „ frosted „

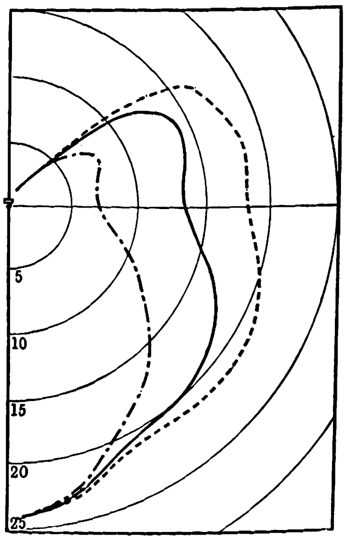


Fig. 5.—Vertical Light Distribution Curves for 200 volt 0·25 ampere Nernst Lamp with Frosted Globe.

—·—· Distribution in plane of glower.
– – – „ „ perpendicular to glower.
——— Mean distribution curve.

The figures for mean spherical candle-power in Tables I. and III. show that there is a distinct increase in light by using a globe. Thus, for the 1 ampere lamp the mean spherical candle-power rises from 81 to 82, or a little over 1 per cent., whilst for the ¼ ampere lamp the increase is from 13·4 to 13·9, or 3½ per cent. The actual increase must be greater than this, as the globe certainly absorbs some of the light. This increase in candle-power is due to the filament burning in a hot atmosphere, and not being subject to the cooling action of air currents: it has been frequently noted by several observers, and use was made of this property in the original American design of the Nernst lamp by enclosing the filament (or filaments) in very small globes, so that they might be in as hot an atmosphere as possible. It was not possible, with the large globes used in these experiments, to detect any appreciable change in the current taken by the lamp. It is this peculiarity of the Nernst filament which renders it unsuitable for experiments on the light-absorbing power of globes. It would be interesting to know how far other artificial illuminants are affected in a like manner; from *a priori* considerations it would seem that only incandescent electric lamps and enclosed arcs can be unaffected. If all due allowance be made for this effect, it still seems that the figure of 10 to 15 per cent., which is usually given for the absorption by clear-glass globes, is too high. The same conclusion is suggested by the mean spherical candle-powers with frosted globes; the globes used were acid frosted, and the frosting, though not heavy, was sufficient to produce a fair diffusion of the light. In the case of the ½ ampere lamp, it will be seen that the mean spherical candle-power is the same with all three globes: with the 1 ampere lamp the mean spherical candle-power with the frosted globe is 94 per cent. of that with a clear globe; with the ¼ ampere lamp it is 98·5 per cent. The figures generally given for the absorption by frosted glass vary from 15 to 30 per cent.

Whilst it is not claimed that the accuracy of the candle-power determinations was very high, the writer nevertheless believes that they were correct to at least 2 per cent., and when it is remembered that the mean spherical candle-power is necessarily obtained from a large number of individual measurements it does not seem possible that any very large errors can exist. This conclusion is confirmed by the fact that the results for all three lamps are consistent in indicating low values for the absorption. It was thought that the temperature inside a frosted globe might possibly be higher than in a clear globe (though this was the reverse of what was to be expected) and for this reason the two different sized frosted globes were used with the ½ ampere lamp. The figures indicate that any effect from this cause must be small. If instead of taking the mean spherical candle-power as the basis of comparison the mean horizontal candle-power be taken, the results are quite different, but it is obviously incorrect to compare the globes on any other basis than that of mean spherical candle-power.

The method by which the mean spherical candle-power of the ¼ ampere lamps was obtained is applicable to all unsymmetrical light sources and was as follows: The distribution of light in three planes was measured experimentally (*a*) the horizontal plane through the filament, (*b*) the vertical plane at right angles to the filament, and (*c*) the vertical plane through the filament. The distribution curves obtained in (*b*) and (*c*) are shewn in Fig. 5. As the Nernst filament is a straight rod the horizontal distribution curve may be divided into four similar quadrants, and it is only necessary in what follows to consider one such quadrant, the value of the candle-power at the various angles in this being taken as the mean of the values for the corresponding angles in all four quadrants. These values are plotted as a curve (90 deg. Fig. 6) to rectangular co-ordinates, the abscissæ representing angles made with the axis of the filament and the ordinates candle-powers. The mean height of this curve, which can be found by measuring its area with a planimeter, represents the mean horizontal candle-power. Consider now the distribution of light below the horizontal. If a sphere be described around the source of light and be divided into a number of horizontal zones we can obtain the mean spherical candle-power by Rousseau's method if we know the mean intensity of light on each zone. The problem, then, is to find the mean value of the candle-power for each zone, or, in other words, the mean candle-power along the surface of a cone having a given vertical angle, and to obtain this we have to determine the distribution of light for this particular angle. The distribution for a cone having a vertical angle of 0 deg.—*i.e.*, in a direction vertically downwards—is obviously a circle, and hence is represented on the curve sheet by a straight line. (0 deg. Fig. 6). For this reason both the curves 0 deg. and 90 deg. are drawn in full, as both may be considered as determined experimentally. As we pass from the horizontal plane to the vertical the curve of distribution must obviously change gradually in shape from that of curve 90 deg. to that of curve 0 deg.: but the starting and finishing points of all these curves are already known, since they have been determined in the measurements of vertical distribution in the two vertical planes at right angles. The values found in the plane of the filament are plotted on the ordinate AD, and those found in the plane at right angles to the filament on the ordinate BC. These points are then joined by a series of curves merging gradually from the shape of the curve 90 deg. to that of curve 0 deg. These curves are shown in the figure for angles of 15 deg., 30 deg., 45 deg., 60 deg. and 75 deg. with the vertical: they are shown dotted as only the first and last points are actually observed values. By measuring the area of any one of these curves the value of the mean candle-power is obtained. In a similar way the mean candle-power for angles above the horizontal can be obtained (105 deg. to 160 deg.). If the mean values thus obtained be now plotted as a vertical distribution curve, we obtain the full line curve in Fig. 5, which represents the vertical distribution for an axially symmetrical source of light having the same mean spherical candle-power as the lamp and from which the mean spherical candle-power can be obtained by the usual graphical construction.

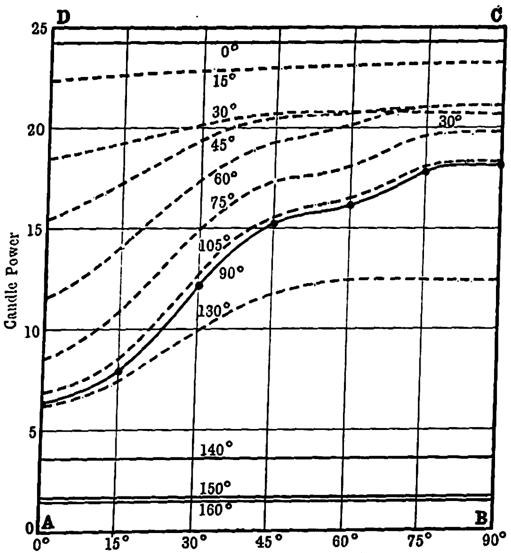
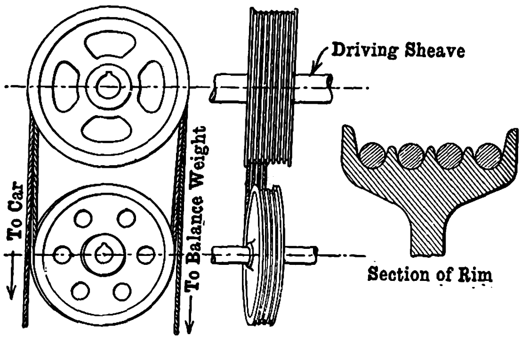


Fig. 6.—Method of obtaining Mean Vertical Distribution Curves for an Asymmetrical Source of Light (½ ampere Lamp with Frosted Globe).

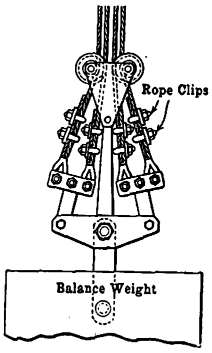
## ELECTRICAL EXHIBITION AT OLYMPIA.

(Seventh Notice.)

The Easton Lift Co. (Ltd.) exhibited two of their directly-coupled electric passenger lifts, each designed to carry 12 persons from the ground floor up to the balcony, a height of 20 ft. 1½ in., the speed of each lift being 150 ft. per minute. We are informed that the average number of passengers carried each day between the hours of 12 noon and 10 o'clock in the evening during the run of the Exhibition has been 4,500. At times as many as 18 persons squeezed themselves into the car. Each lift is controlled by means of the firm's own design of car switch, which is fitted with magnetic blow-outs where required and carbon contacts throughout. In the exhibition lifts the attendant controls the operations by a small switch fixed in the lift, connection between the moving cage and the stationary switch and motor gear at the bottom of the pit being made by flexible conductors hanging from the bottom of the cage. When the switch is turned on, a relay at the bottom of the pit is energised. This causes a local circuit to be closed and the handle of the starting switch of the lift motor is moved over the contacts against the pull of a counterweight, the movement being retarded by an air dash-pot. The motor, of the enclosed-ventilated type, is directly-coupled to the worm gear, consisting of a case-hardened double-threaded worm engaging with a phosphor bronze worm wheel. The thrust of the worm is taken by one of Messrs. Hoffmann's ball-thrust bearings. Between the motor and worm gear there is an electro-mechanical brake, the coupling itself forming the brake drum. When the lift is in operation, the brake shoes are lifted off the drum by means of a solenoid, but when the current supply is switched off or interrupted from any cause, the brake is applied by a heavy counterweight. These lifts are fitted with the firm's tandem cross-over drive, as shown in our first sketch. It consists of a driving drum with eight grooves and an auxiliary sheave having four grooves. The lift ropes are attached, at one end, to the safety gear of the car; the ropes pass then around four grooves of the driving sheave, the four grooves of the auxiliary sheave and around the remaining four grooves of the driving drum from whence the ropes finally pass to the balance weight. It is claimed that this drive prevents the rope from becoming slack and slipping. Another feature of the Easton Co.'s lifts is the equalising gear used upon the balance weight, as shown in our second sketch. It has been adopted to keep all four ropes at the same tension. The guide rails of the lifts consist of planished steel bar 2 in. in diameter, and the safety gear, should it come into action, grips these rails. An automatic switch is provided for stopping the lift at the two extremes of the travel in the event of the attendant neglecting to do so.



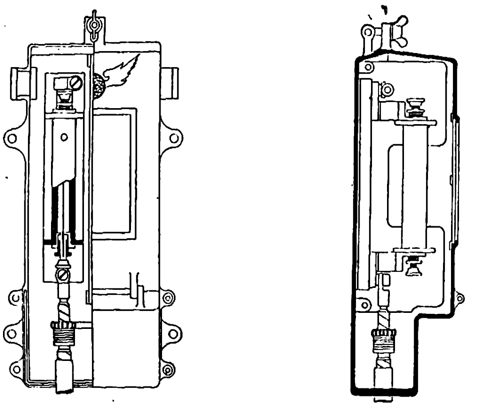
The Tandem Cross-over Drive.



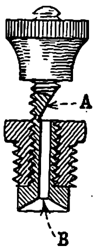
The Equalising Device adopted by the Easton Lift Co.

The Davies Patent Boiler Co. had a section of the Davies boiler and a self-charging vertical gas retort on view. The Davies boiler consists of a combination of a Lancashire or other suitable type of boiler with a watertube boiler. To this end a large number of solid drawn steel tubes, 2 in. in diameter, protrude vertically through the flue of the boiler and help to abstract the heat from the furnace gases. Great efficiency is claimed for this design, the following being the results of some tests carried out at the Kersal Bleaching Co.'s works at Manchester: Lancashire boiler size, 28 ft. by 7 ft.; diameter of flue, 2 ft. 8½ in.; heating surface of flues and boiler shell, 1,311 sq. ft.; area of firegrate surface, 32½ sq. ft.; temperature of feed water entering boiler, 40°F.; temperature of water in boiler at start, 212°F.; mean steam pressure during test, 56 lb. per sq. in.; water evaporated in pounds during test, 5,400 lb.; water evaporated per pound of actual coal, 8·64 lb.; water evaporated per pound of combustible, 9·37 lb.; equivalent evaporation from and at 212°F. per pound of actual coal, 9·85 lb.

The New Brotherton Tube Co. had a stand arranged in an original manner, the design bringing into use the firm's various patterns of tubing and pipes. This firm manufactures enamelled steel conduits and fittings for interior wiring, and also pipes for various purposes in connection with electrical engineering.

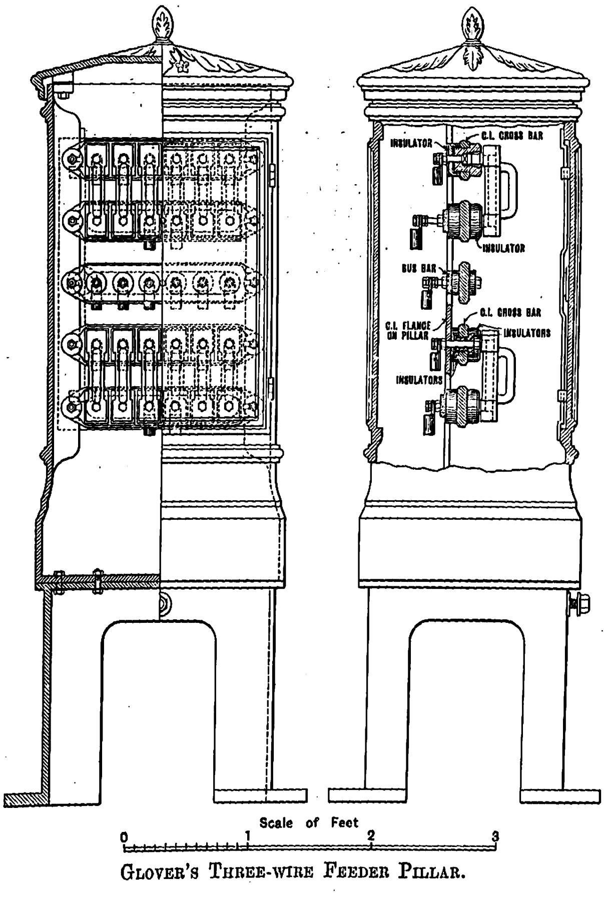


Glover House Fuse Box.



Screw for Fuse.
(Two-thirds full size.)

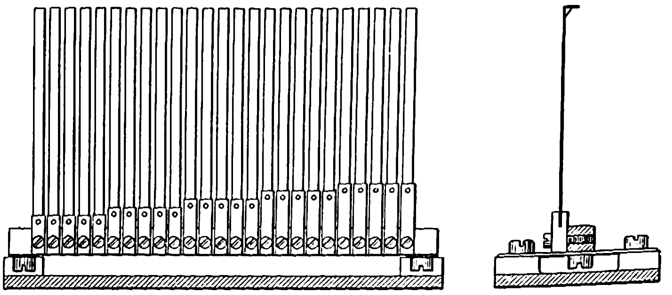
Messrs. W. T. Glover & Co. had a variety of exhibits. A new consumers' fuse box of the design below is noticeable for the fact that the mains come in at the side instead of the top, so that there is less tendency for moisture to creep in along the cables. An enclosed fuse is used with a mica window lightly fixed, so that it is blown out when the fuse blows, if the expansion of air is so sudden that it would otherwise crack the fuse holder. The screw used to fasten the fuse is illustrated in the drawing annexed. The fuse wire is passed through the hole B in the centre of the screw, and is brought out at A and given a couple of turns, after which it is held down firmly by the milled nut. Another exhibit which Messrs. Glover's representative pointed to with pride was a model of the ingenious drum carriage recently described in our columns (*The Electrician*, June 2, 1905, p. 256.) Specimens of joints made with "guttaroid" tape were also shown, this material being especially suitable for preparing ends of cables It is a compound tape with no fibre in it and is lapped on cold, after which a covering of ordinary tape is placed over it and it is dipped in the hot compound pot for a few minutes. The whole covering of tape then joins up solid, similarly to a cured vulcanised joint, and it may be pared with a knife without undoing the turns. The drawing below shows a new three-wire feeder pillar which is of practical design, although not too expensive. As is seen in the drawing, six sets of three-wire distributors can be connected up in it. A practical detail is the arrangement of the connecting lugs and bolts for the three sets of mains, the bolts being of different lengths so that the cables may be brought up straight to them without confusion. It is small points such as these that are appreciated by mains engineers. Messrs. Glover also showed a Wordingham feeder pillar, a cable of 8 sq. in. conductor section (which, needless to say, is for ornament and not for use, its diameter being 5½ in.) a mutoscope in which there is a picture of an arc endeavouring to wreak vengence on a fire-resisting cable, a sample of a leather-braided vulcanised rubber cable for use as a trailing cable in workshop and colliery work, and also a "paper leadless" cable.



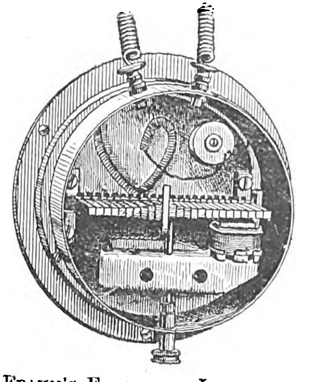
Glover's Three-wire Feeder Pillar.

Messrs. Foxcroft & Duncan showed a number of instruments of various types, the stand being lighted by "Sappho" enclosed and "Phœnix" and "S.S." open arc lamps. It may be mentioned that this firm supplied one of the searchlights used by the Electrical Engineer Volunteers in the gallery. This lamp was supplied to the Army Ordnance Department, Woolwich Dockyard.

Messrs. W. Lucy & Co. exhibited very few specimens of their ironwork, but they showed one or two ingenious German measuring instruments for which they are agents. One of these is Frahm's speed indicator and frequency teller. It is based on a principle not unlike that of the frequency indicator already described in connection with the Union Electric Co.'s exhibit. A number of flat springs of watch-spring steel are mounted on a base. The dimensions of these springs are 40 mm. to 55 mm. high, 3 mm. wide and 0·25 mm. thick. Each spring is bent over for about 4 mm. at its upper end, and this head is covered with white enamel. A drop of solder is placed at the angle which the head makes with the stem of the spring. By adjusting the length of the spring and the mass of solder, any desired natural period of oscillation between 35 and 100 vibrations per second can be obtained. A tappet wheel or cam is connected to the shaft whose revolutions it is desired to measure, and this communicates the vibrations to the comb of springs, and the spring corresponding with the speed which is to be indicated is set into vibration. The two figures above show a set of springs arranged in this manner. The heads of the springs are seen through the glass front of the instrument. Instead of a mechanical method of communicating the vibrations, an electrical method is used in some of the instruments, so that the actual instrument may be put at a distance from the shaft. In this case, the vibrations are communicated magneto-electrically, the equivalent of a small magneto-electric machine being placed in connection with the shaft whose speed is being measured. The frequency indicator works on a similar principle, a view of it being seen in the illustration above, and the same instrument may be used as a synchroniser. In the illustration it is seen with a spring nearly in the centre of the indicator in violent vibration, and the period marked on the spring corresponds to the frequency. The small laminated electromagnet which actuates the springs is also clearly seen in this figure. The same firm exhibited two time switches, also of German manufacture.

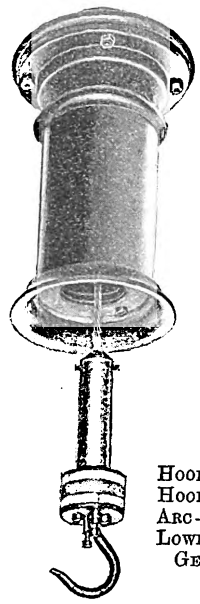


Line of Springs of Frahm's Speed Indicator.

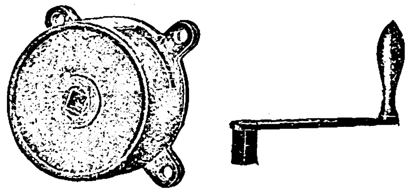


Frahm's Frequency Indicator.

An arc lamp lowering gear, which embodies two new and ingenious mechanical contrivances was exhibited at this stand on behalf of the London Electric Firm. The winch consists of four robust parts. One of these, forming the base of the whole device and provided with holes for fixing purposes, has a continuous groove, the form of which resembles three semi-circles linked together. The second part takes the shape of a flat disc through which protrude at either side four equidistant pins. A circular hole is machined in this flat disc, not in the centre, and the third piece which is provided with an eccentric to fit this hole, is turned by the winch handle concentrically with the base plate and fits within the boss of the winding drum. All four parts fit compactly within one another, the four pins mentioned engage on one side of the flat disc with the groove in the base plate and on the other side with four circular recesses in the side of one flange of the winding drum. By turning the winch handle the eccentric is caused to rotate and the flat disc receives a motion partly oscillating, partly rotating, and the device thus gives a 4 : 1 reduction of speed without the use of gear wheels. The winch is self-sustaining in any position. The second device is for holding the arc lamp securely when once raised to the top, thus taking the strain of the rope. To this end the hook supporting the arc lamp extends upwards into a cylindrical plunger to which the rope is attached. A strong pin protrudes diametrically through the plunger near its upper end. The plunger is drawn into a collar of cast brass in the circumference of which a zig-zag slot is cut. The shape of the slot is such that the first time the lamp is lifted and lowered the pin in the plunger rests at the bottom of one pair of the zig-zag teeth, and the next time it clears them.

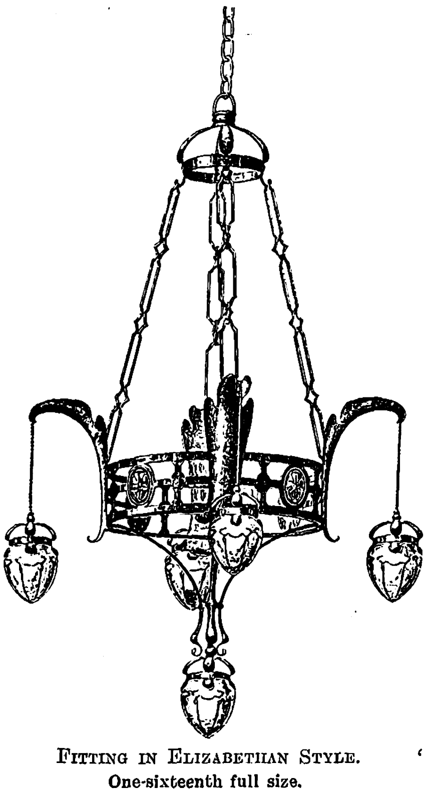


Hood and Hook of Arc-lamp Lowering Gear.

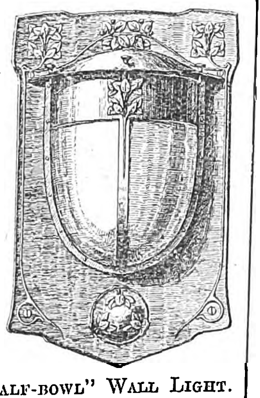


External View of Winch.

The London Electrical Fittings Co.'s exhibit embraced an extremely artistic and attractive display of electric light fittings manufactured by this firm, together with their own accessories and the switches, &c., of the Wandsworth Electric Mfg Co. The accompanying illustration shows a large fitting suitable for public buildings or hotels, carried out in the "Elizabethan" style; it has an extremely graceful appearance. Another illustration which we give shows a wall light in the shape of a half-bowl, mounted in a repoussé placque. This is carried out in "new art" style in a very pleasing manner. The style in question is often objectionable, but the result of its application to this fitting is very effective. An exceedingly useful device was the firm's two-light adjustable and expanding counterweight fitting for the toilet table. This fitting, it is claimed, is the only one of its kind on the market and is quite a novelty. By means of a thumb screw the spread can be altered from 24 in. down to any size as far as 12 in.

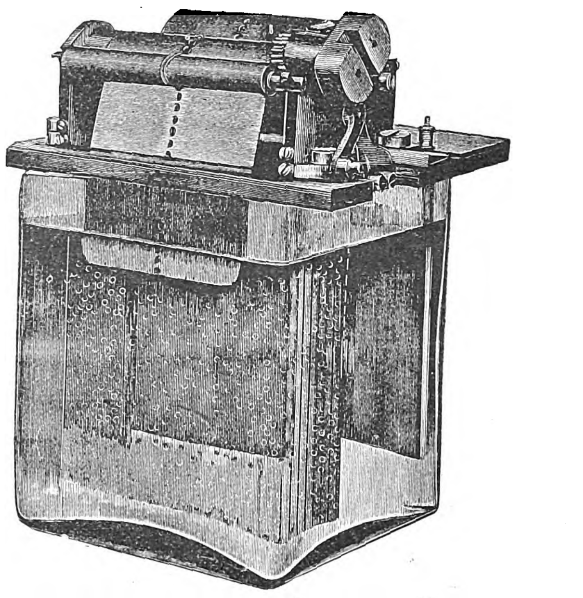


Fitting in Elizabethan Style.
One-sixteenth full size.



"Half-bowl" Wall Light.
One-eighth full size.

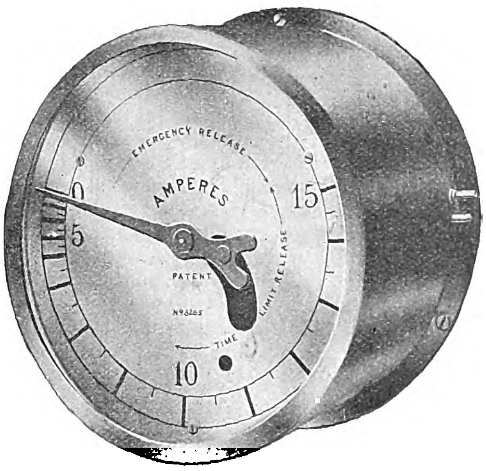
The Mordey-Fricker electrolytic prepayment meter was the greatest feature of interest at Messrs. Fricker & Miller's exhibit. In this meter, beyond the manual operation of prepaying coins into the till as required, there are no mechanical movements whatever. The illustration given is almost self-explanatory. As will be seen, the meter comprises a depositing cell wherein the cathode is fixed and partitioned off from the anode by a perforated celluloid diaphragm. The anode is in the form of a roll of thin copper strip carried on the upper part of the plate covering the cell. A definite length of this strip, which is rolled to a uniform thickness, is fed into the electrolyte over a sprocket roller, through a slot in the cover plate, by the operation of each coin. When the portion thus immersed has all been dissolved by electrolysis and a like quantity deposited on the cathode, the circuit is automatically broken at the surface of the electrolyte. In the penny meters a maximum feed corresponding to eight coins may be immersed. The average drop depends upon the length of anode immersed, and with one penny's worth only does not exceed 1·3 volts per ampere passed. The anode rolls are made to serve for 600 coins, and, together with the cathode plates, are readily renewed. The difference between the value of the copper in the rolled anode form and as deposited on the cathode is about 1 per cent. of the revenue from the meter. Copper nitrate is employed as an electrolyte, and is unaltered by the action of the current, merely serving as a carrier of copper from anode to cathode. Copper nitrate being a deliquescent salt there is no evaporation of water, and consequently no "creeping" of the salt itself. The solution requires filtering from the "sludge" of fine copper sheddings at long intervals; the makers estimate that once in two years would probably be sufficient. A counter records continuously the number of coins paid in, and this record, multiplied by a constant, gives the units consumed. The amount of prepaid energy available at any time may be approximately estimated by the appearance of the immersed anode copper as seen through the window in the front of the meter case. Considerable attention was also attracted to the Fricker thermal volt and ampere meters exhibited at this stand. In these instruments a differential air thermometer is immersed in water, and the air in one bulb is heated by an internal resistance wound over a slip of thin mica and connected to platinum wires which are sealed into the glass. The water bath acts as a temperature equaliser, so that changes in the comparative thermal conditions of the two bulbs are rapidly indexed by the column of liquid in the connecting tube. Differential thermometers heated by conductors placed round or near one of the bulbs have been suggested as ampere meters and volt meters, but the sluggishness of the indications of such instruments in air is great. By keeping the bulbs in intimate contact with a medium having a great heat capacity like water, this sluggishness is remarkably reduced, and the rate at which changes are indexed becomes quite rapid enough for practical utility. We are informed that the instrument is not liable to changes in the zero, nor does it absorb a large amount of energy. Another ingenious device shown was the Fricker remote control switch. This is an apparatus designed to be operated by a momentary fall in pressure, and to be used on consumers' services in connection with two-rate meters, demand indicators, &c. It comprises a wound-up clock train with an escapement. The pallet lever is held over by an electro-magnet against the force of a light helical spring. This electro-magnet is normally energised across the supply mains, and is wound with very fine wire and absorbs about 1 watt. If the pressure is momentarily interrupted or greatly reduced the magnet lets go and the spring rocks the pallet lever back, the magnet immediately recovering and pulling it again into the normal position. Thus one tooth of the escapement is slipped at each momentary drop in the pressure. A cam on the escapement shaft transforms these angular movements of the shaft to alternate up and down movements of a light balance rod carrying short circuiting forks at the ends, dipping in and out of mercury cups. The apparatus would be operated twice in the 24 hours, and a single winding of the mechanism would last for some 30 years at the slow rate of release, consequently the question of re-winding need not be considered.



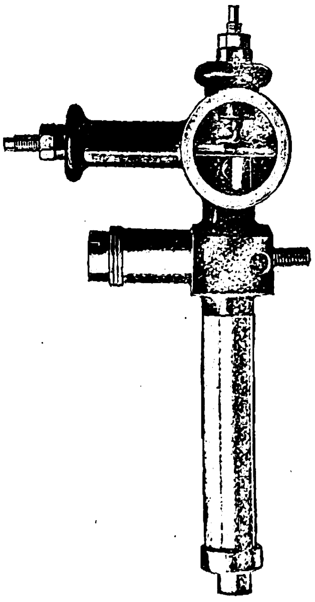
Mordey Fricker Electrolytic Prepayment Meter.

The principal exhibits at the stand of Messrs. **Stewarts & Lloyds** were tramway poles, some consisting of a single piece 31 ft. long and tapered uniformly from end to end, while the others were built up of three parallel lap-welded tubes shrunk together and of a similar over-all length. These poles carried mountings representing the latest practice in span wire and in side arm and double arm construction, both with bent and straight arms. On the same stand were also some fine examples of lap-welded steel steam mains fitted with welded-on flanges. Interesting samples of long tubular steel derricks 33 ft. long in one piece, having their maximum diameter in the centre and tapered uniformly to both ends, were exhibited. Among the numerous pipes and tubes shown, one tube was designed to withstand a working pressure of 2,500 lb. to the square inch.

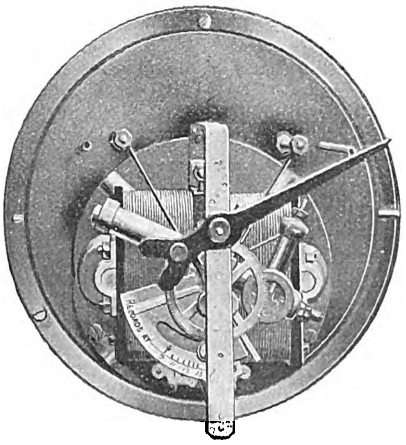
In addition to the resistance apparatus which Messrs. **Monté Callow & Co.** exhibited at their stands, there were also some features of novelty. One of these is Atkinson's patent time-lag overload release, combined with an ammeter. The release mechanism consists of two contacts mounted in a chamber filled with oil; one of these contacts is fixed in position, while the other is carried on a flexible support. The movable contact is fitted with a mica vane which damps its movement. At one side of this chamber a tubular extension is mounted which carries a metal ball, free to roll from end to end of the tube; this tube is also filled with oil. Under normal conditions the tube is inclined, so that the ball rests at the end remote from the contact chamber, but when the predetermined load is exceeded, the tube becomes inclined till the ball starts to roll along it. When the ball reaches the contact chamber it presses the flexible contact against the fixed contact, and operates the release. The time taken for the ball to roll from end to end of the tube can be adjusted between the limits of three seconds and 60 seconds, while the current at which the ball starts to roll can be set between the limits of 60 and 100 per cent. of the maximum reading of the ammeter. In the event of the instrument being subjected to a heavy overload or a short-circuit, the operating tube is inclined so much that the weight of the flexible contact is sufficient to make contact with the fixed contact without the assistance of the ball, and the release operates at once. These instruments may be used for operating circuit-breakers either by short-circuiting a "hold on" coil, or by operating a relay coil; they may be used for operating motor starters by short-circuiting "no volt" release coils. When desired they may be used for ringing a bell to draw attention to the fact that the predetermined load has been exceeded for the predetermined time.



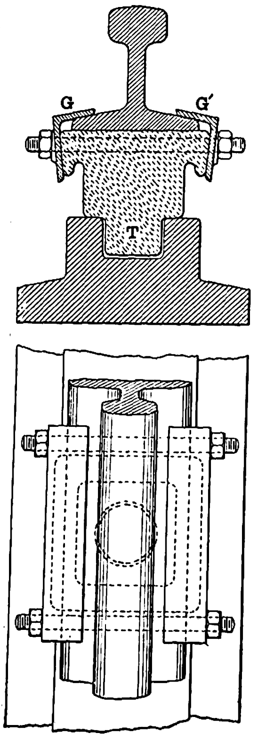
Atkinson Time-lag Ammeter.



Atkinson Time-lag Release Mechanism.



Interior of Atkinson Ammeter.

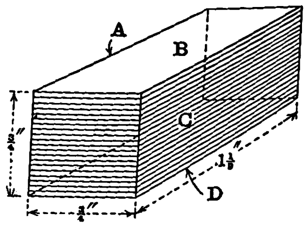


Monté-Callow's New Third-rail Insulator.

Another interesting device at this stand is a new third-rail insulator, consisting of a solid block of glass shaped as shown in the accompanying illustration. The advantage claimed for this appliance is that it permits of greater flexibility than the ordinary third-rail insulator, such as is used on certain electric railways. When these insulators are fixed on the same sleepers as the running rails, it is obvious that a certain amount of tension is put on them when a train passes over. This is because they are incapable of vertical motion relatively to the sleeper, as they are, of course, rigidly attached to the conductor rail. Messrs. Monté Callow's insulator overcomes this difficulty by means of a circular boss, which fits into the wooden supporting base, and hence the insulator is capable of both vertical and circular motion relatively to the sleeper.

The **Temperley Transporter Co.** were, of necessity, compelled to exhibit models of their apparatus, although a traveller was shown capable of lifting and carrying loads of 35 cwt. The working models at this stand included a fixed transporter with grab, as employed at electric generating stations, showing how coal can be discharged from a lighter directly into storage hoppers over a boiler, or on to a stock heap. There was also a model of a Temperley travelling tower transporter, showing the method of discharging coal from vessels on to a stock heap or into railway waggons.

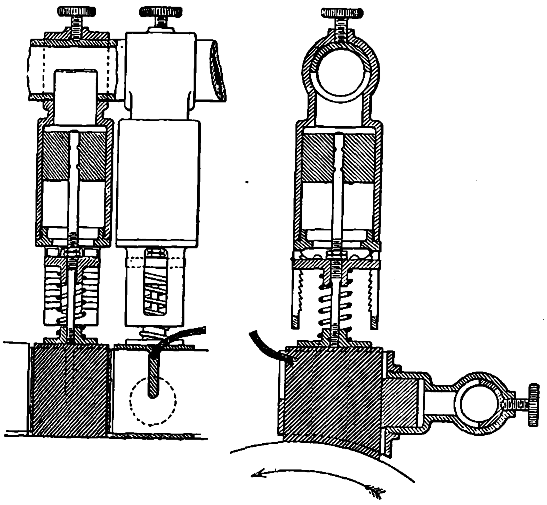
Three novelties were shown for the first time by the **Morgan Crucible Co.**—viz., the "Morganite" brush for motors and dynamos, "Morganite" dash-pot plungers and "Morganite" self-lubricating bearings. The first novelty relates to a self-lubricating brush, the resistance of which is greater across the brush than in a direction normal to the commutator. This result is obtained by making the brush of a very great number of thin layers of a compound of which graphite is the chief component. This is done by special machinery, and in the finished product these layers cannot be distinguished, but their presence may be detected by measuring the drop of voltage in two directions at right angles to each other across the brush. This we did at the stand, and found the ratio of the two resistances in question to be as 19 : 111. In this respect the following report by the National Physical Laboratory of tests on carbon and "Morganite" blocks are of interest: The two blocks were practically the same in shape and dimensions, No. 1 being of ordinary carbon for brushes and No. 2 being of special "Morganite" material. The following results were obtained at a temperature of 15°C. :—



Sketch showing Dimensions of Test Piece.

| | | | | | | |
|---|---|---|---|---|---|---|
| Resistance of ordinary carbon from | face A | to face | C | .. | 0·0016 | ohm |
| | ,, B | ,, | D | .. | 0·0020 | ,, |
| ,, ,, "Morganite" material from | ,, A | ,, | C | .. | 0·0006 | ,, |
| | ,, B | ,, | D | .. | 0 0046 | ,, |

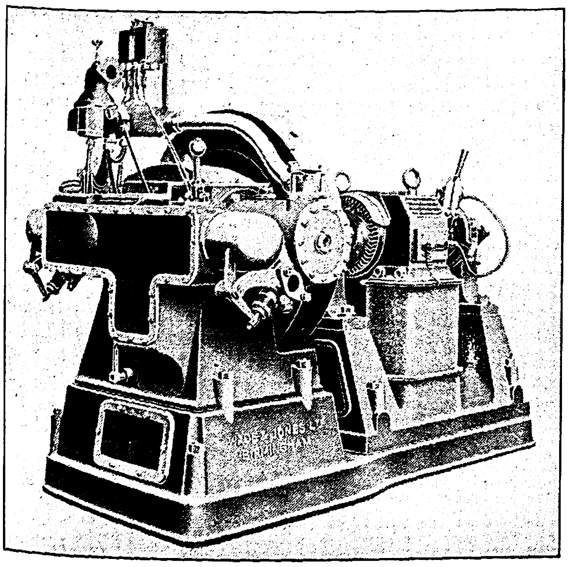
There was a large assortment of these "Morganite" brushes, of many sizes and various grades, on view. The type "link-one" is suitable for general use at any voltage, and is claimed to have an exceptionally low friction coefficient. "Link-two" type is for carrying heavy currents and for alternating currents. "Link-three" is so constructed that the contact resistance is very low at one edge and higher at the other, the resistance being graded between these extremes. It is suitable for machines working in one direction only, and must be so fixed that the higher resistance edge is the edge which breaks contact with each segment. The greater part of the current will thus pass through the entering edge, as it is of lower resistance, and comparatively little through the leaving edge, where sparking usually occurs. Type "link-four," for reversible motors, has exactly the same properties as "link-three," except that the high conductivity portion of the brush is in the middle, and both edges are of lower conductivity. Regarding the current densities allowable, it is stated that the first type works satisfactorily with 50 amperes per square inch, the other types operating well with 100 amperes per square inch. If desired, the flexible lead is embedded in the brushes during the process of manufacture. The brushes require to be carefully embedded on the commutator to start with, as the wear of the brush itself is very small. A pressure not less than 2½ lb. per square inch of brush contact surface is recommended. We understand that these brushes are being used in connection with turbo-generators in this country and abroad.



Brush Gear for Turbo-Generators by the Morgan Crucible Co.
(One-quarter full size.)

Our drawing represents the firm's brush gear for turbo-generators, the place of the usual springs being taken by compressed air, which is led to the brush holders through the hollow brush spindles as shown, and causes the brush to be pressed from above and from the side. The object of this design is to mitigate the "dancing" of the brushes by reducing the inertia of the moving parts.

At stands Nos. 109 and 134 Messrs. A. P. **Wright** & Co., who are London agents for Messrs. Wade & Jones, of Birmingham, showed in operation a neat and compact type of "oil dynamo," as it is called, and an "oil fan." These, of course, are merely a dynamo and a fan driven by an oil engine, but the engine has several features of note, in which a departure has been made from ordinary practice.



Wade & Jones' "Oil Dynamo" Set.

These engines, designed by Messrs Wade and Jones, are made by both Messrs. Belliss and Morcom and Messrs. Willans and Robinson, and although they have been three years on the market little publicity has hitherto been given to them. The general principle of these engines is that of the ordinary motor-car petrol engine, they being started by hand with petrol, at half compression and the whole load taken up within 15 seconds. Soon after the load is on, however, the supply of petrol is discontinued, and the working of the engine is maintained with ordinary paraffin, the two oils, at the time of the change, mixing together without deleterious effects. A new carburetter is used in order to allow of the use of paraffin. Ordinary electric ignition is employed. It is claimed that the engine runs better with paraffin, and that the explosions are not nearly so pronounced as with petrol, being more like a whistle. In order to prevent condensation of the mixture before it reaches the cylinder, the inlet pipes are lined with asbestos, one of the main objects of the designers being to maintain the temperature throughout. Lubrication is effected by a positive piston pump, copper tubes being carried to every bearing. The oil is forced at a pressure of 30 lb., and the arrangements are such that a pool of oil remains in every bearing. For this purpose a tank, capable of holding 7 gallons of oil, is constructed as a portion of the frame of the engine, the sediment being drawn off by a cock. As will be seen by our illustration the cylinders of the engine are horizontal, one being on either side of the crank shaft. A departure from ordinary motor-car engine construction is noticeable here for the cylinders overhang the pistons instead of vice versa. The cam operating the exhaust valve also is a fixture, and in order to secure half compression at starting, a sliding cam is brought into operation by hand. It is claimed that there is no sooting up of the cylinder walls and valves by the use of paraffin. The dynamos coupled to the engines on show were made by the General Electric Co. and Messrs. Thomas Parker (Ltd.), and were directly connected to the engines by means of a flexible coupling of great mechanical strength, there being no springs. The sets on view worked at 700 revs. per min. and gave continuously 12 B.H.P. and a maximum of 16 B.H.P. for a short time. They are made in various sizes from 4 H.P. upwards, and are designed for ship and country house lighting where skilled attendance is not available.

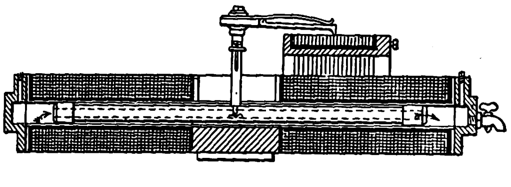
A very fine display of arc lamps was made by the **Brockie-Pell Arc Lamp** Co., and included some of their famous open-type lamps as well as a number of the company's new enclosed lamps. These latter were designed by Mr. Brockie, and are of the single-enclosure type. A standard time of 60 to 70 hours for burning with one pair of carbons has been adopted, but lamps requiring less frequent renewal of carbons are supplied when specially desired.

Messrs. **Frankenburg** & Sons exhibited samples and specimens of cables for electric light, transmission of power, telephones and telegraphic purposes. In addition to pure and vulcanised indiarubber wire and cable, some lead-covered and armoured cable was shown and specimens of "fire-resisting" cables. There were also some samples of macintosh coats, caps, leggings and overalls, and a wax motor-man, clad in a waterproof suit and stationed in front of a tramcar controller.

Messrs. W. **Burt** & Co. showed a considerable variety of French and English electric light fittings, switch plates, bell pushes, switches with ornamental covers, &c. Among the novelties at this stand was Cooper's illuminating tablecloth, which has already been described in these columns, and the Hunter patent candle lamp. This latter device is so constructed that the opal glass, representing the wax of the candle, is illuminated from the interior so as to give a very faithful idea of an actual candle.

The **Efandem** Co. had a most interesting stand. The first thing that caught the eye was the so-called "wireless" sign. The method of construction of this is as follows: There is a double-carrying bar formed of two flat metal rods insulated from each other at intervals. At each end of the bar is a bracket piece fitted with a socket, into which the end of the wire supplying the current is inserted. This bracket piece supplies the current to one of the bars only, so that, for instance, the current from one bracket piece at one end is supplied to the front bar, and from the other end to the back bar, the brackets being insulated accordingly. The letters themselves are formed of double plates of highly-polished nickeled brass, each plate being insulated from the other, as in the case of the carrying bar, and fitted at the bottom with spring socket pieces. These socket pieces fit fairly tightly inside the double-carrying bar, and thus connection is made in supplying the current to both plates. The lamps are small miniature lamps with a loop filament, and have been designed specially for this sign. They work at 10 volts, and are fitted with a double socket, this being formed of a combined screw cap and plug. The two plates of the letter carry a number of holes corresponding to the number of lamps forming the letter. The front holes are cut with a screw thread. This takes the screw-socket cap of the lamp. The back plates carry smaller holes, in which the plug of the lamp socket fits, thus making a perfect connection between the two plates.

Our drawings indicate the construction and operation of the Chapman automatic voltage regulator shown at this stand. The principle on which this regulator works is the automatic adjustment of a resistance placed in the field magnet circuit of the generator. The regulator consists essentially of three parts—a rheostat, a working solenoid to operate the rheostat, and a relay to detect any slight variation in voltage. According to the size of the generator to be governed, the rheostat is composed of from one to four sets of coils, each being connected to a set of segments numbering from 41 to 61 in a set. German silver is the material used for the coils, which are stretched between slate plates. The segments of the rheostat are made of rolled copper, and are arranged on top of the working solenoid, side by side, insulated by mica, and resemble a flat commutator. A German silver brush moves over the upper surface of the segments, and is operatively connected to the core of the working solenoid. The working solenoid (see illustration) consists of two differentially-wound coils of wire mounted on a brass tube. Inside of the tube is an iron core, cone-shaped at either end, and adapted to serve a double purpose, that of a magnetic movable core, and that of a piston in a cylinder. The ends of the tube are closed, and the space inside the tube at each end is filled with oil. It is clear that the core can move only as it displaces the oil. A passage way is provided for the oil to pass from one end to the other, and a valve is arranged in the passage for adjusting the freedom of flow of the oil. As may be gathered from the illustration, the vertical plunger is controlled by a small thumb nut. By this means the rapidity of movement of the core may be checked to any desired extent to adapt the movements of the regulator to the characteristics of the particular generator to which it may be connected. The valve should be set just tight enough to prevent "hunting." Each of the two coils composing the working solenoid are made up of three sections of wire; an inside section, an outside section and a middle section. The inside section and outside sections are connected as one, and the number of turns of wire in the two together is exactly equal to the number of turns of wire in the middle section. Under normal conditions, with the relay balanced, there is a current flowing only through the middle section of each coil. This magnetises the core strongly and pulls it equally in opposite directions, so that it remains indifferently in any position where it happens to be.



Section through the Working Solenoid.

The relay has two platinum contacts. Should the voltage rise 1 per cent., the relay armature abuts against one of the platinum contacts, thus admitting current to the inner and outer section of the coil at the right-hand side of the regulator; this exactly neutralises the magnetic effect of the current already in the middle section of that coil, and the core then moves in response to the pull of the middle section of the left-hand coil. If the voltage drops 1 per cent. below normal, the relay makes contact on the other side and the core is pulled the other way; and since the sections of the large solenoid are exactly balanced against each other, the effects of self-induction are entirely neutralised, and there is no spark at the platinum contact points.

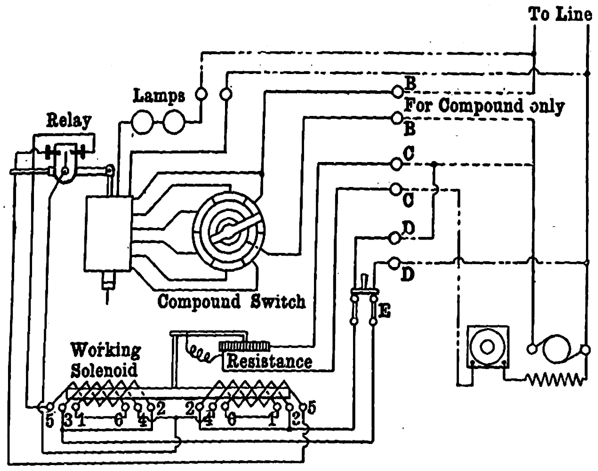


Diagram of Connections of the Automatic Regulator.

A new idea in electrically-controlled door locks was also shown at this stand, the apparatus being capable of attachment to any existing lock, a slight alteration only being necessary in the catch into which the lock fits on the door frame. A spring catch is fitted instead of the ordinary fixture, and this is drawn back by two small magnets fitted into the door frame, thus leaving the door free, practically, to open by itself. The apparatus can be worked from an ordinary electric bell circuit, and special usefulness is claimed for it for tradesmen's entrances, lodge gates, &c. A new patent friction clutch for use with electric motors was also shown. This works with springs, and allows the motors to get up speed before full-load is applied. The whole of the load can then be put on gradually by means of a lever. There was also a very fine display of miniature electric lamps and all kinds of fittings in brass and bronze.

(*To be continued.*)

## THE SINGLE-PHASE RAILWAY IN PRACTICAL OPERATION.*

In order to show with what success, from an operating point of view, the several single-phase railways now installed in this country have met, an account is given below of operating experience with the three equipments of this kind which for some months have been in regular service.

*Schenectady-Ballston Line.*—This line (of which a full description was published in *The Electrician*, Vol. LII., p. 826), has been in practically continuous operation during the past year for the stated purpose of determining just what defects would develop in actual service. It is worthy of note that, although the armatures differed inappreciably from those used in direct-current practice and were provided with no auxiliary means for preventing sparking, they have given excellent satisfaction. The effectiveness of the initial design may be learned from the fact that the new motors which are now being installed differ from the earlier ones practically in respect only to the speed. The first motors operated at a normal speed of 1,500 revs. per min., while the motors of the latest equipment have been designed for 1,350 revs. per min. This change has been found desirable on account of the short life of the brushes at the higher speed. It will be recalled that the low voltage for the motors on the initial equipment was obtained from a single tap of an air-cooled transformer, the motors being operated on the series-parallel method, with and without resistance for variations in speed. On the equipment now being installed, the motors are connected permanently four in series, and the control of the speed is accomplished by varying the E.M.F. impressed upon the circuits of the motors. The variable voltage is obtained from five intermediate points on an oil-insulated self-cooling auto-transformer, referred to as a "compensator." The object in changing from an air to an oil transformer has been to avoid the dust and moisture which was found to collect in the ventilating ducts in the air-cooled transformer. The oil transformer differs inappreciably in design from the standard stationary apparatus, except that it possesses only a single winding, and is mounted under the car in such a position as to occupy the least possible space in the vertical direction. The oil is contained in a strong, well-corrugated sheet steel case, which is held in place by means of rubber washers which serve to deaden the shock due to the attempted movement of the liquid when the car is accelerating or retarding.

An interesting feature of the equipment is found in the method used for changing from one tap on the auto-transformer to another without opening the circuit to the motors or short-circuiting the intervening coil on the transformer. In passing from a tap to the one next higher in voltage, an impedance is first connected between the two taps. Then the connection to the lower-voltage tap is broken, leaving the impedance in series with the motor circuits. Finally the impedance is short-circuited, leaving the motor circuits connected directly to the higher-voltage tap. It may be of interest to observe that if the impedance is of such a value that when connected between adjacent transformer taps it takes exactly the same amount of current at the same lag-angle as do the motor circuits when connected to the lower-voltage tap, then there will be absolutely no change in performance of the equipment and no sparking whatsoever in the controller when the lower voltage tap is disconnected. There is an increase in current and a corresponding change in acceleration when the impedance is short-circuited, but the sparking in the controller is practically eliminated. The impedance referred to consists of the blow-out magnet coils for each tip of the controller and a certain additional resistance. It is evident, from the description just given, that the blow-out magnets are in circuit only when the controller is being changed from one running position to another. A notched wheel on the drum shaft serves to ensure that the controller will not be left in an intermediate position, so that the energy lost in the preventive impedance is practically negligible.

One of the objections which have been urged against the use of a high-potential railway relates to the fact that, in the event of sand or other good insulating substance being upon the rail, the circuit to ground would be incomplete while the metallic frame of the car would be at the potential of the trolley wire, thus introducing a serious danger element. This danger has been eliminated in the recent installations by the use in the high potential circuit of a main-line switch which remains closed only when the circuit to ground is complete. This switch, which is of the oil type and closed by hand, is provided with a retaining coil which receives its current through a circuit entirely independent of the motors, and which loses its strength when the wheels of the car are insulated from the rails. A characteristic difference between the single-phase motor and either the direct-current or polyphase motor is found in the fact that while the torque of the first machine pulsates with twice the frequency of the alternating current, the torque of each of the other machines is relatively constant. It is evident that the maximum torque exerted at the rim of the car wheels cannot be allowed to exceed the maximum adhesive force between the track and the rails. Since only the average torque is effective in producing acceleration, it would seem that for the same maximum acceleration the single-phase equipment must be much heavier than the direct-current or the polyphase—in fact, if certain modifying features be neglected, it is theoretically impossible for the single-phase motor to produce an acceleration as high as the other machines. Experience has shown that the single-phase motor can be so suspended through springs that the theoretical maximum torque of the machine never reaches the wheels, and the maximum average accelerating torque is but slightly less than that corresponding to the adhesive force at the rails, and the acceleration actually obtained compares favourably with that found in direct-current practice. As was the case in the earlier installation, the latest equipment has also been designed for operation by either direct or alternating current. A change has been made in the new equipment in that for direct-current service the four motors were formerly placed in two groups of two motors in series, and these two groups were connected either in series or in parallel, while in the new equipment all motors are connected permanently in series and plain rheostatic control will be used. It is evident that the elimination of the series-parallel feature of the controller serves to simplify the cross-connecting circuits of the car.

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* From the *Electrical World* of New York.

It is believed that the particular service for which the single-phase equipment is preferable to the direct current is in connection with long-distance inter-urban work, in which direct current will be used only within the city limits where slow speed will be necessary. Obviously such work would seldom require the motors to be placed in parallel. In regard to the disadvantage of having motors in series when the wheels of one may spin and thereby rob the others of sufficient power for acceleration, it is to be noted that the wheels tend to slip only when the car is first started from rest, under which condition the accepted practice with direct-current equipments is to have all of the motors in series. Since the armature of that motor which spins is subjected to an excess of E.M.F., it is necessary to provide each motor with insulation to withstand the highest voltage. It is to be noted, however, that the value of the current to be commutated under such conditions is even less than normal. The motors are of the conductively-compensated series type, and hence are at once operative by either direct or alternating current. For alternating-current work it is desirable to have the fields very much weaker than for direct-current work. For this reason the field coils of each motor are divided into two parts, which are placed in parallel for alternating current and in series for direct current. The commutating switch, which is employed for making the changes in the connection of the field coils, serves also to substitute the rheostatic for the variable-voltage control as desired, and to insure that the main oil switch to the auto-transformer is open when the direct-current connections are made, and to hold the main direct-current switch open when the auto-transformer is being used. The half-field circuit of each motor is connected in series with the corresponding half circuits of the other motors, thus forming two separate field circuits for the four motors. The four armatures and the four compensating coils respectively, are permanently connected in series, making only one armature circuit and one compensating circuit for the whole equipment. Since the change of the field circuits from series to parallel connection is accomplished by means of the commutating switch, the wiring of the reversing drum at the controller is as simple as though it were intended for a single motor. The motor for driving the compressor of the air-brake equipment is of the same type as the main-car motors, and is provided with two field circuits, which are placed either in series or in parallel by the commutating switch, according to the character of the current by which it is to be driven. This motor is so designed that when the field circuits are in series it may be operated from the direct-current trolley circuit. This line was electrically equipped by the General Electric Co. of America.

*Indianapolis-Rushville Line.*—The line of the Indianapolis and Cincinnati Traction Co., between Indianapolis and Rushville, Ind. (see *The Electrician*, Vol. LIV., p. 787), which began operation early this year, is at present the most important of the several single-phase roads in the United States. It is a road operating very heavy cars at very high speeds, the cars weighing about 48 tons and running at maximum speeds of about 70 miles per hour. Most of this 40-mile road is on a private right-of-way, with a 3,300 volt trolley hung from a catenary wire supported by brackets. The transmission voltage is 16,500. In Indianapolis the cars operate from the regular 525 volt, direct-current trolley circuit. Each car is equipped with four Westinghouse series commutator motors rated at 75 H.P. each, with compensating field windings. Electro-pneumatic train control is employed. For direct-current operation in the city of Indianapolis, rheostatic control is provided. For operating on alternating current, voltage control is obtained by using two different taps from the transformer.

The motors have field cores of laminated iron, which fit inside an outer casing of cast steel, which forms the frame of the motor. The field poles are slotted like the stationary armature of an alternator. The main field coils surround the field poles in the usual manner. The compensating windings occupy the slots in the field poles, so that they overlap the field coils. Thus one side of a compensating coil occupies a slot in one pole piece while the other side of the coil occupies a slot in an adjacent pole piece. The armature is lap wound and therefore has cross-connections like many generator armatures. The armature winding is connected to the commutator by spark-preventing leads of German-silver bars which have the same function as the preventive resistance used in many forms of alternating-current controllers. These leads extend the length of the armature and are placed in the bottoms of the coil slots. The copper windings are connected to the German-silver commutator leads at the opposite ends of the armature from the commutator, at which point the cross-connections are placed. A sliding-contact bow trolley is used in the country on the high-tension trolley wire. The ordinary wheel trolley is used in Indianapolis. The bow has a flat contact surface 4 ft. long by 5 in. wide, made of an aluminium alloy. It is raised and held against the wire by compressed air.

The results of the first eight months of operation of this road are such as to be most gratifying. Although there have been troubles, as there always are when new devices are being tried for the first time on a large commercial scale, these have all been of minor importance. The important and fundamental troubles, which were most to be feared, have not shown themselves. Sparking at the commutator seems to be less, if anything, than on direct-current railway motors. Practically all of the troubles experienced can be traced to the necessity for haste in getting out apparatus in order to place the road in operation in a specified time. For example, the motors used were intended for operation by 250 volt alternating current with a non-grounded circuit, or, in other words, on a purely alternating-current system, such as first outlined by the Westinghouse engineers. Operating these on a 500 volt grounded circuit, as was necessary in this case, resulted in a number of motor burn-outs, due to insufficient insulation. This trouble was stopped by re-winding the motors with heavier insulation. It is not one that is inherent in the system and there is no reason to expect further unusual trouble from this source. Tests made to determine the heating of these motors in service show that they are within the safe heating limit. The trouble, therefore, was due entirely to insufficient thickness of insulation.

The sliding-contact bow trolley is proving an entire success, and has required much less experimental work to perfect it than was expected. The wearing surface has probably as long a life as would be the case with a trolley wheel under the same service conditions—namely, on 48-ton cars running between 60 and 65 miles per hour, and perhaps even longer. The life of the wearing surface is from one to two weeks, and there is a strong probability that it can be increased by staggering the trolley wire more than at present. The tendency now is to wear grooves in the bearing surface. Even if the sliding bow did not possess a life as long as the trolley wheel, the freedom from the possibility of its leaving the wire at high speeds makes it immeasurably superior to the wheel trolley. The wearing surface of the bow trolleys consists of three pieces of aluminium alloy fastened to a wood back. Two angle pieces which form the edges have about 1 in. width of wearing surface. There is a flat plate 3 in. wide in the middle. Between the pieces is left a large crack in which grease is placed. The whole wearing surface is liberally greased when in service. These contact plates would last much longer if the wear were more evenly distributed over them. At present a groove usually wears through at one point. By putting in a new piece at this point but little material is needed to make the contact surface nearly as good as new. The insulators which support the catenary cable are in saddles which can be moved either way from the centre. Owing to the necessity of operating with the common wheel trolley when the road first started, the trolley wire has not been staggered as much as is possible. The aluminium wearing plates weigh about 5·5 lb., while a brass trolley wheel weighs about 4 lb.

The cars, as now operated when on the 3,300 volt lines, accelerate more slowly while starting than is usual with direct-current cars. The acceleration is very similar to that of a steam train of five or six cars. The acceleration has been placed at a low value in order to reduce the maximum current at the power station. During the latter stages of acceleration the rate of acceleration is more rapid than is frequently found on direct-current lines because of the low line losses. The time tables show that these cars make the fastest schedules of any cars leaving Indianapolis. Express trains make the run of 40 miles from Rushville to the centre of Indianapolis in 1 hour 30 minutes. Local trains make it in 1 hour 50 minutes. The car equipments have been somewhat improved, lighted and simplified since the inauguration. In passing from direct to alternating current or the reverse it is only necessary to change from wheel to bow trolley and to throw two small switches in the cab. One of these switches is a part of the master controller and effects the necessary changes in the connections of the control circuits, and the other is an ordinary single-pole double-throw knife switch, which controls the lighting and pump motor circuits. The air pump motor operates like the main motors on either direct or alternating current.

After all is said and done, the surest indication that the single-phase system is believed by the owners and engineers of this property to be the best for the purpose, and that it is more satisfactory than a direct-current system for these conditions is the fact that the company has decided to equip its line from Indianapolis to Shelbyville with the same system. This line is at present a direct-current road which has been in operation several years, and was recently bought by the Indianapolis & Cincinnati Traction Co. The decision to replace the direct-current system on the Shelbyville line with the single-phase alternating-current system was reached only after full consideration by the management of the company and upon recommendation of their consulting engineers. Although this change involved the throwing out of considerable direct-current apparatus, the advantages of the single-phase system were considered by the engineers as ample justification for this move. When the Shelbyville division is changed and the extensions now under way have been completed, the company will own over 100 miles of single-phase trolley wire.

*Pontiac-Odell Line.*—The Bloomington, Pontiac and Joliet Electric Railway is a single-phase road equipped by the General Electric Co., which began operation between Pontiac and Odell, Ill., a distance of 10·4 miles, on March 15, 1905. The most notable thing about the operation of this road is the uneventful way in which it has maintained its regular schedules from the beginning without any mishaps. From March 15th until about August 1st there was but one car. This left no equipment as a reserve until the second car arrived in July, but the regular schedule of eight round trips per day between Pontiac and Odell was maintained without interruption. In other words, over 23,000 miles was made by this first car in regular service before it was possible to take it off the road to make any repairs that could not be attended to between 9 p.m. and 7 a.m. For over two months there was no car shed, so that inspection and repairs had to be carried on out-doors. This would have been an unfortunate state of affairs had the equipment required much care, but as it did not require this care it speaks more for the satisfactory operation of the equipment than anything else that can be said. Of course, small minor improvements suggested themselves, but on the whole there is very little to say about the performance of the single-phase equipment on this road for the reason that it has behaved itself very much as would be true of any good direct-current equipment operating under the same conditions. The car makes a round trip of 20·8 miles between Pontiac and Odell in one hour. The first car had motors similar to those on the Schenectady-Ballston line, where this type of motor was first tried. The second car has an improved motor and a different method of control. The first car carried a step-down transformer. This transformer had various taps from the secondary. The controller was arranged to start the motors with a low-voltage tap, and gradually increase the voltage by changing the connections to higher-voltage taps. To avoid short-circuiting the transformer section between taps at the instant of moving from one point of the controller to the other, a resistance was momentarily placed in series at the instant a section of the secondary was cut in or out. This resistance was in circuit only between the controller points. The new controller is similar to the old except that a compensating coil is used instead of a transformer, and various taps are taken from the compensator to the controller. The new equipment is such that it can be readily adapted to operate also on a direct-current line by the addition of throw-over commutating switches and resistance.

The catenary form of overhead construction is used on this line. Cars are equipped with the ordinary trolley wheel. The original intention was to support the trolley wire from the catenary wire at intervals of 10 ft. As yet much of the line is equipped with supports only midway between the poles. The arrangement seems to work very well. The current is taken from the trolley base in iron-pipe conduit to an oil switch located under one platform and from thence to the compensator. The lightning arrester and fuse box are located on top of the car. The new car weighs complete about 31 tons and is 41 ft. overall. The acceleration for the first two or three seconds is not nearly as rapid as with direct-current equipments, but after that the speed increases fully as rapidly as in ordinary direct-current practice.

To sum up, it can be said that this little road in the first six months of its operation has had a car-mileage of over 30,000 miles. It has carried over 60,000 passengers, making schedule speeds including layovers at terminals of 20·8 miles per hour. This is a type of road where economy in construction was of first importance as the population per mile of track did not justify expensive construction. When completed from Pontiac to Dwight the road will be about 20 miles long. The cost, as nearly as can be judged, will be considerably less than for an equally well constructed direct-current road of the same length.

**Thunderstorm.**—An unseasonable thunderstorm occurred at Panxworth, Norfolk, on Sunday afternoon. Three boys sheltered under a tree which was struck and one boy was seriously injured.

## USES OF ELECTRICITY IN MINES.*

BY HENRY WILLOCK RAVENSHAW.

### LECTURE II.

In my last lecture I went into the question of electrical transmission of power. I will now take a few of the minor applications, some of which, such as signalling, are almost of equal importance.

*Electric Lighting.*—The electric lighting of a colliery is generally independent of the power plant, and, as a rule, a continuous service is maintained. A pressure of 220 volts direct current is usually employed, and the shaft cables (in some cases 600 yds. to 1,000 yds. long) have to be of ample section to prevent an undue drop of pressure. As a man is required to attend to the ventilating fan engine night and day, the electric-lighting dynamos are frequently so placed that he can look after them. Owing to the large amount of dust from the surface works, and the general dampness of the atmosphere due to steam from the exhaust of the winding engines, it is very difficult to maintain a good insulation resistance on the surface. It is, therefore, excellent practice to have a separate dynamo for supplying the underground lighting. It is a curious fact that even in a damp mine it is easier to maintain a good insulation underground than on the surface. Where motors are used at a considerable distance from the pit bottom, it is very convenient to light their engine rooms and the adjacent roadways by lamps, in series, on the power mains. Electric accumulator lamps are sometimes employed, but they are not very largely used, the extra weight and first cost being against them.

For officials and inspections, small dry battery hand lamps are very convenient as an auxiliary to the ordinary safety lamp. Electricity has also been applied to the lighting of the ordinary oil safety lamps, and Messrs. Johnson, Clapham and Morris have kindly lent me a lamplighter which shows the expedition with which a number of lamps can be lighted. The arrangement consists of a single-cell accumulator, and each lamp has a short piece of wire close to the wick connected to studs which can make contact with the battery circuit. When the current passes through the wire it becomes incandescent, and lights the lamp. When the men are going down the pit, a very large number of lamps have to be lighted for them, and as they all have to be sealed and examined a great deal of oil is saved where an electrical arrangement can be used to light each lamp as it is issued.

*Signalling.*—The earliest forms of signalling were by word of mouth, and in some pits in Belgium this custom survives in the form of a short prayer for their safety, which is sung out by the banksmen when men are descending. In some parts of Durham the banksman sings out, "throw nought down." The somewhat primitive "rapper," where a hammer is lifted by a wire, and allowed to drop on a piece of loose iron plate, is still largely used, but for long distances these have to be worked by relays of men, and the work is very arduous. Electric signalling bells have now become very popular, and in some cases as many as 20 primary cells are used on a circuit. In order to prevent danger from sparking at the contacts, the new Home Office rules limit the pressure on signalling circuits to 15 volts in fiery mines. The bells and keys are generally fitted so as to be dust and damp tight. On roads where mechanical haulage is employed, two bare wires are stretched overhead at such a distance that they can be pinched together with the hand. These wires are connected to a bell circuit so that signals can be transmitted from any point on the roadway to the engineman. The cost of primary batteries in a large colliery is considerable, and amounts to as much as £80 a year for material alone. Telephones are largely used, but it is remarkable that until quite recently a large number of collieries were not fitted with them.

*Shot Firing.*—Two systems are in general use for electrically igniting the fuses—namely, the low tension and the high tension. In both cases magneto-generators are generally used which are turned by hand, but, in the case of shaft sinking, shots are frequently fired from the lighting circuits. In the case of the low tension, the current heats a fine platinum wire which fires the detonating charge. A pressure of only a few volts is employed, and when several shots are to be fired the fuses are arranged in series. With this system it is possible to test for continuity of circuit, but this advantage is somewhat discounted by the fact that it is practically impossible to distinguish between a complete circuit and a short circuit. Batteries, either primary or secondary, are sometimes used for low-tension fuses. With high-tension ignition the points are a short distance apart, and they are generally coated with conducting and inflammable chemicals. A pressure only of from 30 volts to 150 volts is required, and it is probable that an arc is actually formed. In this system the fuses are arranged in parallel. High-tension fuses are somewhat cheaper than low-tension, and appear to be the more popular with the officials who have to use them.

*Alternating and Direct Currents.*—Both direct and alternating currents have been largely used in mines with success, but experience points to the fact that the alternating system is the more suitable. Where large powers are required, the difficulty in breaking heavy direct currents in enclosed boxes is very great; oil switches cannot safely be employed owing to the quick break causing a heavy rise of potential in the circuit, and the same objections apply to magnetic blow-outs. With alternating currents oil switches can be safely used, and this one point alone is sufficient to give that system a great advantage. The absence of brushes and the possibility of using squirrel-cage rotors is also an advantage, although the modern motor gives very little trouble at the commutator. High pressures have no great advantages for use inbye, as the distance from the distributing centre is not, as a rule, more than 2 to 3 miles, or well within the economical limit for a pressure of 500 volts.

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* Cantor Lectures delivered at the Society of Arts.

*Precautions.*—It is of absolute importance that the safety of the mine is ensured, and a very long step towards immunity from accident is to put down a first-rate plant in the first place. In a colliery where capital expenditure is of necessity kept low, there is a temptation to buy in the cheapest market. Electrical machinery, however, has been reduced in price to a remarkable extent, and there is no possible excuse for those responsible risking the lives of men in their charge by purchasing in the very lowest market. I speak strongly on this question, as I have seen a great deal of dangerous rubbish in use, and I am glad to say that the report of the Home Office Committee made a very strong point of this question.

Next to a good plant, proper maintenance is of the greatest importance, the insulation of every detail being properly maintained. All plants, particularly in safety lamp mines, should be systematically and independently inspected several times a year. In safety lamp mines motors should always be placed in the intake air, and in my own practice, whenever possible, the motor room sare used as lamp-lighting stations, so that special precautions are taken to keep them free from gas. The question of enclosed motors is an important one, and the experiments made by Mr. W. E. Garforth, and described by him in his evidence before the Home Office Committee, appears to me to cover the whole ground. The experiments are fully described, with eleven fine photographs, in the minutes of evidence taken before the Committee, and the conclusions arrived at are as follows: It is possible to run an entirely enclosed motor, the covers being machine faced and efficiently gas tight, in an explosive mixture for one hour without ignition. An unenclosed direct-current motor will ignite gas. If an enclosed motor is surrounded for 14 hours by an explosive mixture the gas may diffuse into the case and cause an internal explosion. The internal explosion above-mentioned will not of necessity ignite the external mixture.

*Home Office Committee and Rules.*—In 1902 a committee of six members was appointed by H.M. Principal Secretary of State of the Home Department to inquire into the use of electricity in coal and metalliferous mines, and evidence was first taken on November 26, 1902; 6,958 questions were put to the 57 witnesses who were invited to give evidence. A report* was issued on January 19, 1904, including a code of rules which it was suggested should be adopted. Special rules,† which differed considerably from those originally suggested, were issued in February, 1905, by the Home Office, and these are now in force in this country.

Although any new regulations are sure to cause a certain amount of hardship on those who come within their sphere, colliery owners having properly-installed plants have been put to very little expense in complying with the new rules. Rule 6, Section III., which requires that leather or other flexible material shall be used for suspending cables underground, is the only one which is likely to cause any real hardship. This rule is of somewhat "cast-iron" character, as hundreds of miles of cables are already fixed up by cleats, and in many places, especially where there is very little room, competent colliery managers are of opinion that a flexible suspension is not suitable.

I have already pointed out the importance of the proper maintenance of insulation, and the new rules require that this point should be specially safeguarded. Rules 6 and 7, Section I., require that the leakage current shall not exceed one-thousandth of the maximum supply current, and earth detectors are required to be connected up to show immediately any defect in the insulation of the system. The readings from these instruments have to be recorded daily. The leakage current permitted does not err on the side of stringency, as in a properly-maintained plant it should not exceed one ten-thousandth. The detector specified has presented a difficult problem to the manufacturers, but they have risen to the occasion and produced instruments which comply fairly well with the specification. None of these instruments actually comply with the letter of the rule, but they usually show when there is a serious leak, and by actuating a small switch the pole can be located and a fairly accurate measurement obtained. The simplest arrangement for direct currents is perhaps that shown in Fig. 10, where a high resistance is connected across from positive to negative pole, and the centre connected to earth through a sensitive polarised instrument. To obtain the insulation resistance one side or the other of the resistance is disconnected, and the deflections noted. To obtain an accurate result, a calculation must be made from the two readings, or better still, a table can be used from which the results can be read.

This system does not accurately show leakage in all cases, without a certain amount of manipulation, as for instance, where the insulation resistance of both poles, whether high or low, is equal, no deflection is shown. If properly used, however, the arrangement is a great safeguard against mishap. For three-phase circuits, Mr. Raphael proposes to make a star connection between the phases through high resistances, connecting the centre through an instrument to earth. By disconnecting the phases in rotation the earth can be located. This instrument has defects somewhat similar to that for direct currents, but they are both in advance of their predecessors. The following rules may be noted: Where safety lamps are required the pressure is limited to 650 volts and under. Telephone communication has to be maintained between the surface and the distribution centre. Open motors are allowed in properly ventilated places. The pressure for signalling circuits is limited to 15 volts. (There are 56 rules divided in 11 sections.)

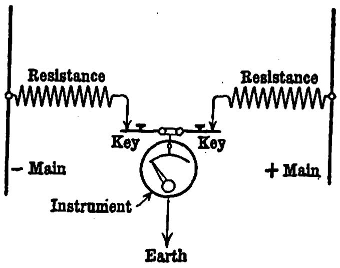

FIG. 10.

*Costs.*—The questions of capital expenditure and running cost are of the greatest importance, and it may be safely said that where proper economy has not been exercised in putting down a plant, there will be likely to be found heavy working costs and unreliable running. For colliery work the plant must be of the highest quality, but simplicity of design is of the greatest importance. Where steam engines are used an excellent electric generating plant, suitable for a works or colliery, can be put down for £22 per kilowatt output. A gas engine plant using coke or anthracite would cost £24 per kilowatt, and if coke oven gas is used £22 per kilowatt. An exhaust steam plant of the Rateau type would probably cost from £18 to £20 per kilowatt. These figures are taken from actual practice and make no allowance for spare plant. A margin of about 20 per cent. is generally allowed for spares. Depreciation and interest on capital expended are items that are of the greatest importance in calculating costs, and it is an astonishing fact that until quite recently the question of depreciation has been practically ignored by many of the large electricity supply undertakings. Municipal authorities have actually borrowed money to be repaid in from 30 to 40 years to purchase machinery that has become obsolete and been sold for practically scrap price in less than a third of that time.

In commercial undertakings of high standing this question is always taken into careful consideration, and true costs cannot be obtained unless at least 5 per cent. be allowed for depreciation and 5 per cent. for interest on capital. Where there is a low power factor, which is usually the case with a public supply, these items will be found to exceed considerably the total working costs, but in a mine where the first costs of a generating and distributing plant are comparatively low and a good load factor is generally maintained, interest and depreciation should not exceed 0·25d. per unit.

With regard to coal consumption, it must be remembered that, although coal may be cheap, boilers cost money to put down and maintain I have gone rather thoroughly into this question, and I find that, on an average, for every ton of coal burnt the costs for labour, boiler repairs, depreciation and interest on capital amount to at least 2s. 6d., consequently, even if the coal cost nothing, a ton saved per day would mean a saving of at least £40 per annum. In large collieries from 50 to 80 tons a day are burnt under the boilers, and in many cases it is practically certain that this consumption could be reduced by one half.

The following consumptions, if obtained all the year round, are not likely to be improved on with a 200 kw. plant working 16 hours a day: Steam engines, 5 lb. per kilowatt gas engine with anthracite, 1·85 lb. per kilowatt; gas engine with coke, 2·25 lb. per kilowatt.

The costs with a good load factor should not exceed:—

| | |
|---|---|
| Coal and boiler or producer charges .. | 0·20d. per unit |
| Labour, stores, repairs............ | 0·15d. ,, |
| Depreciation and interest .......... | 0·25d. ,, |
| | 0·60d. |

With a plant of double the size, the costs can be reduced to 0·5d. per unit. When it is considered that with a 200 kw. plant working for 10 hours a day, a saving of $\frac{1}{10}$d. per unit means £250 per annum, the importance of economy is evident. The fact that the cost of electrical machinery has been enormously reduced in the last 10 years is of great advantage to power users, and has given an enormous impetus to electrical transmissions. A slow-speed 40 H.P. motor which used to cost £220, can now be bought for £100, or about £2. 10s. per horse-power, a great contrast to high-steam engines which cost about £5 per horse-power.

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* *The Electrician*, Vol. LII., p. 608.

† *The Electrician*, Vol. LIV., p. 756.

In putting down an electrical power plant the cost of the generating station must be considered, but it is an interesting fact that where there are a good many motors working on variable loads the demand seldom exceeds one-half of their aggregate maximum capacity. For instance, a 500 H.P. dynamo will generally be sufficient to supply current to 1,000 H.P. of motors. I am convinced that a colliery of fair size can generate electricity for its own use at a considerably lower rate than a public supply can afford to sell it at a profit, if a proper allowance is made for depreciation in both cases.

The history of this application hardly goes back further than 20 years, and I am glad to say that practically all the pioneers are still hard at work. Mr. Frank Brain, of Trafalgar Collieries, in the Forest of Dean, is probably the earliest pioneer, as he used electric signals as far back as 1866, and an electric pump in 1882. Most of the early work from 1885 to 1891 was done in this country by Messrs. Immisch, Scott & Mountain, and Goolden & Co., and I can recall the names of Messrs. L. & C. Atkinson, Selby Bigge, S. Corlett, M. Deacon, W. C. Mountain and Albion Snell as being prominent workers in those days.

The advantages of the use of electricity in mines is in many cases obvious, and it is certain that, as new collieries are opened out and old ones reorganised, the electric motor will be almost universally used; in fact, I feel fairly safe in saying that where compressed air has to be used the air compressors of the future will be electrically driven in the mine itself. With regard to winding, a great deal has to be done in devising simple and economical electrical methods before they are generally adopted, but it is more than likely that this class of plant will be of great importance in the future. Electrical driving is being almost universally adopted all over the world for its all-round economy and convenience, and these advantages are being rapidly appreciated among mining engineers.

## PHYSICAL SOCIETY.

At a meeting of the Physical Society on Friday, October 27th, Prof. J. H. Poynting, F.R.S., President, in the chair, a Paper on

### "The Theory of Phasemeters"

was read by Dr. W. E. SUMPNER. Phasemeters are instruments of the dynamometer type for indicating the phase relations of the currents and potentials in alternating-current circuits. With few exceptions, they are made for use on multiphase circuits. Such instruments consist essentially of two sets of coils, of which one set is fixed and the other forms a single moving system which is not provided with any form of control. The currents in one set of coils are determined by the voltages of the main circuits; while those in the other set are produced by the circuit currents. With rare exceptions the magnetic circuits of phasemeters are air-circuits, containing no iron, so that the magnetic fields associated with them are weak, and the instruments in consequence are of somewhat delicate construction. There, however, appears to be no reason why the use of iron should be avoided in these instruments, and the author shows in the Paper that the theory of the instruments is the same whether they contain iron or not and however the coils may be arranged; that they can be calibrated by direct current methods, although for use on alternating-current circuits; and that a new type of instrument, containing iron, conforms to the theory given. In all the cases considered, it is assumed (1) that the induction density at any point due to the current $\mathbf{A}$ in a fixed coil is represented by $\mathbf{A}$F, where $\mathbf{A}$ is the instantaneous value of the current A, and F is a quantity dependent merely on the coil and the position of the point considered, and (2) that the principle of superposition holds—viz., $\mathbf{B} = \mathbf{A}_1 F_1 + \mathbf{A}_2 F_2 + \mathbf{A}_3 F_3$, where $\mathbf{A}_1$, $\mathbf{A}_2$, $\mathbf{A}_3$ are the currents in the three fixed coils, and the quantities F are functions of the position of the point corresponding to these fixed coils. The author shows that these assumptions hold good even when the path of the lines of force lies partly through (suitably laminated) iron, and it is necessary to consider the effect of varying permeability and hysteresis. The main results of the investigation are:—

1. Phasemeters for multiphase circuits are all equally accurate on balanced loads provided they have been correctly calibrated and possess no faults due to purely mechanical causes. Their accuracy is not affected by variations in wave form or in current frequency. The calibration of the scale is affected by the number of coils used in the instrument, by the ratios of the ampere-turns used with these coils, by the distribution of the windings and by the magnetic nature and properties of the magnetic circuits, especially if these contain iron; but the accuracy of the indications is not dependent upon any of these considerations, if the working of the instrument is satisfactory from a mechanical point of view.

2. Phasemeters can be simply and accurately calibrated for balanced loads by means of a direct-current method of test.

3. The error of phasemeters on unbalanced circuits is generally serious for loads which are badly out of balance. The error, like that of a wattmeter, increases rapidly as the power factor of the load diminishes. It can only be reduced at the expense of complication in the instrument, by increasing the number of coils used in the fixed and moving systems, and by arranging the coils and magnetic circuits to be symmetrical in regard to one another. If the true power factor of the load is $\cos\phi$, the reading of the instrument is

$$\cos\phi + \theta \sin\phi,$$

where $\theta$ is the phase error due to the unbalanced load, and is the product of two factors, one of which is the maximum value of $\theta$ determined by the amount the load is out of balance, and the other may have any value between $+1$ and $-1$ and determines whether the instrument reads high or low.

The secretary read a letter from Mr. A. Russell referring to one of the fundamental assumptions made by Dr. Sumpner. The magnetic force $\mathbf{B}$ at any point on the conductor of the moving coil had been represented by $\mathbf{A}_1 F_1 + \mathbf{A}_2 F_2 + \mathbf{A}_3 F_3$, where $F_1$, $F_2$ and $F_3$ were considered constant. The instantaneous value of the magnetic force at any point was the resultant of the three magnetic forces $k_1\mathbf{A}_1$, $k_2\mathbf{A}_2$ and $k_3\mathbf{A}_3$, acting in fixed directions at that point. At any instant, therefore,

$$\mathbf{B} = k_1\mathbf{A}_1 \cos\phi_1 + k_2\mathbf{A}_2 \cos\phi_2 + k_3\mathbf{A}_3 \cos\phi_3,$$

where $\phi_1$, $\phi_2$ and $\phi_3$ are the angles between $\mathbf{B}$ and $k_1\mathbf{A}_1$, $k_2\mathbf{A}_2$ and $k_3\mathbf{A}_3$. As $\mathbf{A}_1$, $\mathbf{A}_2$ and $\mathbf{A}_3$ are not in phase with one another, the direction of the resultant magnetic force is continually altering, and thus $\phi_1$, $\phi_2$ and $\phi_3$ are functions of the time. Hence also the author's factors $F_1$, $F_2$ and $F_3$ are not constants but functions of the time, and thus the conclusions arrived at in the Paper must be modified. Dr. Sumpner's method of calibrating by means of direct currents was novel and valuable, but little confidence could be placed in the readings of phasemeters when the applied waves of P.D. did not follow the harmonic law.

Mr. A. CAMPBELL, referring to the stepped nature of one of the calibration curves obtained by the author, asked if the use of a smooth core instead of a channelled one would result in a smoother curve.

Mr. K. EDGCUMBE expressed his interest in the Paper, and said it was valuable because phasemeters were coming into general use and the literature on the subject was small. Dr. Sumpner had stated in his Paper that previous theories had neglected the question of the currents being unbalanced, but he pointed out that Punga in 1902 had described power-factor indicators and showed how they could be used with unbalanced loads. It was important to define exactly what is meant by average power factor. The author had given a mathematical definition, but a simpler definition would be that the average power factor is that quantity which multiplied by the phase voltage and the sum of the three currents gives the total power supplied to the line. A disadvantage of power-factor indicators was the difficulty of testing them.

Mr. W. DUDDELL asked if the author had assumed that the three voltages were in symmetrical phase relation, and pointed out that in practice differences of as much as 10 deg. might occur.

Dr. SUMPNER, in reply, said that in the proof of the Paper $\mathbf{B}$ was not the maximum flux, but the effective part of it, that at right angles to the direction of motion of the conductor. He was aware that it was possible to obtain smoother curves, and had partially done it by a suitable distribution of winding giving a gradually varying flux. In reply to Mr. Duddell he said he had assumed equal voltages and equal phase relations.

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"The Coal Fields of Great Britain; their History, Structure and Resources." By Prof. Edward Hull, F.R.S. 5th edition. (London: Hugh Rees.) 14s.

"Alternateurs mono-et Polyphasés; determination de la chute de tension par diagramme." By J. Rezelman. (Paris: Gauthiers-Villars.)

"Elementary Electrical Engineering." By J. H. Alexander. (London: Crosby, Lockwood & Co.)

"Fowler's Mechanical Engineer's Pocket Book, 1906." Edited by W. H. Fowler. (Manchester: Scientific Publishing Co.) 1s. 6d.

"Entwurf von Schaltungen und Schaltapparaten (Schaltungstheorie)." By R. Edler. Vol. I. (Hanover: Dr. Max Jänecke.) 6m.

Die drahtlose Telegraphie und ihr Einfluss auf den Wirtschaftsverkehr unter besonderer Berücksichtigung des Systems "Telefunken." By Dr. Eugen Nesper. (Berlin: Julius Springer.) 3m.

"Science Abstracts." October, 1905. Section A: Physics. Section B: Electrical Engineering. (London: E. & F. N. Spon, Ltd.) 1s. 6d. each.

"Die Messtechnik." By Dr. C. Heinke and Dr. J. Kollert. (Leipzig: S. Hirzel.) 20m.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

*Origin of Atmospheric Electricity.*—H. Gerdien reviews at length the theories hitherto advanced to account for the negative charge of the earth and the positive charge of the atmosphere. Elster and Geitel's theory was based upon the action of vegetation in modifying the electric field near the earth's surface, whereas Ebert's theory dealt chiefly with ionisation underground by radio-active substances, and the penetration of ions, chiefly positive, into the atmosphere. The author now shows that both these theories leave much to be desired, and advances a new theory based upon the action of ions of whatever origin as condensation nuclei. It is known that negative ions have a greater condensing action than positive ions. In any drop of rain there is as a rule more negative than positive electricity. The positive ions themselves act as condensation nuclei at a sixfold supersaturation, but the author calculates that at an approximate height of 3,800 m. above the earth's surface there is a large preponderance of negative condensation. Those positive ions that are not precipitated are repelled upwards, and when they reach an altitude of some 7,000 m. they are rapidly borne away by the high winds, and serve to generalise the positive charge of the whole atmosphere. In spite of this, there will be a minimum potential gradient over rainless districts, as is actually observed in Northern Africa.

[H. Gerdien, *Physikalische Zeitschrift*, October 15, 1905.]

*Charging Action of Röntgen Rays.*—The discharging effect of Röntgen rays has been known from the first. That they are also capable of charging bodies has been maintained by Righi and emphatically denied by others. K. Hahn has made a careful study of the whole matter, and has placed the charging action of the rays beyond a doubt. The disagreement of previous observers is due to the masking action of secondary Röntgen rays, which must be avoided to show the phenomenon in a pure manner. All bodies impinged upon by Röntgen rays acquire a positive charge. The pulse is absorbed in the body, and breaks down some valency bonds, setting free both positive ions and electrons. If the pulse is strong enough, it will project some of the ions outside the metal, and mostly the electrons, whose mass is small. Their projection leaves the metal negatively charged. The charge acquired increases for the first 20 seconds and then remains stationary. Hard rays are most effective in charging. A high atomic weight also facilitates the charge. The author believes that his results decide the controversy with regard to the nature of the $\gamma$-rays of radium. Paschen regarded these as very rapid cathode rays. Their charging action may be explained on the above consideration when they are regarded as ether pulses. They are the counterpart of Röntgen rays, and give rise to secondary cathode rays on impact.

[K. Hahn, *Annalen der Physik*, No. 11, 1905.]

*Dielectric Constant of Air.*—A. Occhialini has determined the specific inductive capacity of air at pressures up to 200 atmospheres, using a glass condenser of variable capacity for comparison and a 7 H.P. electric motor for the compression. He corroborates Mossotti's formula—

$$\frac{K-1}{K+2}\cdot\frac{1}{D}=0{\cdot}00016$$

for all pressures examined. Applying it to liquid air, he obtains 1·475 for its dielectric constant. He admits that the structure of liquid air may offer other points of difference besides mere density, but the value deduced is not far from Dewar's actual value, 1·495.

[A. Occhialini, *Physikalische Zeitschrift*, October 15, 1905.]

*Resistance of Submerged Wires.*—When thin bare silver wires are immersed in flowing water kept at a uniform temperature, and the current through them is gradually increased, the resistance decreases at first and then increases again. This phenomenon has been discovered and studied by E. Rogovski, who finds that the current for minimum resistance of a wire 0·87 mm. in diameter in water of 16°C. is 2·6 amperes. He gives a satisfactory explanation, based upon the presence of a molecular layer of water adhering to the wire. This layer prevents the temperature of the wire from becoming that of the surrounding water. It allows it to rise above it, and the resistance measured is not that of the wire at the temperature of the flowing water, but the resistance at a temperature a few degrees higher than that, and therefore greater than the value sought. When the current becomes stronger, the difference of temperature on both sides of the molecular layer increases, and when it becomes about 4 deg. the layer breaks up and allows the water to flow in immediate contact with the wire. The resistance of the wire is then the true resistance at the temperature of the water. In determining the resistances of wires at various temperatures this source of error should be guarded against.

[E. Rogovski, *Comptes Rendus*, October 16, 1905.]

*Phosphorescence of Zinc Sulphide.*—Among the substances whose luminescence is sufficiently bright for spectrophotometric study Sidot blende, or phosphorescent zinc sulphide, seems especially well suited to bring out the relationships that doubtless exist between different types of luminescence; for not only is this substance excited to luminescence by all known existing agents—light, Röntgen rays, radium rays, cathode rays, &c.—but the stimulating effect of heat, and the property possessed by the red and infra-red rays of suppressing phosphorescence, are exhibited in unusual degree. The similarity between the effects of ultra-violet light and those of Röntgen rays as exciting sources is worthy of note. In each case the chief luminescence is in the extreme violet, and is of short duration. But in each case also this is accompanied by luminescence in the green, which is relatively faint but of long duration. As is illustrated in numerous other cases, the Röntgen rays, when comparable at all with rays of light, are rather to be compared with ultra-violet light than with the rays of the visible spectrum. E. L. Nichols and E. Merritt find that the green band is most brilliantly excited by the violet, although rays from all parts of the ultraviolet spectrum are also capable of producing a considerable effect. Thus there is the same general relation between the position of the luminescence spectrum and that of the exciting light as in the case of fluorescence, and Stokes' law is violated in both cases. As regards the change of colour often observed as phosphorescence dies away, the behaviour of Sidot blende is typical, and in no case of phosphorescence is there any change in the form of the spectrum during decadence. In complex cases of phosphorescence this does not mean that the phosphorescence spectrum as a whole remains unchanged in form, but rather that the distribution of intensity in each band is unaltered. If the phosphorescence consists of several bands, it is to be expected that the different bands will decay at different rates. In fact Sidot blende itself furnishes an extreme illustration of this, for the violet bands die out in one or two-tenths of a second, while the green band persists for hours. Numerous cases in which the colour of a phosphorescent substance seems to change as the phosphorescence dies out at first appear to contradict this view absolutely. But in these cases there is either a multiplicity of bands decaying at different rates, as in anisic acid, or the eye becomes colour blind at the lower intensities.

[Nichols and Merritt, *Physical Review*, October, 1905.]

**Auxiliary Poles for Single-Phase Motors.**—According to the *Elektrotechnische Zeitschrift*, the Siemens-Schuckert Co. have been granted a Swiss patent for a new method of preventing or reducing sparking in single-phase series motors. It is pointed out in the patent specification that the voltage induced in the coils undergoing commutation by the alternating field flux lags 90 deg. behind the main current. If the auxiliary poles were in series with the armature, the flux from the auxiliary poles would pass through zero value at the time the "transformer voltage" in the short-circuited coils is at its maximum. So as to bring the current more into phase with this voltage, the auxiliary poles, together with suitable resistances and choking coils, are connected in shunt across the armature.

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## LAMP GLOBES.

In the early days of electric lighting, the consumer paid less attention than he does now to the efficiency of the lamp. Electric light was then admittedly a luxury. It was adopted in the private house and club because it was a healthier, cooler and cleaner light than gas, it was easier to light and extinguish, and it was more artistic, lending itself better to varied schemes of decoration to suit individual taste. The business man and tradesman were chiefly influenced by the great adaptability of electric light for purposes in which local concentration of light was desirable, its safety, and last, but not least, its value as an advertising medium. The latter class of consumer usually preferred plain globes, so that the brilliancy of the incandescent filament might appeal directly to the eye. In private house lighting, on the other hand, the choice lay usually between two methods. One was to fit the lamps with shades so that the light should be directed downwards, for at that time an even illumination of a room had not been easily obtainable with artificial light, and was not sought after as it is now. The other method was to swaddle up the light in shades, the object being exactly opposite to that of the shopkeeper, namely, that people should not be dazzled by the brightness of the lamp. During the past decade, however, electric lighting has been so reduced in cost that its use has been extended to those with whom economical lighting has to be the greatest consideration. Although, as was pointed out so happily by Mr. SWINBURNE in a recent lecture, it would still pay better to have electric light even if gas cost nothing, on account of the less rapid deterioration of stock and internal decorations, the class of consumer who is now in the majority is one to whom a saving in his lighting bill is of far more importance than it was to the consumer of ten years ago. He will take considerable trouble to improve the useful efficiency of his lamps; and it is to the electrical engineer's interest to assist him in this, for the gas engineer has been compelled to improve his methods of lighting by the keen competition of electric light, and the rivalry between the two illuminants is now as ardent as ever.

While the greatest advances must of necessity be made in the lamp itself, yet much may be done to improve the effectiveness of the ordinary lamp now on the market by a judicious choice of globes and reflector shades. The spread of electric light has increased the standard of illumination to which people accustom themselves, and the patchy light with strong shadows, which was formerly the characteristic of an artificially lighted room, is now generally avoided whether electricity or gas be employed. Two things are therefore important: first, that the greater part of the light should be emitted in the lower half of the sphere of which the lamp is the centre, and, secondly, that it should be diffused as evenly as possible over this hemisphere. Of course, neither of these ideas is new. Both date back almost to those early days of electric lighting when, as we have said, their importance was far less than it is now. It has always been realised that, even with the whitest of ceilings and the brightest of wall papers, a large proportion of light was absorbed by the fitting, but for a long time all reflectors were either ugly or inefficient, and neither the consumer nor the contractor could be educated up to an appreciation of "holophane" glass adequate to the high price which had to be paid for it. As a means of diffusing the light, the "frosting" of the globe was always recognised, although the consumer usually thought of this device simply as a means of shielding the eye from the glare of a visible filament. But somebody said that this glass absorbed 30 per cent. of the light—or rather it must have been a Somebody, for this announcement has remained unquestioned for many years. We have a shrewd suspicion that this test must have been made by interposing a sheet of the glass between a lamp and the photometer screen so that the reflected light was not allowed for. Tests published by Mr. Maurice Solomon on another page show that the loss is nearer 3 than 30 per cent. in a Nernst lamp, and although the tests were not made with ordinary incandescent lamps, it is evident that the difference cannot be accounted for by a better heat insulation of the frosted glass and the consequent higher temperature of the Nernst burner.

The whole of Mr. Solomon's article is of interest and of value, and we only single out this particular matter for special reference because it suggests an easy field of investigation which has been too much neglected hitherto, although it would lead to useful results. In the first place, we would urge lamp manufacturers to repeat the comparative tests between frosted and unfrosted lamps with ordinary carbon-filament lamps and with different methods of frosting. We feel confident that by this means the final blow will be given to the 30 per cent. fallacy. This could with advantage be followed by an investigation to determine the best shape of globe to obtain the maximum and best diffused light in the lower hemisphere. Some tests of this nature were published when the internal reflector and the door-knob-shaped lamps first came into fashion, and some polar curves of the light distribution of the more recent large-globe lamps with reflectors have been made recently, but something more systematic is desirable. At the recent electrical exhibition an increase in the taste for lamps of varying degrees of "crinkledness" was evident, and this may be taken as a sign that the public would not object to a change in the standard shape of the incandescent lamp if a more useful illumination would result. The matter is probably not of sufficient importance to warrant the attention of the Engineering Standards Committee, but there is no reason why the lamp manufacturers should not agree upon a new standard among themselves. It is not improbable that a better shape of incandescent lamp globe for general use than the present form could be arrived at.

# REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign book.)

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**Telegraphy.** By Sir H. W. Preece, K.C.B., F.R.S., and Sir J. Sivewright, M.A., K.C.M.G. Eighteenth impression. New edition. (London: Longmans, Green & Co.) 1905. 7s. 6d.

By dint of constant revision, "Preece and Sivewright" maintains its position as one of the best volumes of Messrs. Longmans' "Text-Books of Science Series" and the standard technical book for those who wish to undertake a study of telegraphy. The student, possessing a previous elementary knowledge of electricity, will be well grounded in the subject of telegraphy when he has mastered the contents of this text-book, and will have obtained an intimate acquaintance with land telegraphy, which, when supplemented with actual experience in practice, will enable him to become a proficient telegraph engineer. At the same time he will be qualified to read the more advanced works on particular branches of the subject, such as submarine telegraphy, and testing, a complete treatment of which is outside the province of the present volume.

In the new edition, short descriptions have been added of the Pollak-Virag system of high-speed telegraphy, and Mr. Donald Murray's improvements in the Wheatstone automatic apparatus, but neither of these are illustrated, probably because further modifications in design are expected before these systems can be taken into actual service. On the other hand, undue prominence is given to the slow working Steljes type-printer which is a reversion to the old "A B C" instrument, and more space might with advantage have been devoted to the details of the Exchange Telegraph Co.'s system and to other more recent work that has been done towards the improvement of direct-working type-printing instruments, as these, we believe, are not dealt with completely in any other book. The new chapters on paper-insulated cables and on the telegraph-switching system, recently adopted by the Post Office, and embodying the features of telephone switching which are applicable to telegraph work, are to be commended; they afford a strong contrast to the chapter on telephony which should be re-written almost entirely or else should be omitted altogether. A new chapter on wireless telegraphy has also been added.

**Leçons sur l'Électricité.** By Eric Gerard. Vol. II. 7th edition. (Paris: Gauthier Villars.) 1905. 12fr.

One of the greatest difficulties of a writer of books on electrical engineering is the revision of his work for successive editions. Especially in the case of a book covering a wide subject, the amount of revision necessary is so great that in many cases the work has practically to be re-written for each edition, or else part of it must remain out of date. This difficulty is less in the case of a text book for students than in a technical treatise for engineers, and in the former case also it is possible to minimise the labour of revision by suitable arrangement of the subject matter. Yet even books for students must contain descriptive examples taken from current practical engineering work, and these must of necessity be altered in each edition that appears. M. Gerard has been extremely successful in arranging his text book so that the revision may keep pace with the demand for successive re-issues, and his seventh edition bears little evidence that the book was written many years ago. He has evidently kept himself well informed of the progress which has been made in the various branches of the electrical engineering industry, and the students for whom his lessons in electricity form a foundation upon which to build their knowlege of electrical engineering will have little to unlearn when they enter practical life. Moreover, in his discrimination as to the amount of importance to be attached to the various sections of his subjects, M. Gerard shows a sense of proportion which is not always possessed by teachers and writers.

**Gas Producers.** By W. A. Tookey. (London: Percival Marshall & Co.) 1s.

To the man who has to look after a gas producer, this little book will supply a good deal of useful information. The author does not claim that his work is a highly technical treatise, but he holds that it will aid those whose knowledge of the subject is limited, and we think he is justified.

## BRITISH SCIENCE GUILD.

The inaugural meeting of the British Science Guild was held on Monday at the Mansion House, the Lord Mayor being in the chair.

In order to state clearly the objects of the British Science Guild we cannot do better than give verbatim the circular issued by the secretary, setting forth the motives that have prompted the organisers to add one more to the existing list of scientific institutions in Great Britain.

It has been a frequent subject of comment that, although the contribution of this country to the progress of science has been second to that of no other nation, the English people do not manifest that interest in, and belief in the powers of, science which are noticeable among the peoples of the Continent or of America. In spite of the efforts of many years, the scientific spirit, essential to all true progress, is still too rare, and, indeed, is often sadly lacking in some of those who are responsible for the proper conduct of many of the nation's activities. It is with a view of attempting to remedy this evil, and to bring home to all classes the necessity of applying scientific treatment to affairs of all kinds, that the proposal is made to bring together those convinced of this necessity by founding "The British Science Guild."

The objects and organisation of the Guild, which will be entirely disconnected from party politics, are as follows :—

### OBJECTS.

1. To bring together as members of the Guild all those throughout the Empire interested in science and scientific method, in order, by joint action, to convince the people, by means of publications and meetings, of the necessity of applying the methods of science to all branches of human endeavour, and thus to further the progress and increase the welfare of the Empire.

2. To bring before the Government the scientific aspects of all matters affecting the national welfare.

3. To promote and extend the application of scientific principles to industrial and general purposes.

4. To promote scientific education by encouraging the support of universities and other institutions where the bounds of science are extended, or where new applications of science are devised.

*Methods of Attaining these Objects.*—(*a*) By publications. (*b*) By meetings. (*c*) By conferences and lectures. (*d*) By deputations.

### ORGANISATION.

*Admission of Members.*—All British subjects, both men and women, are eligible for membership of the Guild; it is expected, however, that its members will be recruited principally from the following:—The House of Lords; the House of Commons; Colonial Legislatures; County, District, Borough and Parish Councils; Municipalities; Educational committees; scientific, technical and literary societies and organisations; commercial and industrial chambers and organisations; the learned professions; universities, colleges, educational bodies and graduates of all British universities; representatives of labour.

At a meeting of the promoters of the Guild, held, by permission of the officers, at the Rooms of the Royal Society, on April 20, 1904, it was decided that the steps preliminary to the formation of the Guild should be taken by an Organising committee, of which the following were appointed members, with power to add to their number: Lord Avebury, F.R.S., Prof. W. E. Ayrton, F.R.S., Sir Geo. Sydenham Clark, K.C.M.G., F.R.S., Capt. E. W. Creak, R.N., C.B., F.R.S., Mr. Clive Cuthbertson, Dr. William Garnett, Mr. Sidney Lee, Sir Norman Lockyer, K.C.B., F.R.S., Lady Lockyer, Mr. N. Maccoll, Prof. Raphael Meldola, F.R.S., Prof. J. Perry, F.R.S., Sir Gilbert Parker, M.P., Sir William Ramsay, K.C.B., F.R.S., Dr. W. N. Shaw, F.R.S., Prof. S. P. Thompson, F.R.S., Dr. Augustus Waller, F.R.S., Sir Henry Trueman Wood.

The organising committee has elected Sir Norman Lockyer president, Lord Avebury honorary treasurer, Lady Lockyer honorary assistant treasurer and Mr. C. Cuthbertson honorary secretary. It was resolved that life members of the Guild shall pay, on admission, two guineas, which includes a registration fee of 2s. 6d., and that annual subscribers shall pay, on admission, 5s., and in each subsequent year 2s. 6d. It was also resolved that donations may be accepted. The committee are now engaged in communicating with those corporate bodies and individuals whose support and sympathy are desired.

A general committee will be appointed, which will subsequently select from its members an executive committee for the management of the affairs of the Guild. The executive committee will meet from time to time as their chairman may direct, and will formulate such rules as experience may suggest, for the approval of the general committee. The general committee will probably take power to appoint or approve local and special committees, which will act as branches of the guild.

The first efforts of the organising committee were directed to making known the scope and objects of the movement as widely as possible, without having recourse to advertisement. Notices of the formation of the Guild were sent to the Press, and were published by a large number of the leading newspapers and periodicals at home and abroad. At the same time invitations to join were sent to the Fellows of the Royal Society and the members of both Houses of Parliament. A considerable number of the former body signified their approval of the scheme, but the response from the Lords and Commons was less encouraging. Inquiries were made as to the best means of bringing the Guild to the notice of other important societies. By the courtesy of the County Councils Association a number of invitations were distributed among the leading members of county councils and their education committees. Circulars inviting the co-operation of chambers of commerce throughout the kingdom were issued, and, where the reply was favourable, letters were sent to all members of the chamber. In the Society of Arts the committee hoped to find a body whose sympathies would be with the Guild; nor have they been disappointed in this expectation. Circulars are being forwarded to all members of the society, and many have already joined.

By such steps the membership of the Guild had reached on May 24, 1905, a total of 335, of whom 134 were annual subscribers, and 201 were life members. The subscriptions and donations received have amounted to £495. 12s. 6d., and the expenses, chiefly for stationery and printing, to £78. 11s. 2d., leaving a balance of £417. 1s. 4d. in hand on May 24, 1905.

During the first stage of the existence of the Guild the public activity of the committee has been limited by reasons of policy. The committee think, however, that the time has now come when it is advisable to advance beyond the general statement of aims and objects, which was all that an organising committee was in a position to formulate, and to proceed to the formation of a general committee which would be empowered to draw up a definite programme, and to take action in furtherance of the objects of the Guild. In order that the general committee, on its formation, may have at its command the best advice with regard to the questions which will be brought under its consideration, it has been decided to enlarge the organising committee so as to include among its members representatives of many important departments of national activity. From this body it is proposed to organise sub-committees, who would be asked to consider the condition of the profession or industry which they represent, and to report to the general committee in what way they can recommend that the influence of the Guild should be exerted. It is suggested that these reports, drawn up by distinguished members of a profession and signed by others, should be published by the guild, and it is hoped that in this way, among others, public attention may be aroused with regard to many questions in which progress is a matter of national concern.

To prevent the possibility of misconception, the committee give the following explanation of their view of the position which the guild is intended to occupy in relation to other bodies whose aims are also of a scientific character. The Royal Society was founded for the promotion of natural knowledge; the British Association for the advancement of science; the Society of Arts for the encouragement of arts, manufactures, and commerce. The Science Guild, though in sympathy with all these objects, is not identical in aim with any of them. The promotion of natural knowledge is outside its sphere. Its purpose is to stimulate, not so much the acquisition of scientific knowledge, as the appreciation of its value, and the advantage of employing the methods of scientific inquiry, the study of cause and effect, in affairs of every kind.

Such methods are not less applicable to the problems which confront the statesman, the official, the merchant, the manufacturer, the soldier, and the schoolmaster than to those of the chemist or the biologist; and the value of a scientific education lies in the cultivation which it gives of the power to grasp and apply the principles of investigation employed in the laboratory to the problems which modern life presents.

At the inaugural meeting there was a large attendance, the Lord Mayor being supported on the platform by the Lord Bishop of Ripon, Lord Strathcona and Mount Royal, Right Hon. R. B. Haldane, K.C., M.P., Admiral Sir Cyprian Bridge, G.C.B., Gen. Sir Frederick Maurice, K.C.B., Sir John Wolfe-Barry, K.C.B, F.R.S., Sir William Ramsay, K.C.B., F.R.S., Sir Norman Lockyer, K.C.B., F.R.S, Prof. John Perry, F.R.S., Dr. R. T. Glazebrook, F.R.S., Mr. James Swinburne, Mr. Alexander Siemens, Dr. R. Mullineux Walmsley and a number of others.

Sir NORMAN LOCKYER, K.C.B., F.R.S., speaking with regard to the necessity for such a movement as this, said he had expressed the view some time ago that the object of the guild might be brought about by extending the functions of some existing organisation, such as the British Association, but he was soon made to see that this was to take too narrow a view of the matter. This was not merely a question of science and scientific men, but a question of conducting our national activities, State services, and private services under the best possible conditions with the greatest possible brain power. A complete education must be based upon things and thinking as well as upon words and memory; one education was wanted for everybody—viz., the best, and this education should be carried as far as possible in the case of each individual, whether the time available for education and instruction was long or short. No one should be stopped—save by his own incapacity—from proceeding further down the fair stream of education which should make the complete man both intellectually and physically; we wanted this stream freed from the impediments with which it was at present dammed; spell the word how they liked. These impediments were absolutely hurtful, and most of them unnecessary. We wanted to revert to the ideal ancient university, under the curriculum of which the *natura rerum* was never absent, and the poor student was always cared for. Most people had wondered at the rise of the army and navy of Japan, but there was nothing to wonder at, although most of the reasons suggested were wrong. What really had happened in Japan was that for the last 30 years everybody from the Mikado to the smallest boy and girl had been taught to think, and they represented at the present moment the maximum brain power and efficiency as the result of that treatment. Mr. Chamberlain, Lord Rosebery and others had referred to the great relative advance in the commerce and industry of Germany and the United States. He would like to point out that these were *par excellence* the lands of State-aided universities. It was more than a coincidence. If the Guild helped in any way to improve our national position in this respect it would not have been founded in vain; but there was certainly much for it to do along many lines.

The LORD BISHOP OF RIPON then moved a resolution: "That the Right Hon. R. B. Haldane be elected President of the British Science Guild." He said that he believed the time had arrived when such an institution should take its place among the useful institutions and societies of this country. After commenting on the general backwardness of Great Britain as compared with other countries, the speaker gave two examples of this. In Holland and Germany, he said, there were two great institutions called museums of safety, and the purpose was to show in working models every appliance devised by the great study of scientific men for the protection of life and limb and for the promotion of health. These institutions were open to the public—to both master and man—and were living witnesses to the urgent importance of showing how scientific methods and human study might be brought to bear for the protection of health and the life of the people of the world. The urgency for the foundation of this Guild was clear to him, as also was the method of carrying it on. A difficulty had arisen as to the nature of the man who should be president, but he thought a happy combination of the qualities necessary for the office were to be found in Mr. Haldane, whom he had very much pleasure in proposing.

LORD STRATHCONA AND MOUNT ROYAL in a brief speech seconded the proposal.

Sir WILLIAM MATHER, in supporting the resolution, thought we should not underrate ourselves. We had plenty of science and processes, but the trouble was that the people of England had not been trained by those responsible for the national education to use the methods of science available. There was no difficulty in getting men—doctors of science and so on—to take charge of departments and to take leading positions, but it was in the subordinate positions, such as assistant managers, foremen, &c., and even in the workpeople themselves, that there was a great weakness. He had recently been for a four months' tour in the United States. Ten years ago, at the leading 30 universities there, 32,000 day students attended, whilst at present there was 65,000. The total number of colleges and universities in the States was about 500, and from these last year there graduated 20,000 students. Obviously a large proportion of these could not take leading positions, and it would thus be seen what a vast quantity of trained intelligence was being yearly placed upon the ordinary labour market. In Great Britain the yearly average of students graduating in this manner was only 1,200 or 1,500. The greatest work of this Guild was to work upon the Government of the day, Liberal or Conservative, and to take care that there should be sufficient expenditure to enable our people to have the same opportunities that the people of America had had.

The election of Mr. Haldane as president was then unanimously agreed to.

Mr. HALDANE, in returning thanks, touched upon a variety of points, mostly of a political and social nature. With regard to the conditions in Germany, he said that, figuratively speaking, the German was ruled with a birch from the cradle to the grave, and that as a matter of fact an outcry was being made for the freer conditions of Great Britain. He thought that a compromise between the two systems would be beneficial. He hoped to see the day when there would be a corps of scientists at the elbow of the Government to guide the scientific welfare of the nation. We possessed the right material, and if we were given the chance we could beat the world, but we wanted knowledge to accomplish this.

Mr. C. W. MACARA, President of the Federation of Master Cotton Spinners' Associations, moved the election of the list of proposed vice-presidents (given in our issue for Oct. 20).

Admiral Sir CYPRIAN BRIDGE seconded and Major-General J. F. MAURICE supported.

The resolution was carried unanimously.

Sir JOHN WOLFE-BARRY, F.R.S., K.C.B., in moving that the President and vice-presidents be elected members of the General committee, said this movement must be looked upon as distinctly an educational movement to educate the people at large and the Governments and political parties not to undervalue the great resources of science in the development of the kingdom.

This resolution was seconded and carried.

A vote of thanks to the Lord Mayor terminated the proceedings. The list of vice-presidents was given in our issue for October 20. Since then the Right Hon. Lord Alverstone, G.C.M.G., F.R.S., and the Right Hon. Lord Rayleigh, F.R.S., have been added. The remaining officers of the Guild are as follows:—

*Chairman of Committees.*—Sir Norman Lockyer, K.C.B., F.R.S. *Vice-Chairmen.*—Sir William Abney, K.C.B., F.R.S.; Sir Lauder Brunton, F.R.S.; the Hon. Sir. John Cockburn, K.C.M.G.; Sir Gilbert Parker, M.P. *General Committee.*—J. W. Alsop, Esq., Birkenhead.; Prof. Ayrton, F.R.S.; G. T. Beilby, Esq.; Shelford Bidwell, Esq., F.R.S.; Prof. Biles, Glasgow; Sir James Blyth. Bart.; Sir William Bousfield; Thomas Burt, Esq., M.P.; Sir E. W. Brabrook, C.B.; R. H. Caird, Esq.; Dr. Robert Caird, Greenock; Michael Carteighe, Esq.; Prof. Church, F.R.S.; Capt. Ettrick Creak, R.N., C.B., F.R.S.; Col. Crompton, C.B.; Sir William Crookes, F.R.S.; C. Cuthbertson, Esq.; Prof. George Darwin, F.R.S.; Dr. Henry Dyer; Dr. F. Elgar, F.R.S.; Sir Charles Eliot, Vice-Chancellor, Sheffield University; D. Ferrier, Esq., M.D., F.R.S.; Dr. William Garnett; C. E. Gifford, Esq., R.N., C.B.; Prof. Andrew Gray, F.R.S., Glasgow; R. Kaye Gray, Esq.; R. A. Hadfield, Esq.; Prof. W. D. Halliburton, M.D., F.R.S.; Prof. F. W. Hardwick, Sheffield; Prof. Herdman, F.R.S.; Sir Henry Hibbert; Sir James Hoy; Miss Hurlbatt; Prof. A. H. Leahy; Sidney Lee, Esq.; Prof. A. Liversidge, F.R.S., Melbourne; Sir Oliver Lodge, F.R.S., Principal, Birmingham University; Prof. A. E. H. Love, F.R.S.; C. W. Macara, Esq., president of Federation of Master Cotton Spinners' Associations; Sir Philip Magnus; Major-Gen. Sir Frederick Maurice, K.C.B.; Prof. Meldola, F.R.S.; Prof. C. Lloyd Morgan, F.R.S.; Sydney Morse, Esq.; A. Mosely, Esq., C.M.G.; E. K. Muspratt, Esq., Liverpool; Sir A. Noble, Bart., K.C.B., F.R.S.; Harry Nuttall, Esq., president, Chamber of Commerce, Manchester; the Hon. C. A. Parsons, C.B., F.R.S.; Prof. J. Perry, F.R.S.; Prof. E. B. Poulton, F.R S,; Sir William Preece, K.C.B., F.R.S.; Sir William Ramsay, K.C.B., F.R.S.; J. H. Reynolds, Esq., School of Technology, Manchester; Sir Henry Roscoe, F.R.S.; S. W. Royse, Esq., Manchester; Sir Arthur Rücker, F.R.S., Principal, London University; F. W. Rudler, Esq.; Prof. M. E. Sadler; Dr. W. N. Shaw, F.R.S.; Alexander Siemens, Esq.; Prof. E. H. Starling, F.R.S.; the Rev. Thomas Stebbing, F.R.S.; the Right Hon. Lord Strathcona and Mount Royal, G.C.M.G.; Sir Joseph Swan, F.R.S.; James Swinburne, Esq.; Carmichael Thomas, Esq.; Prof. Silvanus Thompson, F.R.S.; F. Verney, Esq., L.C.C.; the Very Rev. H. Wace, D.D., Dean of Canterbury; Dr. Augustus Waller, F.R.S.; Prof. R. M. Walmsley; Sir Philip Watts, K.C.B., F.R.S.; Rear-Admiral Sir W. J. L. Wharton, K.C.B., F.R.S.; W. Whitaker, Esq., F.R.S.; Spenser Wilkinson, Esq.; Sir John Wolfe-Barry, K.C.B., F.R.S.; Sir Henry Trueman Wood; A. F. Yarrow, Esq.

## STREET LIGHTING IN LONDON.

Mr. Sydney Dobson, chief engineer of the St. James' & Pall Mall Electric Light Co., writes us as follows:—

I agree with you that it should not be difficult to prove that the streets could be more efficiently lighted by modern electric lamps than by gas. The gas companies will, of course, draw the comparison between their present prices, which are very low, and some old prices for electric lighting, which are unduly high, and it must be borne in mind that, if electric light is to hold its own, many of the present prices will have to be considerably reduced. My own company has recently secured the renewal of its contract in the City of Westminster at the price of £17 per 10 ampere lamp per annum, in the face of the most determined effort of the gas company to obtain it, and we have, further, agreed to provide 900 c.p. per lamp as against 700 c.p. given at present. If you will apply these figures to the part of Fleet-street to which you refer, you will see that for £204 a light of 10,800 c.p. would be given by electric light, as against 8,000 c.p. given by gas at a cost of £208. There are on the market even now flame lamps which could be run at about the same cost, and would give about twice the candle-power stated for the ordinary lamps, and, with these, I think competition by gas would be impossible.

You mention that the lanterns of the existing electric lamps in Fleet-street are inefficient, and this well-known defect is alone sufficient to vitiate any comparison between the possibilities of gas and electric light. My own company has suffered in the same manner, the street lamps having been fitted, in accordance with the orders of the late St. James's Vestry, with globes of Muranese glass. We have recently induced the Westminster City Council to allow us to substitute ordinary opalescent globes, with the result that the candle-power of the lamps has been increased from about 475 to 700.

You have, no doubt, seen the reports of Mr. Bradley, the engineer to the Westminster City Council, on the street lighting in the City. They contain figures of the candle-powers of various illuminants, measured under actual working conditions and they will thus enable you to make a better comparison between the costs than any estimate which I should be able to give you.

[Mr. Bradley's report summarising tests made over 18 months was published in *The Electrician*, Vol. LII., p. 812.—ED. *E.*]

Messrs. Johnson & Phillips (Ltd.) write:—

By means of incandescent gas the gas companies have recently made a claim that they are able to better illuminate streets and open spaces and at a much cheaper rate than can be done by means of arc lamps, and they take as an example Fleet-street, where 12 arc lamps have been replaced by 34 gas standards. In order to make a fair comparison between the two forms of lighting it would only be fair to compare them on somewhat the same basis, and not compare them as the gas companies have done—namely, high-pressure or ordinary incandescent gas in clear lanterns against the old-type arc lamps fitted inside Muranese glass lanterns. The comparison should be made with both types of lamps in clear glass globes.

At the time when arc lamps were first brought into use for lighting, the change was so sudden from paraffin lamps and the old flat-flame gas burner, objections were immediately brought forward to the effect that the light was injurious to the sight, and in order to overcome this difficulty the arc lamps were provided with either ground glass or Muranese glass lanterns, the glass cutting off about 35 to 40 per cent. of the light. In the meantime, gas has been advancing as regards its illuminating power, but the change has been very gradual and consequently the same objection to incandescent gas lighting has not been raised, as the public have got accustomed to powerful lighting effects. As a matter of fact, however, the light from the present type of gas mantle is not only more injurious to the sight compared with flame arc lamps, but also, as the gas burners are arranged at the same height as the old type of gas burner, the lamps are in direct line of vision of persons in charge of vehicular traffic, increasing the liability of accidents. With arc lamps having clear glass globes this objection would not apply, as the lamps would be suspended at a much greater height.

It is also well known that light has less fog penetrating power the nearer it approaches the higher vibrations of the spectra, this accounting for ordinary arc lamps being scarcely visible in foggy weather. On account of this, flame arc lamps have a considerably more penetrating effect in fogs than incandescent gas. In the case of arc lighting by means of direct current, the light is reflected naturally downwards. In the case of gas, to obtain the same effect it is necessary to reflect the light, the reflection being attended with its usual losses.

According to the latest number of the *Journal of Gas Lighting* the gas company has given figures as to the consumption of gas for the lighting of Fleet-street, and according to this report 4,300 hours of lighting are assumed as against 4,500 which have been assumed for arc lighting. The total cost for gas, attendance, cleaning and mantle renewals amounts to £5. 13s. 2d. per annum per double-burner lamp; this works out to £192. 7s. 8d. We notice also, according to this report, that the charge which the gas company makes for 1,000 c.p. high-pressure lamp is £18 per annum, including cost of maintenance, gas compression, &c.

Whilst on the question of gas lighting, we notice in several recent instances that where the gas companies have made comparisons no amount has been allowed for depreciation, maintenance, &c., in the case of high pressure gas. This item is an extremely important one on account of the pumps and machinery requisite to drive same, so that in comparing gas lighting by means of high pressure gas with arc lighting the comparison would be about fair, in our opinion, neglecting depreciation in both cases.

Flame lamps of Messrs. Johnson & Phillips (Ltd.) latest design, having converging carbons and casting no shadows, provided with clear globes and taking 10 amperes, would give approximately in the road 16,000 c.p. from the 12 arc lamps. Taking in this case also 4,500 hours' burning, the cost of current at 1d. per unit amounts to £112. 10s., carbons £35, cleaning, &c., £11. 14s., making a total of £159. 4s., exclusive of depreciation, &c. A considerable saving is shown over and above the cost of gas lighting, besides obtaining more than three times the candle-power which is obtained from gas.

It must be admitted, however, that a more effective light diffusion is obtained from the 34 gas standards than from 12 arc lamps, and a more satisfactory method of lighting streets would be by means of a larger number of smaller arc lamps; in this case the cost of running would also be less than by means of gas for the same amount of useful illumination.

Another point which should not be lost sight of is that the candle-power of the arc lamps is practically constant from day to day, whereas the candle-power from the high-pressure gas lanterns decreases from the moment the mantle is put on new and lit up.

From the results already published comparing street lighting by means of gas with one or two flame arc lamps which have been installed in the City, there is not the slightest doubt as to the most effective method of street lighting. The number of flame lamps installed, however, is only very small, and we would suggest that the only way in which this difference will be settled will be for the public to decide. This decision could be obtained in some town where the municipality own both the gas and electricity works, by installing flame arc lamps in one of the streets where incandescent gas is already burning, and burning the flame arc lamps on alternate nights; this, we think, would satisfactorily end the matter.

We have also received an interesting letter on the subject from a firm of consulting engineers, who inform us that in the cases of several towns with which they are connected, they find that the action of the City Corporation has greatly impressed the councillors, though they generally have obtained wholly misleading ideas as to what is actually taking place in London. In one case, for instance, some of the members of the Corporation had got the idea that throughout the whole of London electricity for the street lighting was being displaced by gas!

## ON THE THEORY OF MAGNETISM.*

BY P. LANGEVIN.

1. The magnetic properties of bodies, and the various ways in which they act when introduced into a magnetic field, appear at first sight extremely complicated. The ferromagnetic substances take an intense magnetisation, which is a function, not only of the actual magnetising field, but, owing to the phenomenon of remanent magnetism, of the whole series of previous fields. Other bodies are slightly magnetised in the direction of the external field, and in a constant ratio to it, in accordance with a coefficient, the paramagnetic susceptibility, which M. Curie has shown to vary inversely as the absolute temperature. Furthermore, experiment shows that an elevation of temperature makes the same substance pass in a continuous manner from the ferromagnetic to the paramagnetic state, just as it enables a body to pass continuously from the liquid to the gaseous state.

Finally, other bodies, perhaps the most numerous, are very feebly polarised in a direction opposed to that of the magnetising field, and are called diamagnetic. No transition can be observed between this property and the two first. Besides, another profound difference lies in the fact that the diamagnetic susceptibility is, except in the case of bismuth, rigorously independent of the temperature and the physical state.

Hitherto no satisfactory account has been given of these complexities; Ampère's hypothesis of molecular currents, elaborated by Ewing, accounts for certain facts of ferromagnetism and paramagnetism, but says nothing about the origin of these currents and the cause which maintains them. Weber, on the other hand, accounts for diamagnetism by the supposed existence within the molecules of circuits of zero resistance in which the establishment of an external field produces induced currents such that the total flux traversing the circuits remains zero; the direction of these currents by Lenz's law corresponds to diamagnetism. Maxwell, in his *Treatise*, has endeavoured to unify the hypotheses of Ampère and Weber without, however, obtaining any accurate solution for lack of data concerning molecular structure.

2. Nowadays we possess such data, thanks to the theory which makes of matter an agglomeration of electrons in motion, of electrified centres of both signs, whose displacement produces in the ether a magnetic field like that due to a current element, and proportional to the charge of the electron and to its velocity. The creation of this magnetic field at the moment when the electron is set in motion implies an expenditure of energy proportional to the square of the velocity acquired and represented by the self-induction of the equivalent current. It is of the same form as kinetic energy. An electrified centre, therefore, possesses an inertia by the mere fact of its being electrified, and it appears probable to-day that all inertia is electromagnetic, the inertia of a material molecule being but the sum of the electromagnetic inertias of the electrons which constitute it.

Further, an electromagnetic or luminous radiation is emitted every time an electron undergoes a change of velocity, an acceleration or retardation, and it is natural to find in the electrons which gravitate in closed orbits within the molecules the origin of the spectrum rays. The period of luminous vibrations, being about $10^{-15}$ seconds, must be of the order of $\tau$, the period of revolution of the electrons in their orbits.

We know how this conception allowed Prof. Lorentz to anticipate certain peculiarities of Zeeman's phenomenon, and how experiment entirely confirmed them.

3. It is natural to identify these electrons gravitating in closed orbits with Ampère's elementary currents. It is easily shown that such an orbit, of surface S, described for a time, $\tau$, by an electron of charge $e$, is equivalent, as regards the generation of an average external magnetic field, to a magnet normal to the plane of the orbit and of magnetic moment,

$$M = eS/\tau = Si;$$

in other words, the orbit is equivalent to a circuit traversed by a current of intensity $e/\tau$.

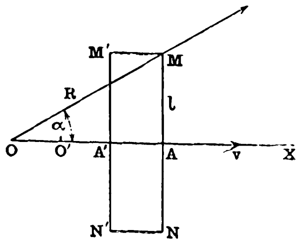

FIG. 1.

It is useful perhaps to recall that the production of a magnetic field by an electrified particle in motion with respect to the ether is a necessary consequence of Hertz's equations. These, completely borne out by experiment, translate into mathematical language the existence of Maxwell's displacement current and the phenomena of induction according to which, in a vacuum, every variation of either the electric or magnetic field suffices to produce the other, thus:—

*a.* The integral of the electric field along a closed circuit equals the time-variation of the flux of magnetic force traversing the circuit (induction).

*b.* The integral of the magnetic force along a closed circuit equals the time variation of the flux of electric force traversing the circuit (displacement current).

The last rule supposes that the surface bordered by the circuit is not traversed by any electric charge, by any free electrons.

Let us now consider an electrified particle O of charge $e$, moving along OX with velocity $v$ with respect to the medium (supposed, in Lorentz's theory, to be quite immovable), and let us apply the second one of the above rules to a circumference of radius $AM = l$, having its plane perpendicular to the direction OX.

The electrified particle being a solid of revolution about OX, it is impossible that the magnetic field, being the same at every point of the circumference MN by symmetry, should be zero on that circumference, because the flux of electric force traversing it varies on account of the motion of the particle. Further, the magnetic field H at M is necessarily tangent to the circumference, that is to say, normal to the plane of the figure, for the whole system is evidently applicable to its own image with respect to this plane, and because a magnetic field which possesses the symmetry of a revolving cylinder,* has only one plane of symmetry normal to its direction.

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* From the *Journal de Physique* of October, 1905.

The integral of the magnetic field along a circumference of length $2\pi l$ is $2\pi l$ H. To calculate the time variation of the flux of electric force, let us find the variation of this flux when the particle is displaced during the time $dt$ by the length $OO' = vdt$ The new flux produced by O′ across MN equals that produced by O across the circumference M′N′, equal to MN and distant from it by the length $AA' = vdt$. But the difference of fluxes produced by O across the two circles is, by Gauss's theorem, equal to the flux across the cylindrical space MNM′N′ which makes with the circles a closed surface containing no charge. This flux is

$$d\phi = \frac{e}{R^2} \sin\alpha \, 2\pi l v dt,$$

$$\frac{d\phi}{dt} = 2\pi l H = \frac{e}{R^2} \sin\alpha \, 2\pi l v dt,$$

$$H = \frac{ev}{R^2} \sin\alpha.$$

This is exactly the magnetic field which would be produced in M by a current element of length $\delta s$ placed at O, parallel to OX, and of moment $i\delta s = ev$.

The value $e/R^2$, taken for the electric field at M, supposes that this field is not modified by motion, a supposition which remains practically accurate so long as the velocity $v$ does not approach that of light; otherwise the law of induction shows that the magnetic field generated reacts in turn upon the electric field, changing its distribution, the lines of force tending, at a distance O, large in comparison with the radius of the particle, to accumulate in the plane normal to OX.

The expression obtained for H remains applicable even to electrons present in the molecule, since their speed does not in general appear to become greater than one-hundredth of that of light.

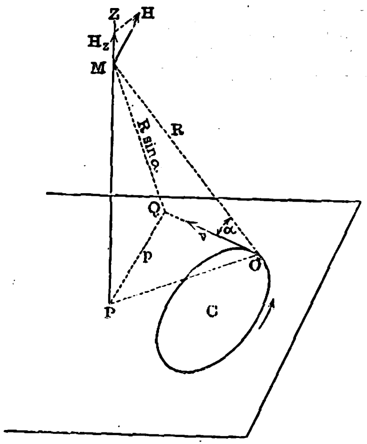

FIG. 2.

It is easy, as various authors have already done, to calculate, on the basis of the preceding result, the projection $H_z$, in any direction PM, of the magnetic field H produced at the point M by an electrified particle O describing a closed orbit, small in comparison with the distance R, along a curve whose projection C upon a plane normal to PM is the only matter of importance, since the component of the velocity parallel to PM produces in M a magnetic field normal to PM whose projection is zero. Let $v$ be the velocity projected. If $p$ is the distance between this velocity and the point P, the similarity of the triangles PQM and ZMH gives $H_z = HR^2/R \sin\alpha$ Whence, on replacing H by its value $ev \sin\alpha/R^2$, we have $H_z = epv/R^3$.

The moment $pv$ of the velocity with respect to PM is also equal to double the *areolar velocity* A of the point O on the projected orbit, with respect to the point P, and is counted positively in the trigonometrical sense. Therefore, $H_z = 2eA/R^3$.

This projected magnetic field $H_z$ will remain constant in the special case where the motion of the electron would be due to central forces emanating from a point, C, within the orbit, and where the direction MP would pass through this point C, since the areolar velocity A would then remain constant, as well as the distance R, supposed great in comparison with the dimensions of the orbit.

In all other cases $\overline{H}_z$ will be variable, and the quantity which then concerns us is its mean value $H_z$ as a function of the time. If the variations of R with the displacement of O are of the second order with regard to the dimensions of the orbit, which supposes R great with regard to $p$—*i.e.*, $\alpha$ always near a right angle, R may be considered invariable, and we have, if $\bar{A}$ represents the mean value of the areolar velocity,

$$\overline{H}_z = \frac{2e\bar{A}}{R^3}.$$

If S represents the surface of the orbit projected and $\tau$ the period of revolution, we have evidently $\bar{A} = S/\tau$, and hence

$$H_z = \frac{2e}{R^3} \frac{S}{\tau}.$$

The elementary current is therefore equivalent, as regards this mean field, to an elementary magnet of moment

$$M = eS/\tau = e\bar{A} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

It is easy to show that this equivalence holds good, for the distant points of the orbit, in any direction, so long as the variations of R are of the order of the dimensions of the orbit. Hence, on the whole, the *mean* magnetic field produced by an elementary current at a distance is the same as that of a magnet normal to the plan of the orbit and of moment $eS/\tau = e\bar{A}$.

A molecule contains as many such elementary currents as it contains electrons in motion. The collection of equivalent magnets may have a zero magnetic moment as a resultant. This will be the case if the molecular edifice possesses a sufficiently high degree of symmetry to ensure that it is incompatible with the dissymmetry of a magnetic moment comparable with that of a turning cylinder. If, on the contrary, the molecule has for its group of symmetry an intergroup of that of the turning cylinder, a resultant moment may exist, and the molecule will be a small magnet.

We shall see that in all cases the creation of an external magnetic field modifies the elementary currents, as Weber supposed, by *diamagnetically polarising all the molecules.* This effect is the only effect produced if the resultant moment is zero: the material is diamagnetic in the ordinary sense of the word. If the resultant moment is not zero, another phenomenon, due to the orientation of the molecular magnets by the external field, is superposed upon the initial diamagnetic phenomenon: the substance is then paramagnetic, if the mutual actions between the molecular magnets are negligible as in the case of gases or solutions, but ferromagnetic in cases where these mutual actions play the essential part. As soon as the paramagnetism appears it is enormous in comparison with the initial diamagnetism, and masks it completely. This explains the absence of continuity between para- and diamagnetism: the substance either possesses, or does not possess, the dissymmetry of the turning cylinder. Paramagnetism either exists or does not exist, and, when it does exist, it completely masks the underlying initial diamagnetism.

(*To be concluded.*)

## ELECTRIC POWER SUPPLY IN LONDON.

The following report has been prepared by the Highways Committee of the London County Council with regard to the question of the supply of electric power in London, as the result of the various proposals by companies in the last session of Parliament concerning this matter. The report which is dated October 23, was put in the hands of members before last Tuesday's meeting of the Council, but for the reason stated below it could not be dealt with at that meeting. The Highways committee has been advised that as regards any proposals for legislation in this direction it will be necessary to proceed under the Borough Fund Acts 1872, as applied by the County Council (Bills in Parliament) Act, 1903. Notice will therefore have to be given by public advertisement that the question of promoting legislation dealing with the supply of electrical energy will be considered by the Council at a meeting to be held on a specified date, which it is suggested should be November 14th next. It will be necessary at that meeting for a resolution to be passed by an absolute majority of the whole Council to promote such legislation and to defray out of the county funds the costs and expenses of so doing. The Council will afterwards, in accordance with the provisions of the Borough Funds Acts, have to obtain the approval of the Local Government Board to the course indicated in the resolution.

The report is as follows:—

*Supply of Electrical Energy in London. Proposed Application to Parliament—Session 1906.*

1. We desire to direct the attention of the Council to the very important issues which have been raised in connection with the introduction into Parliament, in the session of 1905, of several bills dealing on a much larger scale than any brought forward hitherto with the supply of electrical energy in London and certain adjacent districts. The largest of these schemes, that promoted by the Administrative County of London and District Electric Power Company, contemplated the supply of energy, both in bulk and also to large retail consumers over an area of upwards of 500 square miles. The basis of this scheme was that the company should by agreement, or failing this, by competition with the consent of the Board of Trade eventually become suppliers of electrical energy in bulk to all the local authorities and companies supplying in London, and in a large area outside London, or else absorb the existing undertakings and carry on the whole service. In the event of the existing supplying authorities not being absorbed, they would "scrap" their generating stations and become retailers or distributors of the energy sold to them in bulk or wholesale by the Administrative Company. At the present time about hal

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* P. Curie, *Journal de Physique*, III., p. 415, 1894.

London is supplied with electrical energy by local authorities' undertakings, each confined to a single borough, and the other half is supplied by companies whose undertakings are, with a few minor exceptions, compulsorily purchasable by the borough councils in 1931.

This right of purchase by the borough councils, which is a cardinal feature of the Electric Lighting Acts of 1882 and 1888, still exists, but its value and practicability have become seriously jeopardised by the character which the companies' undertakings have assumed.

Inasmuch as a single company's undertaking often extends through several boroughs, whilst there is only one generating station, many local authorities will, if present circumstances continue, only be able to buy mains and no station, while others only will be able to buy mains and a station far too large for the needs of a single borough. In some cases, moreover, the stations are outside areas of supply, and, it is contended, not purchasable at all.

We have frequently drawn attention to these difficulties when, on former occasions, schemes much more restricted in character and extent have been put forward. The scheme of the Administrative Company, however, raises these issues in a far more acute form. Had the bill become law an enormous monopoly would have been created in the supply of what is now one of the most important and vital factors in the commercial development of London and the neighbouring districts. The danger of such a state of affairs is such that we do not feel it necessary to enlarge upon it now. It will be sufficient to remind the Council that the electrical supply, in common with the water, gas and tramways services, in most of the large cities in England is in the hands of the local authorities respectively concerned; it being clearly considered that a monopoly in services of this character, which are vital to the welfare of the community, should not be in private hands. It seems clear, however, from the fact that this scheme (although it largely ignored the statutory rights of existing undertakers and tended to the creation of a private monopoly) received the approval of Committees of both Houses of Parliament, that those committees must have been convinced that electrical energy was not at the time supplied in a sufficiently attractive and cheap form to meet the needs of manufacturers and others in London and the immediate neighbourhood, and that, to enable a satisfactory supply to be given, a scheme or schemes on a much larger scale than any then authorised was necessary. A great feature of the case for the Administrative Company's Bill was that existing areas were too small to admit of the generation and distribution of energy on the most economical scale, and, consequently, at the lowest prices.

While admitting the proposition that larger areas than several of those at present existing are necessary to secure these ends, we do not feel that it is necessary either to entirely disregard the statutory rights of existing undertakings or to place them in such a position as will make it impossible for them to carry out their service.

What is required at this juncture of the history of the electricity question is, in our opinion, that a complete view of the case should be stated by an authority capable of putting that case before Parliament. Up to the present all that has been attempted has been to deal with the problem separately from the company's standpoint and the borough council's standpoint, which together do not, however, make up the whole case so far as it concerns London. This for the reasons set out in this report can, we think, be most adequately done by the Council, as the central municipal authority. We have accordingly carefully considered how the advantages aimed at can be gained otherwise than by the creation of a private monopoly, and we have arrived at the conclusion that, having regard to the extent of area necessary to secure economical supply, and to the importance of preserving, as far as possible, the existing rights of local authorities and the principle of municipal ownership contemplated by the Acts of 1882 and 1888, the only possible alternative is for the Council to obtain such powers as will enable it to supply electrical energy in London and the neighbourhood, the Council being the only London municipal authority entrusted with an area large enough to allow of generation on the necessary economical scale. The fact that the Council already has a very large generating station to supply electrical power for the tramways of London is, in itself, largely in its favour by rendering possible a load of the most economical character. We would point out, too, that one important objection which was raised in the case of the Administrative Bill was the enormous powers that would be conferred on private individuals in respect of the breaking up of streets and the interference in other ways with public property. It seems obviously desirable that such extensive rights as would have been conferred in regard to public property should be in the hands of a public authority, and, moreover, as the Council is itself from time to time laying electric mains in all parts of London for tramway purposes, considerable convenience and economy of work would be gained were the two services in the Council's hands. In addition, there is the fact that the Council is already responsible for the conduct of very large services involving the consumption of such similar stores and the formation of such similar organisations as would be necessary for the supply of electrical energy. In view, therefore, of these considerations of economy, and also the importance of retaining in public hands the control of a service so essential to the development of London in the future, we believe that the Council will think it right to seek powers to enable it to supply electrical energy as proposed. The authority to be sought should, we think, include power (1) to supply energy in bulk throughout the whole of the area in question, and (2) to supply energy to large individual consumers, as, for instance, railway, canal and tramways companies or authorities where these undertakings extend over more than one area.

We have not at present gone fully into the details of a definite scheme for the supply of electrical energy, but, from reports which we have had before us, and having regard to the favourable position in which the Council stands in many respects, we are of opinion that it will be quite practicable to put forward a satisfactory scheme, bearing in mind the importance of providing cheap electrical energy for general use in London, and at the same time securing continuity of the policy of public control which was intended to be ensured by the purchase clauses of the Electric Lighting Acts of 1882 and 1888.

The Council on October 24, 1905, authorised us with the Parliamentary Committee to confer with representatives of the London local authorities upon the whole question of the supply of electrical energy in London. It is proposed to hold this conference on Monday, November 20, 1905, and we will then place our proposals, in the event of the Council adopting them, very fully before the local authorities. In the meantime, however, we have thought it right, having regard to the short time available for the issue of the necessary Parliamentary notices as to the deposit of a bill, &c., to place before the Council this outline of the policy which we recommend it to adopt. We have, as required by Standing Orders Nos. A.27 and A.161, informed the Finance and Parliamentary Committees of our intention to recommend the Council in this sense. It is, however, necessary for us to ask the Council to suspend the operation of Standing Order No. A.161, which requires that all proposals relating to applications to Parliament for powers shall be submitted to the Council not later than its first meeting in June of each year. We think that this is clearly a case of urgency, which comes within the class contemplated by Standing Order No. A.162, inasmuch as it was not until August that it was known that the Administrative Company's Bill would not pass. We have consulted the solicitor, in accordance with Standing Order No. A.163, and he is of opinion that the Council has power to promote legislation in the direction indicated, provided that the provisions of the Borough Funds Act, 1872, as applied by the County Councils (Bills in Parliament) Act, 1903, are adopted. We recommend :—

(*a*) That the operation of standing order No. A. 161, relating to the time for the submission to the Council of schemes involving application to Parliament, be suspended, in order that the following recommendations may be considered.

(*b*) That authority be sought in the session of Parliament of 1906 (i.) to enable the Council to supply electrical energy in London and certain surrounding districts on the lines indicated in this report; (ii.) to confer upon the Council power to carry out any necessary works, including the erection of buildings, the laying of mains, &c., necessary to give effect to such powers; (iii.) to empower the Council to make arrangements with local authorities and others having power to supply electrical energy, and to enter into agreements to give effect thereto; and (iv.) to confer upon the Council any general powers which may be necessary to enable it effectively to supply electrical energy.

(*c*) That the costs and expenses of promoting the legislation referred to in the foregoing resolution be defrayed out of the County fund.

NOTE.—The Finance committee will report under Standing Order No. A. 27 when this report is considered on November 14, 1905.

NOTE.—Any expense to be incurred in promoting this bill must be in pursuance of a resolution of an absolute majority of the whole number of the Council.

The following, which took place at Tuesday's meeting of the London County Council, has an important bearing on this matter. On the recommendation of the Finance Committee to lend £25,000 to the Fulham Borough Council for extending the electric lighting plant,

Sir R. M. BEACHCROFT moved the following amendment: "That the matter be postponed for further consideration." There was good reason, he said, to believe that sooner or later electricity would be supplied at ½d. per unit, a price at which the borough council could not supply.

Dr. NAPIER seconded the amendment, and it was carried on a show of hands.

## MR. A. B. MOUNTAIN'S PRESIDENTIAL ADDRESS TO THE LEEDS LOCAL SECTION OF THE INSTITUTION OF ELECTRICAL ENGINEERS.*

The honour you have conferred upon me by selecting me to be the chairman of this important section of our institution, which I fully appreciate, places upon me considerable responsibilities, which I can only efficiently discharge with your earnest assistance. The Leeds section in the past, under the chairmanship of Mr. Dickenson and Mr. Emmott, has made considerable progress, and has already proved of great value to those members or associates who are unable to attend the London meetings, but there are very many connected with the electrical industries throughout Yorkshire who have not joined the institution, and whose presence at our meetings we would gladly welcome.

I think the discussions we shall have upon the important Papers to be read this session, and our visits to various works in this and other towns, will prove an attraction, and I hope, with your assistance, to see the membership of this section largely increased during my year of office. Unfortunately, unlike Mr. Emmott who has just retired from the chair, which he has filled with conspicuous ability, my experience in connection with electrical matters has been confined mainly to the generation and distribution of electricity and points of financial interest connected with the management of electricity supply undertakings. I have thought that it may be of interest to you if I referred briefly to the development of electricity supply undertakings during the last 10 years, with some conclusions which, I think, may be drawn from the approximate figures I shall place before you.

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* Delivered October 25th

At the end of 1894 there were 60 undertakings with a capital expenditure of £6,107,680; at the end of 1904 there were 445 undertakings, with a capital expended of £61,961,313. The consuming devices reduced to the equivalent of lamps connected in 1894 numbered 2,031,398, and at the end of 1904 19,971,435. The units sold in 1894 numbered 30,203,766, and in 1904 448,078,057. The average price obtained per unit sold in 1894 was, by companies 6·08d., and by municipalities 5·32d.; in 1904 the average price obtained by companies was 3·9, and by municipalities 2·7.

From these figures you will see the splendid progress made in 10 years, the capital expended and lamps connected have each increased proportionately by 10 times, and the units sold by nearly 15 times, while the price obtained has decreased by 48 per cent.; but interesting as these figures may be as a summary of the result of 10 years, they are much more interesting if we try to appreciate the condition of things at either end of the period under consideration. In 1894 the difficulties surrounding the erection of an electricity works and the selection of the best system of supply were very considerable. The uncertainty of such works proving financially successful or growing to the extent they have done forced engineers to plan the works upon much too small a scale, but even if the desire to erect larger generating plant had been there, it was practically impossible to obtain reliable and economical plants of large size. In addition to these difficulties, the selection of the system of supply was very much a choice between two evils: if an alternating-current system of supply was adopted, motive power developments were a matter of hope only; whereas if direct current was selected, owing to the low pressure then generally in use, the cost of distribution over large areas was prohibitive. The result was that most of the works constructed at this time were planned upon a small scale, with small generating plants, in some cases placed in most unsuitable positions; the mistakes, if they are to be so called, have in most cases been recognised and extension made upon sound lines, with generating plant of much greater capacity; still, the original errors have added largely to the capital expended. This explains to some extent why the capital expenditure has increased at the same rate as the lamps connected; if we consider at what cost we can put down works at the present time to meet our present requirements, we find that by providing large generating plant our capital expenditure upon our works would be reduced by about 50 per cent., and that we are able to provide distributing mains at a cost of about 20 per cent. less than in 1894; and owing to the fact that the pressure of supply has been doubled, such distributing mains will now supply four times the number of lamps, so that it is difficult to understand, and most unsatisfactory to find the capital expenditure and lamps connected increasing at the same rate. The explanation is probably that the extension of works and mains have been carried out upon extensive lines to meet future requirements, and if, as I think, this is so, then further lamp connections should improve to a very large extent the results we have obtained from our undertakings. As an actual fact I find the total capital expended upon an undertaking with which I am connected per 8 c.p. lamp was, in 1894, £3; it is now £1. 5s. 1d.

The question of depreciation has not received the attention it should have done, and is of great importance to the numerous electric supply companies. Municipalities are compelled to repay their loans within short periods, and have already either repaid or accumulated for repayment very substantial sums, and if we venture to look forward say 15 or 20 years, a comparison between the results of the working of companies and municipal undertakings will be entirely in favour of the latter, because the interest and sinking fund charges represent approximately half the total expended upon revenue account, and if the capital is repaid these charges will not exist, and the result will be that the municipal undertakings will be able to reduce the price charged per unit by approximately one-half, whereas, unless the companies make more substantial provision for depreciation, their charges will have to be maintained or the profits reduced. I do not wish to convey the impression that I think the amount annually contributed by local authorities to the sinking fund is sufficient provision for depreciation. They are allowed by Parliament to accumulate profit to the extent of one-tenth of the capital expended, and this should certainly be done before large sums are handed over for the relief of the rates of those who do and those who do not use electricity.

Perhaps the most interesting part of our results are the figures relating to the average price obtained for the units of energy sold; we find the charges have been reduced by companies to the extent of 2·1d. per unit, and by municipalities to the extent of 2·7d. per unit, and we also find the natural result that the units sold have increased more rapidly as the price has been reduced. The reductions in the cost of production have been due to improved load factors, caused by the introduction of electric traction, the general adoption of electricity for motive power purposes, and the increased consumption for lighting purposes due to reduced charges, the division of standing charges over an enormously greater output, the great improvement in economy due to the use of larger generating plants, and the general improvements in other departments, including that of management. From the consumers' point of view the results should be considered satisfactory; if the latest type of lamps have been adopted, not only are they obtaining their energy for lighting purposes at approximately one-third the cost, but with the same quantity of energy they may obtain practically double the amount of light, which is equivalent to a total reduction of 66 per cent.

The conclusions which I think may be drawn from this very brief glance at the progress of electric supply undertakings are, that greater care must be exercised in the expenditure of capital, that the introduction of large generating plants will lead to ultimate economy and will enable us to compete with the comparatively small engines employed for driving factories, and that reduced charges will still further enormously increase the output of energy for both lighting and motive power purposes, if we by exhibition or other practical demonstration show the actual advantages to be derived from the use of electricity.

# CORRESPONDENCE.

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## THE NATIONAL PHYSICAL LABORATORY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The leader in your last issue raises an important question which has been much discussed in the technical Press and which has for a considerable time received a large amount of quiet attention from scientific men and from the official representatives of our technical and learned societies.

The National Physical Laboratory is nominally under the control of a well-chosen and thoroughly representative body of qualified men, selected, as Dr. Glazebrook points out, from the Royal Society and six of the leading technical societies, and on them, and on them only, rests the actual responsibility of seeing that the work of the institution is confined to the objects which led to its inception and justify its existence.

These objects are set out in the report of the committee who recommended to the Treasury the establishment of the National Physical Laboratory, and the legitimate work is admittedly confined to such as cannot be properly carried out in private laboratories.

Dr. Glazebrook says: "It is the business of such a laboratory to solve conundrums for the good of industry; it is the business of the university to advance knowledge for the benefit of all. . . . Work at a laboratory like the Versuchsanstalt at Berlin can readily be treated as confidential. . . ." If by this Dr. Glazebrook means, as he appears to mean, that the National Physical Laboratory might properly perform confidential research work for individuals, or even corporations, he will find many who disagree with him absolutely.

The institution is not expected to be self-supporting. It is supplied with funds obtained from the public purse as well as with subscriptions from societies and individuals, and the results of its labours should be public property and its work should be such as will benefit industry generally.

Probably the institution can do excellent research work on many of the lines indicated by Dr. Glazebrook, but, unless the results are published fully and promptly, the National Physical Laboratory will be merely an institution expending public funds for the benefit of private individuals, and will thus hold an untenable position which will soon lead to its extinction.

It is not necessary to dwell upon the suggestion that the laboratory has in the past been in the habit of undertaking commercial and other tests and analyses which are admittedly outside its scope, as it may be taken for granted that, if such be the case, the strong representations which have been made to the committee have for ever rendered its recurrence impossible. This matter has been fully ventilated in the Press, and the fact that any reports of analyses issued by such an institution would carry what would appear to be an official guarantee, which would certainly be employed by the unscrupulous to deceive the public, fully justifies the firm stand which has been taken against the alleged practice.

The need for a National Physical Laboratory is admitted by all. Much of its work has been admirable, and more and better work can be done if funds are forthcoming. The appeal for an additional grant which is now under consideration will, undoubtedly, be better supported if the committee will let it be definitely known that the money will be applied only to purposes which justify the existence of the laboratory for the public good, and not to its conversion into or retention as an institution were researches, tests or analyses may be carried out for the benefit of individuals.

So serious are the fears entertained by many prominent and influential men as to the intentions of those having actual or nominal authority in the National Physical Laboratory, that it is very desirable that the Executive Committee should let us know the intended future scope of the work. If they will guarantee that such work will be limited to that defined in the report of the Treasury Committee, they will secure the support of many who are now strongly opposed to the granting of further funds; they will draw to their side many who are sitting on the fence, and they will more firmly secure the allegiance of those who are already on their side. Any vacillation at this moment will certainly result in the loss of grants from some of the technical societies, and will probably prevent the acquisition of the public money which is so urgently needed and which, properly applied, could produce such excellent results.—Yours, &c., GEORGE T. HOLLOWAY.

57, Chancery-lane, W.C., Oct. 31, 1905.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : I was much pleased to see the plain-spoken leader in your last issue dealing with the National Physical Laboratory and its methods.

An institution conducted on the lines indicated by the report of the committee who advised its creation we all felt would be a national advantage. That there is an immense amount of work awaiting its investigation which is well within its "terms of reference" is patent to all. Hardly any electrical manufacturer could not, from experience in his own work, make out a list which would keep Bushey busy for several years. We are only one branch : probably metallurgists could send them a list just as long, chemists another, and so with many other branches. Yet, instead of attacking all this legitimate work for which the laboratory obtains its grant, it is touting round for the very class which their terms of reference say it is most undesirable they should undertake.

It may be expedient that there should be some department, similar to the Standards Office, for official verification of instruments. This already exists, however, at the Board of Trade Laboratory, to which I have always advised instruments in dispute to be sent, and I see no reason to stop doing so. If you will refer to "The Electrician" Blue Book you will find that the limitation to "sub-standard" work mentioned in your leader only refers to supply meters.

Now, let us see how much of its legitimate work Bushey has done and published. Vol. I. came out last March, and contains five researches. (I abridge the titles.)

1. Analysis of Kew magnetometer results for 11 years, 1890-1900.
2. Comparison of electrical and gas thermometers.
3. Construction of mercury standards of resistance.
4. Work on iron carbon alloys.
5. Air-current pressure on plates.

No. 1 is a most interesting Paper. The Committee's report says "work useful both to science and industry." It is, therefore, quite legitimate—*if* "both" is disjunctive, not conjunctive. None of the actual readings were done at Bushey, only the clerical work.

No. 2 should be a most valuable subject of research, and might be taken as a sample of what the laboratory was intended for and for what it gets its grant.

No. 3. If there is still anyone who does not realise that the mercury standard ohm is merely a ponderous academic joke this Paper is not without its use. If he reads it he will now realise it fully.

No. 4. I am no metallurgist, but surely this is already being fully dealt with by far higher authorities.

No. 5. Similarly I am no bridge builder ; but from what little I know on the subject I should imagine this was work that still wants doing.

Only five investigations that the laboratory think worth publishing! Yet it is advertising for the commercial work that it was specifically told by the Committee was to be avoided.—Yours, &c., C. G. S.

## THE HIGH-PRESSURE ELECTRIC CONDENSER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : In reference to the request for information, of Mr. F. Jervis-Smith, contained in your issue of September 22, 1905, I am able to contribute the following. Being out of town at present I have been unable to give the exact dates in some cases, but have given sufficient reference to enable the exact date to be obtained.

The fact that the dielectric strength of air and other gases increases with pressure has been known for some time. J. J. Thomson and Mr. Peace investigated this subject more than 15 years ago, I believe, and some of their results are published in J. J. Thomson's "Recent Researches." The results of some other experimenters are also there given in the same publication.

Mr. Westinghouse was, I believe, the first to propose the use of air at a pressure higher than the atmosphere for use in connection with electrical distribution. He proposed, about 1880 I believe, placing the telephone ducts in Philadelphia and other cities under an air pressure above the atmosphere for the purpose of preventing the entrance of water or moisture to the ducts.

The writer made experiments on the dielectric strength of compressed air in the laboratory of the United States Electric Co. (Eastern branch of the Westinghouse Company) in 1891 for lightning arrester purposes. About 1893 the writer conceived the idea of using compressed air to insulate the proposed power lines between Niagara Falls and Buffalo. This was worked out with considerable detail, including methods of drying the air, supporting the conductors inside the steel tubes, &c. This method was laid before Mr. L. B. Stillwell and Mr. Coleman Sellers, the engineers for the Niagara Falls installation, in some detail several years latter—*i.e.*, about 1896 or 1897. The pressure proposed was about 100 lb. It was pointed out that compressed air insulation possessed many advantages : that it was much cheaper than rubber or any solid dielectric (in fact its cost is almost negligible, as the thickness of steel necessary to stand the pressure is not much thicker than that necessary to insure safety against punctures by a pick in the hands of a careless workman) ; that it had very small dielectric capacity and no dielectric losses ; that the leakage current was practically zero ; that in case of any small puncture or breakage the compressed air would prevent moisture from getting in ; that with two parallel mains connected at every section by cross pipes with suitable valves and cut-outs a complete breakdown was not apt to happen. An overhead system was, however, finally adopted. I do not, however, think that this was because Messrs. Stillwell & Sellers considered the compressed insulation impracticable, but because the amount of power which it was contemplated transmitting at that time was not sufficient to justify the large initial outlay. I may be mistaken in this, and possibly if Mr. Stillwell should happen to see this note he may care to discuss the matter.

The first actual publication in regard to the use of compressed air for practical purposes as an insulating material was, it is believed, made by the writer in his Paper on "Insulation and Conduction" (*Trans.* Amer. Inst. E.E., March 23, 1898, p. 147).

I will only mention two methods which have occurred to me as feasible for certain purposes. One is based on the fact that the dielectric strength of air, as shown by the experiments of J. J. Thomson and Peace, increases very rapidly with the pressure at 90 lb. per square inch, being equal to that of a good quality of rubber.

As mentioned by Mr. Jervis-Smith, the provisional specification of one of the early Marconi patents, 1896, I believe, states that the insulated balls of the spark gap may be separated by "small air spaces or high-vacuum space or compressed air or gas or insulating liquids kept in place," &c. This description is evidently, however, merely the usual blanket description used by many inventors specifying all kinds of practicable and impracticable devices. Four of the devices mentioned are either impracticable or else no better than the ordinary spark-gap in air, and, as Mr. Jervis-Smith points out, the compressed air-gap is not claimed or mentioned in the complete specification, and there is nothing to imply that any better effects were to be obtained by the use of the compressed gases over the other impracticable or unimportant modifications included in the description. One reason for this may be the fact that the advantages of using compressed air are negligible if low pressures are used.

A patent to Shoemaker, issued about 1901, shows a Righi oscillator, in which the central glass tube contains compressed air instead of the vaseline or oil used by Righi. The advantage of the compressed air is stated to be that it does not carbonise as the oil does. The fact that the two outside spark-gaps were in air at atmospheric pressure, and the fact that the glass vessel did not sustain a very heavy pressure were doubtless what prevented Mr. Shoemaker from noticing the peculiar efficiency which obtains with a discharge in compressed air above a certain pressure, which is generally about 45 lb. to 80 lb. per square inch.

In 1900 the writer noted the difficulty mentioned by Hertz in his Papers in regard to the spark becoming non-oscillatory when over a centimetre in length. A great many experiments were carried out during the years 1900-1901 in respect to ionisation, &c. Various vapours, chloride of ammonia, mercury vapour, iodine, &c., were tried; also a great variety of spark-gaps of different kinds and shapes, in multiples and in series; also a great variety of arrangements of inductances, and capacities and resistances, &c. It was finally found that with compressed air above a certain pressure the phenomenon noticed by Hertz disappeared, and the spark remained oscillatory up to potentials as high as were used, *i.e.*, up to 8 in. or 10 in. spark potential in air, and that the efficiency curve, even at the lower potentials, was higher than that in free air. A curve illustrating these results was given by the writer in U.S. patent 706,741, filed November 5, 1901, and issued August 12, 1902. From this curve it will be noted that above 1 cm. the radiation from the spark-gap in air fails to increase with increasing spark length, and in fact decreases, so that a 5 cm. spark in air gives actually less radiation than a 1 cm. spark. From the compressed air curve it will be noted, however, that if the same potential which would cause a 5 cm. spark in air is caused to produce a spark in compressed air (the length of the actual spark being, of course, much less—*i.e.*, about $\frac{1}{3}$ cm.) the radiation current is more than five times as great as that with a 1 in. spark in air. In other words, the damping out noticed by Hertz does not exist in compressed air above a certain pressure, and the spark potential may be increased to any desired extent with a corresponding increase in energy.

It is to be noted that the best results are to be obtained by the arrangement shown in the patent—*i.e.*, point and disc and metal containing cylinder. Here both terminals are pointed, but the effects are not so good. It may also be noted that if the air is compressed at a point at about 45 lb., then the spark jumps the same length, whether the point is made positive or negative. Above this pressure the polarity of the point which gives the longest discharge is the reverse of that which gives the longest discharge at atmospheric pressure. The discharge is noiseless and produces a very steady and intense radiation from the antennæ. The steadiness of this discharge is due to the fact that the air-gap breaks down at the same voltage within about 1 or 2 per cent. every time, and consequently the unevenness of the discharge which is so annoying when making measurements does not occur.

In this connection, I would say that while a mercury tube gives very good results, it is subject to considerable unevenness as it heats and the writer has found that the only really accurate method (which he feels at liberty to publish now) is to use a selector device and to cause a discharge to pass between an aluminium point and platinum-iridium disc in compressed air. For ordinary purposes, however, an aluminium point and platinum-iridium disc give very good results with an ordinary induction coil in air, if connected up so that the sign of the terminals is such as to produce the shorter spark.

The efficiency of the compressed-air spark-gap does not depend, as is sometimes assumed, solely, or indeed chiefly, on the *suddenness* of the discharge. There is another and more complicated phenomenon involved which is well worth investigation, and which, if followed out, will give results of very considerable scientific importance.

Accompanying the work done on the compressed-air spark-gap the compressed-air condenser was developed, which also gave very good results. The amount of the losses in an ordinary plate-glass condenser for wireless high-frequency current may be realised when it is pointed out that if a glass-plate condenser and a compressed-air condenser of equal capacity are caused to discharge through the same inductance the hot-wire ammeter will record more than three times the current with the compressed air than with the glass-plate condenser. In practice it is found that a compressed-air condenser will transmit signals approximately twice as far as a glass plate condenser of the same capacity.

In addition, the cost of the compressed-air condenser is quite low and the condenser is very compact. For equal capacities and potentials a compressed-air condenser occupies about one-tenth of the space that an oil condenser does, and a somewhat less space than a glass-plate condenser. By mounting compressed-air condenser, inductance and spark-gap all in the same chamber a very compact and noiseless oscillating system is obtained. As an instance of the low cost of the compressed-air condenser, I would say that the compressed-air condensers now in course of manufacture for the National Electric Signalling Co.'s trans-Atlantic experimental stations, which it is hoped will be completed in the spring or early summer of next year, will cost less than $1,000.

Mr. Bennett, my chief assistant, has made a number of measurements on the spark distance in compressed air, and, curiously enough, it would appear that the relation between voltage and discharge distance is a linear one, but that below 45 lb. per square inch there is an inflection in the curve.

In addition to the work above-mentioned, Prof. Ryan, of Cornell, during the last couple of years has carried out a number of experiments on compressed air for insulating purposes, some of the results of which he has published.

Trusting that the above may furnish, at least to some extent, the information desired by Mr. Jervis-Smith.—Yours, &c.,

REGINALD A. FESSENDEN.

Brant Rock, Massachusetts, U.S.A., Oct. 21.

## "MOLECULAR FORCES AND NEWTONIAN LAWS."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I observe your notice of the above in this week's issue. Electrical engineers do not yet apprehend the importance of that work in connection with their profession. The subject is one in which they receive no instruction. They are taught many theories, such as induction, repulsion and difference of potential between the extremities of an electric circuit. These are abstruse topics, and are happily forgotten as soon as the young electrician has passed his examination. What I have endeavoured to show, and I think successfully, is that the whole science of magnetism and electricity, so far as the electrical engineer is concerned, can be learned in a few simple lessons, and once learned can never be forgotten, for all the facts are in accordance with a single law as simple and universal in its operation as the law of gravitation. The first necessary step towards a better state of things is a change of front in our universities and technical colleges. Students are helpless in the matter. When spoken to on the subject their reply is, "Do not put these ideas into our heads till we have passed our exam." But surely it is unworthy of our time that students seeking advancement in their professional studies should be required to pass examinations in a system of theories of no practical value, and, as often as not, self-contradictory. By failure to apprehend the simple laws of force and motion, as taught by Newton, and by substituting in their stead a series of obscure hypotheses, our highest instructors in science are unconsciously placing a stumbling block in the path of every aspirant to the electrical profession.—Yours, &c.,

Glasgow, Oct. 28. THE AUTHOR.

[The generally accepted theories of electricity and magnetism may not be quite so simple and straightforward as the electrical engineer could desire; but, it is quite certain that he will not accept a theory of magnetism that requires the direction of a small magnetised needle, in the neighbourhood of a straight magnet, to be tangential to an ellipse, the poles of the magnet being the foci—*i.e.*, place the needle on the axis of the magnet and it will point in a direction perpendicular to the axis.—THE REVIEWER.]

**The 1907 Meeting of the British Association.**—The General Committee of the British Association met on Tuesday to discuss the question of the town in which the 1907 meeting of the Association should be held. It was unanimously decided to accept the invitation of the Leicester Corporation to hold a meeting in that town in 1907. A resolution to this effect was passed, and an appreciation of the invitation to hold the meeting in Dublin was added. The committee expressed the hope that the invitation to hold a meeting in Dublin might be renewed at an early date.

# LEGAL INTELLIGENCE.

### Adams v. Shaddock.

This case came before the Court of Appeal (the Master of the Rolls and Lords Justices Romer and Mathew) on Tuesday on appeal from an award of the County Court Judge of Plymouth sitting as arbitrator under the Workmen's Compensation Act, 1897.

Mr. J. SANKEY said the County Court Judge had decided the arbitration in favour of respondents on two grounds—(1) That the husband of the appellant (who was killed while at work) was not engaged in an employment to which the act applied, and (2) that the respondent was not an "undertaker" within the meaning of the act. Engineering work, within the act meant any work of construction, repair, or alteration of a railroad, and the real question was whether the work the man was engaged on was the alteration of a tramway. The respondent (the employer) was engaged in putting down at Plymouth telephone wires to connect the various private instruments with the exchange, and to do that he had to open trenches in various streets. In one of the streets an electric tramway had been constructed, and a trench had been dug from the side of the street up to the one rail of the tramway, and then another trench between the two rails of the tramroad. It became necessary to bore a hole underneath the rail so that the wire might be put through the hole underneath the rail. Applicant's husband had assisted to dig the trench, and while he was making the hole a tram-car came along and killed him. He (counsel) submitted that the man was engaged in, on or about the alteration of a tramroad, and that the surface of the road was part of the tramway. As soon as the trench got within 18 in. of the outer rails it was part of the tramway.

Lord Justice MATHEW: Supposing a man was employed filling up the trench between the rails and he was knocked down and killed, would he be held to be repairing the tramway?

Mr. SANKEY contended that he would.

Mr. SHAKESPEARE, on behalf of respondents, supported the decision of the County Court Judge. The work which was being done did not alter the tramway or interfere with it. The trams continued running the whole of the time, and unless it could be shown that the Tramway Co. was prima facie liable to repair the part of the road in question the case for the applicant could not be put. There was nothing to show that there was a duty on the Tramway Co. to repair the road which lay between the two sides of metals. Under the Tramways Act the duty of the company to repair that part of the road only arose where the two sets of tramlines were at a specified distance one from the other. The opening of the intervening space between the two sets of tramline had in this case nothing to do with the Tramway Co. The Telephone Co. had power to do the work in question whether the Tramway Co. desired it or not. It was not putting the popular meaning upon an Act of Parliament to hold that this work constituted an alteration of the tramway, although the tramlines were not touched and the traffic was not interfered with. There was no intention to interfere with the tramlines in any way, and "intention" was a matter which ought to be taken into consideration.

The MASTER of the ROLLS, in giving judgment, said this was one of those numerous conundrums that arose under the Workmen's Compensation Act, and he could not say that he had been able to form a clear or satisfactory judgment upon the matter, particularly in view of the fact that the Court were not entirely at one upon the meaning of this definition. He had, however, come to the conclusion upon it—not, he was bound to say with any, great certainty, because he did not think that this particular Act admitted of certainty in attempting to interpret its definitions. The applicant was in the employ of certain contractors, and in carrying out their undertaking he had to take electric wires across and under the area of a high road occupied by tramlines under statute. The point was whether the applicant in doing this work was engaged in engineering work. Under the Workmen's Compensation Act a definition of engineering work was "any work of construction or alteration or repair of a railroad." In this particular case the work which applicant was employed to do was not work which the owners of the tramway were concerned in. Applicant was employed by persons who had statutory rights to pass their wires across the tramway. He made a trench at right angles to the line of tramway, and when he came within a short distance, about one and a half feet from the line itself, instead of continuing the trench he made a continuous small tunnel to admit of a wire being carried in it under the tramlines and the road space between the lines. When he came to the intervening space between the up and the down line he made another trench and his purpose was to pass the wire under the tramlines and so carry it across the whole of the roadway. That work undoubtedly did involve alteration of the physical condition of the surface of the roadway between the up and down lines of the tramway. The question was whether a person engaged in that work was engaged in engineering work—that was, in the work of construction or alteration or repair of a railroad. The court had to apply the definition, and he thought they were justified as far as it was possible to look at the scheme of the act, which was to single out certain classes of employment and put certain persons engaged in such employment under the protection of the act. It was obviously intended by the legislature that there should be some distinction between different employments. It looked probable that there was some notion in this Act of Parliament of the different elements of danger in different employments, and those employments which were thought to have special elements of danger were brought within the act. In dealing with engineering work and looking at the definition, "construction, alteration or repair of a railroad," it seemed to him the idea was that persons engaged in that work were subject to special risks. Obviously the governing notion was that that work was such as would bring the man employed on it into specially dangerous relations; therefore by whomsoever that person was employed, whether by the owner of the tramway or other persons, if he was engaged in work which entailed physical alteration in the railroad he came within the line of danger, and required special protection. Here was a physical alteration made in the surface of the road along which a tramway was laid. The question was whether that could be described as alteration or repair of a railroad. The argument that the definition did not cover this particular work was mainly that the intervening space between the up and down lines of tramway being upon the high road was not part of a railroad within the meaning of the definition. Properly speaking, a railroad, when applied to one of those statutory tramways, such as the one in question, did not embrace the part between the rails, but must be limited to the rails themselves. Inasmuch as the surface upon which the tramway was laid was originally part of the highway, and remained the highway, it was originally repairable by the highway authority, and was now under statute only made repairable in the first instance by the Tramway Co., but leaving the underlying obligation to the highway authority to this extent—that they were charged with the duty of themselves intervening. At all events, they had the right of themselves intervening and repairing if the tramway authority within a certain time neglected to do so. It was contended that that part intervening between the rails could not therefore be described as coming under the definition of a railroad, and that a person engaged in altering that part of the physical area could not be said to be engaged in the alteration of a railroad. He had come to the conclusion, not without hesitation and difficulty, that the definition must be taken to embrace work which was done in this particular case, and which undoubtedly did involve alteration of the physical condition of that part of the road where the tramway was laid. What did the word railroad embrace, taking the definition of railroad as expressed by the ordinary man in the street? There were a great many things called railroads quite apart from what the Court understood to be railways. It had been decided that having regard to the special definition of railways given in this act, tramways were included in it. They had been told by the House of Lords that as far as possible they should give a practical common-sense meaning to the different words used in the act, and not to put any strained or artificial construction upon them. It seemed to him that the definition of the word railroad involved the use of the roadway as well as the iron rails on which the wheels ran. The whole thing, road and railway together were embraced in the word railroad as applied to those tramways which were very common in particular colliery districts long before ordinary street tramways were introduced. In dealing with such a tramway as that it seemed to him that an alteration by any person who had undertaken to make it would be engineering work within the meaning of the definition in the Act. If, as here, there had been a contract by the undertaker to carry an electric wire across such a tramway or railroad, and that involved the digging of a trench in the roadway between rails, it seemed to him that that would be an alteration of a railroad within the meaning of the Act. It could not depend upon whether the Tramway Co., by the special terms of its existence, was under obligation to repair that part, or whether the obligation rested exclusively upon another person. That could not affect the question whether the particular subject matter embracing roadway as well as iron rails might fairly be described as railroad. If it could be so described it did not matter on whom the obligation rested. The applicant by virtue of his employment was brought into juxtaposition and placed on that thing which the legislature deemed to be properly one of the class of things in respect to which there ought to be special protection. He was on engineering work, although the owner of the tramway was not the undertaker, but the person who employed him was undertaking the work which involved the physical alteration of what could be termed in popular terms a railroad. It seemed to him, therefore, that the learned judge had misdirected himself in this case by reference to special obligations imposed upon owners of railroads in the matter of repair. There was no evidence before the learned judge that this was not a railroad within the definition. Therefore, the applicant was entitled to succeed.

Lord Justice ROMER disagreed. He thought the County Court judge had come to a right conclusion. He did not see how the Court could or ought to differ from the County Court judge. On the conclusion of fact he had come to his lordship thought it could not be said that because a tramway was laid upon a public highway under statutory authority, the whole of the public road became part of the tramway, so that every alteration of any part of the road was, as a matter of law, an alteration of the tramway within the meaning of the Workmen's Compensation Act. Nor even if the road between the up and down lines of such a tramway had to be repaired by the Tramway Co.—which, in fact, had not been proved in this case—would it, in his opinion, make the part of road between the two lines so much part of the tramroad that every opening effected in that road by a stranger to the tramways or any dealing with it would of necessity and as a matter of law be work falling within the definition of an alteration of the tramway. In considering whether an employment is one concerning the alteration of a tramroad within the Act the matter should be looked at from what he might call a common sense point of view. From that point of view he asked himself was this workman employed in an alteration of the tramroad in any fair or reasonable sense of the term as used in the Act. In his opinion the man certainly was not. No alteration of the tramway was contemplated, or intended, and certainly on the evidence none was effected. The man was not employed to construct, to alter or to repair the tramway. On the contrary he was employed to do work about a telephone which in no way necessitated any alteration of the tramroad, or the working of it. In his opinion there was ample evidence to support the finding of the County Court judge.

Lord Justice MATHEW supported the judgment given by the Master of the Rolls.

By a majority, therefore, the appeal was allowed. Stay of execution was granted pending an appeal to the House of Lords.

### Rogers v. Cardiff Corporation.

In the Court of Appeal, on Friday, the Master of the Rolls and Lords Justices Romer and Mathew concluded the hearing of an appeal by the Cardiff Corporation from an award made by the County Court judge at Cardiff under the Workmen's Compensation Act, 1897.

Mr. BAILHACHE, for appellants, said the claim had been brought in respect of an accident which happened to one of their servants named Rogers. Rogers was employed in doing repairs to the overhead wires of the Corporation tramways, and to enable him to do these repairs used a tower waggon, which was drawn by a horse. On Sept. 5, 1903, he had repaired some wires, and was on his way to do repairs elsewhere when the horse bolted and Rogers sustained injuries. Rogers claimed and received an award of compensation. The question was whether or not Rogers was engaged at the time on, in, or about any employment to which the Act of 1897 related. He submitted that the learned County Court judge was wrong in giving an award.

Mr. A. PARSONS having supported the award,

The MASTER of the ROLLS, in giving judgment, said he had come to the conclusion that the question turned on the facts, and the County Court judge had found the facts. Unless they found that there had been some misdirection which led the County Court judge to find as he did they could not interfere. The question in this case was as to engineering work, and it was only by referring to the engineering work as work undertaken by the undertakers that they could be held liable for this accident. Engineering work did embrace a certain physical area, the expression pointing to there being local limits to the work; and the applicant must be shown to have been employed on, in or about that area. The County Court judge defined for himself the geographical limits, and found that the limits included the point where the accident happened. If it was not on the tram line it was in close proximity to it. In his opinion there was evidence which justified the County Court judge in considering that the area of the engineering work was co-extensive with the tramway itself. They could not define the area without seeing what the undertakers had undertaken to do. The County Court judge found as a fact that the area as to which the obligations of the undertakers extended was the whole area of the tramway, and that the applicant was employed by them to do such work as was necessary and obligatory on them as such undertakers. The whole work of repairing the wires of the tramway included the business of inspecting and ascertaining where the defects existed and it was the duty of the applicant to ascertain defects and amend them. It seemed to him that the County Court judge had, without any misdirection, arrived at the conclusion that the accident happened within the physical area of the engineering work. As this was a decision of fact, which was not arrived at through the medium of any misdirection, the appeal failed.

The LORDS JUSTICES delivered judgment to the same effect and the appeal was accordingly dismissed with costs.

**Re W. F. Mason (Ltd.)**—In the Winding-up Court on Tuesday, before Mr. Justice Buckley, the petition of Mason's Gas Power Co. for winding up this company was dismissed without costs.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT AND FILLED.

Barking District Council invite applications for the appointment of electrical engineer and manager of the light railway. Salary £225, rising by annual increments of £25 to £300 per annum. Applications to the clerk (Mr. H. Hargreaves), Public Offices, Barking, by noon Nov. 10. Further particulars are given in an advertisement.

The Council of the University of Leeds require an assistant lecturer and demonstrator in electrical engineering. Salary £175. Particulars from the Registrar. Applications by Nov. 18. See an advertisement.

Thomas Smith & Sons, Steam and Electric Crane Works, Rodley, near Leeds, require a first-class draughtsman, accustomed to electric cranes and lifting machinery. See advertisement.

An assistant engineer is wanted for direct current dynamos and motors. Applications to Messrs. Vickers, Sons & Maxim (Electrical Department), Sheffield. See an advertisement.

An outdoor representative is wanted to interview power consumers. Technical knowledge and commercial experience required. See an advertisement.

An assistant tester is wanted for outdoor work, well up in d.-c. and a.-c. work. Applications to the Brush Electrical Engineering Co., Ltd., Loughborough. See an advertisement.

The directors of the East Indian Railway Co. require an electrical foreman in the locomotive department of the company in India. The terms are four years' agreement with second class passage to India and home on satisfactory completion of engagement. Salary 300 rupees, rising to 400 rupees, per calendar month. Applications to the secretary (Mr. C. W. Young), 28-30, Nicholas-lane, London, E.C., by Nov. 8.

Burnley Guardians require an electrician to take charge of electric lighting plant at the workhouse. Wages £2. 2s. per week. Applications by 15th inst.

Mr. J. W. Seabrook, A.M.I.E.E., A.M.I.M.E., of Barking, has been appointed (out of 73 applicants) borough electrical engineer of West Ham. In addition to Mr. Seabrook, Messrs. W. E. Barton (Leicester), T. A. Beauchamp (Sheffield) and F. H. Whysall (Manchester) were in the short list from which the final choice was made.

Mr. Seabrook has resigned the position of chief electrical engineer to Barking Council, which he has occupied for nearly five years, and regret is expressed in Barking at the prospective loss of a capable and popular official. Mr. Seabrook was born at Boreham, Essex, and served his apprenticeship with Crompton & Co., Chelmsford. He then became assistant electrical engineer to Great Yarmouth Corporation, and in 1898 was appointed assistant engineer at Hampstead, where he remained until Jan., 1901, when he was selected to fill the position at Barking. On his appointment there the undertaking was losing some £1,000 per annum, the works costs amounting to 3·42d. per unit, which has now been reduced to 1·5d. per unit. Owing to this decrease in works costs, Barking Council have been able to reduce the average charges for current for lighting, power and traction. Except during the first year of Mr. Seabrook's appointment (when the loss was brought down from £1,000 to £274) the undertaking has made a net profit, each year being an increase on the preceding one. The most important development, however, has been with regard to the supply of energy for power. As the Council having been able to offer current at so low a rate as 1d. per unit, about 90 per cent. of the power users in the district have adopted electric motors for driving their machinery.

Mr. A. E. Eames has been appointed controller and Mr. J. Newlands deputy controller of the Post Office Central Telegraph Office in succession to Mr. E. Trenam and Mr. J. W. Eames, who are retiring. Mr. Trenam has been in the service of the postal telegraph department and their predecessors, the International Telegraph Co. and the British and Irish Magnetic Co. since 1856. Mr. J. W. Eames has also been in the service nearly fifty years. The new controller (Mr. A. E. Eames) has hitherto been senior assistant to the controller, and Mr. J. Newlands is being promoted from the position of traffic manager.

The Governing Body of Battersea (London) Polytechnic have appointed Mr. E. G. Tottle, M.I.M.E., to the post of superintendent of the drawing office and workshops in the department of mechanical engineering. Mr. Tottle has had considerable experience as a mechanical and electrical engineer, both in the workshops and drawing offices, and is at present on the teaching staff of Chiswick Polytechnic and the Welcome Institute, Deptford.

Mr. Chas. W. Manton of the Westminster Electric Supply Corpn. has been appointed charge engineer at Willesden.

Mr. T. Margery, senior mains engineer at Islington for the past six months, has been permanently appointed superintendent of mains at £200 per annum.

Mr. J. Allward, senior shift engineer at Islington, has been appointed, on probation for six months, station superintendent at £180 per annum.

Mr. Francis H. Davies is leaving the British Westinghouse Co. to take up an appointment in the electricity department of Marylebone Borough Council.

**Assessment of Tramways and Electricity Works.**—On Saturday the Merthyr Assessment committee considered the adjourned appeal of the Merthyr Electric Traction & Lighting Co.

Mr. J. RUMBOLDT, for the company, asked that they should be assessed on the receipts and expenditure basis. At present the tramways and appurtenances were put at £2,400 gross and £1,200 ratable, and the depot, yards, &c., at Penydarren at £600 gross and £480 ratable.

It was decided that the assessment of the entire undertaking be reduced to £864 ratable, arrived at by taking 6 per cent. on the gross receipts, and that relief be granted in the half-yearly rates extending from April, 1905, to April, 1906.

**Barking.**—The Electricity and Tramways committee have requested the accountant and the electrical engineer (Mr. A. H. Seabrook) to report as to what extent the electrical undertaking is dependent upon public lighting for its success, and whether any material saving can be secured by extinguishing a number of street lamps at midnight.

**Beckenham.**—The accounts of the electricity works (which are maintained and worked by the British Insulated & Helsby Cables, Ltd., under contract with the Council) show capital expenditure £76,989. 8s. 2d. at March 31, an increase of £7,142. 17s. 5d.

Receipts were £8,059. 8s. 2d. Total expenses were £3,311. 14s. 11d. and gross profit was £4,830. 15s. 4d. Interest required £2,208. 8s. 1d., and instalments of capital £2,160. 17s. 5d., while £97. 10s. was transferred to sinking fund. The net profit was then £364, compared with a loss of £764 on the previous year. Works costs were 1·64d. per unit (against 2·23d.), and total costs 2 04d. against 2·84d. 548,773 units were generated, 22,722 supplied to public lamps, and 354,814 to private consumers. The equivalent of 33,928 8 c.p. lamps for private lighting was connected, against 24,315 in 1904. The total maximum supply demanded was 310 kw.

The energetic engineer and manager of the works (Mr. J. E. Tapper) is distributing among householders in the district two pamphlets, one giving particulars of the free wiring scheme adopted and pointing out in a brief and clear style the advantages of electric lighting, heating, cooking, &c., and the other devoted to setting forth the advantages of electricity for power, The British Electric Traction Company have notified that they will require a supply of electricity for the Penge tramways on or about January 6, but they are not prepared to entertain the charge of 2d. per unit suggested by the Council. The Council have replied that the company are not entitled to insist upon supply until April 1, 1906. The general question of affording supply has been referred to a sub-committee, with a suggestion that the arbitration of the Board of Trade be invoked to settle the particular point at issue.

**Bexley.**—The Council have received sanction to borrow £3,954 for tramcars, the provision of repair and paint shops, &c., and the enlargement of the storage battery.

**Birstall (Yorks.).**—An inquiry was recently held into the application of the Council to borrow £2,000 for electricity supply. The Council will take current in bulk from the Yorkshire Electric Power Co. and distribute it from a sub station at 4d. per unit for private lighting.

**Boiler House Economies.**—Hever Castle power station, Hever, Kent, is well abreast of the times in boiler house economies. An installation of four Bennis stokers and natural draught furnaces for the Lancashire boilers has just been arranged. The Midland Electric Corpn. for Power Distribution, Wolverhampton, have placed an order for three stokers and compressed air furnaces for water-tube boiler. A detailed account of the economies and other advantages resulting from machine firing was recently given in a Paper read before the Keighley Association of Engineers, by Mr. A. W. Bennis, and appeared in our issue of the 27th ult. A free copy of the lecture may be obtained on application to Messrs. Ed. Bennis & Co., Little Hulton, Bolton.

**Bolton.**—The Council have refused the application of Bolton Cooperative Society for permission to take an underground cable from their central premises to another building of theirs some distance away in order to supply to both their premises electricity from their own plant. When the vote was taken the Town Clerk ruled that councillors interested in the society could not vote on the matter.

**Bradford.**—The Electricity committee have issued a report upon the work of their department during the past year, which gives particulars of the various additions to generating plant, extensions of mains, &c., during the period.

The report states, that the committee have authorised the laying of 16 additional lighting feeders, and this work is being carried out. The introduction of fuses for the purpose of dividing the distributing mains into sections corresponding approximately to the different feeders has also been decided upon and the work of installation is in progress. Early in the year the committee had under consideration the distribution of electricity over the tramways system, with a view to bringing it into line with the Board of Trade regulation regarding the voltage drop on the negative return. The committee accordingly gave instructions for the augmentation of the supply to the tramways by laying four additional feeders and the erection of two sub-stations on the extra high-tension system, the outcome being that the tramways distribution system will be divided into 19 instead of 8 sections, as at present. It having been decided to supply the districts outside the present area of supply by means of extra high-tension feeders, sub stations and transformer chambers have been arranged for. It has also been decided to lay a number of extra high-tension feeders for general supply on this system for both transmission and distribution to several of the outlying portions of the city. The Board of Trade consent has been received. The total number of consumers has increased from 1,923 to 2,049.

In a report of the Tramways committee for the year ended Aug. 31 it is stated that—

The route mileage now worked by the Corporation is 53¾ miles, Bradford being fourth in this respect among the principal provincial cities where municipalities are operating tramways. The tramways serve a population of 324,000, including 40,000 outside the city, and the number of passengers carried during the year was 42,282,618. The car mileage increased from 4,856,023 to 4,975,080, and the receipts by £8,118. The parcels department carried between Jan. 1 and Aug. 31, about 300,000 parcels, an average of 8,654 parcels per week. During the period the department received altogether for carriage, storage, &c., £2,375. 12s. An arrangement has been made between the Yorkshire Woollen District Electric Tramways Co. and Halifax Corporation tramways for the interchange of parcels. Between 300 and 400 parcels are despatched weekly between these systems and the department, and the whole system is working admirably. The department has been very successful in the collection and delivery of parcels, and up-to-date only one parcel has been lost. Claims have been met for damage to parcels to the extent of £5. The motor vans have been in use continuously, and have proved that they are well adapted for quick despatch and collection of parcels which could not otherwise have been undertaken. The accounts for the year ended March 31 last show revenue from traffic £223,541, and with advertisements, parcel traffic and other sources, £230,085. Traffic expenses absorbed £67,226, general expenses £20,221, general repairs and maintenance £32,177, and power £39,196. The balance carried to revenue account was £70,228, of which £23,942 was applied to meeting interest on capital and £24,491 contributed to sinking fund, £15;929 being carried to reserve or renewals fund.

**Brynmawr (Brecon).**—Before proceeding with the subject of electricity supply the Council decided on Tuesday to invite Nantyglo and Blaina Council to attend a conference as to undertaking a joint scheme.

**Buxton.**—The electrical engineer (Mr. W. J. Leeming) recently received complaints of a fluctuation in electric lamps which he attributed to irregular demand for current by a cinematograph exhibition which took about 100 amperes and switched the supply on and off several times during one evening. Mr. Leeming has now been authorised to refuse to supply current for cinematographs in future.

The report of the electricity department for the hal-year ended Sept. shows revenue £1,913. 8s. 7d. (compared with £1,735. 1s. 7d. in the corresponding period last year), 135,978 units generated (against 107,138) and 21,762 equivalent 8 c.p. lamps connected (against 19,955).

**Chichester.**—The Council are in negotiation for a transfer of their electric lighting order to a company.

**Dartford.**—The Council, it is reported, have decided not to renew the contract for "free" wiring in the district, but to "do small jobs themselves."

**Darwen.**—The Corporation tramways have made a profit of £937 on the half-year ended September, after paying £955 in interest and £853 to redemption of capital.

**Dundee.**—The Tay Ferries committee decided on Monday to adopt electric lighting at the Craig Pier. The engineer has been authorised to place the contract for laying the cables. Current will be taken from the Corporation mains.

**Dunfermline.**—At a special meeting of the Council on Monday a resolution to apply for a provisional electric lighting order for the burgh and certain contiguous areas was carried.

**Edinburgh.**—A report has been submitted by the town clerk (Mr. Thos. Hunter, W.S) with regard to the tramway policy of the Corporation.

The total expenditure on the tramways has (the report states) been £1,300,000, including cost of street widenings and about £340,000 paid to the old tramway companies for subjects which to a considerable extent disappeared in the cabling operations. Notwithstanding these unproductive items the tramways yield at present a net profit of considerably over £100,000 per annum, after paying for repairs and maintenance. The cabled lines have the advantage of being in the streets where most traffic may be expected. The same rate of capital expenditure upon tramways in suburban routes would not be able to produce a similar return. Hence the desirability of looking for a cheaper system. Recent advances in electric traction furnish practicable alternative systems which dispense with the overhead equipment. Embodied in the report is Sir A. B. W. Kennedy's recent report, and a map showing proposed new lines.

In Sir A. Kennedy's report it is stated that the question at present is chiefly concerned with the proposed route from Gilmore-place to Colinton. For such a route or any similar route, Sir Alex. Kennedy considers that the expense of laying down the conduit system was out of the question. Even if the traffic justified such an expense, it would probably be better to extend the cable lines than to introduce an entirely different system of equal cost for short distances. It had been suggested that these outlying lines should be worked by petroleum motor tram cars. There was no trustworthy experience of information as yet as to the cost of running or of maintaining such cars, and travelling in them would be much less comfortable than travelling in ordinary tramcars. He therefore thought the Council's choice practically lay between extensions on the overhead or by some surface-contact system. Of the Dolter and the Lorain systems (continues the report) the latter has certainly had by far the larger amount of practical use, but the former had had sufficient use to enable him to form the opinion that it had been brought into practical working condition. He thought that with proper care either of the two systems might be used on the Gilmore-place line. He was not prepared to say positively that either of the two systems was better than the other on the whole. A comparison between the two was a complicated matter. At present he would only suggest further that it might be advisable presently to ask both the Lorain and the Dolter Companies to supply them with three or four "dummy" studs, which they might put down at their proper intended level between the rails, so as to find out by practical trial whether their shape or elevation above the general road level caused any practical inconvenience. He believed that it would be found after the first few days that neither drivers nor cyclists would find any real trouble from them, although at first they looked somewhat conspicuous.

**Electric v. Steam Traction on Railways.**—In connection with the distribution of the prizes at the North-Eastern Railway Literary Institute, Gateshead, on Tuesday evening,

The chief mechanical engineer (Mr. WILSON WORSDELL) asked how they could expect, as a manufacturing nation, to hold their own against Germany and the United States if their youths abstained from improving themselves technically and scientifically. It was not the fault of our Governments or institutions so much as of individual predilections. He feared that for too many years they had been on hard-and-fast lines of red-tapeism in following old-fashioned patterns.

Sir WALTER PLUMMER, M.P., who presented the prizes, spoke of the high appreciation in which the Institute was held by the directors of the company. Commenting on the fact that more students had entered for electrical than for steam study, Sir Walter said that whether steam or electricity was the motive power of the future, the North-Eastern Co. would not be behindhand.

**Elgin.**—On Monday the Council resolved to apply for a provisional electric lighting order.

**Elland.**—The Council have conditionally accepted the terms of the National Electric Construction Co. for the construction of tramways from Huddersfield to Halifax, and have agreed to oppose a scheme to tap the Halifax system at West Vale through Elland to Huddersfield.

**Exhibition.**—The North of Scotland Electric Light & Power Co. are holding an exhibition of electric light fittings, electric motors, lamps, cooking and heating apparatus, &c., at the Corona Hall, Brechin.

**Exhibition Award.**—In connection with the Naval, Shipping and Fisheries Exhibition, Earl's Court, which closed at the end of October, the Stirling Boiler Co., of Motherwell, Edinburgh, London, &c., have been awarded a diploma and gold medal for their exhibit.

This exhibit included a marine Stirling boiler of 280 H.P. Part of the casing was removed to show the arrangement of the drums and tubes in the boiler. A special feature in the boiler was that it was lined with diatomite brick, which created considerable interest, inasmuch as it has a great advantage over ordinary firebrick, being a much more efficient non-conductor and at the same time only one-seventh of the weight. The various tube cleaners used for the company's boilers were also on exhibition. One of the tubes was split from end to end and a turbine cleaner inserted, thus showing how the cleaner is worked. Similar boilers to that exhibited are at present in service in merchant vessels, shallow draught steamers, &c.

**Folkestone-Sandgate Tramways.**—Folkestone and Sandgate Councils have decided to support the electric tramway scheme of the National Electric Traction Co.

**Foots Cray.**—The Board of Trade have informed the Council of their consent to the electric lighting order 1901 being transferred to a company, and an extension of time has been granted.

**Fulham (London).**—The Finance committee reported at Wednesday's meeting of the Council having received, in reply to an application to the London County Council to sanction a loan of £67,328 for electric lighting extensions, a request for information whether the Borough Council had considered what would be the effect upon their electricity undertaking of the passing of any bill for the supply of electricity in bulk in their area.

The Borough Treasurer had answered that the Council had committed itself to carry out various necessary schemes of extension to the full amount of the loan applied for, and had in fact already spent about £25,000 in connection therewith, therefore any electricity bill could not affect the present application.

An offer by Belliss & Morcom, to store the steam engine for the new 1,000 kw. G.E.-Bellis set for £10. 10s. per month was accepted. The General Electric Co. have agreed to store the electric generator free of charge.

**Glasgow.**—On 24th ult. the members of the Electricity committee inspected the extensions at the Port Dundas work and examined the two 4,500 H P. turbines built by Willans & Robinson, Rugby, coupled to Dick-Kerr alternators which have now been delivered by the makers.

One of the turbines has been erected and was running at the time of visit, and the other is in course of erection. The present generating plant consists of nine reciprocating engines, varying from 400 H.P. to 2,400 H.P., and aggregating 10,050 H.P., and two turbines of 4,500 H.P. each, making a total of 19,550 H.P. The reciprocating engines are coupled direct to direct-current dynamos, and the turbines to alternators which generate three-phase current at 6,500 volts. This current is transmitted to sub-stations where it is transformed to continuous-current at 250 and 500 volts. Two small storage batteries are also erected in the station.

A long debate took place at last week's meeting of the Corporation on a motion by Mr. Alston in favour of the formation of a works department; 35 members voted for the previous question, and 13 for the motion.

**Gloucester.**—The Electricity committee are considering the question of reducing the scale of charges for electric current for power, and the borough electrical engineer (Mr. G. R. White) has been requested to report on the matter.

**Horsham.**—The formal starting of the new plant at the electricity works took place yesterday (Thursday).

**King's Norton.**—At last week's Council meeting the chairman of the Electric Lighting committee (Mr. W. H. Davison) presented his report, and said that, after protracted correspondence with the Board of Trade as to their consent to the proposed transfer of the Council's electric lighting order, 1898, to Callender's Co., Belliss & Morcom and the Electric Construction Co.,

They now understood that the Board would be prepared to consider a proposal to transfer on the lines suggested if submitted to them by the Council after compliance and in accordance with the provisions of sec. 59 of the order, provided the proposed transferees were one company, either one of the companies above referred to, or a company to be formed for carrying out the proposed arrangement. The committee had conferred with the three companies, and it was proposed to form a new company to carry out the terms of the order, the shares to be held by the three companies.

It was also stated that the L.G.B. would consider an application by the Council for sanction to a loan subject to the consent of the Board of Trade to the transfer, to the terms of the agreement being such as the L.G.B. considered satisfactory, and to the financial position of the Council interposing no obstacle.

In order to establish a complete scheme of electricity supply the original estimate of £36,000, made some years ago, would be inadequate, and the committee understood that at a conference with the three companies an initial outlay of £50,000 was anticipated, and that as the demand for current increased it might be necessary to increase the capital outlay to about £100,000. The committee were in communication with the companies as to the arrangements to be made to meet the requirements of the Board of Trade. The committee recommended that they continue the negotiations, and the Council adopted this recommendation.

**Liversedge.**—On Monday consideration of a recommendation to borrow £1,500 for the supply and distribution of electricity (which is to be obtained in bulk from Yorkshire Electric Power Co.) was postponed.

**London County Council.**—At Tuesday's meeting loans for electric lighting purposes were recommended for Battersea £9,792, Fulham £25,000, Hampstead £6,000, St. Marylebone £90,405 and Stepney £10,000. (We refer elsewhere to the recommendation as it applies to the Fulham loan, which was postponed.)

*Tramways.*—It was agreed to apply for Parliamentary powers to confirm an agreement entered into with the North Metropolitan Tramway Co. for the Council taking over about 3 miles of tramway track.

The Highways committee brought up a long report recommending the reconstruction for electric traction of the first section of the Northern tramways (about 22½ miles in length), comprising the lines: (*a*) Theobald's-road terminus, via Clerkenwell-road, Old-street, Great Eastern-street, Commercial-street and Leman-street to near the London Docks; (*b*) Norton Folgate terminus, via Shoreditch, Kingsland-road, High-street and Stoke Newington-road, to Stamford Hill; (*c*) Aldgate terminus, via Commercial-road, Commercial-road East, and East India Dock-road to Poplar; (*d*) Moorgate-street terminus, via Finsbury-pavement and City-road to junction with Old-street; (*e*) Holborn terminus, via Gray's Inn-road to junction with Theobald's-road; and (*f*) along Old-street, between Great Eastern-street and Shoreditch. The committee hoped to complete the reconstruction of this section by Christmas, 1906. By dealing with this portion of the lines first the committee say it will be practicable to run electric car services on complete routes with a minimum of interference with the services on other lines.

It was further recommended: (*a*) That the capital vote of £10,000, approved July 18, for stoneware ducts for electric cables required in connection with the reconstruction of the first section of the Northern tramways, be cancelled; (*b*) that the estimate of expenditure on capital account of £112,000 be approved in respect of the erection of car-sheds and sub-stations for this section of the Northern tramways; (*c*) that the estimate of expenditure of £26,000 be approved in respect of necessary reconstruction of bridges; (*d*) that the estimate of expenditure on capital account of £665,600 be approved in respect of this reconstruction and equipment for electrical traction of this first section of the Northern tramways, namely, trackwork, including rails, &c., £415,600, rolling stock, cables, cable ducts, machinery, plant, &c., £250,000; and (*e*) that the Highways committee be authorised to obtain tenders, and to take other steps preliminary to the execution of the works.—Consideration of report postponed.

*Electric Power for London.*—The report of the Highways committee (which is to be discussed on Nov. 14) on the above subject will be found in another part of this issue.

**Macroom (Cork).**—The following resolution was passed at the last meeting of the District Council:—

That we instruct our clerk to notify the Macroom Electric Light Co. that as they have failed to comply with the terms of the contract *re* the lighting of the town, the Council will not require any light after Nov. 20, and will terminate their contract on that date.

The Clerk was directed to advertise for tenders for lighting the town by electric light or acetylene gas.

**Manchester.**—On Friday an inquiry was held into the application of the Corporation for sanction to a loan of £60,000 for extensions of the electricity works.

The chairman of the Electricity committee (Mr. Geo. Howarth) said the chief items in the application were: Additional plant £22,295, railway in Stuart-street station £17,850, distributing and balancing stations £14,285. Those extensions were needed to enable the Corporation to deal with the increasing demand for electrical energy for lighting, power and traction both within the city area and in the adjoining districts.

On going through the details the inspector (Mr. H. Ross Hooper) discovered that the railway at Stuart-street had been completed, though £17,850 further was required for it, the total cost being £32,500. He said this reduced the present proceedings to a farce. The Corporation supplied him with particulars of the loans required and with other information, extending over nearly 20 large pages, and yet not a word was said that the work had been partly finished. It was hardly a satisfactory position, and he could not understand why the Corporation should have withheld that information. Was an inspector to come to Manchester, examine plans, and then advise the Board as to what was to be done when the whole of the work had been carried out?

The city surveyor (Mr. T. De Courcey Meade) explained that the department was assured before the work was begun that there would be a sufficient surplus out of the previous loan to meet the cost.

The Inspector said it was very unsatisfactory for him to have to inquire into the details of work which had been carried out three years before. He had had no intimation of any sort that the Board's sanction had been anticipated in that way.

The City Surveyor said he took every precaution for the proper carrying out of the work, and it would never have been begun but for the assurance of the gentlemen who had in hand the financial side of the undertaking that they would have enough money to carry it through.

The town clerk (Mr. W. H. Talbot): We were very sorry that the situation has arisen.

After hearing the circumstances under which the work was undertaken, the Inspector said he could understand that the department believed that they would have ample funds to complete the work. He added that, when dealing with £14,285 for excess expenditure on the distributing and balancing stations, there was a difficulty in following the accounts. The only way that the total of £14,000 odd had been arrived at was by adding up the total assets and the total liabilities and then striking a balance. Then they found that they were £14,000 to the bad. Each sanction should have been kept separate, so that they could see how the money was actually being spent. He did not see how they could deal with that amount from the particulars before him. The Council had been running an account on a floating capital, and now they had come to a settling day. They should have had a settling day before. He pointed out that the committee was asking for a 25 years' loan for expenditure which had actually been incurred 13 years ago. That did not seem to him to be quite right.

The Town Clerk said the Corporation threw themselves on the indulgence of the Court. All concerned felt that they should have as long a period as possible for repayment.

The Inspector said his recommendation to the committee was to have their settling days oftener. He knew the department had had a great many difficulties. He was afraid that some of the items might not be allowed at the rate of 25 years for repayment.

The new car building and repairing works of the Corporation electric tramways department at Hyde-road were formally opened by the Lord Mayor last week. The works are claimed to be the most modern and best equipped of the kind in the country. The area taken up is about 4 acres, 2½ acres of which is roof covered.

A luncheon followed the opening ceremony, when it was announced that the tramways undertaking had last year receipts of £632,000 and expenditure of £411,500. If the undertaking were an ordinary private concern a dividend at the rate of about 13¾ per cent. would, it was claimed, be divisible among the shareholders. If from the gross profit were deducted the sum set aside for depreciation and renewal a net profit of £137,000 was shown, equal to a dividend of 8¾ per cent. It was further claimed that another £50,000 might be added to the gross profits in reduced fares and another £50,000 as representing the better conditions and wages of the men employed.

**Marble Arch-Cricklewood Tramways.**—Marylebone (London) Council have assented to the London County Council's projected electric tramway from the Marble Arch along the Edgware-road to Cricklewood, provided they are not called upon to contribute towards cost of street widening.

**Market Lighting.**—As announced in our issue of 20th ult., the City of London Corporation have decided to adopt electric lighting at the Foreign Cattle Market, Deptford, and have entered into a contract with the London Electric Supply Corpn. for supply of electric current at 1½d. per unit. Tenders have been obtained to a specification prepared by Mr. S. G. Castle Russell, M.I.E.E., consulting engineer, and Mr. Horace Dove, F.I.A., chairman of the Markets committee, has succeeded in inducing his committee to bring the lighting of the market up to date. Messrs. Lund Bros. have secured the contract for carrying out the whole of the work required, which will include 218 Verity's Aston-Worsley patent twin-carbon enclosed arc lamps, arranged, roughly speaking, in equal numbers alternately connected to the mains of the London Electric Supply Corpn., at a pressure of 210 volts for the alternating and 460 volts for the continuous circuits. There is also a scheme for incandescent electric lighting under consideration.

**Mitchelstown (Co. Cork).**—An inquiry will shortly be held into the application of the Council for permission to borrow £2,000 for electric lighting.

**Middlesex.**—At the last meeting of the County Council the Light Railways committee reported that clause 5 of the agreement with the Metropolitan Electric Tramways (Ltd.) provided that the current used by the company for their various lines was to be measured separately from all other current by meters placed in such positions as might be agreed upon within or close to the sub-stations.

The company now asked the Council to consent to the current used being apportioned to the various sections on the basis of the car-mileage run. Clause 5 was open to objection on the ground of its impracticability on such a system as that of the Metropolitan Co., where there was a variety of ownership.

The committee recommended the granting of the application, as the Council would be a gainer under the altered arrangement.—Agreed.

Motions were adopted (1) for a bill to be introduced next session, authorising a line from Edgware-road, Cricklewood, to High-road, Kilburn, (2) for application to be made to the Light Railway Commissioners for authority to construct a line from Edgware, through Stanmore to the county boundary, and (3) for a similar application in regard to a line from Wembley through Wealdstone to Edgware.

**Municipal Honours.**—Mr. G. Gilkes, of Gilbert Gilkes & Co, electrical engineers and turbine makers, Kendal, has been re-elected a member of the local Town Council.

Ald. Mills, chairman of the Islington Lighting committee, has been selected for the position of Mayor of the Borough for the ensuing year.

Mr. R. R Fairburn, tramway manager, has been re-elected unopposed a member of Worcester City Council.

**Municipal Telephony.**—At the meeting of Hull Telephone committee on Tuesday the chairman (Mr. J. Brown) presented a financial statement of the working of the municipal telephone department during the six months ended Sept. 30, which showed (it is reported) that the undertaking has now become a paying concern. The charge for an unlimited service is £6. 6s. and £5. 5s. for private houses.

**Newcastle-on-Tyne.**—The manager of the Corporation tramways (Mr. Ernest Hatton) has prepared a supplementary report on street lighting, in which comparison is made of the merits of arc lamps and incandescent gas for street lighting.

Mr. Hatton refers the Lighting committee to his previous report on the subject, and points out the benefit that would accrue to the ratepayers by utilising the existing plant in the power station for generating electric current for the proposed 180 additional street arc lamps. In a table accompanying the report it is shown that the candle-power of arc lamps is fairly constant, while for incandescent gas lamps photometric tests reveal an extremely varying candle-power, according to the condition of the mantles.

**North-Eastern Railway Electrification.**—A rumour is current locally that the North-Eastern Railway Co. are making arrangements to electrify their line on the south side of the Tyne, between Newcastle and South Shields.

**Oldham.**—The resumed inquiry into the Council's application for sanction to a further loan of £48,114 for extensions of the electricity supply undertaking, was held last week.

The town clerk (Mr. J. H. Hallsworth) said the getting out of the figures for the inquiry led to the discovery of an error in the original figures. A sum of £1,517. 8s. 8d. had been put down as representing certain cable in stock. It had been included twice over in the original figures, first as part of the cable expenditure at the Greenhill station under the heading of cables, which, he understood, was the proper heading under which it had been carried out, and was for street cable for connecting the station with the Rhodes Bank station. It was also included in the amount for cables in stock. There was another small error, as £85. 9s. 9d., the apportionment of the street expenses for sewering and paving of Preston-street, had also been included twice.

The first item on the detailed particulars of the loan now applied for was £359 for fixed furniture at the Greenhill station.

The Inspector (Mr. H. Ross Hooper) asked when that debt was incurred.

The Town Clerk said in April, 1903.

Exception was taken by the Inspector to an item (No. 2) for diverting a footpath across the Greenhill site, and the Town Clerk explained that this was made by order of the Court of Chancery.

After further questions, the Inspector said that but for the mistake which was undoubtedly made in connection with the footpath, and if the matter had been properly looked into and the Council had satisfied themselves whether the footpath could be diverted or not, a large portion of this £1,356 would not have needed to be incurred.

The Inspector also criticised an expenditure of about £700 for laying a temporary cable by road to connect the two stations, because the cable bridge across the railway was not ready, the reason for that being that the Corporation, in his opinion, had delayed too long in opening the negotiations with the railway company. He expressed the hope that the Town Clerk would advise his Council for the future against entering on such large expenditure without applying for sanction.

**Ossett.**—The Board of Trade have revoked the Ossett electric lighting order obtained in 1897.

The General Purposes committee have asked the Board to reconsider the matter, agreeing to adopt a scheme at a cost of about £3,000, or to enter into an agreement for leasing the order on terms to be arranged. The scheme prepared by Mr. A. E. Mottram (the gas manager) has been provisionally adopted and application has been made for power to borrow £3,500, the estimated cost. This decision was come to after the rejection of a proposal to ask the Yorkshire Electric Power Co. their terms for electricity supply in bulk.

**Paisley.**—The accounts of the electricity department for the year ended May 15 show capital expenditure £151,258. 17s. 6d., an increase of £17,861. 13s. 9d.

Revenue was £16,710. 13s. 4d. (compared with £10,853. 8s. 6d. in previous year) and gross profit £8,352. 3s. 4d. (against £4,645. 9s. 10d.). Interest required £4,376. 4s. 11d. (£3,773. 19s. 5d.) and sinking fund £2,817. 18s. 6d. (£1,956. 14s. 2d.), the net profit being £1,157. 19s. 11d. (against deficit of £1,085. 3s. 9d.). 2,001,948 units were generated (1,215,055), 240,843 supplied to public lamps (176,499) and 1,516,957 to private consumers (671,372). The total maximum supply demanded was 1,340 kw. (703 kw.).

**Police.**—At Marlborough-street (London) Police Court, Alfred Wray, described as a medical electrician, Henry Townsend, Henry Mostyn (clerk) and Frank Orchard were charged on remand before Mr. Kennedy with sending a postal packet containing improper books and articles from Volta House, Wardour-street, W.

The defendants, who pleaded guilty, were arrested on Oct. 13, when a quantity of literature relating to Dr. Bell's "electric" belts was found at Volta House. Mr. Muir (for the prosecution) said for some time past the public had made complaints to the police about certain literature that had been sent through the post from the address in question. The literature related to a so-called electric belt called "Dr. Bell's Self-Restorer." In a prosecution like this it did not matter whether the article was genuine or was the rankest quackery. Persons were not entitled to use the Post Office to advertise by such literature in this way. Wray was proprietor of the establishment, and the other defendants were in his employ. For the defence it was urged that the business was an old one, that Wray was a respectable man, and was prepared to discontinue sending out the circulars complained of. Mr. Kennedy fined Wray £10 and £5 costs, Townsend £5 and £1 costs, and ordered the other defendants to be bound over for 12 months.

**Presentations.**—The staff at the Electric Construction Co.'s works, Bushbury, Wolverhampton, have presented the retiring works manager, Mr. Richard Jones, with a marble clock, a pair of bronzes and a purse of gold. Mr. E. W. S. Moore made the presentation, Mr. William Bulloch being in the chair.

On Tuesday, at the Central Telegraph Office, G.P.O., E.C., Mr. E. Trenam, I.S.O., the retiring controller, was presented with a gold watch and chain as a token of esteem and regard by his London and provincial colleagues, the chair being taken by the Secretary to the Post Office, Mr. H. Babington Smith.

Mr. Martin F. Roberts, assistant engineer-in-chief, said that one of the most gratifying features in connection with the testimonial was the fact that it had been subscribed for by officers of every branch of the service.

Sir John Lamb, K.C.B., late of the G.P.O., testified to the zeal that had been one of Mr. Trenam's leading characteristics. At Leeds and Manchester he had rendered good service and as traffic manager his earnest and successful efforts to improve the telegraphic communication between London and the provinces had secured for him the approbation of the highest authorities.

Mr. Babington Smith, in asking Mr. Trenam's acceptance of the watch and chain, together with a diamond ring for Mrs. Trenam, expressed the hope that he would for many years enjoy health and happiness in the retirement which he had so well earned.

Mr. Trenam acknowledged on behalf of himself and Mrs. Trenam the handsome presents which his friends had been kind enough to give him. In closing his official life and parting with friends of a lifetime it was most gratifying to feel that he was taking away with him the goodwill and sympathy of so many of his colleagues, who had by their cordial co-operation so materially assisted him in his work.

Presentations have also been made to Mr. J. W. Eames, deputy-controller, and Mr. C. A. Morgan, assistant controller of the technical branch.

At midnight on Tuesday the Men's Provident Society of the London United Electric Tramways held its annual meeting at Chiswick, and the whole of the staff, upwards of 1,500, were entertained at supper by Sir Clifton Robinson (managing director), Lady Robinson and Mr. Clifton Robinson (superintendent). An address of congratulation on his recent knighthood was presented to Sir Clifton Robinson by the departmental staff on behalf of the men, and a handsome silver writing-table set was presented to Lady Robinson.

Mr. G. N. Tooker, of Plymouth P.O. Telegraphs, was on Monday presented by his colleagues with a marble clock prior to his departure for Filey.

The staff of Ilford Council's electricity works have presented to the private installation inspector (Mr. S. Watskow), who is leaving for South Africa, a marble timepiece.

The employés of the Scarborough Tramway Co. have presented a marble clock to Mr. Nicoll, secretary to the company, on his marriage, and a silver cigarette case to Mr. Phipps, who has been appointed overhead inspector at Belfast.

The staff of the Peterborough Electric Traction Co. have presented a case of silver-plated fish knives and forks and a pair of silver salt cellars to Mr. Coomber, the late manager, who is proceeding to Belfast.

**Preston.**—The receipts on the Corporation's tramways for the half-year ended Sept. 27 were £17,367. 4s. 10d., or 10·80d per car mile. 3,808,789 passengers were carried and 385,849·76 car-miles run.

**Pwllheli.**—The Council have decided to accept the proposals of a Yorkshire syndicate in regard to an application for a provisional electric lighting order and the erection of electricity works in the town.

**Rawtenstall.**—The Council have received sanction to a loan of £12,000 for electricity supply.

**R.E. Volunteers.**—It is stated that the Army Council have resolved upon the conversion of the sections of Coast Battalion R.E. into searchlight companies, for co-operation with companies of Royal Garrison Artillery in the defence of mercantile ports. The officers of the Coast Battalion will be appointed for duty with the new companies, but an early opportunity will be taken of putting them through a lengthened course of electric light instruction.

**Salford.**—At the meeting of the Electric Lighting committee last week, the Mayor (Sir Wm. Stephens) presented an address to Mr. Ald. Shaw, the chairman of the committee, who is retiring owing to ill-health.

**South African Lighthouse Communication.**—It is reported that the Cape Ministry propose to deal with the proposal to connect all lighthouses on the South African coast by telephone or telegraph with the nearest port from which assistance could be sent to distressed vessels. The question of lighting the coast is also to be considered.

**South Durham.**—Cleveland & South Durham Electrical Power Co. hope to be able to supply energy from their Grangetown station by Christmas.

**Stourbridge.**—The Council have instructed the Electric Powers committee to submit a scheme of electricity supply.

**Sunderland.**—The report of the deputation appointed to visit the recent Electrical Exhibition at Olympia, London, was presented to the Electricity and Lighting committee last week and, as a result, it was decided to exhibit various kinds of lamps in the electricity department's offices, so that customers may be able to see the most up-to-date class of lighting arrangements available.

**Torquay.**—A special meeting of the Council to discuss the position in regard to the supply of current to the Dolter Electric Traction Co. was held on Monday.

Ald. Winter moved that efforts be made to arrive at an amicable settlement of the points in dispute. A great deal of the present trouble had arisen from the Council's refusal to comply with the request of the company to be allowed to make a deviation of routes.

The chairman of the Electricity committee (Mr. Taylor) defended the attitude of the committee. He thought the Torbay route would be worth £500 a year to the company, but they were not likely to get it.

Mr. Luxmoor said that the company, in asking for the Lymington-road and Lucius-street routes to be given up, asked for what was worth £27,500 to them. He was in favour of letting the company and the Council abide by the company's act.

The Town Clerk said the company had elected to be bound by their Act and the Corporation must likewise be bound by it.

It was decided to arrange a conference with the company.

An inquiry was held on Tuesday into the Council's application for permission to borrow £9,500 for additional plant for their existing electricity works to enable them to supply current for the Dolter Co.'s tramways.

The town clerk (Mr. F. S. Hex) gave particulars as to population, assessable value, &c., and asked for the loan for the longest possible period.

The inspector (Mr. H. Ross Hooper) said the period was likely to be somewhat under 25 years, as only expenditure on plant was proposed, and plant could not be expected to last a quarter of a century. He said the L.G.B. would look closely into the present proposals, as the representations made at the original inquiry, prior to the starting of the works, had not been realised.

Mr. Pearce (for the Corporation) said they had had the advice of Mr. E. Manville (consulting engineer to the Corporation) and Mr. Mitchell (engineer to the Dolter Co.). The latter submitted a scheme, which had been approved in principle by the L.G. Board, and the former in his report on the scheme estimated that it would yield an annual profit of £640.

Mr. Manville tendered detailed estimates of the plant required, and said that when the outside sections of the tramways were completed the profit would probably increase from £640 to £1,100 or £1,200 a year. The plant proposed to be added would suffice for three years.

The Inspector said the proposed extension would carry them on till 1908, and inquired what position they would be in then. The present scheme was good so far as it went.

Mr. Manville suggested that by superseding one of the generating units by one of greater capacity, and putting in an additional boiler, they would be able to go on for six years, when there would be a considerably less amount outstanding on capital account, and they would by that time have the full benefit of the whole of the tramway load.

Councillor Luxmoor criticised the policy of the Council in its present position, and said the Council had had before them an offer to erect an up-to-date station on the refuse destructor site in Upton Valley, to supply power for the tramways alone, for £9,500.

The Town Clerk said that the scheme mentioned by Mr. Luxmoor had only been received on the previous day, so that there had not been time to consider it.

The Inspector considered that there was an insufficient appreciation on the part of the Corporation of their financial position; they were not in a position to meet the agreement, and hence the difficulties that had arisen.

Mr. H. Lancaster, manager of the Dolter Co., said they only received notice of the inquiry on Saturday. The company had done their best to meet the Council, and they supported the application.

The Town Clerk asked that the L.G.B. should convey their decision as quickly as possible, having regard to the urgency of the case.

The Inspector offered to do the best he could. There would be no harm in asking for tenders to save time.

**Traffic Board for London**—It is reported that the Government propose to take steps to introduce a bill next session for the establishment of a Traffic Board for London on the lines recently recommended by the Royal Commission.

**Tramways over Blackfriars and Westminster Bridges.**—The Bridge House Estates committee sat on Monday and decided to recommend the Common Council to provide for the passage of tramways over Blackfriars Bridge by widening that structure to the extent of 40 ft., and that the City Police should have control of the bridge and its approaches, and also of a subway which it is proposed that the London County Council will be asked to erect in connection with the bridge. No tramcars will be allowed to stop while passing over either bridge or within a specified distance. Other conditions were also imposed. Yesterday (Thursday) the Council adopted the resolutions.

**Utilisation of Waste Gases of Blast Furnaces.**—A bill will be introduced next session to incorporate a company for erecting plant for utilising the waste gases of blast furnaces in West Cumberland for the generation of electrical energy.

**West Hartlepool.**—An inquiry was held last week into the Council's application for sanction to borrow £5,000 for electric lighting extensions.

It was stated that the total expenditure upon electricity supply was £75,000. The present loan was for extensions of mains for power supply. The Council had already been supplying power to some works, but the chief reason for the present extension was to supply electric energy to the Seaton Carew Ironworks, which would require 300 H.P. to 400 H.P. annually.

**Dinner.**—The members of the Glasgow section of the Institution of Electrical Engineers held their fourth annual dinner on Friday evening last.

There were about 200 present. Mr. J. M. M. Munro presided, the croupiers being Messrs. Frank A. Newington (chief engineer, Edinburgh), Henry A. Mavor, Prof. Magnus Maclean, W. W. Lackie (chief engineer, Glasgow) and Walter Dixon. Among the company were the Lord Provost, Lord Kingsburgh, Mr. R. Kaye Gray, ex-Bailie Mackenzie (Edinburgh), Councillor J. Alexander, Sir J. Shearer, Col. J. Drummond Young, &c.

Sir J. SHEARER proposed "The Imperial Forces," and Lord Kingsburgh, in reply, said he could remember when leading scientists denounced as preposterous the idea of electricity being used as a mechanical power because zinc was so much a pound.

The toast of "Glasgow Corporation" was proposed by ex-Bailie MACKENZIE, who congratulated the Corporation on the defeat of the proposal to start a works department.

In his reply, the LORD PROVOST criticised the action of the citizens for not sending the proper men to the Council, and spoke against the formation of a works department. He proposed "The Institution of Electrical Engineers," and prognosticated the day when the porridge-pot would be "developed" by electricity.

Mr. R. KAYE GRAY, past president of the Institution, replied, and proposed the toast of the Local Section, to which the chairman appropriately replied.

## TRADE NOTES AND NOTICES.

### TENDERS INVITED.

*Barrow-in-Furness* Corporation invite tenders for supply and erection of one 500 kw. combined steam engine and generator, one balancer booster, switchboard panels and connections for generator and booster, one water-tube boiler with superheater, one mechanical stoker, steam and exhaust pipes, valves, &c., one economiser, ironwork, one 15 ton travelling crane and one cooling tower. Tenders (addressed to Chairman of Electricity committee) to the town clerk (Mr. C. F. Preston), Town Hall, Barrow-in-Furness, by noon Nov. 13. See also an advertisement.

*Bristol* Electrical committee require tenders for E.H.P. and L.T. three-phase cables. Particulars from the city electrical engineer, Mr. H. Faraday Proctor. See also an advertisement.

*Shoreditch* (London) Council invite tenders for three water-tube boilers, superheater, &c., steam, feed and drain pipes, valves, &c., and overhead steel flue for Whiston-street generating station. Tenders by noon Nov. 7.

*Clacton-on-Sea* District Council invite tenders for supply and erection of gas engines and dynamos, switchboard, underground mains, accumulators, meters, crane and buildings. Tenders to the clerk of the Council (Mr. G. T. Lewis) before 3 p.m. Nov. 6.

*London* County Council want tenders by 10 a.m. Nov. 7 for about 1,000 tons of steel conductor tee rails. Forms of tender from the engineer's department, Spring-gardens, S.W.

*Wallasey* Council require tenders by 15th inst. for 12 months' stores for the tramways department, including wheels, trolley heads, steel axles, oils, &c.

*Middlesex* County Council Light Railways and Tramways committee want tenders by 16th inst. for construction of a bridge over the Grand Junction Canal at Acton.

*Salford* Corporation want tenders by 4 p.m. 13th inst. for erection of a transformer station.

*Finchley* District Council require tenders by 5 p.m., Nov. 24, for electrically-operated pumping machinery for sewage works.

*Manchester* Tramways committee want tenders by 1 p.m. Nov. 11, for tramcar trucks and electrical equipments for cars.

*Macroom* (*Cork*) Council invite tenders until Nov. 10 for public lighting.

Tenders are invited for the supply of electric lights for ships of the Italian navy up to the value of about £1,300 (33,150 lire). Tenders have to be accompanied by a deposit of 4,000 lire (about £150) and local representation is necessary. Full particulars are obtainable from the Ministry of Marine at the Royal Arsenals at Spezia, Naples, Venice or Taranto.

### TENDERS RECEIVED AND ACCEPTED.

Dartford Council have accepted the tender of Reavell & Co for connecting rods for the engines at the electricity works at £52, and that of the Improved Wood Paving Co for wood paving for the tramway track at £2,280.

Middlesex County Council received the following tenders for the construction of the permanent way of the tramway in Bound Green-road, Wood Green :--

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Wimpey & Co. (*acc.*). | **£35,884** | **2** | **7** | G. Holloway........ | 39,800 | 0 | 0 |
| J. Strachan ........ | 50,700 | 0 | 0 | Pethick Bros. ...... | 39,777 | 0 | 0 |
| C. Wall ............ | 44,319 | 0 | 0 | F. Osman.......... | 38,500 | 0 | 0 |
| Mowlem & Co....... | 42,024 | 0 | 0 | Ford Clift.......... | 38,387 | 0 | 0 |
| Grounds & Newton.. | 41,873 | 0 | 6 | Dick, Kerr & Co..... | 38,386 | 19 | 2 |
| G. Hay & Co. ...... | 40,833 | 13 | 7 | W. Griffiths & Co. .. | 37,980 | 10 | 0 |
| G. Bell ............ | 40,235 | 0 | 0 | British Elec. Equipment Co. ........ | 37,488 | 5 | 8 |
| T. Adams.......... | 39,818 | 3 | 2 | | | | |

The County engineer's estimate was £38,911. 14s. 7d.

The following tenders were received by London County Council for 4,210 tons of acid steel track rails and fastenings :—

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Bolckow, Vaughan & Co. (*accepted*) .. | **£31,131** | **15** | **0** | P. & W. Maclellan | £32,813 | 2 | 6 |
| Barrow Hæmatite Steel Co. ........ | 32,249 | 5 | 0 | Lorain Steel Co. (not to specification) .. | 27,121 | 10 | 0 |

Islington Lighting committee has provisionally accepted the tender of Phillips & Co. for 5,000 tons of bituminous nutty slack coal at 2s. 6d. per ton at the pit's mouth and 9s. 3d. per ton delivered.

Eccles Council have accepted the tender of R. J. Nicholson & Co. for wiring and fitting up 46 workmen's dwellings for electric lighting at £138.

James Young & Co., Glasgow, have secured the contract for the construction of the Campbelltown-Machrihanish light railway.

Chelmsford Council are recommended by the Lighting committee to renew the contract for the public lighting for another year.

J. W. Fielding & Co. have obtained a contract for wiring the North-Western Co-operative Convalescent Home at Blackpool.

Bolton Tramways committee have accepted the tender of Burrows & Sons for erection of tramway offices.

### BUSINESS NOTICES.

Mr. Wilfrid L. Spence, until recently managing director of the British Electric Plant Co (Ltd.), Alloa, N.B., having severed his connection with the company, the directors have appointed Mr. R. H. Willis (for many years holding controlling positions in the electrical department of Mather & Platt) to undertake the general management of the business. The designing and technical staff of the company remain otherwise unchanged

Mr. Wilfrid L. Spence, A.M.I.C.E., M.I.M.E., who resigned last month the office of engineer to and managing director of the British Electric Plant Co. (Ltd.), is now practising as a consulting engineer at 31, St. Vincent-place, Glasgow. (Telegrams: "Electrify Glasgow." Telephone No. 1500 Royal.) Mr. Spence will make a speciality of electrical and electro mechanical subjects.

The offices of the Hull electric tramways department have been removed to Queen's Dock-chambers, Alfred Gelder-street, Hull.

The address of the Universal Battery Co, is now Mid-Kent Works, Southey-street, Penge, London, S.E. Telegrams "Umbaco London"; telephone 166 Sydenham.

The Direct Spanish Telegraph Co. have opened an office in Glasgow at 5, Royal Bank-place (telephone No. 3436 Royal), which is in direct communication with their cable system between England and Spain, via Bilbao.

Escher, Wyss & Co., engineers and turbine makers, inform us that from Aug. 1 Mr. A. Steiger ceased to act as their representative, and they have entered into an arrangement with Mr. Jens Orten-Böving, 72, Victoria-street, London, S.W., to represent them in the United Kingdom and in all British colonies. Mr. Böving has been connected with the company's business for some years.

A separate branch of the well-known business of Kelvin & James White (Ltd.) has been established, under the title of "Kelvin & James White (Ltd.) & Hutton," at 11, Billiter-street, London, E.C., for the purpose of dealing exclusively with the nautical section of the company's business. Mr. Hutton was until recently a partner in the firm of Penlington & Hutton, of Liverpool. The electrical side of the company's marine instrument work will be especially developed by the new branch.

The firms of Orenstein and Koppel and Arthur Koppel have been amalgamated, and in future the business of the two firms (that of manufacturers of tramway and railway permanent way materials, locomotives, wagons, &c.) in the United Kingdom will be carried on by Messrs. Arthur Koppel at 27, Clement's-lane, London, E.C.

Elizabeth Hahner and Max Wolff (trading as the Empire Telephone Co.), 30, Falkner-street, Liverpool, have dissolved partnership. Debts by E. Hahner.

Thos. Rickard Bawden Nunn and Frank Herbert Watts (trading as Nunn, Watts & Co.), electrical engineers, 82, Mark-lane, London, E.C., have dissolved partnership. Debts by Mr. Watts, who continues under the old style.

**Personal.**—Mr. J. Archibald Kyle states that he will shortly be resigning his position as assistant engineer and technical representative of Aron Electricity Meter (Ltd.), which he has held for the past three years.

Mr. Theodore Rich, lately with Bruce Peebles & Co., and also well-known as an officer in the Electrical Engineers Volunteers, has taken up a position in the Soudan Public Works Department. Mr. Rich carries with him the best wishes of his many friends both in London and in the provinces.

## BANKRUPTCIES, LIQUIDATIONS, &c.

Harry Jones and Gwilt Lloyd Cathrall, electrical engineers, &c., 19, Chester-street, Wrexham, have been adjudicated bankrupt.

A first and final dividend of 6d. is payable at 19, Exchange-street, Bolton, in the bankruptcy of Alex. Holland (trading as the Electrical & Mechanical Engineering Co.), 13, Bridgewater-street, Farnworth.

Claims against the Delafone Batteries Synd. (Ltd.) to E. Williams and Chas. B. Hahn, 12, Norfolk-street, Manchester, by Dec. 2.

A meeting will be held on Dec. 4 at 9, Wool Exchange, London, E.C., to receive an account of the winding up of the Tin Electro-Smelting (Zinnoxyd) Co. (Ltd.).

**Bankruptcy Petition.**—Notice is given of the presentation on Oct. 12 of a bankruptcy petition against Wm. Geo. Leather (trading as Windus Electric Co.), 25, Howard-street, Sheffield, and of substituted service of notice to debtor. The petition will be heard at County Court Hall, Sheffield, on Nov. 23.

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**Premises to Let, &c.**—Messrs. Marshall & Co., Campbell Works, Stoke Newington, London, N., have to let premises suitable for electrical works or light engineering trades. See an advertisement.

Messrs. Dann & Lucas, 23, Budge-row, London, E.C., have for sale a small family mansion within 12 miles of London, suitable for conversion into business premises. See an advertisement.

A substantial brick-built and slated building of three floors, each 4,200 sq. ft., is advertised to be let in another column.

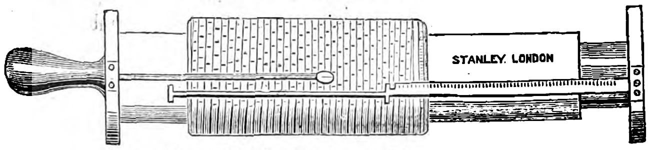
Mr. Adams, Chichester House, Chancery lane, London, W.C., has some factory premises in Clerkenwell and Shoreditch to let. See an advertisement.

**Apparatus, &c., for Sale.**—Mr. R. Archer, Horsforth, Leeds, advertises for sale Evershed testing sets.

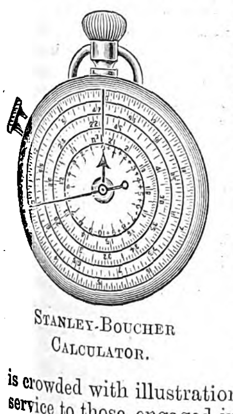
Cambridge Scientific Instrument Co., Cambridge, advertise for sale a 19 H.P. Stockport gas engine, suitable for driving electric lighting plant.

**Storage Battery Wanted.**—Messrs. Rose Bros., Albion Works, Gainsborough, advertise for a lighting battery for a 110-volt circuit and regulating switchboard.

**Calculating Instruments.**—In a fine new catalogue (H) issued by W. F. Stanley & Co., of Great Turnstile, Holborn, London, (price 1s.) a number of very useful calculating instruments are included, of which we give two illustrations. The first is Prof. Fuller's calculating slide rule, equal to a slide rule 83 ft. long, giving logarithms, multiplication, division, proportion, &c., giving results up to five figures. Its range is greater than that of most arithmetical machines, as besides the operations of multiplication and division which many instruments can only perform, results requiring the reciprocals, powers, roots or logarithms of numbers, can be quickly and easily obtained by its use Fig 2 is a "Stanley-Boucher" calculator, which is an improvement upon the Boucher instrument of the same class, as there is the addition of a third index hand which indicates the total movement of the front hand so that continuous workings show a final result + or −, thus indicating the correct reading of the result. Instructions are supplied for the use of these instruments. Messrs. Stanley's catalogue contains a large variety of instruments for all kinds of drawing work for engineers, electricians, surveyors, &c., and the new list is crowded with illustrations and particulars which will be found of service to those engaged in electrical or engineering work, whether in the laboratory, the office or the works. W. F. Stanley & Co. have made a speciality of these instruments and apparatus for very many years, and are famed for the good workmanship and design of their manufactures.



PROF. FULLER'S CALCULATING SLIDE RULE.



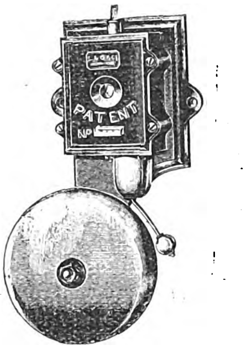
STANLEY-BOUCHER CALCULATOR.

**Railway Station Indicator.**—It is stated that a large indicator frame, electrically operated, is to be fixed at each station on the Metropolitan District Railway, notifying the stopping places and destinations of trains and times of arrival at the individual stations.

**Increased Prices of Accumulator Cells, &c.**—The Electrical Power Storage Co. notify that, from and after Nov. 1, 1905, all prices in the company's catalogue for complete cells, renewals and plates are increased by 5 per cent. This increase is necessitated by the continued advance in the prices of raw materials, especially lead, during the past three months. The increase applies to all outstanding estimates.

**"Synchronome" Clocks at Olympia.**—We are informed that at the request of the Motor Industry and Traders' Association the Synchronome Co. have arranged that the time-circuit of 20 electrically propelled dials (which were installed during the recently held Electrical Exhibition) shall remain at Olympia for the forthcoming motor show. Those who were unable to visit the Electrical Exhibition will thus have an opportunity of seeing how the electrical method of timekeeping works.

**Catalogues, &c.**—A number of new lists, including "Stellite" controllers for cranes, machine tools, &c., "Stellite-Gradual" patent magnetic motor-starters and regulators, "Stellite" portable electric drills and appliances connected therewith, and "Stellite" watertight, gas-tight and dust-proof bells, signalling apparatus, &c., have been issued by the Electric & Ordnance Accessories Co., Stellite Works, Birmingham. One "Fleetwood" pattern of watertight trembling bell is shown in the accompanying Fig. 1 and a table pattern single-stroke bell with signalling key, specially made for winding shaft signals, is shown in Fig. 2. A transportable electric drill equipment (the Hispeed) is shown in Fig. 3. These equipments are supplied for any desired speed and output up to 2½ in. with boring bar. The speeds of standard equipments are made to suit high-speed twist drills.



"FLEETWOOD" WATERTIGHT BELL.

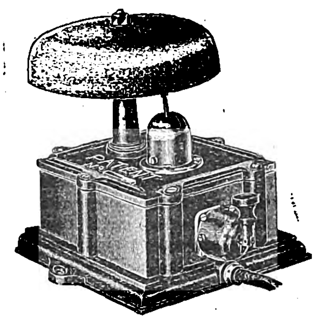
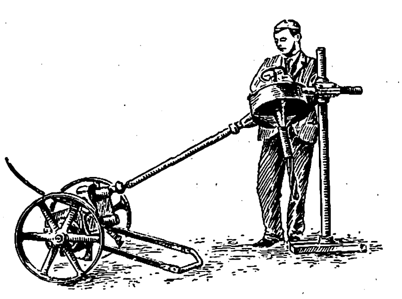


TABLE PATTERN WATERTIGHT BELL.



"HISPEED" TRANSPORTABLE MOTOR AND DRILL.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Oct. 25 to 31 with the ports of destination :—

*Africa.*—Alexandria, £416 (telegraph poles); Cape Town, £882 (including £395 telegraph material); Delagoa Bay, £193; Durban, £1,242; East London, £171 (including £71 telegraph material); Suakim, £215 (telegraph material) and 105 loads telegraph poles. *Argentina*—Rosario, £185 (telegraph material). *Australasia*—Adelaide, £19 (telegraph material); Hobart, £30; Lyttelton, £181; Melbourne, £35 (telegraph material); Perth, £21; Sydney, £119; Wellington, £3,454 (including £1,017 telegraph material). *Balek-Pappon*, £56. *Belgium*—Ostend, £27. *Ceylon*—Colombo, £12. *Chili*—Valparaiso, £265. *China*—Shanghai, £201; Tientsin, £175. *France*—Boulogne, £50; La Treport, £22; Paris, £35. *Germany*—Cologne, £25. *Gibraltar*, £20. *Holland*—Amsterdam, £207; Rotterdam, £115 (including £65 telegraph material). *Hong Kong*, £657 (including £190 telegraph material). *India*—Bombay, £460 (including £41 telegraph material); Calcutta, £1,895; Karachi, £179; Madras, £1,358; Mombasa, £141 (including £39 telegraph material). *Jamaica*, £59. *Japan*—Nagasaki, £156; Yokohama, £1,037. *Malta*, £2,750. *Portugal*—Oporto, £70. *Russia*—Kure, £707; St. Petersburg, £241. *St. Helena*, £28 (telegraph material). *Straits Settlements*—Penang, £203 (including £57 telegraph material); Singapore, £85 (including £28 telegraph material). *Sweden*—Gothenburg, £22 (telegraph material). *U.S.A.*—Boston, £55. *West Indies*—Trinidad, £39. Total, £18,515, against £25,985 in the corresponding week last year (Oct. 26 to Nov. 1).

# COMPANIES' MEETINGS AND REPORTS.

## Westminster Electric Supply Corpn. (Ltd.)

Meetings of the preference and ordinary shareholders were held on Tuesday, Lord Suffield presiding.

The SECRETARY (Mr. Frank Iago) read the notices convening the meetings, and Mr. HAYES FISHER, M.P., moved "That, as from Dec. 31, 1905, the preferential dividend payable upon the preference shares of the Company be at the rate of 4½ per cent. instead of at the rate of 5 per cent. per annum, and the rights of the holders of such shares be and are hereby modified accordingly." In commending the motion to the shareholders, Mr. HAYES FISHER said the purpose of the motion was to give the directors power to raise such additional capital as, after a careful estimate, they thought would be necessary during the remainder of the Company's concession—*i.e.*, during the next 26 years. He continued: Our present expenditure of capital may be roughly taken at a million pounds. We contemplate the expenditure of a further £1,000,000. Of this sum we shall require to spend one-fourth during the next few years. This we propose to issue at once in preference shares. We started our business in 1889 with £100,000 in ordinary shares. There were no preference shares and no debentures. By 1893 the share capital had been increased to £300,000 ordinary shares, on which a 4 per cent. dividend was paid, and £100,000 mortgage debentures bearing interest, some at 5 and some at 4½ per cent. By 1898 the share capital had been raised to £400,000, on which a dividend of 12 per cent. was paid, while the old debentures (£100,000) had been paid off and new debentures to the extent of £200,000 at the reduced interest of 3½ per cent. had been substituted. In 1902 the ordinary capital had been raised to £550,000 (at which it now stands) and a dividend of 12 per cent. paid; the debentures to £250,000, at which also they stand to-day; and 5 per cent. preference shares to an amount of £140,755 had been issued. The dividends for the past two years have been 13½ and 14 per cent. on the ordinary shares. This works out at an average of $8\frac{3}{8}$ths, or £8. 8s. per cent., to the original shareholders. The ordinary man in the street who read that last year the shareholders in the Westminster Electric Company received 14 per cent. probably concluded that those who had found the money to light the City of Westminster were making inordinate profits. Let me examine this. To produce the excellent light now given by our Corporation, and power, the demand for which is rapidly expanding, £1,000,000 has been spent. Broadly speaking, a fraction over 4 per cent. has been paid on half that amount, and (if you take the average dividend over the whole period) less than 8½ per cent. has been paid on the other half. So that the real substantial truth is that the ordinary consumer in Westminster, who is a ratepayer, has run no risks with his money as a ratepayer, and has had an excellent supply of light at a price which has not been at any time dear, and will, we hope, become considerably cheaper, especially as the demand for a day-load—*i.e.*, mainly power, gradually develops. Now let us turn to the expenditure of the Company. At the end of 1891, £297,640 had been expended; of 1894, £411,000; of 1898, £626,365; 1902, £951,806; 1904, £1,065,000. At the present time expenditure was £1,097,000; share capital and debentures issued, £941,255; overspent on capital account, £155,700. This is not a sum borrowed from bankers, because out of the profits of the Company the Directors have each year made what they are advised are proper allowances for depreciation. This depreciation fund has been invested in the Company's business, which has rendered unnecessary until now the issue of further capital. They feel that however sound this policy may have been in the past, looking to the fact that we are so many years nearer to the end of our concession, the time has now arrived when they should commence to invest this fund in securities outside the Company's undertaking, so as to be available in case of necessity. Formidable, therefore, as the present proposal for future capital may appear, it will be seen that it is only following on the lines of past experience. The demand for electric current shows no signs of diminishing; it is being used now for many more purposes than formerly, and the increase is greater in the current sold at the lower rates; in fact, increase of business appears to depend largely on the rate at which we can afford to sell. Within the last few years a considerable demand for power has sprung up. Leases are falling in in a large part of our area at present almost untouched, and as new buildings are erected they require a supply. Other sources of demand are almost certain to arise, and it is by no means improbable that our output at the end of our term may be three times what it is now. To meet this two more transformer stations of about the same capacity as Duke-street will be eventually required, part of which must be put in hand almost immediately. Provision has also to be made for the mains' department within the next few years, in connection with which it is suggested that stores should be erected at Eccleston-place. There is still a considerable balance on account of Duke-street to be paid. The other two stations will probably cost very much less than Duke-street, but, taking it all round, it can hardly be said that less than £150,000 will be required for land and buildings by the end of our term. Plant and machinery to equip these three transformer stations would cost approximately £200,000. We have already spent nearly £400,000 on mains, and taking high-tension feeders into account we may expect to spend another £500,000 under this heading. For meters we have spent nearly £60,000 and shall probably spend nearly another £100,000, while £20,000 or so may be required for street lighting if the local authorities decide to extend the present very satisfactory system of arc lighting. These figures can, of course, only be taken as rough guides to the amounts which will probably be required, but they are sufficient to show that we may expect to expend something like another £1,000,000 capital by the end of our term, while it is possible that new developments may increase this considerably. The Directors have power to issue further mortgage debentures or to create a debenture stock, but they consider it to be in the interests of the shareholders of both classes to create a security that will rank equally with the present preference capital instead of before it. The present mortgage debentures fall due for repayment in 1920, and it might then happen that they could not be replaced without an increased interest and the provision of a sinking fund, which would be a much heavier charge on the revenue of the company than that entailed by the increase of capital now proposed. Of course it was possible to have obtained the required capital by the issue of ordinary shares at par or at a premium, but having carefully considered the matter during the past six months, and having consulted with the Company's brokers, the Board have unanimously come to the conclusion that the proposed rearrangement of the Company's capital account is best in the interests of both classes of shareholders. They, therefore, recommend that the authorised amount of share capital be increased to £2,000,000, divided into £1,000,000 cumulative preference share capital and £1,000,000 ordinary share capital. The above £1,000,000 preference capital to carry a preferential right over the ordinary shares of the Company in the distribution of the assets in the case of the winding-up of the Company and a pro rata share of any surplus after repayment of ordinary capital at par. That the preference shares of the Company for the time being issued should carry a cumulative preference dividend of £4. 10s. per cent. per annum, instead of £5 per cent. per annum, and that the holders of the £140,755 of 5 per cent. preference shares be allotted an amount of £15,640 in 3,128 preference shares of £5 each to be paid for by a bonus free of income tax out of the reserve fund of the Corporation. The effect of our proposals will be that present holders of debentures will find their position strengthened, as the new capital raised at a cheap rate will be put into a remunerative business; the present preference shareholders will receive the same interest as formerly on their holding with an addition of 11 per cent. to their capital; while the ordinary shareholders will reap the benefit of the new capital invested in the business of the Company at a low rate of interest, and we are advised that so soon as this is appreciated by the investing public the market for both classes of shareholders will be strengthened. The Directors propose that an amount of £250,000 preference share capital be allotted to existing shareholders (ordinary and preference) pro rata to their present holding at three-eighths (7s. 6d.) premium per share. The premium received will be placed to reserve and be applied to cost of conversion of existing preference shares from 5 per cent. to 4½ per cent., and other expenses, the balance of the capital to be retained and issued as the needs of the Company require. The allotment will be in the proportion of one new share to three now held payable as to £1. 7s. 6d. in December next, and the balance of £4 per share at the end of March, 1906. Interest will accrue on any shares paid up in full on the Jan. 3 next. They further propose that the bonus shares for the conversion of the present 5 per cent. preference shares to to 4½ per cent. should be issued in January. Fractions of shares can be issued so that all shareholders will receive full value, and arrangements will be made so that fractions may be made up to full shares or the difference paid in cash. I trust that this review of the position of the Company has enabled the shareholders to grasp the situation in which their Directors find themselves, and that our proposals will meet with your cordial and unanimous approval.

Lord KINNAIRD seconded the motion.

Sir F. DIXON-HARTLAND, M.P., asked whether, after the issue of the first £250,000 of new capital, would the other three quarters of a million be issued by the Directors without appealing to the shareholders. The preference shareholders were quite satisfied that the present issue of £250,000 was not excessive.

Mr. HAYES FISHER: I think we should be bound to call the shareholders together.

Sir F. DIXON-HARTLAND: That is very satisfactory. The other question is, you propose a very large expenditure of £1,000,000 more upon the business, and you are aware a bill was brought into Parliament last year for general powers. Would not that bill, if passed, have a very great effect upon our business. What are the ideas of the Directors on that subject?

Mr. HAYES FISHER: I can assure you we thoroughly appreciate the importance of what Sir F. Dixon-Hartland has brought to your notice, that is the struggle of both this big Company and other companies, and the London County Council, to enter our area and other companies' areas for the purpose of supplying power. They have not got any yet, and I believe that one of the best means of preventing them getting any is to gradually expand our own capital in strengthening our works, so that we can supply power at a cheap rate in our own area. We have recently signed a contract to supply power at a penny a unit. We are acting under the advice of one of the best engineers, Sir A. B. W. Kennedy, and he is of opinion that we should be able to compete with anyone in our own area for supply of power at a cheap rate, provided we took the proper steps to do it, and as part of the procedure by which we might effect that object and can supply as cheaply as any other Company we ask you to give us power to create this new capital. The shareholders of this and all other Companies can largely aid our efforts in Parliament by instructing the public as to what after all is best in our interest and theirs. The public should see you could not divorce a capacity to supply power from that of supplying light. If you want to get light any cheaper you must increase your day load, by which you act in the interest of the public themselves. Companies that are strong and first in the field should be given a fair opportunity of supplying power at a cheap rate. If they can do it as a day load they can supply light at a cheaper rate, but you have to instruct the public.

The CHAIRMAN put the resolution, and it was carried unanimously.

A meeting of the ordinary shareholders was then held, and the proposals of the directors were carried unanimously.

Then followed an extraordinary general meeting, at which the directors proposals were submitted in the form of a group resolution, and unanimously approved.

Mr. SIMPSON : May I ask one question I omitted to put before. I see you have a balance of unissued preference of £21,849 shares. Would those be utilised before the further issue of the other shares took place?

Mr. HAYES FISHER : Those are 5 per cent. shares. They would be extinguished. They are converted and are not issued in that form.

The meeting then concluded.

## Eastern Extension, Australasia & China Telegraph Co. (Ltd.)

The sixty-fourth half-yearly ordinary general meeting was held on Wednesday at River Plate House, Finsbury-circus, under the presidency of Sir John Wolfe Barry, K.C.B.

The General Manager and Secretary (Mr. F. E. HESSE) read the notice convening the meeting, and other formal business having been disposed of,

The CHAIRMAN said : The report having been taken as read, I venture to offer a few remarks. I think that the shareholders will agree with me that the report and accounts are, on the whole, satisfactory. The gross revenue for the half year under review amounted in round numbers to £349,000, against £300,000 for the corresponding period of 1904 ; showing an increase of £49,000 (cheers). This result is not entirely due to growth of traffic. A portion (some £19,000) of the increase consists of revenue that was earned in 1904, but not included in that year's accounts owing to unavoidable delay in adjusting accounts with other telegraph companies, and consequently the increase during the past half-year actually due to growth of traffic was about £30,000. A portion of this increase is undoubtedly attributable to the war in the Far East, but as the bulk of it is spread over the company's whole system, with the exception of the Australasian, where a small decrease was experienced, we may draw the encouraging conclusion that a considerable portion of the increase is due to general growth of business. Since the conclusion of peace between Russia and Japan a falling off has been noticeable in the China and Japan traffic, but, on the other hand, I am glad to say the traffic with Australasia has shown some improvement during the last few months, and we may hope that growth of business with China and Japan, when relieved of the incubus of war, will equal the abnormal growth due to the late exhausting hostilities.

The working and other expenses amounted in round numbers to £136,000, against £142,000 for the corresponding period of 1904, showing a decrease of £6,000. Although station salaries show an increase of nearly £5,000, due mainly to a larger staff having been engaged in order to efficiently deal with the increased traffic, it will be seen from the accounts that there have been reductions in many other items of expenditure, notably in the cost of maintenance of cables, which alone accounts for £4,000 of the decrease. This arises from our having an exceptionally small number of cable interruptions during the past half-year and to the fact that they have occurred in our shallow water sections, which, as you are aware, represent a considerable proportion of our extensive cable system. Consequently we have been able to employ the small steamer "Magnet" for this work, and it has only been necessary to keep the larger vessels, "Patrol" and "Recorder," in reserve ready to effect repairs in the deep-water cables whenever required, instead of in full commission. The comparative immunity from cable interruptions, to which I have just alluded, may largely be attributed to the extensive renewal work which we have carried out from time to time whenever the old cables have shown signs of serious deterioration. However this may be, cable repairs have been, comparatively speaking, light during the period under consideration, and it would not be prudent to look upon the present as necessarily an index of the future.

The net profit for the half-year is, roundly, £195,000, and after adding to it the credit balance of £22,000 brought forward from the previous half-year, there remains an available balance of £217,000. The usual quarterly interim dividends of 2s. 6d. per share have been paid for the past half-year, leaving a balance of £142,000, of which £100,000 has been transferred to the general reserve fund and £42,000 is carried forward to the current half-year (applause). You will have seen from the report that the tariff for telegrams between Europe and Japan by this Company's route was reduced from July 1 last from 5s. 8d. to 4s. 10s. per word, making it the same as by the Great Northern Company's route via Russia. The Pacific Cable Conference, as you have doubtless learned from the announcements in the newspapers, was held a few months ago under the presidency of the Secretary of State for the Colonies, and you have probably seen the Parliamentary paper that was published shortly before the adjournment of Parliament embodying the conclusions arrived at by the Conference. I do not, however, think that I need allude further to that matter, as it does not affect us in any material manner, and I will conclude by moving—"That the report and accounts of the Directors, now submitted, be received and adopted."

The Most Hon. the Marquis of TWEEDDALE, K.T., seconded the motion.

The CHAIRMAN then invited discussion, but no shareholder rising to address the meeting, he put the motion, which was carried unanimously.

Mr. JOSEPH SHENNAN proposed a vote of thanks to the Directors and staff for their able management of the Company's affairs. It was a great pleasure to be connected with a Company which had been so successful for so many years. As far as could be judged wireless telegraphy was not likely to injure the Company in any way.

Mr. JOHN NEWTON seconded the motion, which was carried unanimously.

The CHAIRMAN : Gentlemen, on behalf of the Directors and the staff, I beg to tender my sincere thanks for this vote of thanks, and to assure the shareholders that there is nothing which the Directors value so much as the unanimous approval of those whom we are pleased to meet on these occasions.

The proceedings then terminated.

## Western Telegraph Co. (Ltd.)

The sixty-fourth ordinary general meeting was held at River Plate House, on Wednesday, under the presidency of Sir John Wolfe Barry, K.C.B.

The SECRETARY (Mr. E. Steer Hodson) read the notice calling the meeting.

The CHAIRMAN then said: Gentlemen, it again affords me great pleasure to call your attention to the continuance of the prosperous condition of affairs in South America, and to the consequent satisfactory improvement in the Company's revenue. Our message receipts for the half-year ended June 30 last amounted in round figures to £253,000, and for the corresponding period in 1904 to £216,000, being an increase of between £37,000 and £38,000. During the current half-year it is gratifying to observe that this improvement is being maintained. I would, however, remark that although the prospect is encouraging, we must be prepared for times of depression and slackness of trade, which appear to be inevitable, sooner or later, to every community. The fortunes of a Company like ours are directly dependent on those of the countries which we serve. Our increased revenue has not been obtained without some increased expenditure, to which I will now allude, and I must premise that a large proportion of the extra working cost is accounted for by the enhanced value of Brazilian currency, which, while augmenting the value of our remittances, causes a corresponding increase in the necessary expenditure in Brazil. General expenses in London show a net increase of £345. Comparing the disbursements at the stations, there is a net increase of £5,261, being the balance of increases under seven heads amounting to £9,281, and decreases under 10 heads amounting to £4,020. Dealing with the increases, salaries and wages were more by £7,601, and of this large amount nearly £4,500 was due to the higher rate of exchange at Brazilian stations already referred to. The balance is accounted for by the annual increments according to scale, and an increased number of staff required to deal with the extra traffic and to maintain our reputation for speed and accuracy in the transmission of telegrams. Rent, house allowance, fuel and light cost £1,130 more than in 1904, also due to the higher rate of exchange. The other five items—namely, expenses of training staff, agencies, maintenance of land lines, postage and bankers' commission show increases amounting in the aggregate to £550. These items make up the total gross increase already referred to of £9,281. On the other hand, dealing with the savings, travelling expenses were less by £348, and repairs to buildings only amounted to £449 odd, a saving thus being effected of £2,694. In repairs and renewals of furniture there was a reduction of £217, and stationery and printing is less by £394, as in June, 1904, the cost of the stock of stationery then in hand was written off against revenue. A satisfactory feature is the smaller amount expended on medical attendance, the decrease being £111. The remaining five items showing decreased expenditure are petty expenses, insurance, advertising, subscriptions to Consular Chapels and legal expenses, showing a collective saving of £256, or a gross decrease of £4,020, which, deducted from the gross increase, leaves a net increase of £5,261, to which I previously referred. The amount of repairs of cables during the half-year has been heavy, showing the large increase of £16,207. The working expenses of the present "Norseman" have been £2,916 more than those of the smaller vessel, the "Norse," which she replaced. The "Norna's" expenses were increased by £440. Further, it was necessary to charter cable repairing steamers to effect repairs for which our own vessels were not available. This accounts for an increase of £3,250, and cost of insurance of stock cable was more by £100. The most important increase, however, was in the value of the submarine cable used in repairs, which represented a sum of nearly £20,000, and exceeded the expenditure in the corresponding period by £12,212. These figures together make a gross increase of £18,918. This gross sum was reduced by decreases in the expenditure on the "Cormorant," sundry expenses at stations in connection with repairs and depreciation of cable in stock amounting to £656, and sums received for the charter of the "Norse" and "Cormorant" amounting to £2,055, these two items reducing the gross increase by £2,711, and producing a net increase of £16,207. The remaining accounts call for no special comment, excepting a decrease of over £4,000 in the expenses in connection with improved apparatus, which were somewhat heavy in 1904. The net result of the half-year's business is an increase of £41,379 in revenue from all sources and an increase in working expenses of £17,118. After providing £14,146 for debenture stock and debenture interest and sinking fund and £5,136 for income tax, there remains a balance of £147,411. To this is added £3,891 brought forward, making £151,303. A quarterly interim dividend amounting to £31,189. 10s. has been paid, £60,000 has been transferred to the general reserve fund, and £5,000 to the maintenance ships' reserve fund. The Directors now recommend the declaration of a final dividend of 3s. per share, making with the interim dividends a total dividend of 6 per cent. for the year, and also the payment of a bonus of 2s. per share, both free of income tax, which together will amount to £51,982. 10s., leaving a balance of £3,131. 11s. 7d. to be carried forward. The dividend and bonus will be payable on Nov. 2. Since our last meeting we have had a change in the members of the board. Mr. Andrews has felt it necessary on account of health to resign his directorship, and we have had to fill the vacancy so created. Mr. Andrews had been a director of the Western & Brazilian Telegraph Co., amalgamated into the Western Telegraph Co. in 1898, for 28 years, during the greater part of which time he acted as chairman. We all owe him great obligations and much regret his resignation. We have been fortunate in having been able to elect Lord Balfour of Burleigh to fill Mr. Andrews' seat on the board. I have received a communication from an honourable proprietor stating his opinion that a larger dividend should be paid on the share capital of the Company, and I have also seen observations made in newspapers to the effect that an increase in the dividend might be anticipated, but I must remind the shareholders that our main line deep sea cables were laid many years ago, in the one case over 30 years and in the other 20 years; and although when interruptions have occurred we have thus far been fortunately able to repair these cables, we must be prepared for the time when this will no longer be possible. As such an operation would necessitate the expenditure of several hundred thousand pounds, I am sure the majority of the shareholders will continue to approve of the policy of the Board in building up a reserve fund to enable us to meet such contingencies as those to which I have referred, and by judiciously conserving our resources, to assure as far as possible the continuance and stability of the very handsome dividend of 7 per cent. I call attention to this matter, as I should be sorry if proprietors were induced to increase their holdings in the expectation of a higher return in the shape of dividends. I now move the adoption of the report and accounts, and that a dividend be now declared of 3s. per share, making with the interim dividends already paid a total dividend of 6 per cent. for the year, and also a bonus of 2s. per share, making in the aggregate a distribution of 7 per cent. in respect of the profits for the year ended June 30, 1905, the said dividend and bonus to be respectively free of income tax.

The DEPUTY-CHAIRMAN (Sir John Denison-Pender, K.C.M.G.) seconded the motion.

Mr. G. ENNIS assured the Directors of the practical, if not the unanimous, support of the shareholders in regard to the question of dividend.

Mr. NEWBY said he thought that the Company ought to be provided with an exceptionally strong sinking or reserve fund, in view of their future responsibilities. After inquiring the Chairman's views as to the effect on trade of the opening of the Panama Canal "two years hence," the speaker continued to urge that the Company's investments should be given at the market price of the day.

The CHAIRMAN: If no other shareholder rises I will try to deal with the matters to which the two shareholders who have addressed the meeting referred. I am sure the Board feel very much gratified to know that their policy of increasing the reserve fund has the cordial approval of this meeting. There is no dissentient voice on that point, and it is pleasant to know that Mr. Ennis agrees with our more severe critic, Mr. Newby, in the matter. Answering the question of depreciation of cable, this depreciation is really a matter of precaution, and rather a matter of accounts. The cable is there, but having been bought at a price, we do not think it right to treat it as always worth the amount that we paid for it. I do not mean to say that it is depreciating altogether at the rate by which it is being written down. There is, in addition, a certain amount of cable we pick up from the bottom of the sea, and with which we deal with a view of relaying it. We deal with that in the same way as in the other case, which seems to be cautious. With regard to Mr. Newby's remarks, we are very glad, as I have said, to hear that he agrees with our policy as to the reserve. I do not think, however, that I will endeavour to follow him into all the subjects he has referred to. As to the effect of the Panama Canal on the Suez Canal, it appears to me to be more a matter for the bondholders of the Suez Canal than for the shareholders of the Western Telegraph Co., but I may say that I should not be rash enough to predict what the effect upon trade will be by the opening of the Panama Canal; it will have a considerable effect. For my own part, however, I do not think its opening is likely to occur in two years, or anything like two years, judging from its past history; but whether that is so or not, I venture to say that it can have comparatively little effect on the traffic of the Company, which deals with the great State of Brazil and the equally important States grouped under the term "the Argentina." I do not see myself what effect the opening of the Panama Canal is going to have on our prospects there. Mr. Newby asked about pensions. We have not got the exact figures before us, but I think I am right in saying that the amount of the pensions is about £700 a year, which is not a very extravagant thing to contemplate when you think about the large numbers of our staff and the service rendered to us by them in tropical countries. He thinks we have been extravagant in keeping up our furniture and spending £1,500 in doing so. Well, I am old enough to think—and I believe I am right in thinking—that there is nothing so silly as to let things go down and fall into a condition of ruin. We have 13 or 14 large stations, with an immense amount of furniture, and it must be kept up or we must buy new when it goes to rack and ruin. Part of this expenditure, I may say, is in the replacing of furniture. There is another little matter which, perhaps, Mr. Newby does not take into account—that there is a certain animal, whose use in nature I do not exactly know, called the white ant. He tunnels his way through chairs, bookshelves, and even books themselves; and when we talk about depreciation of furniture, we have also to take the white ant into consideration. Mr. Newby is a little under a misapprehension about the question of our reserves. We do not say that the value of the various investments forming our reserves is the value which is set out in the right-hand column in the statement submitted to you. If he looks at the top of the right-hand column he will see the word "cost." We give the shareholders what the various securities cost us, and I venture to think that that is the only proper way of letting them know the position of affairs in regard to this matter. Any shareholder can depreciate or appreciate these securities to the best of his ability, but we cannot venture upon any absolute statement of what the whole aggregate value of our reserves may come to. If you could imagine that the whole of these reserves had to be realised you could not say what the result would be. They are only realised as required, and then we take the items which are at the best price. It may, however, allay the alarm of some of the shareholders if I tell them that in the items Mr. Newby selected I think the difference between the cost price and the cost of the day is about 2 per cent., and if you take the whole amount of our investments and compare their cost price with the market price of the day, you will find a depreciation of a little over 4 per cent. We cannot help that. How can anyone help the depreciation in gilt-edged securities? And everyone knows that the depreciation in gilt-edged securities has been exceedingly severe during the past two or three years. I think the position is a little better now, and there is rather a tendency in the other direction; but, still, the depreciation has been great. Nevertheless, I do not suppose that anyone would tell us not to buy gilt-edged securities. We should certainly be very wrong in our trust if we bought speculative securities. If we did that, the prices might be up or down in a very much larger ratio than anything we have to report in regard to the investments we hold. I submit to the shareholders—whatever opinion they may hold on this point—that the whole position is disclosed in the accounts by our putting above the column the word "cost"; and we could not, practically speaking, report the matter in any other way.

Mr. JOHN NEWTON said he dissented altogether from the view expressed by Mr. Newby as to the way in which the cost of the Company's investments should be shown. The only business way of dealing with this matter was as the Directors had done. He might point out that if the Chairman had had to deal a few years ago with the point raised by Mr. Newby he would have been able to state that the value of the Company's investments showed an appreciation instead of a depreciation. As to the Panama Canal, he thought it was a question which might be relegated to the children of the Directors and to the grandchildren of most of the shareholders.

The CHAIRMAN then put the motion and it was carried unanimously, and resolutions were afterwards passed re-electing the retiring Directors (Sir J. Denison-Pender, Mr. D. H. Goodsall and the Duke de Loulé) and the auditors (Messrs. Deloitte, Plender, Griffiths & Co. and Messrs. Gane, Jackson, Jefferys, Wells & Co.).

A vote of thanks to the Chairman and Directors brought the meeting to a close.

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**BRITISH THOMSON-HOUSTON CO. (LTD.)**—The report for the year ended March 31 states that the trading profit was £29,026, added to £2,822 brought forward, making £31,848. After allowing for depreciation, writing £1,944 off goodwill, and £8,000 off suspense account, the balance (£1,696) is to be carried forward. At Rugby the buildings and machinery have been maintained in first-class condition, and the directors have followed their usual practice in providing for depreciation. During the year the company secured contracts for the electrical equipment of all the remaining trains on railways controlled by the Underground Electric Railways Co. of London, including its various tube railways. The system of control is the multiple unit system, similar to that furnished to the District, the Central London, the Great Northern & City and the North-Eastern Railways. The electrical equipments furnished are operating satisfactorily. The manufacture of the Curtis turbine has progressed satisfactorily, and a number have been built in the Rugby works, all giving excellent results. The directors believe that the company has good value in the enterprises in which it has investments. Since the closing of the books on March 1 the company has disposed of a large amount of these securities and reduced proportionately its liabilities. As shown by the balance-sheet last year, the excess cost of manufacturing incident to the establishment of the manufacturing business amounted to £63,326, of which £20,000 was at that time written off. There has been added to this account during the year £3,934, and there has been written off a further sum of £8,000, leaving £39,261, from which further amounts will be written off from time to time until finally disposed of.

**EDISON & SWAN UNITED ELECTRIC LIGHT CO. (LTD.)**—At the confirmatory meeting on Monday the resolutions passed on Oct. 12 (reducing the capital of the company and authorising the payment of 750 guineas extra to the directors) were confirmed.

**ELECTROLYTIC ALKALI CO. (LTD.)**—The report for the year ended Aug. 31 states that the net profit, after allowing for depreciation, mortgage, debenture interest and expenditure on maintenance of buildings, plant, &c., is £4,746, to which is added £1,374 from last year, making £6,120. The directors propose payment on the cumulative preference shares of one year's dividend on account of arrears of 7 per cent. on all the preference shares issued prior to April, 1902, and at the same rate upon all the preference shares issued since that date. This will leave £519 to be carried forward. The process continues to work satisfactorily and there is a good demand for the company's products. The great depression which existed in the market price of bleaching powder during 1902, 1903 and 1904 has continued, though to a less extent, during the past year. Towards the close of the year the erection of additional manufacturing plant was continued.

**RICHARDSONS, WESTGARTH & CO. (LTD.)**—At the meeting on Tuesday, Sir C. Furness, M.P., said the past year had been one of very severe depression and exceptionally keen competition in the engineering trade, particularly in marine engineering, and, taking that into consideration, the result of the year's operations had been satisfactory. That was largely due to the fact that, although marine engines and boilers formed their principal manufacture, yet they had, in addition, a range of specialities which contributed very materially to their business at Hartlepool. Their new turbine works at Hartlepool were now completed and were well supplied with work. At Middlesbrough the development of the gas engine business had been continuous and satisfactory. The Sunderland works produced marine machinery only, but had been fully employed. Extensions to various works of the company had been considerable, and included a large new brass foundry at Hartlepool. They had at present a larger order book than a year ago, and, as trade was distinctly improving, they were hoping for more remunerative prices.

**ROSARIO ELECTRIC CO. (LTD.)**—At the meeting on Tuesday, Col. W. F. Leese, who presided, gave a sketch of the company's progress. At the end of June they had 1,325 customers, and on Aug. 31 112 more, with 3,800 8 c.p. extra lights. With the old plant they had no motors, but on June 30 last they had 113, equal to 545 H.P., and this section of their

### ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | | Amount. | Inc. or Dec. (a) | Aggregate. No. of weeks | Aggregate. Amount. | Aggregate. Inc. or Dec. (a) |
|---|---|---|---|---|---|---|---|
| | | | £ | £ | | £ | £ |
| Aberdeen Corporation | Oct. | 28 | 1,219 | + 32 | 22 | 32,924 | − 1,614 |
| Airdrie | ,, | 20 | 208 | + 7 | 42 | 8,636 | + 140 |
| Anglo-Argentine | ,, | 28 | 13,358 | + 117 | 43 | 571,379 | + 35,756 |
| Ayr Corporation | ,, | 28 | 178 | − 8 | 23 | 8,925 | − 116 |
| Barcelona Trams Co. | ... | | ... | ... | ... | ... | ... |
| Barcelona, Ensanche, Gracia | ... | | ... | ... | ... | ... | ... |
| Barnsley | ,, | 20 | 152 | − 7 | 42 | 6,796 | − 302 |
| *Barrow | ,, | 20 | 201 | + 2 | 42 | 10,318 | + 2,116 |
| Bath Electric Trams, Ltd. | ,, | 25 | 639 | − 13 | 43 | 29,720 | + 1,750 |
| Birkenhead | ,, | 29 | 926 | − 35 | 4 | 3,856 | − 155 |
| Birmingham Corporation | ,, | 28 | 367 | + 42 | 30 | 10,832 | + 1,258 |
| *Birmingham & Mid. | ,, | 20 | 1,344 | − 202 | 42 | 67,592 | + 547 |
| Blackpool Corporation | ,, | 26 | 404 | − 31 | 30 | 42,614 | + 1,891 |
| Blackpool and Fleetwood | ,, | 28 | 241 | − 97 | 17 | 18,612 | − 927 |
| Bolton Corporation | ,, | 29 | 1,786 | + 106 | 31 | 60,391 | + 2,141 |
| Bournemouth Corporation | ,, | 25 | 1,337 | + 383 | †29 | 43,780 | + 7,619 |
| Bradford Corporation | ,, | 28 | 4,174 | − 344 | 30 | 135,914 | − 7,351 |
| Brighton Corporation | ,, | 29 | 787 | − 96 | 31 | 33,705 | + 530 |
| Bristol Trams & Carriage | ,, | 27 | 4,497 | − 336 | 12 | 60,666 | + 850 |
| Buenos Ayres & Belgrano | ,, | 29 | 2,855 | − 420 | 43 | 148,722 | + 6,996 |
| Buenos Ayres Elec. Trams | Sept. | 30 | 1,223 | ... | 39 | 44,891 | ... |
| Burnley Corporation | Oct. | 28 | 1,109 | + 66 | 30 | 44,075 | + 1,973 |
| Burton Corporation | ,, | 29 | 282 | − 22 | §30 | 9,860 | − 1,255 |
| Bury Corporation | ,, | 22 | 699 | ... | §29 | 21,948 | ... |
| Calcutta Tramways Co. | ,, | 28 | R37,810 | + R4,234 | 17 | R721,884 | + R88,869 |
| Camborne-Redruth | ,, | 28 | 99 | − 16 | 26 | 3,044 | ... |
| Cardiff Corporation | ,, | 28 | 1,866 | + 8 | 30 | 68,959 | + 140 |
| Carlisle Tramways Co. | ,, | 28 | 161 | − 9 | 43 | 8,025 | − 540 |
| Cavehill | ... | | ... | ... | ... | ... | ... |
| Central London Railway | ,, | 28 | 7,003 | + 232 | 17 | 102,756 | − 1,270 |
| Chatham & Dist. Lt. Rys. | ,, | 26 | 550 | − 18 | 43 | 28,695 | + 3,018 |
| *City of Birm'gh'm Tram Co. | ,, | 20 | 4,942 | − 632 | 42 | 226,766 | + 1,894 |
| City & South London Rly. | ,, | 29 | 2,741 | + 123 | 17 | 41,354 | − 805 |
| Colchester Corporation | ,, | 26 | 147 | − 63 | 13 | 4,062 | − 1,186 |
| Cork Electric Trams Co. | ,, | 26 | 405 | − 46 | 43 | 21,153 | + 719 |
| Devonport & Dist. Trams | ,, | 20 | 414 | − 76 | 42 | 19,617 | − 2,955 |
| Dover Corporation | ,, | 28 | 200 | + 7 | 30 | 7,331 | − 128 |
| Dublin & Lucan Railway | ,, | 27 | 96 | − 5 | 17 | 2,356 | + 2 |
| Dublin Southern District | ,, | 27 | 803 | − 35 | }17 | 69,618 | − 966 |
| Dublin United | ,, | 27 | 3,663 | − 78 | | | |
| Dudley—Stourbridge | ,, | 20 | 794 | + 41 | 42 | 38,250 | + 1,341 |
| Dundee Corporation | ,, | 25 | 890 | + 70 | §23 | 21,399 | + 1,002 |
| East Ham Council | ,, | 28 | 718 | + 84 | 30 | 25,649 | + 2,641 |
| Gateshead & Dist. Trams | ,, | 20 | 921 | − 1 | 42 | 83,727 | + 698 |
| Glasgow Corporation | ,, | 28 | 15,033 | + 443 | 22 | 832,259 | + 16,242 |
| Glossop | ,, | 28 | 123 | + 18 | 43 | 5,277 | + 469 |
| Gloucester Corporation | ,, | 25 | 239 | − 29 | 30 | 9,527 | ... |
| Gravesend—Northfleet | ,, | 20 | 208 | − 15 | 42 | 9,908 | − 935 |
| Gt. Northern & City Rly. | ,, | 18 | 1,670 | + 275 | 17 | 25,348 | + 6,220 |
| Greenock & Port Glasgow | ,, | 20 | 559 | + 52 | 42 | 27,317 | + 2,970 |
| Halifax Corporation | ... | | ... | ... | ... | ... | ... |
| Hartlepool Tramways | ,, | 20 | 286 | − 80 | 42 | 11,347 | − 1,181 |
| Hastings Elec. Trams Co. | ,, | 26 | 339 | ... | 12 | 7,595 | ... |
| Huddersfield | ,, | 28 | 1,335 | + 123 | 30 | 41,691 | + 1,242 |
| Hull Corporation | ,, | 28 | 2,083 | − 52 | 30 | 67,614 | + 521 |
| Ilford Dist. Coun. | ,, | 28 | 385 | + 2 | 31 | 15,075 | + 224 |
| Ipswich Corporation | ,, | 28 | 332 | − 82 | 30 | 14,141 | − 1,777 |
| Isle of Thanet Co. | ,, | 28 | 293 | − 61 | 4 | 12,406 | − 162 |
| Kidderminster & District | ,, | 20 | 93 | − 13 | 42 | 5,256 | − 298 |
| Kilmarnock Corporation | ... | | ... | ... | ... | ... | ... |
| Kirkcaldy Corporation | ,, | 25 | 186 | − 15 | 8 | 1,662 | − 52 |
| Lanarkshire Trams Co. | ,, | 26 | 945 | + 129 | 43 | 81,956 | + 3,810 |
| Leamington | ,, | 2) | 187 | + 45 | 14 | 3,009 | + 1,175 |
| Leeds Corporation | ,, | 28 | 5,618 | + 198 | 30 | 186,382 | + 3,719 |
| Leicester Corporation | ... | | ... | ... | ... | ... | ... |
| Liverpool Corporation | ,, | 21 | 10,110 | − 327 | 42 | 445,689 | + 8,617 |
| Liverpool Overhead Rly. | ,, | 29 | 1,369 | − 152 | 17 | 27,961 | − 1,124 |
| *London County Council | ,, | 21 | 14,208 | + 820 | 29 | 441,526 | + 64,891 |
| Lowestoft | ,, | 28 | 151 | − 9 | 4 | 666 | − 47 |
| Maidstone Corporation | ,, | 26 | 91 | − 35 | 30 | 4,125 | ... |
| Manchester Corporation | ,, | 28 | 12,385 | + 827 | 30 | 393,544 | + 15,690 |
| Mersey Railway | ,, | 28 | 1,572 | + 86 | 17 | 26,503 | + 1,656 |
| Merthyr | ,, | 20 | 180 | − 10 | 42 | 8,087 | − 442 |
| *Metropolitan Elec. Trams | ,, | 20 | 2,634 | + 849 | 42 | 112,829 | + 49,526 |
| Middleton | ,, | 20 | 287 | + 8 | 42 | 14,507 | + 614 |
| Musselburgh | ,, | 19 | 135 | ... | 41 | 10,258 | ... |
| Nelson Corporation | ,, | 28 | 128 | + 14 | 31 | 4,153 | + 432 |
| Newcastle-on-Tyne Corp. | ,, | 28 | 4,149 | + 522 | 30 | 116,891 | + 3,347 |
| Newport (Mon.) | ,, | 28 | 520 | + 55 | 4 | 2,144 | + 191 |
| Northampton Corporation | ,, | 27 | 352 | − 21 | 29 | 12,881 | + 4,780 |
| Oldham, Ashton & Hyde | ,, | 20 | 546 | + 8 | 42 | 23,529 | + 435 |
| Oldham Corporation | ,, | 29 | 1,692 | + 435 | 31 | 51,492 | + 13,884 |
| Perth (W. A.) Elec. Trams | ,, | 27 | 1,481 | + 84 | 43 | 58,899 | + 3,417 |
| Peterborough | ,, | 20 | 101 | − 26 | 42 | 5,896 | − 598 |
| Pontypridd Dist. Council | ,, | 28 | 143 | ... | 30 | 5,060 | ... |
| Portsmouth Corporation | ,, | 28 | 1,415 | − 118 | 30 | 65,715 | + 1,103 |
| Potteries | ,, | 20 | 1,750 | − 41 | 42 | 71,460 | + 448 |
| Preston Corporation | ,, | 25 | 578 | + 55 | 4 | 19,786 | + 7,919 |
| Reading Corporation | ,, | 26 | 545 | − 78 | 4 | 2,819 | − 179 |
| Rotherham Corporation | ,, | 26 | 444 | − 5 | 30 | 13,779 | − 753 |
| Rothesay | ,, | 20 | 57 | + 11 | 42 | 9,252 | + 2,648 |
| Salford Corporation | ,, | 30 | 4,076 | + 52 | 31 | 183,842 | + 6,618 |
| Sheerness | ,, | 18 | 57 | − 1 | 42 | 9,040 | + 804 |
| Sheffield Corporation | ,, | 29 | 4,779 | + 220 | 31 | 153,985 | + 6,897 |
| Southampton Corporation | ,, | 25 | 847 | − 57 | †4 | 3,133 | − 451 |
| Southend Corporation | ... | | ... | ... | ... | ... | ... |
| Southport Tramways | ,, | 20 | 235 | − 23 | 42 | 13,581 | − 456 |
| S. Staffordshire Trams. | ,, | 20 | 831 | + 123 | 42 | 30,816 | + 939 |
| Stockport Corporation | ,, | 27 | 755 | + 228 | 30 | 23,110 | + 4,800 |
| Sunderland Corporation | ,, | 29 | 1,127 | + 102 | 30 | 41,?30 | + 1,083 |
| Swansea Trams | ,, | 20 | 754 | + 255 | 42 | 30,287 | + 7,298 |
| Swindon Corporation | ... | | ... | ... | ... | ... | ... |
| Taunton Trams | ... | | ... | ... | ... | ... | ... |
| Tynemouth and District | ,, | 20 | 181 | − 13 | 42 | 11,340 | − 1,539 |
| Tyneside Trams Co. | ,, | 25 | 479 | + 114 | 43 | 18,406 | + 997 |
| Wallasey District Council | ,, | 28 | 677 | + 8 | 30 | 24,531 | + 648 |
| Walsall | ,, | 28 | 482 | + 18 | 42 | 21,141 | + 228 |
| Warrington Corporation | ,, | 23 | 331 | + 9 | 30 | 10,319 | + 499 |
| West Ham Corporation | ,, | 26 | 1,810 | + 730 | 30 | 54,002 | + 22,612 |
| Weston-super-Mare | ,, | 18 | 50 | + 4 | 42 | 6,576 | + 625 |
| Wolverhampton Corpn. | ,, | 25 | 764 | ... | 4 | 8,092 | ... |
| Wolverhampton District | ,, | 20 | 395 | − 13 | 42 | 16,716 | + 140 |
| *Worcester | ,, | 20 | 200 | − 41 | 42 | 13,017 | + 528 |
| Wrexham | ,, | 20 | 87 | − 12 | 42 | 4,800 | − 386 |
| Yorkshire Woollen District | ,, | 20 | 688 | + 129 | 42 | 27,625 | + 2,757 |

(a) These comparisons are with the corresponding period last year. † Minus 3 days. § Plus 2 days. * Partly electrical.

business was progressing satisfactorily. By next May the whole of the present plant would be fully loaded, and at present they had no proper reserve. The question of public lighting in Rosario was in the same state as before, but it was probable that it might be put up to competition. Quite recently the Council granted a concession to a Belgian syndicate for the electrification of the city tramways. The best way of preparing for such competition was to be in a position to meet any demand for electricity supply. When the chairman (Mr. Western) returned from Argentina, the board would go carefully into the question of further capital outlay.

## CITY NOTES.

**MEMORANDA** (Nov. 2).—Bank rate 4 per cent. (since Sept. 28, 1905). Price of silver 28$\frac{15}{16}$d. per oz. Consols 88¼—88⅜ for money, 88$\frac{9}{16}$—88$\frac{11}{16}$ for account; 2½ per cent. annuities 87½—87¾. Consols Pay Day, Dec. 1; Stocks and Shares Continuation Day, Nov. 13; Ticket Days, Nov. 14 and 29; Pay Day, Nov. 15; Mining Share Carry-over Day, Nov. 10.

**CITY OF BUENOS AYRES TRAMWAYS CO. (1904) (LTD.)**—The directors have declared a dividend of 1s. 3d. per share, less tax, for the three months ended Sept. 30.

**COMPANY STRUCK OFF REGISTER.**—The "London Gazette" for Oct. 27 contains a notification that Neild's Sleeve Electric Joint Synd., amongst other joint-stock companies, has been removed from the register.

**ST. JAMES' & PALL MALL ELECTRIC LIGHT CO. (LTD.)**—The amount of electricity sold by this company for the quarter ended Michaelmas is returned at 1,375,210 units, estimated to produce £20,055, against 1,238,880 units, which produced £19,306, for the corresponding period of last year

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Tues., Oct. 31. | Rate per Cent. Yielded. | Dividend Due. | Business, 6 Days to Oct. 31. Highest. | Business, 6 Days to Oct. 31. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | £ s. d. | | | |
| 5 | 3/0 | Anglo-Argentine Ord. Shares | 8⅝–8⅞ | 4 10 5 | Ap, Oct | 8$\frac{29}{32}$ | 8$\frac{11}{16}$ |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞–6⅛ | 4 9 8 | – | 6$\frac{1}{16}$ | 5$\frac{31}{32}$ |
| St. | 6% | Do. Permanent 6% Deb. Stock | 141–144 | 4 3 3 | – | .. | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 105–107 | 4 13 5 | – | 106 | .. |
| 10 | 12/0 | Barcelona Tramways Ord. | 13¾–14¼ | 4 4 0 | – | .. | .. |
| 10 | 5/0 | Do. 5% Cum. Pref. | 9½–10 | 5 0 0 | – | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock (red.) | 97–102 | 4 8 3 | – | .. | .. |
| 100 | 5% | Do. 5 per Cent. Debs. | 93–101 | 4 19 0 | – | .. | .. |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1–1½ | .. | .. | .. | .. |
| 5 | 2/6 | † Do. 5 per Cent. Cum. Pref. | 3¾–4¼ | 5 17 8 | – | 4⅛ | 4 |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 95–98 | 4 12 0 | – | 97¼ | 96¾ |
| St. | 6% | † British Columbia Elec. Rlwy. Def. Ord. | 123–126 | 4 15 3 | – | 126 | 125½ |
| St. | 5% | Do. Pref. Ord. Stock | 110–118 | 4 8 6 | – | .. | .. |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock. | 105–109 | 4 11 8 | – | 103⅛ | .. |
| 40 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%–105% | 4 5 9 | – | .. | .. |
| 100 | 4½% | Do. Vancouver Power Debs. | 101–104 | 4 6 7 | – | .. | – |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | 3¼–3⅝ | 5 1 6 | – | 3⅜ | 3¾ |
| 5 | 3/0 | Do. 6 per Cent. "A" Cm. Pref. | 5$\frac{13}{16}$–5$\frac{15}{16}$ | 5 2 0 | – | 6$\frac{1}{16}$ | 5$\frac{11}{16}$ |
| 5 | 3/0 | Do. "B" | 5–5½ | 5 9 1 | – | 5$\frac{1}{16}$ | .. |
| St. | 5% | Do. 5 per Cent. Debs. | 106–108 | 4 12 6 | – | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102–105 | 4 15 3 | – | 105 | 103⅞ |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 98–100 | 5 0 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 101–105 | 5 4 9 | .. | 103 | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 101–108 | 5 11 1 | .. | 106 | .. |
| 5 | 5/6 | Calcutta Tramways (Nos. 1 to 105) | 9–9½ | 4 9 6 | – | 9½ | 9$\frac{7}{16}$ |
| 5 | 0/3 | Do. Nos. 105,001 to 137,610 | 8½–9 | .. | .. | .. | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 107–109 | 4 2 7 | – | .. | .. |
| 1 | 0/6 | Cape Electric Tram Shares | 1–1¼ | 4 0 0 | – | .. | .. |
| St. | 5% | † Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 102–104 | 4 16 3 | – | .. | .. |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 97–99% | .. | .. | 98⅜ | 97¾ |
| 1 | .. | Lisbon Elec. Trams Ord. | 1$\frac{9}{32}$–1$\frac{11}{32}$ | .. | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛–1¼ | 4 13 0 | .. | .. | .. |
| 100 | 6% | Do. 6% Reg. Mort. Deb. | 101–103 | 4 17 0 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 103–105 | 4 15 3 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101–104 | 4 16 2 | | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102–104 | 4 6 7 | – | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 104–107 | 4 18 5 | – | .. | .. |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 145–148 | 5 8 1 | .. | .. | – |
| .. | .. | Do. 5% 1st Mt. $100 Dbs. | 100–102 | .. | .. | 100¾ | .. |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | 5/0 | Calcutta Elec. (1-30,000) ex new | 9–9½ | 4 4 2 | – | .. | .. |
| 5 | 2/1¾ | Do. (60,001-80,000) ex new | 9–9½ | 4 11 9 | .. | .. | .. |
| 10 | % | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50–52 | 4 16 1 | .. | .. | .. |
| .. | .. | Cordoba Lt. and Power Co. 1st Mt. Stk. £100 000 5% Bds. | 96–98 | .. | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½–3 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Debs. | 85–90 | 5 11 1 | – | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | 9–10 | .. | – | .. | – |
| 100 | 15/6 | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 94–96 | 5 4 2 | – | .. | .. |
| 1 | 5·33d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | $\frac{15}{16}$–1$\frac{1}{16}$ | 5 18 0 | .. | .. | .. |
| 1 | 1/0 | Rand Electric | 1¼–1⅜ | .. | – | .. | – |
| 1 | .. | River Plate Electricity Co. Ord. | ⅝–¾ | .. | – | .. | – |
| 1 | .. | Do. 6% Non. Cum. Pref | $\frac{15}{16}$–1$\frac{1}{16}$ | .. | .. | .. | .. |
| St. | .. | Do. 5% Deb. Stock | 102–104 | .. | .. | .. | .. |
| 5 | 8/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5⅜–5⅝ | 5 6 8 | .. | .. | .. |
| 5 | 3·13d | Do. (12,001-20,000) | 5–5½ | 3 8 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100–103 | 4 7 5 | Ap, Oct | .. | .. |
| .. | 10/9 | Shawinigan Water and Power 5% Bds., Scrip | 99–101 | 4 19 0 | .. | 99½ | .. |

* In calculating the yield, allowance has been made for accrued interest but *no* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Share. | Last Dividend | Name. | Price Tues., Oct. 31. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business, 6 Days to Oct. 31. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| 1 | .. | Bath Elec. Trams Pref. Ord. | ⅞–1 | .. | .. | 1⅛ | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16–1 1/16 | 4 14 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 102–104 | 4 6 7 | .. | .. | .. |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 103–105 | 4 5 9 | .. | .. | .. |
| 10 | 9% | Bristol Tramways and Carriage Ord. | 17–17½ | 5 2 11 | Feb, Aug | .. | .. |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10–10¼ | 3 18 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Debs. | 105–107 | 3 14 10 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 9⅝–10⅛ | 5 18 3 | .. | 10 | 9⅞ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 11–11½ | 5 4 4 | Feb, Aug | 11 5/16 | 11 1/16 |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 121–123 | 4 1 4 | .. | 122¼ | .. |
| St. | 4½% | † Do. 4½ per Cent. 2nd Deb. Stock | 97–99 | 4 11 0 | .. | 101 | .. |
| St. | 4% | Central London Ordinary Stock | 91–93 | 4 6 0 | June, Dec | 92½ | 91⅛ |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 101–103 | 3 17 8 | .. | .. | .. |
| St. | 4% | Do. Deferred Stock | 83–86 | 4 13 1 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 110–112 | 3 11 5 | .. | 111¾ | 111¼ |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 4⅞–5⅛ | 4 17 6 | .. | 5⅛ | 5 1/16 |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 100–103 | 3 17 8 | .. | .. | .. |
| St. | 2% | City and South London Rly. Con. Ord. | 43–45 | 4 4 6 | Feb, Aug | 44¾ | 43 |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 118–121 | 4 2 8 | Feb, Aug | 119 | .. |
| St. | 5% | Do. (1896) | 117–120 | 4 3 4 | .. | .. | .. |
| St. | 5% | Do. (1901) | 113–116 | 4 6 8 | .. | .. | .. |
| St. | 4% | † Do. 4 per Cent. Perpetual Debs | 105–108 | 3 14 1 | May, Nov | .. | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13½–14½ | 4 2 8 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 15–16 | 3 5 0 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5–5½ | 7 5 5 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8–9 | 4 8 11 | .. | .. | .. |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 100–102 | 4 8 3 | .. | 101½ | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 17–18 | 5 0 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 13¾–14¼ | 4 4 2 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 108–110 | 4 1 10 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼–2¾ | 9 8 6 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 83–88 | 4 10 11 | — | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8 1/16–8 13/16 | 3 13 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref | 9¾–10¼ | 4 15 3 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99–102 | 3 19 3 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9¾–10¼ | 4 17 6 | — | 10⅛ | .. |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 100–103 | 3 17 8 | — | 102 | .. |
| St. | .. | Mersey Con. Ord. Stock | 7–9 | — | — | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8–11 | — | — | .. | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32–9/32 | .. | — | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1–1 1/16 | 4 14 1 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106–108 | 4 3 3 | — | .. | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½–1½ | .. | May ... | ½ | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾–9¼ | 5 5 3 | .. | .. | .. |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9¼–9¾ | 5 2 6 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 102–105 | 4 5 9 | — | .. | .. |
| 1 | — | South Lancs. Elec. Trac. & Power Ord. | .. | .. | — | .. | .. |
| 1 | — | Do. 6% Pref. (£1 paid) | — | — | April, Oct | — | .. |
| St. | — | Do. 4½% Deb. Stock (100% paid) | .. | .. | Jan, July | — | — |
| 100 | .. | Sunderland Dist. Elec. Trams. 5% 1st Mort. Debs. | 95–99 | .. | .. | 98½ | 98 |
| .. | 5% | Underground Elec. Rys. Co. of London | 99½–100½ | 4 19 6 | .. | 100⅛ | .. |
| St. | 3% | Waterloo and City Ord. | 88–90 | 3 6 8 | June, Dec | 88 | .. |
| St. | 12/11 | Yorkshire W. R. Elec. Trams Co. 4% 1st Debs. | 92–95 | 4 14 6 | .. | .. | .. |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | * African Direct Tel. 4% Mrt. Deb. (red.) | 99–102 | 3 13 5 | Jan, July | .. | .. |
| 10 | — | Amazon Telegraph | 3¼–3¾ | .. | Jn, Dec .. | 3⅝ | 3¼ |
| 100 | .. | Do. 5% Debs. (red.) | 82–87 | 5 14 11 | .. | 83 | 82 |
| St. | 15/0 | Anglo-American | 60–62 | 4 16 9 | F, My, Ag, N | .. | .. |
| St. | 30/0 | Do. Preferred | 107½–108½ | 5 9 0 | F, My, Ag, N | 108⅛ | 107½ |
| St. | 2/0 | Do. Deferred | 15⅝–15⅞ | .. | F, My Ag, N | 16¼ | 15 11/16 |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 97–99 | 4 0 10 | Jn Ap, Jy, O | 97¼ | .. |
| 10 | 5/0 | Cuba Submarine Ord. | 8¾–9¼ | 5 8 8 | Feb, Aug | .. | .. |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17–18 | 5 11 2 | Feb, Aug | .. | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜–3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 9½–9¾ | 5 2 6 | April, Oct | .. | .. |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 100%–103% | 4 7 5 | Jan, July | .. | .. |
| 20 | 3/0 | Direct United States Cable | 13–13½ | 4 16 4 | Ja, Ap, Jy, O | 13⅝ | 13 |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 100–102 | 4 8 3 | Jn, Dec .. | .. | .. |
| St. | 25/0 | Eastern Ordinary | 143–146 | 4 15 10 | Ja, Ap, Jy, O | 145¾ | 145 |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 89–91 | 3 16 11 | Ja Ap, Jy, O | 90 | 89 |
| St. | 4% | † Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 106–108 | 3 14 1 | May, Nov | .. | .. |
| 10 | 2/6 | Eastern Extension | 14¼–14¾ | 4 15 0 | Ja, Ap, Jy, O | 14¾ | 14 7/16 |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 106–108 | 3 14 1 | Feb, Aug | 107½ | .. |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 99½–101½ | 3 18 9 | Feb, Aug | .. | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101½%–103½% | 3 17 4 | May, Nov | .. | .. |
| 10 | 5/0 | G. N. (of Copenhagen) | 35½–36½ | 6 16 11 | Jan, July | .. | .. |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 100–102 | 4 8 3 | June, Dec | .. | .. |
| 25 | 12/6 | † Indo-European | 54½–56½ | 5 15 1 | May, Nov | .. | .. |
| 100 | $1 | Mackay Companies Common | 46⅞ | 4 5 7 | Jan, July | .. | .. |
| 100 | 4% | Do. Preference | 74 1/16 | 5 6 8 | Ja, Ap, Jy, O | .. | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1⅜–1½ | .. | .. | 1 13/32 | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 100–103 | 3 17 8 | June, Dec | .. | .. |
| 10 | 5/0 | West African Telegraph Shares | 10–10½ | 4 15 3 | .. | .. | .. |
| 2½ | .. | West Coast of America | 9/16–11/16 | .. | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100–102 | 3 18 5 | Jan, July | .. | .. |
| 10 | .. | West India and Panama | 1⅛–1 3/16 | .. | May, Nov | .. | .. |
| 10 | 5/0 | Do. 6% 1st Pref. | 8½–9 | 6 13 4 | May, Nov | .. | .. |
| 10 | — | Do. 6 per Cent. 2nd Pref. | 7½–8 | .. | May, Nov | .. | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 101–104 | 4 16 2 | Jan, July | .. | .. |
| 10 | 3/0 | Western Telegraph | 14¼–14¾ | 4 15 0 | Mr, Jn, O, D | 14½ | 14 5/16 |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 101–103 | 4 17 1 | June, Dec | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 102½–104½ | 3 16 5 | .. | .. | .. |
| | | **TELEPHONES.** | | | | | |
| 5 | 5/0 | Chili Telephone (fully paid) | 7¼–7¾ | 5 3 3 | August .. | .. | .. |
| 1 | 0/9¾ | † Monte Video Telephone Ord. | 1 3/16–1 5/16 | 3 14 5 | — | .. | .. |
| 1 | 1/0 | † Do. 5% Pref. | 1 3/16–1 5/16 | 5 4 6 | .. | 1⅛ | .. |
| St. | 6% | National Co. Pref. Stock | 112–113 | 5 6 2 | — | 112⅛ | 112 |
| St. | 5% | Do. Def. Stock | 107–108 | 4 12 6 | — | 107⅞ | 107 |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13–15 | 4 0 0 | Feb, Aug | 14¼ | 14 |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 12–13 | 4 12 4 | Feb, Aug | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅝–5⅞ | 4 5 2 | Feb, Aug | 5⅞ | 5 25/32 |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 97–99 | 3 10 8 | June, Dec | 98½ | 98 |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 104–106 | 3 15 6 | — | 104½ | .. |
| 1 | 0/7½ | † Oriental | 1¼–1⅜ | 3 12 9 | April, Oct | .. | .. |
| 1 | 0/7½ | † Do. 6 per Cent. Cum. Pref. | 1 3/16–1 5/16 | 4 11 6 | — | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 102–105 | 4 5 9 | .. | .. | .. |
| 5 | 5/0 | United River Plate | 7–7½ | 5 6 8 | July .... | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5¼–5½ | 4 10 11 | June, Dec | .. | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 110–112 | 4 10 3 | June, Dec | .. | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 4¾–5¼ | 5 14 4 | .. | .. | .. |
| 10 | 2/0 | † Globe Telegraph and Trust | 10⅝–10⅞ | 5 1 0 | Ja, Ap, Jy, O | 10 11/16 | 10⅝ |
| 10 | 3/0 | † Do. 6 per Cent. Pref | 14⅛–14⅜ | 4 3 0 | Ja, Ap, Jy, O | 14½ | 14⅛ |
| 10 | 6% | Submarine Cables Trust (Cert.) | 125–128 | 4 13 9 | April, Oct | .. | .. |

| Share. | Last Dividend | Name | Price Tues., Oct. 31. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business, 6 Days to Oct. 31. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12¼–12¾ | 5 9 10 | .. | — | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10⅜–10⅝ | 4 4 9 | .. | 10 7/16 | 10⅜ |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 12¼–12¾ | 4 18 0 | .. | 12 1/16 | — |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 107–109 | 4 2 6 | .. | — | .. |
| 5 | 2 0 | Bromley (Kent) El. Lt. & Power Shares | 5¼–5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | † Do. Do. 1st Debs | 102–105 | 4 5 9 | — | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 9⅞–10⅛ | 4 19 0 | — | 9 15/16 | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 9¼–9¾ | 3 11 9 | Mar, Sept | — | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 105–108 | 3 14 1 | — | .. | .. |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 7½–8 | 4 1 0 | Feb, Aug | 7 11/16 | 7 |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5½–5¾ | 3 18 3 | Feb, Aug | 5 19/32 | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 103–105 | 3 16 2 | — | .. | .. |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4¾–5 | 4 10 0 | — | .. | .. |
| 5 | 2/3 | Do. Do. (1903) | 4¾–5 | 4 10 0 | .. | — | .. |
| 5 | 2/3 | Chelsea Electric Supply Ord. | 5¾–6¼ | 4 16 0 | March .. | .. | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 110–112 | 4 0 4 | Jn, Dec .. | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 12⅛–12⅝ | 4 11 6 | Feb, Aug | 12 9/16 | 12 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13¾–14¼ | 4 4 2 | Jan, July | 13⅞ | 13 |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 124–128 | 3 18 1 | Jn, Dec .. | .. | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 104–106 | 4 4 10 | .. | .. | .. |
| 5 | .. | County of Durham Elec. P. D. Ord. £2 pd. | 2 3/16–2¼ | .. | April, Oct | .. | .. |
| 5 | 6¾d. | Do. Do. 5% non cum. pref. | 5⅛–5½ | .. | April, Oct | .. | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 9¾–10¼ | 4 7 10 | — | 10 1/16 | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅜–12⅞ | 4 13 2 | Mar, Sept | 12⅝ | .. |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 111–114 | 3 18 11 | .. | .. | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 102–104 | 4 6 7 | .. | .. | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼–5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5–5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 100–103 | 4 7 5 | — | .. | .. |
| 5 | 4 0 | Hove Electric Lighting Ord. | 8⅛–8⅝ | 4 18 7 | .. | 8½ | .. |
| St. | 4½% | † I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 99–102 | 4 8 3 | — | .. | .. |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 12–12¾ | 4 14 1½ | .. | 12 1/16 | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½–7 | 4 5 9 | Jan, July | — | — |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98–101 | 3 19 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101–103 | 3 17 8 | .. | .. | .. |
| 8 | 1/9⅜ | London Electric Supply Ord. | 1¾–2¼ | 4 0 0 | .. | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5⅜–5⅝ | 5 6 8 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 99–102 | 3 18 5 | Mr, Jn, S, D | .. | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 10–10½ | 5 4 9 | April, Oct | 10 3/16 | 10 |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5⅝–5⅞ | 3 16 8 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 109–113 | 3 19 7 | Jn, Dec .. | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 98–100 | 3 10 0 | — | .. | .. |
| 100 | 4½% | Midland Elec. Corp. for P. D. 1st Mort. Db. | 101–103% | 4 7 5 | — | 102 | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 12½–12¾ | 5 11 1 | Feb, Aug | .. | .. |
| 100 | .. | Do. 4½% Deb. | 104½–106½ | .. | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8 3/16–8¼ | 4 18 2 | Feb, Aug | 8¼ | 8⅛ |
| 5 | 5% | Do. 5 per Cent. Non Cum. Pref. | 6 5/16–6 7/16 | 3 17 8 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99–100 | 4 0 0 | Jan, July | .. | .. |
| 1 | 8% | Northern Counties Elec. Sup. 17/- paid | 27/32–⅞ | 2 15 7 | Mar, Aug | .. | .. |
| 100 | .. | Do. 4½% Deb. | 100½–101½ | .. | Jan, July | .. | .. |
| 10 | 6/0 | Notting Hill Electric Ord. | 14–15 | 4 0 0 | March ... | .. | — |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98–100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅜–6⅞ | 5 1 6 | March .. | 6⅝ | — |
| St. | 4% | Do. 4% Deb. Stock | 100–102 | 3 18 5 | — | .. | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 14–15 | 5 0 0 | Feb, Aug | .. | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 8½–9½ | 3 13 8 | Feb, Aug | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 98–100 | 3 10 0 | — | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2–2½ | 8 0 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76–80 | 5 0 0 | — | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 3½–4 | 5 0 0 | .. | 3 11/16 | 3⅝ |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | 1⅜–1⅝ | .. | .. | 1⅜ | .. |
| 1 | 0/8¾ | Do. 7% Cum. Pref. | 1 5/16–1 7/16 | 4 17 2 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 103–105 | 4 3 8 | — | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4½–4¾ | 5 5 8 | — | 4⅝ | .. |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5–5¼ | 4 15 8 | — | .. | .. |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 103–105 | 4 5 9 | .. | .. | .. |
| 5 | 6/6 | Westminster Electric Supply Ord. | 12¼–12¾ | 5 9 10 | Mar, Sept | 12 11/16 | 12 |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 6–6½ | 3 16 11 | .. | 6 3/16 | .. |
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝–⅞ | 5 6 6 | — | .. | .. |
| 1 | 6d. | Aron Elec. Meter 6% Cum. Pref. | 1 7/16–1 9/16 | .. | .. | .. | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 1¾–2 | 5 0 0 | .. | 1 25/32 | 1¾ |
| 1 | 7½d. | Do. Pref | 1 7/16–1 9/16 | 3 16 10 | .. | 1 15/32 | .. |
| 5 | 4/0 | British Insulated & Helsby Cables Ord. | 6¾–7¼ | 5 10 3 | July, Feb | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾–6¼ | 4 16 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103–106 | 4 4 11 | .. | 105½ | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98–100 | 4 10 0 | .. | .. | .. |
| 5 | 3/0 | British Westinghouse 6% Pref. | 2⅝–2⅞ | 11 4 6 | .. | 2⅝ | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 85–89 | 4 9 11 | .. | .. | .. |
| 2 | .. | Brush Electrical Engineering | ½–¾ | .. | March .. | .. | .. |
| 2 | 2/4⅘ | Do. 6 per Cent. Pref. Non-Cum. | 1¼–1¾ | 6 17 2 | Mar, Sept | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 93–97 | 4 12 10 | Mar, Sept | 96¾ | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 78–81 | 5 12 6 | Jan, July | .. | .. |
| 5 | 5/0 | † Callender's Cable Con. Ord. | 11–12 | 5 0 0 | Jan, July | 11 11/16 | 11 |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝–5⅞ | 4 5 2 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 109–111 | 4 1 1 | Nov, May | .. | .. |
| 1 | 9⅜d. | Castner-Kellner Alkali Co. | 1⅛–1 3/16 | 3 15 4 | .. | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 97–102 | 4 8 3 | — | 99 | .. |
| 1 | 9⅜d. | Chadburn's (Ship) Telegraph Ord. | 1 3/16–1 5/16 | 4 10 6 | .. | — | — |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1 1/16–1 3/16 | 5 2 7 | .. | 1 3/32 | .. |
| 2 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 1½–1¾ | 4 0 0 | Jan, July | .. | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 94–99 | 5 1 0 | Jan, July | .. | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8½–9 | 5 11 1 | Sept ... | 8¾ | .. |
| 5 | 3/0 | Do. 6% Cum. Pref. | 6–6½ | 4 16 0 | Sept ... | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106–108 | 4 4 1 | .. | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅜–1⅝ | .. | Feb, Aug | 1 15/32 | .. |
| 5 | 2/6 | Do. (£5 paid) | 2–2½ | .. | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 85–90 | 4 8 11 | June, Dec | 86½ | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92–97 | 5 3 1 | .. | .. | .. |
| 5 | 4/6 | Edmundson's Elec. Corp. Ord. | 5½–6 | 5 16 8 | H'lf-yearly | 5¾ | 5 11/16 |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 6 1/32–6 9/32 | 4 16 0 | .. | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 109–111 | 4 1 1 | .. | .. | .. |
| 2 | 1/7½ | Electric Construction Co. | ⅝–⅞ | 8 0 0 | July ... | .. | .. |
| 2 | 2/9⅗ | Do. 7 per Cent. Cum. Pref | 1⅞–2⅛ | 5 18 8 | July .... | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 92–95 | 4 4 2 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9½–10 | 5 0 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96–100 | 4 0 0 | .. | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 12–13 | 5 15 5 | Feb, Aug | 12⅜ | 12¼ |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5⅛–5⅜ | 4 3 7 | Feb, Aug | 5 3/16 | .. |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | 108–111 | 4 1 1 | Feb, Aug | .. | .. |
| 10 | 5/0 | India Rubber, Gutta Percha, &c., Wrks. | 15½–16½ | 3 0 7½ | Feb, Aug | 16 5/16 | 16 |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99–102 | 3 18 5 | Mar, Sept | .. | .. |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¼–11¾ | 4 5 1 | Mar, Sept | .. | .. |
| 15 | 12/0 | Telegraph Construction & Mainten'ce. | 33½–35½ | 5 2 0 | Mar, July | 34 | 33⅝ |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 102–104 | 3 16 11 | Jan, July | .. | .. |
| 5 | — | Willans and Robinson Ord. | 1½–2 | — | Apr, Oct | 1 11/16 | 1¾ |
| 5 | — | Do. 6 per Cent. Cum. Pref. | 2¼–2½ | — | Apr. Oct | .. | .. |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 77–82 | 4 16 8 | May Nov | 81 | — |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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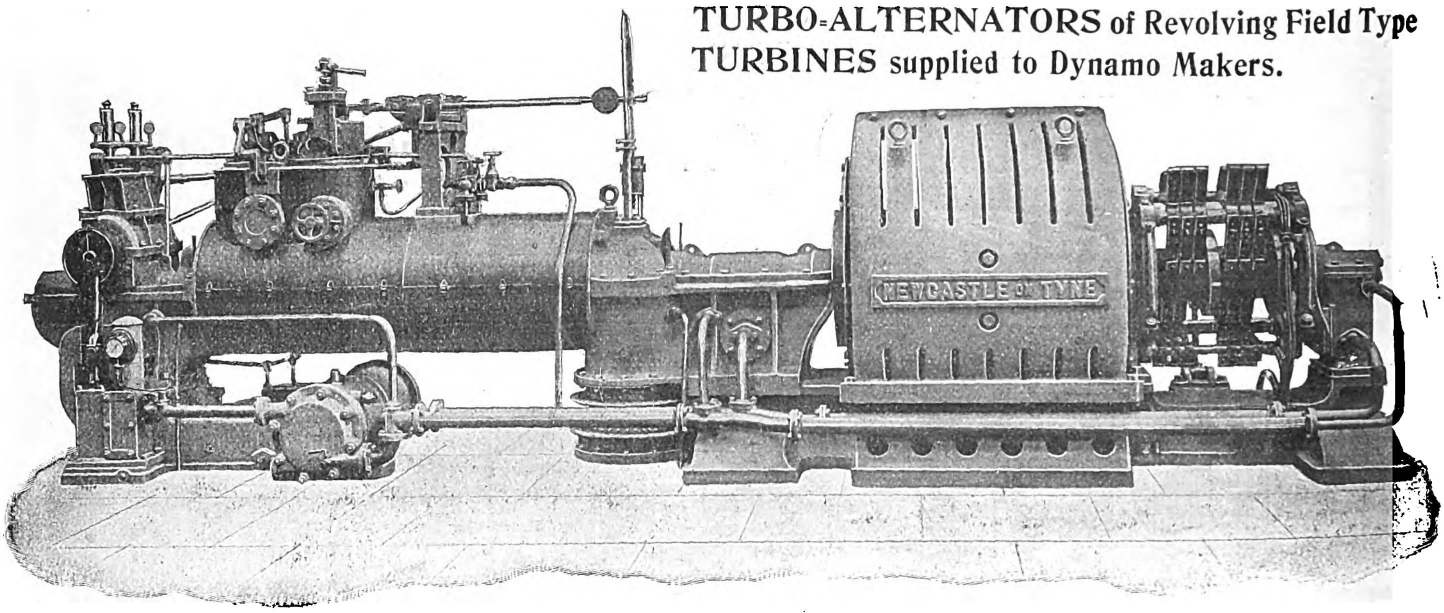

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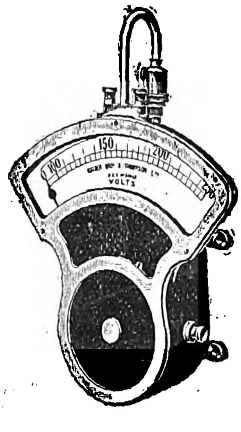

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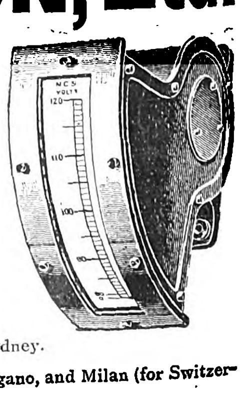

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F. J. WALKER, General Manager and Secretary.

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**MISCELLANEOUS PLANT FOR SALE** continued on next page.

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## TENDERS INVITED.

### CORPORATION OF RAWTENSTALL.

FREE LIBRARY.

The Corporation of Rawtenstall invite TENDERS for the **ELECTRIC LIGHT WIRING AND FITTINGS** of the New Free Library. Copies of the General Conditions, Specification and Form of Tender may be obtained from Messrs. Lacey, Sillar & Leigh, 78, King-street, Manchester, on and after Friday, the 10th inst., on payment of a fee of One Guinea, which amount will be returned on receipt of a bona fide Tender. A copy of the Specification may be seen at the London Office of the Consulting Engineers, at 2, Queen Anne's-gate, Westminster, but cannot be obtained from there, and the plan showing the approximate position of the various apparatus may be seen at their Manchester Office only.

Additional copies of the Specification may be obtained on payment of a further fee of Half-a-Guinea per copy, which amount will not be returned.

The firm whose Tender is accepted will be required to find two sureties and to enter into a contract to be prepared by and to contain such clauses as the Town Clerk may deem necessary.

Tenders on the prescribed form, and accompanied by the Specification and General Conditions intact, and endorsed "Tender for Electric Light Wiring and Fittings," must be delivered to Messrs. Lacey, Sillar & Leigh, 78, King-street, Manchester not later than MONDAY, the 20th November, 1905.

The Corporation do not bind themselves to accept the lowest or any Tender.

By order,
JAMES WHALLEY, Town Clerk.

Municipal Offices, Rawtenstall, November, 1905.

### EBBW VALE URBAN DISTRICT COUNCIL.

The Urban District Council of Ebbw Vale are prepared to receive TENDERS for the following:—

Section E. **FREE WIRING.**
Section F. **SUPPLY OF INCANDESCENT LAMPS.**

Specifications, General Conditions and Forms of Tender may be obtained on and after Saturday, November 11th, at the Offices of the Consulting Engineer, Mr. Reginald P. Wilson, on payment of a sum of Three Guineas for each Section.

This sum is required as a deposit and will, after the Council shall have entered into a Contract upon the Tenders received, but not before, be returned to the tenderer, provided that he shall have sent in a bona fide Tender, and shall not have withdrawn the same. In any other case this deposit will be forfeited.

The Tenders must be sent in on the Official Form and all instructions contained therein must be complied with.

All Tenders (endorsed "Section E, Free Wiring," or "Section F, Supply of Incandescent Lamps") must be addressed to the Clerk of the Ebbw Vale Urban District Council, and must be delivered at the Council Offices, Ebbw Vale, not later than 12 noon on SATURDAY, November 25th, 1905.

The Council do not bind themselves to accept the lowest or any Tender, and in the case of Section E, Free Wiring, reserve to themselves the right to place two or more Contracts.

THOMAS HUGHES, Clerk to the Council.

Council Offices, Ebbw Vale, Mon.

### BOROUGH OF TORQUAY.

The Torquay Town Council invite TENDERS for the following:—

ONE COMBINED 250 kw. D.C. TRACTION and 75 kw. A.C. STEAM GENERATOR SET.
ONE 200 kw MOTOR GENERATOR.
ONE AUTOMATIC REVERSIBLE BOOSTER.
ONE TRACTION BATTERY.
ONE TRACTION SWITCHBOARD.

Contractors desirous of submitting Tenders can obtain Specification and Form of Tender on application to the undersigned. All applications must be made before the 20th of NOVEMBER, 1905.

The Council do not bind themselves to accept the lowest or any Tender.

FREDK. S. HEX, Town Clerk.

Town Hall, Torquay, November 6th, 1905.

### THE DUBLIN UNITED TRAMWAYS COMPANY (1896), Limited.

The Company is prepared to receive Tenders for the Supply of **GENERAL STORES**, including Car Fittings, Iron, Steel, Castings, Oils, Paints, Glass, Brushes, Ironmongery, Harness Materials, Electrical Supplies, Timber, &c., for the year ending 31st December, 1906.

Forms of Tender (price 2s. each), Conditions, and all information can be obtained, and patterns seen, at the Secretary's Office, 9, Upper Sackville-street, Dublin, from 9th to 22nd November instant.

Tenders, sealed and marked on the outside "Tenders for Stores," and addressed to the Chairman, to be lodged with me on or before 27th NOVEMBER instant.

By order, R. S. TRESILIAN, Secretary.

9, Upper Sackville-street, Dublin, November 7th, 1905.

**TENDERS INVITED** continued on next page.

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## TENDERS INVITED—*continued.*

### CALEDONIAN RAILWAY COMPANY.

**CONTRACTS FOR STORES.**

The Directors of the Caledonian Railway Company are prepared to receive TENDERS for the Supply of the undermentioned STORES, for Twelve Months, from 1st January, 1906:—

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2. Bolts and Nuts.
5. Bricks, Clay and Chimney Cans.
6. Chamois Skins and Sponges.
7. Brooms, Brushes, &c.
9. Candles and Soap.
10. Canvas.
11. Carriage Furnishings.
12. Carriage Laces.
13. Carriage Trimmings, &c.
17. Colours and Paints.
18. Copper, Rivets, &c.
19. Cotton Waste and Sponge Cloths.
20. Crucibles.
21. Drysalteries.
24. Gas and Water Fittings.
24A. Malleable Iron Pipes and Fittings.
25. Glass.
27. Hammer Shafts, &c.
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29. Indiarubber Goods, &c.
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33. Iron Rivets.
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38. Lamp-Wick Cottons.
39. Leather.
40. Locks.
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51. Joint Pins, Set Screws and Split Taper Pins.
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53. Transfers.
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60. Telegraph Appliances, Telephones, &c.
60A. Electric Lighting Material and Fittings.
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66. Tools.
71. Ambulance Requirements.
72. Office Furniture and Wall Paper.
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74. Moulder's Blackings, Sands, &c.
75. Enamelled Name Plates.
76. Lorry Fittings.

Specifications and Forms of Tender, and any other necessary information, may be obtained on and after the 6th November, from Mr. Jas. Lorimer, Stores Superintendent, Caledonian Railway, Charles-street, St. Rollox, Glasgow.

Patterns may be inspected from Monday, 6th November, till Friday, 17th November, from 9 a.m. till 5 p.m., at the Company's Stores, Charles-street, St. Rollox (Saturday 9 a.m till 1 p.m.), and all Tenders must be to the Company's samples and patterns.

Tenders, endorsed "Tender for Stores," to be lodged with the Secretary, 302, Buchanan-street, Glasgow, not later than MONDAY, 20th November, 1905.

The Directors do not bind themselves to accept the lowest or any offer.

J. BLACKBURN, Secretary.

Company's Offices, 302, Buchanan-street, Glasgow,
November 3rd, 1905.

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No. 1,434. [No. 4. Vol. LVI.] FRIDAY, NOVEMBER 10, 1905. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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## NOTES.

We commence in this issue the publication of the Presidential Address delivered by Mr. John Gavey, C.B., before the Institution of Electrical Engineers last night. While his address appealed chiefly to the engineer who takes an interest in telegraph and telephone matters, an important announcement was made at the commencement which will be welcomed by the "heavier" electrical engineer—viz., that preliminary steps have been taken by the Institution with a view to arriving at an international agreement with regard to the revision of existing standards, and the standardisation of nomenclature and of the rating of machinery.

In the portion of the Address which we publish this week, the development of the older branches of telegraphy are reviewed. In this part of his address, Mr. Gavey gives as his opinion that although "the lusty child," telephony, threatens to monopolise the greater portion of the short-distance telegraphic work, there is small prospect of serious competition after a certain critical distance has been reached. The latter part of his address, dealing with the latest developments in telephone line construction, gives a very different impression, however. In the earlier days of telegraphy, the slur was often cast on the engineers of the Post Office that they adhered to rule-of-thumb and unscientific methods; at the present day such an assertion would certainly not be justified. The difficult problem of the most efficient design of long distance telephone lines has been taken up in a proper engineering spirit, and Mr. Gavey's address shows that a successful endeavour has been made to give practical application to the abstruse writings of Heaviside, Pupin and Campbell. An empirical formula has been arrived at for the limiting distance over which speech is possible on certain standard classes of overhead wire and cable, and Mr. Gavey showed by a table that the results arrived at with this formula agreed, not only with the results calculated by the more complicated formulæ derived by Pupin and Campbell from Heaviside's exposition on the subject, but also with the results obtained by actual trials on the various classes of line. Another method of investigating the problem was shown by the exhibition of some interesting oscillograph curves by means of which the attenuation and distortion of the telephonic currents transmitted can be actually measured. Abroad, telephone engineers have been content to make their quantitative measurements with ordinary currents of high frequency and in which the shape of the impressed wave was doubtful. This method can not be assumed to give results applicable without reserve to the currents of a very different nature which are sent out by a telephone transmitter, and the employment of the oscillograph constitutes a great advance.

We are glad to learn also that the Post Office has been making experiments on the distribution of inductance coils in telephone cables, and that useful quantitative data have been obtained. In the case of a cable containing 56 100-lb. conductors, the insertion of inductance coils at intervals of a mile, raising the inductance from 1·4 to 40 millihenries, increased the speaking range from 66 to 176 miles. The experiments are being continued, and we trust that they will lead to useful results. Experimental work in connection with underground telegraph cables has reached a further stage, and, to use Mr. GAVEY'S own words, something like a revolution is in progress. With the latest type of underground cable containing 37 pairs of paper-insulated wires surrounded with 29 copper-screened single wires, it has been possible to obtain satisfactory working with quadruplex or Wheatstone automatic on each metallic loop and to super-impose on each loop key duplex. It has been proved that between London and Glasgow, with a repeater at Preston or Warrington, 200 words a minute can be transmitted on these wires with Wheatstone apparatus. The extension of the underground telegraph line to the north is therefore being pushed forward, and the London–Glasgow line will be completed by next March or April.

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MR. GAVEY in the course of his address gave a well-deserved testimonial to British manufacturers who had spared neither time, trouble nor expense in their endeavour to meet the most difficult specifications; without their assistance the record of progress which we have referred to could not have been realised. This tribute was the more willingly rendered by Mr. GAVEY, and is the more willingly repeated by ourselves, because it has lately become the fashion for irresponsible writers in the public Press to decry the British manufacturer as being behind the times, and not ready to meet the requirements of modern practice.

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THE results of the tests on tantalum lamps by Prof. W. WEDDING, which we publish in this issue, constitute confirmatory evidence of the superiority of these lamps as compared with the ordinary carbon-filament lamps. It will be observed that the distribution of light in a vertical plane is represented by a curve approximating very nearly to a circle, and this is just what one would have expected from the shape of the filament. At the same time, this is hardly the ideal condition of affairs to be aimed at, for it means that the greatest intensity of illumination is obtained at a point in the same horizontal plane as that of the lamp itself. We would suggest, therefore, that for ordinary domestic purposes a lamp should be constructed whose filament might have the shape of an inverted cone. With this form the maximum intensity of illumination would be observed in a direction at an angle with the horizontal.

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As far as the life and efficiency of the tantalum lamp are concerned, they are, of course, a distinct advance on similar properties possessed by any existing carbon-filament lamp. Such an efficiency as 1·94 watts per candle-power after 1,582 hours has never been approached before, and the fact that one lamp survived 1,989 hours and then consumed only 2·03 watts per candle-power, can only be considered as very remarkable. Prof. WEDDING does not offer any explanation of the different efficiencies observed at various periods of the lamps' life, nor does he give any indication as to whether continuous or alternating current was employed in the tests. Presumably, however, he used continuous current, as it is now known that the behaviour of the tantalum lamp on alternating-current circuits is not all that might be desired.

MR. R. C. CLINKER'S pithy article on "Wave-Shapes in Three-phase Transformers" will afford keen enjoyment to many readers. It has hitherto been assumed that, if three similar transformers be star-connected to a three-phase supply having a sine wave-form, the voltage across each transformer is $1/\sqrt{3}$ times the voltage between mains. Mr. CLINKER shows not only that this assumption is incorrect in certain instances, but also that the no-load loss per transformer differs materially from the no-load loss when the transformers are delta-connected to a sine wave supply, having $1/\sqrt{3}$ times the voltage of the previous case. These apparent paradoxes which, as far as we know, have not excited much attention hitherto, are explainable as follows: In a star-connected generator, the phase of the fundamental term of current and voltage is successively displaced by one-third of a cycle in successive legs. The phase of a triple-frequency component is, therefore, successively displaced by a complete cycle—that is to say, all the triple-frequency effects in the three legs are in step. The three legs of the generator winding, together with their respective lines, form therefore, as far as the triple-frequency terms are concerned, three single-phase circuits bunched together at the neutral point—*i.e.*, three single-phase circuits working in parallel but without any return main. Hence, no triple-frequency voltage components are apparent in the wave form taken between line and line, and, as long as the neutral point is not connected to the load, no triple-frequency currents can flow along the line-wires. Similarly, a delta-connected generator or load behaves like a black-beetle trap towards triple-frequency currents; they can circulate within the trap but they cannot find an exit. Now the single-phase transformer requires a triple-frequency current term in order that it may respond to a sine-wave impressed E.M.F. If the transformers are star connected, this triple-frequency current term cannot get through the breeches, so that, although the supply wave form is sinusoidal, the voltage wave form across each transformer is not. On the other hand, a triple-frequency voltage term is manufactured in each transformer; but as this also cannot get out of the breeches, it is not inconsistent with the sine-wave supply. It is this triple-frequency voltage which causes the E.M.F. per transformer to be greater than the line voltage $\div \sqrt{3}$, and decreases the iron loss.

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AN interesting fact which now presents itself is that the system has two neutral points which have different potentials, for the centre point of the star-connected transformers must be a neutral point, in so far as it is symmetrically placed with regard to the three line potentials. To account for this we must picture a three-dimensional diagram—a triangular pyramid. The equilateral triangle which forms the base represents the three phases, and its centre point is the neutral point that is obtained by connecting three equal non-inductive resistances to the supply mains. The perpendicular dropped from the apex of the pyramid to the centre of the base represents the triple-frequency voltage manufactured in the load transformers. The apex which is symmetrically placed with regard to the supply voltage forms the second neutral point, and differs in potential from the first.

In these comments we have used advisedly the term "triple-frequency-component" in place of Mr. Clinker's "third harmonic," for he really alluded to the second harmonic, not the third. As ordinarily understood, first comes the fundamental, twice this frequency is the first harmonic, three times the frequency is the second harmonic, and so on. The term "triple-frequency" is more expressive than second harmonic, and avoids risk of the error into which Mr. Clinker has fallen. The point is a small one, and detracts in no way from the real value of Mr. Clinker's Paper; we only call attention to it in order to warn others of the same catch.

The Westinghouse railway motors, described in another column, illustrate the tendency of modern practice to make traction motors as far as possible accurately built-up machines, comparable in robustness and ease of maintenance with the motion of a locomotive. The most novel feature is, perhaps, that allowing the surface armature conductors to be removed without disturbing the remainder of the same coils. The description only suggests that there must be a joint of some kind at the pinion end of each surface conductor. Such a construction has been used in bar-wound generator armatures for a very long time, and is found to facilitate the location of hidden faults, as well as the repair of surface damage. The net value evidently depends upon the reliability of the joints. The strip-on-edge field coils should make a very firm winding, and are, of course, only novel as applied to traction motors. The diagonal splitting of the gear case adds to the general accessibility for examination, changing of armature and similar operations. Both Sperry, in the United States, and Siemens and Halske, in Germany, built motor cases so divided in very early traction days, but in small sizes, where the advantages over the usual horizontal division are not marked.

It was only a question of time till the electron theory should invade the domain of magnetism with the same success with which it has tackled gas discharges, electrolysis, electro-optics, thermo-electricity and conduction. The work of M. Langevin, of which we conclude a translation in this number, is perhaps the most brilliant contribution to the theory of magnetism which has appeared since Ewing propounded his theory of molecular magnets in 1890. As in other cases, the main outlines of previous theories are retained, but a flood of new light is thrown upon them by a rational interpretation of conceptions which before seemed vague or even fantastic. Ampère's molecular currents, Weber's circuits of zero resistance, and Ewing's molecular magnets are all identified with electrons revolving about centres of attraction, such as constitute the basis of Lorentz's theory of the Zeeman phenomenon. These electrons are identical with currents circulating round the atom, and there are as many such currents as there are electrons. These currents may circulate in all directions. Each atom is, as it were, a solar system, with electrons for planets, only Jupiter may go round in a direction opposite to Mars, and Venus or Saturn may pass through the pole of the ecliptic. When there are as many currents in one direction as in the opposite one the atom is non-magnetic. When there is a prevalence of electrons revolving in a particular sense, we get a magnetic atom of definite moment. Such atoms make up paramagnetic bodies and serve all the purposes of Ewing's theory.

But the most striking novelty of Langevin's theory is that *all* matter is diamagnetic, whether made up of magnetic or non-magnetic atoms. For however the electrons may revolve and the "currents" circulate, they are always retarded by the establishment of a magnetic field in the same sense, and accelerated by a magnetic field in the opposite sense. This is but a simple statement of the Zeeman phenomenon, which appears in all matter, and requires no further proof. Any closed coil of wire, if it could be given zero resistance, and brought into a magnetic field, would behave as a diamagnetic body. A current would be induced in it in opposition to the field, and that current would go on circulating, there being no resistance to stop it. All atoms are, therefore diamagnetic, but the diamagnetic effect is always very small—one in 10,000—and it is easily masked by the contrary moment brought into play when magnetic atoms are turned into parallelism with the external field, as in paramagnetic bodies. What renders this theory of special interest lies in the fact that it explains Curie's two laws of magnetism according to which diamagnetism is independent of the temperature, whereas paramagnetic susceptibility varies inversely as the absolute temperature.

**Royal Commission on London Traffic.**—Two further reports have been published by the Royal Commission on London Traffic—viz., Vol. II., Minutes of Evidence, Index and Digest; Vol. III., Appendices to Evidence and Index.

**Annual Dinner of the Newcastle Section, I.E.E.**—The Annual Dinner of the Newcastle Local Section of the Institution of Electrical Engineers will be held on Wednesday next, November 15th, at 7:15 p.m., at the Turk's Head Hotel, Newcastle-on-Tyne.

**The British Science Guild.**—We are informed that the inaugural meeting of the British Science Guild, held at the Mansion House, has had the effect of largely increasing the list of applications for membership. Sir Norman Lockyer desires it to be known that would-be members should apply for particulars to the Honorary Secretary, 16, Penywern-road, S.W.

**Electric Power Distribution on the Rand.**—Our attention has been called to the fact that in our reprint of Mr. Robert Hammond's Paper before the British Association at Johannesburg on August 30th (*The Electrician*, September 29th), the price at which electrical energy could be delivered was given at 7d. per unit. It is quite obvious that this should be 0·7d. per unit.

**British Association Meeting, 1906.**—*Nature* learns that at a meeting of the Council of the British Association on November 3rd it was decided to open the meeting at York next year on Wednesday, August 1st. It is also stated that the Council of this association has received a gift of £50 from Mrs. John Hopkinson, to be devoted to some investigation which may be suggested at the next meeting by the Committee of recommendations.

**Royal Society Medals.**—Among those to whom the Royal Society has this year awarded medals are the following: The Copley medal to Prof. Dmitri Ivanovitch Mendeléef, of St. Petersburg, for his contributions to chemical and physical science; a Royal medal to Prof. John Henry Poynting, F.R.S., for his researches in physical science, especially in connection with the constant of gravitation and the theories of electrodynamics and radiation; the Hughes medal to Prof. Augusto Righi, of Bologna, on the ground of his experimental researches in electrical science.

**Birmingham Local Section of the I.E.E.**—The opening meeting of the Birmingham Local Section of the Institution of Electrical Engineers will be held at the Birmingham University on Wednesday, November 22nd, when Prof. R. Threlfall, F.R.S., will deliver his opening address. The monthly meetings of this section have been arranged as follows: December 13th, January 17th, February 14th, March 14th, April 4th, and May 9th (Annual General Meeting).

**Cable Interruptions and Repairs.**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Tarifa—Tangier | Jan. 18, 1904 | — |
| Jamaica—Colon | Jan. 10, 1905 | — |
| Cadiz—Teneriffe | July 20, 1905 | — |
| Kotonou—Grand Bassam | Oct. 4, 1905 | — |
| Medan—Olehleh | Oct. 26, 1905 | — |
| Oran—Tangier | Oct. 30, 1905 | — |
| Tangier—Cadiz | Oct. 30, 1905 | — |
| Falmouth—Bilbao | Oct. 31, 1905 | Nov. 9, 1905 |

**Electric Furnaces.**—On Saturday evening Mr. J. H. Stansbie read a Paper on this subject before a special meeting of the Birmingham Electric Club. He commenced by explaining that there are two main classes of electric furnace —viz., those which depend upon thermal principles and those which depend upon electrolytic principles. Several familiar types of furnace were then described, including those of Kjellin, Acheson, Héroult, Stassano, Keller and Siemens. The author gave some successful demonstrations, and the Paper was well received.

**District Railway.**—In spite of the announcement which has appeared in certain newspapers to the effect that all steam-drawn trains would be withdrawn from the District Railway service on Monday, we are officially informed that this is not the case. The L. & N.W. trains running from Mansion House to Broad-street, via Willesden, are still drawn by steam locomotives, and will be until December 1st. These trains were always the slowest running on the line, owing to their low acceleration, and at the present time they are allowed a four minutes' headway at the Mansion House station, the electric trains making up the difference by the time Earl's Court is reached.

**University of Liverpool Engineering Society.**—The opening meeting of this Society was held on October 10th, when Prof. W. H. Watkinson read a Paper on "Steam Turbines." An abstract of this Paper was given in our issue for October 13th. Further Papers of interest to our readers are as follows:—December 5th, "The Generation of Electrical Energy by Water Power," by H. W. Wilson; January 16th, Presidential Address by H. G. Williams; February 13th, "Labour-saving Appliances Used in the Carbonisation of Coal," by H. E. Bloor; February 27th, "Wireless Telegraphy," by F. A. Lawson; March 13th, "The Training of a German Engineer," by W. Siebert. The Annual Dinner takes place on December 9th.

**Rugby Engineering Society.**—The following Papers have been arranged for by the committee of the Rugby Engineering Society:—November 16th, "The Generation of Steam," by Messrs. J. Brierley and T. Robertshaw; November 30th, "The Conversion of Steam Energy into Mechanical Energy," by Messrs. E. R. Briggs and E. A. Reynolds; December 14th, "High Lift Pumps," by P. A. Mossay; January 14th, "The Conversion of Mechanical into Electric Energy," by F. R. Clough; January 18th, "The Design of a Large Shop for Electric Manufacturing," by F. J. Sharr; February 1st, "The Transmission of Electric Energy," by C. McCarthy-Jones; February 15th, "Lubrication," by W. J. Parish; March 1st, this date has been reserved for a number of short Papers not yet submitted; March 15, "High Speed Steel," by J. M. Gledhill.

**The Late Archibald P. Head.**—It has been decided to raise a fund in memory of the late Archibald P. Head, who met his death in the "20th Century Limited" train in America. For this purpose a small committee, with Sir Alexander B. W. Kennedy as chairman, has been formed to raise a fund to establish a gold medal or scholarship in connection with the Engineering Department, University College, London. As the committee feel that they have not been able to obtain the addresses of all those who would no doubt be glad to avail themselves of the opportunity of doing something to perpetuate his memory, if they knew what was being done, we have been asked to announce that contributions may be sent either to the hon. treasurer, C. T. Millis, Borough Polytechnic, London, S.E., or direct to Messrs. Hoare, bankers, 37, Fleet-street, for the Archibald P. Head Memorial Fund account.

**Utilisation of Victoria Falls.**—*The Times* announces that, according to Reuter's Agency, the question of utilising the Victoria Falls for the generation of electrical energy and its transmission to the Witwatersrand is receiving close attention at the hands of the African Concessions Syndicate. American and Continental engineers are agreed that such a project could be made commercially successful, especially as the climate is most favourable to the scheme, being extremely dry, whilst there is no ice in the rivers to interfere with the working of the turbines, and no snow to break down the transmission lines. It is estimated that in the dryest season yet experienced 500,000 H.P. could have been developed. The available head of water is about 330 ft., but a head of 1,000 ft. could be obtained by engineering works of a comparatively light type. This head of water would produce 1,000,000 H.P. At present £3,000,000 is spent annually on power on the Rand.

**Obituary.**—We regret to announce the death of Mr. C. G. Mott, Chairman of the City and South London Railway Co., who died at Stanmore on Tuesday at the age of 72. Mr. Mott, with the assistance of the late J. H. Greathead, as engineer, was responsible for the construction of the City and South London line, the first tube railway in London. At that time there were no electric railways in existence, and it was owing to his enterprise and his advocacy of electric traction that the first electric tube railway was constructed. He found the funds, and subsequently, under his control and advice, the line was extended to Stockwell and Clapham Common to the south, and again on the north from Moorgate-street to The Angel, Islington, and is now being extended to Euston. Mr. Mott had been a director of the Great Western Railway Co. since 1868, being one of the oldest members of the board. He was also a directtor of other railway companies.

**The Grant and Transfer of Provisional Orders.**—The following memorandum has been sent us by the Board of Trade, dated November 7, 1905:—

I am directed by the Board of Trade to state that their attention has been called to the large number of instances in which they have in recent years found it necessary to revoke provisional orders which have been obtained by local authorities under the Electric Lighting Acts, or in which local authorities (having obtained provisional orders) have entered into agreements with companies for carrying the order into effect, these agreements being in many cases *ultra vires*, or at least of doubtful validity.

It appears to the Board that it is undesirable that a local authority should apply for a provisional order without having a definite intention of exercising the powers under the order when obtained, and in future the Board will not be prepared to grant an order to a local authority unless they are satisfied that the powers will be exercised either by the local authority themselves, or in exceptional cases by a company (to be named in the order) where special power is taken to transfer to the company within a limited period.

I am at the same time to state that the Board have observed that there is a growing practice for individuals or unregistered companies or firms to apply for provisional orders under the Electric Lighting Acts. In such cases the Board, having in view the undesirability of individuals or unregistered bodies exercising statutory powers involving the breaking up of streets, have inserted in the order, as granted, a provision that the powers under the order shall not be exercised unless within a fixed period they are transferred to a registered company approved by the Board. In the majority of cases the company is named in the order.

This procedure has proved to be unsatisfactory and inconvenient—in some cases the orders have lapsed by reason of the grantees being unable to form a company with a capital sufficient for the purposes of the undertaking, and in others the submission to the Board of the proposal to transfer has been postponed to so late a date as to leave insufficient time for the due consideration of the matter.

In these circumstances the Board have decided that in regard to any future application of this nature they will require that the proposal to transfer shall be submitted to the Board not less than three months before the expiration of the period fixed by the order for the completion of the transfer.—I am, your obedient servant, T. H. W. PELHAM.

**Society of Arts.**—The Society of Arts commences its 152nd Session on November 15th with an opening address from the chairman of its council, Sir Owen Roberts. Among the Papers set down for the Wednesday evenings before Christmas is one by Sir William Preece on "The British Association in South Africa," to be read on November 29th. A course of Cantor lectures by Prof. J. A. Fleming on "Electric Waves" will also be given on November 27th, December 4th, 11th and 18th. Among the lectures announced for the meetings after Christmas are three under the Howard Trust, by Prof. Silvanus P. Thompson, on "High-speed Electric Generators," to be delivered on January 18th and 25th and February 1st.

**Junior Institution of Engineers.**—The annual general meeting of this Institution, which took place on October 27th, was also the first general meeting of the society after its constitution as an incorporated body, and was held under the requirements of the Articles of Association. In the annual report of the Council, reference was made to the increase in membership to 888, and to arrangements which had been made for the ensuing session. On December 8th, a Paper on "Electric Mains for Power Transmission Work" will be read by Prof. J. T. Morris. Other meetings, &c., of the new session have been arranged as follows: January 26th, "Some Notes on Boiler Trials," by Prof. J. D. Cormack; February 2nd, "Some Recent Electrical Engineering Measuring Instruments," by Mr. Kenelm Edgcumbe; February 10th, Anniversary Dinner in the Victoria Hall of the Hotel Cecil; March 10th, Conversazione.

**Royal Society.**—The following have been recommended by the President and Council of the Royal Society for election to the Council for the year 1906 at the anniversary meeting on November 30th:—*President*: Lord Rayleigh, M.A., D.C.L., O.M. *Treasurer*: Mr. Alfred Bray Kempe, M.A. *Secretaries*: Prof. Joseph Larmor, D.Sc., D.C.L., LL.D., and Sir Archibald Geikie, D.C.L., Sc.D., LL.D. *Foreign secretary*: Mr. Francis Darwin, M.A., M.B. *Other members of the Council*: Dr. Shelford Bidwell, Sir T. Lauder Brunton, M.D., Prof. J. Norman Collie, Ph.D., Prof. Wyndham R. Dunstan, M.A., Prof. John Bretland Farmer, M.A., Professor Francis Gotch, D.Sc., Dr. Sidney Frederic Harmer, Sir William Huggins, K.C.B., O.M., Prof. Edwin Ray Lankester, M.A., Dr. John Edward Marr, Mr. George Ballard Mathews, M.A., Mr. Hugh Frank Newall, M.A., Sir William Davidson Niven, K.C.B., Prof. John Perry, D.Sc., Prof. Ernest Henry Starling, M.D., Prof. William Augustus Tilden, D.Sc.

**Society of Engineers.**—At a meeting of the Society of Engineers on Monday evening, a Paper was read on "The Metallic Preservation and Ornamentation of Iron and Steel Surfaces" by Mr. Sherard Cowper-Coles. The greater portion of the Paper was devoted to a new process of dry galvanising or "Sherardising," invented by the author. In this process, iron or steel can be coated with metallic zinc by bedding it in zinc dust in a drum. When the drum has been charged with the articles to be treated and zinc dust, it is placed in the furnace which is heated to 500°F. or 600°F., which is some 200 deg. below the melting point of zinc, the thickness of zinc coating being dependent on time and temperature. On opening the drum, the articles are found to be covered with a silvery coating of zinc, which has become alloyed or amalgamated with the iron surface. The process of dry galvanising is found to be cheaper than hot or electro-galvanising, as there is no waste of material, whilst the expenditure of fuel is small and the plant simple and inexpensive.

**The Institution of Civil Engineers.**—At the inaugural meeting of the 87th session of the Institution, held on Tuesday, Sir Guilford L. Molesworth, K.C.I.E., the retiring President, alluded to the loss which the Institution and the engineering profession generally had sustained during the recess by the deaths of Mr. James Mansergh, F.R.S., and Mr. George Robert Stephenson, past presidents, and of Sir William Shelford, K.C.M.G., Member of Council. He then formally introduced to the members his successor in the Chair, Sir Alexander Binnie. Sir Alexander Binnie delivered an address to the members, in which he traced the influence of scientific thought and investigation upon the development of engineering practice, referring specifically to the gigantic strides made in electrical science and industry. He referred briefly to the life histories of the early engineers, and maintained that the development of engineering contributed largely to the material prosperity of the country. He also described the circumstances which led up to the foundation of the Institution of Civil Engineers. The President subsequently presented the medals and premiums awarded by the Council for Papers dealt with at the Institution in the course of the past session, and afterwards received the members in the library. A list of the Papers of electrical engineering interest that received premiums has already been published in our columns.

**Manchester Section of the Institution of Electrical Engineers.**—The first meeting of the Manchester Local Section of the Institution of Electrical Engineers will be held at the Grand Hotel, Manchester, on Friday, November 17th, when the chairman, Mr. S. L. Pearce, will give his address. The remaining meetings of the Session will be held at the Physical Laboratory of the Manchester University. The committee have arranged that members sending in their application, together with a remittance of 4s., before the date of the first meeting, may have a complete set of the Papers read before this section reserved and bound in plain cloth for them at the close of the session. We give the full list of Papers for the Session below:

November 17th.—S. L. Pearce, Chairman's Address. November 28th.—Dr. W. G. Rhodes, "Theoretical Considerations of Feeder Systems." S. J. Watson, "Street Cable Systems." December 12th.—Haydn Harrison, "Street Lighting." January 16th.—W. C. Mountain, "Electric Winding as applied to Main Shafts, considered Practically and Commercially." January 30th.—James Atkinson, "Gas Engines applied to Electric Driving." February 13th.—M. B. Field, "Idle Currents." February 27th.—T. H. Schœpf, "Single-phase Railway Working." March 2nd.—Annual Dinner. March 13th.—J. R. Salter, "Economic considerations in the employment of Storage Batteries." March 27th.—L. J. Hunt, "Alternating Current Motors." April 10th.—Annual General Meeting. The following Paper will also be read: H. C. Crews, "Lifts and Hoists."

**Single-phase Traction on the New York, New Haven & Hartford Railway.**—According to the *Street Railway Journal*, the Westinghouse Company has received an order to supply 25 locomotives for high-speed passenger service on the New York, New Haven & Hartford Railroad Co. Each will weigh approximately 78 tons, and will be capable of maintaining a schedule speed of 26 miles per hour in local service with a 200-ton train, stopping every 2·2 miles and reaching a maximum speed of about 45 miles per hour between stations. In express service a speed of from 60 to 70 miles per hour can be maintained with a train weighing 250 tons. To handle heavier trains two or more locomotives will be coupled together and controlled from the forward cab by the multiple-unit control system. The motors will be of the Westinghouse single-phase commutating type, which can be used with direct current, so that the locomotive will be able to operate over the direct-current section now being installed by the New York Central Railroad Co., an important feature, as the New York, New Haven & Hartford Railroad utilises the tracks of the latter company between Woodlawn and the Grand Central Depot in New York City. Each locomotive is to be equipped with four gearless motors permanently connected in pairs in series. On direct current the pairs of motors will be operated in series-parallel, and on alternating current by voltage control. The motors will be spring-supported and connected by flexible drive in such a way that all dead weight will be taken off the axles. On direct current each motor will be capable of developing 400 H.P.

**The Fessenden "Barretter" Patent.**—A decision was given in the United States courts, on Oct. 16, relating to the action brought by the National Electric Signalling Co. (Fessenden system) against the American De Forest Wireless Telegraph Co. for infringement of the liquid barretter patent. The following of the plaintiff's claims were upheld:—

11. An electrical receiver consisting of a liquid and an extremely fine terminal projecting into the liquid, substantially as set forth.

23. In an electrical wave-detector, the combination of a liquid and a terminal projecting thereinto, and having in the liquid so small an immersed area that a highly resistant layer is formed about the terminal, substantially as described.

25. As a telegraphic receiver, the combination of liquid and an extremely fine terminal projecting into the liquid and so arranged that the passage of an electric current will produce thermal effects in the liquid, substantially as described.

The other claims were not discussed. We are informed that this receiver was used by the United States Signal Corps for their Alaska installation and by the De Forest Company on the dispatch boat "Haimun" in the Russo-Japanese war, and in the tests made by the same company in England. It is said that in the U.S. Navy official test a distance of more than 2,000 miles was obtained by its use from shore to ship, under unfavourable circumstances, and a distance of 320 miles was obtained on an official test during day time between the "Illinois" and

"Alabama" with the expenditure of ½ H.P. In the course of his judgment, the Judge said "there is a dispute as to whether the change of resistance is thermal or otherwise, but that does not seem material except as to this limitation. If the same physical appliances produce the same results they cannot be justly said to do it in different ways because of such merely disputable variances in hidden processes."

**Electric Traction in Berlin.**—According to the *Elektrotechnische Zeitschrift*, two companies—viz., the Grosse Berliner Strassenbahn and the Continentale Gesellschaft für Elektrische Unternehmungen—are asking for powers to build a number of traction lines in Berlin to meet the ever-increasing traffic requirements. The Grosse Berliner Strassenbahn (which company runs most of the tramway lines in the metropolis) proposes to construct two shallow subways, which are to emerge to the surface at various places to connect up with the existing tramways. One of the lines is to connect the Siegesallee with the Platz am Opernhaus, while the other line is to run from the Potsdam Bridge to the Ross Strasse. A considerable portion of the lines is to be laid with four tracks, the remainder being double track. Current for lighting the shallow subway is to be supplied from a special lighting circuit quite independent of the traction supply. The gradients of the approaches are to range from 1 in 30 to 1 in 20. More interest attaches, perhaps, to the line proposed by the Continentale Gesellschaft. This company proposes to connect the Gesundbrunnen Station, in the north of Berlin, with Britz, in the south, by a mono rail overhead railway of the type existing between Barmen and Elberfeld (see *The Electrician*, Vol. XLV., p. 395). The total length of railway is to be some 12 km. (7½ miles), and there are to be 15 stations. No gradient is to exceed 1 in 30. According to the nature of the streets, the rails will be supported by arches of girderwork or by central structures. Each car is to be 15 metres (49 ft.) long, with room to accommodate 85 passengers, and will be provided with a centre door besides the usual doors at the car ends. There will be smoking and non-smoking compartments, but only one class. The car is to be supported from two bogies, each bogie being driven by a motor. At times of heavy traffic a number of cars are to be coupled together to form a train.

**"Welcome Home" to Mr. Kapp.**—A dinner was given at the Imperial Restaurant on Friday last, to Mr. Gisbert Kapp, the newly-appointed professor of electrical engineering at the Birmingham University, to welcome him on his return to this country. The following gentlemen were present:—

G. L. Addenbrooke, W. H. Allen, Prof. W. E. Ayrton, Frank Bailey, Major Bagnold, C. H. W. Biggs, R. A. Chattock, Col. R. E. B. Crompton, R. S. Erskine, W. B. Esson, Druitt Halpin, H. E. Harrison, A. W. Heaviside, H. Hirst, Sir A. B. W. Kennedy, W. M. Madden, W. L. Madgen, W. M. Mordey, Ald. G. Pearson, A. H. Preece, H. F. Proctor, F. C. Raphael, B. S. Raworth, J. S. Raworth, Mark Robinson, Alex. Siemens, Sidney Sharp, C. P. Sparks, Lieut.-Col. A. M. Stuart, Sir J. W. Swan, J. Swinburne, A. A. C. Swinton, Prof. S. P. Thompson, A. P. Trotter, Prof. W. C. Unwin, R. W. Weekes, H. D. Wilkinson.

These members included the majority of the gentlemen who gave Mr. Kapp a "send-off" dinner at the Whitehall Club in 1894, when he left England for Germany. The speeches were of an enthusiastic character throughout. Col. Crompton, who occupied the chair, called on Prof. S. P. Thompson to propose the toast of the evening. Prof. Thompson said that he was glad to think that the University of Birmingham did not advertise for the cheapest man to fill the Professorship of Electrical Engineering, but communicated privately with Mr. Kapp, recognising that he was the man to fill the post, just as they had done when Sir Oliver Lodge was appointed Principal of the University. Mr. Kapp would be even more welcome than before he left England on account of the wider experience he had gained in the interval. Mr. James Swinburne then related some amusing anecdotes with regard to some of Mr. Kapp's early experiments in dynamo design and engine-valve regulation. Mr. J. S. Raworth followed with some appreciative remarks, and Mr. W. H. Allen related how he had been instrumental in the engagement of Mr. Kapp at Messrs. Gwynne & Co.'s works in 1872. Prof. Kapp then responded, thanking those present for their cordial welcome to the home of his adoption. He remembered his first engagement in England in 1872 with Messrs. Gwynne & Co. as chief draughtsman. Then later on, when he came back in the middle of the first electric lighting "boom," he was informed by electric lighting companies that they had no use for mechanical engineers, but only wanted men who could influence capital. Mr. Crompton, however, wanted a manager, and had told Mr. Kapp that if he was a good mechanical engineer he himself would teach him electrical engineering, and he engaged him. His return again now had been due to the persuasion of Prof. Silvanus P. Thompson. He hoped that manufacturers in this country would lend him the same assistance as the German manufacturers had done. There, if he had a machine to test and found that it was a good one, he asked the manufacturers for drawings which would enable him to teach his students the best dynamo design, and the manufacturers responded to his request. Mr. A. P. Trotter, Ald. G. Pearson and Mr. Alexander Siemens also spoke, as well as Mr. W. M. Mordey, who had acted as honorary secretary to the dinner committee. The death of Mrs. F. H. Webb, wife of the past secretary of the Institution and Sir William H. Preece's sister, accounted for the absence of these two members of the party, who had been present at the send-off dinner in 1894. Major Cardew, Prof. G. Forbes and Mr. W. Massey also wrote expressing regret at their absence and welcoming Mr. Kapp back again.

## ARRANGEMENTS FOR THE WEEK.

**(To-day) FRIDAY, November 10th.**

PHYSICAL SOCIETY.

*8 p.m.* Meeting at Royal College of Science, Exhibition-road, South Kensington. Agenda.—(1) The question of Temperature and Efficiency of Thermal Radiation, by James Swinburne. (2) Note on Constant-deviation Prisms, by T. H. Blakesley.

**SATURDAY, November 11th.**

BIRMINGHAM AND DISTRICT ELECTRIC CLUB.

*7:30 p.m.* Meeting at the Colonnade Hotel, New-street, Birmingham. The following matters will be discussed: "Direct *v.* Alternating-current Motors," opened by J. A. Jeckell; "Copper *v.* Carbon Brushes," opened by W. Smith; "Telegraphs and Telephones," opened by W. H. WHITEHOUSE.

**MONDAY, November 13th.**

INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' ASSOCIATION.

*8 p.m.* Meeting at Storey's Gate, Westminster. Paper to be read: "Boiler House Practice and Design," by Edward Barrs.

**TUESDAY, November 14th.**

INSTITUTION OF ELECTRICAL ENGINEERS: GLASGOW LOCAL SECTION.

*8 p.m.* Meeting at 207, Bath-street, when Mr. J. M. M. Munro, the chairman, will deliver his Opening Address.

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be read: "On Waterways in Great Britain," by J. A. Saner.

**WEDNESDAY, November 15th.**

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting, when Sir Owen Roberts, chairman of the Council, will deliver the Inaugural Address.

INSTITUTION OF ELECTRICAL ENGINEERS: NEWCASTLE LOCAL SECTION.

*7:15 p.m.* Annual Dinner at the Turk's Head Hotel, Newcastle.

"DYNAMICABLES."

*7:30 p.m.* Dinner at the Trocadero Restaurant, Piccadilly Circus.

INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.

*7:30 p.m.* Meeting at 92, Victoria-street, Westminster. Mr. W. M. Mordey, Vice-President, will deliver a lecture on "Some Aspects of Electric Traction."

**THURSDAY, November 16th.**

RUGBY ENGINEERING SOCIETY.

*8 p.m.* Meeting in the Benn Building, High-street, Rugby. Paper to be read: "The Generation of Steam," by J. Brierley and T. Robertshaw.

**FRIDAY, November 17th.**

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER LOCAL SECTION.

*7:30 p.m.* Meeting in the University. Mr. S. L. Pearce, chairman, will deliver his Opening Address.

INSTITUTION OF MECHANICAL ENGINEERS.

*8 p.m.* Meeting at Storey's Gate, Westminster. Paper to be read: "On the Properties of a Series of Iron-Nickel-Manganese-Carbon Alloys," by Dr. H. C. H. Carpenter, R. A. Hadfield and Percy Longmuir.

ELECTRO-HARMONIC SOCIETY.

*8 p.m.* Concert (Ladies' Night) at the King's Hall, Holborn Restaurant.

**SATURDAY, November 18th.**

JUNIOR INSTITUTION OF ENGINEERS.

*2:30 p.m.* Visit to Messrs. Barclay, Perkins & Co., Park-street, Southwark-bridge.

GLASGOW TECHNICAL COLLEGE SCIENTIFIC SOCIETY.

*7:30 p.m.* Meeting at the Glasgow and West of Scotland Technical College, George-street, Glasgow. Paper to be read: "The Commercial Efficiency of Prime Movers," by A. Marshall Downie.

## ELECTRICITY METERS.*

BY C. H. W. GERHARDI.

(*Continued from page 52.*)

### INSTRUMENTS, APPARATUS AND ACCESSORIES.

Equally important as the convenience and arrangement of the test rooms is the provision of accurate standard instruments, which, however, should not be kept simply for the checking of other instruments, but should be used constantly, and every meter should be compared with them.

*Kelvin Balances.*—The watt and ampere balances invented by Lord Kelvin are, perhaps, the most suitable instruments for the purpose. They are simple, constant, and it is possible to ascertain by observation if they are in working order. Meters, as a rule, are tested at a round number of amperes, consequently no recourse has to be made to the table of doubled square roots provided with the balances, as the weights are set to a definite point on the fixed scale. By using a magnifying glass (a reading glass acts perfectly) with an aluminium screen attached, as in Fig. 139, the index can be quite easily seen 12 ft. or 14 ft. from the balance. The screen, which should be lamp-blacked on the side away from the balance, causes the index to be seen at a glance and hides all reflections from the balance case. Mounted on a stand in the way shown in the figure, the hole A drilled up the handle—a medium tight fit—it can be raised or lowered to the correct position.

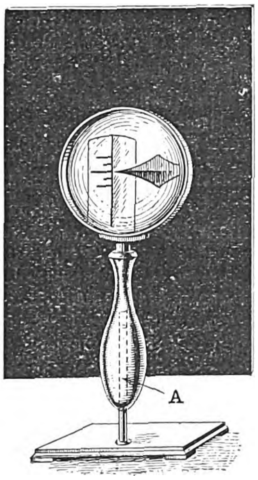

Fig. 139.—Magnifying Glass with Screen for use with Kelvin Balance.

Great care should be taken that, once being set to a definite position, the weight of the Kelvin balance is not accidentally shifted. At the ends of the silk cords which are attached to the sliding platform are usually two buttons. If one of these falls off the shelf on which the balance stands, or if anyone passes and rubs up against the cord, the weight is liable to be shifted. To prevent this a good plan is to replace the two cords by one which is brought from the sliding platform through the case in the ordinary way, through two pulleys fixed to the shelf—one under each end of the base where the cords come out—back through the case at the other end and thence to the sliding platform. In this way, no matter what the position of the sliding weight, there is no slack cord.

The watt balances are very similar to the ampere balances. The shunt current is taken into the movable coils, and the main current passes through the fixed ones. The resistance of the shunt coils is about 14 ohms, and as they are designed to work with a current of 0·2 ampere in the shunt circuit the total resistance is made up to 500 ohms (non-inductive) per 100 volts.

The shut circuit, even on 100 volts, therefore, is fairly non-inductive, but, of course, becomes more so on higher voltages. Where meters are required for both alternating and continuous-current supplies it simplifies matters a lot to have standard instruments equally suitable for both kinds of current; these balances being so they are most convenient.

*Voltmeters.*—A number of voltmeters should be provided of different types and different ranges. A set of electrostatic voltmeters for different voltages are very useful, especially for use in taking shunt currents of meters. They are very handy for calibrating or checking other alternating-current voltmeters. As a standard voltmeter, a reflecting electrostatic voltmeter with a scale forming an arc of a circle of one meter radius is recommended. The instrument and scale should both be fixed in position, and preferably the scale should only be calibrated, by means of a potentiometer, after it has been put up.

*Potentiometer.*—For standardising generally (on continuous current), and, indeed, for testing continuous-current ampere-hour meters, a good potentiometer is extremely useful. If at any time doubt as to the accuracy of the standard instruments arises, as it is bound to at some time or other, possibly owing to a batch of meters all being found about the same amount slow or fast, then to be able to check the instruments with some quite different apparatus is desirable.

*Standard of Time.*—Having standard instruments for the measurement of watts, amperes, volts and ohms, the meter test room still requires a further and most important standard instrument—it is a standard of time. Chronographs are most convenient instruments for timing the revolutions of some quick-moving portion of a motor meter, but it is very important that they should be frequently tested themselves and for the *same period of time that they are to be used for* in testing. These time indicators develop starting errors and may change their speed so that, if not checked, errors due to them might be ascribed to the meters under test. A chronometer is the most compact standard. Fixed in some convenient position, on a wall (away from mains carrying heavy currents) about 3 ft. 6 in. from the ground, it can be used with comfort for checking chronographs. For long time tests such an instrument is most useful, as also for rating clocks used in time switches or two-rate meters.

Beside the standard instruments others will be required. An ammeter and voltmeter of the capacity of each watt balance should be permanently fixed in the circuit. These should be suitable for alternating as well as continuous current where both are likely to be used; in fact, it is evident that all apparatus should be capable of working on either current in order that the whole equipment may be used, if necessary, to turn out work for one or the other supply.

For testing *in situ* portable instruments are, of course, required. Some very neat testing sets have been put on the market of recent years by several makers. For testing watt-hour meters of the motor type a watt meter is to be preferred, as only one reading has to be taken. Good watt meters of the portable type can be obtained suitable for both supplies. Where, however, testing is to be done on continuous-current circuits, permanent magnet instruments are to be preferred, being so dead-beat and unaffected by stray fields. They should always be provided with mirrors under the needle, as very true readings are required to prevent the errors in the test being greater than the meter errors. A portable low-reading ammeter (reading to 0·1) should be provided for measuring meter-shunt currents, and a portable voltmeter (reading to 1 volt) for the measurement of the drop in the main coils.

For the measurement of insulation resistance to case, an ohmmeter will be found most convenient. A couple of ordinary detector galvanometers, with their batteries, are most useful for the testing and detection of faults in meters. These are more convenient if the batteries are enclosed in the same case as the instrument.

*Frequency Measuring.*—In alternating-current testing a frequency teller will be required. Should the testing department be at the station the alternators will be accessible and the frequency ascertained by taking the speed of the machines running. This would, however, take too much time, and an instrument should be close at hand by which the frequency can be easily read.

A convenient form of frequency teller is that due to Mr. Albert Campbell, B.A.,* in which a thin iron strip is slid in or out of a clamp over the face of an electromagnet around which the current—the frequency of which is required—passes. The iron strip vibrates when its length from the clamp is such that its natural period of vibration is double that of the frequency of the current, when it emits a note. A rack and pinion to which the needle is attached are worked from the non vibrating end of the strip, the needle indicating on the scale different points according to the length of strip free to vibrate. The scale can thus be calibrated in periods per second, the reading being obtained by sliding the strip until the note is audible.

Another method of measuring the frequency is by altering the length of a weighted wire carrying an alternating current and passing through the field of a permanent magnet. At a definite length the wire will vibrate. Fig. 140 illustrates an instrument made on these lines. The index slides up and down the beam in the front of which is the scale. To this sliding index is attached a rod, on the end of which is a jewel with a rounded hole through which the phosphor bronze wire passes, a weight being hung on the end of the wire. The weight is increased or diminished so as to get a suitable range, after which it is unaltered.

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* From a forthcoming book to be published by 'The Electrician" Printing and Publishing Co. All rights are reserved.

* *The Electrician*, Vol. XXXVII., p. 437.

To use the instrument, the slider is slowly lowered until the wire vibrates to a definite amount. It is found that there is a definite point for each frequency where the wave appears to have a third wire, and this is the point taken. The instrument is calibrated by finding this point on known frequencies by slowly moving the slider down.

The length of wire free to vibrate multiplied by the frequency equals a constant; thus, by taking three or four readings on different frequencies the constant is determined for the given wire and weight and the scale then made.

*Apparatus for Measuring Torque.*—In order to measure the torque of meters it is necessary to have some sort of apparatus possessing small friction by which the pull can be measured. In Fig. 141 such an appliance is shown. A vertical brass rod fixed to a lead base carries two brackets, the height of which can be adjusted. The top one supports a light wheel having a V-shaped rim and a steel spindle running in jewelled bearings. One end of a fine silk thread is attached to the main spindle of the meter, and the other end carries an aluminium scalepan which weighs 1 gramme. The lower bracket acts as a rest for this scalepan. A box of weights and a good micrometer—the latter for obtaining the diameter of the spindle—complete the set. In the case of meters having light main moving parts it is necessary to provide a duplicate set and place it so that its thread pulls in the opposite direction; then if half the weight be put in each scalepan a uniform moment is produced, and the meter main spindle is not pulled off its jewel bearing.

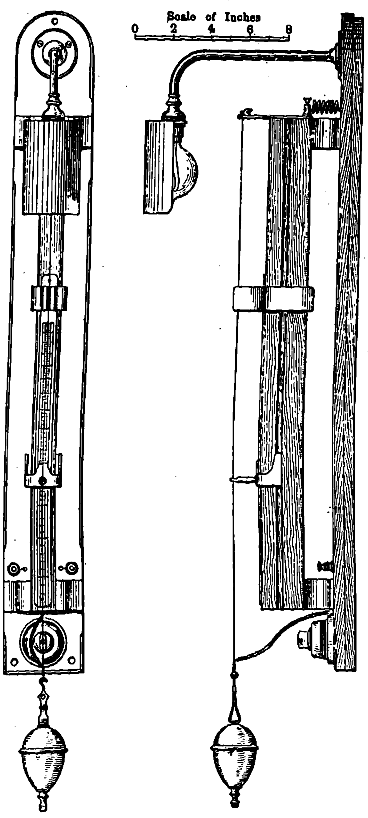


Fig. 140.—Frequency Meter.

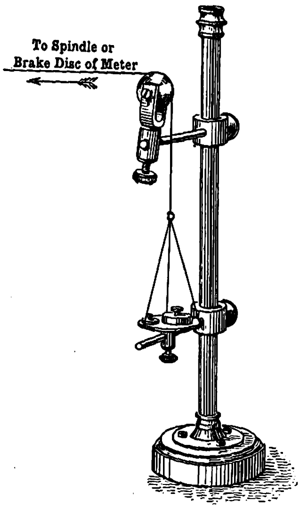


Fig. .—Torque Measuring Apparatus.

In using the apparatus if 1 gramme (the weight of the scalepan) is too heavy a gramme weight can be attached to a very fine silk thread passing over the wheel to counterbalance the scalepan. For this purpose the silk used for galvanometer suspensions is the best. With meters having a high torque it is sometimes convenient to attach the silk to the rim of the brake disc, as by increasing the distance at which the weight acts the weight is reduced, as it acts at a greater leverage and the tendancy to displace the moving part of the meter is thereby reduced.

Although it is very satisfactory to see the actual weight being held up by the meter, measurements of torque with such an apparatus cannot be made quickly, and usually time is a consideration where much work has to be turned out. For the quick measurement of meter torques, therefore, a spring balance is perhaps the most convenient instrument to use, and very good results can be obtained in this manner very quickly. An instrument of this description is illustrated in Fig. 142. It is easily made and, by means of the previously-described apparatus, its calibration becomes a simple operation. Upon a piece of aluminium, A, about 0·2 cm. thick a small spindle, B, is bolted, having lock nuts underneath. To the upper end of this spindle, one end of a piece of watch mainspring, C, is fixed (either by soldering it in a saw cut or otherwise), and to the other end of the spring a straight piece of aluminium wire D is attached. This can be done by slightly flattening the wire, lashing it to the end of the spring with silk, and finally, shellacing the joint. The straight wire is allowed to project beyond the edge of the plate by about 1·4 cm., and at, say, 0·7 cm. from the end it is marked by a line to indicate the point to be used both in calibrating and when measurements are taken.

A small spirit level, E, is screwed to the plate as an indicator to show that the plate is at the same level when being used as when being calibrated. The level is necessary in order to avoid any error being introduced by the weight of the pointer, which would cause a deflection. The instrument is intended to be used with the plate horizontal, and the needle is set to a zero line by turning the spindle B. To calibrate this balance a loop is made at each end of a short length of very fine silk thread; one loop is passed over the end of D to the marked point, and different weights are hung on the other loop, the thread passing over the pulley of the apparatus previously described, which is adjusted for height. It is convenient to lay the balance on a box for this operation. The pointer being deflected, the plate is turned in the opposite direction until the pointer is brought back to a position at right angles to the silk for each weight, and in this manner the points are easily marked on the plate on either side of the zero.

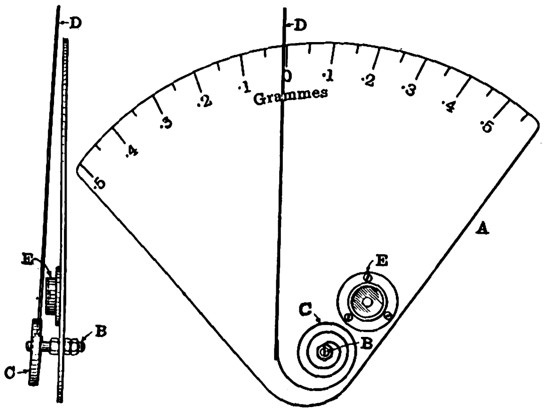


Fig. 142.—Spring-balance for Measuring Meter Torques.

In using the instrument a small spring clip, made out of, say, No. 24 phosphor bronze wire, is slid on to the brake disc of the meter. The end of this clip is bent to stand vertical so as to meet D (at the marked point) at right angles. The plate is turned as in calibrating to bring the pointer D at right angles to the deflecting force. In the instrument illustrated the length of the pointer is 14·5 cm., and a deflection of approximately 2 cm. per decigramme is obtained. It is convenient to have two or three spring balances similar to the above having varying ranges to suit various types of meter having different torques, or, by making clips which project beyond the periphery of the brake disc, the same instrument may be used. Where such clips are employed, care must be taken to ascertain that the disc has no tendency to rotate due to want of level and the weight of the clip. Owing to the use of magnets in so many meters, it is very important that the use of steel wire either for the clip or for the pointer D is avoided. Where the torque of a number of similar meters having discs of equal diameter is to be taken, it is convenient to make a clip, the end of which stands out from the axis of turning by preferably 10 cm. and to design the balance to give a good deflection when used with this clip. The torque is then ascertained without calculation as the instrument can be calibrated in gramme-centimetres.

(*To be continued.*)

## WAVE SHAPES IN THREE-PHASE TRANSFORMERS.

BY R. C. CLINKER.

It is well known that the voltage wave of a three-phase generator contains no harmonics having a frequency of three or a multiple of three times the fundamental frequency. It is also clear that the current in a three-phase line carrying a balanced load cannot contain a triple harmonic, as otherwise the sum of the instantaneous currents would not equal zero. Consideration of these properties of a three-phase circuit lead to interesting conclusions regarding the magnetising currents of transformers connected to such a circuit. If a transformer be connected to a single-phase circuit having a sine wave of E.M.F., the induction in the core will also have a sine shape and the current wave will contain a third harmonic produced by hysteresis in the iron. This harmonic will always be present, and will increase rapidly as the saturation increases.

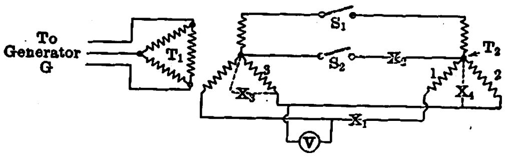


FIG. 1.

Now a three-phase line cannot supply this harmonic. Hence, if the transformers are "delta"-connected, the harmonic will circulate only in the delta, but if "star" connection is used, the induction curve must be modified so as not to require the triple harmonic of current. Evidently this modification of the flux wave is equivalent to the introduction of a third harmonic of flux and of voltage across the terminals of the transformer. We are, therefore, led to the conclusion that (1) the E.M.F. wave across each leg of a set of star-connected transformers will have a different shape from that across the lines, and (2) the core loss of a "star"-connected transformer may be different from that of the same transformer "delta"-connected for the same voltage.

The writer recently made some tests to verify these conclusions. Records of wave shapes were made with the Hospitalier ondograph, an instrument supplied by the British Thomson-Houston Co. and which is excellently suited for recording waves under steady conditions. The connections were arranged as shown in Fig. 1. A three-phase generator fed the delta-connected primaries of three single-phase 20 kw. transformers $T_1$.

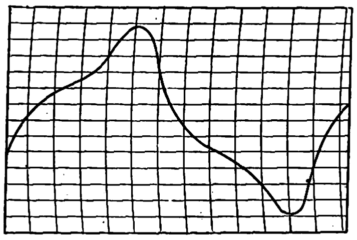


FIG. 2.

The L.T. sides of these transformers were star-connected and joined up to the L.T. sides of three star-connected 15 kw. transformers, $T_2$, whose H.T. windings were left open. The ondograph could be placed at $X_1$ and $X_2$ to record current waves, or $X_3$ and $X_4$ to record voltage waves. Switch $S_1$ served to cut off one of the three-phase lines, leaving transformers 1 and 2 on single phase, while $S_2$ could be arranged to connect or disconnect the two neutrals. Voltmeter V measured the line voltage.

The curve in Fig. 2 was taken at $X_1$, with $S_1$ and $S_2$ open—*i.e.*, with a single-phase connection—and shows the well-known form of magnetising current with a prominent third harmonic. Curve B in Fig. 3 is a similar curve, but taken with both $S_1$ and $S_2$ closed, giving again the single-phase condition. $S_2$ was then opened so as to separate the neutrals. Curve C shows the current under these conditions, and it will be seen that the third harmonic, which showed so prominently in curve B, has practically disappeared, leaving a prominent fifth. The maximum value has been reduced by about 25 per cent., so that the maximum value of the flux has also been reduced. The ondograph was then placed at $X_2$ and $S_2$ was closed. Curve A shows the current wave flowing in the neutral, which is practically a pure third harmonic. As this current is the sum of the three harmonics in the line wires, it is approximately three times in amplitude the difference between curves B and C. Combined with this harmonic is also a very small current of fundamental frequency, due probably to a slight want of symmetry in the transformers and connections. It should be noted that this harmonic was not produced by any irregularity in the voltage curve of the generator (which was practically a pure sine), but solely by the variation of permeability in the iron of transformers $T_2$. In order to allow this neutral current to flow, it was necessary to ensure that the voltage waves on the individual transformers of group $T_1$ were sine waves. This was done by connecting their primaries in delta.

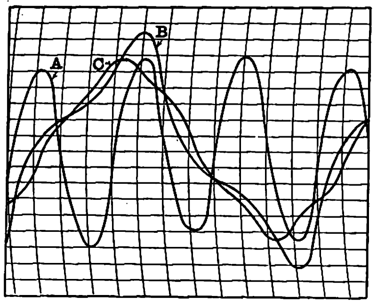


FIG. 3.

In taking the above wave shapes the voltages across the lines were held constant.

Fig. 4 shows the voltage waves taken at $X_3$ and $X_4$ with the neutrals separated. The wave on transformer 3 is, of course, the same shape as the generator wave, and practically a sine curve. The wave taken on transformer 2, however, contains a strong third harmonic. It has a 40 per cent. larger maximum, and is 9 per cent. less in area than the generator wave. Hence the maximum induction is decreased by 9 per cent. and the hysteresis loss by about 15 per cent.

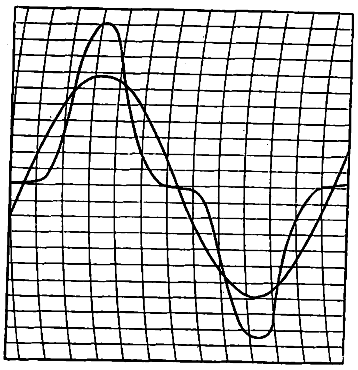


FIG. 4.

During the tracing of these curves the R.M.S. voltages were as follows :—

| | |
|---|---|
| Across transformer 3.......... | 155 volts. |
| Across transformer 2.......... | 172 volts. |
| Across lines.................... | 275 volts. |
| Between neutrals ............ | 69 volts at triple frequency. |

It is interesting to note that the line voltage is only 1·6 times the voltage across 2, whilst it is 1·77 or practically $\sqrt{3}$ times that across 3. Also, as the resultant of two voltages of different frequency is equal to the square root of the sum of their squares, we have voltage across $2 = \sqrt{155^2 + 69^2} = 170$ This agrees well with the observed value of 172.

In tracing the current waves in Fig. 3 it was necessary to place a resistance in the line of about 1 ohm to obtain the necessary drop to work the ondograph. This accounts for any inaccuracy of position and magnitude of the harmonic wave. The curves as drawn by the instrument are on squared paper, the ordinates being slightly curved to the radius of the pen, so that the curves appear slightly distorted.

The maximum density in the iron cores of the transformers during the taking of the curves in Fig. 3 was about 65 kilolines per square inch. The curves in Fig. 4 were taken with a density of 8 per cent. less than this. Core loss measurements were also made on the transformers with and without the neutrals connected. A wattmeter was placed with its current coil in one line, and its potential coil between line and the neutral of group $T_2$, so as to indicate the loss in one transformer. The curves in Fig. 5 illustrate the results of these measurements where the core loss in watts is plotted against voltage.

Curve A shows the values for open neutrals, *i.e.*, with the distorted wave shown in Fig. 4. Curve C shows the values for closed neutrals, *i.e.*, for a sine wave of voltage. Curve B shows the values for open neutrals plotted against line voltage $\div \sqrt{3}$. The comparison between curves A and C shows a considerable decrease of hysteresis loss for the same effective voltage when the neutrals are open, indicating a voltage wave of decreased area, as shown by the ondograph.

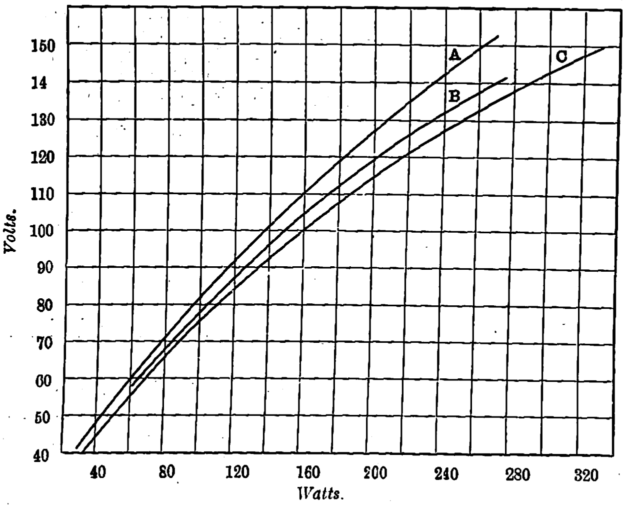


Fig. 5.

Curve B still shows a decrease of core loss, although the difference is less when compared on the basis of equal line voltages.

The wave distortion shown by the curves occurs in practice only with a star connection on both primary and secondary. A delta connection on either winding at once provides a circuit for the triple harmonic, and allows the voltage wave on each transformer to become similar to that of the generator.

## A NEW METHOD OF COPPER WIRE MANUFACTURE.

A new method of producing copper wire directly from the crude material has been devised by Mr. Sherard Cowper-Coles and was demonstrated by him to our representative a few days ago.

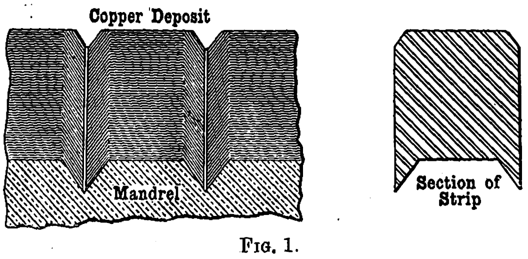


Fig. 1.

The production of copper wire by electrolytic means is a more difficult problem than the production of copper tubes and sheets. Various processes have been suggested and tried from time to time, such as electro-depositing copper on a thin copper wire until it has attained a considerable thickness, and then drawing the thickened wire down again to a comparatively fine wire. Other experimenters have tried placing insulating strips on a cylindrical mandrel so as to produce long copper spirals; the spirals thus produced are uneven and unsuitable for drawing down to wire on account of the roughnesses formed on the edges. The method employed in conjunction with Mr. Cowper-Coles' centrifugal process consists in making on the mandrel a spiral scratch. The effect of this scratch, which must be angular, is to affect the molecular structure of the copper and to form a cleavage plane, as shown in Fig. 1; if the scratch is not angular but round at the base the copper will not divide. The line of cleavage is no doubt formed in the same way as in a cast metal, as shown in Fig. 2, which is a sample of copper cast in a rectangular mould. In this case the lines of cleavage can be clearly seen; if the mould has rounded corners the crystallisation would be radial and there would be no cleavage plane. The crystalline structure of the deposited copper has a line of cleavage starting with the sharp point of the scratch on the mandrel. The copper separates more readily if unwound at an angle to the axis of the mandrel, as shown in Fig. 3.

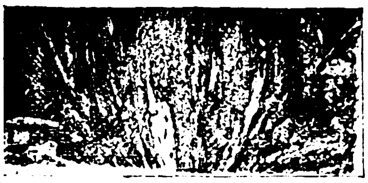


Fig. 2.

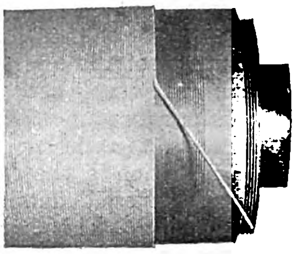


Fig. 3.

The construction of mandrel capable of making 3 or 4 miles of wire in one operation in a few hours from crude copper is shown in Fig. 4. The vat is annular in construction, the mandrel being 7 ft. in diameter and making about 50 revs. per min. A great feature of such a vat is that there are no working parts in the electrolyte and no stuffing boxes and glands.

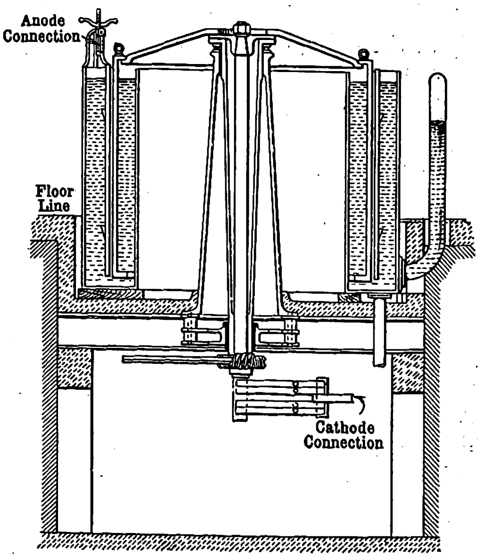


Fig. 4.—Sectional Elevation of Depositing Vat for Centrifugal Copper Process.

Mr. Cowper-Coles informs us that the capital expenditure on plant required for the centrifugal process compares very favourably with an up-to-date rolling mill and wire-drawing plant; the cost of such a plant with buildings, engines and the necessary plant is about £80,000 for an output of about 100 tons per week or 5,000 tons per annum.

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"La Separation Electromagnétique et Electrostatique des Minerals." By Désiré Korda. (Paris: "L'Eclairage Electrique."), 6 fr.

"Les Quantités Élémentaires d'Électricité: Ions, Électrons, Corpuscles." By Henri Abraham and Paul Langevin. Parts I. and II. (Paris: Gauthier-Villars.) 35fr.

"Essais des Materiaux. Notions Fondamentales Relatives aux Déformations élastiques et permanentes." By H. Bouasse. (Paris: Gauthier-Villars.) 5fr.

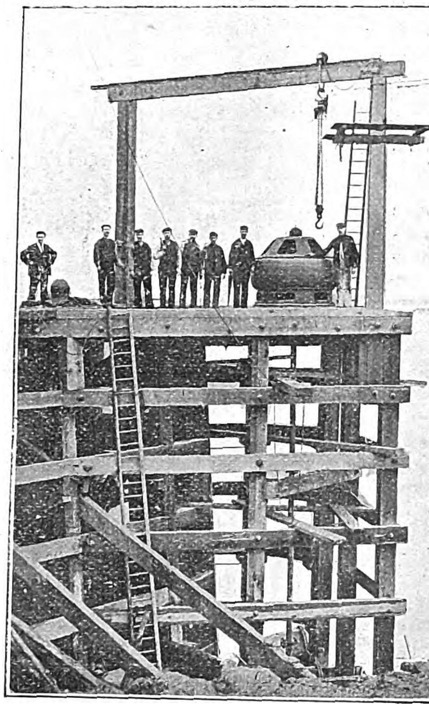
"Müller-Pouillets Lehrbuch der Physik und Meteorologie." Edited by Leop. Pfaundler. Vol. I. 10th edition. "Mechanik u. Akustik." By Leop. Pfaundler. (Brunswick: F. Vieweg & Son.) 7m.

Dr. J. Frick's "Physikalische Technik." 7th edition. Revised and re-written by Dr. Otto Lehmann. Vol. I., part II. "Anleitung zu Physikalischen Demonstrationen." (Brunswick: F. Vieweg & Son.) 24m.

"Calendar for Session 1905-6 of University College of North Wales." (Manchester: J. E. Cornish, Ltd.)

## A MOTOR-DRIVEN CENTRIFUGAL PUMP.

We illustrate herewith an interesting, though small, installation, in which direct current transmission is employed for actuating a vertical motor driving a pump at the Alexandra Docks, Newport, Mon. The motor is of the Westinghouse direct-current multipolar type, is supplied with current at 500 volts, and develops 320 H.P. It drives a centrifugal pump at 300 revs. per min., the pump raising a million gallons of water per hour against a head of 25 ft. The water is pumped from the river into an adjacent dock for the purpose of keeping up the level of the water in the latter. The Westinghouse generator which supplies the necessary current is of 300 kw. capacity and is rope-driven at 325 revs. per min., it being of sufficient capacity to work other motors besides that illustrated. Bare copper conductors of about 0·5 sq. in. sectional area constitute the overhead transmission line, and are suspended on special hook insulators supported on steel lattice poles. The work was carried out by the British Westinghouse Electric & Mfg. Co.


ELECTRICALLY-DRIVEN CENTRIFUGAL PUMP.

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## ELECTRICAL EXHIBITION AT OLYMPIA.

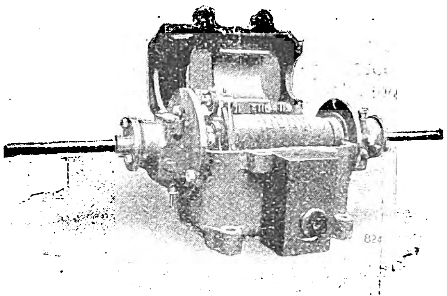
### (EIGHTH NOTICE.)

Messrs. **CROMPTON** & Co. are among the English manufacturers who are taking up "flame" arc lamps, and specimens of both alternating and continuous-current lamps of this pattern were burning with great steadiness on the stand. Owing to the fact that the lamp is only emerging from the experimental stage we have been requested to refrain from publishing details of its construction, but we may say that the regulating mechanism is of the chain-brake type with the usual solenoids and rocking lever resembling that in the well-known open arc lamps of the firm's manufacture. Ordinary open and enclosed arc lamps (the latter of the double carbon type designed to burn directly on a 200 volt supply) and the new "Midget" arcs were also shown. Projectors as used in the Navy were also on view, arranged for automatic as well as hand feed.

Motors formed another important feature of Messrs. Crompton & Co.'s exhibit, and it is evident from the specimens shown that the firm has carried standardisation almost to its extreme limit. A 30 H.P. single-phase motor drove a "protected" type dynamo which was employed for supplying continuous current to several of the motors and arc lamps on the stand. Although a three-phase motor, rated at 50 H.P. at about 750 revs. per min., it had been reconnected to work on the single phase mains supplying current in the exhibition. The machine was of the slip-ring pattern. Another exhibit was the carcase of a single phase lift motor of the reactance type, designed to start against heavy loads with a small starting current. The motor in question was designed to give 10 H.P. under ordinary lift conditions, and to run at a speed of 750 revs. per min. The rotor is of the usual construction, provided with three-phase star-connected winding, the neutral and the free ends of the winding being connected to a special form of slip-ring. There are three or more of these rings; on each ring is fitted a number of insulated bars equal to the number of poles on the motor, and spaced equidistantly on the rings. These insulated bars are all connected to the neutral point of the rotor winding, and the action of the motor when starting is as follows:—

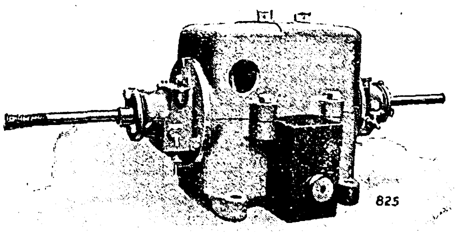
When one of the brushes is in a position to connect the insulated bar and ring, it short-circuits one of the rotor phases and produces a repulsion torque. By properly staggering the brushes on the different rings, a continuous repulsion torque is obtained. The brushes on the rings are also connected to an ordinary starting resistance, this resistance being gradually cut out. As soon as the motor has reached its normal speed, and the starting resistance is short-circuited, the machine acts as an ordinary induction motor, and runs practically at synchronous speed, irrespective of the load. When used for lift or crane work the motor can be reversed by shifting the brush gear through a small angle, and for this purpose the brush gear is connected mechanically to the controller.

With motors of this description, we are informed, a large starting torque is obtained with a small current consumption—a desideratum. Some tests at Messrs. Crompton's works, we understand, showed that the motor was capable of exerting 1·75 times the full-load torque with only 1·5 times the normal full-load current.


BUFFING MACHINE MOTOR. Open.

As has been explained, the rotor circuit is quite distinct from the stator circuit, so that the rotor and starting resistance can be arranged for a low voltage. The special starting switch for use with these motors resembles a three-phase reversing switch with several starting contacts, but the movement of the switch arm in each direction is controlled by a dash-pot, so that however rapidly the lift rope may be pulled the motor is still switched on slowly. A device is added, however, which causes the switch to return to the "off" position with a quick motion, the dash pot only acting when the switch is moving to the full-speed position in each direction.

Various types of speed-reducing gear for motors were shown: spur-reducing gear, worm-reduction gear used with the boiler feed pumps, and very neat application of the Humpage gear which was shown in connection with an air pump. This pump is of the three-throw "Edwards" type, having plungers 8 in. in diameter with 6 in. stroke, and it runs at 180 revs. per min. It is driven by a $3\frac{1}{2}$ H.P. shunt-wound motor running at 1,280 revs. per min., and the Humpage reducing gear is embodied in the design of the motor end cover, the ratio of reduction being 7 to 1. A special form of flexible coupling is provided between the motor and air pump shaft.



BUFFING MACHINE MOTOR. Closed.

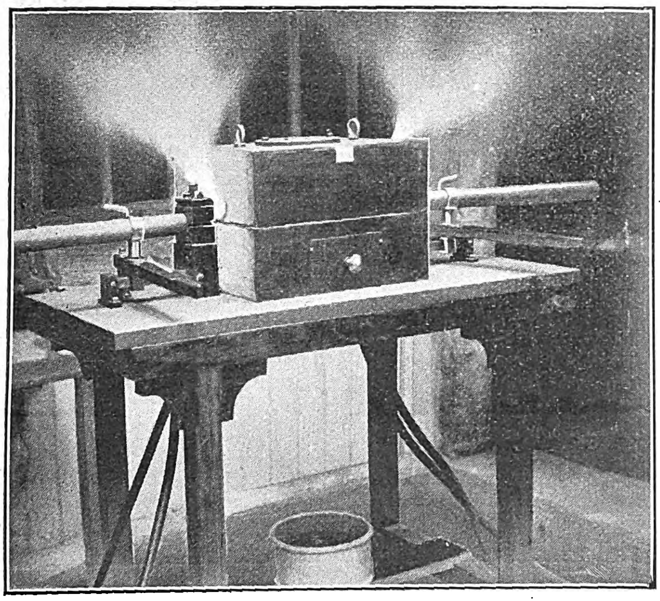
Another motor that may be mentioned is one which was connected to a very compact buffing machine. This was of the double-ended type, the motor being designed for an output of 1 H.P., at a speed of about 2,000 revs. per min. The motor, which is illustrated above, is of the totally enclosed type, with dust-proof glands, and is designed for the heaviest class of buffing work.

A selection of switches, cut-outs, lamp post gear and instruments were well representative of the firm's patterns.

Messrs. **SHOOLBRED & CONNELL**, besides exhibiting some electric lighting fittings, showed the "Red Cross" lubricant for commutators which, we were told, is largely used in America. This lubricant is a compound of secret composition, and is claimed to reduce the friction losses of commutators by coating their surfaces with a thin film of lubricant without increasing the contact resistance between brush and commutator.

The **NATIONAL GAS ENGINE** Co. exhibited a series of gas engines and gas-driven generating sets ranging in capacity from 2 kw. to 20 kw. Some of the sets were shown running. The "S" type gas engine is capable of developing 27 H.P. when supplied with town gas and 21 H.P. when suction gas is used. In the latter case the firm is prepared to guarantee that it will not cost more than $1\frac{1}{2}$d. to 2d. per hour to run the engine at full load when using Welsh anthracite or gas coke.

Messrs. Marryat and Place, at a stand in the annexe, exhibited an electric furnace of great power in operation. A special service of 200 kw. had been run for this purpose. For most experiments a current of 50 amperes was sufficient, but for some as much as 1,000 amperes at 200 volts was employed. The furnace was of the Moissan type, and permits of easy modification in various ways for different classes of experiment. The lining is of magnesia and carbon, and is renewed daily. The electrodes are of round carbon 2 in. by 36 in., and a convenient arrangement of the holders allows the arc to be instantly extended from contact to 14 in. Temperatures can be obtained up to 4,000°C. (7,232°F.), at which point all known substances volatilise. A Féry pyrometer has been fitted up for checking the temperatures between 1,600°C. and 4,000°C. A feature of this type of furnace is the elipsoidal roof cavity which acts as a reflector, condensing the heat rays from the arc upon the crucible below. Even though the roof may be fusing rapidly, the fused material runs down the sides and does not drop into the crucible, and the shape of the reflector remains the same long enough for the experiment to be performed. The exhibitors are repeating Prof. Moissan's classical experiments, including those on the artificial production of diamond. Our illustration shows the furnace arranged for this purpose. Messrs. Marryat and Place also had on view an open-arc two-pole furnace suitable for raising 4 cwt. charges of iron to the necessary temperature for steel production. The exhibit was only a model intended to show the principle upon which the highest grades of tool steel are produced in existing installations.

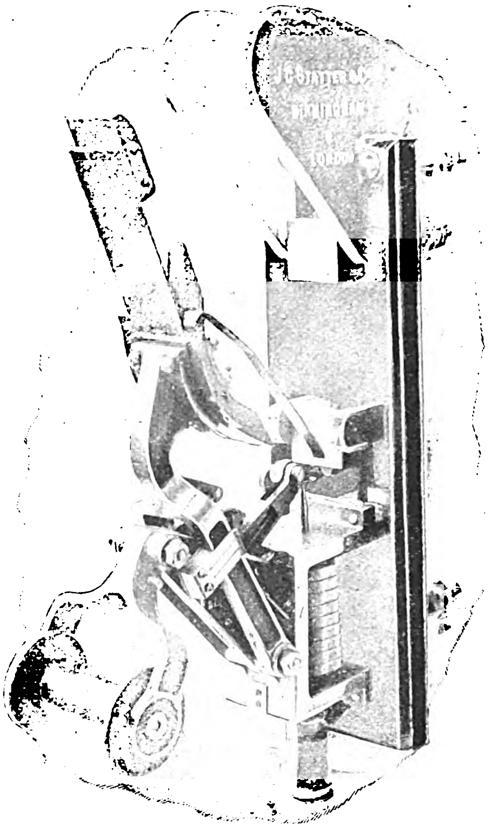


An Electric Furnace by Messrs. Marryat and Place.

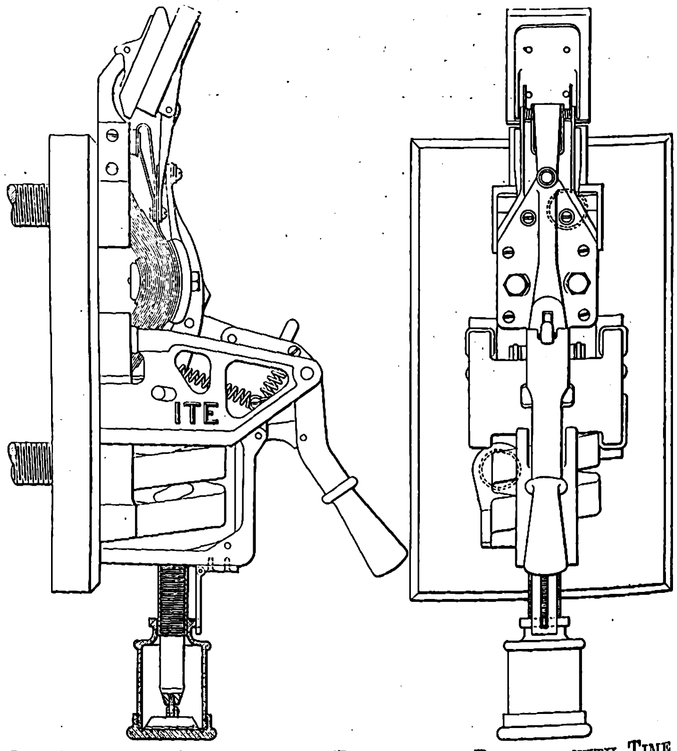
The Spherical Metallic Packing Co., exhibited a number of specimens of their ingenious metallic packing. The piston rod passes through a split sphere which allows for any want of alignment. Within this sphere are bronze rings cut into sections, and held together by a spring laid in a groove cut into the periphery of the ring. The only pressure on the rod is that exerted by light springs round the bronze anti-friction metal pieces, which is only about ·5 to 1 lb. per square inch surface contact, and therefore reduces the friction to a minimum. This pressure is the same under all loads and steam pressures, and it does not increase proportionally with increase of boiler pressure as in the steam setting type of packing. Another device shown was Redford's patent trolley-wire holder. This has been designed so as to enable the holder to support the trolley wire firmly without the aid of solder, and to ensure that the trolley wheel need not break contact with the substance of the trolley wire at the points of support. It consists of a pair of bronze plates articulated between their upper and lower edges, and shaped to form a set of jaws. The lower jaws are shaped to seize and hold more than a semi-circumference of the trolley wire. The upper jaws are fitted with means for suspending the holder, and at the same time for holding the jaws firmly apart, so that they cannot approach while in use. It follows from the intermediate articulation or jointing together of the plates that while the upper pair of jaws are firmly held or forced apart the lower pair will be firmly held upon the trolley wire. The holder is suspended by means of the usual insulated stud.

At the stand of Messrs. John Barker & Co. demonstrations were given from time to time of the capabilities of Kennedy's bending machine. No. 1 machine is capable of bending cold and without loading brass and copper tubes from ¼ in. to ⅞ in., or iron pipes from ⅛ in. to ½ in.; while machine No. 2 will bend tubes of all metals up to 1 in. in diameter.

Some fine generator and feeder panels for lighting and traction purposes were exhibited by the Switchgear Co., previously Messrs. J. G. Statter & Co. They were fitted with up-to-date instruments, and the circuit breakers with maximum and reverse current release (see the illustrations), are examples of strong design and good workmanship. All the breakers have free handles, that is to say, the handle does not move when the breaker opens automatically, so that the breaker is free to operate although the attendant may be in the act of closing it. Circuit breakers for high voltages, where the opening of the breaker is accompanied by both noise and flash, are provided with magnetic blow-outs, as indicated in our illustration. At the moment of rupture the arc is enclosed between the two side plates (which are faced with uralite) and the carbon and its attachment, which fill up the whole of the space between the two plates. It is, therefore, impossible for the arc to flash in the eyes of the attendant, and it is claimed that the breaker may open safely when he is handling it on a heavy discharge at high voltage. Another point of novelty lies in the ready way in which the pressure of the brush on its contacts may be adjusted. The method of leverage employed is a st wheel running up an inclined plane. The latter is made of a piece of steel provided with an adjusting screw. As the screw is easy to get at, it is a simple matter to adjust the pressure of the brush to a

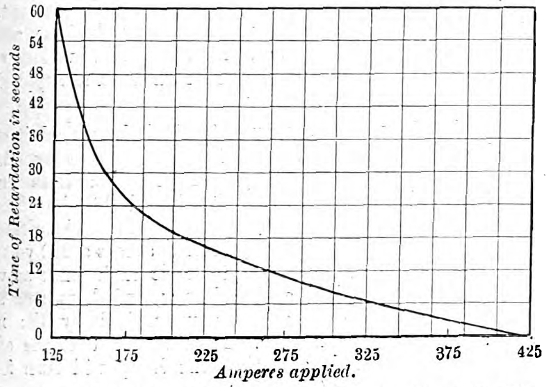


The Switchgear Co.'s Circuit Breaker with Overload Release, Time-limit Device and Magnetic Blow-out.

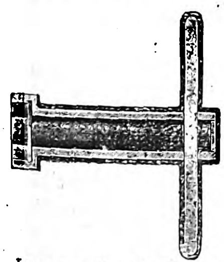


The Switchgear Co.'s Edgewise Type Circuit Breaker, with Time Limit Attachment, 1,000 amps. 400 volts. (One-sixth full size.)

nicety. In the illustration a long wiper will be noticed attached to the brush. The wiper is to keep up the continuity between the brush and the lower contact until the arc is extinguished, and consequently to prevent all sparking upon the lower contact. Finally, however, the wiper leaves the round rubbing parts before the brush has reached the end of its travel, and the latter, and all the parts connected therewith, are consequently dead when the breaker is open. We understand that the firm's standard 500-ampere breaker has been tested with the time-limit attachment to 3,000 amperes, and has withstood that test perfectly, at 500 volts. The reverse current release acts on the following principle: The shunt coil, which is wound on a hinged armature, is connected across the 'bus bars. It acts on the same magnetic circuit as the main coil through which the main current flows, so that both coils normally assist each other in attracting the armature. As soon, however, as the main current reverses, the coils oppose each other, and at a certain value of the reversed main current the resultant magnetic flux has become so small that the armature flies back by spring action, thus tripping the switch. The proportions of the shunt coil to that of the main coil are such that the heavier the reverse current the more energetically and quickly does the breaker open. Also, the intensity of the magnetic field in the armature is such that a considerable decrease of E.M.F. may take place without affecting it, but if the voltage falls to, say, one-third of the normal, it acts as a no-voltage release and opens the breaker. The maximum current circuit breaker on the feeder panel is fitted with the firm's so-called "inverse" time limit appliance, an illustrated description of which appeared in *The Electrician* for July 7th, p. 470. Its action depends on the suction between two flat metal surfaces, coated with a film of glycerine or oil; the thickness of such a film ought not to be more than $\frac{1}{16}$ in. It can be set for different time limits by altering the pull of the actuating solenoid, and is ordinarily adjusted to trip the main switch after about 5 seconds at 50 per cent. overload. When so set an overload of, say, four times the normal carrying capacity opens the circuit breaker practically instantly. With a load equal to double the normal current, opening takes place in about $2\frac{1}{2}$ seconds; with 50 per cent. overload, 5 seconds, as above; 25 per cent. overload, about 15 seconds delay in opening, and a greater length of time with lesser overloads. The accompanying curve indicates how the time of retardation decreases with the overload. The curve shown relates to a normal current of 100 amperes. If desired, a retardation of much more than a minute can be given for 25 per cent. overload, but the curve shown is the firm's usual standard. This setting gives a retardation of several minutes when the overload does not exceed 15 per cent., and still more for 10 per cent. and 5 per cent. overloads. There are some cases in which it is desired to give almost a constant retardation to the circuit breaker, whatever the overload may be. This condition can be met in the following way: The moveable suction disc, instead of being attached to the core in a manner that permits of no back-lash, is attached by a link allowing the core to move through such portion of its travel as may be found necessary, before its pull comes upon the disc. A breaker fitted in this way will, the moment the current reaches a point beyond the setting, raise its armature to the distance permitted by the link, and so shorten the air gap in its magnetic circuit by an amount sufficient to bring up the excitation in the magnetic circuit of the breaker almost to saturation. This effect brings a sudden and almost constant pull upon the moveable disc, irrespective of the current, and under such conditions the time taken to separate the two discs is almost constant. By suitably proportioning the length of the link a curve of almost any degree of flatness can be obtained. Among the other exhibits were a set of insulated spanners, one pattern of which is shown in our illustration. It will be noted that the spindle of the box spanner illustrated is hollow, thus allowing a nut to be screwed far down a bolt of any length, the shank of the bolt passing into the hollow spindle of the spanner.



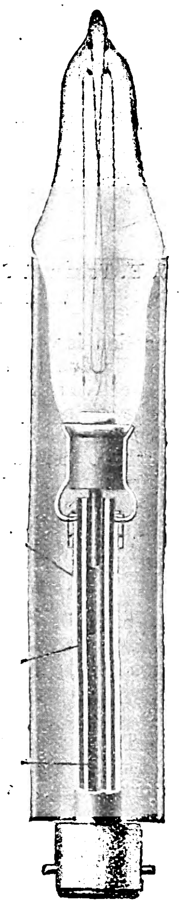
CURVES SHOWING OPERATION OF TIME LIMIT APPARATUS FOR THE SWITCHGEAR CO.'S FREE HANDLE CIRCUIT BREAKER.



INSULATED BOX SPANNER MADE BY THE SWITCHGEAR CO.

At the stand of Messrs. W. G. WALKER & Co. were to be seen electrically-driven ventilating fans and dynamometers of the absorption type. These latter consist essentially of two aluminium air vanes which are attached at the ends of a shaft fixed to the motor shaft and rotating with it. The dynamometers shown had a range from ¼ H.P. to 26 H.P. at speeds varying from 250 to 2,000 revs. per min. Provision is made for fixing the air vanes nearer to or farther from the motor shaft so as to adjust the braking power.

Messrs. D. H. BONNELLA & SON made the proud boast that everything on their stand was new. At any rate, anything in the nature of standard or commonplace apparatus had been eliminated. Many designs of bell pushes, switches and such like had been specially prepared for the Exhibition, and the decorative effects of the majority of these were most noticeable. As a show of such apparatus, made in all possible kinds of material, this stand was probably unique. As a substitute for celluloid, with its attendant dangers, this firm has introduced a new material, which will only scorch even when flame is applied to it, and can be produced in any form. A new candle fitting, in which cheapness is a principal feature, was interesting. We give an illustration below. This lamp has been designed to meet a demand for a correct and effective imitation of an ordinary wax candle. The lamp consists of three parts—viz., the interior, the lamp and the opal tube—all of which are renewable at a small cost. The interior is formed of an inner and outer metal case, insulated from each other by a glass tube, and connected at one end to the two terminals of an ordinary S.B.C. cap. On the upper end of the outer tube is screwed a spring clamp, which makes contact with the outer contact of the lamp, the inner tube receiving the pin or second contact of the lamp. It will be seen that the light passes for only a short distance down the opal covering, thus giving it the appearance of a lighted wax candle when a shade is fixed over the lamp. A special spring socket or holder is supplied for fitting into the sconces of pianos, &c., three springs projecting from the outside and holding the socket tight when pushed into the sconce. An improved electric illuminating sign is constructed of metal or wood as desired, the cases also containing corrugated mirrors or reflectors, which give a prismatic effect. A special feature of these signs is the small number of lamps employed to illuminate them, a letter 18 in. high and 15 in. wide being well illuminated by only four 5 c.p. lamps. Between the reflectors and the lamps a frame of coloured glass may be inserted, which produces a multi-coloured as well as a prismatic effect. A lavatory door switch shown at this stand obviates the necessity for having lamps always burning. When a person enters and closes the door, the action of pushing the bolt indicates on the outside that the lavatory is engaged and at the same time switches on a lamp.

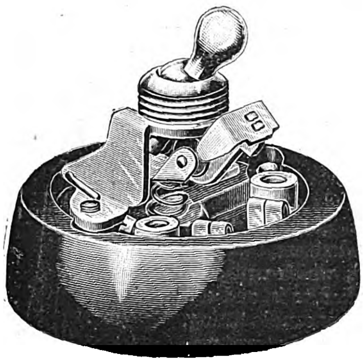


MESSRS. D. H. BONNELLA & SON'S CANDLE LAMP.

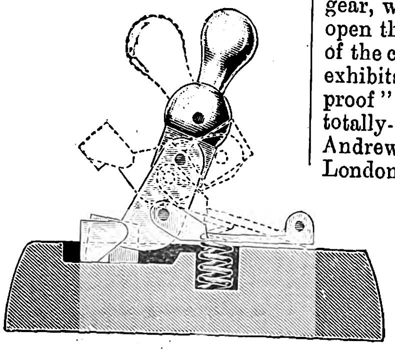
LE CARBONE exhibited carbons for many purposes, notably for use as brushes for dynamos and motors. For switches, motor starters and so on, very hard refractory carbons are recommended, and for slip rings the firm's "X" carbon (which is made in the electric furnace) is said to be particularly suitable on account of its high conductivity combined with a low friction coefficient. As a substitute for and improvement upon ordinary copper gauze brushes, foliated rolled-metal dynamo brushes are put forward by this firm. These consist of soft anti-friction metal sheets rolled very thin, folded and formed under pressure to the size required. The principal constituent of the metal composition is copper. Each metal lamination is only about 1,000th of an inch thick. It is stated that the resistance in the direction along the laminations is exceptionally small, while the resistance at right angles to the laminations is comparatively large. The firm's improved method of fastening flexible conductors to carbon brushes, which was illustrated and described in *The Electrician* for July 14, p. 515, was also shown, and the remainder of the exhibits included sealed cells (with small vent hole) for tramway bells, carbon bushes for trolley wheels, microphone carbons and other carbon material for various purposes.

The stand of the KLEIN ENGINEERING Co. contained models of the firm's specialities in cooling and condensing plants and automatic weighing and recording machines. The principal attraction in this exhibit was the working model of an Ingrey patent automatic weighing and recording machine, of which the Klein Engineering Co. are the sole licensees and makers. The object of this machine is to weigh all classes of material and automatically to record the weight on a dial which, in addition to indicating the individual weight, adds up the total so that at any moment reference may be made to the dial and the exact quantity passed through the machine ascertained at a glance. It is specially designed for feeding boilers and is perfectly automatic in its action, requiring no attention from the stoker.

Messrs. J. H. TUCKER & Co. exhibited a tumbler switch, illustrated below. The first figure is a general view without cover and the second figure allows the action of the switch to be followed. The action is very easy, even in the 20-ampere size, this being essentially due to the fact that the leverage (see illustration) is most effective at the time when the contact arm is entering and leaving the contact springs. No metal carrying current is exposed at the back of the base, the latter being, we were told, of best English porcelain. The action is positive and the break rapid and long. The firm's iron-cased switches, with a handle for turning outside and an action similar to a tumbler switch, should be serviceable for situations in which a watertight switch is needed. An accumulator switchboard for charging, discharging or running direct was the most prominent feature of the stand, and around it were grouped distribution boards, on enamelled slate and marble, fitted with various types of switches and fuses, D.P. "service" switches (in glazed cases), the handles of which may be locked in the on or off position, wall sockets and plugs, ceiling roses, cut-outs, lamp-holders, asylum switches with locking covers, and much other well made material of a similar character.



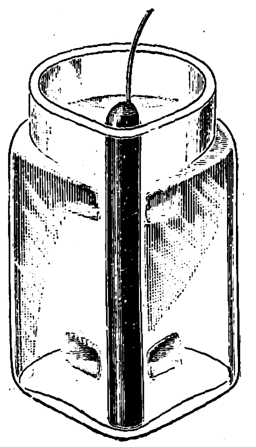
J. H. TUCKER & CO.'S TUMBLER SWITCH WITH COVER OFF.



SKETCH SHOWING MECHANISM OF TUMBLER SWITCH.

The AMALGAMATED DRY BATTERIES (LTD.) had a large assortment of standard material in the way of wet and dry batteries, accumulators, electric torches, miniature motors, insulated wires, &c., on view, but they also showed a novelty, small in its way but none the less useful, in the form of a jar for Leclanché cells fitted with four glass projections to hold the zinc rod in position as indicated in our sketch.

Not the least interesting feature of the Exhibition was the official time circuit of 20 "Synchronome" clock dials, manufactured by The SYNCHRONOME Co. The self-wound controlling pendulum operating this circuit was in the entrance hall (Addison-road). At each end of the main hall and hanging in mid-air were two 5 ft. skeleton iron dials. The "one-wheel" step-by-step dial movements which propelled the hands were invisible, being covered by the bosses of the hands. On the gallery front at each side of the main hall were two 3 ft. dials complete in metal cases, which latter were japanned black with gilt bands. They were dust and weather-proof, and the hands and dials were protected by glass. This pattern was obviously an ideal one for workshops and courtyards. In the annexe was a 2 ft. dial of the same pattern, and there was also another one under the gallery by the entrance. The remainder of the dials comprising this official time circuit were distributed throughout the dining rooms and refreshment bars. They were all of 12 in. diameter, some of them in handsome turned-wood cases, and some in stamped metal frames, highly finished to imitate hardwood.



LECLANCHÉ GLASS JAR WITH GLASS PROJECTIONS FOR HOLDING THE ZINC ROD IN POSITION.

One of the finest displays of switchgear for continuous as well as alternating currents was shown by Messrs. COWANS, who shared their stand with the Key Engineering Co. A 500-ampere and a 1,000-ampere circuit breaker were shown in the centre of the stand, these instruments being of the type made to the specification of the Admiralty for the battleship "Hibernia," and others. They are of the double-pole tandem pattern, with overload release combined with time element in both poles and reverse current release of the "Andrews" type in one pole. Circuit breakers are fitted with a magnetic blow-out of moderate strength, in accordance with this firm's standard practice. Since the magnetic blow-out is combined with a wide spring break, the strong magnetic field usually adopted is not necessary, as, with all moderate currents, the circuit is opened safely, without the assistance of the magnetic field. In consequence, the breakers do not rupture the circuits with explosive violence with the consequent rise of pressure in a circuit of any appreciable inductance. The breakers are fitted with a free operation handle, so that they are free to open the circuit when the handle is grasped by the attendant. The "Andrews" reverse-current release acts directly on the tripping gear, without the intervention of any relay, and is guaranteed to open the circuit breaker with a reverse current, though the pressure of the current fall to 25 per cent. of the normal. Amongst the other exhibits were discriminating cut-outs for alternating-current, "fool-proof" motor starters of the pillar type, polyphase automatic totally-enclosed oil switches (with no-voltage and overload release), Andrews' time-limit relays, a generator rheostat as supplied to the London County Council, fuses, &c.

The KEY ENGINEERING Co. had fibre conduit on view. It is claimed that already 100,000 yds. of this conduit have been sold in this country. There was also shown an arc lamp which emitted a soft white light, the effect being obtained with pure carbons without any chemicals. Two lamps may be burned in series across a 220 volt supply. The carbons are inclined towards each other as with the ordinary chemical carbon lamps, and there is no shadow, the positive crater being unmasked by the negative carbon and its holder. It is stated that the efficiency of the lamp is very high, and that the lamp will burn for about 15 hours before requiring trimming.

(*To be concluded.*)

## A NEW WESTINGHOUSE RAILWAY MOTOR.

The accompanying diagrams refer to a new line of motors ranging from 75 H.P. to 200 H.P. for heavy traction now being made by the Westinghouse Co. Among the features of these motors may be mentioned the diagonally divided field frame which makes every part accessible; the gear case supported entirely at the ends, so as to avoid the side strains which have been responsible for so many broken gear cases; housings for armature bearings clamped between the two halves of the frame; armature and commutator assembled upon a single spider; bar-wound armature with split coils; commutators with many bars; bolted-in laminated poles; and sealed field coils wound with strap. All motors have cast steel frames split at an angle of 45 deg. with the horizontal. The axle bearings are carried by the lower half of the field frame and are divided at an angle of 35 deg. with the perpendicular, so that the weight of the motor is supported almost entirely by the part of the frame extending over the axle rather than by the axle cap bolts. By lifting off the upper half of the field casting the armature may be removed from the frame without taking the motor from the truck; or the motor may be removed from the truck by simply taking off the gear case and axle caps. Bolts with nuts and lock washers hold the two halves of the frame together and the axle caps in proper position. Housings for the armature bearings are circular in form and are turned slightly larger in diameter than their seats in the frames, so that when clamped in place all the advantages of a press fit are obtained. Finished shoulders on the housings prevent any lateral movement and also take the entire end thrust of the armature instead of imposing this severe strain on the clamping bolts. Two bolts through the frame at each end prevent the housing from turning.

The armature bearings are made of solid phosphor-bronze bushings finished all over, with a $\frac{3}{32}$ in. lining of babbitt metal. If from neglect the bearing should become so hot as to melt the babbitt the armature would be supported on the brass shell, and would not strike the poles. Both oil and waste lubrication are provided. The waste is supplied with oil from separate pockets from below; in this way it is filtered before reaching the bearing. The amount of oil in the reservoirs may be gauged so that it may be kept at the proper level for economical service. It is stated that with intelligent care these bearings will run 100,000 to 150,000 miles. The axle bearings are similar in construction to those of the commutator, except that split bushings are used.

The laminated pole pieces are bolted to the top, bottom and sides of the motor frame, which, being almost square in cross-section, permits the use of flat field coils. These coils are wound of copper strap insulated between turns with treated asbestos ribbon and then carefully taped and given repeated dippings in specially prepared insulating compounds and varnishes which make them moisture repelling and able to stand internal heat. Brass hangers hold the coils in place independently of the poles.

The shaft is forced into the finished armature and keyed thereto and may be removed, should necessity arise, without disturbing the windings or commutator. The armature coils are strap wound and made in two parts. As the top coils are more liable to injury this design makes it possible to remove the damaged part without disturbing any other part of the winding. The coils are liberally insulated with mica, and sealed and further insulated by dipping in varnishes which are oil-proof and moisture-repelling. On each end the armature slots are made deeper and wider, thereby providing space for mica cells, which greatly reinforce the insulation at these points. As a further protection fibre strips are taped to the upper sides of the top coils. Countersunk bands of steel wire on the core hold the coils firm and secure. Openings through the spider and core allow a free passage of air, which is thrown forcibly against the field coils. The brush holders are of the sliding type with springs of phosphor bronze. Leads of flame-proof flexible rubber-covered cables are brought out at the front of the motor over the commutator through insulating bushings. Access to the brushes and brush holders is provided through a large opening in the frame over the commutator which extends well down the side, making inspection easy from the pit. A hole in the rear end bell and an opening under the commutator provide means for inspecting the clearance between the armature and field poles. Pinions used on these motors are machined from solid steel forgings and held on tapered seats by keys, nuts and lock washers. Gear cases are made of malleable iron and divided along the centre line of armature and axle. Nose suspension with safety lugs is used for all motors of this design.

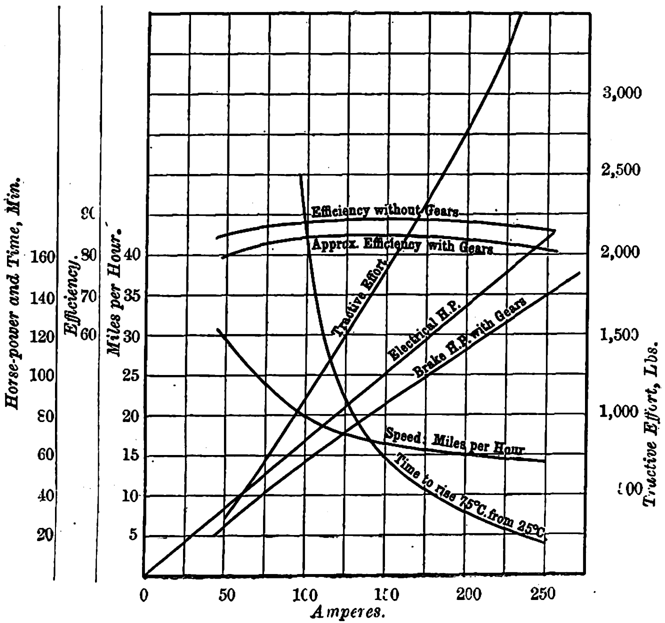


FIG. 1.—CHARACTERISTIC CURVES OF 85 H.P. RAILWAY MOTOR, 500 VOLTS.

Gear ratio, 17 : 58. 33 in. wheels.
Continuous capacity, 80 amperes at 300 volts.
" " 75 " " 400 "

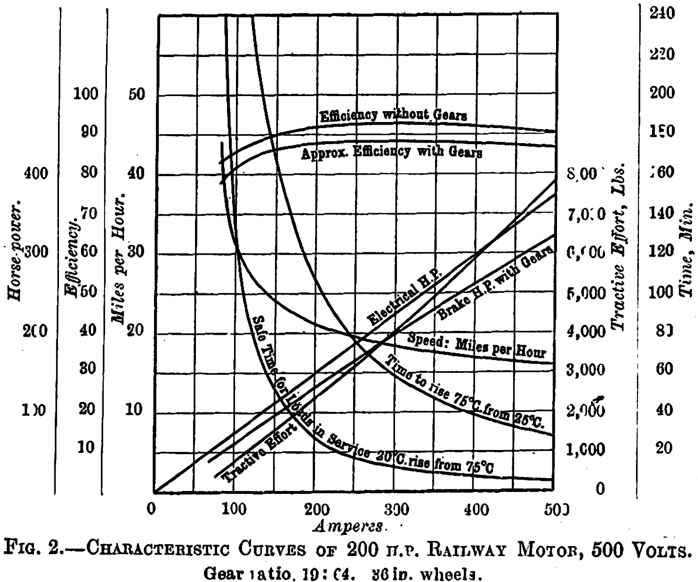


FIG. 2.—CHARACTERISTIC CURVES OF 200 H.P. RAILWAY MOTOR, 500 VOLTS.

Gear ratio, 19 : 64. 36 in. wheels.
Continuous capacity, entirely closed, 135 amperes at 350 volts.
" " " open, 176 " "

# ON THE THEORY OF MAGNETISM.*

BY P. LANGEVIN.

*(Concluded from page 109.)*

4. It can, indeed, be proved that the creation of an external magnetic field, which, according to the Maxwell-Hertz equations, is accompanied by the production of an electric field, modifies the motion of the electrons in their orbits, and of all the electrons, in the manner corresponding to magnetism. The magnetic moment of any elementary current normal to the direction of the field H is increased by $\Delta M = -He^2S/4\pi m$ if $m$ is the mass of the electron.

I shall here demonstrate this formula only for the particular case of an electron gravitating along a circular orbit round a centre which attracts it according to any function of the distance. The magnetic moment of the magnet equivalent to the elementary current equals the product of the charge $e$ of the electron into its areloar velocity (this being constant as long as the central force alone acts). If $\omega$ is the angular velocity and $r$ the radius of the orbit, we have $M = eA = e\omega r^2/2$.

If an external force acts upon the electron, such as the electric force induced by the establishment of the magnetic field H, there will be a change of the areolar velocity A, and therefore also of M, in accordance with the well-known law $2m\,dA/dt$ = moment of external force.

If E is the component of the induced electric field along the tangent to the orbit, the moment of the force is $Eer$; hence

$$dM = e\,dA = \frac{e^2}{2m} Er\,dt.$$

Now the speed of the electron is $\omega r$, so that the element $ds$ of the path traversed in the time $dt$ is $\omega r\,dt$, wherefore

$$dm = \frac{e^2}{2\omega m} E\,ds.$$

Let $\delta M$ be the variation of moment during one revolution of the electron. This revolution will always in practice have a period which is very small in comparison with the time required for the establishment of the magnetic field, and $\omega$ may therefore be considered as constant during this revolution. Therefore

$$\delta M = \frac{e^2}{2\omega m}\int E\,ds.$$

But according to the law of induction quoted above, this integral, which is the line integral of the electric force along the orbit, equals the time variation of the flux of magnetic force HS:

$$-\int E\,ds = \frac{dHS}{dt} = \frac{1}{\tau}\delta HS,$$

the minus sign indicating the direction according to the law of Lenz. Substituting $\omega = \frac{2\pi}{\tau}$, we have $\delta M = -e^2\delta HS/2\pi m$.

From this we deduce the total variation $\Delta M$ resulting from the establishment of the magnetic field H: $\Delta M = -He^2S/4\pi m$.

The supposition made with regard to the slow establishment of the field is eliminated on considering the effect upon a large number of similar orbits oriented in every conceivable direction, as is the case in practice.

This diamagnetic modification is independent of the manner in which the superposition of the elementary current and the external field is carried out, whether the latter is created by a current, or whether the molecule is displaced in an existing field. It is always extremely feeble. We have, in fact,

$$\frac{\Delta M}{M} = \frac{H\tau}{4\pi}\,\frac{e}{m} < 10^{-9}H,$$

since the largest known value of $\frac{e}{m}$ is $1{\cdot}8 \times 10^7$, corresponding to the cathode rays, and since $\tau$ is of the order $10^{-15}$. The most intense fields we are able to produce, always below $10^5$ units, do not, therefore, change the magnetic moment of the elementary currents by more than 1 in 10,000.

5. The smallness of this modification is corroborated by the smallness of the Zeeman phenomenon, which is a manifestation of the diamagnetic modification. In fact, the change of intensity of the elementary currents produced at the moment of the establishment of the field corresponds to an increase in the period of the electrons which revolve in one direction, and a diminution of the period of those revolving in an opposite direction, in conformity with the changes constituting the Zeeman effect. The extreme smallness of the effect justifies what has been said concerning the smallness of the diamagnetic modification. Further, the generality of the Zeeman phenomenon proves the generality of the diamagnetic effect. Even in iron, which shows the Zeeman effect, the elementary currents are modified in the diamagnetic sense.

It is of some interest to show that, in the particular case supposed above of a circular orbit with any central force, $f(r)$, the establishment of the magnetic force does not change the radius of the orbit, but only the period of the electron, at least so long as the magnetic field is feeble enough to produce but a slight modification, as we have seen to be always the case. In the absence of the magnetic field, the condition of steady motion is

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* From the *Journal de Physique* of October, 1905.

$$f(r) = m\omega^2 r \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

If both $\omega$ and $r$ are affected by the magnetic field, to the extent of $\Delta\omega$ and $\Delta r$ respectively, the new condition of steady motion under the magnetic force $He\omega r$ may be written

$$f(r+\Delta r) = m(\omega+\Delta\omega)^2(r+\Delta r)+He\omega r,$$

and retaining only terms of the first order:

$$\{f'(r) - m\omega^2\}\Delta r = 2m\omega r\Delta\omega + He\omega r \quad . \quad . \quad . \quad . \quad (2)$$

On the other hand, the value obtained above for the diamagnetic modification gives $\Delta A = \Delta\frac{\omega r^2}{2} = -\frac{He}{4m}r^2 - 4m\omega\Delta^2 r = 2m\omega r\Delta\omega + He\omega r.$ Subtracting this from (2) we have $\{f'(r)+3m\omega^2\}\Delta r = 0$, which gives the conditions $\Delta r = 0$; $\Delta\omega = -He/2m$, unless the law of central force obeys the particular relation $f'(r) + 3m\omega^2 = 0$, which, combined with (1) gives $f(r)/f(r) = -3/r$, $f(r) = K/r^3$.

Therefore, unless the attractive force which maintains the electron in its orbit varies exactly in the inverse ratio of the cube of the distance, the diamagnetic modification will not change the dimensions of the orbit, but only the period of revolution, in the manner corresponding to the Zeeman effect.

6. The elementary currents behave like circuits of zero resistance and appropriate inductance. Indeed, such a circuit of inductance L would be modified by the external field in such a manner that the total flux remains constant: $dLi/dt = -d(HS)/dt$, whence on the establishment of a field, H: $\Delta Li = -HS$.

The circuit considered would be identical with the elementary current if $\Delta M = -e^2HS/4\pi m = e^2\Delta Li/4\pi m$. $L = 4\pi mM/e^2i = 4\pi^2r^2m/e^2$, if the orbit is a circle of radius $r$. The magnetic energy of the circuit will be $Li^2/2 = 4\pi^2r^2m/2\tau^2 = mv^2/2$, which means that the elementary current will be identical with a circuit of zero resistance if the inertia of the electron constituting it is entirely electromagnetic—*i.e.*, if the kinetic energy $\frac{1}{2}mv^2$ of the electron is entirely in a magnetic form. The diamagnetic modification being extremely feeble, the elementary currents may be considered as rigid and of sensibly constant intensity, and a complete presentation of the facts of paramagnetism and of the exchanges of energy between magnets and currents may be obtained on the hypothesis that magnets are constituted by such circuits, to which the laws of ordinary electrodynamics rigidly apply.

7. If the molecules have a zero resultant moment, no action of the external field will follow the diamagnetic modification and there will be no change of their aggregate motion. The ulterior encounters between molecules will be produced as before, there will be no change of temperature, and the diamagnetic property acquired will alone subsist. Conversely, no change of temperature will modify this property. All the electrons within the molecule contribute to its production, and the motion of these, as shown by the constancy of the spectrum rays, does not depend upon the temperature. Thus we obtain the law found experimentally by Mr. Curie on the changelessness of the diamagnetic constant with the temperature.

If, starting from the experimental diamagnetic constants, we seek to calculate the surfaces of the orbits such as S, we obtain a result entirely like what we might expect from the molecular dimensions and from the assumption that the orbits are intra-molecular. The smallness of the diamagnetic effects is necessitated by the smallness of the molecular dimensions.

8. If the molecules have a resultant moment which is not zero, they first of all undergo the general diamagnetic modification, after which the external field tends to turn their magnetic axes to bring them into parallelism with itself; hence results a change of the aggregate motion of the molecules, of their thermal agitation in fact, which corresponds to an unequal distribution of the kinetic energy among the molecules, those whose magnetic axis is parallel to the field having a greater kinetic energy than the others. This is incompatible with the thermal equilibrium, and, by means of mutual collisions in the case of a gas, a rearrangement is produced, after which the temperature will be uniform and the molecular magnets will be directed by preference along the external magnetic field, and the paramagnetic property will have appeared. If this rearrangement results in an increase $dM$ of the resultant magnetic moment, the system producing the magnetic field furnishes to the aggregate motion of the molecules an amount of work which, in the case of gaseous or dissolved bodies, appears as a rise in the temperature of the medium, and is given by $dW = HdM$, and in order to keep the gas at a constant temperature, an equivalent quantity of heat must be abstracted:

$$dQ = HdM = H\left(\frac{\delta M}{\delta H}dH + \frac{\delta M}{\delta T}dT\right);$$

on writing down $dQ/T$ as an exact differential, we get the relation $M = f(H/T)$, and in the case of a magnetisation proportional to the field, $M = kH/T$, which is Curie's law declaring that the paramagnetic susceptibility is inversely proportional to the absolute temperature.

The following comparison will make the preceding theory more intelligible: Imagine a mass of gas contained in a closed vessel and not subject to the action of gravitation. The molecules will distribute themselves in such a manner that the density of the gas is the same at all points, just as in the absence of an external magnetic field the molecules of a magnetic gas like oxygen have their axes distributed uniformly in all directions. If now a gravitational field is created, the molecules will take an acceleration downwards, and, in the absence of mutual collisions, each molecule will have a greater velocity at the bottom than at the top of the vessel. But this inequality of speed is incompatible with thermal equilibrium, and a rearrangement will take place by means of collisions. As a consequence, the distribution governed by the barometric formula will establish itself: the centre of gravity is lowered, and, to maintain the gas at the original temperature, it is necessary to abstract a quantity of heat equivalent to the product of the weight of the gas into this lowering of the centre of gravity. By a thermodynamic reasoning analogous to the above, it may be shown that this lowering of the centre of gravity is inversely proportional to the absolute temperature.

The thermodynamic reasoning does not allow of the calculation of the function $f(T)$ in the equation (3) for the magnetic moment. To get further, we must employ kinetic considerations and determine when the thermal equilibrium is re-established, the distribution of the magnetic molecules in the various directions, or, in the case of gravity, the variation of density with height given by the barometric formula.

After the rearrangement in a mass of gas of uniform temperature, the redistribution of the molecules is made in the various regions in such a manner that the molecules are most numerous where the potential energy is feeblest that is, at the lowest point in the case of gravity. The law according to which this redistribution takes place is the generalisation given by Boltzmann[*] for the barometric formula. The ratio of the densities of the gas at two points between which the potential energy of the molecule varies by W is

$$e^{\frac{W}{rT}},$$

where $e$ is the basis of the Napierian logarithms, T the absolute temperature of the gas, and $r$ is the constant of perfect gases reduced to one molecule, and such that, according to the kinetic theory, $rT$ represents two-thirds of the mean kinetic energy of translation—*i.e.*, double the kinetic energy corresponding to each of the three degrees of liberty of that translation. Now we know that a molecule, like that of oxygen, also possesses two degrees of liberty of rotation, as indicated by the value of $C/c$, and that to each of these degrees of liberty there corresponds a mean kinetic energy also equal to $rT/2$, and therefore $= rT$ for the whole rotation.

The redistribution of the molecules among the various orientations will be determined by the static equilibrium under the influence of the superposed magnetic potential energy $-MH\cos a$ and of the energy $rT$ of thermal agitation, the molecules being by preference oriented in the direction of least potential energy—*i.e.*, having their magnetic axis towards the direction of the field. If the magnetic axes are distributed among the various directions, the density per unit solid angle will vary from one direction to another in proportion with

$$e^{\frac{MH\cos a}{rT}},$$

all directions being equally probable if either M or H are zero.

The number of molecules whose magnetic axis is directed within the solid angle $d\omega$ will be, therefore,

$$dn = Ke^{\frac{MH\cos a}{rT}}d\omega.$$

Let us take as an element $d\omega$ a zone of aperture $da$ about the direction of the field, $d\omega = 2\pi\sin a\,da$, $a$ varying from 0 to $\pi$. If N is the total number of molecules, K is determined. For, putting $MH/rT = a$, we have

$$N = 2\pi K\int_0^\pi e^{a\cos a}\sin a\,da = 2\pi K\int_{-1}^{+1} e^{ax}dx,$$

$$N = \frac{2\pi K}{a}(e^a - e^{-a}),$$

or

$$K = Na/4\pi Sha.$$

The total magnetic moment of the N molecules is evidently directed parallel to the field and equals the sum of the projections of the component moments upon this direction. For unit volume containing N molecules, this resultant moment represents the magnetic intensity I;

$$I = \int M\cos a\,dn = \int_{-1}^{+1} 2\pi MKxe^{ax}dx.$$

Hence

$$\int_{-1}^{+1} xe^{ax}dx = 2\left(\frac{Cha}{a} - \frac{Sha}{a^2}\right)$$

and

$$I = MN\left(\frac{Cha}{Sha} - \frac{1}{a}\right).$$

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[*] L. Boltzmann, "Theory of Gases," Part I., p. 127. French edition.

For a given number of molecules, a given mass of gas, I is therefore solely a function of $a$—*i.e.*, of $H/T$, in accordance with the result of the thermodynamic reasoning.

9. If mutual actions between elementary magnets are possible—*i.e.*, if the substance is ferromagnetic, the heat disengaged is only equivalent to the work supplied in a closed cycle, and then we get the heat of hysteresis: $Q = \int H\,dM$. This case of ferromagnetic bodies naturally appears much more complex than the preceding cases of diamagnetism and paramagnetism, on account of the intervention of mutual actions between molecular magnets, just as the theory of liquids and solids, where cohesion intervenes, is infinitely more difficult and less advanced than that of gases, where cohesion does not sensibly act. The ideas here presented are, therefore, a kind of magnetic equivalent to the theory of gases. To make further progress, it will be necessary to study the directive actions between magnetised particles, and perhaps the simplest case is that of crystallised media, on the magnetic properties of which the work of M. Weiss has given us valuable hints, and promises more, while the results of M. Maurain on electrolytic deposits of iron indicate that the directive actions may be exerted over considerable distances.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

*Condensation Nuclei.*—C. Barus has pursued his investigations of condensation nuclei in the atmosphere, and has elucidated the relations between them and ions. The latter are much larger. The nuclei studied by the author are of molecular dimensions, and exist in air by the million per cubic centimetre instead of by the hundred, like the ions. He calls the nuclei "colloidal air molecules." In moist air the nuclei are perpetually regenerated. Their generation is greatly aided by $\gamma$-rays of radium. When the nuclei are precipitated and the water is evaporated the nuclei do not, like a solute, remain behind, but evaporate with the water, and are then ready to act again. In this manner they differ from ions. Röntgen rays are powerful producers of nuclei. Their action in this respect is not confined to their immediate path, but extends much further. Nor does the law of inverse squares apply to this action, for at distances where the fluorescent screen ceases to show any action the production of nuclei is but slightly weakened. The interposition of lead screens reduces the action to a certain minimum—say, 1 per cent.—but this minimum cannot be further reduced by interposing a lead screen many centimetres thick. For the $\gamma$-rays of radium this minimum is much higher. The author photographs fog by precipitating the droplets on a film of sticky oil.

[C. Barus, *Physikalische Zeitschrift*, October 26, 1905.]

*Heat Evolved by Radium.*—Knut Angström has endeavoured to get some decisive answer to the question as to whether the $\alpha$, $\beta$ and $\gamma$-rays of radium account for the heat evolved by it or not. He finds that the energy represented by these rays is but a very small part of the total energy evolved. Paschen, on the other hand, thought that the $\gamma$-rays represented more than half the total energy evolved, but since announcing that result he has found an unsuspected source of error in his experimental arrangement. Angstrom's new experiments were made with calorimeters of lead, copper and aluminium, constructed with walls 1 cm. thick, so that in the case of lead the $\gamma$-rays are absorbed by the walls. Two such calorimeters were used in each case, one containing a tube with 87 mgr. of pure radium bromide, the other a manganin coil heated by a known current and producing the same quantity of heat as the radium, the comparison being made by thermo-couples inserted in the calorimeter walls. No difference could be detected in the action of the various metals, and it must be concluded that the absorption of all the rays given out by the radium does not appreciably add to the heat received by the calorimeter. Hence the bulk of the energy given out must be in the form of radiant heat.

[K. Angström, *Physikalische Zeitschrift*, October 26, 1905.]

*Radio-activity of Breathing Wells.*—Gerlier has recently described a number of Swiss wells which alternately absorb and expire air in accordance with the state of barometic pressure. They equalise the atmospheric and subterranean pressures, but with some retardation owing to the slowness of the flow through the strata. The latter usually consist of coarse gravel. E. Sarasin has measured the radio-activity of air expired by one of these wells in a square in the village of Meyrin, near Geneva. He found a radio-activity about ten times that of ordinary air, positive charges being dissipated a little more rapidly than negative. The activity varied with the strength of the air current.

[E. Sarasin, *Physikalische Zeitschrift*, October 26th, 1905.]

*Radio-activity of Lava.*—T. Tommasina has examined lava from last year's eruption of Vesuvius. The pieces examined included a piece taken warm from the summit of the crater and four pieces from the Valle d'Inferno, each containing a coin or medal. The lumps produced a dissipation of charge amounting to 42 volts per hour, whereas the apparatus when empty discharged 10 volts per hour. The author also powdered the specimens and distributed the powder over the inner surface of the apparatus. He then found a rate of dissipation as high as 84 volts per hour.

[T. Tommasina, *Physikalische Zeitschrift*, October 26, 1905.]

*Ions in Coloured Flames.*—MacClelland has shown that the ions in colourless flames have velocities ranging from 0·53 cm. per second at 230 deg. to 0·9 cm. per second at 105 deg. Now, the rate of discharge of an electroscope brought near a Bunsen flame is greatly reduced when the salt of an alkali metal is introduced into it. Since in this case the ionisation of the flame is considerably increased, it is natural to conclude that the ionic velocities are much smaller in the coloured than in the colourless flame. The ionisation is known to be increased about 20 times by blowing a spray of a saturated NaCl solution into the flame. Now, the author finds that the velocity of the ions in the coloured flame is about 50 times less, so that the difference of conductivity is accounted for, the current being proportional both to the number of ions and their velocity. All alkali metals furnish ions of nearly the same velocity. The velocities of ions of the alkaline earths are a little less than half that. The negative ions have a velocity slightly exceeding that of the positive ions, but in all cases the ionic velocity varies inversely as the square root of the concentration. The real concentration of the salt in the flame is, of course, an unknown quantity.

[P. Lewis, *Physikalische Zeitschrift*, October 26, 1905.]

*Emission of Electrons by Alkali Metals.*—Elster and Geitel announced long ago that the alkali metals when exposed to light give out electrons, even when the light is of very feeble intensity. A piece of glass rod heated to a dull red heat is sufficient to make rubidium emit corpuscles. But J. J. Thomson has now found that there is a small emission of electrons even when all external light is excluded. The electroscope was mounted in a vacuum over rubidium or an alloy of potassium and sodium in an exceedingly low vacuum. It was read by red light, which produced but a slight leak. When the leaves of the electroscope were charged with positive electricity there was always a small leak of electricity from the leaves, while there was no perceptible leak when the leaves were negatively charged. The positive leak was entirely stopped by a transverse magnetic field. This proves that it is due to negative electrons emitted by the metal. The presence of a small quantity of fresh hydrogen considerably increases the production of electrons, owing to its simultaneous absorption by the metal. The alkali metals also give off electrons when in the gaseous state. The atoms then become positively charged, and deposit themselves by preference on a negatively-charged surface. The author concludes that the alkali metals are in reality radio-active, and, like other radio-active bodies, give off slow $\beta$-rays. But in contradistinction to them, the evolving of these slow electrons is to a certain extent under our control, being influenced by light, heat and chemical forces. These act as detonators, and split up atoms which have become unstable. This process probably goes on in all matter. If it goes on in the whole earth, the emission by every atom of an electron once in a thousand million years would be sufficient to account for the earth's internal heat. The "fatigue" of platinum and other substances after prolonged incandescence may be due to such an atomic modification.

[J. J. Thomson, *Philosophical Magazine*, November, 1905.]

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## GAS TURBINES.

The steam turbine has always been a fascinating subject for inventors and investigators. Its history extends centuries further back than that of the reciprocating engine, but for some unaccountable reason its development has been delayed to such an extent that its most economical application was not properly recognised until the dawn of the twentieth century. It was not until the historic labours of that pioneer in turbine work, the Hon. C. A. PARSONS, began to bear fruit that the era of the turbine really commenced, and the advantages of large turbines over reciprocating engines have only been generally appreciated during the last few years. While Mr. PARSONS devoted most of his efforts to the steam turbine yet he fully appreciated the fact that a turbine driven by gas was by no means an impossibility. This is borne out by one of his early patent specifications, alluded to by Mr. DUGALD CLERK in his Presidential Address to the Junior Institution of Engineers, which appears in another column. Nevertheless, he recognised that the steam turbine and not the gas turbine was the machine capable of commercial development. The gas turbine is an exceedingly interesting piece of apparatus in theory; but Mr. DUGALD CLERK showed clearly that it is quite unworkable in practice. Indeed, he even went so far as to warn young and inexperienced engineers against having anything to do with the matter, except as a scientific study. Undoubtedly, the rising generation can employ its time and energy to better advantage than in trying to invent a practical gas turbine, but we can hardly agree with Mr. DUGALD CLERK that the subject should be left so severely alone. When Mr. PARSONS was engaged in his early labours he was assured by very eminent engineers that his machine would never get far beyond the "toy" stage, and a quarter of the rebuffs which he encountered would have been more than sufficient to deter the average man. But he persevered, and some of his machines now working in various parts of the world are very large toys.

We agree that the outlook for the gas turbine is not promising; indeed, within the limits of our present knowledge, the machine is quite impracticable. The great difficulty is the temperature of the gases which must impinge on the blades. For the machine to be as efficient as an ordinary reciprocating gas engine, the temperature must be of such an order that the melting point of the blades would probably be reached. Obviously it would be quite out of the question to employ the temperatures that are found in the cylinder of a gas engine. High temperature has two principal effects. It may cause an actual physical deterioration of the metal, not immediately perhaps, but inevitably after repeated applications; or it may cause such great expansions as to be seriously harmful. Theoretically, of course, oxidation of steel ought not to be possible except in presence of water and air, but chemical action certainly does occur at high temperatures in the apparent absence of one of these bodies. Apart from this action, however, the characteristic changes in a metal after being repeatedly subjected to high temperatures are sure to take place. The expansion of the metal due to high temperatures causes serious mechanical trouble, as Mr. DUGALD CLERK pointed out. There is very little clearance between the tips of the blades or shrouding and the enclosing casing. If this were not so, the loss of efficiency would be unduly great. In existing steam turbines the slightest want of alignment of the rotor is fatal, for where very highly superheated steam is used the clearance must be extremely small after the machine has been running for a short time. If this is the case with turbines which work at a temperature somewhere in the neighbourhood of 200°C., it would be infinitely worse for a machine working at 400°C. or 500°C.—a temperature which would be rather low for a gas turbine.

The question as to whether jet expansion is more efficient than piston expansion does not meet with unanimity from experts, but, as a matter of fact, there is really very little known about it when considering expansion from flame temperatures. There is room for systematic investigation in this direction, although it may seem that no practical application is possible.

It has been urged that, though the gas turbine may be less efficient than the reciprocating gas engine, yet it will have a much steadier turning moment, and will therefore be of more value for driving electrical machinery. This is perhaps true enough as it stands, but it must not be forgotten that this irregularity is not the chief feature which is barring the way to the more rapid adoption of the gas engine. Nevertheless, the subject of the gas turbine is one that is well worth attention if only from its scientific interest, and it would be regrettable if investigations were carried no further.

## REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign book.)

◆

**Principles of Electric Power** (CONTINUOUS CURRENT). By A. H. BATE. (London: E. & F. N. Spon, Ltd.) 4s. 6d.

Regarded as a concise practical treatise for a person who is familiar with engineering practice and yet is unfamiliar with electric motors, we have seldom seen anything superior to Mr. Bate's book. To power users, whose motors are driven by continuous current, it can be safely recommended, and it was obviously written more particularly for this purpose. Without wasting valuable time, the author gives a clear description of the principles governing the different types of continuous-current machines, and then proceeds to enlarge upon their application. At the end of the book is a most useful table giving the horse-power absorbed by various machine tools, and as these examples have been taken from different Papers read before engineering societies their reliability may probably be taken for granted. In view of the great developments now taking place in the applications of electric power-driving to numerous industries, the appearance of Mr. Bate's book is most opportune; and perhaps we might suggest that future editions should deal with alternating as well as continuous currents, as it is in this direction that most new work is being done.

**Fowler's Mechanical Engineer's Pocket Book, 1906.** Edited by W. H. FOWLER. (Manchester: Scientific Publishing Co.) 1s. 6d.

Once more this familiar volume has reached us, and once more we take much pleasure in paying a tribute to its excellence. With certain exceptions it is practically identical with last year's edition. Substantial additions have been made to the section dealing with machine tools, however, and there are several new tables of proportions concerning details which will probably prove of service to the designer and manufacturer.

**Fowler's Electrical Engineer's Year Book, 1906.** (Manchester: Scientific Publishing Co.) 1s. 6d.

This is a companion to the "Mechanical Engineer's Pocket Book," and is brought thoroughly up-to-date, including, as it does, descriptions of the osmium and tantalum lamps. One omission, however, is any reference to the various forms of flame arc lamps, with the exception of the Bremer. The most recent Board of Trade regulations relating to elecric tramways and railways are included, as well as the Home Office rules for the use of electricity in mines. Other fresh matter relates to turbo-generators, but the descriptions of the individual types are very cursory.

**Elementary Electrical Engineering.** By P. T. WHITE. (Wigan: Strowger & Son.) 4s. 6d.

For the past year or two authors have been very busy bringing new technical books into existence. Good, bad and indifferent, they have been thrust forth by their makers, some to achieve success and others to receive anything but a favourable reception.

We fear that Mr. White's book will never become famous as a success. It has been written "with the object of serving as an introduction to the most advanced study of electrical engineering," but the definitions with which he commences are not always as nicely worded as they should be in a work that aims so high. Later on the author refers to "electrical friction" as causing the rise of temperature in a conductor. $PbO_2$ is given as $PbO^2$, and P.D. becomes D.P.

**Wireless Telegraphy and Hertzian Waves.** By S. R. BOTTONE. (London: Whittaker & Co.) 3rd edition. 3s.

The revision of the book has not been thorough. Inaccuracies which we pointed out in the first edition about five years ago have not been corrected, and little is said of the progress in wireless telegraphy that has been made since that date. We can find no mention of the magnetic detector, nor are the ingenious receiving devices of Fessenden and De Forest described, and the Lodge mercury coherer is not alluded to.

**Wireless Telegraphy: Its History, Theory and Practice.** By A. FREDERICK COLLINS. (McGraw Publishing Co., New York.)

In the first few pages one reads that "by the term electric wave we differentiate waves emitted by electricity and electricity itself"; that "the Faraday-Maxwell electromagnetic theory of light . . . means that light, electricity and magnetism are transmitted by the same ether." And the further one reads the more and more misinformation on electric waves does one gather. This might be forgiven if in other parts of the theoretical discussion of wireless telegraphy sounder instruction were offered. But when we are told, for instance, that Ohm's law is reserved for direct currents, and Joule's law for alternating currents of high frequency, and again, that Leyden (of jar fame) is in Germany, we grow vindictive. Rather than exhibit himself thus an author should, when in difficulty, hide. Not that the art of concealment is wholly neglected by our author. Here is an instance: "Fitzgerald employed a sensitive galvanometer as a detector, the field of force created by the oscillations exerted a final influence on the galvanometer system."

The author is happier when he comes to apparatus description. But here his classifications of detectors and of oscillators must be pronounced bad. For sometimes instruments essentially different in type are discussed in the same sentence, while, at another time, instruments essentially the same are separated in treatment on account of some accidental difference. This redeeming feature the book possesses: there is a wealth of good illustrations.

**Gleichstromerzeuger und Motoren.** By W. Winkelmann. (Hanover: Gebrüder Jänecke.) 3.40m.

So many good books on the design and calculation of continuous current generators and motors are on the market, that there is no excuse for additional publications unless they contain some novel matter or treat the subject in an improved way. Such a compliment cannot be paid to the 120 pages of fragments served up in the volume under review. The information given, being of a purely theoretical nature, is frequently of questionable value to the practical man, and the student, for whom this book is primarily intended, will not derive much real benefit from it. What could be more misleading, for instance, than the unqualified statement on p. 5 that no voltage exists between the terminals of a short-circuited series motor, and that no current flows through the short-circuit for this reason? We should feel sorry for the student who, on the strength of this statement, fancied he could short-circuit (as this term is ordinarily understood) a series motor with impunity; and must not such bare theoretical pronouncements as these confuse the minds of budding electricians who are given to understand, from other sources, that traction motors are short-circuited to act as brakes? This example will suffice to indicate the tenour of the book, which is open to similiar criticism throughout. One novelty may be mentioned, however—namely, that of expressing the volume of an armature in litres.

**Notions d'Électricité.** Par Jacques Guillaume. (Paris: Gauthier Villars.)

This book has been written with the object of setting forth in a clear and practical manner the principles underlying a large number of industrial electrical appliances. It is based on a series of lectures delivered before artisans, mechanics and others at evening classes. The opening chapters are devoted to fundamental magnetic phenomena, while subsequently dynamos and motors, for both continuous and alternating current, are dealt with. In the later chapters typical apparatus used in generating stations and on distribution networks are described. Mathematics are avoided, but some simple arithmetical problems are worked out and are quite sufficient for the purpose. We can recommend the book to demonstrators and lecturers at evening classes in electro-technics.

**Précis de la Theorie du Magnetisme et de l'Électricité.** Par A. Nouguier. (Paris: Librairie Polytechnique.) 1905.

This is a book of rather an advanced type, and is not suited to the requirements of any except those who have a thorough knowledge of higher mathematics, including the calculus. For the average student of electrical engineering M. Nouguier's book contains much more than is really necessary, but it would probably prove of value to a student engaged in writing a graduating thesis on a "pure science" subject.

## TESTS ON THE TANTALUM LAMP.

Some interesting life and efficiency tests of tantalum lamps have recently been published by Prof. W. Wedding in the *Elektrotechnische Zeitschrift*. Fig. 1 indicates the distribution of light of the 25 c.p. 110 volt lamp tested, the current taken by the lamp being 0·3625 amperes. The mean spherical intensity was found to be 19·3 Hefner candles, so that the consumption per mean spherical candle-power works out at 2·065 watts, the consumption per candle-power in the horizontal plane being 1·6 watts. As regards the absolute efficiency of the lamp, the author calculates it to be less than 1 per cent., 0·866 of 1 per cent. to be exact. Four new 25 c.p. lamps were tested until they collapsed. At the same time four ordinary filament lamps of 25 c.p. and 16 c.p. respectively were tested in the same manner. The average results are shown in Fig. 2, the four small crosses indicating the first breakage of filament in each of the tantalum lamps. As is well known, a breakage of the tantalum filament does not necessarily terminate the lamp's life; on the contrary, the broken ends generally make contact with some part or other of the filament, and the lamp continues to burn. But the breakages afterwards generally occur at shorter and shorter intervals, until the lamp becomes useless (see Fig. 3). At the commencement of the tests the average consumption of the four tantalum lamps per candle-power at right angles to the lamp axis was 1·68 watts. This figure dropped to 1·57 watts after seven hours and then rose to 1·60 watts after 17 hours, 1·62 watts after 37 hours, 1·67 watts after 85 hours, 1·64 watts after 179 hours, 1·66 watts after 256 hours, 1·79 watts after 370 hours, 1·89 watts after 637 hours, 2·04 watts after 905 hours, and 1·94 watts after 1,582 hours. The efficiency of the last lamp which survived, measured after 1,989 hours of burning, was found to be 2·03 watts per candle-power. The 25 c.p. carbon filament lamps commenced with an average efficiency of 3·44 watts. After 21½ hours this figure had dropped to 2·79 watts, after 110 hours to 2·94 watts, after 344 hours to 3·36 watts, after 609 hours to 3·52 watts, after 850 hours to 3·85 watts, after 1,420 hours to 4·38 watts, and after 1,826 hours, finally, to 5·25 watts. Similar figures were obtained for the 16 c.p. lamp—viz., 3·23 watts per candle-power at the start, 2·81 after 21½ hours, and 5·44 after 1,826 hours.

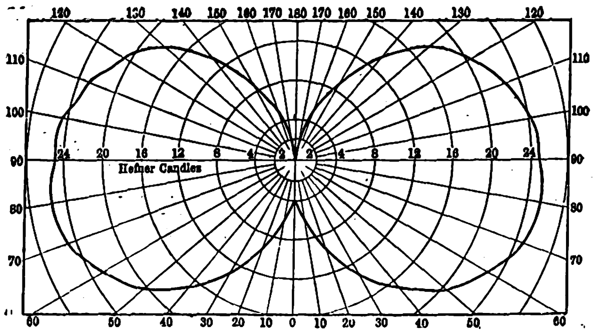

Fig. 1.—Distribution of Light in a Vertical Plane.

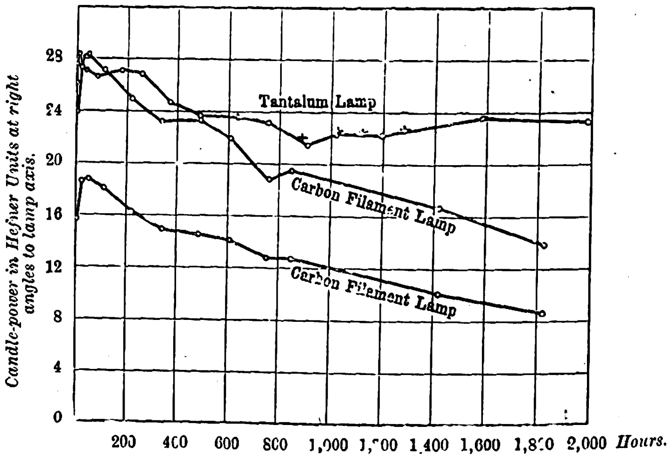

Fig. 2.—Curves showing the Variation of Candle-power with the Time.

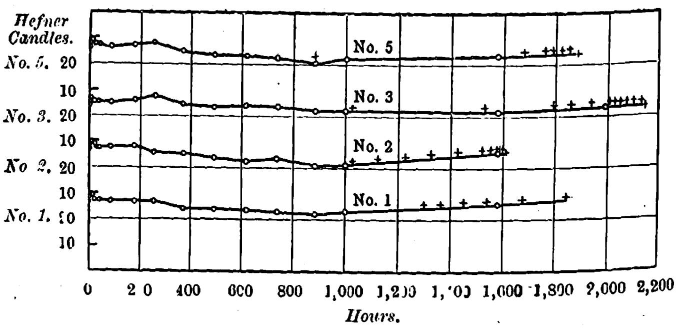

Fig. 3.—Life Tests of Four Tantalum Lamps.

## THE PROBLEM OF THE GAS TURBINE.*

The wonderful success obtained by your distinguished past-president, the Hon. C. A. Parsons, and his many able followers, with the steam turbine in its various forms, has naturally attracted the attention of engineers to the apparently analogous problem of the internal combustion turbine. Accordingly, much mathematical and engineering ability has been recently devoted to the subject—so far, I am sorry to say, without concrete result. In this subject, as yet, the dreams of the theorist obstinately decline to realise themselves in tangible iron and steel. I have not been able to find any gas turbine in a state of effective rotation doing useful work, although I have noted many statements in the Press to the effect that some wonderful German, French or Italian gas turbine had worked, or was about to work, in such manner at to relegate the ordinary cylinder and piston gas engine to the museum, with which many engineers used to threaten the steam engine. One gas turbine only has really rotated within my own direct knowledge. It was designed by Mr. F. W. Lanchester, of Birmingham, to operate with the exhaust gases from one of the petrol engines used in his well-known motor cars. He assured me a few days ago that it really rotated at a high speed, and made a loud shrieking noise, but only gave, he said, a total brake horse-power equal to that capable of being evolved by two blue-bottle flies. This power he did not consider to be satisfactory.

Speaking seriously, it does seem remarkable that so much interest should be taken by so many able men, without any sort of result in practice. Why is this? I propose to-night to answer the question in so far as I can. It appears to me that most of those who have written on gas turbines, and have even designed and patented them, have given too little weight to certain differences between the steam and internal combustion engine problems. Many, indeed, have assumed that the solution of the gas turbine problem is the easier of the two, and that few difficulties exist which have not already been met and conquered by Mr. Parsons in the steam turbine. Many distinguished men have been of this opinion, and even Mr. Parsons himself, so early as his first turbine patent (No. 6,735 of 1884), appears to have been of opinion that the hot gas or internal combustion turbine presented practically the same problem as the steam turbine. In that specification he makes the following statement: "Motors according to my invention are applicable to a variety of purposes, and if such an apparatus be driven it becomes a pump, and can be used for actuating a fluid column, or producing pressure in a fluid. Such a fluid pressure producer can be combined with a multiple motor according to my invention, so that the necessary motive power to drive the motor for any required purpose may be obtained from fuel or combustible gases of any kind. For this purpose I employ the pressure producer to force air or combustible gases into a close furnace of any suitable kind, such as used for caloric engines, into which furnace there may or may not be introduced other fuel (liquid or solid). From the furnace the products of combustion can be led, in a heated state, to the multiple motor, which they will actuate. Conveniently the pressure producer and multiple motor can be mounted on the same shaft, the former to be driven by the latter; but I do not confine myself to this arrangement of parts." Clearly here Mr. Parsons intended to apply his invention to the gas turbine as well as to the steam turbine, and in this paragraph he outlined the fundamental idea of nearly all subsequent proposals of gas turbines. Many other inventors have followed him, but I may only mention two well known names—those of Ferranti and Stodola. Both have proposed turbines similar to this, with more or less elaboration, as well as other modifications intended to overcome certain difficulties.

In a very able Paper† read before the Institution of Mechanical Engineers last year, Mr. R. M. Neilson discusses various cycles of operation which can conceivably be applied to gas turbines, and he calculates the efficiencies of these cycles in various combinations. More recently, too, the subject has excited great interest in America, and very interesting articles are to be found in the *Engineering Magazine* by Dr. Charles E. Lucke and Prof. Sidney A. Reeve. These gentlemen take somewhat opposing views of the position of the problem.

In most of the recent discussions upon gas-turbine problems, it has been recognised that the temperatures possible in the cylinder gas engine are impossible for the gas turbine. It has been fully proved by many investigators, including myself, that the temperatures quite common in ordinary gas-engine practice range as high as 2,000°C., although in the best practice, for most economical results, 1,500°C. or 1,600°C. appears to be an upper limit. With the temperatures of 1,500°C. or 1,600°C., a first-class modern gas engine of about 50 H.P. will give an indicated efficiency of 35 per cent. At the same time the negative work of the cycle is so low that the mechanical efficiency of the engine may be as high as 86 per cent., or even over. If one realises what the temperature 2,000°C. means, it becomes very evident that no turbine constructed either on the lines of Parsons or Laval could possibly be made to work with continuous supply of such gases; 2,000°C. is considerably over the melting-point of platinum. It is much higher than the temperature at which cast-iron flows from the crucible, or, indeed, the temperature of the interior of the blast furnace itself. Any blades of iron, steel, or, in fact, of any other material, even brick-fire itself, becomes fluid or semi-fluid at this temperature. It is obviously hopeless, therefore, to attempt, in the gas turbine, temperatures which are quite feasible in the cylinder engine. This fact, as I have said, is generally recognised. It is accordingly said, by those who take a favourable view of the gas turbine, that it is necessary to supply the turbine with gases at a much lower temperature. Mr. Neilson fixes the temperature of 700°C. as one which steel-turbine blades would probably stand, without too rapid deterioration. I fear that on this point I must differ from him, because, in my experience, oxidation of steel, and even iron, is a fairly rapid process at this temperature. Nothing new has been proposed as to the thermodynamic cycle of the gas turbine, so that all reasoning upon efficiencies depends upon the deductions already made from internal combustion engine practice.

Seeing the impossibility of constructing a turbine with materials to stand a high temperature, many have proposed to convert high temperature into kinetic energy, so that instead of having work stored up in the gas in the form of heat, the heat shall disappear, and the energy of the heat be transformed into motion of the gaseous particles at a high velocity. Such proposals, then, include the compressing of a gaseous mixture to, say, 50 lb. or 60 lb. above atmosphere, the igniting of that mixture within a combustion chamber at constant pressure, and the expansion of the mixture through an expanding jet of the Laval type, so as to drop the temperature and obtain its equivalent in kinetic energy or velocity of the gaseous particles. The rapidly moving particles at the relatively low pressure and temperature are then allowed to impinge upon rapidly rotating blades of sickle configuration, and they are supposed to give up their energy of motion to those blades, and so expend work upon the turbine. This appears to be the most feasible of all the gas turbine proposals, so I will proceed to examine it a little more minutely.

Success by this cycle of operations requires: (1) A rotary or turbine compressor of high relative efficiency. (2) An expanding nozzle which shall ensure that free expansion is quantitatively equivalent to adiabatic expansion behind a piston. (3) A rotating turbine of such construction as to secure very high efficiency of transformation of kinetic energy of the moving gas into effective work available at the turbine shaft.

Assuming air to be the working fluid, and specific heat to be constant through the temperature range, it is easy to calculate the efficiency of the Joule or Brayton cycle, which these operations in effect represent. It would be useless to attempt to work a turbine at a pressure so low as to be relatively inefficient compared with the gas engine, so I have chosen a Joule cycle of, say, 48 per cent. ideal efficiency, which in a cylinder gas engine would probably give in practice about 30 per cent. indicated efficiency. For this ideal efficiency the pressure of compression would require to be 141 lb. per square inch absolute. To give power with a reasonably small pump, I shall assume a maximum temperature of 1,700°C. That is, assuming a perfect compressor and a perfect nozzle expander, the temperature would only fall from 1,700°C. to 750°C. Plainly this temperature would be too high for a Laval disc with blades. In order to get a reasonable temperature on expansion, it would be necessary to assume a maximum temperature in the combustion chamber no higher than 1,000 deg., and this would bring down the temperature after complete expansion to about 500 deg., which no doubt steel turbine blades can be expected to stand for some considerable time. With these assumptions, however, the gas turbine would not be very economical as compared with cylinder engines, even assuming all difficulties overcome. The theoretical and practical difficulties, however, are very serious indeed. To begin with, the question of an efficient air compressor. I am not aware of any turbine compressor capable of compressing up to 140 lb. absolute from atmosphere with anything like 60 per cent. efficiency. Before success could be attained this efficiency of compression, so far as diagram is concerned, should be at least 90 per cent., in order to allow for unavoidable mechanical and other losses in the subsequent processes. It has, it is true, been proposed to substitute cylinder compressors operated from the turbine instead of turbine compressors; but this, it appears to me, would be equivalent to abandoning at once all the advantages of the turbine principle. If reciprocating cylinders are to be used for compressing, there is no objection to using them also for expanding. No gas turbine with cylinder compressors could, in my view, succeed.

Assuming, however, even 90 per cent. efficiency from a turbine compressor, and assuming that we have a compressed gaseous mixture burning freely in the combustion chamber at the desired pressure and temperature, we have yet to face the problem of the expanding nozzle. It is always assumed that with the use of an expanding nozzle temperature drop can be as certainly attained as with an expanding piston in a cylinder. This, it seems to me, has been by no means proved. You will all recollect Dr. Joule's famous experiment with two vessels immersed in water and connected together by a pipe having a stop cock upon it. Air was compressed into one of those vessels, the water round the vessels stirred, and equilibrium obtained, while the other vessel was rendered as vacuous as possible. The stop cock between the two vessels was opened, and it was then found that when the water was stirred again no disturbance of the equilibrium ensued. This, of course, meant that although heat was lost in the one vessel, giving velocity to the gases, it was gained in the other vessel by the impact of the gases against the walls. Joule modified this experiment by placing the two air vessels in separate water containers. He then found that the temperature of the one vessel dropped, due to expansion, but the temperature of the other vessel rose as much as the first dropped. Now apply this experiment to reasoning on the behaviour of the flame in an expanding nozzle. Assume the two vessels to be connected together by a Laval nozzle, and assume, that while in the nozzle, the gases experienced the full temperature fall due to adiabatic expansion. Immediately, however, on contact with the walls of the second vessel the velocity of the particles would be stopped and the temperature would be restored to a point somewhat above the original temperature—that is, the mass of expanding flame in the pressure vessel would gain heat by the amount the first vessel lost. That is the result of the final process. It will be easily recognised that to obtain a sufficient temperature drop in an expanding nozzle necessitates the practical absence of turbulent motion of every kind—that is, to expand adiabatically the jet must be so constructed that there is an absolutely smooth flow from high pressure to low, and no impact or loss of velocity from any cause whatever. So far as I understand expanding jets, no adiabatic expansion so perfect as this has ever been obtained.

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* Mr. Dugald Clerk's Presidential Address to the Junior Institution of Engineers. Delivered last Friday.

† *The Electrician*, Vol. LIV., pp. 62, 104, 132.

Assume, however, that the efficiency of expansion in such a jet is, say, 90 per cent. We now come to the question of the efficiency of conversion by the turbine blades. In many calculations from diagrams it is assumed that the efficiency of conversion of motion into work is practically perfect. This, however, is by no means the case in present turbines. Even the steam turbine, high as its efficiency is, compared with the reciprocating engine, has no very high efficiency of conversion in any of the forms of turbine at present on the market. That is, if we assume a mass of gas to exist in a compressed state in a reservoir, and we choose to expand this mass of gas in two ways, for the sake of comparison—(1) behind a piston, and (2) by means of a Laval jet and turbine, we shall find that the efficiency of conversion of the turbine, once high velocity is attained, does not exceed 80 per cent. In this respect the efficiency of conversion of rotating turbine blades is inferior to that of a moving piston in a cylinder. The reason of this is obvious. It is impossible to so arrange the impact of a rapidly-moving gas with a turbine blade or blades in such manner as to entirely avoid turbulent motion. The impact, for example, of swiftly-moving gases on a fixed surface results ultimately entirely in turbulent motion, which restores to the gas or to the blade struck all the heat which has disappeared in temperature fall due to adiabatic expansion. What is true of a fixed blade is to some extent also true of the moving turbine blades. A certain proportion of the energy existing in the gas in the form of motion is inevitably lost whenever this gas comes into contact with any solid surfaces. So much is this the fact that in designing steam turbine blades for any type of turbine the shape of the blades, the shape of the space between the blades, both moving and fixed blades, or fixed jet and moving blades, is of the first importance, and it has only been found by experiment that certain shapes of blades and passages have a much higher efficiency of conversion than other shapes. In this respect, too, the turbine principle is inferior to the cylinder and piston. In a cylinder, gases expanding behind the piston, the efficiency of expansion may be considered to be 100 per cent., and even the efficiency of compression in many gas engines is also of the same order. I do not here refer, of course, to heat losses due to conduction or anything of that kind, but to efficiency of adiabatic compression or expansion.

Although the efficiency of expansion is relatively low for gases in steam turbines, yet the turbine offers a great advantage in total work obtained from steam. This is due to the fact that the turbine avoids initial condensation; and, further, it permits of the utilisation of a very long range of expansion at the low-pressure end, which is not available in the case of steam engines. By saving, therefore, in minimising initial condensation, and in obtaining added work from pressures wasted in the ordinary steam engine, the Parsons' steam turbine more than compensates for any inefficiency of expansion as compared with the cylinder engine. It is well known, however, in turbines of practically all constructions, including Mr. Parsons', that the efficiency of the steam turbine at the high-pressure end is not so great as that at the low-pressure end. This is partly due to difficulty of adjusting the velocity of blades to suit the necessarily varying velocities at different points of the flow of the steam. This, however, is a small difficulty with the steam turbine, but it is a very great difficulty with the gas turbine. Compared with cylinder expansion, I cannot see how it is possible with present knowledge to obtain an efficiency of conversion in a gas turbine greater than 80 per cent. This, of course, is partly due to the high velocity or the issuing hot gases. To produce an efficient gas turbine, therefore, on the favourite cycle so much discussed recently, it is necessary first to have, as I have said, a very efficient compressor, a very efficient expanding nozzle, and a very efficient conversion when the moving gases strike the turbine blades. Using the numbers I have suggested, of 90 per cent. efficiency of compression, 90 per cent. efficiency of nozzle expansion, and 80 per cent. efficiency of conversion in turbine, we have, with a cycle having negative work equal to 0·4, the following efficiencies: To get 0·4 of work in compression, we shall require 0·445 of work put into the compression. On expanding in the nozzle we shall obtain 0·9 only of the total energy of the flame gases in the shape of kinetic energy, and of that 0·9 we shall only get 0·8 returned in the shape of available work by the turbine part. That is, we shall get a total work from the turbine of 0·72, and deducting the negative work $0{\cdot}72-0{\cdot}445=0{\cdot}275$—that is, from a cycle which should give us 0·6 in work, we shall only get 0·275, or about 22 per cent. The practical efficiency of an engine of this kind will only be 22 per cent., even assuming the high efficiencies of compression and jet expansion which I have mentioned. In my view, no such efficiencies of compression or jet expansion are at present known, and accordingly there appears no likelihood of the production of any gas turbine which can rival the reciprocating gas engine in efficiency and in economy. To produce such a turbine requires the solution of three problems: (1) An efficient turbine compressor, comparable in efficiency with cylinder compression. (2) An efficient nozzle expander with a higher efficiency than 90 per cent. (3) An efficiency of conversion of kinetic energy of the moving gases into work delivered at the turbine spindle of greater than 80 per cent. Either these problems must be satisfactorily solved or else new materials discovered which will stand temperatures which at present melt fire-brick. The outlook, I fear, is not hopeful. This thermal efficiency of 22 per cent. assumes no losses in the combustion chamber due to heat conduction, no losses in the expanding jet due to heat conduction, and no losses in the turbine itself from the same cause. Considering the losses in gas engine cylinders of small size, it would not be too much to allow in a turbine a heat flow loss of at least 25 per cent. This, of course, reduces the efficiency from 22 per cent. to 16·5. In arriving at this figure, I have assumed that no greater loss would be incurred from heat flow in the turbine than in the cylinder engine; but even with reduced temperatures when striking the turbine, the very fact of requiring a reservoir for combustion to operate, and the forcing of the whole of the hot products through a relatively small nozzle, necessarily means greater loss than I have assumed. Assuming, however, no more loss than I have given, an engine with an efficiency of only 16½ per cent. of the total heat given to it could not compete with internal combustion motors of existing construction. It may be said that the advantage of continuous rotation is so great that even at this low efficiency the gas turbine would be successful. Personally, I doubt it very much, because the mechanical difficulties with gas turbines would be much greater than the mechanical difficulties of the steam turbine. In all steam turbines, as you, I am sure, know, it is necessary to work with relatively small clearances between the tips of the blades or shrouding and the enclosing casing. This is also true as to endwise clearance between fixed and moving blades. Comparatively small clearances are necessary for economy. The use of even temperatures so high as 400°C. or 500°C., by introducing unequal expansions, greatly increase the difficulty of obtaining economy. No doubt if a plentiful supply of relatively low temperature gases under considerable pressures could be obtained, these gases might with advantage be expanded in a nozzle and used to operate a turbine. To carry this idea into effect has already been attempted, as I have said, by Mr. Lanchester, and there is some hope of operating in this way. I fear, however, that the temperature of the gases in the exhaust in the gas engine are too high as they stand to be so used. Gases, however, from an exhaust or air supercompression engine, such as I have lately been working with, could no doubt give considerable efficiencies in turbines. I do not see, however, any solution of the gas turbine problem here, because the amount of energy available for the turbine after the gases leave the gas engine is too small for consideration in connection with any really high-power machines.

Some of the difficulties I have discussed with you have been mentioned by Dr. Lucke. He adopts the view that jet expansion is not as efficient as piston expansion, and here I agree with him. No doubt the type of jet expansion has to be carefully considered, and the efficiency of a jet as a means of converting the expansion from a high pressure to a low into kinetic energy depends entirely upon its configuration, and the design of the proper areas and relative lengths for the nozzle. All this, however, is as yet a relatively new field, and much study will be required before any certainty can be attained in the design of expanding jets. Prof. Reeve, in another able article which I have already mentioned, differs from Dr. Lucke, and considers that he has over-stated the difficulties of the expanding jet. He accordingly takes a more favourable view of the turbine problem. There is a great deal of truth, however, in what Dr. Lucke has said. Even the best expanding jets yet known appear to have a low efficiency, and nothing is known of the efficiency of expansion starting from flame temperatures. Apart from the mechanical efficiency of the expansion, as I have already pointed out, the heat loss due to conductivity will be great in such nozzles. I quite agree with Prof. Reeve, however, that the more hopeful line for the gas turbine lies in the use of steam to provide the working fluid under compression without a compressor, and in the heating of this steam when produced by a very small quantity of combustible mixture of gas and air under pressure. Such a turbine would be a compromise between what I may call the flame turbine and the steam turbine, and it presents more possibilities; but its efficiency would not be high, although no doubt such a machine could be got to operate mechanically with fair success. This line of work depends upon the fact that negative work may be greatly reduced by using steam as working fluid, when steam is heated highly by internal combustion of a relatively small amount of inflammable gas and air. This proposal is more hopeful, but for success, even, it requires temperatures, in my view, too great for existing turbines to stand with economy. This proposal may be considered to be analagous to that of an excessive superheat, as used in an existing steam turbine.

Many methods have been discussed which depend upon the use of regenerators. I have a great distrust of regenerators, so far as engine work is concerned. Many able men have proposed regenerative contrivances, from the time of Stirling, in 1817, down to the present day; but I am not aware of any actual working engine which has ever succeeded in practice, using a regenerator.

From what I have said, you will see that my view of the future of the gas turbine is not favourable; but, notwithstanding, the subject is so fascinating that many inventors and scientific men will doubtless continue to investigate the problem, and possibly new solutions may be discovered which are not dreamt of to-day. I am the last man in the world to deprecate daring in any practical and scientific work, but I would advise the junior engineers—members of our Institution—to avoid the subject except as a scientific study. I fear there is little hope for a young man to make a position and a business success of any internal combustion turbine, so far as our present knowledge carries us.

## WEDNESBURY CORPORATION ELECTRICITY DISTRIBUTION UNDERTAKING.

The Wednesbury Corporation obtained a provisional order in 1899, an agreement having been previously entered into with the Midland Electric Power Co. In accordance with this agreement the Corporation did not oppose the company's application for a provisional order to supply within the borough, on the understanding that, in the event of the Corporation also applying subsequently for a provisional order, the company would not offer opposition. The arrangement now is that the Corporation supplies electricity in detail to all consumers in Wednesbury, the company supplying the Corporation only in bulk.

The electricity is generated on the two-phase system at a pressure of 7,000 volts at the Power Company's station at Ocker Hill. It is then transmitted to the company's sub-station in Wednesbury, where it is transformed down to a pressure of 2,700 volts and again to 200 volts. At this pressure it is delivered to the two-phase "receiving mains" in the Corporation's sub-station, where it is converted to continuous current. Five feeders supply the distributing network of mains laid in about 3½ miles of the principal streets which are in the form of a triangle in the centre of the borough, and from each corner radiate the main roads.

The sub-station buildings comprise a generator room and switch gallery, accumulator room, workshop, office, test room and stores. The three last named are connected to the main building by a corridor. The buildings are arranged so that they may be easily extended.

The transforming plant includes two motor generators manufactured by the Phœnix Dynamo Mfg. Co. These each consist of a two-phase induction motor directly coupled to a continuous-current generator capable of delivering a current of 300 amperes at a pressure of 250 volts. Two special pillars fixed next to the machines contain the starting gear.

The battery consists of 117 cells, each capable of delivering 325 amperes for three hours. The containing cases are constructed entirely of lead, the crate being in the form of an antimony ⊥ section frame burnt together and lined with 6 lb. sheet lead at sides, and 10 lb. lead at bottom, and supported on a slate base. Each cell has 27 plates, the positive plates being of the Planté type and the negative of the pasted type. The cells have been supplied and erected on heavy pitch pipe stands by the British Accumulator Co.

There is a charge and discharge booster of the Highfield type manufactured by the British Westinghouse Co. The booster dynamo is capable of a maximum back-boost of 75 volts during charging of the battery, and is capable of keeping the pressure practically constant on charge or discharge automatically within a limit of 30 volts difference of battery and line voltage, under all conditions of load (up to 325 amperes) and battery voltage. The exciter is directly coupled to the booster, and the machine may be driven by either a continuous-current motor of 30 H.P. or a two phase motor of similar size. The continuous current motor is connected to the booster through a clutch and the two phase motor is similarly connected to the continuous-current machine. These clutches permit of the following arrangements: (1) Two-phase motor driving continuous-current machine as a dynamo-booster dis-connected; (2) two-phase machine driving booster through continuous-current shaft, the latter idle; (3) the same as (2) but continuous-current machine being run as a generator as well; and (4) continuous-current machine only driving booster.

In addition a portable "milking" booster has been provided, consisting of a 200-volt two-phase motor coupled directly to a shunt dynamo capable of delivering 150 amperes at 6 volts. This plant is capable of being moved about the accumulator room to enable one or two cells to be charged as required.

The switchboard, which consists almost entirely of metal and marble, is arranged in a "bay" form, the central portion being reserved for the two-phase feeder gear, and the continuous-current main ammeter, voltmeter and time piece. On the left side of the bay the continuous-current feeder panels are fixed, and on the right the machine panels.

The switch gallery is raised about 1 ft. from the floor level, and contains also the starting pillar of the booster. Behind the switchboard, ample space has been allowed which forms practically a separate small room, and contains in addition to the switchboard connections the main two-phase meters and the main continuous-current meter. The switchboard is arranged to control the following: Duplicate two-phase "receiving" mains, three motors (two main and one booster), five continuous-current feeding cables, two main dynamos and two boosters on the continuous-current side Spare panels have been allowed for one spare motor, dynamo and booster respectively, and there are two spare feeder panels.

A system of subways leads from the switchboard to the machines, battery, &c., and to the street, for conveying the connecting cables. The switchboard was manufactured locally by Mr. W. Sanders, and the instruments are of the permanent magnet edgewise and sector types mostly supplied by Messrs. Nalder Bros. & Thompson.

The mains consist of two-phase twin concentric 0·3, 0·3, 0·45 sq. in. lead-covered "receiving" cables (connecting the Corporation's sub-station with the Power Company's sub-station), concentric lead-covered feeders and single lead-covered cables for distributing mains. The distribution is carried out on the two-wire system, the pressure of supply being 230 volts. All cables are laid on the solid system; they are supported on wooden bridges in wooden troughs protected by hard-burnt tiles. Generally, where there are tramway lines and in important streets, the distributing mains are laid on both sides of the roadway under the footpaths, but in the less important streets on one side of the road only. The cables were manufactured and laid by Messrs. W. T. Glover & Co. and are of their diatrine paper-insulated type.

The contract for meters, &c., was divided, the electrolytic and motor meters, maximum-demand indicators, as well as the house-service fuses and fuse boards, having been supplied by the Reason Mfg. Co. (Ltd.), and the prepayment meters by the British Thomson-Houston Co. The charges for the supply are as follows: Lighting, 6d. and 2d. per unit on the maximum-demand (one hour) system. Power, 3d and 1½d. per unit, or a flat rate of 1½d. per unit in the day time and 3d. during lighting hours.

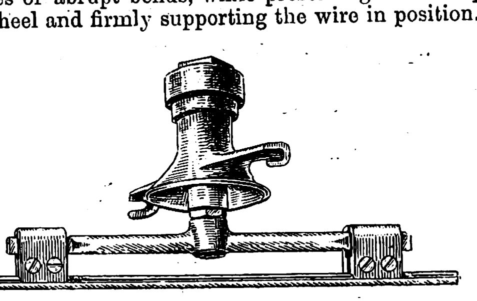
The charge for electric power in bulk to the Corporation is 3d. for the first hour of maximum demand for each day, and 0·825d. per unit for all further supply. The losses as regards inefficiency of transformation and losses in the battery and mains appear principally in units at the lower charge, and the losses in the accumulators are entirely low-rate units. Further, the accumulators reduce the Corporation's maximum demand on the Power Company.

A few figures as to the results of 18 months' working may be of interest. The consumers number about 90, and the connections have reached the equivalent of 5,258 8 c.p. lamps, including 28 H.P. in motors; also 596 lamps of 8 c.p. equivalent have been applied for in addition, but have not, so far, been connected. Various extensions of the mains have been carried out by the staff to cope with the demand which has arisen. A noticeable point, we are informed, has been the even pressure which has been maintained, rendering the use of Nernst lamps very satisfactory. It would not otherwise have been possible to compete successfully with incandescent gas lighting in the borough. Electricity has been introduced into the following public buildings: Town Hall, Municipal Offices, Art Gallery, Public Library and Public Baths, the arrangements having been planned and the work supervised by the consulting engineer.

The technical negotiations with the Power Company were carried out by Mr. F. J. Warden-Stevens, who has acted as consulting engineer to the Corporation, and under his supervision the undertaking has been completed and operated. Mr. W. Fennell acted as assistant to the consulting engineer, and subsequently as resident engineer, and Mr. T. H. M. Swinburne as clerk of works. The undertaking has been carried on for 18 months under the instructions of the consulting engineer.

## A FLEXIBLE SUSPENSION FOR GROOVED TROLLEY WIRE.

With the usual rigid suspension of the trolley wire there is a tendency for the wire to break near the ends of the ear, if care has not been taken in its erection, for there is a continual and abrupt flexure of the wire at such points, caused by vibration of the free spans. This tendency, as is well known, is much aggravated where soldered ears are used, on account of the effect of the heating of the wire in the soldering operation impairing the mechanical strength of the wire locally. The vibration above mentioned is produced in a vertical direction by the upward pressure of the trolley, and in a horizontal direction by the action of the wind, or, on roads with side-bracket construction, by the tendency of the trolley to swing inwards. The B.T.-H. patent flexible suspension ear has been specially designed with a view to overcome these disadvantages, and for this purpose the clamps for the wire are so supported as to allow practically free movement in any direction without producing unnatural curves or abrupt bends, while preserving an even path for the trolley wheel and firmly supporting the wire in position.



B.T.-H. Flexible Suspension.

Upward movement of the wire and clamps, which is caused by the trolley wheel in passing under the ear, is practically parallel, and since the clamps are capable of a limited longitudinal displacement on the supporting bar, the wire should take up a natural curve in which there are no abnormal stresses in any part of its section. This improved form of suspension, it is claimed, also obviates the objectionable hammer blow which takes place when the trolley wheel passes on to a suspension ear of the ordinary rigid type, and thus conduces to smoother running and fewer repairs.

## MR. P. SHEARDOWN'S INAUGURAL ADDRESS TO THE DUBLIN LOCAL SECTION OF THE INSTITUTION OF ELECTRICAL ENGINEERS.*

After some consideration as to what should be the subject matter of the address I am to have the honour of delivering to you this evening, it occurred to me that it might be profitable to try and incorporate in it information given and opinions arrived at by the authors of some Papers presented at the recent International Congress at St. Louis, the complete *Transactions* of which, with the discussions thereon, have only recently been placed in the hands of members, and may be therefore considered practically the latest information procurable on the subjects dealt with.

The first Paper presented to Section 2 dealt with the generation of electrical power in Switzerland (Enrico Bignami). The country possesses 226 electrical stations, 162 being principal stations; together they represent a rated capacity of 180,000 kw. Of the 162 principal stations, 148 generate from water power, five with steam power, and nine with gas. 25 important stations utilise not only water power, but also have installed gas or steam engines as a reserve for an eventual lack of water. The normal capacity represented by these 25 plants is 25,000 kw., with 10,000 kw. for the engine reserve. This necessity for reserve steam power would appear to increase the capital cost very much. The highest voltage directly produced is—for continuous current 2,250 volts, and for alternating current 10,400 volts. The kind of current generated varies largely, but 44 stations generate single-phase and 38 three-phase. The periodicity employed varies very much, but 40 or 50 cycles is most general. In the discussion, notice was drawn to the very high-load factor obtained, there being only five stations in Switzerland having a load factor of less than 50 per cent., and there were five stations mentioned in which the average load is above nine-tenths of the maximum. This result is largely brought about by the very large number of motors connected up on the condition that they are operated only outside the peak load.

The discussion on Mr. J. S. Peck's Paper was very interesting, it being shown that, although a transformer can be designed for an efficiency of 98 per cent., this will cost twice as much as one with 96 per cent. efficiency. One speaker drew attention to the fact that if a fire starts near an oil-cooled transformer, and heats it up sufficient, it will be turned into a gas-producer, and that sufficient gas can be turned out to melt up all the ironwork and machinery in any power house. Another fact brought out was that there is very little advantage with regard to radiating heat in ribbing the insides of transformer cases, as the heat is easily passed from the oil to the iron, the heat potential drop being altogether between the outside surface of the iron and the air in contact with it.

A Paper which created a great deal of interest among engineers connected with high-tension long-distance transmission was read by Prof. F. G. Baum, who has under successful operation the district of the Sierra Nevada Mountains of California. The Paper stated that the system described had continuously in operation about 700 miles of line at 50,000 volts, 70 miles at 40,000 volts, and a great many miles at 3,000, 16,000, 10,000 and 5,000 volts, and mentioned that in a short time some of these lines would be operating at 100,000 volts. The longest distance to which power is regularly transmitted is 200 miles. The amount of power available on the system is 43,650 kw., which will soon be increased by the addition of two 5,000 kw. generators. The author gave some simple methods of line calculations with regard to (1) circuits, (2) charging or capacity current, (3) rise in pressure due to charge in current, (4) regulation of transmission system, (5) electrical surging, giving in all cases practical examples illustrating the working of his formulæ.

Part 2 dealt with high-potential control, or the apparatus in use, and contained some practical information with regard to insulators, the author mentioning that they had in use glass insulators, porcelain insulators, and combinations of both porcelain and glass; in the mountains, away from fog, 7 in. glass insulators, with two petticoats, did very well up to 40,000 volts, but to go from 40,000 to 60,000 volts required a 14 in. porcelain insulator with three petticoats. With regard to line operation, they had the lines patrolled from one to three times a week. Their line troubles were due to a few weak insulators, and in some localities they have a good many insulators shot off. Some of their unexpected causes of trouble have been crows or geese flying into the lines, cats crawling up the poles, green hay carried by wind across line, an engine starting up under the lines, and a long-tailed rat crossing temporary 'bus bars. Their high-tension transformers had given very little trouble. He recommended that on test the primary of each transformer should stand a test about equal to double the star voltage for which the transformer is made. With regard to switches, they had found that the oil-break switch was the only one that will stand heavy duty, and that this type is less likely to produce violent surging on opening a circuit than has been experienced with the flare type of air-break switch. The writer gave illustrations of a line of cheap and satisfactory oil-break switches that they had designed and manufactured, these operating up to 60,000 volts; the switch referred to being capable of opening 10,000 kw. at 60,000 volts on short-circuit. With regard to lightning arresters, they pinned their faith to simple horn-type arresters made with single or double air-gap. Their general practice was to generate current at 2,300 volts and then step up, the primary of the transformer being star connected with earthed neutral, the writer having come to believe that the earthed neutral had more in its favour than against it. They took advantage of the earthed neutral, and very often installed a single transformer in a sub-station, one side going to line, the other to earth. Where the load was larger but did not warrant three transformers, two transformers were used on two legs of the primary and open delta on the secondary. They are not bothered by unbalancing of load at the power-houses. At the power-houses no fuses or circuit breakers are installed, as they prefer to hang on to a short rather than take the chances of being pulled out for every slight interruption; but at sub-stations the transformers are generally fused. All their energy is developed by water power, the size of unit having developed from 300 kw. in 1897 to the present 5,000 kw. unit. With this latter type they could instal 20,000 kw. in a building 100 ft. long by 50 ft. wide. Their greatest trouble is occasioned by fog, and this in districts near the ocean settles on the insulation and reduces it to such an extent that the pins, cross-arms, or poles, if of wood, are sometimes set on fire. In the mountain district with modern insulators their line troubles are nil. The author considers that the weak point of the transmission system is the insulator, and that with an insulator to stand 100,000 volts, in his opinion, this pressure is possible. To sum up, he thought it easier to operate a line, say, from 30 miles up, at 50,000 or 60,000 volts than at half that pressure, assuming that a considerable amount of power is transmitted.

The discussion on the Paper confined itself largely to the lightning arrester. On most other systems working at lower voltage the trouble of getting rid of lightning on the line was very considerable. The writer of the Paper, however, stated that lightning gave him very little trouble, and that practically all the lightning arresters he had tried provided instead of saving trouble for him, and the only type he used was an ordinary horn lightning arrester with a 4½ in. air-gap, which would require a pressure of 90,000 volts to start an arc. The opinion arrived at finally seemed to be that by getting up the voltage as high as 60,000 the insulation of the line has to be made very much more perfect, and that hence lightning discharges which break down insulators on lower voltage systems were rendered comparatively harmless over the very large insulators employed on the line under discussion. A second reason for the immunity from trouble was ascribed to the fact that the small current produced a less serious rise in voltage due to a surging current and hence static discharges were less frequently produced.

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* Delivered yesterday. Abstract.

In his Paper on "Storage Batteries as an Adjunct to Central Station Equipment," the writer (G. Gaettling) claims that battery rooms should be located close to the switchboard room to save voltage loss and to keep the cable connections short; that it is unwise to erect batteries so that inspection cannot easily be made; that the floor of a battery room must be both acid proof and fire proof; that a flooring in vitrified brick on a layer of 6 in. of concrete is most satisfactory; and that the bricks be grouted in with hot pitch. Cells should be installed in one tier, as a double-tier installation is difficult to inspect.

In the discussion surprise was shown by the English engineers that the value of the reversible booster seemed to be unknown in America—they did not appear to appreciate how much the life and upkeep of a battery depended on the life and cost of upkeep of the regulating cells; that in America they were still using the old end cell regulation, whereas in England they were gradually introducing a fixed number of cells and booster regulation. It was also shown that, whereas in America the system of maintenance by contract had been practically abandoned, in England it had become almost universal and worked out at about 7·5 per cent. per annum of the original cost, and for that amount those who guarantee the battery have to keep it up to 100 per cent. capacity. One advantage claimed for this maintenance system is that the guarantor insists on certain tests and inspections being made which in actual practice tend to increase the life of the battery. The American opinion seemed to be that they placed so much importance to and faith in their storage batteries in the cases of emergency that they did not like to run the risk of impairing their reliability by coupling to them a piece of rotary machinery which they claim might be an element of failure, and they stated that, owing to the fairly steady load that they had on their batteries, the regulating cells had not given them much trouble. The splendid results obtained with wooden separators were emphasised, the capacity of the batteries having been increased very much. The boards affected only the negative plates, it having been proved that after a short time in use the negative plates gave only 80 per cent. of their guaranteed capacity, but that, after this board diaphragm had superseded glass separators, in three weeks' time they could get from 110 to 115 per cent., so the life of the negative plate is increased by at least two years.

A very interesting Paper was given by Mr. Alexander Dow on the direct-current distributing systems of American cities. The general system of distribution in large American cities is a three-wire direct-current low-pressure system, the potential across the outers usually being in the neighbourhood of from 210 to 220 volts. Mr. Dow gives evidence in favour of the low-pressure system originally installed, and still adhered to in large American cities—meaning cities of a population of 250,000 or upwards. The custom in the States is for the supply and maintenance of the lamps to be included in the price charged for current, and therefore it is a matter of great importance to the supplier first of all to operate a lamp which requires a small consumption of energy, and, secondly, to have a lamp that will give a long life before breakage of the filament or loss of power makes renewal necessary. Their standard lamp is 16 c.p. operating on 3·1 watts per candle. The author thought that, by working with a high-efficiency lamp, they had a saving in current of about 20 per cent., and rather pertinently remarked that the object of a lighting company should be to supply light, and not electrical power, at the cheapest possible rate to the consumer. With the 3·1 watt lamp referred to they were able to realise an average life of over 470 hours per lamp before the candle-power was reduced by blackening to 80 per cent. of the initial candle-power. 5 per cent. of all the lamps manufactured for them are selected at random before being packed and tested for watts per candle at the rated voltage, and out of this 5 per cent. one-tenth are given a continuous life test, being run at marked voltage until the candle-power has fallen to 80 per cent. initial value. With regard to alternating current, although it has the advantage of requiring less cost for plant in the sub-stations, and a smaller amount of attendance than rotary converter apparatus, the author claimed that with a mixed system of lighting and motors (the latter being largely used for lift service), the power factor would seldom be higher than 0·9 and frequently lower than 0·8, which would mean larger generating plant and larger mains, and naturally this low power factor means still greater difficulty in voltage regulations.

Several important Papers were read on steam turbines, and naturally commanded a good deal of attention. The first Paper was by Mr. W. R. L. Emmett, who has been largely responsible for the development of the Curtis steam turbine as manufactured by the General Electric Co. With regard to efficiency, he admitted that up to the present the best class of steam engine had attained results under favourable conditions quite as good as had been obtained with the steam turbine, with the following difference: That in the case of an ordinary reciprocating engine the greatest difficulty was attained at one given load, but that the efficiency fell off very rapidly either when unloaded or overloaded, which was a very important point, because, especially in the case of ordinary generating stations, it was very hard indeed to keep an engine loaded with a constant steady load, but in the case of the steam-turbine the efficiency at half load and 25 or 30 per cent. overload was very nearly as good as at the load for which the turbine was designed to run with maximum efficiency. The energy available in expanding 1 lb. of steam from a pressure of 150 lb. to a vacuum of 29 in. is 27 per cent. more than if expanded to a vacuum of 25 in., yet the efficiency of the modern reciprocating engine is only improved by 1 per cent. if the vacuum it discharges into is increased from 25 in. to 29 in., because the best engines open the exhaust at a pressure of 7 lb. to 8 lb. absolute, and consequently lose a large proportion of the expansive force of steam below that point, the degree of vacuum below the point of exhaust only serving to diminish the back pressure and not employing an effective expansion to the vacuum point. The reason of this is that as steam expands to low pressure the volume increases in a rapidly increasing ratio, and this increase of volume is so great that it soon passes the limit of capacity for which cylinders can be profitably designed. The steam turbine possesses the inherent advantage that it can be designed to work effectively to very high degrees of expansion in the steam; since the steam in the turbine is not confined to chambers where it must exert pressure, it is available for doing work as long as it possesses expansive force capable of imparting an effective velocity to the steam itself.

Another Paper (Francis Hodgkinson) of great interest dealt with steam-turbine performances, some valuable information dealing with actual tests made on Westinghouse-Parsons steam turbines being given. The tests on a 750 kw. turbine showed that when running with a boiler pressure of 140 lb. non-condensing, and with no superheat, the consumption per brake horse-power hour at full load was 28·26 lb., but with the steam turbine running on a 28 in. vacuum, boiler pressure 150 lb., superheated 100 deg., the consumption was reduced to 12·38 lb. On another 750 kw. turbine, boiler pressure 150 lb., vacuum 26 in., superheat 150 deg., at full load the consumption was 13·18 lb. per brake horse-power hour, but with similar conditions, except that the vacuum was increased to 28 in., the consumption was reduced to 11·79 lb. In another 400 kw. turbine it was found that when operating with 150 lb. boiler pressure, 28 in. vacuum, and dry superheated steam, the consumption at little over full load was 13·89 lb. per brake horse-power hour, but by superheating 100 deg. this was reduced to 12·48 lb. With regard to the efficiency over a wide range of load, this consumption of a 750 kw. turbine was given at 0·479 per cent. of full load as 13·85 lb. of steam per brake horse-power hour; at full load, 11·79 lb. of steam; at 24 per cent. overloaded, 11·42 lb. of steam; and at 41 per cent., 11·5 lb. per brake horse-power hour.

In a Paper on aluminium as an electric conductor the following points were brought out by H. W. Buck: That at the present its electric utility is practically confined to (A) 'bus bars in power stations, (B) high-tension overhead uninsulated conductors, (C) low-voltage feeders, usually insulated with weather-proof braid only. It is debarred from use in a number of cases on account of the practical impossibility of applying the ordinary methods of soldering. At the present relative cost of the two metals, aluminium is about 10 to 13 per cent. cheaper than copper of the same resistance. Aluminium, owing to its low conductivity, and necessarily greater diameter, makes it more expensive for use on cables where costly materials are used for insulation. Aluminium wire is not suitable for telephone work on account of its coefficient of expansion and its comparatively low tensile strength, which causes a greater sag at high temperatures than in copper wire, although it is stated that where it has been used the speaking appears particularly good, which may possibly be due to the particular balance which exists in the aluminium wire between the resistance, inductance, and capacity, aluminium having somewhat less self-induction and more capacity than a copper wire of the same resistance. Aluminium is particularly well suited for 'bus bar construction owing to the great saving in weight and the lower cost, but care should be taken when using aluminium for such purposes to provide for expansion and contraction. Aluminium also is very widely used for low-voltage direct-current feeders for railway work. The 53 per cent. reduction in weight as compared with copper requiring smaller poles, and the increased radiating surface of the aluminium feeder, allows a greater overload to be carried by it than by copper. The most prominent use of aluminium electrically is for overhead high-voltage transmission circuits.

A good many Papers were read dealing with the single-phase motor for railway work, as there seems to be a strong influence at work in the States proclaiming the virtues of this type of machine, which a few years ago nobody had a good word for. A very interesting Paper was read giving a description of Mr. Arnold's method of utilising single-phase synchronous motors for railway work in connection with air-compressor engines and air-storage tanks.*

# PRESIDENTIAL ADDRESS TO THE INSTITUTION OF ELECTRICAL ENGINEERS.†

BY JOHN GAVEY, C.B.

In tendering my thanks for the high honour you have conferred on me, may I say that I fully recognise that I have been selected as a representative of the great body of telegraph engineers, the original founders of this institution, as well, perhaps, as a representative for the time being of the new and growing telephone industry, rather than because of any merits of my own? Under the circumstances, and in view of the fact that these industries have not been reviewed recently, I propose with your permission to attempt that task in my address.

One of the penalties attached to advancing age, whether of individuals or of institutions, is the periodical loss of old friends or co-workers in the field in which we are labourers. Last year the President had to announce the loss by death of Major-General Webber. This year it is with deep regret that I have to refer to the death of Mr. W. E. Langdon, one of our earliest members, for some time Secretary and late President of the Institution. It was my good fortune to be closely associated with him from the early sixties, and I need scarcely say to those so well acquainted with his work as the members of this institution are that in his death we have lost one of the very able, energetic and upright of our colleagues. Another well-known figure in the telegraphic world has also passed away in the person of the late Mr. Gerhardi, a gentleman closely associated with cable enterprise, he having formed one of the group of pioneers connected with the 1856 Atlantic cable, and later having been for a long period the general manager of the Direct Spanish Cable Co.

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* *The Electrician* Vol. LII., p. 600.

† Delivered last night.

Before I commence the main subject of my address, I may perhaps refer to one of two question in which the institution is largely interested, and in which its members are taking an active part. Dealing first with the Engineering Standards Committee, and more especially with the important work entrusted to the committee on electrical plant, the latter has appointed sub-committees to consider the following subjects: (1) Generators and motors, (2) transformers, (3) prime movers for electrical purposes, (4) physical standards, (5) telegraphs and telephones, (6) cables, (7) electrical tramways, (8) electrical nomenclature, (9) electric automobiles, (10) electrical plant accessories, (11) publications and calculations. Some of these committees have reported, and all the work is well in hand, but it necessarily in many cases can only progress slowly if it is to be of a permanent character. It is difficult to overestimate the advantages, both to the profession and to the public, that will ultimately result from the labours of these committees. Again, in reference to the proposals made at the Electrical Congress held in St. Louis last year, to the effect that the revision of the existing electrical standards should be undertaken, and that an endeavour should be made to arrive at an international agreement on the subject of the standardisation of electrical nomenclature and rating of machinery, you will be glad to hear that the preliminary steps have been taken to carry out the views of the congress, and it is to be hoped that satisfactory conclusions will ultimately be arrived at.

The art of telegraphy considered in its broadest sense as a means of conveying intelligence over distances beyond the reach of the human voice may be classed under three different heads :—

1. The communication of a limited number of definite orders or items of information by certain prearranged arbitrary signals. Under this heading may be included railway signalling, lighthouse signals, fire-alarms and other kindred uses.

2. Communication of all classes of information by means of alphabets, either arbitrary or those in common use, including semaphore and flag-signalling, Morse and other signals, printing and writing telegraphs.

3. Communication by actual exchange of speech, the telephone.

### TELEGRAPHS FOR SPECIAL REQUIREMENTS.

Under this heading, one of the most important of the applications of telegraphy is that of directing and controlling the movements of trains on railways. For this purpose a modification of the old semaphore telegraph was introduced in the early railway days mainly for the protection of traffic at stations and crossings. The range over which a mechanical semaphore can be worked is about 1,000 yards as a maximum, and the introduction of electricity for the working of telegraphs was soon followed by the invention of electrical miniature signals or indicators, placed in railway cabins from which the outdoor manual signals were worked in accord with the indications recorded electrically. By this means the range of the signals was extended so as to cover the whole length of a section, and this led to the practical introduction of the block system of working traffic. Successive improvements in the electrical apparatus have been introduced ; for example, on single lines this apparatus is now associated with the train staff or tablet, without which no driver is allowed to enter a section of line, and as a second staff or tablet can only be withdrawn at the far end when the first train has arrived, the possibility of two trains meeting on a section is obviated. Repeaters of various types, which show the position of points, the indication of signals, the presence or absence of trains in defined localities, and other information, keep the signalman advised of all the facts with which he should be acquainted, and it is not too much to say that the safety and regularity with which the heavy railway traffic in this country is conducted is largely due to the work of the electrical engineer. Lately definite advances have been made in two directions in this field of applied electricity. In the first, complete electrical systems of actuating points and signals have been introduced, the apparatus providing interlocking gear and indicators which give the signalman positive information as to the position of every point and signal; the working being easy, rapid, and apparently reliable in so far that every eventuality and cause of trouble appears to have been foreseen and provided against. This method admits of working points and signals at distances far in excess of the manual system, such distances, in fact, only being limited by considerations of safety and convenience, and the heavy and cumbersome lines of levers that under old methods could in many cases only be worked by the full exertions of the signalman's strength can now be replaced by miniature levers which only need intelligence to work them.

In another direction, automatic methods have been designed for working outdoor signals directly by the action of the train itself, its entry, continuance in and exit from a section being faithfully followed by the appropriate movements of the semaphores. In one system sets of batteries consisting of a few cells are connected across the running rails in each section, and in all sections that are clear the corresponding batteries actuate relays which, either through the agency of compressed air or by means of electromotors, move and retain the semaphores at "Line clear." The entry of a train into a section short-circuits the local battery, the relay tongue is withdrawn by its retractile spring and the signals are automatically placed at danger.

In a recent journey across the American continent, where hundreds of miles of desert are traversed by single lines of railway with numerous sidings for the crossings of trains, I watched with great interest the perfect and regular working of the signals without the direct intervention of human agency. Each section was, of course, guarded by two signals, one for the up and one for the down traffic. As the train left one section for another, the signal guarding the former moved from danger to clear, whilst that guarding the latter moved from clear to danger. This method, of course, involves the necessity for bonding the rails throughout, although others have been designed which are actuated through special conductors. Automatic signals appear to meet a definite want on certain classes of railway, although no doubt the day is far distant when the trained signalman will be dispensed with at complicated junctions and stations. It is not too much, however, to say that without the various methods of electrical control that have been devised and which are in general use, it would be utterly impossible for great railways of the world to carry one-half the traffic they are now dealing with daily with safety and despatch. In this branch of electrical work steady progress is being made, and apart from the question of haulage the extension of the methods of electrical control will probably be considerable in the immediate future.

Fire-alarm signals have within the last few years assumed a position of considerable importance, owing to the growth of great cities, the increasing height of commercial buildings, and the large quantities of combustible material necessarily stored in the great centres of population. Starting from a simple alarum, which was merely the old fire-bell worked electrically, complete systems of fire alarms and indicators have been devised, which, when actuated from any given point, give the appropriate signals at all the fire stations concerned, and admit of a rapid concentration of the necessary fire plant at any given spot in an incredibly short space of time. America has been in the past, and probably still is, in the forefront in the matter of fire-alarms appliances, and in my recent visit to that country I witnessed one example of the alacrity with which fire engines can be called to any given spot. We had been visiting a number of telephone exchanges in New York and neighbourhood, and were motoring down on the long avenues on Manhattan Island. As we passed one shop I noticed that some children leaning out of a first-floor window had just set fire to the canvas sun blind, which was burning over an area of half a square yard, so that it had only just been set alight. Before we had got out of sight of the burning blind we were passed by a steam fire engine, a fire escape and a hose reel.

For the purpose of transmitting defined but limited items of information for special instructions or for making demands, innumerable electrical appliances have been designed, but there is a general tendency to replace such apparatus by telephones which simply extend the range of speed the natural method of intercommunication to any distance, and which render these subsidiary aids unnecessary.

### ORDINARY TELEGRAPHS.

In considering the question of ordinary telegraphy, it may almost be appropriate to apply to it the old adage, "Blessed is the country that has no history," if this be interpreted as signifying freedom from subjects of heated debate or controversial troubles, financial or political, which so frequently retard the development of new enterprises, it being, however, understood to imply steady progress and the full growth that is necessary to meet the requirements of the public and to spread the civilising influences of modern life into the dark corners of the world. Telegraphic statistics have been furnished on previous occasions in presidential addresses and in Papers presented to the Institution, and it may not be amiss here to compare former figures with those now available.

First dealing with telegraphs for the use of railways in the United Kingdom, I am able, through the courtesy of the various companies, to submit a table which illustrates the growth since the year 1879, up to which date definite information was supplied in a Paper read by the late Mr. E. Graves in May, 1880.

*Comparison of Railway Telegraphs in 1879 and in 1904.*

| | 1879. | 1904. |
|---|---|---|
| Mileage of poles | 14,889¼ | 19,484½ |
| „ „ wire | 62,009½ | 161,741¾ |
| Number of telegraph instruments | 13,128 | 19,978 |
| „ telephone „ | nil | 27,980 |
| „ block „ | 22,411 | 56,176 |
| „ repeater or signal instruments | 11,308 | 81,682 |

This table illustrates in a forcible manner the readiness with which our great railway companies avail themselves of the resources for the regulation and safeguarding of their traffic placed at their disposal by the electrical profession, and it is not too much to claim that the comparatively absolute freedom from serious railway disasters in this country is largely due to this wise policy.

Turning to the question of ordinary commercial telegraphy, the following figures may prove interesting:—

*Telegraphs and Telephones provided by the British Post Office.*

| | March 31, 1880. | March 31, 1905. |
|---|---|---|
| Mileage telegraph poles, underground and cable .. | 25,675 | .. 38,032 |
| ,, telephone poles, underground and cable .. | Nil | .. 14,898 |
| ,, telegraph wire ........................ | 114,242 | .. 338,120 |
| ,, telephone ,, ........................ | 40 | .. 253,521 |
| Number of telegraph instruments ................ | 12,754 | .. 33,267 |
| ,, ,, telephone ,, ................ | 61 | .. 48,118 |

The growth of the traffic was until recently proportioned to the growth of plant, and although the ordinary telegraph traffic has now been checked by the advent of the telephone, that young and lusty child threatening to monopolise the greater portion of the short-distance work in all countries where it has free play, still for long distances the questions of cost and the physical limitations of the telephone will check the rivalry of the latter, and there appears to be but a small prospect of serious interference or serious competition between the two methods of communication after a certain critical distance is reached. It may be convenient at this point to refer to the general statistics relating to the plant in use for telegraphs and telephones in those countries from which returns are obtainable, and so far as I have been able to gather them, they were represented by the following figures at the end of the year 1902:—

*Telegraphs.*

Mileage of Overhead and Underground Telegraph Wire.

| Aerial. | Underground. | Total. | Instruments. |
|---|---|---|---|
| 3,433,911 ...... | 225,748 ........ | 3,659,659 ........ | 265,835 |

*Telephones.*

Mileage of Overhead and Underground Wire.

| Aerial. | Underground. | Submarine. | Total. | Stations. |
|---|---|---|---|---|
| 4,197,416 .... | 2,530,215 .... | 11,145 .... | 7,467,417 .... | 3,534,036 |

The statistics showing the growth of the telephone systems in the United States are perhaps the most remarkable. The following table repeats the figures given by Sir William Preece in a Paper read before the Institution in 1904, and those which appear in the American Bureau of the census report for 1902:—

| | 1893. | | 1902. |
|---|---|---|---|
| Mileage of wire .......... | 532,256 | .... | 4,850,486 |
| Telephones in use ........ | 276,360 | .... | 2,315,297 |
| Telephone subscribers .... | 232,140 | .... | 2,178,366 |
| Number of talks .......... | 600,000,000 | .... | 5,070,000,000 |
| Capital at par ............ | .. | .... | 348,031,058 |

The growth from the year 1902 to the present time has shown no signs of diminution, so that it is difficult even for the most skilled experts in the States, or those best acquainted with the general situation, to forecast the ultimate development.

As to the amount of capital expended on telegraphs and telephones, the full facts are not forthcoming, as so much of the plant has been provided by the various governments which do not keep ordinary commercial capital accounts, but it certainly amounts to hundreds of millions of pounds sterling. A consideration of these facts, however, tends to show that whether in capital invested, in plant provided, in staff engaged, or in commercial activity, both the telegraph and its daughter, the telephone, show no signs of lagging behind the other branches of electrical engineering; and so far as the telephone is concerned, notwithstanding the progress it has made up to the present date, there is every reason to think that we have only seen the commencement of its development in the United Kingdom. Much of its future success depends, however, on the action of local authorities, who will have to show a more accommodating spirit than many of them have done in the past, unless they desire that the constituencies that they represent shall lag behind the remainder of the world in the enjoyment of the facilities for intercommunication that science has placed at their disposal. For these bodies to insist that all telephonic connections shall be laid underground without regard to the number of wires to be provided, to the capital cost involved, or to the fact that long telephone trunk lines must in the present state of our knowledge be provided by means of overhead wires, is to place an insuperable bar to the provision of a cheap and efficient service. In its own interest and for the good of the service which it controls a telephone administration will always place its wires undergound where it is either possible to work its circuits satisfactorily or it is not absolutely uneconomical to do so, but for local authorities to insist on this method being followed in every case simply means either the stifling of the industry or its provision at a cost beyond the reach of the ordinary user. When a corporation has to provide the capital expenditure for public undertakings it takes good care to see that no waste of funds takes place, but when the cost has to be provided by others there is a tendency to make demands that would not be considered in carrying out its own works, the authorities appearing to be oblivious of the fact that the expenditure must be ultimately met in some form by those whom they represent.

If we now consider the actual apparatus by means of which commercial telegraphy is effected, perhaps the most surprising fact that strikes the observer is the predominance of the use of the ordinary Morse code and Morse apparatus throughout the world. At first it seems surprising that, notwithstanding the innumerable inventions of printing, writing, and drawing telegraphs, the original system—of course, much improved—still holds the field generally, notwithstanding the partial use of the Hughes and Baudot printing systems on the continent of Europe. On consideration, however, it will no doubt be seen that, in comparing Morse with other systems that at first would appear to be superior, its simplicity, its relative freedom from trouble, electrical or mechanical, the ease with which its alphabet is learned and a skilled telegraphist is trained, and its adaptability to high-speed or multiplex working, all help to maintain it in the forefront, and undoubtedly these qualities will for a long time prevent or delay its general replacement by other types of instrument where the speed of working that is necessary is not greater than can be achieved by an operator manipulating a key. Where high-speed automatic Morse apparatus, however, is in use, the want of a means of automatic transcription which would save the labour and delay of manual transcription has long been felt, and extremely promising systems have been devised whereby the problem has been solved in two different ways. In one, as was recently illustrated in a paper read before the Institution, a perforated slip is used for transmission, as in the ordinary Wheatstone system, but instead of the signals being received in Morse characters at the far end, a second slip is perforated, the exact counterpart of the original; this is placed in an automatic typewriter which prints the message in ordinary type. Two different methods of applying this system are now under the consideration of the Post Office. In others the transmission is effected by means of a perforated tape, the message, however, being printed by the receiving instrument, either by a direct impression from a type-wheel, or in one case by a photographic reproduction of each letter as the type-wheel revolves.

It is interesting to note how the practice in the ordinary telegraph service has materially benefited by the development of other branches of applied electricity. Thus for testing and localising faults, and in order to obtain control over the large mass of wires entering the principal offices in this country, these were formerly attached to screw terminals fixed in a test box, which was bulky and which occupied much valuable space in a costly building. The practice in the Post Office now is to terminate these wires on telephone jacks, and to provide for connections for testing, crossing or other purposes by means of plugs and flexible cords, the modern arrangement only occupying one-third the space of the old type. Again, the extended introduction of secondary cells charged from lighting plant by means of motor generators has resulted in the last few years in the abolition of about 150,000 primary cells in the Post Office service, this change leading to a proportionate saving of space and to a great economy in generating energy and in upkeep. Again, the great extent of modern London necessitates a very considerable amount of local telegraphic traffic. The number of inter-metropolitan messages, viz., those from one part of London to another, some time ago amounted to 18,000 per diem. These were all re-transmitted at the Central Office, for it was obviously impossible to provide direct connecting wires between every one of some 600 telegraph offices. The Post Office therefore determined to revert to the system of switching lines through to one another as required, a method which had proved a failure when tried on long and costly trunk circuits, as these could obviously deal with a much larger percentage of traffic when a constant stream of messages was fed into them than was possible when switching connections had to be made. Where local circuits are concerned which are short and inexpensive, and in the majority of cases not filled with traffic, the conditions are altered, and it is a wise policy to increase the number of wires where necessary and to save the delay and cost of re-transmission. A special switching board based on telephonic lines was therefore designed to meet telegraphic requirements, and a section providing for 138 lines was fitted up at the Central Telegraph Office and brought into use experimentally on Nov. 13, 1902. Now any office connected to the switch which wants to communicate with another similarly connected merely calls the latter, and the switch clerk hearing the call simply joins the two lines through in the manner adopted for telephonic service. Suitable signals are provided to indicate when lines are engaged, and the number of wires to important offices has been increased. In designing the arrangement, provision has been made for working all the wires from a secondary battery installed in the Central Telegraph Office, so that the large number of primary cells previously installed in each office has been dispensed with. The result has been so satisfactory that the whole of the metropolitan circuits are now being treated in a similar manner, and this handling of 18,000 messages twice over each day is about to be entirely obviated.

In submarine cable work the same progress may be noted as in other branches of telegraphy. The growth in half a century is represented by the following figures:—

| | | |
|---|---|---|
| 1852 | 87 | nautical miles |
| 1892 | 139,594 | ,, ,, |
| 1902 | 212,894 | ,, ,, |

and it goes on without interruption.

Types of submarine cable have in practice not been materially changed, with the one exception of the air-spaced submarine cable designed for telephone purposes by Mr. Willoughby Smith, one of which was laid by the Post Office between Nevin, in North Wales, and Newcastle, in Ireland, in the year 1892. The problem of devising submarine cables for long-distance telephones is, however, still to be solved. The longest telephone cable of the old Paris type was laid by the Post Office in the year 1902 for communication between London and Brussels. It is 47 knots in length, and this is about the practical limit of distance over which satisfactory telephonic speech is possible under existing conditions when allowance is made for the addition of the connecting land-lines and of the local subscribers' plant.

As one of the results of cable enterprise, it may not be inappropriate here to refer to the extended knowledge of the character and constitution of the sea bottom which has been derived from the extensive soundings and surveys that have been made in the Atlantic and Pacific Oceans, preliminary to the laying of deep-sea cables. On a reference to Admiralty charts, the track of deep-sea cables can be followed along the continuous lines of soundings at short intervals which appear where cables have been laid, whereas other portions of the sea bottom are comparatively uncharted. I have especially in mind some of the admirable charts and reports prepared by Mr. R. E. Peake in connection with cable enterprises with which he has been associated.

(*To be concluded.*)

## LEGAL INTELLIGENCE.

### Chitty v. British Westinghouse Electric Mfg. Co. (Ltd.).

This case came before the Court of Appeal (the Master of the Rolls and Lord Justice Mathew) on Monday, on appeal from an order of Mr. Justice Bucknill reversing an order of Lord Dunboyne, which directed that the action should be tried by a special jury. Mr. Justice Bucknill ordered that the case be tried by a judge alone. Counsel for plaintiff said the action was for damages for breach of an agreement. The statement of claim set forth that "by an indenture dated Oct. 15, 1902, made between plaintiff and defendants, after reciting (inter alia that plaintiff was possessed of valuable technical information and knowledge in the construction of dynamo-electric machines in accordance with certain inventions of plaintiff's therein more particularly mentioned, and that such machines included certain further improvements invented by plaintiff, and reciting that defendants had commenced negotiations with plaintiff for the acquisition of his rights. They had requested plaintiff to give them an opportunity of investigating the matter and inspecting and testing the said machines, which plaintiff had agreed to give them upon their giving security against disclosure. Defendants thereby covenanted with plaintiff that they would not directly or indirectly disclose or give information to any person as to the said improvements, the method of construction of machines or any special technical information communicated or ascertained in the course of the investigation, and tests of the said machines." Counsel said that plaintiff went to the defendants' works and took with him two experimental machines, which were subjected to certain tests, and plaintiff's case was that in the course of that investigation and testing, and whilst he was at plaintiff's works, giving them the benefit of his technical knowledge and experience he communicated to them, in four particular respects, certain improvements in the method of constructing dynamo machines which, whether patentable inventions of his or not, were at any rate new to defendants. The question to be tried was not a question for scientific investigation or an issue such as would be raised in a patent action, but was purely a question as to good faith between the parties. Did plaintiff in fact communicate to defendants certain improved methods of constructing machines which, it was admitted, defendants, after October, 1902, proceeded to manufacture by the thousand, and which, plaintiff alleged, incorporated the improvements he had communicated to the defendants? If defendants had done that, and had practically thrown plaintiff overboard, the question then was, did defendants behave in accordance with the letter and spirit of the agreement? The matters in dispute were clearly proper matters for trial before a special jury. Defendants said that plaintiff had not communicated to them anything they did not know before he approached them. Although defendants admitted that they had changed the system of manufacture, they said that was in no way due to communications plaintiff had made to them. Such improvements defendants said were well-known to them prior to October, 1902, and were published and described. Another issue which had to be tried dealt with the ownership of a certain motor which was constructed by defendants under a later agreement with plaintiff, made in November, 1902. Defendants denied that such an agreement was made, and they said that plaintiff was neither co-owner nor sole owner of the machine, that it was no good, and that it was only fit for scrap. There was nothing in the pleadings which a special jury could not deal with, and counsel, therefore, submitted that the decision of Mr. Justice Bucknill ought to be reversed. As to the measure of damages, counsel suggested that a fair way to look at that question was this: "If defendants decided to adopt the devices and recommendations of plaintiff and kept faith with him, what sum of money would you have paid to procure a release from the covenants by which you were restrained from making use of his suggestions and knowledge?" Such damages could more properly be considered by a special jury of business men than by a judge alone.

Mr. GRAHAM (for defendants) said the question involved was not one of good faith. Plaintiff went to defendants, and said he had made a number of inventions which would be valuable to defendants, and the company said, "Very well, we will look into them," and they thereupon entered into the agreement with plaintiff. Defendants knew nothing at the time the agreement was made as to whether the things were inventions or not. They took the plaintiff's word for it, but defendants now said that the matters brought before them by plaintiff were not new inventions. Defendants did not wish to be imperilled by the finding of a jury, and they contended that the agreement referred only to improvements which Mr. Chitty had invented, and that the things he showed them were all old. Some of the things were known at the time to be old, and others had since been found to be old. A jury was a very unsuitable tribunal for dealing with electrical matters, and the present case was one particularly unsuitable for trial by jury.

Lord Justice MATHEW: There are two distinct issues here. First, as to the meaning of the contract; and second, as to whether the contract has been broken.

Mr. GRAHAM said troublesome questions had to be tried. The question of whether the inventions plaintiff claimed were old would, sooner or later, have to be decided, and that was a question a jury was very unsuited to try. The directors of the company looked upon it as an important case, and they did not want to have it left to a jury to say whether they were to be committed or not.

Lord Justice MATHEW: I think the directors may have every confidence in the law of this country.

Mr. GRAHAM said defendants were going to call a great number of eminent electrical engineers, and the case was one which would involve a great deal of expert evidence.

The MASTER of the ROLLS, in giving judgment, said: I am of opinion that the original order made by Master Dunboyne is the proper order in this case. It seems to me when you have a judge to construe the contract the best tribunal for determining the issue of fact in this case is a special jury. It is not purely and simply a matter of technical patent law. There is a broad basis of common fact capable of being dealt with by ordinary people of intelligence and common sense, and I can conceive no better tribunal for dealing with that than a judge and jury. The difficulties are no more than the ordinary ones to be met with in cases where technical terms have to be construed. When the technical terms are explained by those who understand them the matter becomes one of pure every day fact. A special jury would very probably embrace persons who are cognisant with those matters and who would be quite as competent to decide it as any of the judges. I am, therefore, of opinion that the appeal ought to be allowed.

Lord Justice MATHEW concurred.

The appeal was accordingly allowed, the Master's order for a trial by special jury restored, and the costs of the appeal made costs in the cause.

### Mica Insulator Co. (Ltd.) v. Bruce Peebles & Co. (Ltd.)

In an action brought in the Court of Seccion, Edinburgh (First Division), before the Lord President, the following judgment was delivered on Friday last.

The LORD PRESIDENT: This is a case at the instance of the Mica Insulator Co., of London, against Bruce Peebles & Co., electrical engineers, Edinburgh, who are sued under an alleged breach of contract for having bought certain materials from others than the pursuers, contrary to the manner the defendants had contracted to do. Damages are also claimed on the ground that defenders had themselves sold and used electrical material which they have themselves manufactured, and by such manufacture infringed the provisions of two letters patents belonging to pursuers, or have bought these articles from others, the said articles having been constructed in accordance with the said patents, and so thereby also infringing. There is no dispute between the parties that on the point of breach of contract there must be proof before the case can be disposed of. But defenders plead in reply to the second branch of the case that pursuers' allegations are not relevant, as they are wanting in sufficient specification. The Lord Ordinary appears, with considerable doubt, to have come to the opinion that the inquiry in regard to want of specification could not be refused. Against that a reclaiming note has been brought. This makes it extremely necessary to scan somewhat closely the averments of pursuers, which, as I have mentioned, include the averment that defenders have infringed the letters patent under which pursuers manufacture micanite and extra flexible micanite cloth; that defenders have sold and used such material, which they have themselves manufactured, or have bought from others who have manufactured, and so have infringed the said letters patent, despite the fact that defenders were under contract with pursuers to purchase such materials from them. In particular, pursurers averred that on various dates since the beginning of 1902 defenders have purchased from one Brandt of Hamburg and used in their machines in Scotland micanite made in contravention of the said letters patent, and have purchased from the Bergmann Elektricitäts Gesellschaft, of Berlin, machines insulated in infringement of the said letters patent, and have sold these machines to various persons in England and Scotland. The patents which pursuers say have been infringed are patents of which they are the owners. Now, your lordships are aware that it was a long time ago held by this Court that it is not necessary to have a separate statement of particulars such as is necessary in England, as the particulars would necessarily be given with just the same care and distinctness in our form of Process as would be given in a statement of particulars in England. This is statutorily recognised in the Patent Act, 1883, which regulates these matters in both countries. I take the meaning of this to be that although the Scottish Court is not to depart from its own form, yet the requirements of the act, so far as they go to the merits, are just as much requirements in Scotland as they are in England. Therefore the plaintiff has to deliver in his statement of claim particulars of the breaches complained of. That being so, this must be strictly insisted upon in all cases relating to patents. Turning to pursuers' averment in this action I do not think this fulfils the proper requirements. Pursuers have come into Court with two patents, both of which were amended, and it is expressly set out in sec. 20 of the Patent Act that where an amendment has been made under the provisions of the act no damages shall be given in any case in respect of the use of the invention before the disclaimer, correction or explanation, unless the patentee establishes to the satisfaction of the Court that his original claim was framed in good faith and with reasonable skill and knowledge. This requires that in any claim for damages the sums claimed before and after the disclaimer must be clearly set out. In this case nothing of the sort has been done. There is also another objection which I think is a fatal one to the averment as it stands, and that is, that there are no proper particulars of breach. All that is alleged is that defenders have used and employed pursuers' manufactured cloth, and in doing so have used and employed the invention which is protected by their two letters patent. They do not say anywhere what the defenders are doing, except that they are making "extra flexible micanite cloth." Now, when we go to the patents we see that the claims made are for certain combinations of things which make an extra flexible micanite cloth. Mica, of course, enters into both patents, but the way in which mica is treated, and the way it is fixed together by certain substances, varies in the two patents. I think defenders are entitled to be told what it is alleged by the other side they have done wrong. In other words, pursuers must specify wherein defenders' micanite cloth contravenes either their one patent or the other. As to the second branch of this subject, I think there is sufficient specification in pursuers saying from whom the material which is alleged to be infringed is bought, but I imagine pursuers would not be allowed to prove any purchases made by defenders from anyone except Brandt and the Bergmann Co. Here again I think pursuers must say how Brandt's cloth and Bergmann's cloth contravenes their patents. I am, therefore, of opinion that the Lord Ordinary's interlocutor should be recalled, but that a further opportunity should be given to pursuers to consider as to whether they will amend. In any event the case will have to go back to the Lord Ordinary for further disposal. Defenders will have the expenses in this motion, whether the proof is amended or not.

Ten days' stay of execution was ordered.

### Private Wire & Telephone Installation Co. v. Portman & Co.

At Westminster (London) County Court, on Friday, this case came before Judge Lush-Wilson, K C. It was a claim for £30 telephone rent and hire of a private instrument. Counsel for plaintiffs said the Consolidated Electrical Co. assigned their rights under the contract to plaintiffs and notice was given to defendants. There were four private wires between John-street and Adam-street, Adelphi; 100, Strand; Regent-street, W.; and Sussex-mews, Maida Vale. Defendants had paid money to plaintiffs after the assignment. The action had been remitted from the High Court, and defendants had filed a counter claim.

The Managing Director of plaintiffs gave evidence, and admitted that plaintiffs had not a licence from the Postmaster-General. There had been complaints from defendants, and they had been attended to.

Counsel for the defence contended there was no case, and that plaintiffs had contravened secs. 4 and 6 of the Telegraph Act, 1869, as it had been held that a telephonic message was a telegram.

The JUDGE raised the point of the exclusive use of the wires by the defendants.

Counsel for plaintiffs said his clients knew no one in the matter but defendants. Other people in the same buildings as defendants might have used the instruments.

The Managing Director, re-called, said he had no idea the telephones were being used by anyone but defendants.

The JUDGE: Why should plaintiffs not recover?

Counsel for defendants replied: Because it is an unlawful contract.

The JUDGE said notice of this defence ought to have been given, and he granted an adjournment to enable defendants to put in a statutory defence.

### Bainbridge and Another v. The Postmaster-General.

This case came before the Court of Appeal (the Master of the Rolls and Lord Justice Mathew) on Monday, on the appeal of the Postmaster-General from an order of Mr. Justice Walton.

The ATTORNEY-GENERAL said the question for decision was whether the Postmaster-General was liable to be sued in that Court in his corporate capacity. He asserted that he was not, and was not liable at common law, and that there was nothing in the statutes which made him for this purpose a corporation or which imposes upon him any liability to be sued. The action was one brought in respect of injuries sustained by plaintiff, Elizabeth Bainbridge, by reason of the alleged defective execution of works connected with the laying of telephone lines. The action was originally commenced against Mr. Crane, the district engineer, alone, he being in charge of the work. But a summons was taken out before the Registrar to add the Postmaster-General as a party generally. The application was to add the Postmaster-General by name, but although the Registrar did not make the order in that form he did add the Postmaster-General as such. The Postmaster-General then took out a summons to have that order disallowed. The matter came before Mr. Justice Walton in chambers, who said that the question was one of difficulty, and it did not seem to him to be a matter to be determined on summons. His lordship refused to strike out the name on the summons, but gave leave to appeal. The Attorney-General now submitted that the Postmaster-General was the head of a Government department, and neither he nor the head of any other Government department was liable to be sued for the default of his subordinates.

Judgment was reserved.

### Ingleton Electric Lighting & Power Co. v. Ingleton Gas Co.

Mr. Justice Warrington on Wednesday commenced the hearing of this action for damages for injuries done to plaintiffs' electric cables by defendants in laying or re-laying gas mains. Plaintiffs also sought injunctions to restrain defendants from laying their pipes within 3ft. of plaintiffs' cables and lines, and from laying them so as to interfere with the plaintiffs having free access to their cables and lines, and for laying them without giving three days' notice of intention to do so, and without permitting the work to be under the superintendence of plaintiffs' officers. The case was continued yesterday (Thursday) and was adjourned till to-day (Friday). A report of the case will appear in our next issue.

### Infraction of Tramway Bye-Laws.

Before the Wakefield magistrates last week, Mr. Jas. Horner was charged with an offence against the bye-laws of the Wakefield & District Light Railway Co. by refusing to deliver up his ticket for examination. It was stated that on Oct. 18 Mr. Horner was travelling on a Leeds–Wakefield tramcar, and when asked by an inspector for his ticket for examination refused. He showed the ticket but would not let it out of his hand.

For the defence it was urged that the prosecution had no case. The bye-law said that a passenger should "either deliver up his ticket or pay the fare legally demanded," and as no fare had been demanded in that case there was no completed offence.

The Bench held that an offence had been committed, and fined defendant 1s. and £1. 10s. 6d. costs. The Bench agreed to state a case.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT AND FILLED.

Barking District Council invite applications for the appointment of electrical engineer and manager of the light railway. Salary £225, rising by annual increments of £25 to £300 per annum. Applications to the clerk (Mr. H. Hargreaves), Public Offices, Barking, by noon Nov. 10.

Vickers, Sons & Maxim, River Don Works, Sheffield, require a thoroughly capable and experienced superintendent for their electrical manufacturing shops. See an advertisement.

An assistant engineer is wanted for direct current dynamos and motors. Applications to Messrs. Vickers, Sons & Maxim (Electrical Department), Sheffield. See an advertisement.

Thomas Smith & Sons, Steam and Electric Crane Works, Rodley, near Leeds, require a first-class draughtsman, accustomed to electric cranes and lifting machinery. See advertisement.

The Council of the University of Leeds require an assistant lecturer and demonstrator in electrical engineering. Salary £175. Particulars from the Registrar. Applications by Nov. 18.

The governors of Battersea Polytechnic, London, S.W., require a laboratory and workshop assistant in the department of physics and electrical engineering. Commencing salary 20s. per week. Particulars from the secretary. See an advertisement.

Out of the 65 applicants for the position of manager of the South Shields Corporation tramways the following five have been selected from whom the appointment will be made: Mr. Richard Chadwick, A.M.I.M.E. (chief assistant, Birkenhead tramways); Mr. Frederick Taylor (assistant tramway engineer, Bolton); Mr. John Williams, A.I.E.E. (deputy engineer and deputy tramway manager, Rotherham); Mr. William Ogilvie (assistant stock rolling superintendent, Newcastle-on-Tyne) and Mr. John Wilson (manager South Shields Tramway Co.)

**Alleged Extensive Frauds on Electrical Firms.**—At the Guildhall, London, on Saturday last, the prisoners Leslie, Cheesman, Webber and Rosenberg were committed for trial on a charge of conspiring to defraud certain electrical firms of large sums of money.

**Argentina.**—Messrs. T. B. Gandulfo & Co. have secured a concession for an electric tramway between Avellaneda and La Plata via Quilmes.

This firm have disposed of their concession for a line in the Port of Buenos Ayres.

Buenos Ayres Council have already granted a concession to Varela, Cuneo & Co. for electric tramways, which will cover the routes of portions of the existing lines of other concessionaires in the city, and the Public Works department have now reported favourably upon an application by Urdaniz & Co. for permission to establish a service with similar running powers over other owners' lines.

The Argentine Government are about to invite tenders for the electric lighting of a large landing stage and refuge for emigrants to be built at Buenos Ayres.

**Australasia.**—Launceston (Tasmania) Corporation have installed an 80 H.P. electric motor at their stone quarry.

Electrically-driven sheep shearing machines are being used to a considerable extent in the Commonwealth.

The municipal plant at Subiaco, a suburb of Perth (W.A.), which has been working for about two years, is now overloaded, and extensions are to be put in hand forthwith, the Council having accepted the tender of W. H. Kidston & Co., of Perth, for the supply of two 76 H.P. Babcock & Wilcox boilers, two 46 kw. and one 92 kw. E.C.C.-Belliss sets, together with balancer, switchboard, crane, &c., at a cost of about £4,000.

Sydney Electric Light committee recently instructed the city electrical engineer (Mr. T. Rooke) to prepare plans for the proposed extensions of plant, estimated to cost £130,000, and the erection of sub-stations in the city and at Elizabeth Bay and Pyrmont.

The Metropolitan Gas Co. (Melbourne) recently applied for an injunction to restrain the City Council from employing differential methods of charging for electric energy, alleging that the practice was contrary to the terms of the Electric Light and Power Act.

The Council charge a flat rate of 4½d. per unit for current for all purposes or under the maximum-demand system 7d. per unit for 45 hours' maximum demand per month and 2d. per unit for any quantity in excess.

The Chief Justice referred the whole case to the Full Court. In 1902 the company took proceedings against the Council for supplying current at different rates for lighting and power. The Chief Justice then decided in favour of the Council. The Full Court, however, reversed his decision, and the Legislature afterwards passed an act permitting the practice adopted by the Council.

Sir Joseph Ward, replying to a question in the New Zealand House of Representatives recently, said

There was no doubt that imposition was being practised by means of so-called "electric" belts. Such belts were absolutely valueless in the cure of disease, but though they did no good to the wearer, they certainly did no harm, and were doubtless a comfort to certain neurotic persons who believed in them. Measures should certainly be taken to prevent the introduction into the colony of the pernicious literature of which the electric belt was the outcome, but it was not proposed to restrict the importation of the belts.

**Awards.**—Marconi's Wireless Telegraph Co. (Ltd.) announce that they have obtained the highest possible award at Liège Exhibition.

Reavell & Co. (Ltd.) have been awarded a gold medal for their patent quadruplex direct-coupled electrically-driven air compressors at the Liége Exhibition.

Messrs. Babcock & Wilcox have obtained a diploma of honour for the excellence of their entire exhibit at the Naval, Shipping and Fisheries' Exhibition at Earl's Court. The exhibit consisted of a marine type boiler of 600 H P., a coal conveyor in motion, models of land type boiler, fitted with superheater chain-grate stoker, water softener, and a collection of wrought iron steam pipes.

**Barking.**—Mr. A. H. Seabrook who, as stated in our last issue, has been appointed borough electrical engineer at West Ham, is leaving Barking at the end of this month to take up his duties at West Ham.

**Barrow-in-Furness.**—The Council have adopted a recommendation of the borough electrical engineer (Mr. H. R. Burnett) to carry out extensions of the electric lighting mains, &c., at an estimated cost of £1,145.

**Battersea (London).**—The Lighting committee reported on Wednesday on the past year's working of the electricity department.

There was a net profit of £294. 17s. 10d. There had during the year been a considerable increase in the demand for energy, for both lighting and power, and a material reduction in works costs. The repayment of loans, which was suspended for three years, took effect during the year. London County Council suggested the formation of a reserve or renewal fund, and the committee had replied that though they were in favour of the views expressed in the County Council's communication they did not see their way to form such a fund at present, but the net profit had been carried forward.

The committee have decided to abolish meter rentals after the Michaelmas quarter readings.

**Beaconsfield.**—The Uxbridge & District Electric Supply Co. have asked the Council to assent to their application for a provisional order. The company desires to pass through to supply Penn and Seer Green, for which consent has been obtained.

**Belfast.**—A deputation, including the chairmen of the Police and Works committees and the borough engineer and borough electrical engineer, started on Monday on a visit to Glasgow, with the object of studying the best methods of lighting the streets and the new City Hall-square by electricity in conjunction with the new electric tramway service, which will shortly come into operation. The deputation will also visit Edinburgh, Dundee, Newcastle-on-Tyne, Leeds, Bradford, Manchester, Liverpool and London.

**Bermondsey.**—On Tuesday the Electric Lighting committee submitted to the Council correspondence which had passed between them and the County of London Electric Supply Co. and the London Electric Supply Corpn.

The former company offered to supply the Council with current in bulk at a price cheaper than the Council could generate it, or to take over the undertaking on lease, the company guaranteeing the Council a sum sufficient to provide sinking fund and depreciation on the capital expended. An interview was asked to discuss the matter, but this was refused by the committee.

Mr. R. Stewart Bain, managing director of the London Electric Supply Corpn., wrote in reference to the proposal of the Council to increase their plant, and suggesting a meeting between the engineers of the Council and the corporation, that they might be able to put forward a suggestion which would obviate any further capital outlay by the Council.

The Electric Lighting committee considered there would be no advantage gained by a meeting as suggested, and this view was, after discussion, adopted.

**City of London.**—At a meeting of the Court of Common Council last week

Deputy Wilkinson inquired whether the notice to the City of London Electric Lighting Co., instructing them to remove the electric light standards from the streets now lighted by incandescent gas, could be withheld until it had been discovered whether the incandescent gas system was superior to electric lighting.

Mr. Morton said the company had suggested that the question of street lighting should be entirely removed from the hands of that committee. The Streets committee could not give information to the Court, as the question was under consideration.

**Durham.**—At Wednesday's meeting of the Council the report of the Electricity Supply committee, recommending the Council to promote a bill to authorise the erection of electricity supply works was rejected.

**Edinburgh.**—Last week the Council adopted a report of the Electric Lighting committee recommending the provision of condensing plant at Dewar-place station at an estimated cost of £13,000 and at M'Donald-road station at a cost of £28,500, and that the consulting engineers (Messrs. Kennedy & Jenkin) be instructed to prepare the necessary specifications and drawings.

**Exhibitions.**—An electrical exhibition organised by the Corporation was opened at Exeter municipal electricity works by the Mayor on Tuesday and will remain open until to-morrow (Saturday). A number of very interesting exhibits are made by some of the leading supply houses.

The participation of all nations is invited to an international exhibition which is to be opened at Christchurch, New Zealand, in Nov., 1906.

It is announced that an International Exhibition will be held at Ghent, Belgium, in 1908.

**Greenwich.**—Major-Gen. C. S. Hutchinson has been appointed by the Board of Trade to inquire into the appeal of the London Electric Supply Corpn. against the conditions imposed by the Council as to certain works proposed to be executed by the company.

**Grimsby.**—The Highways committee have conditionally approved the local tramway company's scheme for the construction of further tramway routes.

**Hanley.**—A number of extensions of the electric lighting and power mains have been authorised. The electrical engineer (Mr. Yeaman) is endeavouring to develop the motor load by supplying electric current to many of the largest factories in the district.

**Harbour Lighting.**—Montrose Harbour trustees are recommended to accept an offer of the North of Scotland Electric Light & Power Co. for lighting the harbour by four 1,400 c.p. arcs and six incandescents of 40 c.p. each. The Dockgate house is also to be wired.

**Haslingden.**—The Council propose to enter into an agreement with the Lancashire Electric Power Co. for a supply of electricity in bulk. Parliamentary powers to construct and work tramways in the district are also to be obtained by the Council.

**Haywards Heath.**—The Council will assent to an application by a company for a provisional electric lighting order.

**Holborn (London).**—The Council have decided to raise the rental of the telephone kiosks from £15 to £30 each per annum after this year.

**Inquests.**—An inquest was held at Cheltenham on Saturday into the death of John Moore, an employé of the Corporation electric light department.

The evidence was to the effect that deceased, with a mate named Birt, was engaged on Oct. 27 in cleaning the purifier attached to one of the boilers at the works, and, in the temporary absence of Birt, turned on the cock in the purifier to let out the accumulated water, and then, while the cock was still turned, got partially inside the purifier to carry out his work. He had not been inside many seconds, however, before the man in charge of the other boilers "blew" steam into the boiler, with the result that, the valve being open in the purifier, deceased received the full force of the steam on his face, arms and upper part of the body. He died from the effects of the scalds.

Mr. W. J. Bache, borough electrical engineer, said that if deceased had given it a thought he must have understood the risk he was running in getting into the purifier while the cock was still on. It was not absolutely necessary to let the water out that way, although it was the usual practice. A non-return valve would have minimised the danger, but he explained why such valves were not used. It was unusual for the blowing to be done while the men were at work on the boilers, but not improper. There were no printed regulations on the subject.

After hearing the evidence, the jury returned a verdict to the effect that death was due to septic absorption and exhaustion following scalds accidentally sustained, adding a rider: "That the accident was in a great measure due to the want of rules and regulations at the works, and we suggest that more individual care be taken by the workmen in the future."

The Town Clerk, in expressing the regret of the Corporation at the accident, said the jury's rider should be laid before the Lighting committee. The difficulty, however, was in making regulations sufficiently comprehensive for all cases without at the same time making them so elaborate and complicated as to be unworkable.

A regrettable accident, having a fatal termination, occurred at the Hammersmith Borough Council electricity works on Saturday.

Mr. A. H. Boswell, a rectifier attendant and junior charge engineer at the station, was instructed to change an ammeter on a Ferranti high-tension feeder board, and the plates in the front of this board were taken up to allow the jointers to move the cable. Boswell proceeded to remove the ammeter with the usual insulating key, but used a sponge cloth instead of the customary rubber gloves. He also omitted to have the plates replaced in front of the board and covered with the usual rubber mat. He was standing in an awkward position, with one foot on a rubber mat, and in order to get a better pull at the ammeter, he moved his right foot on to the iron framework of the switchboard. The outer of the concentric system is permanently earthed, so that he thus received the full 2,300 volts. Mr. Bell, the borough electrical engineer, informs us that Boswell was a very efficient officer, and had received an excellent testimonial a few days prior to the accident to enable him to secure a better appointment.

On Tuesday Mr. Luxmoore Drew held an inquest into the circumstances attending the death of Mr. Boswell, and, after hearing the evidence, the jury returned a verdict of accidental death.

**Kiew (Russia).**—The Deutsche Gesellschaft für Elektr. Unternehmungen have purchased all the shares of the local electric Supply Co.

**Leith**—The formal opening of the municipal electric tramways took place on Friday last.

**Leyton.**—The salary of the electrical engineer (Mr. F. Harman Lewis) has been increased by £100 a year as from July 1. In future Mr. Lewis will have the control and management of the tramways electrical equipment.

**Light Railways.**—Barking District Council give notice of intention to lease to Ilford Council their light railways from Loxford Bridge to the junction of Fanshawe-avenue with Longbridge-road, for seven years at a rent of £285. 16s. 8d. per annum, with certain provisos as to extension.

The British Electric Traction Co. have applied to the Board of Trade for approval of the transfer of the Kinver Light Railway undertaking to the Dudley & District Electric Traction Co.

The Mansfield & District Light Railway Co. are applying for an extension of six months to enable them to carry out the whole of the work authorised by their order.

The Bideford, Clovelly and Hartland Light Railway Order has been submitted to the Board of Trade for confirmation.

Dublin County Council have conditionally approved the proposal of the Lucan & Leixlip Electric Co. to extend the line from Leixlip to Lucan.

**Llangollen.**—The District Council have unanimously accepted the tender of Llangollen Electric Lighting Co. for the extension of the present lighting system to the urban area. Arc lamps will be used in the main thoroughfares, with incandescent lamps for the narrow streets, the latter being attached to the present gas standards.

**London County Council.**—At Tuesday's meeting it was agreed to loan Hammersmith £13,700 for electric lighting, the local authority proposing to repay the loan in 10 years. A loan was made to Woolwich of £991 for electric lighting.

A further report was presented by the Finance committee with reference to the application of Fulham Council for a loan of £25,000 for electric lighting. At the last meeting it was resolved to postpone the application pending the expected debate on the question of the Electric Power Bills for London. The committee now pointed out that the plant already installed at Fulham is only just sufficient to supply the estimated maximum demand during the coming winter, and as it appeared necessary that an immediate addition should be made they recommended that the loan be granted at once.

Mr. W. Thompson asked if the Finance committee knew that the Metropolitan Electric Supply Co. had powers to supply electricity in bulk to Fulham Council. He thought that company would be able to supply electricity at a much cheaper rate than the Council could generate for itself.

Col. Rotton moved that the recommendation be referred back, on the ground that the works comprehended in the loan had already been proceeded with.

Sir H. Bliss seconded the amendment.

Mr. T. Davies said he believed the Metropolitan Co. had no such powers. Fulham Council was generating electricity and selling it at a profit to the ratepayers, and they had already spent the money for which the loan was asked.

Dr. Napier thought it extraordinary that Mr. Davies should coolly tell them the money had been spent. This was flying in the face of the principle of London local government.

Mr. Buxton said the present system of the County Council in advancing money for electric lighting would inevitably lead them into difficulties. For all other things except electric lighting the loans had to be repaid within the life of the material, but in the case of electric lighting they allowed 42 years. When the plant was worn out where was the money coming from to replace it? There was £2,900,000 invested in the municpal electric lighting concerns of London, and only £730 was set aside as reserve last year.

Mr. Hunt said no body of business men could start works before they knew where they were to get the money.

Mr. Bruce said that in the act of the Metropolitan Electric Supply Co. of last session power was given to supply in Fulham.

Lord Welby said the committee had not the fact before it that the Metropolitan Electric Supply Co. had power to supply in bulk in Fulham, and if the Council wished the committee would consider the matter.

The amendment was then defeated and the recommendation carried.

*Tramways.*—The report of the Highways committee dealing with the expenditure of £665,000 on the electrification of the first section of the Northern Tramways was again postponed pending a report from the Finance committee.

The Highways committee brought up a report with reference to the construction and reconstruction of tramways in the south of London, for which the Council at different dates have passed estimates of £75,000. The committee point out that while these votes meet the requirements of these lines, yet in carrying out the work it was necessary to provide cable ducts and high-tension cables for further lines which are to be dealt with at some future time. This will increase the cost to £99,280, and it was recommended that the amount be now voted.—Postponed.

It was agreed to ask the Board of Trade to amend the regulations so as to enable trailers to be used in connection with the single-deck cars in the subway under Aldwych.

A recommendation to apply to Parliament for authority to abandon tramways from Canonbury-road via St. Paul's-road to Ball's Pond-road, from Cassland-road to a point near Victoria Park, and from Aldgate via the Tower Bridge northern approach to a point near the Tower Bridge, was withdrawn.

**London County Council Tramways.**—The Highways committee of the Council received on Friday last a deputation representing Lewisham Council and ratepayers of Forest Hill and Sydenham asking the County Council to extend their tramways from Camberwell to the existing tramway at Catford. The proposed route would pass within a short distance of the Crystal Palace.

**London Electric Power Schemes.**—In addition to the County Council scheme for the generation and supply of electricity in bulk, certain of the London Borough Councils are discussing a suggested combination for promoting a scheme of their own, in opposition to L.C.C. and company proposals.

*Hackney* Electric Lighting committee reported to the Borough Council on Monday having had under consideration the question of what steps it was desirable to take with the object of protecting the interests of the municipal electricity undertaking.

After referring to the Administrative County of London Electric Power Bill of 1905 and to the probability of its being re-introduced next year, the committee thought it the duty of the Borough Council to again oppose the bill unless protective clauses are inserted, and they had accordingly directed their attention to the desirability of placing the municipal undertaking in such a position as would enable them to offer the strongest opposition to any scheme which would have a detrimental effect upon it. The committee urge that it is necessary to obtain wider Parliamentary powers for the development of the undertaking. These powers include the right to connect up the works with the works of any of the local authorities whose areas adjoin for giving or taking, as occasion serves, a supply of electric energy in bulk. The adjoining authorities to Hackney are Islington, Shoreditch, Bethnal Green, Poplar, West Ham, Leyton and Walthamstow, and the committee believe that these authorities would favourably entertain the proposal and give it their support. The powers to be sought should include supply of electrical energy to premises situated partly within and partly without the area of supply, and for the hire and supply of electric motors, wires and fittings to consumers. The committee attach the greatest importance to the power to supply motors on hire. The committee further consider that it will be well to obtain the insertion of a "stand-by" clause in any bill prepared with the above-mentioned objects.

In a further report the committee stated that the Town Clerk and Engineers had been in conference with the officers of the Bethnal Green, Islington, Leyton, Poplar, Shoreditch, Walthamstow and West Ham Councils on the question of placing the various electric lighting undertakings in a position to defy successfully any competition; also to consider the advisability of the generation of electricity on a large scale; and to endeavour to arrive at an agreement with respect to supplying energy in bulk. As a result of the conference and inquiries made it appeared that the proposals would probably receive the support of the authorities named. Finally the committee reported that they had decided in favour of the following: "That application be made to Parliament in 1906 for general electricity powers—viz., (1) To enable Hackney Council to enter into agreements with the Councils of Islington, Shoreditch, Bethnal Green, Poplar, West Ham, Leyton and Walthamstow, for giving or taking a supply of electrical energy in bulk. (2) To enable Hackney Council to hire, fix or supply motors, wires and fittings for consumers' premises for the use of electric energy, and to obtain loans for this purpose. (3) To enable Hackney Council to give a supply of electric energy to the whole or any premises situated partly within and partly without the borough. (4) To provide that any consumer or intending consumer shall not be entitled to demand or to receive a supply of electric energy for any premises having a separate supply, unless he has agreed to pay Hackney Council such annual sum as will give them a reasonable return on the capital expenditure incurred in connection with such supply and to cover all other standing charges.

On Tuesday *Shoreditch* Council adopted a report similar to the above from their Lighting committee as to the recent conference of representatives of the boroughs of Bermondsey, Hackney, Islington, Poplar, Shoreditch, Stepney, Woolwich, East and West Ham, and the urban councils of Ilford and Leyton, when it was agreed to take united action with regard to legislation enabling municipalities to give a bulk supply of electricity at their boundaries or outside their areas, either by combining to establish a joint bulk station or stations, or by linking up the existing sources of supply, or by both methods. The committee made a similar recommendation to that of Hackney on this subject. A further recommendation was that the borough electrical engineer (Mr. C. Newton Russell) should be instructed to co-operate with other engineers in preparing a scheme for linking up existing municipal supplies or supplying from one or more large generating stations, so that the financial results of such schemes could be laid before the executive committee.

On Tuesday *Bermondsey* Council resolved to take the necessary steps for promoting, jointly with the Councils of Hackney, Islington, Poplar, Shoreditch, Stepney, Woolwich, East and West Ham and the District Councils of Ilford and Leyton, legislation relative to the supply of electricity in bulk, &c.

On Wednesday *Stepney* Council were recommended by the Electric Lighting committee to participate in the promotion of the bill, referred to above, for powers to supply electricity in bulk, &c. A special report was presented by the consulting electrical engineer (Mr. Arthur Wright) and the borough electrical engineer (Mr. W. C. P. Tapper) in reference to the compromise effected by the Council with the promoters of the Administrative County of London and District Electric Power Co.'s Bill, and they contend that had the company succeeded in getting the bill through, Stepney, by the arrangement entered into, provided they ran Osborne-street station at its full capacity, would make an annual saving of £3,289, while had the company obtained the bill with competing powers in Stepney, as originally proposed, there is no doubt that a huge loss would have been made which must have eventually ended in financial disaster for the undertaking.

*Southwark* Council have refused to send delegates to the proposed conference called by the L.C.C. to discuss the question of electricity supply in London on the 20th inst., but they have resolved that "any legislation for the supply of electricity in bulk should be initiated by the County Council."

**Malta.**—The electricity supply undertaking in Malta is owned by the Government. There are now 132 consumers, the equivalent 8 c.p. lamps connected being 18,400.

The Malta tramways (owned by Messrs. Macartney, McElroy & Co., of London) are to be opened on Feb. 23 next.

A new generating station for H.M. Dockyard is in course of construction and equipment.

A correspondent informs us that there is an opening in Malta for the introduction of ship fittings, 80 to 100 volt lamps, electric fans, bells, &c.; also for 100 to 200 volt lamps, lampholders and fittings, cables, alternating-current fans (for 100 ~) carbons, small enclosed arc lamps, switches, cutouts, &c.

**Manchester.**—On Thursday, last week, an interesting lecture was delivered by the chairman of the Electricity committee (Councillor Geo. Howarth) on "Electric Power and Lighting."

Ald. Bowes, who presided, said that nine months after the electricity works were started they had 400 customers; they now had 5,945 taking current, and last year the works turned out 33,686,000 units, when the revenue from sales amounted to £302,000, and day by day fresh applications were coming in.

Councillor Howarth touched on the question of municipal trading, and said it was the duty of any Corporation committee engaged in trading to work on strict business lines. A trading department was instituted for providing the citizens with the best article at the lowest possible price, and to keep on giving sums for relief of rates out of profits of a department was simply taxing the consumer. Indirect taxation of that kind was not wise, and he would prefer to see the profits devoted to a reduction in the price of the article supplied. The supply of electricity for power was developing, and during the last 12 months there had been an increase of 96 per cent. At present approximately half the annual output of current was taken by the Tramways department, and electricity for traction had proved a great success. The committee hoped before long to induce the Council to go further in the direction of lighting the streets by electricity than they had done up to the present. Manchester had now, he said, the largest municipal electricity undertaking in the kingdom.

**Manchester and Oldham Tramways**—A deputation from Oldham Corporation waited on Manchester Tramways committee on Wednesday to submit a proposal for a through tramway service between Piccadilly, Manchester, and Waterhead, Oldham. Under the scheme each Corporation would provide and run its proper proportion of rolling stock, the whole of the earnings on the Manchester lines to be taken by Manchester, and those on the Oldham lines by Oldham. The general manager of Manchester tramways (Mr. J. M. McElroy) is to confer with the manager of Oldham tramways (Mr. Lewis Slattery) in preparing a detailed scheme.

**Metropolitan District Railway.**—The directors have decided upon the new zone fares, which will come into operation as soon as the last steam train has been taken off and the pneumatic signalling arrangements are introduced. The new signalling system will probably be at work by the end of this month. A two-minute service will be run on the main section between the City and Gloucester-road and Earl's Court, and the company hope eventually to run a 1½ minute service.

**Milan Exhibition, 1906.**—The increased demand on the part of Italian and foreign competitors for space at the Exhibition has obliged the authorities to acquire an additional site of about 500,000 sq. ft. on the Via Buonaroti, not far from the Piazzi d'Armi, the smaller of the two exhibition sites.

The hon. executive commissioner (Mr. A. Serena, 1 and 2, Oxford-court, Cannon-st., London, E.C.) has issued particulars relating to the electrical section of this exhibition, and these are being circulated by Mr. C. P. Sparks, chairman of the Electrical and Allied Trades Section of the London Chamber of Commerce. The comprehensive character of the electrical division of the exhibition are set out in these particulars. Electric Traction comes under Division VI. and Section I. (Land Transportation), groups 33 to 37 are formed as described below:—

SECTION I. LAND TRANSPORTATION. DIVISION VI. (ELECTRIC TRACTION).

Group 33. *Generating Plant.*—Class 50: Plans, drawings, models of hydraulic, steam and gas installations and of power stations for electric traction. Class 51: Dynamos, alternators and transformers for traction purposes. Class 52: Stationary accumulators of traction type.

Group 34. *Electric Railways and Tramways.*—Class 53: Poles, supports, insulators, systems of suspension, attachment of wires, &c. Class 54: Overhead lines for long distance transmission and service lines, third rail, conductors and insulators. Class 55: Electric railway track, systems of bonding, switches, special types of permanent way for conduit and surface contact systems. Class 56: Fittings for electric lines, signalling apparatus, special telegraphs and telephones for electric railways and tramways, special steering apparatus and safety appliances, lightning arresters, &c.

Group 35. *Rolling Stock.*—Class 57: Special motors for electric traction. Class 58: Special parts of carriages for electric traction, carriages, fittings for the motormen's cabins, controllers, fittings for taking up current. Class 59: Complete motor cars for tramway service, trailers. Class 60: Complete motor cars for electric traction on main railway lines, electric locomotives, trailers. Class 61: Motor trolley vehicles on ordinary roads. Class 62: Electric accumulators for traction purposes. Class 63. Accessory services on cars, lighting, heating, &c.

Group 36. *Various Applications of Electric Traction.*—Class 64: Ropeways, aerial transportation. Class 65: Electric cranes, capstans, lifts. Class 66: Special electric plant for mines.

Group 37. *Documents.*—Class 67: Plans, designs and models in general. Class 68: Statistical information on the construction and running of electric tramways and railways, details regarding cost and profits resulting therefrom.

Division IX. is for post telegraphs and telephones. Four groups are allotted to this division (48, 50, 51 and 52) as under:—

DIVISION IX.—POSTS, TELEGRAPHS, TELEPHONES.

Group 48. *Projects.*—Class 98: Designs, models, photographs of buildings for postal, telegraph and telephone service; organisation and regulations, charges.

Group 50. *Telegraphs and Apparatus. Wireless Telegraphy* (included in maritime transportation).—Class 100: Supports, insulators, wires, crossings, erecting, laying down telegraphic apparatus, controlling and measuring instruments, appliances for telegraphing.

Group 51. Class 101: Wireless telegraphy and Marconi's apparatus.

Group 52. *Telephone Lines and Apparatus.*—Class 102: Supports, insulators, wires, cables, crossings, underground lines, telephones, microphones, standard and multiple switchboards, controlling apparatus, appliances for telephoning, phonographs and similar instruments.

In Section IV. (Manufacture and Decorative Arts) a class (No. 202) is allotted to lighting and heating apparatus, electric appliances and fittings and adjuncts for lighting in all branches.

We have previously notified that the King of Italy has given £4,000 in prizes to be awarded by the international jury of the Exhibition. Of these prizes £200 is to be given for the best method of detecting electric currents of high potential without danger to the operator. This competition will take place under the following regulations:—

*General Rules.*

1. Competitors to present their applications before Dec. 31, 1905. This may be made through a representative if the inventor desires to maintain his name secret, and in this case the party signing the application must indicate explicitly that he is acting on behalf of a person to be named hereafter. The agent must give his own address, and shall present himself to answer any official communication addressed to the interested party.

2. When lodging application for admission each competitor must remit to the executive committee of the exhibition 16s. as registration fee.

3. To the application for admission must be added not less than two copies (on one side of foolscap paper) of an intelligible description of the invention, either in Italian or French; also approximately, in detail, the cost of the appliance.

4. The chief technical conditions the appliance has to satisfy are: (*a*) Must be easy to handle, conveniently portable and not exceeding 7 lbs. (3 kilos.) in weight; (*b*) Must reliably reveal clearly and safely differences of potential of not less than 300 volts; (*c*) Must not require special conditions of application, and must give indications easily readable and of a nature to avoid all uncertainty; (*d*) Cost of the appliance must be low, wherefore (other things being equal) the most economical will be preferred. It must be easy of repair, and so constructed that the breakdowns in working to which it may be subject as a whole or in any part shall be easily detected and noticed, and such as not to give rise to any dangerous uncertainty; (*e*) Shall not be liable to easily get out of order or repair, even when subjected to very great differences of potential, or through atmospheric influences, shocks, abnormal position, &c.; (*f*) The method of mounting the parts subjected to wear and tear and exchange shall be such as to clearly disclose any getting out of order which may be dangerous.

Other clauses refer to the constitution of the jury, which will be appointed by the Executive committee of the Exhibition and by the Italian Electrotechnic Association. The exhibits under this competition will have space accorded them gratis. The decision of the jury will be final. The appliance receiving the prize, as well as others exhibited, will, of course, remain the property of the competitors. The jury may award honourable mention, without monetary prize, to those among the competitors deemed worthy of this special honour.

**Motor 'Buses as Electric Railway Feeders.**—Mersey Railway Co. have applied to Birkenhead Corporation for licences for motor omnibuses which the company propose to run in connection with their railway. The Corporation, whose tramway receipts may be adversely affected by the innovation, have so far refused the licences on the ground that only 16 in. instead of the statutory 18 in. seating space per passenger has been allowed. The Corporation themselves have a motor 'bus scheme in contemplation.

**Municipal Honours.**—Mr. Alexander Glegg, M.I.E.E., telegraph engineer, has been elected Mayor of Wandsworth (London) for 1905-6.

**Mynyddislwyn.**—The Council have assented to the application of a company for a provisional electric lighting order on condition that the Council obtain the right of purchase at 7, 14, 21, or 28 years.

**National Association of Teachers in Technical Institutes.**—Mr. W. J. Lineham presided at the annual general meeting on Saturday.

The Association, which was founded a year ago, has a membership of 300, exclusive of the affiliated Association of Teachers of Domestic Sciences. A scheme for the registration of teachers had been drawn up by the council, and a circular had been issued to members pointing out its importance upon the future status and professional position of teachers in technical institutes. A scheme for registration had already been formulated by the teachers of domestic science. In reply to a circular issued inviting criticisms, &c., suggestions were received relating principally to the applied mechanics, building construction and practical organic chemistry syllabuses. Those were under consideration, and would be forwarded to the Board of Education. The Council recommended that steps be taken at an early date to urge upon the public examining authorities the importance of securing closer connection between the examiner and the teacher.

**Ottawa (Canada).**—The electricity supply undertaking of the Ottawa Electric Co. now serves a population of 65,000 persons. There is an equivalent of 335,500 8 c.p. lamps connected to the system, the consumers numbering 7,300. There are also 540 public arc lamps. The charge for current for lighting is 3·6d., and for power from 5d. to 1d. Supply is wholly by overhead cables.

**Pontardawe.**—The Council recently decided not to apply for a provisional electric lighting order, and it is probable a company will shortly apply for an order.

**Printing Office Electrical Equipments.**—A full equipment of electrical plant and machinery has recently been put in at the offices of the "Daily Telegraph," Sydney, N.S.W. The issue of the journal for Sept. 6 contains a good account of the installation, and shows one of the large three-roll Hoe presses to which electric driving has been applied. The motor outfit of the establishment includes the driving of the paper-wetting machines, stereotyping plant, linotype machine equipment, and, in fact, all machinery and apparatus to which an electric motor can be attached. The same issue of the "Daily Telegraph" contains an interview with Mr. Kilburn Scott, who explains. in a popular manner, the advantages which electric driving introduces into such establishments.

**Presentation.**—Last week Mr. W. J. Bache was presented by the staff of Gloucester electricity works with a self-adjusting reading chair, suitably inscribed.

Mr. James Fielding, chairman of the Electricity Supply committee, made the presention in the presence of the town clerk (Mr. G. S. Blakeway), the city surveyor (Mr. R. Read) and Mr. White (Mr. Bache's chief assistant and successor) and a number of the staff. Mr. Fielding remarked that the committee had placed on record their high appreciation of the valuable services of Mr. Bache as electrical engineer, and now the staff of the works and the Guildhall were anxious to do so. Mr. Bache had been with them five or six years, and had during that time given the greatest satisfaction.

Mr. Bache, in acknowledging the presentation, said he must express to them his appreciation of the kindness and goodwill always extended to him during his residence as chief engineer. They had fortunately been able to make the works a success, thanks to the harmonious manner in which they had all worked and the consideration he had received from every member of the staff, a consideration which, he hoped, would be shown to his successor, Mr. White.

The Town Clerk paid a tribute to Mr. Bache's services, and spoke of the friendly relations existing between the staffs at the Guildhall and the electricity works.

**Provisional Order Revocation.**—The Board of Trade has revoked the Bognor Electric Lighting Order, 1899.

**Railway Signalling.**—It is announced that the London & North-Western Railway Company's Crewe station is being fitted with signal-boxes which will contain the finest electric signalling equipment in the world.

**Reading.**—The Tramways committee are obtaining a report from the manager of the tramways (Mr. W. Binns) as to the provision of roof covers for the tramcars.

**Robbing Telephone Call Boxes.**—At Marlborough-street (London) Police-court yesterday John Facer was sentenced to six months' hard labour for stealing money from a telephone call-box belonging to the National Telephone Co.

**Smoke Prosecutions.**—The Underground Electric Railway Co. of London was fined on Tuesday £10 and costs for permitting black smoke to issue from the generating station chimneys in Lots-road, Chelsea.

Mr. F. Smith (for Chelsea Council, who prosecuted) pressed for a prohibition order, but Mr. W. Stewart (for the company) said that might compel a stoppage of the electric trains and cause great inconvenience to the public. The company was doing everything possible to mitigate the smoke nuisance.

Mr. H. B. Halswell, chairman of the bench, said they could not inconvenience the public, and he granted an abatement order.

Sir Wm. Armstrong, Whitworth & Co. were summoned at Manchester on Wednesday for allowing black smoke to escape from a chimney on their works at Openshaw.

Mr. Rook, of the Corporation sanitary department, said the chimney had seven boilers connected with it for use during a certain process in the manufacture of steel plates. The defendants claimed exemption on the ground that an order against them would be an "obstruction and interference" with their business.

Mr. Openshaw, for the company, said that unless certain processes of manufacture at the Openshaw Works were to be suspended the emission of black smoke at intervals could not be avoided. Those processes were of the utmost importance. The steel plates were used for the armour plating of battleships. An ingot weighing 20 to 45 tons was heated to a certain point, and in the heated state was transferred to rollers and reduced in thickness from about 40 in. to 15 in. To obtain the requisite power seven boilers had to be worked far in excess of the ordinary steam pressure. When this plate rolling had to be done they had to use 50 per cent. more fuel and more energy to keep up the pressure than was necessary for ordinary purposes. Under a section of the Public Health Act defendants claimed exemption, because no means were known of achieving the desired results in any other way and without causing smoke. The process had to be resorted to only once or twice daily, and all efforts to prevent smoke from escaping into the atmosphere had failed. No means known to science could prevent it. If the Court made an order against them, the company could no longer carry on their manufacture of steel plates in Manchester.

Mr. C. E. Stromeyer, chief engineer of the Manchester Steam Users' Association, having given evidence in support of this view, the magistrate dismissed the summons, holding that the company were protected by the clause in the Public Health Act under which they claimed exemption.

**Southampton.**—The report of the past six months' working of the tramways states that working expenses, exclusive of cost of reconstruction of track (£4,663), which has been charged to revenue, show a decrease of about £240, and a further saving of £150 has been effected in the cost of electric energy. Traffic receipts were £26,939, against £27,464, interference in traffic by works of reconstruction being partly responsible for the decrease. The gross profit for the six months is £10,272. 10s. 8d., or after payment of the expenditure on reconstruction £4,367. 14s. 5d.

**Spain**—The tender of Don H. F. Birlayn has been accepted for a concession for the construction and working of an electric tramway in Cadiz.

**Southwick.**—The Council have decided to apply for a provisional electric lighting order provided Portslade and New Shoreham Councils also proceed with their proposed applications. Negotiations are going on with Brighton Corporation as to whether the terms offered 18 months ago for bulk supply cannot be modified.

**Suez (Egypt).**—The electricity undertaking of the Société Electrique d'Ismailia, which, besides Suez, now also supplies Port Tewfik, has a total connection equivalent to 3,000 8 c.p. lamps, and there are 87 consumers. The same company are owners of the gas undertaking, the gas being made in the electric lighting station from imported anthracite coal. The charge for electric current for lighting is 13d. per unit at Suez, and 14·3d. at Port Tewfik. For power the charge is 6·5d. The supply has been given in Suez for nearly 12 months, and the Port Tewfik extension was completed this year.

**Swanage.**—The Council have approved the electric lighting scheme submitted by Bournemouth & Poole Electric Supply Co. Current will be supplied for lighting at 7d. and for power at 2½d. per unit. An electric tramway scheme, submitted by a private company connecting the town with Bournemouth has also been approved.

**Telephone Communication with Cab Ranks.**—The Telephone Department of the G.P.O. recently arranged with the committee of the Cabmen's Shelter Fund to connect the shelters with the telephone exchanges in such manner that subscribers can call a cab from the rank, but that the apparatus cannot be used for any other purpose. Connection has already been made with a number of the ranks, and arrangements for the extension of the system are in progress.

**Underground Telegraph Wires.**—The deputy-stipendiary (Mr. Milner Jones) of Cardiff recently sat as arbitrator to hear an application by the Postmaster-General for permission to lay telegraph wires in a main thoroughfare of Cardiff.

It was explained that the postal authorities desired to erect a new trunk overhead wire for telephone purposes between Cardiff and Pontypridd, and to place several of the existing telegraph wires underground. It was contended that the efficiency of trunk telephone wires was impaired by the interposition of short sections of underground cable, and it was, therefore, desirable that telephone wires should be carried above ground.

Major O'Meara, C.M.G., assistant engineer-in-chief, gave evidence in support of the application. He said that in America they could speak 2,000 miles over the telephone on account of the overhead trunk wire system, while in England they could only speak about 700 miles, owing to the trunk wires in some towns being underground.

Mr. F. W. Ensor, for Cardiff Council, said the Corporation were desirous of giving every facility to the Post Office, but they thought that the time had come when the whole of the telegraph wires in the city should be laid underground, and they desired the Court to impose that condition. He thought the objection could not be a very serious one, as the National Telephone Co. were at present pressing the Council to allow them to place their wires underground.

Mr. W. Harpur, city engineer, also gave evidence for the Corporation.

Mr. Milner Jones gave his considered decision this week in favour of the Post office Authorities, with costs.

**Ventilation of Public Telephone Call-Boxes.**—In his report to the Corporation for the past 13 weeks the medical officer of health for the City of London states that he had recently had an opportunity of viewing a specimen of the improved cabinets which the National Telephone Co. proposed to erect in future. Ample ventilation is provided by an ingenious mechanical arrangement which keeps an opening in the roof always open except when the instrument within is in actual use. A hard, smooth, impervious material, painted in enamel, has been used for lining the interior of the new pattern call-box.

**West Ham.**—The mayor (Ald. J. Byford), who laid the foundation-stone of the new electric tramcar depot at Greengate-street, Plaistow, on Friday, said that for the year ended Sept. 30 the tramways earned £47,000, and it was fairly certain that for the second year's working (ending March, 1906) the receipts would reach £100,000. Nearly 30,000,000 passengers would be carried for this sum. They had had the most gratifying net profit of over £10,000 on the first year's working.

**Wishaw.**—Electricity supply was formally inaugurated on Friday last. Current is supplied in bulk by the Clyde Valley Electric Power Co. and distributed by the Corporation.

**Worcester.**—The Water and Sewerage committee recommend the Council to adopt electric in lieu of gas engine driven pumping plant at Bromwich, provided the Electricity committee supply current to the sewerage department at ¾d. per unit. The Electricity committee have offered to supply current at 1d. per unit up to 100,000 units per annum and ¾d. for all additional current.

**Concert.**—A bohemian concert of the Eltradion Athletic Club will be held at University Tavern, Chenies-street, Tottenham Court-road, London, W.C., to-morrow (Saturday) at 8 p.m., when Mr. A. Ewer will preside.

## TRADE NOTES AND NOTICES.

### TENDERS INVITED.

The Directors of the *Caledonian Railway Co.* invite tenders for stores for the 12 months from Jan. 1, 1906, including telegraph appliances, telephones, &c., electric lighting material and fittings, asbestos and guttapercha goods, balata belting, packings, galvanised wire, oils and grease, screws, copper rivets, cotton waste, malleable iron pipes and fittings, hardware, tools, time-pieces, &c. Specifications and forms of tender from the Stores Superintendent (Mr. Jas. Lorimer), Caledonian Railway, Charles-street, St. Rollox, Glasgow, and patterns can be inspected until Nov. 17, at the company's stores. Tenders to the secretary (Mr. J. Blackburn), 302, Buchanan-street, Glasgow, by Nov. 20. Further particulars are given in an advertisement.

*Rawtenstall* Corporation invite tenders for the electric light wiring and fittings to the new free library. Specifications from the consulting engineers (Messrs. Lacey, Sillar & Leigh), 78, King street, Manchester, after 10th inst., and specifications may also be seen at (but not obtained from) the London offices of the firm, 2, Queen Anne's-gate, Westminster, S.W. Tenders to Messrs. Lacey, Sillar & Leigh, 78, King-street, Manchester, by 20th inst. See also an advertisement.

*Torquay* Town Council invite tenders for one combined 250 kw. d.c. traction and 75 kw. a.c. steam generator set, one 200 kw. motor generator, one automatic reversible booster, one traction battery, and one traction switchboard. Applications for specifications to the town clerk (Mr. F. S. Hex), Town Hall, Torquay, before Nov. 20. See also an advertisement.

*Dublin United Tramways Co. (Ltd.)* invite tenders for supply of general stores, including car fittings, iron and steel castings, oil, electrical supplies, timber, &c., for the year ended Dec. 31, 1906. Forms of tender (after Nov. 22) from the Secretary's office, 9, Upper Sackville-street. Tenders, addressed to the Chairman, by Nov. 27. See also an advertisement.

*Ebbw Vale* Urban District Council invite tenders for free wiring and for the supply of incandescent lamps. Specifications, &c., from the consulting engineer (Mr. Reginald P. Wilson), 66, Victoria-street, Westminster, S.W. Tenders, addressed to the clerk of the Council (Mr. Thomas Hughes), Council Offices, Ebbw Vale, by noon, Nov. 25. See also an advertisement.

*Barrow-in-Furness* Corporation invite tenders for supply and erection of one 500 kw. combined steam engine and generator, one balancer booster, switchboard panels and connections for generator and booster, one water-tube boiler with superheater, one mechanical stoker, steam and exhaust pipes, valves, &c., one economiser, iron-work, one 15 ton travelling crane and one cooling tower. Tenders (addressed to Chairman of Electricity committee) to the town clerk (Mr. C. F. Preston), Town Hall, Barrow-in-Furness, by noon Nov. 13.

*Cardiff* Asylums committee require tenders by 27th inst. for battery of accumulators, with booster, engines and generators and switchboard, for Whitchurch Ayslum lighting.

*Bristol* Electrical committee require tenders for E.H.P. and L.T. three-phase cables. Particulars from the city electrical engineer, Mr. H. Faraday Proctor.

*Belfast* Improvement committee want tenders by 20th inst. for supply and erection of motor pumps and accessories, overhead travelling crane, &c.

*Leyton* Electric Lighting committee want tenders by 16th inst. for engines, with condenser, and condenser water-cooling tower.

Up to Saturday, Dec. 16, the Deputy Postmaster-General of the Australian Commonwealth will receive tenders for telephone exchange equipment and telephones, including a common battery exchange equipment complete, 700 telephones (wall sets) and 100 telephones (table sets) for use with this system, for the Postmaster General's department in *Tasmania*. Tender forms, &c., can be obtained at the General Post Offices at Hobart, Sydney, Melbourne, Brisbane, Adelaide and Perth, where plans, &c., can also be seen. The usual conditions of Commonwealth tenders must be observed, and tenders have to be sent to the Deputy Postmaster-General, Hobart, Tasmania.

Tenders will be opened on Dec. 20 at the Special Engineering School, *Bilbao*, for the supply of planing machine, cylindrical lathe, small lathe, shaping machine, filing machine, radial drilling machine, small drilling machine, and a 6 H P. electric motor. Particulars from the Secretary of the School.

*Erfurt* (Germany) Municipality have decided to add to the plant at their electricity generating station by the provision of a steam turbine at an estimated cost of 220,000 marks (about £11,000). Further particulars from the Municipal Offices, Erfurt.

Tenders will be received up to Nov. 22 at the Colonial Office, *The Hague*, for the supply of iron telegraph poles. Particulars from M. Nijhoff, the Hague (price 10d.).

## TENDERS RECEIVED AND ACCEPTED.

The following tenders have been accepted by Dublin Corporation:—

British Insulated and Helsby Cables (Ltd.), for mains extensions at £15,151. 12s.; Ferranti Limited, for sub-station switchboards, at £1,879, and for feeder panels at Fleet-street station at £160; British Electrical Transformer Co. for transformers at £2,000, with the extra outlay of £120 should the city electrical engineer consider it advisable to order an alternative design of regulating switch.

Battersea Council have accepted the tender of Mr. J. B. Garnham for the purchase of scrap copper at the electricity works at £68. 5s. per ton, and that of Oswald & Son to purchase scrap iron at 20s. and 38s. per ton.

Southwark Council have accepted the tender of Mosers Limited for seven tons of iron and steel girders at £47 (less 10s. per ton if delivered within one month), and that of the St. Pancras Ironworks Co. for 288 sq. ft. floor lights at 4s. per foot super.

The British Westinghouse Co. have received an order from Bury Corporation for six tramcars, with complete electrical equipment. The same firm is supplying six tramcars and electrical equipment for the Mansfield and District Light Railway Co.

Reavell & Co. have recently received a number of orders for their patent quadruplex direct-coupled, electrically-driven air compressors, including:—

Three 400 c.f. direct-coupled machines for the Japanese Government; one 400 c.f. machine for Eastwood, Swingler & Co., Derby; two 700 c.f. direct-coupled motor-driven air compressors for Scott & Middleton, for use on one of the London Tube Railways contracts; and two 880 c.f. direct-coupled compressors for East Rand Proprietary Mines (these compressors are direct-coupled to polyphase motors and will be the largest compressors on the Rand directly-coupled to motors of this type); three 240 c.f. compressors for Barber, Walker & Co., for Bentley colliery (these are direct-coupled to polyphase motors); one 200 c.f. direct-coupled air compressor for Messrs. Holmes & Co. (for the Bibiani Mines, West Africa, specially constructed to be easily transported, no part exceeding 350 lb. weight); two direct-coupled compressors for the British Admiralty (mounted on special steel carriages, suited for standard railway gauge), and one compressor direct-coupled to a "Gardner" engine (also mounted on a special steel carriage); three 180 c.f. compressors direct-coupled to oil engines for Sumburgh Head Lighthouse for the Northern Lighthouse Board; one 120 c.f. compressor for Manila Railway, for air lift pumping; one motor-driven compressor for Fife Coal Co.; one 170 c.f. compressor for Platt Bros., Oldham; one 160 c.f. steam-driven air compressor for Mountsorrel Granite Co.; one electrically-driven portable compressor for Swaziland Corporation.

The Hart Accumulator Co., Marshgate-lane, Stratford, have obtained a contract from Stoke-on-Trent Guardians for renewing the battery at the workhouse, Newcastle, Staffs.

Bermondsey (London) Council have accepted the following tenders for coal for the electricity works: Chas. Franklin, Shipley peas, 14s. per ton; Hinchliffe & Co., Bwllfa, 20s. per ton.

Leyton Council have accepted the tenders of the Stirling Boiler Co. for a boiler, and of the Tudor Accumulator Co. for a storage battery, in connection with the Council's electric tramway scheme.

Salford Corporation have accepted the tender of the Sturtevant Engineering Co. for motor starters.

Reigate Council have accepted the tender of the General Electric Co. for the maintenance of meters.

## BUSINESS NOTICES.

Mr. Noel Woodhouse, for 12 years with the British Insulated and Helsby Cables, Ltd., Prescot, has resigned his position as assistant contracts manager, and has commenced business with his brother, Mr. Alfred V. Woodhouse, as electrical engineers and contractors. Mr. A. V. Woodhouse, after being with the Brush Co., was until recently chief assistant engineer at Penarth for the B.E.T. Co. Messrs. Woodhouse Bros. have taken offices at 20, North John-street, Liverpool.

James Mellanby Morrish and Ernest Tumber (trading as Morrish, Tumber & Co.), electrical engineers, &c., 26, Linthorpe-road, Middlesbrough and at Thirsk, have dissolved partnership. Debts by Mr. Morrish, who continues.

Mr. E. Stanley Shoults, A.M.I.E.E., has resigned his position as chief engineer and works manager in London of the Aron Electricity Meter (Ltd.), which he has held for nearly 4 years.

Geo. Alfd. Rowland & Wm. Robinson, trading as the Virginia Electric Co., Falcon Works, Southport, have dissolved partnership. Debts by Mr. Robinson.

## BANKRUPTCIES, LIQUIDATIONS, &c.

Thos. Hill, electrical engineer, Vicarage-road, Wolverhampton, was examined at Wolverhampton on Wednesday. Liabilities £178, assets £13. Debtor commenced business in 1900 in Willenhall, with a capital of £40. Although he started business as an electrical engineer, he had no knowledge of the industry except what he had learned at school. He was continually losing money on contracts, and he had to borrow money in consequence.

At St. Albans, on Monday, the adjourned examination of Cornelius Bennet Harness, of Harness belt fame, took place.

Debtor was questioned as to some funds of which he was trustee, and as to his former bankruptcy. Debtor admitted that he traded in New Oxford-street while an undischarged bankrupt. As to his residence at Little Heath, his wife was tenant for life, and the money was advanced by his son. Examination adjourned.

The trustee has been released in the bankruptcy of Harry Cooke, electrical engineer, 102, Buccleuch-road, Normacot, Longton.

Ernst Emil Donat (trading as Donat & Co.), engineer and agent, 21, Spring-gardens, Manchester, has been adjudicated bankrupt.

The British Miller Signal Syndicate (Ltd.) is being wound up voluntarily. Mr. E. H. Stringer, 110, Cannon-street, London, E.C., is liquidator.

Claims against the British Electric Signs Co. (Ltd.) to Mr. G. Ensor Mount, 9, New Broad-street, London, E.C., by Dec. 8.

**Winding-up Petition**—A petition for winding up the British Pioneer Electric Light & Power Co. of India (Ltd.) will be heard in the High Court on 21st inst.

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**Premises to Let, &c.**—Messrs. Marshall & Co., Campbell Works, Stoke Newington, London, N., have to let premises suitable for electrical works or light engineering trades. See an advertisement.

A substantial brick-built and slated building of three floors, each 4,200 sq. ft., is advertised to be let in another column.

Mr. Adams, Chichester House, Chancery lane, London, W.C., has some factory premises in Clerkenwell and Shoreditch to let. See an advertisement.

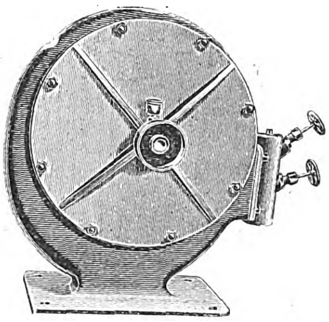
Mr. T. R. Porter, 34, New Bridge-street, London, E.C., advertises for letting (or sale) conveniently-situated warehouse premises in Belvedere-road, London, S.E.

**Plant, &c., for Sale.**—Mr. R. Archer, Horsforth, Leeds, advertises for sale Evershed testing sets.

W. H. Allen, Son & Co., Bedford, have ready for immediate delivery two three-crank three-cylinder enclosed compound engines of 440 B.H.P. each, also a compound engine and dynamo (200 kw. at 500 volts). See an advertisement.

A 1/8 H.P. water motor and a 3/4 H.P. Crossley gas engine are advertised for sale in another column.

**Catalogues, &c.**—The subject of turbines, Pelton wheels and other water motors is one which is of general interest. We would, therefore, call attention to a newly-issued catalogue by Messrs. Carrick & Ritchie, of Edinburgh, dealing with these prime movers. The special merits of these machines is concisely set out in the new list, and the illustrations which are given show the standard types of turbines which this firm have manufactured and supplied for many years. There is a special chapter on "Turbines for Electric Lighting and Transmission of Power." In this section single-discharge, double-discharge and high-pressure double-discharge combined turbines and dynamos are illustrated along with other well-known types of these combined machines. Sectional drawings showing the fixing of turbines are given. There is included in the list several examples of improved jet water wheels on the Pelton principle for high falls. The accompanying illustration shows a "Waverley" jet water motor for small powers, for use for obtaining power from town water supplies or other source where a pressure of 15 lb. per square inch and upwards can be obtained. These motors are employed in many places for driving all kinds of small machinery, and being fitted with double nozzles a great saving of water is effected when the machine is running below its maximum, as one jet may then be shut off. The information contained in the list relating to these machines, to turbine governors, to the construction of head and tail races, the storage of water, &c., makes the list a very useful one, and the group of users of these turbines which completes the catalogue gives a good idea of the many purposes for which these machines can be employed.



"WAVERLEY" JET WATER MOTOR FOR SMALL POWERS.

Messrs. Hobson, Houghton & Co., of Sheffield, have just issued two interesting lists, the one dealing with twist drills, reamers, chucks, &c., and the second with tool steel, rock drills, and steel for various purposes, steel wire, &c., with a large section devoted to files, showing all the different cuts used in general engineering work. Engineers' hammers, boiler snaps, platelayers' hammers, picks and wedges, chisels, wire drawers' tools, blacksmiths' tools, circular and other saws, saw blades, &c., comprising a very large range of these goods. Some valuable hints on the use and grinding of twist drills accompanies the second list.

The Worthington Pump Co. have issued a handsome list of air and gas compressors in which a mass of information and particulars relating to this class of apparatus is furnished. The illustrations are numerous, excellent and informing. The same company have ready a new list of turbine pumps, which is also well illustrated.

**Automatic Circuit Breakers.**—A new list (No. 4,001) of automatic circuit breakers for direct and alternating currents up to 660 volts and 2,500 amperes (for mounting independently and on front of or behind the switchboards) has just been issued by the Union Electric Co., 151, Queen Victoria-street, London, E.C. The list first deals with no-load (minimum) cut-outs of which several illustrations are given, and passes to a description of over-load (maximum) cut-outs. Fig. 1 shows one of these cut-outs. This comes into action when the exciting current of the coil reaches a predetermined maximum value. The weight of the cut-out is from 38 lb. to 40 lb. according to the pattern selected. This type of over-load cut-out is not designed for abnormally severe working conditions, and especially not for tramway circuits, which are provided for in another type of cut-out (S.S.A.) which are also listed and fully described. These latter cut-outs are designed to comply with the severest conditions arising in practical use, and particularly for tramway and power circuits, mining work, rolling mills, &c. Fig. 2 is an automatic cutout designed for alternating currents up to 250 volts. These also are made in two types, minimum and maximum. Our illustration shows a maximum cut-out, weighing 41 lb., which can be fitted if desired with change-over contacts for closing another circuit when released. This cut-out is fitted with series coil winding for protecting a motor or dynamo against overload, and can be adjusted between 100-150 per cent. of the normal working current. Fig. 3 shows an automatic double regulator, which includes a motor contact voltmeter and two safety fuses.

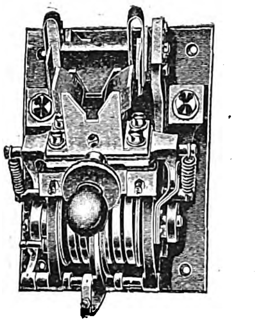


FIG. 1.—"MAX" OVERLOAD CUT-OUT FOR DIRECT CURRENTS.

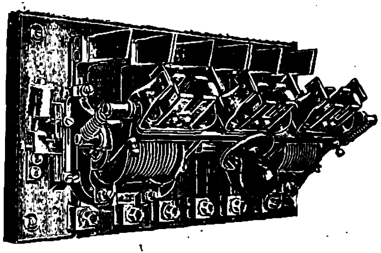


FIG. 2.—"H[illegible]" AUTOMATIC CUT-OUT FOR ALTERNATING CURRENT.

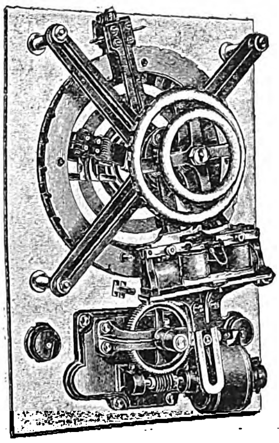


FIG. 3.—AUTOMATIC DOUBLE REGULATOR.

**Imports.**—The following are official values of imports of electrical machinery, material and apparatus into this country during Oct.:—

Electrical machinery, £48,609 (a decrease of £4,524 compared with October, 1904); telegraph cable and apparatus, £7,180 (decrease £136); other electrical goods, £91,846 (increase £28,732). The value of imports of the three classes for the ten months ended Oct. 31 were, respectively, £413,853 (decrease £63,208), £46,790 (increase £6,438) and £773,687 (increase £144,609).

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Nov. 1 to 7, with the ports of destination:—

*Africa.*—Alexandria, £90; Cape Town, £50; Delagoa Bay, £140 (telegraph material); Durban, £2,817 (including £178 telegraph material); East London, £25; Suez, £10 (telegraph material). *Argentina*—Buenos Ayres, £1,806. *Australasia*—Auckland, £2,826; Brisbane, £1,485; Fremantle, £43; Lyttelton, £47; Melbourne, £874; Otago, £371; Perth, £181; Sydney, £908 (including £160 telegraph material); Wellington, £226. *Belgium*—Ostend, £7. *Brazil*—Rio Janeiro, £683 (telegraph material). *Burma*—Rangoon, £42. *Canada*—Montreal, £2,130 (including £2,020 telegraph material). *Ceylon*—Colombo, £42. *Chili*—Valparaiso, £2,233. *China*—Shanghai, £248; Tientsin, £240. *Germany*—Hamburg, £25 (telegraph material). *Holland*—Amsterdam, £122 (including £21 telegraph material). *Hong Kong*, £22. *India*—Bombay, £740; Calcutta, £693 (including £188 telegraph material); Karachi, £838; Madras, £374. *Japan*—Nagasaki, £112; Yokohama, £209. *Madeira*, £7 (telegraph material). *Portugal*—Beira, £212; Lisbon, £22. *Russia*—St. Petersburg, £35. *Spain*—Cadiz, £563 (telegraph material). *Straits Settlements*—Penang, £267 (including £257 telegraph material); Singapore, £92 (including £25 telegraph material). *Sweden*—Stockholm, £135 (telegraph material). *United States*—New York, £75. *Zanzibar*, £32,000 (telegraph cable). Total, £54,067, against £20,924 in the corresponding week last year (Nov. 2 to 8).

# PATENT RECORD.

## APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specification. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

September 25, 1905.

19,342 LUNDBERG. Magnetic apparatus for advertising.
19,345 QUAIN. Holders and connections for incandescent lamps.
19,355 HARE. Automatically operating switches at predetermined times.
19,368 MAWDSLEY. Brush-holders for dynamo-electric machinery.*
19,372 NORTHCOTT, EYRE, TOWNSEND & HOEGERSTALDT. Electro-magnetic valves.*
19,379 DEUTSCHE GASGLÜHLICHT AKT.-GES. (Auer Ges.) Filaments for incandescent lamps. (Date applied for, Jan. 17, 1905.)*†

September 26, 1905.

19,425 OLDENBOURG. Electro-capillary apparatus.
19,447 HILL. Connector for electric conductors.
19,483 BODDAM. Electrically-operated hydraulic lifts.

September 27, 1905.

19,495 COWPER-COLES. Electric radiators or heaters.
19,504 PRENTISS. Trolley-pole controllers.
19,545 TOURTEL. Electricity meters.
19,551 DU BOIS. Electrical time switches.
19,553 NATHAN & LEYLAND. Telephones for partially deaf persons.
19,554 SKELDON & ELLIOTT. Indicating or checking devices for use with telephones.
19,561 DAVY. Arc lamps.

September 28, 1905.

19,558 HOLT & WALLIS. Electrically-controlled signals for railways.
19,603 CROMPTON & CO. & HARRIS. Automatic circuit-breakers.
19,616 SCHAULI. Batteries.
19,631 CHRISTENSEN. Primary batteries.
19,633 MILLINGTON. Sockets for electric lamps and the like.
19,638 BORCHERS, GÜNTHER & FRANKE. Electrolytic production of copper. (Date applied for, Oct. 4, 1904.)*†

September 29, 1905.

19,657 HANCHETT, CONKLING & WINN. Electric transformer controller.*
19,680 MACCALLUM. Holding and insulating flexible cords and wires in electric appliances.
19,681 SMITH & HARDEN. Metallic covering of joints in lead-covered cables.
19,684 BELL. Attaching and detaching reflectors of electric lights.
19,698 VICKERY. Electric lighting apparatus for shop window lighting.
19,706 ROACH. Replacement action for intercommunication telephones.
19,712 BLONDEL. Arc lamps.*
19,719 ELY & GROTE. Reflectors for arc lamps.*
19,746 HEWER. Trolley heads for electric tramcars.
19,749 DIECKMANN. Electrically-driven blower. (Date applied for, Feb. 11, 1905.)*†

September 30, 1905.

19,753 HAYDOCK & JONES. Insulated belts for electric tramway systems and the like.*
19,816 RUMNEY & BISHOP. Electrical fuse or cut-out boxes.
18,819 OPRENDEK. Device for strengthening telephone currents.*
19,823 HEWER. Supporting and insulating overhead conductors.

October 2, 1905.

19,853 CATON. Secondary batteries for propulsion.
19,865 WILSON & WILSON. Electric dispersion of fog.
19,867 GABEAUD. Telephones.
19,892 SIEMENS & HALSKE AKTIENGESELLSCHAFT. Hardening tantalum. (Date applied for, Oct. 13, 1904.)*†
19,899 LUNDELL. Alternating current motors.*
19,906 PARSONS & BALL. Electric clocks and clock systems.

October 3, 1905.

14,660A HARRISON. Vapour electric rectifiers and lamps for alternating current. (Date applied for, July 17, 1905.)
14,660B HARRISON. Heating and in mercury vapour electric lamps used therein. (Date applied for, July 17, 1905.)
19,912 FERRANTI. Turbine engines.
19,915 ADAM. (Downes, U.S.) Apparatus for covering wires.*
19,937 CROMPTON & CO. & TUBBS. Arc lamps.
19,967 MENSING & BRUCE, PEEBLES & CO. Insulator device for electric lamps.
19,968 MENSING & BRUCE, PEEBLES & CO. Switch.
19,969 MENSING & BRUCE, PEEBLES & CO. Case for resistance coils.
19,978 BLACKMORE. Electro-magnetic separators.
19,989 CRAVEN. Electrically opening and closing doors and operating locks.*
19,992 HAHNER. (Hahner, England.) Switches for telephones.

## SPECIFICATIONS PUBLISHED.

These may be obtained at the Sales Department of the Patent Office, Quality-court, Chancery-lane, London, W.C., at a uniform price of 8d.

PUBLISHED OCTOBER 12, 1905.

1904 SPECIFICATIONS.

18,087 KRUYSWIJK. Transmission and distribution of electric power.
19,923 HOMMEL. Electromagnets with polarised armatures. (Date applied for, Dec. 21, 1903.)
19,979 EVERETT & NEWTON. Magnetic wheels or electromagnetic motors.
20,549 CAROLAN. (G.E. Co., U.S.) Dynamo electric machines.
20,009 MUIRHEAD. Telegraphy.
21,966 BILL & BILL. Electric heat alarms.
22,706 CHAMBERLAIN & HOOKHAM & HOLDEN. Electricity meters.
22,903 B.T.-H. Co. (G.E. Co., U.S.) Controllers.
24,700 B.T.-H. Co. (G.E. Co, U.S.) Electric motor control.
24,857 CAPITO. Electricity meters.
24,876 B.T.-H. Co. (G.E. Co., U.S.) Electromagnetic speed-changing and reversing devices.
25,463 MOORE & BOURNE. Brush holders for dynamo-electric machines.
27,707 MICHAUD & DELASSON. Indestructible filament for electric lamps.

1905 SPECIFICATIONS.

403 B.T.-H. Co. (G.E.Co., U.S.) Electric heaters.
1,430 GASTON SAUTTER, HARLÉ, & REY. Compounding alternating current machines. (Date applied for, Feb. 4, 1904.)
2,001 WOOD & OAKSFORD. Agitation of electro-deposition solutions.
5,582 LAPEYRADE. Dynamo electric machines. (Date applied for, March 17, 1904.)
8,168 USENER. Telegraph apparatus.
8,890A SHOEMAKER. Wireless telegraph transmitting apparatus. (Date applied for, April 27, 1905.)
11,606 KINGSBURY. (Western Electric Co.) Telephone current retransmitting and reinforcing apparatus.

## COMPANIES' MEETINGS AND REPORTS.

### Buenos Ayres Grand National Tramways Co. (Ltd.)

The annual general meeting took place on Friday last, Mr. J. IRVING COURTENAY presiding.

The SECRETARY (Mr. F. Thomas) read the notice calling the meeting.

The CHAIRMAN then said: Gentlemen, I intend to review briefly the figures in the balance-sheet and accounts, to tell you of the progress of the electrification of the joint system of the Grand National and New Tramways Cos., and then to call your attention to the financial position of the company. The gross receipts of the Grand National Co. for the period under review are only slightly in excess of those of the previous year (£176,896. 19s., against £172,653. 16s. 2d.), and the working expenses are £130,997. 8s. 2d., compared with £128,140. 7s. 2d. Out of the £5,320. 8s. 1d. at credit of income bonds interest account it is proposed to pay interest of £5 per cent. on these bonds, and also to pay 2 per cent. on them out of the sum (£1,563. 7s. 4d.) transferred from suspense account, and to carry forward £103. 15s. 11d. The contingency fund now amounts to £8,895. 1s. 3d. The percentage of expenses to gross receipts was 74·28, a slight reduction compared with the previous year. After the strikes in November, 1904, the hours of working had to be shortened, and in consequence the wages account was considerably augmented; and the gross expenses per mile run were 0·06d. more than in the previous year. Traffic expenses increased by £2,857. 1s., mainly owing to extra men having been employed to make up for the reduction in working hours and to extra mileage (72,972) run. The number of passengers carried was 20,026,548, an increase of 665,801. The continued working of the system by horse traction was rapidly causing our lines to fall off in popularity, and had the change to electric traction been postponed any longer the company would undoubtedly have entered upon a period of decadence, the signs of which had already made themselves disagreeably apparent in our traffic returns. During my stay in Buenos Ayres last autumn I went over the whole system and noted its lines stretching right across that wide-spreading and rapidly-growing city, and visited, accompanied by the general manager, the many stations and properties of the company. I do not think that anyone, after thus studying the situation, could fail to recognise the unrivalled facilities for rapid transit the joint systems will be able to offer the public of that city, or to be convinced of the excellence of the prospects ahead of us which are only awaiting electrical development to become a paying reality. To give an illustration of the extent of the company's system, the lines now open and under construction, if they were in London, would extend from Addison-road station, near Olympia, to the Agricultural Hall and Dalston Junction via Marble Arch and Oxford-street in one direction, and at right angles in the other direction from Victoria Station to Primrose Hill. The funds for the work of conversion of the system were provided in March, 1904, by the issue of £450,000 conversion debenture stock. A construction committee was appointed, composed of members of the Grand National Co. board, as head of the organisation, with the staff of the La Capital Traction and Electric Co. in London, Buenos Ayres and New York, as the operative body under the orders of the committee. By the beginning of May, 1904, the contract for 4,300 tons of steel rails and the requisite accessories and special track work was placed, and negotiations were practically completed for the placing of an order for 150 cars. Owing to accidents to the rolls at the rail mills, unavoidable delay was experienced in the shipment of track materials, which was aggravated by the loss at sea of one of the early consignments, so that actual construction in Buenos Ayres could not be commenced until January, 1905. From January to July work proceeded at the rate of nearly 2½ miles completed per month, so that at the end of July there were 16½ miles of track completed and ¾ mile in hand. With the 3-mile portion of the Buenos Ayres new tramways system there were 19½ miles completed to the end of July. Included in the routes then completed or in hand there were 8 miles of line belonging to other companies, or in joint ownership with them, already converted to electric traction, making 27½ miles. By cable we learn that the total converted to Oct. 31 was 32½ miles, and that the sections opened to public service by electricity on Oct. 31 covered a distance of 24 miles. The gross returns for October from the lines worked by this company were $225,700 national money, an increase of $15,300 (say, £1,350) over those of the same month last year. The gross traffics for the three months ended June 30 were $623,600 in paper currency, a decrease of $34,400 compared with the corresponding period of 1904, and for the similar period ended Sept. 30, $653,500, an increase of $31,600 over the same period in 1904, showing, as a result of electrification, that the decrease which had occurred while horse traction alone was in force was being neutralised by the returns from the comparatively small portion of the system operated by electricity during the later period. It is thus obvious that the sooner the whole system is converted the better it will be for all those who hold the various shares and stocks of the company, and it is the intention of the directors to make every effort to proceed continuously with the work of electrification to completion.

Now as to the financial position of the company. The directors have for some time past had under consideration, in view of the early completion of the electrical equipment of an important section of the company's system and of the increase in the profit which may be expected therefrom, the question of the reorganisation of the company's capital account, both in regard to loan and share capital, by the consolidation of many of the outstanding issues of debentures and debenture stocks and of shares, and a bill was deposited in Parliament last session, but owing to the many difficulties and complications which arose, and which could not be settled in time, it was found impracticable to proceed therewith. Since that time the board have been in close touch with committees representative of the different classes of share and debenture holders with the result that they have formulated a scheme which, for the present, is confined to dealing with the simplification of the company's share capital, but which also makes provision for the future consolidation or unification of the company's debenture debt so soon as the proper time arrives. Such a scheme involves the conversion of the existing preference issues into a single class of share, the capitalisation of arrears of dividend on the first preference shares, and deals with the balance at the debit of profit and loss account, which would otherwise stand in the way of any distribution of profits. The directors are advised that these objects can only be carried into effect by Act of Parliament. Subject to your approval, a bill will be presented next session. I now move the adoption of the report and accounts.

The VICE-CHAIRMAN (Mr. N. G. Burch) seconded the motion. He congratulated the chairman upon the thorough grasp he had obtained of the company's position.

The CHAIRMAN, replying to questions, said the bill was not deposited, and the directors were now asking the shareholders' permission to deposit it. Notice of the bill had to be given this month, and if the measure went to a second reading, the standing orders of the House required a meeting of the shareholders to approve it or the contrary.

Mr. R. W. CAIRNS referred to the prospects of increased revenue after electrification, and put forward suggestions for the funding of dividends on the first preference shares.

Mr. READ congratulated the directors on the success of the electrification of the line, and assured them that the great body of shareholders fully sympathised with them and would give them their confidence at all times.

Mr. FOX asked the board to consider carefully whether there was not some other way of dealing with the matter.

The CHAIRMAN, in further reply, said the point he wished the shareholders to understand was that unless the company were reconstructed it would be left where it now was—in a waterlogged condition, with a debit balance of about £129,000, which must be dealt with before anyone could be paid anything. He was sure no one wished to leave the company in such a condition as that. The directors had for some months considered the matter; they had consulted all classes of shareholders about it, and they had come to the conclusion that there was no other method of reconstruction which would enable them to put the company in the position financially which they thought it should be in except by a bill in Parliament. If November passed without the bill being deposited, the Standing Orders of Parliament would not have been complied with, and the directors would then be unable to consult the shareholders about it. The proxies which had been sent in to the directors showed that there was a large consensus of opinion favourable to the deposit of the bill.

The resolution was then carried by 16 to 14.

The retiring directors (Dr. W. H. Harris and Mr. James Parker) were re-elected, as were the auditors (Messrs. Monkhouse, Stoneham & Co.), and the proceedings terminated.

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**BRITISH THOMSON-HOUSTON CO. (LTD.)**—At the meeting on Wednesday the chairman (Mr. G. Franklin) moved the adoption of the report given in our last issue, and said that the company had had "a very much longer rope to hold down" at Rugby than they had ever had before. The difficulties which arose in connection with the manufacture there, and the difficulties which had since become manifest by reason of severe competition, were sufficiently serious, and required constant attention on the part of the board.

**ELECTROLYTIC ALKALI CO. (LTD.)**—At the annual meeting on Tuesday Mr. C. C. Connor referred to certain differences of opinion among the directorate. After mature consideration the directors had acquired all the patents for improvements in processes submitted to them which they considered valuable. The company's plant stood in the books at cost, less depreciation, and the majority of the board, as well as the auditors, were satisfied that the published figures were correct. The company had suffered from influences altogether uncontrollable by the directors, and bearing that in mind they considered the report encouraging. The net trading profit was £4,200, against £500 last year. Mr. J. Hargreaves opposed the adoption of the report and maintained that certain salt plant which the company possessed was not adapted to their requirements. After a very long discussion the report was adopted.

**DRAKE & GORHAM (LTD.)**—The directors' report for the year ended June 30 states that after payment of all charges, including bonuses to staff, the net profit is £10,821. 18s. 9d., which, with £1,722. 4s. 4d. from previous year, makes £12,544. 3s. 1d. It is proposed to appropriate this by paying a dividend at rate of 6 per cent. per annum (£7,500), placing £3,000 to reserve, and carrying forward £2,014. 3s. 1d. The directors regard the increase of £2,172. 19s. in the net profit as satisfactory, as during the period under review there has been little improvement in the general condition of electrical business. The Church Stretton supply station has been started, and has worked efficiently from the commencement. In addition to Goodwood, which has been completed, the company are engaged in lighting the village of Fochabers for the Duke of Richmond and Gordon from the water-power generating station which is already supplying light to Gordon Castle. The company have been entrusted with the electrical equipment of a cotton mill in Lancashire, in which power amounting to upwards of 1,000 H.P. will be transmitted electrically. It is anticipated that this work, which has been throughout designed by the company's staff, will lead to important developments. A large number of installations have been carried out during the year, and the work in hand on June 30 was greater than at the corresponding period of the previous year. Negotiations are in progress for the acquisition on lease of further premises for factory purposes, the present arrangements affording insufficient facilities for the manufacturing department of the company's business.

## NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

### NEW COMPANIES.

**CUMBERLAND POWER SYND. (LTD.)** (86,364.)—Reg. Nov. 4, capital £5,000 in £5 shares, to adopt an agreement with J. Sturgeon, B. H. Thwaite, A. R. Chorley and J. Paterson, and to carry on, in Cumberland and elsewhere, the business of an electric power and power-gas supply company, electricians, electrical and general engineers, suppliers of electricity, &c. First directors, A. Lupton, W. F. Smith and J. T. Pullon. Reg. office, 4, South-parade, Leeds.

**JONES & LESLIE (LTD.)** (86,318.)—Reg. Oct. 31, capital £2,000 in £1 shares, to acquire and carry on business of electrical engineers, carried on as Jones & Leslie, manufacturers of electrical and other machinery, tool makers, &c. First directors, T. L. Jones, W. Jones and J. S. Jones.

**MAKIN & CO. (LTD.)** (86,357.)—Reg. Nov. 3, capital £1,000 in £1 shares, to acquire the business carried on at Sheffield as Makin & Co., and to carry on the business of electricians, electrical and mechanical engineers, &c. First directors are J. Makin and R. C. Smith, jun. Reg. office, 23 and 25, Division-street, Sheffield.

**P. M. ELECTRIC MFG. CO. (LTD.)** (86,307.)—Reg. Oct. 30, capital £2,000 in £1 shares, to carry on the business of manufacturers of and dealers in electrical apparatus, sparking plugs, induction coils, tremblers and all accessories, parts or articles used in connection with the electric portion of motor cars, launches and omnibuses and other self-propelled vehicles, manufacturers and vendors of electrical apparatus of any kind, &c. Mr. P. Baxter, permanent director.

**SAXBY & FARMER (INDIA) (LTD.)** (86,274.)—Reg. Oct. 26, capital £50,000 in £1 shares, to acquire factory of Heath and Gresham (Ltd.), Calcutta, and to carry on in any part of the world the business of railway signal and interlocking apparatus manufacturers and contractors, engineers, makers of and dealers in pneumatic and electric tools and appliances and signals, producers, storers and suppliers of electricity, &c. First directors C. Hodgson, G. Terrell and W. Wingfield.

**SOUTH AMERICAN TRACTION CO. (LTD.)** (86,332.)—Reg. Nov. 1, capital £10,000 in £1 shares, to carry on in South America or elsewhere the business of contractors for public and other works and conveniences, tramway, railway, omnibus and van proprietors, manufacturers of tramway and railway carriages, dynamos and accessories, suppliers of electricity, &c.

**TELEGRAPHIC CODE CO. (LTD.)** (86,295.)—Reg. Oct. 28, capital £2,000 in £1 shares, to carry on the business of authors, compilers, adaptors, publishers and sellers of telegraphic codes or secret cyphers, &c., and to adopt an agreement with J. G. Schütte. Reg. office, 2, Royal Exchange-buildings, London, E.C.

### STATUTORY RETURNS.

**ANGLO-PORTUGUESE TELEPHONE CO. (LTD.)**—In return to Aug. 9 capital is £100,000 in £1 shares, of which 75,000 have been taken up. £1 per share has been called up on 1,000, and £1,000 has been received. £74,000 is considered as paid on remainder. Mortgages and charges, £50,000.

**BRITISH ELECTRIC TRACTION CO. (LTD.)**—Return to Aug. 7 gives capital as £4,000,000 in 200,000 ordinary and 200,000 preference shares of £10 each, of which 133,301 ordinary and 161,437 preference have been taken up. £10 per share has been called up on 117,926 ordinary and 142,500 preference, and £2,604,250 has been received. £343,120 is considered as paid on 15,375 ordinary and 18,937 preference. Mortgages and charges, £1,847,307.

**DICK, KERR & CO. (LTD.)**—In return to Oct. 12 capital is £650,000 in 70,000 preference and 60,000 ordinary shares of £5 each, of which 61,000 preference and 52,000 ordinary have been taken up. £5 per share has been called up on 53,000 preference and £265,000 has been received. £300,000 is considered as paid on 8,000 preference and 52,000 ordinary. Mortgages and charges, £294,130.

**DIRECT WEST INDIA CABLE CO. (LTD.)**—In return to Oct. 5 capital is £120,000 in 24,000 shares of £5 each, of which 12,000 have been taken up. £2. 10s. per share has been called up and £30,000 has been received. Mortgages and charges, £74,500.

**ERNEST SCOTT & MOUNTAIN (LTD.)**—According to return to Oct. 12 capital is £150,000 in 100,000 ordinary and 50,000 preferred ordinary shares of £1 each, of which 97,790 ordinary and 29,300 preferred ordinary have been taken up. £1 per share has been called up on 75,790 ordinary and 29,300 preferred ordinary, and £105,090 has been received. 22,000 shares are considered as fully paid. A further £4. 10s. has been received in respect of one forfeited share. Mortgages and charges, £33,900.

**WITTING EBORALL & CO. (LTD.)**—Return to Oct. 9 gives capital as £40,000 in 1,150 A and 850 B shares of £20 each, of which 2,000 A and 850 B have been taken up. £4 per share has been called up on 850 B and £3,400 has been paid. £23,000 is considered as paid on 1,150 shares. Mortgages and charges, nil.

### MORTGAGES AND CHARGES.

**CHEPSTOW ELECTRIC LIGHTING & POWER CO. (LTD.)**—Issue on Oct. 7 of £1,000 first mortgage debentures, part of series created Oct. 29, 1904, to secure £3,000, charged on company's undertaking and property, present and future, including uncalled capital. Holders, India Rubber, Gutta Percha and Telegraph Works Co. No trustees. No previous issue of same series.

**CONSOLIDATED SUPPLY CO. (LTD.)**—Issue on Oct. 6 of £2,500 debentures, part of series created Sep. 22, 1905, to secure £5,000, charged on company's undertaking and property, present and future, including uncalled capital. Holders, Consolidated Electrical Co. No trustees. No previous issue of same series.

**ENGINEERING INSTRUMENTS (LTD.)**—Issue on Oct. 18 of £2,000 debentures, part of series created Oct. 9, 1905, to secure £3,000, charged on company's undertaking and property, present and future, including uncalled capital. No trustees. No previous issue of same series.

## CITY NOTES.

**MEMORANDA** (Nov. 9).—Bank rate 4 per cent. (since Sept. 28, 1905). Price of silver 29d. per oz. Consols $88\frac{9}{16}$—$88\frac{11}{16}$ for money, $88\frac{3}{4}$—$88\frac{7}{8}$ for account; $2\frac{1}{2}$ per cent. annuities $87\frac{3}{4}$—88. Consols Pay Day, Dec. 1; Stocks and Shares Continuation Day, Nov. 13; Ticket Days, Nov. 14 and 29; Pay Day, Nov. 15; Mining Share Carry-over Day, Nov. 10.

**AMAZON TELEGRAPH CO. (LTD.)**—The accounts for the year ended June 30 show a net profit, after providing for interest charges and service of debentures, of £9,836, reducing the debit balance forward to £78,235.

**CASTNER-KELLNER ALKALI CO. (LTD.)**—The directors have declared an interim dividend for the six months ended Sept. 30 at the rate of 4 per cent.

**COMPAGNIE FRANCAISE DES TRAMWAYS ELECTRIQUES ET OMNIBUS DE BORDEAUX.**—The directors announce that a dividend for the half-year ended June 30 will be payable on 15th inst as follows: 4·80f. on registered shares, by endorsement on certificate; 4·59f. on bearer shares.

**W. T. HENLEY'S TELEGRAPH WORKS CO. (LTD.)**—The list of applications will open on Monday next, and will close on or before 4 p.m. Thursday, Nov. 16, in an issue of £150,000 of $4\frac{1}{2}$ per cent. first mortgage debenture stock in the above company. This issue forms part of a total authorised issue of £300,000. Subscriptions are invited for £108,022 at par, in multiples of £1, the balance of the issue being allotted to holders of the existing debenture stock (in the circumstances mentioned below). 10 per cent. is payable on application, 40 per cent. on allotment, and 50 per cent. on June 1. The stock will be secured by a first charge upon the company's freehold works at North Woolwich and Gravesend, on the leasehold offices of the company, and by a floating charge upon the undertaking and all the other properties of the company whatsoever. Interest will be payable June 1 and Dec. 1 in each year, the first half-year's interest upon the 50 per cent. payable on application and allotment will be paid on June 1, 1906. The stock is irredeemable for a period of 10 years from Dec. 1 next, after which the whole or any part may be redeemed at the company's option on six months' notice at 105 per cent. An abridged prospectus of this issue appears on another page. W. T. Henley's Telegraph Works Co. was established as far back as 1880, to acquire the then old-established business of Mr. W. T. Henley, one of the first firms to become associated with the electrical industry in this country. The company's position in this industry is firmly established, and the particulars which are set out in the full prospectus show the extent of the company's business. The total assets, without any allowance for goodwill, reached at Dec. 31 last the formidable sum of £726,718. 14s. 5d. The last 10 years' ordinary dividends range from 8 per cent. in 1895 to 10, 12, 14, 15, 20 and 15 per cent. respectively in subsequent years. For the last two years the ordinary dividend has been 15 per cent. The reserve account at Dec. 31 last stood at £120,000. The nett profit for the year ended Dec. 31 last was £38,263. 11s. 4d. After paying debenture interest, directors' remuneration, auditors' fees, income tax, and allowing £4,500 for depreciation of machinery, &c., the total amount required to meet the interest on the present issue of debenture stock is £6,750, or less than one-sixth of last year's net profits.

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | | Amount. | Inc. or Dec. (a) | AGGREGATE. No. of weeks. | AGGREGATE. Amount. | AGGREGATE. Inc. or Dec. (a) |
|---|---|---|---|---|---|---|---|
| | | | £ | £ | | £ | £ |
| Aberdeen Corporation | Nov. | 4 | 1,249 | + 48 | 28 | 34,173 | − 1,566 |
| Airdrie | Oct. | 27 | 207 | − 19 | 43 | 8,843 | + 121 |
| Anglo-Argentine | Nov. | 4 | 14,020 | + 576 | 44 | 585,899 | + 36,832 |
| Ayr Corporation | " | 4 | 184 | − 3 | 25 | 9,287 | − 128 |
| Barcelona Trams Co. | ... | | ... | ... | ... | ... | ... |
| Barcelona, Ensanche, Gracia | ... | | ... | ... | ... | ... | ... |
| Barnsley | Oct. | 27 | 155 | − 12 | 43 | 6,952 | − 314 |
| *Barrow | " | 27 | 208 | + 7 | 43 | 10,525 | + 2,122 |
| Bath Electric Trams, Ltd. | Nov. | 1 | 645 | + 64 | 44 | 30,365 | + 1,818 |
| Birkenhead | ... | | ... | ... | ... | ... | ... |
| Birmingham Corporation | " | 4 | 588 | + 80 | 31 | 11,220 | + 1,888 |
| *Birmingham & Mid. | Oct. | 27 | 1,861 | − 152 | 43 | 68,953 | + 395 |
| Blackpool Corporation | Nov. | 2 | 340 | − 10 | 31 | 42,955 | + 1,365 |
| Blackpool and Fleetwood | " | 4 | 249 | − 85 | 18 | 18,860 | − 1,014 |
| Bolton Corporation | " | 5 | 1,641 | + 147 | 32 | 62,232 | + 2,287 |
| Bournemouth Corporation | " | 1 | 1,389 | + 417 | †30 | 45,119 | + 8,116 |
| Bradford Corporation | " | 4 | 3,952 | + 26 | 31 | 139,867 | − 7,524 |
| Brighton Corporation | " | 5 | 799 | − 55 | 32 | 34,504 | + 476 |
| Bristol Trams & Carriage | " | 3 | 4,711 | + 52 | 18 | 65,377 | + 902 |
| Buenos Ayres & Belgrano | " | 5 | 3,762 | + 450 | 44 | 152,484 | + 7,221 |
| Buenos Ayres Elec. Trams | Oct. | 7 | 1,336 | ... | 40 | 46,227 | ... |
| Burnley Corporation | Nov. | 4 | 1,064 | + 109 | 31 | 45,189 | + 2,082 |
| Burton Corporation | " | 5 | 275 | − 15 | §31 | 10,135 | − 1,290 |
| Bury Corporation | Oct. | 29 | 699 | ... | §30 | 22,647 | ... |
| Calcutta Tramways Co. | Nov. | 4 | R44,038 | + R7,770 | 18 | R765,922 | + R96,639 |
| Camborne-Redruth | " | 4 | 105 | − 11 | 1 | 105 | ... |
| Cardiff Corporation | Oct. | 28 | 1,866 | + 8 | 31 | 65,880 | + 282 |
| | Nov. | 4 | 1,980 | + 91 | | | |
| Carlisle Tramways Co. | " | 4 | 163 | − 8 | 44 | 548 | − 649 |
| Cavehill | ... | | ... | ... | ... | ... | ... |
| Central London Railway | " | 4 | 6,895 | + 62 | 18 | 109,651 | − 1,208 |
| Chatham & Dist. Lt. Rys. | " | 2 | 596 | + 72 | 44 | 29,291 | + 3,090 |
| *City of Birm'gh'm Tram Co. | Oct. | 27 | 5,066 | − 291 | 43 | 231,852 | + 1,103 |
| City & South London Rly. | Nov. | 5 | 3,035 | + 234 | 18 | 44,389 | − 71 |
| Colchester Corporation | " | 2 | 156 | − 28 | 14 | 4,218 | − 1,214 |
| Cork Electric Trams Co. | " | 2 | 414 | − 43 | 44 | 21,567 | + 675 |
| Devonport & Dist. Trams | Oct. | 27 | 424 | − 97 | 43 | 20,042 | − 3,052 |
| Dover Corporation | Nov. | 4 | 202 | + 17 | 31 | 7,533 | − 112 |
| Dublin & Lucan Railway | " | 3 | 97 | − 15 | 18 | 2,453 | + 12 |
| Dublin Southern District | " | 3 | 795 | − 43 | 18 | 94,256 | − 951 |
| Dublin United | " | 3 | 3,842 | + 66 | | | |
| Dudley—Stourbridge | Oct. | 27 | 796 | − 15 | 43 | 89,046 | + 1,526 |
| Dundee Corporation | Nov. | 1 | 924 | + 107 | §24 | 22,323 | + 1,109 |
| East Ham Council | " | 4 | 763 | + 127 | 31 | 26,412 | + 2,767 |
| Gateshead & Dist. Trams | Oct. | 27 | 929 | + 28 | 43 | 39,656 | + 722 |
| Glasgow Corporation | Nov. | 4 | 15,400 | + 870 | 28 | 347,659 | + 17,113 |
| Glossop | ... | | ... | ... | ... | ... | ... |
| Gloucester Corporation | " | 1 | 243 | + 14 | 31 | 9,769 | ... |
| Gravesend—Northfleet | Oct. | 27 | 193 | − 18 | 43 | 10,101 | − 953 |
| Gt. Northern & City Rly. | Nov. | 4 | 1,670 | + 258 | 18 | 27,018 | + 6,478 |
| Greenock & Port Glasgow | Oct. | 27 | 676 | + 69 | 43 | 27,993 | + 3,039 |
| Halifax Corporation | " | 25 | 1,464 | + 95 | 30 | 49,683 | + 2,583 |
| Hartlepool Tramways | " | 27 | 246 | − 16 | 43 | 11,593 | − 1,197 |
| Hastings Elec. Trams Co. | Nov. | 2 | 866 | ... | 13 | 7,961 | ... |
| Huddersfield | " | 4 | 1,813 | + 130 | 32 | 43,004 | + 1,372 |
| Hull Corporation | " | 4 | 2,195 | + 23 | 31 | 69,809 | + 544 |
| Ilford Dist. Coun. | " | 4 | 413 | + 41 | 32 | 15,168 | + 265 |
| Ipswich Corporation | " | 4 | 356 | − 14 | 31 | 14,497 | − 1,728 |
| Isle of Thanet Co. | " | 4 | 271 | − 47 | 5 | 1,615 | − 412 |
| Kidderminster & District | Oct. | 27 | 93 | − 13 | 43 | 5,350 | − 311 |
| Kilmarnock Corporation | ... | | ... | ... | ... | ... | ... |
| Kirkcaldy Corporation | Nov. | 1 | 194 | − 4 | 9 | 1,836 | − 56 |
| Lanarkshire Trams Co. | " | 2 | 840 | + 117 | 44 | 82,796 | + 3,927 |
| Leamington | Oct. | 27 | 131 | + 17 | 15 | 3,140 | + 1,192 |
| Leeds Corporation | Nov. | 4 | 5,546 | + 185 | 31 | 191,929 | + 3,858 |
| Leicester Corporation | " | 4 | 1,972 | + 293 | 44 | 91,761 | + 28,676 |
| Liverpool Corporation | Oct. | 28 | 10,222 | + 45 | 43 | 455,912 | + 8,663 |
| Liverpool Overhead Rly. | Nov. | 5 | 1,340 | − 148 | 18 | 29,301 | − 1,272 |
| *London County Council | Oct. | 28 | 11,052 | + 1,060 | 30 | 465,579 | + 65,452 |
| Lowestoft | Nov. | 4 | 165 | + 15 | 5 | 832 | − 81 |
| Maidstone Corporation | " | 2 | 97 | − 29 | 31 | 4,222 | ... |
| Manchester Corporation | " | 4 | 12,681 | + 651 | 31 | 406,225 | + 16,415 |
| Mersey Railway | " | 4 | 1,612 | + 58 | 18 | 28,115 | + 1,714 |
| Merthyr | Oct. | 27 | 176 | − 12 | 43 | 8,213 | − 464 |
| *Metropolitan Elec. Trams | " | 27 | 2,6 6 | + 814 | 43 | 115,455 | + 50,340 |
| Middleton | " | 27 | 299 | − 12 | 43 | 14,806 | + 602 |
| Musselburgh | " | 26 | 181 | ... | 17 | 4,680 | ... |
| Nelson Corporation | Nov. | 4 | 127 | + 24 | 32 | 4,280 | + 400 |
| Newcastle-on-Tyne Corp. | " | 4 | 8,884 | + 229 | 31 | 120,275 | + 3,005 |
| Newport (Mon.) | " | 5 | 559 | + 77 | 5 | 2,704 | + 268 |
| Northampton Corporation | " | 3 | 877 | + 11 | 20 | 13,958 | + 4,790 |
| Oldham, Ashton & Hyde | Oct. | 27 | 661 | + 21 | 43 | 24,090 | + 456 |
| Oldham Corporation | Nov. | 5 | 1,606 | + 366 | 32 | 53,099 | + 14,249 |
| Perth (W. A.) Elec. Trams | " | 3 | 1,430 | + 183 | 44 | 60,329 | + 3,600 |
| Peterborough | Oct. | 27 | 86 | − 30 | 43 | 5,993 | − 622 |
| Pontypridd Dist. Council | Nov. | 4 | 141 | ... | 31 | 5,201 | ... |
| Portsmouth Corporation | " | 4 | 1,562 | + 19 | 31 | 67,278 | + 1,128 |
| Potteries | Oct. | 27 | 1,796 | + 15 | 43 | 78,256 | + 403 |
| Preston Corporation | Nov. | 1 | 601 | ... | 5 | 20,887 | ... |
| Reading Corporation | " | 2 | 580 | − 17 | 5 | 2,899 | − 196 |
| Rotherham Corporation | " | 2 | 447 | + 31 | 31 | 14,227 | − 721 |
| Rothesay | Oct. | 27 | 46 | + 5 | 43 | 9,298 | + 2,648 |
| Salford Corporation | Nov. | 6 | 4,050 | + 153 | 32 | 137,892 | + 6,671 |
| Sheerness | Oct. | 25 | 53 | − 5 | 43 | 8,094 | + 289 |
| Sheffield Corporation | Nov. | 5 | 4,616 | + 175 | 32 | 158,631 | + 7,071 |
| Southampton Corporation | " | 1 | 893 | + 18 | †5 | 4,026 | − 437 |
| Southend Corporation | ... | | ... | ... | ... | ... | ... |
| Southport Tramways | Oct. | 27 | 282 | − 42 | 43 | 13,813 | − 498 |
| S. Staffordshire Trams. | " | 27 | 792 | + 91 | 43 | 31,609 | + 1,080 |
| Stockport Corporation | Nov. | 3 | 802 | + 310 | 31 | 24,793 | + 6,011 |
| Sunderland Corporation | " | 5 | 1,167 | + 70 | 31 | 42,417 | + 1,152 |
| Swansea Trams | Oct. | 27 | 734 | + 216 | 43 | 31,020 | + 7,514 |
| Swindon Corporation | ... | | ... | ... | ... | ... | ... |
| Tynemouth and District | " | 27 | 195 | − 16 | 43 | 11,585 | − 1,555 |
| Tyneside Trams Co. | Nov. | 1 | 371 | + 29 | 44 | 18,417 | + 1,026 |
| Wallasey District Council | " | 4 | 683 | + 21 | 31 | 25,213 | + 669 |
| Walsall | " | 4 | 498 | + 37 | 43 | 21,639 | + 265 |
| Warrington Corporation | " | 2 | 336 | + 26 | 31 | 10,666 | + 525 |
| West Ham Corporation | " | 2 | 1,934 | + 360 | 31 | 55,957 | + 23,478 |
| Weston-super-Mare | Oct. | 25 | 88 | − 12 | 43 | 6,613 | + 614 |
| Wolverhampton Corpn. | Nov. | 1 | 749 | ... | 5 | 8,841 | ... |
| Wolverhampton District | Oct. | 27 | 401 | + 31 | 43 | 17,117 | + 171 |
| *Worcester | " | 27 | 240 | − 42 | 43 | 13,314 | + 484 |
| Wrexham | " | 27 | 96 | − 2 | 43 | 4,896 | − 388 |
| Yorkshire Woollen District | " | 27 | 660 | + 140 | 43 | 28,286 | + 2,897 |

(a) These comparisons are with the corresponding period last year. † Minus 3 days. § Plus 2 days. * Partly electrical.

£41,978 of the present issue is to be allocated to paying off the holders of £44,800 of existing debenture stock at a premium of 10 per cent., and part of this issue will, as above mentioned, be allotted to them in pursuance of this arrangement, and the balance in cash. Copies of the prospectus can be obtained from the secretary, Mr. A. E. Salmon, 13 and 14, Blomfield-street, London Wall, London, E.C.; or from the bankers or brokers of the company (Messrs. Barclay & Co., 54, Lombard-street, and Shorters, Son & Co., 26, Birchin-lane, London, E.C.).

**RAND CENTRAL ELECTRIC WORKS (LTD.)**—The result of the working for October is 882,000 units generated, yielding a gross revenue of £8,200, compared with 841,000 units, yielding £7,950 for the corresponding period of last year.

**MONTREAL LIGHT, HEAT & POWER CO.**—The directors have declared a dividend at the rate of 4 per cent. per annum for the three months to Oct. 31.

**STOCK EXCHANGE NOTICES.**—The Stock Exchange committee have appointed Nov. 22 a special settling day in 6,635 £1 fully-paid ordinary shares and £116,667 5 per cent. first mortgage debenture stock of *Johnson & Phillips (Ltd.)* and have granted a quotation to partly-paid provisional certificates for £120,500 6 per cent. construction debenture stock of the *Indian Electric Supply & Traction Co. (Ltd.)* The committee have been asked to allow a further issue of £35,900 5 per cent. £100 debentures of the *Amazon Telegraph Co. (Ltd.)* to be quoted.

**WEST INDIA & PANAMA TELEGRAPH CO. (LTD.)**—The directors will recommend at the approaching meeting that a dividend of 6s. per share be declared on account of arrears of dividend on the first preference shares.

## COLONIAL AND FOREIGN INVESTMENTS.

| SHARE. | LAST DIVIDEND | NAME. | Price Wed., Nov. 8. | RATE PER CENT. YIELDED. | DIVIDEND DUE. | BUSINESS, WEEK TO NOV. 8. Highest. | BUSINESS, WEEK TO NOV. 8. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | £ s. d. | | | |
| 5 | 3/0 | Anglo-Argentine Ord. Shares | 8⅝—8⅞ | 4 19 5 | Ap, Oct | 8 3/32 | 8¾ |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞—6⅛ | 4 9 8 | — | 6 1/16 | 5 31/32 |
| St. | 6% | Do. Permanent 6% Deb. Stock | 141 —144 | 4 3 3 | — | 143½ | 142 |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 105 —107 | 4 13 5 | — | 106¼ | .. |
| 10 | 12/0 | Barcelona Tramways Ord. | 13¾—14¼ | 4 4 0 | — | .. | .. |
| 10 | 5/0 | Do. 5% Cum. Pref. | 9½—10 | 5 0 0 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock (red.) | 97 —102 | 4 8 8 | — | .. | .. |
| 100 | 5% | Do. 5 per Cent. Debs. | 93 —101 | 4 19 0 | — | .. | .. |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1 —1½ | .. | .. | .. | .. |
| 5 | 2/6 | † Do. 5 per Cent. Cum. Pref. | 3¾—4¼ | 5 17 8 | — | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 95 —98 | 4 12 0 | — | 99 | .. |
| St. | 6% | †British Columbia Elec. Rlwy Def. Ord. | 124 —127 | 4 14 6 | — | 126 | 25 |
| St. | 5% | Do. Pref. Ord. Stock | 111 —114 | 4 7 9 | — | .. | .. |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock | 108 —109 | 4 11 8 | — | 108½ | 108 |
| 40 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs | 103%—105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 102 —105 | 4 5 9 | — | 101 | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | 3 11/16—3 15/16 | 5 1 6 | — | 3⅞ | 3 11/16 |
| 5 | 8/0 | Do. 6 per Cent. "A" Cm. Pref | 5 11/16—5 15/16 | 5 2 0 | — | 5 13/16 | 5⅝ |
| 5 | 8/0 | Do. "B" | 5 —5½ | 5 9 1 | — | 5 5/16 | 5 3/16 |
| St. | 5% | Do. 5 per Cent. Debs. | 106 —108 | 4 12 6 | — | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102 —105 | 4 16 3 | — | .. | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 98 —100 | 5 0 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 101 —105 | 5 4 9 | .. | .. | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 101 —108 | 5 11 1 | .. | .. | .. |
| 5 | 8/6 | Calcutta Tramways (Nos. 1 to 105) | 9¼—9¾ | 4 7 2 | — | 9 9/16 | 9½ |
| 5 | 0/3 | Do. Nos. 105,001 to 137,610 | 8½—9 | .. | .. | 8½ | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 107 —109 | 4 2 7 | — | .. | .. |
| 1 | 0/6 | Cape Electric Tram Shares | 1 —1¼ | 4 0 0 | — | 1 1/16 | 1 |
| St. | 5% | †Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 101 —103 | 4 17 2 | — | .. | .. |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 97 —99% | .. | .. | 98½ | 97¼ |
| 1 | .. | Lisbon Elec. Trams Ord. | 1 5/16—1⅜ | .. | .. | 1⅜ | [illegible] |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛—1¼ | 4 15 0 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 100 —103 | 4 17 0 | .. | 101 | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 103 —105 | 4 15 3 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101 —104 | 4 16 2 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102 —104 | 4 6 7 | — | — | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 104 —107 | 4 13 5 | .. | .. | — |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 145 — 148 | 5 8 1 | .. | .. | .. |
| .. | .. | Do. 5% 1st Mt. $100 Dbs. | 100 —102 | .. | .. | 101 | .. |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | 5/0 | Calcutta Elec (1-30,000) ex new | 9 —9½ | 4 4 2 | — | .. | .. |
| 5 | 2/1¾ | Do. (60,001-80,000) ex new | 9 - 9½ | 4 14 9 | .. | .. | .. |
| 10 | 1% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50 —52 | 4 16 1 | .. | .. | .. |
| .. | .. | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 96 —98 | .. | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½—3 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Debs. | 85 —90 | 5 11 1 | — | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | 9 —10 | — | — | .. | .. |
| 100 | 15/6 | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 94 —96 | 5 4 2 | .. | .. | .. |
| St. | .. | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. 50% pd. | 60 —62 | .. | .. | — | .. |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | 1 1/32—1 1/16 | 5 13 0 | — | .. | — |
| 1 | 1/0 | Rand Electric | 1 1/16—1 3/16 | .. | — | .. | — |
| 1 | .. | River Plate Electricity Co. Ord. | ⅝—¾ | .. | .. | .. | .. |
| 1 | .. | Do. 6% Non. Cum. Pref | 1⅛—1 3/16 | .. | .. | .. | .. |
| St. | .. | Do. 5% Deb. Stock | 102 —104 | .. | .. | 103½ | .. |
| 5 | 8/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5⅞—6⅛ | 5 6 8 | .. | .. | .. |
| 5 | 9·13d | Do. (12,001-20,000) | 5 —5½ | 3 8 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100 —103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 10/9 | Shawinigan Water and Power 5% Bds., Scrip | 99 —101 | 4 19 0 | .. | 100 | .. |

* In calculating the yield, allowance has been made for accrued interest but not for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Share. | Last Dividend | Name. | Price Wed., Nov. 8. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business, Week to Nov. 8. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| 1 | .. | Bath Elec. Trams Pref. Ord. | 15/16–1 | .. | .. | 1⅛ | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16–1 1/16 | 4 14 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 103–105 | 4 6 9 | .. | 103¾ | .. |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 104–106 | 4 5 9 | .. | 104¾ | .. |
| 10 | 9% | Bristol Tramways and Carriage Ord. | 17–17½ | 5 2 11 | Feb, Aug | .. | – |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10–10½ | 3 18 0 | .. | .. | – |
| St. | 4% | Do. 4 per Cent. Debs. | 105–107 | 3 14 10 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 9⅞–10¼ | 5 17 0 | – | 10 1/16 | 9 15/16 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 11–11½ | 5 4 4 | Feb, Aug | 11 5/16 | 11 1/16 |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 120–122 | 4 2 0 | .. | 122½ | 121 |
| St. | 4½% | † Do. 4½ per Cent. 2nd Deb. Stock | 98–100 | 4 10 0 | .. | 99 | 98 |
| St. | 4% | Central London Ordinary Stock | 92–94 | 4 5 1 | June, Dec | 93 | 92⅞ |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 101–103 | 3 17 8 | .. | 102 | .. |
| St. | 4% | Do. Deferred Stock | 83–86 | 4 13 1 | .. | 84 | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 110–112 | 3 11 5 | .. | 111¼ | .. |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 4⅞–5⅛ | 4 17 6 | .. | 5⅛ | 5 |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 100–103 | 3 17 8 | .. | .. | .. |
| St. | 2% | City and South London Rly. Con. Ord. | 43–45 | 4 4 6 | Feb, Aug | 45 | 43½ |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 118–121 | 4 2 8 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 117–120 | 4 3 4 | .. | .. | .. |
| St. | 5% | Do. (1901) | 113–116 | 4 6 8 | – | .. | .. |
| St. | 4% | † Do. 4 per Cent. Perpetual Debs | 105–108 | 3 14 1 | May, Nov | 107 | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13½–14½ | 4 2 8 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 15–16 | 3 5 0 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5¼–6¼ | 6 19 2 | .. | 5¾ | 5½ |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8–9 | 4 8 11 | .. | 8¼ | – |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 100–102 | 4 8 8 | .. | – | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 17–18 | 5 0 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 13¾–14¼ | 4 4 2 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 108–110 | 4 1 10 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼–2¾ | 9 8 6 | – | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 83–88 | 4 10 11 | – | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8⅛–8⅜ | 3 13 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾–10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99–102 | 3 19 3 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9¾–10¼ | 4 17 6 | – | 10 1/16 | .. |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 100–103 | 3 17 8 | – | 102¾ | 101 |
| St. | .. | Mersey Con. Ord. Stock | 7–9 | – | – | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8–11 | – | – | 8⅝ | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32–9/32 | .. | – | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1–1 1/16 | 4 14 1 | – | 1 1/32 | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106–108 | 4 3 3 | – | 106¼ | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½–1½ | .. | May | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾–9¼ | 5 5 8 | .. | .. | – |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9¼–9¾ | 5 2 6 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103–106 | 4 4 10 | – | .. | .. |
| 1 | – | South Lancs. Elec. Trac. & Power Ord. | .. | .. | – | .. | .. |
| 1 | – | Do. 6% Pref. (£1 paid) | – | – | April, Oct | – | – |
| St. | – | Do. 4½% Deb. Stock (100% paid) | .. | .. | Jan, July | – | – |
| 100 | .. | Sunderland Dist. Elec. Trams. 5% 1st Mort. Debs. | 95–99 | .. | .. | .. | .. |
| .. | 5% | Underground Elec. Rys. Co. of London | 99½–100½ | 4 19 6 | .. | .. | .. |
| St. | 3% | Waterloo and City Ord. | 87–89 | 3 7 5 | June, Dec | .. | .. |
| St. | 12/11 | Yorkshire W. R. Elec. Trams Co. 4% 1st Debs. | 95–97 | 4 2 6 | .. | 96 | 95 |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | * African Direct Tel. 4% Mrt. Deb. (red.) | 99–102 | 3 18 5 | Jan, July | – | .. |
| 10 | – | Amazon Telegraph | 4–4½ | .. | Jn, Dec .. | 4 7/16 | 2 1/16 |
| 100 | .. | Do. 5% Debs. (red.) | 83–88 | 5 13 7 | .. | 85½ | .. |
| St. | 15/0 | Anglo-American | 60–62 | 4 16 9 | F, My, Ag, N | 61½ | 60 |
| St. | 30/0 | Do. Preferred | 107½–108½ | 5 9 0 | F, My, Ag, N | 108½ | 107½ |
| St. | 2/0 | Do. Deferred | 16⅛–16⅝ | .. | F, My Ag, N | 16 5/16 | 15⅞ |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 96–98 | 4 1 8 | Jn Ap, Jy, O | 99 | 97 |
| 10 | 5/0 | † Cuba Submarine Ord. | 8¾–9¼ | 5 8 8 | Feb, Aug | 9 1/32 | .. |
| 10 | 10/0 | † Do. Preference 10 per Cent. | 17–18 | 5 11 2 | Feb, Aug | .. | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜–3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 9¼–9¾ | 5 2 6 | April, Oct | .. | .. |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 100%–103% | 4 7 5 | Jan, July | .. | .. |
| 20 | 8/0 | Direct United States Cable. | 13½–14½ | 4 9 8 | Ja, Ap, Jy, O | 14 3/16 | 13 13/16 |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 100–102 | 4 8 8 | Jn, Dec .. | .. | .. |
| St. | 25/0 | Eastern Ordinary | 143–146 | 4 15 10 | Ja, Ap, Jy, O | 146 | 144½ |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 89–91 | 3 16 11 | Ja Ap, Jy, O | 90¼ | 89 |
| St. | 4% | † Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 106–108 | 3 14 1 | May, Nov | 107¾ | .. |
| 10 | 2/6 | Eastern Extension | 14½–15 | 4 18 4 | Ja, Ap, Jy, O | 14¾ | 14 7/16 |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 106–108 | 3 14 1 | Feb, Aug | 107¼ | 107¼ |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 99–101 | 3 19 2 | Feb, Aug | .. | .. |
| 25 | 4% | † Do. 4% Mauritius Sub. Debr. (red.) | 99½%–101½% | 3 18 9 | May, Nov | 99½ | .. |
| 10 | 5/0 | G. N. (of Copenhagen) | 35½–36½ | 6 16 11 | Jan, July | 36⅝ | .. |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 100–102 | 4 8 3 | June, Dec | .. | .. |
| 25 | 12/6 | † Indo-European | 55–57 | 5 14 0 | May, Nov | 57 | 55 |
| 100 | $1 | Mackay Companies Common | 50 3/16 | 3 18 9 | Jan, July | .. | .. |
| 100 | 4% | Do. Preference | 74 1/16 | 5 7 0 | Ja, Ap, Jy, O | .. | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1⅜–1½ | .. | .. | .. | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 100–103 | 3 17 8 | June, Dec | 100 | .. |
| 10 | 5/0 | West African Telegraph Shares | 10–10½ | 4 15 8 | .. | .. | .. |
| 2½ | .. | West Coast of America | 9/16–11/16 | .. | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100–102 | 3 18 5 | Jan, July | .. | .. |
| 10 | .. | West India and Panama | 1⅛–1⅜ | .. | May, Nov | – | .. |
| 10 | 5/0 | Do. 6% 1st Pref. | 8½–9 | 6 13 4 | May, Nov | .. | .. |
| 10 | – | Do. 6 per Cent. 2nd Pref. | 7¼–7¾ | .. | May, Nov | 7¼ | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 101–104 | 4 16 2 | Jan, July | .. | .. |
| 10 | 8/0 | Western Telegraph | 14¼–14¾ | 4 15 0 | Mr, Jn, O, D | 14 9/16 | 14½ |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 101–103 | 4 17 1 | June, Dec | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 102½–104½ | 3 16 5 | .. | 104 | .. |
| | | **TELEPHONES.** | | | | | |
| 5 | 5/0 | Chili Telephone (fully paid) | 7¼–7¾ | 5 3 8 | August | .. | .. |
| 1 | 0/9 | † Monte Video Telephone Ord. | [illegible] | 3 14 5 | – | .. | .. |
| 1 | 1/0 | † Do. 6% Pref. | [illegible] | 5 4 6 | .. | .. | .. |
| St. | 6% | National Co. Pref. Stock | 111½–112½ | 5 6 8 | – | 112½ | 111¾ |
| St. | 5% | Do. Def. Stock | 106½–107½ | 4 13 0 | – | 107¾ | 106½ |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13–15 | 4 0 0 | Feb, Aug | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 12–13 | 4 12 4 | Feb, Aug | 12 11/16 | 12¼ |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅝–5⅞ | 4 5 2 | Feb, Aug | 5 13/16 | 5 11/16 |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 97–99 | 3 10 8 | June, Dec | 99 | 97¼ |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 104–106 | 3 15 6 | – | 104½ | .. |
| 1 | 0/7½ | † Oriental | 1¼–1⅜ | 3 12 9 | April, Oct | 1 11/32 | .. |
| 1 | 0/7½ | † Do. 6 per Cent. Cum. Pref. | 1 3/16–1 5/16 | 4 11 6 | – | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 102–105 | 4 5 9 | .. | .. | .. |
| 5 | 5/0 | United River Plate | 7–7½ | 5 6 8 | July | 7½ | 7¼ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝–5⅞ | 4 8 10 | June, Dec | 5 9/16 | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 110–112 | 4 10 3 | June, Dec | .. | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 4¾–5¼ | 5 14 4 | .. | .. | .. |
| 10 | 2/0 | † Globe Telegraph and Trust | 10⅝–10⅞ | 5 1 0 | Ja, Ap, Jy O | 10⅝ | 10 5/16 |
| 10 | 3/0 | † Do. 6 per Cent. Pref | 14⅛–14⅝ | 4 8 0 | Ja Ap, Jy, O | 14⅝ | 14⅛ |
| 10 | 6% | Submarine Cables Trust (Cert.) | 125–128 | 4 13 9 | April, Oct | .. | .. |

| Share. | Last Dividend | Name | Price Wed., Nov. 8. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Busine Week Nov. Highest. |
|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12¼–12¾ | 5 9 10 | .. | 12⅝ |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10⅜–10⅝ | 4 4 9 | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 12¼–12½ | 4 18 0 | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 107–109 | 4 2 6 | .. | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼–5¾ | 4 15 8 | .. | 5⅝ |
| St. | 4½% | † Do. Do. 1st Debs | 102–105 | 4 5 9 | – | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 9½–10 | 5 0 0 | – | 9⅞ |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 6¼–6¾ | 5 11 9 | Mar, Sept | – |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 105–108 | 3 14 1 | – | 105 |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 7–7½ | 4 6 8 | Feb, Aug | .. |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 6¼–6¾ | 3 18 8 | Feb, Aug | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 103–105 | 3 16 2 | – | .. |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4¾–5 | 4 10 0 | – | .. |
| 5 | 2/3 | Do. Do. (1908) | 4¾–5 | 4 10 0 | .. | 4⅝ |
| 5 | 2/3 | Chelsea Electric Supply Ord. | 5¾–6¼ | 4 16 0 | March .. | 6⅛ |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 110–112 | 4 0 4 | Jn, Dec .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 11¾–12¼ | 4 18 0 | Feb, Aug | 12¼ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | [illegible] | 4 4 2 | Jan, July | 13 9/16 |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 124–128 | 3 18 1 | Jn, Dec .. | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 104–106 | 4 4 10 | .. | .. |
| 5 | .. | County of Durham Elec. P. D. Ord. £2 pd. | 2 3/16–2¼ | .. | April, Oct | .. |
| 5 | [illegible] | Do. Do. 5% non cum. pref. | 5⅜–5½ | .. | April, Oct | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 9¾–10¼ | 4 7 10 | – | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅝–12⅞ | 4 13 2 | Mar, Sept | .. |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 111–114 | 3 18 11 | .. | 113 |
| St. | 4½% | † Do. Second Deb. Stock Prov. Certs. | 102–104 | 4 6 7 | .. | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼–5¾ | 4 15 8 | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5–5½ | 4 11 9 | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 100–103 | 4 7 5 | – | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8¼–8¾ | 4 17 2 | .. | .. |
| St. | 4½% | † I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100–103 | 4 7 5 | – | .. |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 11½–12¼ | 4 14 1½ | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½–7 | 4 5 9 | Jan, July | – |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98–101 | 3 19 2 | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101–103 | 3 17 8 | .. | .. |
| 8 | 1/9⅜ | London Electric Supply Ord. | 1¾–2¼ | 4 0 0 | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5–5¼ | 5 14 4 | .. | 5 |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 99–102 | 3 18 5 | Mr, Jn, S, D | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 10–10½ | 5 4 9 | April, Oct | 10 1/16 |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5⅝–5⅞ | 3 16 8 | Jan. July | 5 13/16 |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 109–113 | 3 19 7 | Jn, Dec .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 97–99 | 3 10 8 | – | 97½ |
| 100 | 4½% | Midland Elec. Corp. for P. D. 1st Mort. Db. | 101–103% | 4 7 5 | – | 102½ |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 12½–12¾ | 5 19 1 | Feb, Aug | .. |
| 100 | .. | Do. 4½% Deb. | 104½–106½ | .. | Jan, July | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8 1/16–8¼ | 4 18 2 | Feb, Aug | 8 1/16 |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6 5/16–6 7/16 | 3 17 8 | Feb, Aug | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99–100 | 4 0 0 | Jan, July | .. |
| 1 | 8% | Northern Counties Elec. Sup. 17/- paid | [illegible] | 3 1 1 | Mar, Aug | .. |
| 100 | .. | Do. 4½% Deb. | 100½–101½ | .. | Jan, July | .. |
| 10 | 6/0 | Notting Hill Electric Ord. | 14–15 | 4 0 0 | March.... | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98–100 | 4 0 0 | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅜–6⅞ | 5 1 6 | March .. | 6 11/16 |
| St. | 4% | Do. 4% Deb. Stock | 100–102 | 3 18 5 | – | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 13½–14½ | 5 3 5 | Feb, Aug | 13⅝ |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 8½–9½ | 3 13 8 | Feb, Aug | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 98–100 | 3 10 0 | – | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2–2½ | 8 0 0 | .. | 2 1/32 |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76–80 | 5 0 0 | – | .. |
| 5 | 4/0 | South London Electric Supply Ord | 3½–4 | 5 0 0 | .. | .. |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | 1⅜–1⅝ | .. | .. | .. |
| 1 | 0/8¾ | Do. 7% Cum. Pref. | 1 5/16–1 7/16 | 4 17 2 | .. | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105–108 | 4 3 8 | – | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4½–4¾ | 5 5 8 | – | .. |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5–5¼ | 4 15 8 | – | .. |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 104–106 | 4 4 10 | .. | 104¾ |
| 5 | 6/6 | Westminster Electric Supply Ord. | 12⅜–12⅞ | 5 8 8 | Mar, Sept | 12¾ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 6–6½ | 3 16 11 | .. | 6⅝ |
| | | **ELECTRIC MANUFACTURING, &c.** | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝–⅞ | 5 6 6 | – | – |
| 1 | 6d. | Aron Elec. Meter 6% Cum. Pref. | ½–⅝ | .. | .. | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | [illegible] | 5 0 0 | .. | 1⅛ |
| 1 | 7½d. | Do. Pref | 1 7/16–1 9/16 | 3 16 10 | .. | 1 3/16 |
| 5 | [illegible] | British Insulated & Helsby Cables Ord. | 6⅞–7¼ | 5 10 8 | July, Feb | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾–6¼ | 4 16 0 | Jan, July | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103–106 | 4 4 11 | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98–100 | 4 10 0 | .. | .. |
| 5 | 3/0 | British Westinghouse 6% Pref. | 2¼–2⅝ | 11 4 6 | .. | 2 15/32 |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 86–89 | 4 9 11 | .. | .. |
| 2 | .. | Brush Electrical Engineering | ½–¾ | .. | March .. | .. |
| 2 | 2/4½ | Do. 6 per Cent. Pref. Non-Cum. | 1½–1¾ | 6 17 2 | Mar, Sept | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 93–97 | 4 12 10 | Mar, Sept | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 77–80 | 5 12 6 | Jan, July | .. |
| 5 | 5/0 | † Callender's Cable Con. Ord. | 11–12 | 5 0 0 | Jan, July | 11⅛ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝–5⅞ | 4 5 2 | Jan, July | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 109–111 | 4 1 1 | Nov, May | .. |
| 1 | 9⅜d. | Castner-Kellner Alkali Co. | ⅞–1 1/16 | 3 15 4 | .. | 1 1/32 |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 97–102 | 4 8 8 | – | 99 |
| 1 | 9⅞d. | Chadburn's (Ship) Telegraph Ord. | 1 3/16–1 5/16 | 4 10 6 | .. | 1¼ |
| 1 | 7⅛d. | Do. 6% Cum. Pref. | 1 1/16–1 3/16 | 5 2 7 | .. | .. |
| 8 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 1½–1¾ | 4 0 0 | Jan, July | 2 |
| 100 | 5% | Do. 5 per Cent. 1st Mort. Debs. (red.) | 94–99 | 5 1 0 | Jan, July | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord | 8¾–9 | 5 11 1 | Sept | 8 13/16 |
| 5 | 3/0 | Do. 6% Cum. Pref. | 6–6½ | 4 16 0 | Sept | 6¼ |
| St. | 4½% | Do. 4½% Deb. Stock | 106–108 | 4 4 1 | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅜–1⅝ | .. | Feb, Aug | 1 15/32 |
| 5 | 2/6 | Do. (£5 paid) | 2–2½ | .. | Feb, Aug | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 85–90 | 4 8 11 | June, Dec | 86 |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92–97 | 5 8 1 | .. | .. |
| 5 | 4/6 | Edmundson's Elec. Corp. Ord. | 5½–6 | 5 16 8 | H'lf-yearly | 5 13/16 |
| 5 | 3/0 | † Do. 6 per Cent. Cum. Pref. | 6–6¼ | 4 16 0 | .. | 6⅛ |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 109–111 | 4 1 1 | .. | .. |
| 2 | 1/7½ | Electric Construction Co. | ⅝–⅞ | 8 0 0 | July | .. |
| 2 | 2/9⅜ | Do. 7 per Cent. Cum. Pref | 1⅞–2⅜ | 5 18 8 | July | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 92–95 | 4 4 2 | Jan, July | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9½–10 | 5 0 0 | .. | 9½ |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96–100 | 4 0 0 | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 12–13 | 5 15 5 | Feb, Aug | .. |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5⅛–5⅜ | 4 8 7 | Feb, Aug | 5⅛ |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | 109–111 | 4 1 1 | Feb, Aug | .. |
| 10 | 5/0 | India Rubber, Gutta Percha, &c., Wrks. | 15½–16½ | 3 0 7½ | Feb, Aug | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99–102 | 3 18 5 | Mar, Sept | .. |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¼–11¾ | 4 5 1 | Mar, Sept | .. |
| 12 | 12/0 | Telegraph Construction & Mainten'ce. | 33–35 | 5 2 10 | Mar, July | 33½ |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 102–104 | 3 16 11 | Jan, July | .. |
| 5 | – | Willans and Robinson Ord. | 1½–2 | – | Apr, Oct | 1⅝ |
| 5 | – | Do. 6 per Cent. Cum. Pref. | 2½–3½ | – | Apr. Oct | .. |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 77–82 | 4 16 8 | May Nov | .. |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote thes

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WANTED.—LIGHTING BATTERY for 110-volt circuit, and REGULATING SWITCHBOARD.—Particulars to ROSE BROS., Albion Works, Gainsborough.

GENERATING SET, second-hand, WANTED, about 100 H.P., two-phase, 200-250 volts, or engine only, suitable for attaching alternator.—Full particulars, measurements, age, price, &c., to K. X., care of J. W. Vickers, 5, Nicholas-lane, London, E.C.

WANTED, OLD COPPER and other METALS and ASHES. Good prices given.—DAW, Tudor Refinery, Llanelly.

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FOR SALE.—WATER MOTOR, well finished from brass castings ($\frac{1}{8}$-H.P.); also Gas Engine, Crossley type, in perfect working order ($\frac{3}{4}$-H.P.); castings cost £4. 10s., perfectly new.—Address, "Z.O. 105," Messrs. DEACON'S, Leadenhall-street, London, E.C.

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GLASS SHADES for Electric Lighting in every variety of design and colour.—JOHN WALSH WALSH, Glass Manufacturer, Birmingham.

ACCUMULATORS TESTED. Write for Scale of Fees.—WESTMINSTER ELECTRICAL TESTING LABORATORY, York Mansion, York-street, Westminster, London, S.W.

Telegrams: Turnstile London.

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GOLD MEDAL St. Louis, 1904.

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## TENDERS INVITED.

### CITY OF LAUNCESTON, TASMANIA.

ELECTRIC LIGHT DEPARTMENT.

**TENDERS FOR SUPPLY OF METERS.**

The Mayor and Aldermen of the City of Launceston, Tasmania, are prepared to receive TENDERS for the Supply of 500 or more ELECTRIC METERS and for MAXIMUM DEMAND INDICATORS.

Specifications and Conditions of Contract in duplicate may be obtained on application to Mr. William Corin, City Electrical Engineer, Launceston, Tasmania, or to Messrs. John Terry & Co., 7, Great Winchester-street, London, E.C., England, on payment of Two Guineas, which sum will be refunded on receipt of a bona fide Tender.

Sealed Tenders, endorsed "Tenders for Supply of Electric Meters," must be addressed to the undersigned and lodged in his Office not later than 12 o'clock noon on MONDAY, the 15th day of January, 1906.

Town Hall, Launceston, Tasmania,
25th September, 1905.

C. W. ROCHER, Town Clerk.

### BECKENHAM URBAN DISTRICT COUNCIL.

The Beckenham Urban District Council invite TENDERS for the Supply, Delivery and Erection of **TWO 250kw. DIRECT-CURRENT RAILWAY GENERATORS**, direct-coupled to Two High-speed Vertical Enclosed-type Engines

The attention of firms proposing to submit Tenders is particularly called to the time of delivery, which will be an essential feature of the Contract and which must not in any case exceed three months from the date of the Order, including delivery and erection.

Particulars may be obtained at the offices of the Consulting Engineer, Mr. Reginald P. Wilson, of 66, Victoria-street, Westminster, or Mr. John A. Angell, Surveyor, Council Offices, Beckenham, on deposit of the sum of £2. 2s., which will be returned on receipt of a bona fide Tender.

Tenders, duly sealed and endorsed "Tender for Railway Generators," to reach the undersigned not later than 12 noon THURSDAY, 23rd November, 1905.

The Council do not bind themselves to accept the lowest or any Tender.

F. STEVENS, Clerk to the Council.

THE SALFORD CORPORATION invite TENDERS for the **WIRING** of the Higher Grade Council School for Girls, Victor-street, Salford.

Specification and Form of Tender may be obtained, and Plans and General Conditions inspected, at the Office of the Borough Electrical Engineer, Electricity Works, Frederick-road, Pendleton on payment of a deposit of £1. 1s., which will be refunded on receipt of a bona fide Tender. Duplicate copies 2s. 6d. each, not returnable.

Sealed Tenders, endorsed "Tender for Wiring Higher Grade Council School for Girls," to be delivered at the Office of the Director of Education, Chapel-street, Salford, on or before the 30th NOVEMBER next.

The Corporation do not bind themselves to accept the lowest or any Tender.

L. C. EVANS, Town Clerk.

Town Hall, Salford, 15th November, 1905.

**TENDERS INVITED** continued on next page.

**GAMBRELL BROS.** MANUFACTURERS of ELECTRICAL TESTING INSTRUMENTS.

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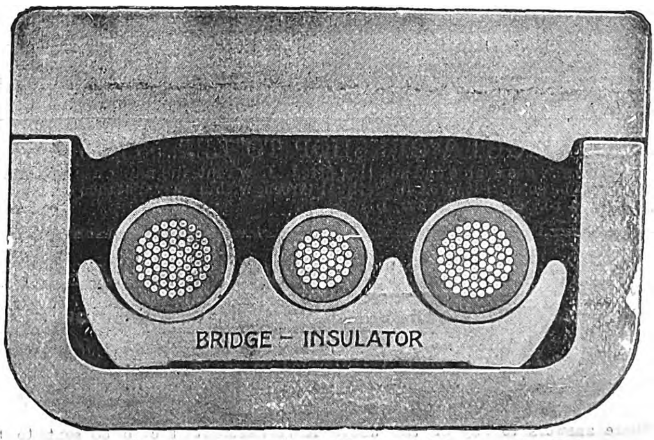
*FURTHER PARTICULARS & QUOTATIONS ON APPLICATION.*



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## TENDERS INVITED—*continued.*

### POPLAR UNION.

The Guardians of the Poor of the Poplar Union are prepared to receive TENDERS for the Supply and Erection of the following **PLANT** at the Children's Homes and Schools now in course of erection at Hutton, Essex:—

Section X. STEAM ENGINES, DYNAMOS, PIPEWORK, &c.
Section Y. Part 1. MAIN SWITCHBOARD, WIRING, MOTORS, &c.
" " Part 2. FIRE ALARMS, TELEPHONES and ELECTRIC BELLS.

Persons desirous of tendering may obtain the General Conditions, Specifications and Schedules and inspect Plans at the Offices of the Consulting Engineer, Mr. Albion T. Snell, M.Inst.C E., Suffolk House, 5, Laurence Pountney-hill, Cannon-street, E.C., between the hours of 10 and 4, on and after the 21st day of November, upon depositing in notes or gold the sum of £10 for Section X, and £20 for Section Y, which sum will be returned upon receipt of bona fide Tenders.

Contractors will be required to pay all workmen employed the trade union rate of wages, and to observe the hours of labour current in the district.

Sealed Tenders upon the Forms supplied, addressed to me, are to be delivered at these Offices before six o'clock p m. on WEDNESDAY, the 13th day of December, 1905, when they will be opened at a meeting of the Guardians.

The Guardians do not bind themselves to accept the lowest or any Tender.

G. HERBERT LOUGH, Clerk to the Guardians.

Guardian's Offices, 45, Upper North-street,
Poplar, E., November 15th, 1905.

## FACTORIES & WAREHOUSES TO LET & WANTED.

TO BE LET, FACTORY PREMISES, substantially-built brick and slated building of three floors, each 4,200 super ft. Lift, water and gas each floor. Chimney shaft in engine house, adjoining, on ground floor. Lease about 17 years, £250 per annum. Also long iron-roofed Shed, 150 ft. by 30 ft., suitable for storage, motor garage, or repairing factory, &c. Lease about 17 years, £100 per annum. Also large open Space, 81 ft. frontage to Bow Common-lane, about 6,000 super ft. Lease about 17 years, £60 per annum. Can be seen any time. —Apply on Premises, Invicta Mills, Bow Common-lane, London, E.

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MANUFACTURING PREMISES to be LET on LEASE, situate in South London, on main road, 5 miles from London Bridge; two minutes from railway station; electric trams will shortly pass the door; premises nearly an acre in extent, with substantial brick-built buildings, having a floor area of about 15,500 ft.; chimney shaft 110 ft. high. Engines and boiler could be taken at valuation. Water obtainable from well.—Apply, EXECUTOR, 40, Loampit-vale, Lewisham, London, S.E.

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FACTORIES.—Clerkenwell, ground floor, 1,200 ft., £120; basement, 800 ft., £50. Shoreditch, first floor, 1,200 ft., £65; ground floor, 1,200 ft., £80.—ADAMS, Chichester House, Chancery-lane (between 83 and 84) London, E.C. 2137 Holborn.

WAREHOUSES, large and commodious, TO BE LET or SOLD, having a frontage of 140 ft. to Belvedere-road, Lambeth, with three floors, office, crane, lifts, &c. Recently erected, and suitable for any business.—Further particulars and order to view, apply to T. E. PORTER, 34, New Bridge-street, London, E.C. Tel. 1336 Holborn.

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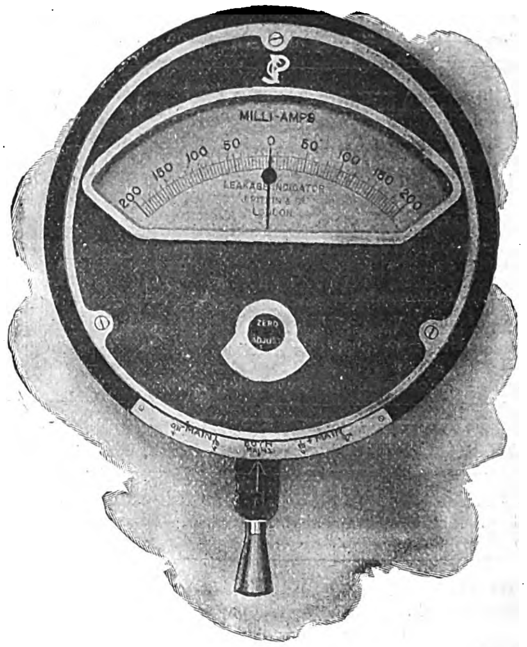

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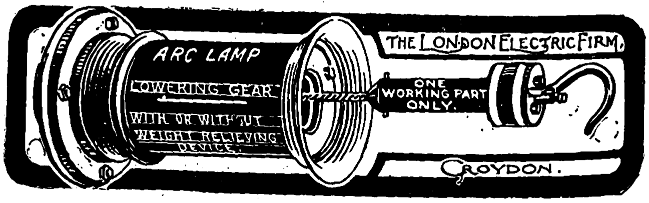

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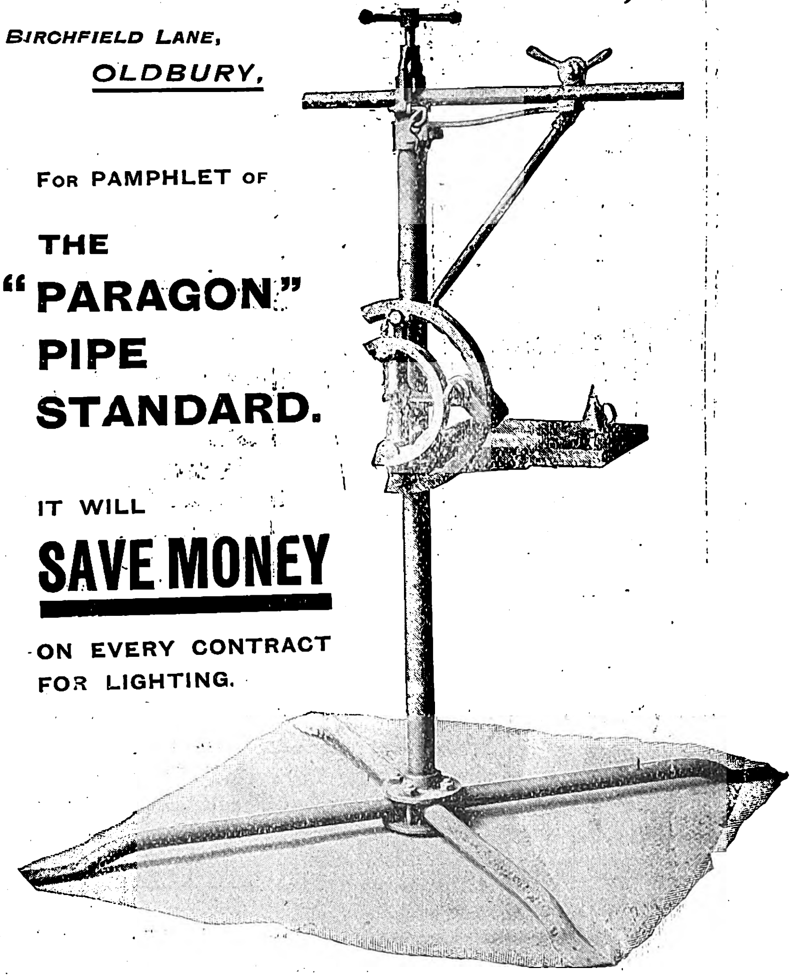

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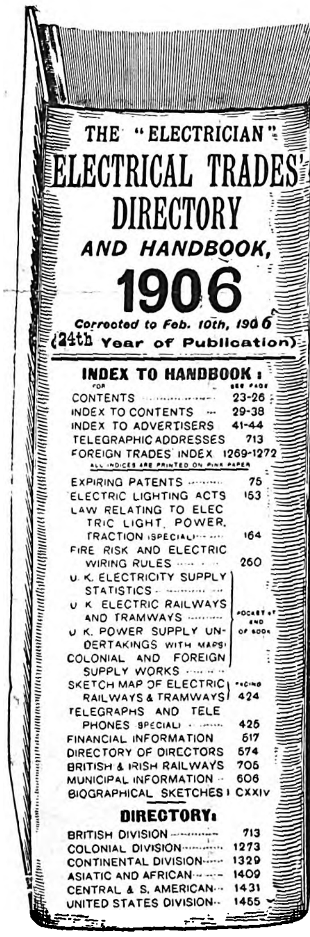

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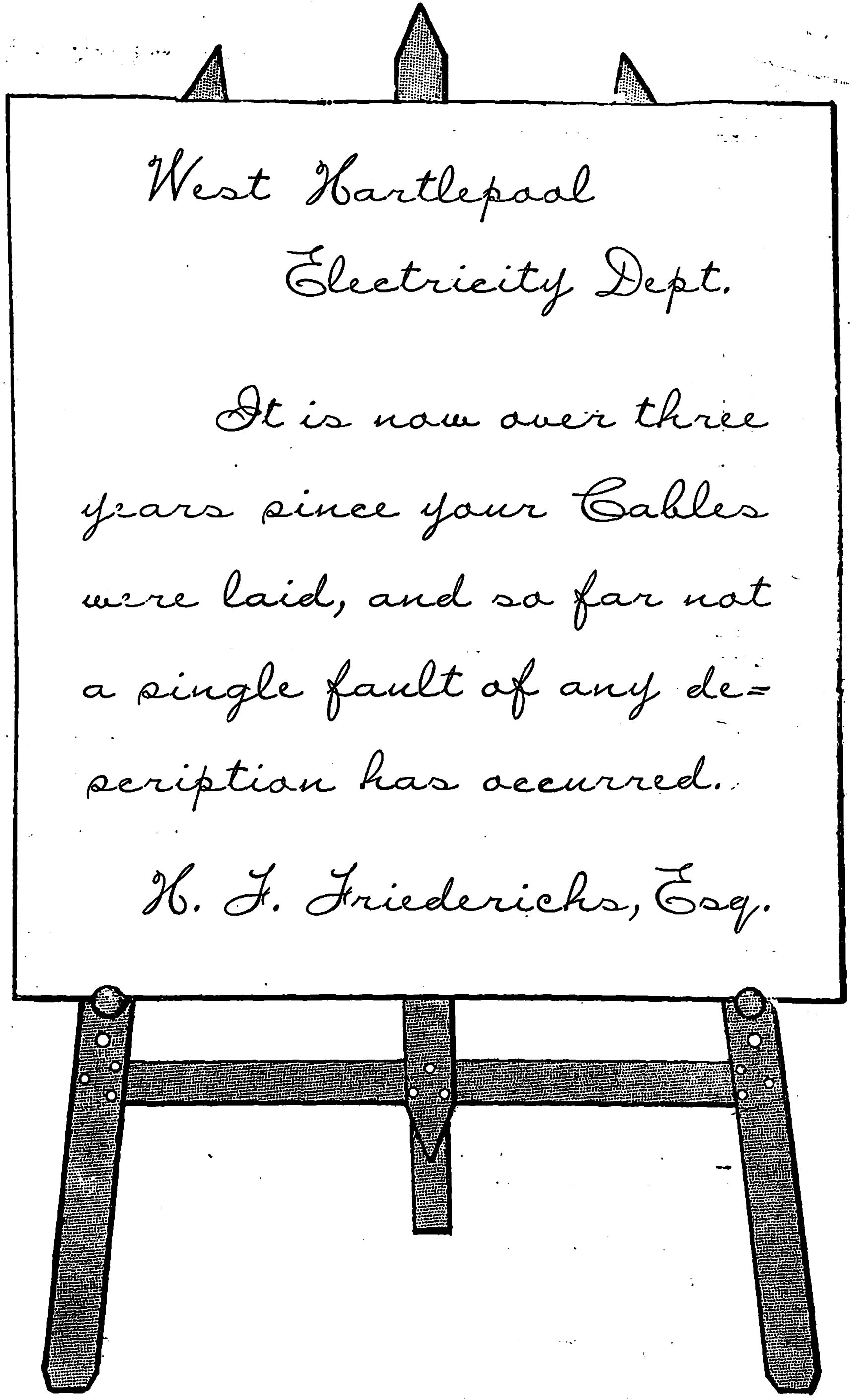

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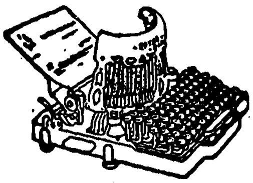

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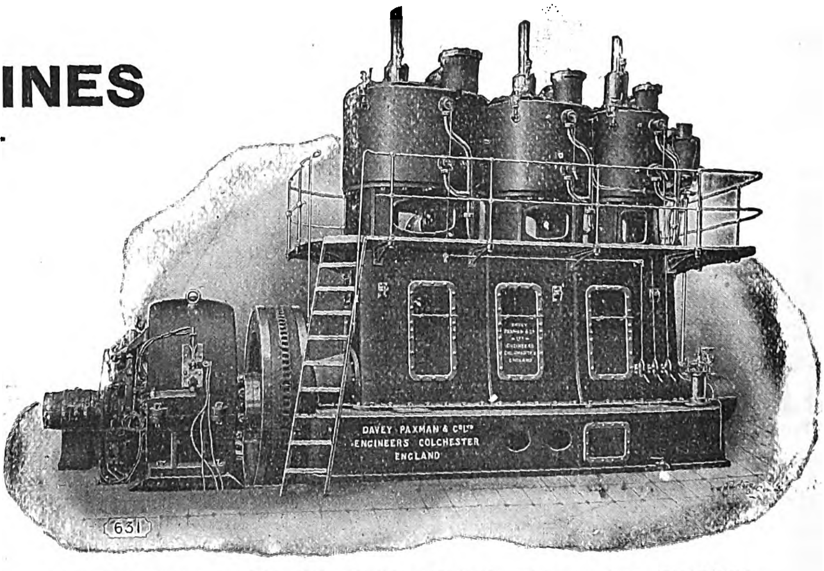

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## NOTES.

It has been our usual custom in recent years to publish the full text of the Institution of Electrical Engineers' Presidential Address on the day following its delivery; but we were prevented from doing this last week by the fact that the oscillographs used as lantern slides to illustrate the latter part of the address were not available until a late hour on Thursday. We were able, however, to publish the first part of the address and to give a summary pointing out and commenting on the leading features of the whole. This week we print the remainder of the address, and we have reproduced on an enlarged scale portions of the oscillographs illustrating it.

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Much enthusiasm has been aroused among telegraph and telephone men by Mr. Gavey's defence of the status of the telegraph and telephone engineer. Whether the importance of the work which this engineer has to carry out be brought home to the mind of his "heavy" engineering confrère better by quoting cubic yards of clay and tons of copper or by calling attention to the intricate and complex problems involved in the design and construction of a telephone exchange is immaterial; he justly resents the imputation that he is not an engineer or even that his engineering is not of an equally high class as that, for instance, involved in the erection of electricity works or the manufacture of heavy units of machinery and plant. We are glad that Mr. Gavey spoke up so bravely for the "milli-ampere man."

◆

Designers of continuous-current traction plant have been increasingly busy of late in attempting to stem the invasion of single-phase traction in lines of medium length by designing continuous-current motors for high voltages and applying the three-wire principle to railway working. In this respect we would remind our readers of the Grenoble–Chapareillan Tramway with 1,200 volts continuous between the outers, of the St. Georges de Commiers–La Mure Railway with 2,400 volts between the outers and four motors permanently connected in series, and of the Vienna Railway which is now being built with 3,000 volts continuous between the outers. It is recognised, of course, that the possibility of transforming alternating voltages up and down with the utmost efficiency and reliability places alternating-current traction in an unassailable position in connection with long lines. For lines of medium length, however, where extra high-tension would conduce to little or no advantage beyond those obtainable with moderately high voltages, high-tension continuous-current traction has still excellent chances. In such cases, in fact, the transmission of electrical energy must take second place in the consideration of the problem, and the cheapness and efficiency of the car equipment becomes the factor which decides between the two competing systems.

◆

In view of the well-known advantages of the continuous-current series motor for lines on which rapid acceleration is of chief importance, we have no doubt that the 1,500-volt continuous-current traction motors built and tested by the eminent Swiss firm of J. J. Rieter & Co. will awaken considerable interest among traction men. The design of these motors, described on another page, differs but slightly from standard traction practice. Auxiliary commutating devices were not found necessary, as good commutation could be secured by employing a very large number of commutator segments and providing a large neutral zone, thus increasing the reluctance of the magnetic path of the short-circuited coils. An unusual feature is the employment of wood wedges in the place of binding wire. Four motors of this type in series would allow the trolley voltage to be raised to 6,000 volts or more—*i.e.*, a voltage which has not often been exceeded in alternating-current traction systems.

Most local authorities owning electricity supply undertakings are anxious that their electrical engineers should attend the annual conference of the Incorporated Municipal Electrical Association, and they are quite willing to pay all expenses. "The spirit is willing, but the flesh is weak," however, for the Local Government Board refuses to sanction such expenditure. At the last annual general meeting of the Association, Ald. Pearson, of Bristol, said he had brought the matter before the Local Government Board, and had met with no encouragement. Now, the Urban District Council of St. Annes-on-the-Sea has brought forward a resolution asking the Executive committee of the Association to make "strong representations" to the Board with reference to this matter, and has sent a circular to other Local Authorities asking their collaboration. We fear that this effort is doomed to failure, even if the Executive Committee deems it expedient to take the suggested step, for the refusal of the Local Government Board was very decided on the previous occasion. There is, however, another and much simpler alternative, which was mentioned at the Incorporated Municipal Association Conference although it was not taken then as a serious suggestion. The Local Authority can make it a condition of the electrical engineer's appointment that he attend the Conference of the Municipal Electrical Association at his own expense, and in fixing his salary due consideration would be taken of this obligation. The difficulty still remains with regard to the expenses of members of the Electricity Committee who may accompany the engineer, but we may safely leave it to themselves to find a way out.

Representations are again being made to the London County Council by certain of the Borough Councils, that the powers to enable the latter to undertake the wiring and fitting of consumers' premises for electric supply be again applied for in the coming session. Already the suggestion has been rejected twice by Parliament, and we hope the municipal electric supply authorities of London will soon see the wisdom of following the lead of the companies in this matter, and leave the work to the wiring contractors. Under their Articles of Association, all the London electric supply companies have wiring powers, but we believe we are right in stating that in no case are they exercised. There is already a superabundance of firms in this branch of the business and the margin of profit is extremely small. Further rate-aided competition, therefore, cannot be good for the consumer, for shoddy work must result if prices are cut still more.

Mr. Druitt Halpin's patent (No. 20,203 of 1891) relating to "Improvements in the Working of Steam Boilers" will expire next Monday. This invention aroused much interest amongst electrical engineers when the Shoreditch dust destructor station was built, but in its application there full advantage was not taken of the system. It was not until the satisfactory results following its adoption at the Kensington and Notting Hill joint electricity works at Wood-lane became generally known (*The Electrician*, Vol. LIII., p. 231) that other electrical engineers decided to make further trials of Mr. Halpin's method. The invention, it may be remembered, covers the storage of hot feed water during slack hours and its utilisation during times of heavy load. There are four claims, the first of which covers

> The method of working steam boilers, whereby any excess of power generated therein over and above that which for the time being requires to be expended in work is transmitted in the shape of hot water and steam to one or more reservoirs separate from the boiler, but capable of being placed in communication therewith through the medium of forcing apparatus, so that the separate store of power thus formed may be subsequently drawn upon when an increased duty has to be performed by the boiler, substantially as described.

In the course of informal discussions, some engineers have expressed the opinion to us that the startling results obtained at Wood-lane have not been solely due to the thermal storage, and therefore we trust that the results of a number of other trials will soon be available, when we devoutly hope the value of this simple means of improving the load factor of the boiler may be firmly established.

We have frequently protested against irresponsible statements in the daily papers regarding fires alleged to have been due to electrical causes. In the majority of such cases there is little or no foundation for the allegation, and, as a rule, it is merely put forward in default of some reasonable explanation. An instance of much interest occurred on Friday last, when Dr. F. J. Waldo, J.P., the city coroner, held an inquiry regarding a fire which broke out at 49, Queen Victoria-street, on the previous Sunday evening. The housekeeper, one of the proprietors of the property, and two officials of the Fire Brigade, expressed the opinion that the fire was due to fusing of electric wires, but they did not produce a scrap of evidence in favour of their assertion. Indeed, Col. Fox, of the Salvage Corps, admitted that the basement was "littered with rubbish, which would smoulder for hours," and Mr. Gamble, of the Fire Brigade, said that a light thrown on this rubbish might have caused the outbreak. It is regrettable that the jury accepted such unsatisfactory evidence and that it was not possible to secure more definite data. As a matter of fact, the Coroner paid a visit to the scene of the fire the morning afterwards, but the electricity meter had already been removed. Now, it is, of course, just possible that the outbreak was caused by defective wiring, especially as it appears that all the work was in wood casing, and, according to one of the witnesses, the basement was very damp. It would be foolish to deny that fires may be caused by defective house wiring; on the contrary it behoves consumers to have their installations carried out in accordance with the best practice and submitted to periodical inspection. Good modern wiring subjected to only average wear and tear is absolutely safe, and not the slightest danger need be apprehended.

Since attention was called to the effect of "surgings" in long conductors carrying currents at high potentials, engineers responsible for the design and maintenance of conducting systems under these conditions have been paying considerable attention to this question. In spite of the study, both analytic and experimental, which has been made in connection with the subject, however, these engineers can still do little more than provide a means to prevent such surgings from having injurious effects on the plant, for the phenomenon is unfortunately too complex for accurate pre-determination. The most dangerous surgings occur, we believe, when the current is interrupted and an arc is drawn in air, and probably nobody knows exactly what are precisely the high-frequency oscillations in such circumstances. But even if this phenomenon be understood, it would be another question altogether to calculate the maximum rise of potential; and then, again, supposing we could calculate the maximum rise, the problem is only begun, for the tendency to break down insulation by these transitory effects depends not only on their maxima but on their duration. Fortunately, even if we cannot count on preventing the surgings, we are able to prevent them from doing damage, now that we know of their existence.

**New Electric Power Scheme for London.**—Last night's *Evening Standard* announces from an "official" source that powers are to be sought this year for the erection of a large power station at St. Neots, on the river Ouse, in Huntingdonshire, from which electrical energy is to be transmitted to London for the supply in bulk to existing electricity supply companies and borough councils, and for the running of railways. It is stated that no compulsory powers will be sought by the promoters which will interfere with the present established distributors. Current is to be conveyed from St. Neots to Enfield, a distance of 40 miles, on an overhead steel lattice pole line along a private right of way adjacent to the Great Northern Railway line, with the consent of the company. From Enfield to London the transmission will be underground. It is stated that coal will be obtainable at between 6s. and 7s. per ton, and that electrical energy will be supplied in London at ½d. per unit. The generating station is to be equipped with turbo-generators, the aggregate capacity of which will be 60,000 kw. normal output, with an overload capacity of 90,000 kw., which can be sustained during the hours of maximum demand. The engineers to the scheme are Messrs. Harper Bros. and Messrs. Kincaid, Waller, Manville & Dawson, and it is estimated that the cost, inclusive of 30 miles of distributors, will not exceed £2,000,000. We are in a position to state that the above particulars are, in the main, correct, and we hope to give our readers fuller information with regard to the scheme in our next issue.

**The New York Subway.**—This electric railway was opened on October 28, 1904, and has therefore just completed its first year's working. During the 12 months no fewer than 106,000,000 passengers were carried, in spite of the fact that great difficulties have been encountered, and only part of the line is actually working.

**Cable Interruptions and Repairs.**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Tarifa—Tangier | Jan. 18, 1904 | — |
| Jamaica—Colon | Jan. 10, 1905 | — |
| Cadiz—Teneriffe | July 20, 1905 | — |
| Kotonou—Grand Bassam | Oct. 4, 1905 | — |
| Medan—Olehleh | Oct. 26, 1905 | Nov. 13, 1905 |
| Oran—Tangier | Oct. 30, 1905 | — |
| Tangier—Cadiz | Oct. 30, 1905 | — |

**The Protection of H.T. Insulators.**—According to the *Canadian Electrical News*, protection for pole-line insulators has become a necessity upon the H.T. transmission lines in California. The natural deposition of moisture upon them in fogs, or of dust in dry weather, is apt to cause short-circuits resulting in burning, and often destroying, the pole. This is now provided against by sheltering all insulators by Λ-shaped boxes or sheds.

**Royal Society.**—Among the Papers down for reading yesterday were "The Transit of Ions in the Electric Arc," by A. A. Campbell-Swinton. Communicated by the Hon. C. A. Parsons, C.B., F.R.S. "On the Laws of Radiation," by Prof. J. H. Jeans. Communicated by Prof. J. Larmor, Sec. R.S. "The Accurate Measurement of Ionic Velocities," by Dr. R. B. Denison and Dr. B. D. Steele. Communicated by Sir William Ramsay, K.C.B., F.R.S. "The Electrical Conductivity of Dilute Solutions of Sulphuric Acid," by W. C. D. Whetham, F.R.S.

**Junior Institution of Engineers.**—As the annual dinner of the Institution of Electrical Engineers has been fixed for Friday, December 8th, it has been decided to postpone the reading of the Paper on "Electric Mains for Power Transmission Work," by Prof. J. T. Morris, to the following Friday, December 15th. In connection with the Paper a visit has been arranged to Messrs. Johnson & Phillips' works at Charlton on Saturday morning, December 16th.

**Northampton Institute Engineering Society.**—The above society has just been formed in connection with the Northampton Institute. The first meeting will be held this evening at the Northampton Institute, St. John-street-road, Clerkenwell, when a Paper will be read by Mr. S. M. Hills on "A Comparison between Gas and Electricity in regard to their use as Illuminants." Dr. R. Mullineux Walmsley, principal of the Institute, will take the chair at 7:30 p.m.

**Electricity in Horticulture.**—It is stated that the United States Department of Agriculture has begun extensive experiments into the growing of plants by electric light. Apparently, most plants grow only during the day and rest at night, and the experiments, aside from their scientific value, will be made with the object of forcing the growth of vegetables, &c., so that they will work 24 hours a day instead of 12 or so under normal conditions. The economic side of the question will also get careful attention to ascertain if the outlay of electricity can be returned at a profit.

**The Board of Trade and Electric Tramways.**—The November circular of the Tramways and Light Railways Association states that on November 1st Sir Herbert Jekyll, on behalf of the Board of Trade, received representatives of the three Tramway Associations in order to discuss certain matters concerning electric tramways. The chief question raised was the Board of Trade memorandum on Details of Equipment of Construction relating to Tramways and Light Railways laid on Public Roads, whilst discussion also took place upon the questions of guard wires and insulator inspection. The Board of Trade has promised to give the matter their careful consideration.

**Transatlantic Telegraphy.**—According to the *Electrical World* of New York, Mr. Marconi recently arrived in the United States on the "Lucania," and under his supervision the Cunarder kept in communication all the way with other steamers. When interviewed, he said: "The most important thing I have to tell you is that we propose soon to instal long-distance transmitting apparatus on the 25-knot Cunarders now being built. That is something that has not been done before—the transmitting of long-distance messages on shipboard. The instruments will cost $25,000 each. We propose to establish in the near future a commercial system between England and Canada." That at any rate—to propose the establishment in the near future of a commercial wireless system between England and Canada—*has* been done before.

**Personal.**—Mr. Sidney Collett, who has for many years been connected with the Eastern and Associated Telegraph Companies, and who has always taken much interest in the religious welfare of the telegraph staff at home and abroad, has just published a book of 300 pages entitled "The Scripture of Truth" (S. W. Partridge & Co., London: price 2s. 6d. net). The book is tastefully bound in cloth boards, and contains, in concise and readable form, information not otherwise easily obtainable on such important subjects, amongst many others, as the origin and plan of the Bible; inspiration; alleged errors and contradictions; Joshua's long day; the "days" of Creation; age of the World; population before the Flood; Science and the Bible—under Anthropology, Geology and Astronomy; also summaries of the sacred Books of the East. The book is interesting as well as instructive, and seems calculated to meet a felt want even amongst the many books which deal with such subjects.

**Wave Shapes in Three-Phase Transformers.**—Prof. F. J. Dykes, Professor of Electrotechnics at H.M. Gunnery and Torpedo School, Portsmouth, has sent us an interesting communication with regard to Mr. Clinker's recent article on "Wave Shapes in Three-Phase Transformers." Prof. Dykes went somewhat fully into the subject of wave forms in polyphase systems three years ago in the engineering laboratories at Cambridge, and amongst other things dealt with this very question of the star voltage wave in a set of three-phase transformers. He has sent us a copy of the thesis in which these results are embodied. In the part of it to which we allude, he arrives, both theoretically and experimentally, at similar conclusions to Mr. Clinker, and investigates the matter somewhat further. We understand that the contents of this and another part of the thesis are to be included in the second volume of Mr. Alexander Russell's "Treatise on the Theory of Alternating Currents," now in the press at Cambridge.

**Electromagnets for Lifting Purposes.**—Considerable use is made in Germany of electromagnets for lifting and transporting iron castings, &c., in workshops. The form of magnet employed varies with the kind of material to be lifted. For lifting objects with an uneven surface, for instance, electromagnets are used, the poles of which are capable of a certain movement so as to adapt themselves to the uneven surface. For lifting material of a thickness of at least 2 in., the best magnet in all respects is said to be the "pot" type of electromagnet. If the object to be carried is long and narrow, it is usual to arrange a number of electromagnets side by side in a common shell, and for transporting sheet metal, the magnet is provided with a number of poles in a cluster. According to *Elektrische Bahnen & Betriebe*, Messrs. L. Stuckenholz & Co. provide certain types of their electromagnets with an arrangement of levers which automatically embrace and support the object when it is raised by the crane. This device prevents the objects from falling should the current fail, and also allows the current to be switched off after the material has once been raised.

**A London Traffic Board.**—Sir Henry Oakley, chairman of the Central London Railway Co., wrote to Sir Francis Hopwood, permanent secretary to the Board of Trade, on November 13th, asking as to the likelihood of any steps being taken by Parliament next session to give effect to the report of the Royal Commission on London traffic. The object of the letter was to secure some information that might serve as guidance and assistance to railway companies in regard to the promotion of new schemes. The following reply was sent by Sir Francis Hopwood:—

> In reply to your note of to-day's date, I am authorised by Lord Salisbury to inform you that His Majesty's Government have sanctioned the preparation of a bill relating to London traffic and involving the establishment of a traffic board, as recommended by the Royal Commission. It is impossible to say what effect (if any) the introduction of the bill will have upon the decisions of Parliamentary committees appointed to deal with railway and other private bills touching the traffic interests of London, but Lord Salisbury thinks it is only fair that notice should be given of the intention of the Government to introduce such a bill, in order that, in the light of this information, promoters might determine what course they think it right to adopt as to proceeding with their proposals during the coming session.

**Standardisation of Glow Lamps.**—We are informed that a conference of glow-lamp makers will be held at the Institution of Civil Engineers on Friday next at 11 a.m. The subject, which is now being dealt with by the sub-committee on Physical Standards, presided over by Dr. Glazebrook, the director of the National Physical Laboratory, has recently come under the notice of the Incorporated Municipal Electrical Association, with the result that Mr. C. D. Taite, of Salford, and Mr. George Wilkinson, of Harrogate, have been appointed to represent the Association on this committee. A circular dealing very completely with the various questions affecting the standardisation of carbon filament glow lamps has lately been issued to the manufacturers, and we understand that very valuable information has been placed at the disposal of the committee. In view, however, of the many difficult questions involved, the Sub-Committee on Physical Standards have decided that before formulating any recommendations to be put before the Electrical Plant committee for transmission to the main committee the interests of all concerned would be best served by convening a conference and, in a friendly manner, discussing those points which appear to be somewhat difficult from the point of view of standardisation.

**A 25,000 Mile Test of an Electric Locomotive.**—The New York Central Railway Co.'s locomotive No. 6,000, which is being tested at the Schenectady experimental track, and was built by the General Electric Co. of America and the American Locomotive Co., completed its 25,000th mile at 1.15 p.m. on October 20th, thus finishing the first half of the 50,000 mile test to which it is being subjected. We learn that the motors on the locomotives are those with which the test began, the commutators are perfectly smooth, the brushes have run the 25,000 miles with a wear of only $\frac{3}{8}$ in., and appear in a condition to complete the 50,000 run. During these tests the locomotive has been in service regardless of weather, running light or with trains up to 12 cars in length. A speed of 85 miles an hour has been indicated, and in competition the electric locomotive has easily beaten the fastest steam trains on the New York Central Railway. The total cost of all repairs on the locomotive, excluding the injury caused when the shed in which it was housed was burned, has been $428·17 for 25,000 miles. This is an average of $0·017 per mile run, and there is every indication that a material reduction of expense will be effected on the second half of the test. We gave a complete description of this locomotive in *The Electrician*, Vol. LIV., pp. 173 and 384, and Vol. LV., p. 337.

**Electric Tramway Brakes with Hydraulic Release.**—In tramcars whose brakes are applied by the action of an electromagnet, it has been the practice to keep the brake in the "on" position by a ratchet and pawl arrangement. According to *Les Annales des Travaux Publics*, this locking device has recently been displaced to a large extent in Germany by a hydraulic arrangement. The plunger of the electromagnet takes the form of a piston moving within a cylinder. When the plunger is sucked up into its solenoid against the pressure of a spring, liquid is drawn into the cylinder from a small tank. If, now, the current to the electromagnet be interrupted, the plunger cannot move backwards because the liquid previously drawn in through the non-return valve cannot escape, and, therefore, the brakes cannot come off. This valve can be lifted to a smaller or greater extent by a separate electromagnet of small dimensions. The application of the brake and the release valve is governed by a small controller near the car driver. The handle of this controller is capable, not only of being rotated, but also of being moved up and down. While a rotary movement of the handle causes more or less current to flow through the main electromagnet, the up or down movement of the handle makes or breaks contact with the small electromagnet. The total weight of the apparatus described, including the brake controller, is stated to be 150 kg. (333 lb.)

**Street Lighting.**—We have received the following letter from Mr. W. J. Davy in connection with the correspondence on the electric lighting of the City of London, which has recently appeared in these columns:—

> I think that every engineer is agreed that the City of London, considering its position in the mercantile world, is one of the worst illuminated cities, and that the old arc lamp standards and lamps are an eyesore, and have been out of date for some years. No attempt has been made to improve the city lighting, notwithstanding the great progress that has been made in electric lighting within recent years.
>
> The present method of planting numerous gas standards on the edge of the footway has increased the obstruction, and has not helped to illuminate the streets properly. In foggy weather, incandescent gas is next to useless, and when a fog comes on it takes a considerable time to light up endless rows of lamps, and just as long to extinguish them again. It is most important that in large cities like London, where fogs are troublesome, to light up the streets immediately a fog appears, and this can only be done satisfactorily by means of electricity.
>
> For the lighting of Fleet-street, instead of 12 arc lamps I would prefer to use 16 flame lamps of a special pattern, for the reason that I should get a better distribution of light on the foot and road-way and a higher efficiency. I would suggest placing the new posts alongside the buildings (provided this was allowable), and would suspend the lamps from swan-necks on these standards, fitted with suitable hoisting gear. The advantage of placing the post near the buildings is that, besides giving a clear footway, it facilitates trimming, and the street can be properly illuminated.
>
> The lamps would take, say, 230 watts each, and assuming the burning hours were 4,000 per annum, the approximate cost works out as follows:—

| | | | |
|---|---|---|---|
| Cost of electricity per annum for 16 lamps ............ | £61 | 0 | 0 |
| Cost of carboning per annum for 16 lamps ............ | 28 | 16 | 0 |
| Cost of trimming and maintenance per annum for 16 lamps | 26 | 0 | 0 |
| Total cost per annum............ | £115 | 16 | 0 |

> The light per candle-foot would be 25 per cent. better than gas as now installed. I have not included in the above costs the interest on capital, &c., and my calculation is based on the assumption that about 100 lamps are installed.

**Wireless Telegraphy in Japan.**—A book on Wireless Telegraphy, printed in Japanese characters throughout, has been sent us by the author, Mr. A. Kimura, an engineer in the Japanese Navy. In a covering letter the author writes as follows:—

TO THE EDITOR OF THE ELECTRICIAN.

Naval Ordnance Depot,
Yokosuka, Sagami, Japan.

DEAR SIR: My little book on wireless telegraphy has been sent to you from the publisher with my compliments. It is not, however, for asking your review, but for acknowledgment of your valuable and exhaustive information as well as for your sound judgment upon the practical aspects of the subject. These I have freely used in my book, because, having had experience in the scientific and practical sides of the subject since 1900, I find your weekly to be the highest authority on all that pertains to the present system of wireless telegraphy. Hence the contents of my book are not new to you, inasmuch as I have refrained from writing anything which our Admiralty holds confidential, and that is *all* about the wireless telegraphy in my navy. The object of writing this book has been to show the dark sides of wireless telegraphy, and that, I deem, is the most important affair to the people and all those who have interest in the subject, either in making the laws for, or in drawing any benefit from, this all-convenient yet very dangerous method of communication.

Perhaps I am too much impressed by the darker side of the subject because I am working for the navy; and, as for the navy, we must think primarily for the time of war. Still, as a civil question, any action taken in ignorance of the real facts might cause a lasting menace to the public safety. Hence this book for the people and specially for those who may have a share in establishing laws.

**Refuse Destructors at Fiume.**—In the course of a lecture before an engineering society in Trieste, Herr L. Bescocca gave some interesting information concerning the refuse destructors which have been in operation at Fiume (Austria) since last May. From 20 to 22 tons of refuse (including from 6 to 7 tons of street refuse) are gathered daily in Fiume. The furnace has four grates and two combustion chambers, the refuse being fed in at the top by one gang of men and spread out over the grate by another gang. The products of combustion contain some 10 per cent. of $CO_2$, and the gases, leaving the boiler at a temperature of about 280°C., pass on to a chimney 130 ft. high. The boiler is of the water-tube type and of Messrs. Simonis & Lanz's make. It is designed for a pressure of 140 lb. to the square inch, and has a total heating surface of 1,930 sq. ft. After leaving the boiler, the steam is superheated to about 250°C., and then passes on to a vertical compound condensing engine which drives a Ganz 100 kw. 5,000-volt 42 ~ three-phase alternator at 210 revs. per min. The larger part of the energy generated is used in the water works near by, the remainder being utilised for lighting purposes and for a 30 H.P. motor employed to drive the fans as well as the machinery for pulverising the slag. In order to abstract iron particles, the pulverised slag is passed between the faces of powerful electromagnets. During a certain test 8·3 tons of refuse were burned in six hours; this is equivalent to 71 lb. of refuse per square foot of grate area per hour. The unburnt residue (ashes and slag) amounted to 2·03 tons (27 per cent.), and 1·034 lb. of water were evaporated per pound of refuse burnt. It is stated that the total cost of the installation amounted to 220,000 kronen (£9,150).

**High-Tension Continuous-Current Traction between Tábor and Bechyně.**—According to *Elektrische Bahnen & Betriebe*, the electric railway between Tábor and Bechyně, approximately 15 miles in length, is worked on the three-wire principle with 1,400 volts between the outers. The two overhead trolley wires constitute the outers while the rails form the middle wire. Current is generated at works situated near the line and about 1 mile from the Tábor terminus, the equipment of the power station comprising two 80 kw. 2 × 700 volt generators belt-driven by two steam engines, two boosters capable of raising the pressure 116 volts on each side, and a storage battery of 700 cells having a capacity of 123 ampere-hours at the one hour's rating. The trolley wires are 9 mm. (0·355 in.) in diameter and are suspended from span wires directly above the track, a distance of nearly 4 ft. being maintained between the parallel trolley wires. A feeder of 100 sq. mm. (0·155 sq. in.) section is run from the works to the centre of the line, and the trolleywires are, of course, also supplied with current near the works. Rails in 30 ft. lengths, and weighing 43½ lb. to the yard, are used. Each motor car collects the current by means of two cylindrical trolleys, and the motor equipment consists of four 4-pole 30 H.P., 650-volt motors running normally at 550 revs. per min. The armature has 61 slots. After a one hour's test at full load, the increases in temperature in the armature, commutator and field above the temperature of the atmosphere were found to be 35°C., 45°C. and 41°C. respectively. Each motor weighs 935 kg. (2,080 lb.) complete with gear wheels and gear case. Speed variation is obtained by series-parallel control, the maximum speed on the level being 30 km. (18·6 miles) per hour.

## ARRANGEMENTS FOR THE WEEK.

**(To-day) FRIDAY, November 17th.**

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER LOCAL SECTION.
*7:30 p.m.* Meeting in the University. Mr. S. L. Pearce, chairman, will deliver his Opening Address.

NORTHAMPTON INSTITUTE ENGINEERING SOCIETY.
*7:30 p.m.* Inaugural Meeting at the Northampton Institute, St. John-street-road, Clerkenwell, London. Paper to be read: "A Comparison between Gas and Electricity in regard to their use as Illuminants," by S. M. Hills.

INSTITUTION OF MECHANICAL ENGINEERS.
*8 p.m.* Meeting at Storey's Gate, Westminster. Paper to be read: "On the Properties of a Series of Iron-Nickel-Manganese-Carbon Alloys," by Dr. H. C. H. Carpenter, R. A. Hadfield and Percy Longmuir.

ELECTRO-HARMONIC SOCIETY.
*8 p.m.* Concert (Ladies' Night) at the King's Hall, Holborn Restaurant.

**SATURDAY, November 18th.**

INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.
*10 a.m.* Visit to the Lot's-road Generating Station, Chelsea, London. Meet at the generating station.

JUNIOR INSTITUTION OF ENGINEERS.
*2:30 p.m.* Visit to Messrs. Barclay, Perkins & Co., Park-street, Southwark-bridge.

GLASGOW TECHNICAL COLLEGE SCIENTIFIC SOCIETY.
*7:30 p.m.* Meeting at the Glasgow and West of Scotland Technical College, George-street, Glasgow. Paper to be read: "The Commercial Efficiency of Prime Movers," by A. Marshall Downie.

**MONDAY, November 20th.**

INSTITUTION OF ELECTRICAL ENGINEERS: NEWCASTLE LOCAL SECTION.
*8 p.m.* Opening Meeting at the Armstrong College of Science, when the Chairman, Dr. W. M. Thornton, will deliver his Inaugural Address.

**TUESDAY, November 21st.**

TRAMWAYS AND LIGHT RAILWAYS ASSOCIATION.
*12 noon.* Visit to the Automobile Exhibition, Olympia.

INSTITUTION OF CIVIL ENGINEERS.
*8 p.m.* Ordinary Meeting. Paper to be further discussed: "On Waterways in Great Britain," by J. A. Saner.

ELECTRICAL CONTRACTORS' ASSOCIATION: LONDON SECTION.
*8 p.m.* Ordinary Meeting at Frascati's, Oxford-street, London, when a Paper on "Workmen's Cards" will be read.

**WEDNESDAY, November 22nd.**

INSTITUTION OF ELECTRICAL ENGINEERS: BIRMINGHAM LOCAL SECTION.
*8 p.m.* Opening Meeting of the Session at the University. The chairman, Prof. R. Threlfall, F.R.S., will deliver his Inaugural Address on "Some Problems in Electro and Electro-Thermal Chemistry."

SOCIETY OF ARTS.
*8 p.m.* Ordinary Meeting. Paper to be read: "The Cinematograph and its Applications," by F. Martin Duncan.

**THURSDAY, November 23rd.**

INSTITUTION OF ELECTRICAL ENGINEERS.
*8 p.m.* Ordinary General Meeting. Paper to be read: "The Applications of Electricity in the Royal Gun Factory, Woolwich Arsenal," by Col. H. C. L. Holden, F.R.S.

TRAMWAYS AND LIGHT RAILWAYS ASSOCIATION.
*8 p.m.* Meeting at the Society of Arts, John-street, Adelphi, W.C. Paper to be read: "Paving of Roadways," by W. L. Green.

**FRIDAY, November 24th.**

PHYSICAL SOCIETY.
*5 p.m.* Meeting at the Royal College of Science, Exhibition-road, South Kensington. Agenda.—(1) "The Dielectric Strength of Air," by A. Russell. (2) "On the Electrical Conductivity of Flames containing Salt Vapours, for Rapidly Alternating Currents," by Dr. H. A. Wilson. (3) "On the Lateral Vibration of Loaded and Unloaded Bars," by J. Morrow.

MANCHESTER STUDENTS' SECTION: INSTITUTION OF ELECTRICAL ENGINEERS.
*7:30 p.m.* Meeting in the Municipal School of Technology, Sackville-street, when Mr. James Swinburne will deliver an Address.

# PRESIDENTIAL ADDRESS TO THE INSTITUTION OF ELECTRICAL ENGINEERS.*

BY JOHN GAVEY, C.B.

(*Concluded from page 154.*)

## WIRELESS TELEGRAPHY.

Wireless telegraphy, so called, has attracted a great deal of intermittent attention for many years past. The various possible methods of communication between two localities not directly connected by wire may be divided under five heads: (1) Leakage across the earth or water between two parallel wires erected on opposite sides of a position which has to be bridged. (2) Electro-magnetic induction between coils placed vertically or horizontally. (3) The combination of the two above systems by the erection of two parallel overhead wires connected to earth at their extremities. (4) Electrostatic effects from vertical conductors. (5) The Hertzian system.

Many attempts have been made to establish communication across rivers, arms of the sea, &c., by the first method, and they have met with varying success, but the system is one the application of which has a limited scope.

The second method has but a limited range; it has only been rendered possible by the use of telephones, but inasmuch as the effective energy available for signals diminishes as the cube of the distance between the coils, the limit beyond which no signals can be received is very rapidly reached.

The third method, which, prior to the invention of the Hertzian method, was fully investigated by the Post Office, has met with a certain measure of success, and at the present time there are two installations still at work in this country. One of them connects Rathlin Island with the mainland at Ballycastle, the parallel wires being at an average distance of 8 miles apart. The second instance is an installation establishing communication between the Skerries, a series of rocky islets off the coast of Holyhead, with the telegraphic service on Holyhead Island itself. The parallel wires are at an average distance of 3 miles apart. The latter installation is worked telephonically—*i.e.*, the wires are fitted with telephone transmitters and receivers, and telephonic speech is actually transmitted from wire to wire.

The fourth system of communication by purely electrostatic effects without the emission of free waves has not been developed on a practical scale.

The fifth, or Hertzian system has created world-wide interest, and its development in the course of the last few years has been very marked As is well known, the method is based on the classical researches of Hertz; it was made possible in the first place by the original inventions of the coherer by Branley, improved later by Lodge, and finally developed into a practical system by Marconi.

It may be of advantage to briefly review the gradual development of the art from the date of Marconi's early work. It will, no doubt, be remembered that after a period of experiments, first in Italy, then in this country, a crucial trial was made in the year 1896, under the auspices of the Post Office, across the Bristol Channel, from Lavernock Point, first to the island of Flatholm, and then to Breamdown, near Weston-super-Mare. At that period, what has by some being termed the "Whip Crack Method" only had been tried; that is to say, a powerful spark coil was connected, one terminal to the vertical conductor, the other to the earth. This arrangement emits a very powerful impulse, which is damped down almost immediately, and it is probably the first single impulse alone which affects the receiver at a distance. Elementary attempts at tuning were made by various experimenters during this period, but the art was not sufficiently developed to admit of any really useful results being obtained. The coherers were probably far too sensitive, and the difficulty experienced in the early days was rather due to their not decohering than their failing to respond to the electrical waves. In course of time this difficulty was remedied by the use of an oscillating transformer in the receiving circuit which admitted of the use of less sensitive coherers, and excellent results were obtained, but owing to the fact that every receiver within a certain definite range of a given transmitting apparatus responded to each impulse, and all receivers were affected by all transmitters within range, it appeared at first as though Marconi's attempt to increase the effective limit of his apparatus would tend to restrict rather than to extend the use of the system. He and others interested in wireless telegraphy, therefore, turned their attention to the establishment of syntony between the transmitting and the receiving apparatus, and a marked degree of success has attended their efforts. This syntony is usually effected by connecting one or more closed oscillating circuits to the source of energy, and coupling these either direct or through an oscillating transformer with the vertical antennæ, the closed oscillating circuit and the vertical attenna being in unison—*i.e.*, having the same frequency. A closed oscillating circuit includes a capacity and inductance, and therefore for each primary impulse a train of waves is generated. The first portion of the wave has not such an amplitude as when the Whip Crack Method is used, but this is more than counter-balanced by the effect of the long train of oscillations, which results in restricting to a great extent the visible effect to receivers tuned in harmony, other receivers not so tuned not responding when a certain critical distance is passed. In the next place, by a judicious combination of oscillating circuits with antennæ of suitable capacity, the amount of energy that can be utilised for the transmission of signals may be increased from the small limits imposed when an ordinary induction coil is used to practically any given amount—an utter impossibility with the original method of working. Of course, where a very powerful exciting system is in use, the radiating surface must be increased proportionately, and the well-known method of multiple antennæ has been designed to achieve this end. At the receiving station, the tuning is effected by the addition either of inductance or of capacity, the receiving installation being brought into as perfect syntony with the transmitter as is possible. In addition to this, special devices have been introduced in the receiving circuit for the elimination of waves of other periodicities so that even Whip Crack transmission can to a great extent be eliminated. The effect of having the transmitting and the receiving apparatus in harmony was shown in an admirable manner by the Post Office experiments, recently carried out and described by Messrs. Duddell and Taylor, which gave graphical measurements of the energy received under both conditions.

The receiving apparatus has undergone many modifications since the original filings coherer was invented. There is, for example, the single point contact, consisting of a pointed carbon lightly resting on a slightly oxidised steel surface; the Brown radioscope, consisting of a lead electrode resting lightly on a surface of peroxide of lead; the Lodge-Muirhead revolving disc, touching lightly on a mercury surface; the Schaffer, so-called anti-coherer, consisting of a fine razor slit across a silvered glass surface; the Italian Navy coherer, in which one or more globules of mercury are enclosed between carbon and steel contacts—all of which are dependent for their action on imperfect contacts; the Bolometer and electrolytic methods claimed by different inventors; and finally, Marconi's electromagnetic receiver. Many of these have been associated with variations in the original method of combining the different electrical elements of each circuit, and have been denominated "Systems." I will not, however, enter the thorny path of attempted discrimination between those that may be considered as systems or those that can only be described as methods.

A great deal has been said by rival inventors as to the possibilities of wireless telegraphy, and some exaggerated claims have been made on their behalf which have led to counter statements by some interested in other methods of communication. Whilst on the one hand it may be fairly assumed that wireless telegraphy is not, under any circumstances, likely to supplant, or even to compete seriously with, inland methods of intercommunication, there is no doubt that there is a very distinct and important sphere of utility awaiting its further development. For intercommunication between ship and shore and ship and ship much has been done, although much remains to be done. For intercommunication between neighbouring coasts there is also a possible future, but this depends almost wholly on the further development of the methods of syntony or tuning. There appears to be no doubt that in cases in which the wave-lengths used on two systems differ to a considerable extent a very marked degree of success has been obtained in the avoidance of mutual interference. Where the wave-lengths, however, are not very widely apart in frequency there is in each case a definite range within which interference arises, and simultaneous working is impossible. That the tuning methods will be improved I think there can be very little doubt. The progress that has been made between the year 1896, when it took a week to receive a few elementary signals over a distance of nine miles, and the present time, when such remarkable results have actually been obtained, is so great that it does not imply the possession of an unduly sanguine disposition if one ventures to predict further improvements, which may be expected to increase the freedom from mutual interference, the speed, and the reliability of this method of communication. It does not appear to be very probable that it will seriously compete with the highly-developed cable communication in the near future, although it may in many instances supplement that service.

## CONSTRUCTION.

No marked changes have taken place in the methods of overhead construction, beyond the general tendency towards the wholesale substitution of hard-drawn copper for iron wire for overhead conductors. The magnetic inertia due to the metal itself which affects high-speed results so largely when iron wires are used is, of course, absent in the case of copper. Although the first cost is higher, the scrap value of the copper when renewed is considerable, and there is the further point that when the time arrives for converting overhead telegraph circuits to telephone uses, the appropriated conductors will at once be available. In other respects there have been, of course, various improvements in details which, however, do not need special mention.

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* Delivered November 9th.

In underground telegraphs, something approaching a revolution is in progress. It is a curious and instructive fact that the majority of the early inventors who designed or imagined methods of telegraphy contemplated the use of underground wires insulated by various ingenious methods which, however, would scarcely have proved efficacious in practice. Further, in this country, two of the great telegraph companies started with the idea of laying telegraphs underground, and very long lengths of gutta percha wire were laid in wooden casing, some of which is re-covered from time to time and is even now found to be in excellent condition. Various reasons lead to the abandonment of underground work in favour of overhead lines, and little was done in later years in the direction of providing a comprehensive underground system until the great work in Germany was initiated in the seventies. Owing, however, to the high cost of gutta percha, and to its great specific inductive capacity, the extended use of this material did not commend itself to the English Government, except, of course, in large towns where underground work was imperative, for, owing to the slow speed attainable on ordinary gutta-percha underground wires, and the vast mass of Press matter that had to be transmitted by the Post Office, there was little temptation to indulge in a heavy expenditure with the object of replacing overhead wires by underground work, even though the overhead wires were occasionally subject to serious interruptions which no human skill or engineering foresight could guard against. The introduction of the modern multiple cable insulated by dry paper and enclosed in lead sheath has gone a long way in the direction of overcoming both these difficulties—viz., the financial difficulty of cost and the electrical difficulty of high static capacity.

Incidentally, it may be of interest to refer to the genesis of the modern air-space dry-core cable, for details of which I am indebted to Mr. Kingsbury. It is, of course, well known that many attempts were made years ago to obtain a cheap substitute for gutta-percha insulated wires, and these attempts generally took the direction of wires covered with cotton or other fibrous material enclosed in a pipe or tube, which was filled with a permanent insulator, either solid or liquid, such as paraffin wax or oil. At a later period paper was substituted for cotton, and it was proved that wires so insulated had a lower static capacity than those covered with cotton. It was at first assumed that this was due to the character of the paper used, but it was soon realised that the actual reason was that with the paper the insulating compound could not be forced into the tube so as to absolutely fill all the interstices, and that numerous air spaces existed throughout its length. From this to the use of the present form of cable was but a step. In cables of this type relatively large conductors weighing from 100 lb. to 200 lb. per mile can be provided with a static capacity of 0·1 microfarad per mile, and where a large number of wires have to be provided, at a total expenditure not very unduly in excess of that necessary for overhead wires.

As soon as this type of cable became available for use, the Post Office took the initial step in the construction of a line containing 76 wires enclosed in a 3 in. iron pipe from London to Birmingham, a distance of 117 miles. This line was commenced in 1897, was completed in 1899, and brought into use after preliminary experiments had been carried out with a view of determining its adaptability for the purposes of the Post Office. It was, of course, foreseen that the wires in close proximity would be subject to a certain amount of mutual disturbance, and it was doubtful to what extent this disturbance would interfere with the various methods of telegraphy in use. To provide for the worst possible case, therefore, the wires were twisted up in pairs like those required for telephone circuits, and the length of the lay of the neighbouring pairs was varied, so as to provide as far as possible for working metallic loops where necessary, either for telegraph or telephone purposes, with the minimum amount of mutual interference. The experiments proved that is was possible to work duplex on neighbouring single wires of a pair, when earthed at each end, without interference when the speed was limited to that possible with manual transmission. Quadruplex working was subject to some slight interference, but under these conditions Wheatstone working was not possible at a higher speed than 50 to 60 words per minute. The general result, however, was admirable from every point of view, and the steadiness of working and the freedom from interference by atmospheric or other causes was so great that the Postmaster-General subsequently decided to extend the London–Birmingham line to Glasgow. The question of the type of cable to be carried forward then came up for consideration. From London to Birmingham there were 38 pairs of wires. In the interval many types of paper insulated cables had been devised with a view to obtain a form suitable for use with earthed circuits, and therefore to a great extent free from mutual induction, either static or electro-magnetic, the ultimate outcome of which was the design of a conductor insulated with paper, each insulated conductor lapped with copper foil and the whole of the wires cabled and sheathed with lead.

It was finally determined to continue the London–Birmingham section northwards by the laying of a cable containing 37 pairs of the ordinary paper insulated wires as a core surrounded by 29 copper screened single-wire conductors: this decision being arrived at after it had been proved conclusively that where quadruplex or high speed circuits were required, it was possible to obtain satisfactory working with the quadruplex or Wheatstone on a metallic loop, and to superimpose thereon a key duplex. Where quadruplex is therefore in use on a long circuit, six channels are obtained on two wires, or a Wheatstone duplex and a key duplex can be worked on each loop. Again, it has been proved that between London and Glasgow, by the use of a repeater at Preston or Warrington, a speed of 200 words per minute can be obtained on these wires with Wheatstone apparatus, so that it will be observed that a great step has been made by the substitution of a moderately economical system of underground work susceptible of working at high rates of speed, for the old costly and slow methods which the use of gutta-percha involved where land telegraphy was concerned. The main underground line from London to Glasgow will be completed by March or April, 1906, and other important sections of main line, notably a section from London to Chatham, are in hand.

Here, perhaps, I may fitly state that the Post Office and the general public owe a debt of gratitude to our British manufacturers of electrical plant for the energetic and able manner in which they meet all requirements, however onerous, made upon them. They spare neither time, trouble, nor expense in an endeavour to meet the most difficult specifications, and it is not too much to say that without their assistance this record of modern progress could not have been realised. I render this tribute all the more willingly because it has lately become the fashion for irresponsible writers in the public Press to decry the British manufacturer as old-fashioned, not up-to-date, and not ready to meet modern requirements. I can truthfully say I have nowhere met reputable firms exhibiting this spirit.

### TELEPHONES.

Not the least remarkable of the modern developments of electrical engineering is the extraordinary growth of the telephone service throughout the whole of the world. Subsequent to the year 1860, when Reis invented his musical telephone, it was thought by the majority of electricians that no further approach towards the attainment of articulate speech could be made. The possibilities attending the use of loose contacts, at that time the most dreaded enemy of the electrical engineer, had not been foreseen, and the conclusion was generally arrived at that it would be impossible to devise a transmitter free from the defect of causing actual breaks in continuity so as to admit of the delicate curves necessary for the transmission of articulate speech being reproduced electrically. Bell's invention in 1876 was received almost in a spirit of incredulity, and when in the following year it was brought to this country it was looked upon as a marvellous development. Although as a receiver the instrument was even then practically perfect, its powers as a transmitter were weak, but the invention of the microphonic transmitters in 1877, by Edison in America and Hughes in England, speedily led to the development of the telephone on commercial lines. Kingsbury has told us in his Paper, read before the Institution in January, 1895, how in 1878 the first telephone exchange was started in London, the old telegraph umschalter switch having been utilised for the purpose. For many years the service was necessarily imperfect, gauged by modern standards, as for a long period open wires carried over house had to be resorted to, and single-wire circuits were practically a matter of necessity at large exchanges, the result being that cross talk could not be eliminated, and comparatively inefficient transmitters were used in order to reduce the amount of this disturbance. The invention and development of the modern paper-insulated air-space cable, with its low electrostatic capacity, led to the general adoption of the one main factor in satisfactory telephone working—viz., the use of well-insulated metallic circuits so constructed as to be free from cross talk. This opened the door to the use of the very best types of telephone transmitter, and paved the way for the successive improvements in exchange plant that are so marked a feature in modern systems, and that have led to the extraordinary increase in telephone statistics that has taken place in the last 10 years.

As the result of successive inventions, a steady and rapid improvement in the indoor plant available for exchange work has taken place, and, so far as modern telephone switch is concerned, these improvements have been wholly in the direction of reducing the amount of talk on the part of the operator that was necessary under the old conditions. This has been brought about by the provision of a complete system of automatic signalling whereby she is kept abreast of her work, so that, with the exception of asking for the number of the subscriber who is wanted, there should in all ordinary cases be no need for conversation between the subscriber and the operator, this being accompanied by a corresponding increase in the speed of working. In fact, one system goes so far as to render it unnecessary even to ask for the number of the subscriber required, that information being printed by the caller on a Morse slip. This tendency to reduce the operator to a species of intelligent automaton naturally suggests the possibility of the entire elimination of the operator, and the introduction of suitable automatic apparatus at the Exchange.

Several very ingenious methods of attaining this end have been devised, and one system has achieved a certain measure of success in America, several exchanges of some magnitude having been equipped with apparatus of this type. Two or three small automatic switches have been installed in Europe, but no European telephone administration has yet faced the problem of establishing an extensive automatic system for the use of towns in which large exchanges are required. To review the reasons for the hesitation so far displayed by the more important of the telephone authorities would be to introduce controversial matter which would be out of place. The subject is, however, not exhausted, for it is being carefully studied at the present time in America, and there appears to be some possibility of development in the not distant future that may lead to important modifications in present methods.

One word may here be added as to the magnitude of the plant required for modern exchange working.

There appears to be an occasional tendency to look upon telegraphs and telephones as a little apart from serious engineering undertakings, because in the actual transmission of telegraphic signals or telephonic speech minute currents measured in milliamperes and microamperes generally suffice. The movement of electric railway trains and street cars or electric cranes, of electric gun training machinery, and other similar mechanical work impresses the imagination far more vividly than does the still, small voice that is heard in a telephone, but when modern telephone practice is considered it will be found that in the complexity of the system, the amount of electrical energy used for the purpose of signalling and the extent of the works undertaken, a telephone system regarded from the engineering standpoint is in no degree behind any other electrical enterprise. As an illustration, it may be stated that in carrying out the preliminary arrangements for serving about one-third of the metropolitan area the Post Office has already excavated 565¼ miles of trench, it has laid 1,251 miles of duct, it has provided 162,216 miles of wire, and the weight of copper buried in the London streets amounts to 2,200 tons, and this apart from the work carried out by the National Telephone Co. in the same districts.

The secondary cells used for signalling and common battery speaking at the Central Exchange have a capacity of 5,500 ampere-hours, and the number of glow lamps in use on the existing Central Exchange for signalling purposes is 25,000. It may be added, however, in illustration of the growth of the system, that the first contracts for the Post Office system in London were entered into on February 24, 1900, and the first exchange was opened on February 24, 1902, with 169 subscribers, the ultimate capacity being 14,000 subscribers. Its growth was so rapid that within two years of its being opened it became necessary to commence the installation of a second exchange, which is being constructed within the same building, and which will shortly be opened with a further capacity of 20,000 subscribers, a corresponding enlargement of the general appliances in the building being involved.

Perhaps the most remarkable development that has taken place in the whole world is that which in the last few years has arisen in America. In the early portion of my address I referred to certain statistics furnished by the American Bureau of the census. The growth in the number of telephones provided by the American telegraph and telephone companies (commonly known as the Bell companies) in the United States of America is absolutely startling. I visited America in 1898, at which date the company had about 400,000 stations open. I have just returned from another visit, and find that they have 1,950,000 stations at work, an increase of 1,450,000 in seven years, and they are still progressing at the same pace. Domestic and other reasons appear to foster the use of the telephone. The number of private houses provided with these modern appliances bears a very high ratio to the number of business premises in which they are installed. All the large hotels have telephones in every room, a central switch connected to the main exchange being located in the hall. Large shops have installations varying from 250 to 1,000 telephones, these in some cases being scattered along the counters so that customers can telephone from their houses direct to the shop assistant whom they know to be acquainted with their wants or fancies.

The most important adjunct to the local exchange system is the trunk line, or long-distance service, as it is variously called. In 1896 the Post Office acquired, by purchase, such of the trunk lines as had been erected by the National Telephone Company and not only did it at once erect such additional wires as were necessary to provide a comprehensive service covering the whole country, but it has been engaged year by year in erecting additional trunks. Such is the favour with which the trunk service generally is regarded, that it is difficult to keep pace with the demand for additional wires. The annual growth is represented by the following figures :—

| Year ending March 31, | | Circuits. | | Miles of wire in actual use. |
|---|---|---|---|---|
| 1896 | .. | 165 | .. | 17,500 |
| 1897 | .. | 804 | .. | 47,855 |
| 1898 | .. | 877 | .. | 55,721 |
| 1899 | .. | 953 | .. | 63,109 |
| 1900 | .. | 1,029 | .. | 69,713 |
| 1901 | .. | 1,116 | .. | 76,831 |
| 1902 | .. | 1,165 | .. | 83,302 |
| 1903 | .. | 1,309 | .. | 93,473 |
| 1904 | .. | 1,418 | .. | 102,799 |
| 1905 | .. | 1,604 | .. | 112,744 |

The determination of the distance over which telephonic speech is possible on various types of telephone circuit is a question of the greatest theoretical and practical interest, and it is one that has received much careful consideration. The theoretical investigations of Clerk Maxwell, Kelvin, Oliver Heaviside, G. A. Campbell, Pupin, and others have done much to elucidate the problem under consideration, and we are now, I think, fairly well acquainted with the various factors that govern and limit the range of possible speech, and the methods by which these limits can, under favourable conditions, be extended ; such, for example, as the partial neutralisation of the effects of static capacity by the addition of self-induction. In connection with the transmission of telegraphic signals through long cables, it will be borne in mind that Lord Kelvin, in the year 1854, enunciated the K.R. law, and at first attempts were made to apply this law to telephonic work. Now the simple K.R. law applies with some degree of accuracy to telephonic cables in cases in which wires of approximately the same gauge are concerned, but it fails in cases in which the electrical constants R K and L vary materially, and it is quite inapplicable as part of a general law to open lines where self-induction is a marked factor or where the conductivity of the wires varies materially. As illustrating this, the following observations made by the able staff of the Bell Companies in America show to what extent the K.R. law fails :—

*Table of Equivalent Circuits.*

| Type of circuit. | Loop resistance per mile. Ohms. | Wire-to-wire capacity. Micro-farads. | Long-distance standard of commercial talk. | | Local service standard of commercial talk. | |
|---|---|---|---|---|---|---|
| | | | Length equal to 1,200 mls No. 8 B.W.G. op'nwire. Miles. | K.R. | Length equal to 750 mls. No. 8 B.W.G. op'nwire. Miles. | K.R. |
| 100 lb. copper aerial .. | 17·73 | 0·007825 | 388 | 20,881 | 253 | 8,880 |
| 176 lb. „ „ .. | 10·26 | 0·008218 | 560 | 26,443 | 360 | 10,927 |
| 425 lb. „ „ .. | 4·08 | 0·008978 | 1,200 | 51,027 | 750 | 20,604 |
| American st'nd'rd c'ble | 88·00 | 0·051 | 41·8 | 7,842 | 26 | 3,034 |
| Boston–Lynn cable .. | 41·80 | 0·042 | 73·2 | 9,407 | 45·5 | 3,635 |
| London – Birmingham cable ............ | 11·00 | 0·063 | 115·0 | 9,165 | 71·5 | 3,543 |

It was quite evident that the K.R. law failed owing to no account being taken of the important factor L, and on comparing a large number of results obtained over Post Office lines of different character, the following rough empirical formulæ were designed to meet ordinary cases. As will be seen further on, these were found to give fairly concordant results within certain limits.

Aerial lines of 100 lb. copper and upwards

$$M=210\sqrt{\frac{l}{KR^{1\cdot75}}}.$$

For unloaded paper cables

$$M=85\sqrt{\frac{l}{KR}}$$

where M=limits in miles.

Before dealing with the more recent formulæ now in use for determining the limiting distances of speech, it may be well perhaps to refer briefly to the theoretical conditions which affect the transmission of telephonic impulse. The ordinary electrical conditions in a circuit which may modify or effect an impulse *in transitu* are the following: Resistance, electrostatic capacity, self-induction, insulation, abrupt and numerous alterations in the circuit which may cause reflection, interference from extraneous cause—*i.e.*, static or magnetic induction, leakage, &c., from neighbouring circuits.

When an electrical impulse is started in a conductor, if the latter had neither resistance, capacity, nor self-induction, and if the insulation were perfect, the wave would move on without attention or distortion. The effect of resistance or of uniformly distributed low insulation, however, results in a definite attenuation which increases with the length of the circuit, and, further, the effect of capacity is to cause the wave to spread out, both forwards and backwards, this "tailing," as it is termed, not only increasing the attenuation by lowering the amplitude, but causing distortion of the wave itself and also of the neighbouring impulses, with which it interferes. This distortion eliminates the higher notes and harmonics, and in extreme cases causes the voice to lose its characteristic tone, and ultimately to become inarticulate.

Now it is obvious that it is a matter of extreme importance to ascertain to what extent each of these elements affects in the most material manner the limiting distance of speech, and much light is thrown on this subject by actual experiments made over long lines of various characters, overhead, underground and submarine. As the result of many trials, it is found that with long circuits free from external disturbance, such as underground wires, the actual practical limit is fixed by the loss of amplitude of the waves ; in other words, by the diminution of volume rather than by the loss of articulation, although when these limits are approached it is found that articulation begins to suffer, and when the line is still further increased, the tones become low and hoarse, and speech ceases to be practicable. This points to the fact that in actual practical work attenuation, due partly to resistance and partly to electrostatic capacity, are the dominant factors, and this attenuation when combined with disturbance from neighbouring electrical conductors actually determines the limits of speech. This view is supported by a comparison of the results obtained by calculation and those obtained by actual experiment. That in actual practice articulation is not materially affected up to the point when the volume of sound becomes too small for practical purposes is probably due to the fact that the inherent self-induction of an ordinary circuit suffices to prevent such an amount of distortion as might otherwise interfere with articulation at more moderate distance than those actually experienced. Oliver Heaviside, in his "Electrical Papers," Vol. II., p. 393, showed the extremely limited range of possible speech in paper cables, assuming an entire absence of self-induction in a closely twisted-up pair, and the extent to which this range is entended even by the limited self-induction which obtains in normal conditions. He thus early anticipated the practical results already referred to. At all events, calculations giving the limiting distance of speech on various types of conductors, based on attenuation only, are found to agree with actual experimental facts. The remaining factors, although they must have some influence on the results, can in practice and under conditions which obtain in a simple metallic circuit be neglected.

As a preliminary to the determination of the limits of speech, it is necessary to ascertain the degree of volume and articulation, or, in other words the audibility, which may be accepted as satisfactory, and further to establish standard circuits with well-known constants of R, L and K to which all lines may be reduced either by calculation, by experiment, or preferably by both. For this purpose, both in America and England, one of the types of ordinary lead-covered paper insulated cables, in which the above constants are measurable, has been selected, and the dimensions of the English standard cable, which agree closely with American figures, are as follows :—

| | Gauge S.W.G. | Weight per mile. | Diameter Mils. | R. (loop). Ohms. | K wire to wire. Microfarad. | L. | Insulation. |
|---|---|---|---|---|---|---|---|
| English.. | 20 | 20 lb. | 36 | 88 | 0·056 | 0·001 | 200 |

Now, in actual practice a telephone on an exchange circuit must be thoroughly effective, whether joined through to another circuit a few yards in length or connected to a long-distance line some hundreds of miles long, but obviously it is quite unreasonable to expect that the conversations shall have the same volume and articulation in both cases, and of course, when a long-distance line approaches the limits at which it is possible to converse, it is absolutely essential that the apparatus and lines shall be in the best working order, that each speaker shall raise his voice and speak distinctly and close to the transmitter, and that both correspondents shall have their apparatus in fairly silent rooms.

In considering this question from the practical point of view, it is necessary to take into account the variable conditions under which long-distance speech is frequently held. The insulation of long overhead wires may in this climate drop in extreme cases to a figure as low as the metallic resistance of the conductors themselves ; slight inductive noises are never really absent, and occasionally they preponderate. In a Paper on "Trunk Telephones," which I read before the Institution in November, 1896, I pointed out how difficult it was to obtain even an approximately perfect static balance between a telephone circuit and neighbouring wires subject to rapidly varying potentials. Again, the human element largely affects the result ; indistinct and muffled speech, disregard of regulations in the use of apparatus, partial deafness, apparatus in noisy and unsuitable localities, all tend to limit long distance speech, and to render the application of very accurate determinations difficult. In fact, it may be said that the limits of error in calculation, whether the empirical or the more accurate formula referred to later are used, are less than the limits of variation in practice, and that as in all engineering matters there must be a considerable factor of safety to ensure satisfactory intercommunication. Telephone administrations have carefully considered what are the extreme limits of effective commercial speech under the last-named conditions, and it is generally considered that from 42 to 46 miles of the above-named standard cable is the effective commercial limit, although conversations have been held by experts over 60 miles of such a cable.

This being accepted, two methods can be adopted for determining the limits of speed on various types of telephone circuits.

In the first place, the attenuation is calculated for various types of cable, say by Pupin's formula, in which the insulation R is so high that attenuation by leakage can be neglected, or by Campbell's formula for overhead wires when leakage must be assumed. By the use of these formulæ, tables of ratios which express the relative equivalence of each type of circuit to the standard cable are prepared, and the limit of commercial speech having been fixed in miles of standard cable, the limit on all other types of conductors is a simple matter of calculation.

The second method, of course, consists in a direct comparison of all existing types of line with a standard cable. A lengthy series of experiments has been made on all classes of Post Office conductors, overhead, underground, and submarine, and they have been balanced by means of a standard apparatus to their equivalent lengths of actual standard paper cable. The equivalent lengths have also been calculated by Pupin's and Campbell's formulæ, and the table below shows the degree of concordance in the results, as also corresponding figures based on calculations made by means of the empirical formulæ already referred to.

It will be observed that the calculated limits of speech based on attenuation agree absolutely with experimental results on all the underground cable. There are, however, variations in the calculated and observed results obtained on overhead lines, and these are no doubt due to variations in insulation and to slight disturbances which affect the audibility materially when approaching the limits.

Another method of investigating the problem of telephonic transmission has been undertaken at the Post Office, and although the experiments are not complete, I propose to attempt to show some of the results which exhibit graphically the attentuation which in practice takes place under varying conditions. Two circuits have been selected, one consisting of a mile of the standard cable already referred to, and the second consisting of 20 miles of similar cable. A Duddell's oscillograph has been used for observing simultaneously the curves due to the action of the induction coil at the transmitting end and the corresponding curves at the receiving end of the circuits. A number of letters, both vowels and consonants, have been rapidly spoken into the transmitter, and the respective transmitted

*Table of Equivalents based on Attenuation and Empirical Formulæ respectively.*

Tests made with the Standard Apparatus described in the Schedule to the Agreement, dated 1905 between the Post Office and the National Telephone Co.

| Type of line. | Constants per mile of loop. | | | Miles of various types of conductors giving equal transmission to 1 mile 20 lb. cable. (Calc. from Pupin's & Campbell's formulæ) | Limiting distance based on speech limit of 43 miles standard cable. (Calc. from preceding column.) | Limiting distance based on empirical formulæ. | Limiting distance based on speech limit of 43 miles standard cable. Observed experimental values. | |
|---|---|---|---|---|---|---|---|---|
| | R. Ohms. | K. M.F. | L. Henries. | | | | | |
| *Underground A.S.P.C. Cable.* | | | | Miles. | Miles. | | | |
| 10 lb. cable | 175·64 | 0·07 | 0·001 | 0·61 | 26 | 25 | 26 | |
| 20 " | 86·0 | 0·055 | 0·001 | 1·0 | 43 | 43 | 43 | |
| 40 " | 42·0 | 0·056 | 0·001 | 1·47 | 63 | 66 | 63 | |
| 70 " | 25·0 | 0·063 | 0·001 | 1·83 | 79 | 72 | .. | |
| 100 " | 17·0 | 0·058 | 0·001 | 2·45 | 105 | 91 | .. | |
| 150 " | 11·7 | 0·065 | 0·001 | 2·95 | 127 | 113 | 127 | |
| 200 " | 8·75 | 0·07 | 0·001 | 3·5 | 151 | 150 | .. | |
| *Submarine Cable.*—160 lb. Cu and 300 lb. G.P. per knot | 12·9 | 0·12 | 0·00165 | 2·3 | 99 | 97 | 88 | |
| *G.P. Quad.*—40 lb. Cu per mile | 43·0 | 0·128 | 0·001 | 0·95 | 41 | 36 | 39 | |
| *Aerial Wires.*—100 lb. Cu open | 18·0 | 0·00808 | 0·0039 | 8·45 | 363 | 357 | .. | |
| 150 lb. Cu open | 11·9 | 0·00839 | 0·00376 | 11·7 | 503 | 490 | 473 | Means of several trials. |
| 200 " " | 9·0 | 0·00862 | 0·00366 | 14·7 | 632 | 613 | 626 | |
| 300 " " | 6 0 | 0·00893 | 0·003545 | 21·0 | 903 | 844 | 903 | |
| 400 " " | 4·5 | 0·00919 | 0·00344 | 26·1 | 1,122 | 1,056 | 1,075 | |
| 600 " " | 2·97 | 0·00958 | 0·00331 | 36·8 | 1,582 | 1,443 | 1,582 | |
| 800 " " | 2·25 | 0·00987 | 0·00322 | 45·8 | 1,969 | 1,804 | not determined owing to disturbance. | |

and received curves for each have been recorded in the usual, photographic manner.*

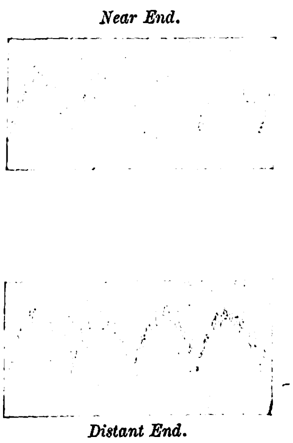
The results are not, I fear, quite so distinct as I could wish, but there are considerable difficulties in manipulation, which perhaps may be overcome later. One, for instance, is due to the great difference in amplitude of the curves at opposite ends of the long length of cable. The spot of light in the transmitting end travels over a longer range than at the received end, and the photographic exposures, therefore, vary in the inverse ratio of the amplitudes. However, I hope enough will be seen to make this line of investigation clear and to prove to some extent the accuracy of the foregoing data. It will be seen that on the one-mile length the curves at opposite ends are almost counterparts one of the other, the difference of amplitude being inappreciable, and all the irregularities of each transmitted curve being faithfully reproduced at the distant end. Where, however, the longer length of cable is introduced the difference of amplitude is most marked, and although it is perhaps somewhat more difficult to compare the shapes of the two curves, they still bear a substantial resemblance one to the other.

It will no doubt be observed that this method of reproducing the curves due to specific sounds affords a great improvement on the old phonautographic method. In the latter, the sharp peaks on each curve which may be observed on the best of the slides just shown are all rounded off in most of the published illustrations, and no other result can be expected where levers are used to increase amplitude. The oscillographic method of producing these curves should be of considerable use in the study of vowel and other elementary sounds.

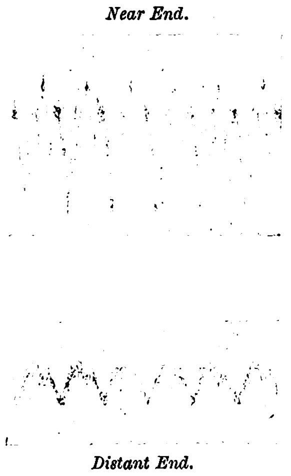
It will, of course, be borne in mind that the foregoing remarks apply to unloaded circuits—*i.e.*, those not fitted with artificial inductances.

Incidentally, the curves on the opposite page may be of some interest. They represent measurements made with a sechometer, on various types of loop, and they illustrate very graphically the fact that on short lengths the self-induction predominates largely over the capacity. As the length of circuit increases the curve first rises, but as the capacity effects increase more rapidly than the inductances, the curve reverses and falls until a point is reached which the self-induction and the capacity neutralise one another. in

I have already referred to the question of increasing the self-induction of telephone lines by the addition of induction coils at definite lengths. In America the question has been dealt with by Dr. Pupin, and considerable work has been done in that country in the direction of loading underground cables, as it is termed. The Post Office took up the subject at an early date in connection with its main underground lines, and a marked measure of success has already been obtained. In one case, that may be taken as an illustration, a cable containing 56 100 lb. conductors, was loaded by the insertion of coils at intervals of a mile; the original factors were R = 17 ohms, K = 0·053 mfds., L = 1·4 millihenries, and the total added inductance per mile amounted to 40 millihenries, the original R being raised to 21·34 ohms per mile by the addition of the coils. The equivalent range of speech was, however, increased from 66 to 176 miles. In the Post Office experiments on its long-distance lines so far, the use of iron in any portion of the coils has been found to be deleterious as compared with coils without iron cores. True, the volume of sound was always materially raised where iron was used, but at the cost of articulation, whilst a judicious addition of self-induction without iron always improved both the volume and the articulation.

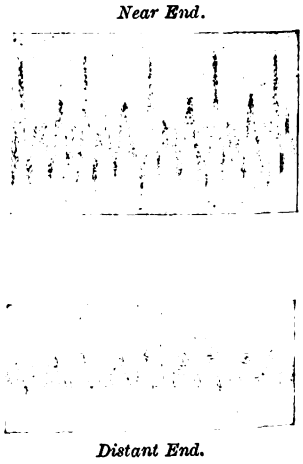


Letter E. One Mile of Cable.



Letter E. 20 Miles of Cable.

Letter H. One Mile of Cable.



Letter H. 20 Miles of Cable.

It is, of course, obvious that any marked improvement in the normal types of telephone apparatus will tend to extend the ranges given in the tables. Further, it will be observed that these ranges are based on a 43-mile limit of standard cable, although under favourable conditions, and with expert users of the telephone, much longer distances are practicable. These limits also presuppose that the telephone is joined directly on to the line, and they have to be cut down when the exchange apparatus and the subscriber's line are added by an amount equal to their equivalent mileage.

Such tables as these admit of a determination of the gauge and type of conductor necessary to serve any given locality, it being borne in mind first that in a country like Great Britain, where main trunk lines pass through towns of considerable size every few miles apart, it is difficult to carry heavy gauge wires intact from one extremity to the other—*i.e.*, lighter gauge open wires and underground work have to be introduced in sections to overcome obstacles, and, further, that telephonic communication differs from telegraphic in so far as this, that where the former is concerned any given town may require to be put through to any other town within the general telephonic range of the service. It is, therefore, obvious that in laying out and adding to a system of telephone trunk communication, the extended use, either of small gauge conductors or of underground work generally, is absolutely inadmissible. Such conductors with limited range can only be used under well-defined conditions. It follows that to provide an efficient and economical service it is necessary to make a careful study of the country as a whole and to lay out the trunk lines in such a manner as to deal with the maximum traffic with the minimum weight of copper, and to provide for general intercommunication by the shortest possible lengths of trunk circuit.

Very satisfactory results have, however, been obtained in America and in Germany by the use of ring-coils with extremely fine iron cores, and further progress in this direction may be anticipated. On this subject a valuable Paper was read by Dr. Hayes at the recent Congress in St. Louis, in which he shows how under suitable conditions the attenuation in long lines is materially diminished by the addition of suitable inductances properly spaced. His Paper is a valuable contribution to our knowledge of the subject.

Experiments with overhead conductors have not proved so satisfactory as with underground cables. The variation in the insulation of the open wires upsets the balancing due to the coils, and lightning troubles have affected the coils. For the present, at all events, this method of increasing the range of open conductors of limited gauge cannot be considered so satisfactory as the corresponding results with underground work, and opinions as to the future of open wire loading appear to be somewhat divergent.

## Unsolved Problems.

Finally, there are the unsolved problems in connection with electrical methods of communication to consider. These are neither few nor unimportant. Dealing with the different heads of my address in order, the telegraphic problem is by no means finally solved, notwithstanding the years which have elapsed and the growth of the system since its introduction. A means whereby telegraphic messages can be received at high rates of speed in type or written character ready for immediate issue to the public or the Press, appears to be one of the desiderata of the future. That this need is fully realised is shown by the ingenious inventions that have from time to time been received and experimented with by the most important of the telegraphic administrations in Europe and America. Incidentally I think I may truly say that one of the most painful duties imposed on the heads of a telegraph service is the rejection of inventions on which an untold amount of skill and labour have been expended, but which for one reason or another are not fully adapted for practical requirements. I have reason to hope, however, that we are now within a measurable distance of a satisfactory solution of one branch of the problem just referred to.

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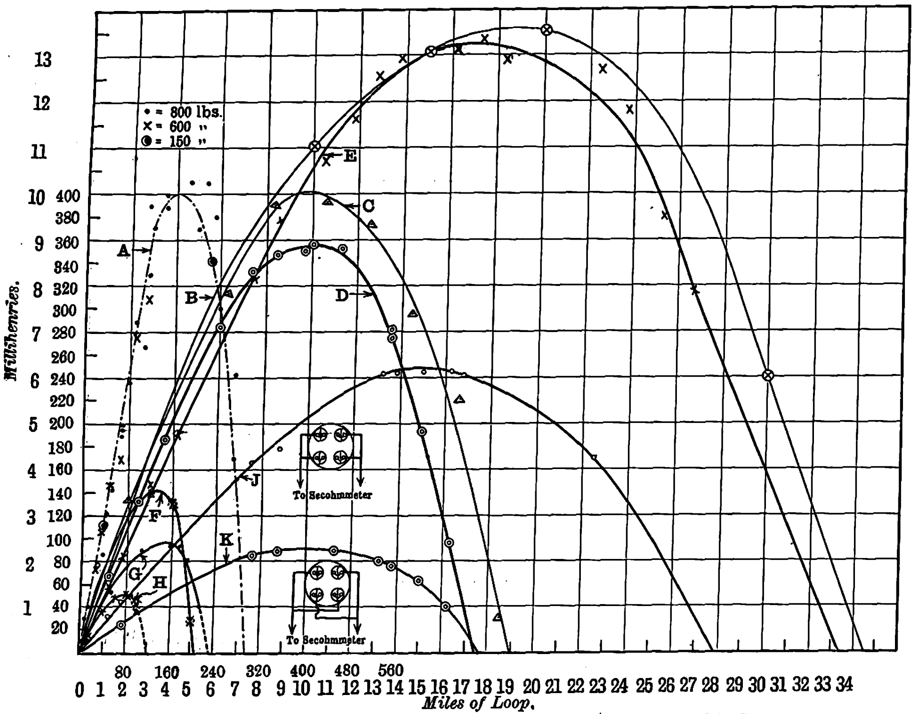
* To bring out the characteristics of the curves in a clearer manner we have reproduced the oscillographs twice the original scale.—Ed. *E.*

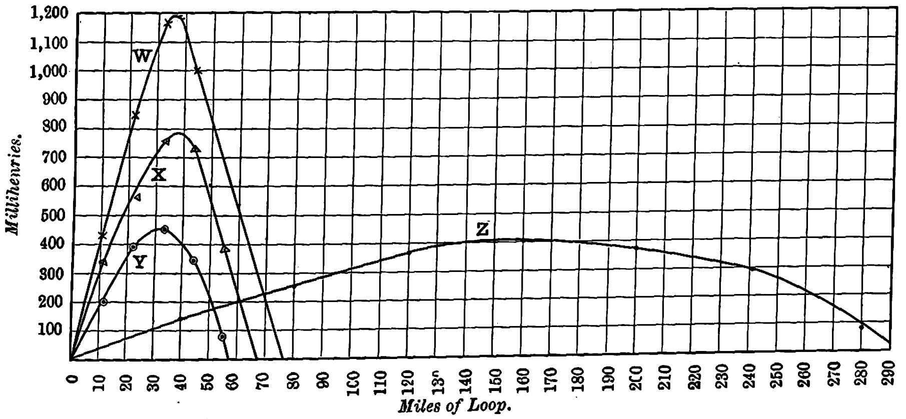
*Note.*—The smaller notation (400, &c.) is to $\frac{1}{40}$th scale, and refers to Aerial Line Curve (— — - — - — - — —) only.



A. Aerial Line ($\frac{1}{40}$th scale).
B. A.S.P.C. $\frac{42}{200}$ and $\frac{48}{100}$ Q.P. K.=0·045 mfd. per mile (200 lb.) R.=8·8ω per mile of loop (200 lb.)
C. A.S.P.C. $\frac{42}{100}$ Q.P. K=0·045 mfd. per mile. R=17·7ω per mile of loop.
D. A.S.P.C. 100 lb. $\frac{56}{100}$ Q.P. K=0·049 mfd. per mile. R=17·7ω per mile of loop.
E. A.S.P.C. 200 lb. $\frac{56}{100}$ Q.P. K=0·068 mfd. per mile. R=8·8ω per mile of loop.
F. 40 lb. G.P. Quad. K=0·13 mfd. per mile. R=45ω per mile of loop.
G. 40 lb. A.S.P.C. K=0·06 mfd. per mile. R=45ω per mile of loop.
H. 20 lb. A.S.P.C. K=0·05 mfd. per mile. R=90ω per mile of loop.
J. A.S.P.C. 400 lb. Q.P. (sides bunched). K=0·13 mfd. per mile. R=4·4ω per mile of loop.
K. 400 lbs. $\frac{56}{100}$ Q.P. (diagonals bunched). K=0·17 mfd. per mile. R=4·4ω per mile of loop.

Observed Inductance of Loops in Cables and Aerial Lines, measured on Various Lengths with Secohmmeter.

Next, in wireless telegraphy, there is the difficult problem of perfect tuning which will obviate all mutual disturbances between different wave-lengths, and in addition it can, I think, scarcely be said that we have arrived either at finality in the matter of wireless receivers. In fact, the impression left on one's mind after a study of all the methods so far evolved is that we are even now far from having a thoroughly effective or reliable receiving arrangement, if we compare the reliability of wireless with that of telegraphic or telephonic communication.



W. A.S.P.C. $\frac{56}{100}$ Q.P. K=0·049 mfd. per mile. Treated Cable. R=17·7ω per mile of Loop. L added about 40 mhys. per mile.
X. A.S.P.C. $\frac{42}{100}$ K=0·045 mfd. R=17·7ω per mile of loop. L added about 30 mhys. per mile.
Y. A.S.P.C. $\frac{42}{100}$ K=0·045 mfd. R=17·7ω per mile of loop. L added about 17 mhys. per mile.
Z. Aerial line, 800 lb.

Observed Inductance of Loops in Cables and Aerial Lines measured on Various Lengths with Secohmmeter.

Then in telephony there are at least two fundamental problems which await solution. First, the invention of an effective telephone relay or repeater; and, secondly, a method of extending the range of communication in submarine cables. In reference to the existing practical limits of speech on circuits of different types, it will be evident that these limits are such that it is not always possible to meet the requirements of the public over Continental areas of great extent, or in cases where long submarine cables are necessary. Until recently all attempts to design a satisfactory telephone relay had failed, but the American Telegraph and Telephone Co. have now under trial an instrument termed an exalter which, when placed in a suitable position on a long line, materially improves the communication. I tried this recently between New York and Chicago, and I hope shortly to have an opportunity of experimenting with it on our long-distance lines and cable circuits. It is the first step that costs, and we may now look forward hopefully to other developments.

Notwithstanding the very great advances made in the modern switchboard, the problem of affording intercommunication between very large numbers of subscribers is by no means finally solved. The largest multiple that can be fitted in practice on one board does not exceed 20,000 lines, and not only in London, but in several American towns, provision is being made in one building for numbers varying from 40,000 to 60,000 telephones, two or three separate exchanges being provided in one building. That this duplication and triplication of exchanges is the final solution of the problem no one would, I think, venture to predict, and, as I have already hinted, there are indications that the difficulty may be met in another manner.

The submarine cable problem for telephonic use is not an easy one, as gutta-percha, which, so far as our present experience goes, must be used in some form, has such a relatively high electrostatic capacity that it has not been found practicable to use it for really long cables, and the problem of loading, which at first sight would appear to offer a solution of the difficulty, has not yet been met in a satisfactory manner. Again, although much has been done in the direction of improving the methods of telephone switching—and only those can judge what progress has been made who are familiar with, for example, the modern central battery board, and can compare its working with that of the older forms—still we are by no means near finality, and there are possible improvements and modifications looming in the not distant future which may profoundly modify our present practice.

Finally, I have little doubt that the progress of electrical means of intercommunication will in the future go on unchecked, and that those associated with and responsible for such progress will in the course of the next few years bring about such developments that they will be in a position to compare in no unfavourable manner the advance of these particular branches of our work with that which we can forsee in all other branches.

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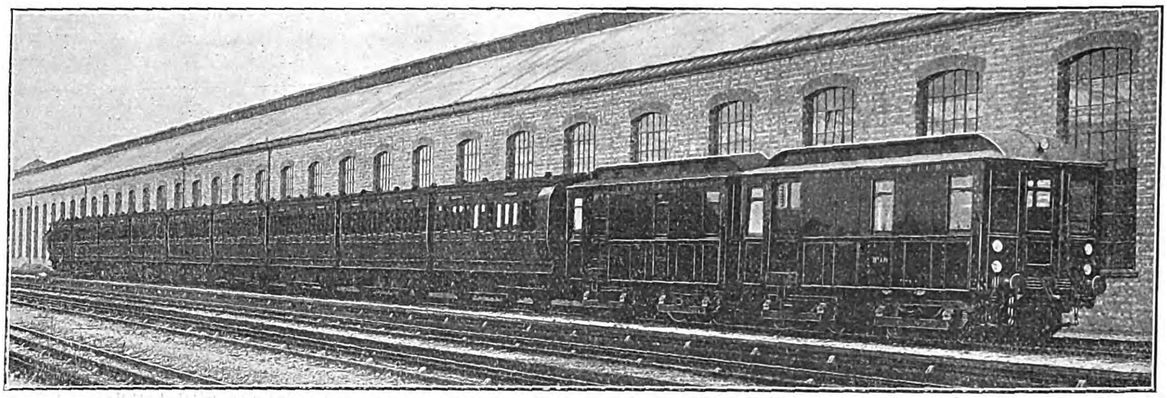
At the conclusion of the address, Prof. SILVANUS P. THOMPSON proposed a vote of thanks. He said that after listening to an address of this nature one was bewildered with the number of matters referred to. But there were several matters of intense interest, the most important probably being the K.R. law, any simplification of which would be hailed with delight. They had heard a lot about jacks, and whether these jacks were jacks-in-office or municipal dogs-in-the-manger, there was no doubt that there were at the Post Office some very able men at the head. Prof. Thompson also referred to the oscillographs, and suggested that they were produced by calling the name of the letter into the transmitter, and not by emitting merely the sound corresponding to the letter.

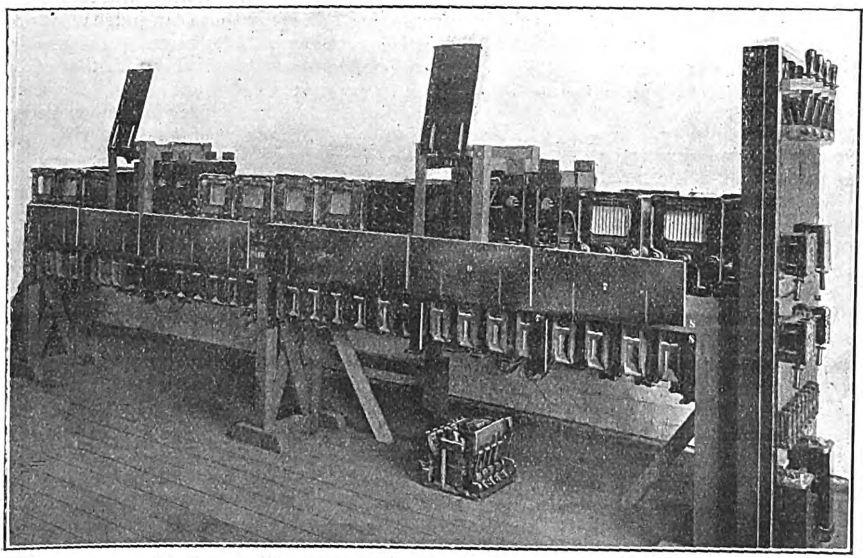
Mr. JAMES SWINBURNE seconded the vote of thanks, and it was carried amid much applause.

## ELECTRIC LOCOMOTIVES FOR THE DISTRICT RAILWAY.

Last week we were enabled to contradict a statement which had appeared in the daily press to the effect that all steam trains would be withdrawn on Monday. This week, by the courtesy of Mr. Jas. R. Chapman, chief engineer of the London Underground Electric Railways (Ltd.), we are in a position to publish an illustrated description of the new electric locomotives which will displace those now driven by steam which haul the London & North-Western trains from the Mansion House to Broad-street, via Willesden. As we explained last week, the L. & N.W. trains have always been the slowest of all which run over the District Company's line, and this fact accounts for the delay in providing a much accelerated service. Actually, the electric trains are kept waiting, both at stations and in between, in spite of the fact that the steam trains are allowed a four minutes' headway at the Mansion House. All this is to be changed, however, by the new electric locomotives, and a greatly improved service will become the rule when these machines are put in commission. The bodies were built by the Metropolitan Amalgamated Railway Carriage & Wagon Co., at their Ashbury works, and the entire electrical equipment was built and fitted by the British Thomson-Houston Co. Each locomotive has four motors of 200 H.P., making an aggregate of 800 H.P. per locomotive. These motors are identical with those employed on the ordinary District Railway trains, while another point in common is the adoption of the Sprague-Thomson-Houston multiple-unit control system. There is a double equipment of contacts, rheostats, circuit-breakers, &c., these being shown in our illustration as actually installed on the locomotive. Briefly, the standard B.T.-H. equipment of the trains has been applied to the locomotives.



Two Electric Locomotives coupled to L. & N. W. Train.



Contactors, Resistances, &c., in New Electric Locomotive.

## A NEW CHAIN FOR MACHINE TOOL DRIVING.

[Communicated.]

Although chain driving is one of the oldest methods of transmitting power, it has for many years remained in a somewhat unsatisfactory state. There were defects which militated against its general adoption—the excessive noise and the objectionable joint wear. Chain makers gave the two points careful attention, recognising that if they were successful in overcoming these difficulties chain driving would become one of the most efficient means of transmitting mechanical power.

To obtain noiseless action each of the links must be a driving member, and must be so shaped that it will fall into place with practically no blow effect; also it is necessary that as the pitch changes through joint wear, the links should take a larger pitch diameter on the wheel and maintain this action until the top of the tooth is reached. The old-fashioned principle of construction involving the solid rivet hinge joint with its insufficient bearing surface in the links, its rubbing, grinding, friction and its need of constant lubrication was never satisfactory in this respect; and it was found that so long as such construction was retained, excessive wear and general unsatisfactory behaviour were the inevitable accompaniments of its use.

The Morse silent joint chain, which is manufactured by the Westinghouse Brake Co. at their works at King's Cross, is an entirely new departure in the principle of chain construction. Involving, as it does, several novel features, the details of its construction and working will be of interest. It has long been recognised that a rocking action between hardened steel surfaces is a perfect means of obtaining motion of parts which move relatively to each other through a limited angle—the precise function required in the chain. Such a joint is almost indestructible, even under enormous pressure, requires no lubrication, and involves no perceptible friction or wear. In addition to all the advantages derived from this frictionless joint construction, the Morse high speed chain possesses fully the silent running and compensating features called for by modern requirements.

The joint, which is the most important part of the chain, is simple in construction, consisting of two pieces of hardened steel shown in two positions in Fig. 1. The piece on the left is called the "seat pin," and presents a plane surface to the second piece termed the "rocker pin." As the joint bends when passing over the wheel the "rocker pin" rocks or rolls on the plane. There is thus no sliding action to cause the joint to wear and the chain to lengthen, but, instead, simply a rolling effect between these hardened steel surfaces, which have ample contact area to withstand the pressure.

As shown in Fig. 2, the "seat pin" is fixed in one end of each link and the "rockerpin" in the other; and when the links are assembled the latter pin of one set of the links bears on the former pin of the other. When the chain is drawn straight the contact surface between the two halves of the joint is greatly increased, thus preventing undue vibration under high speeds.

In a like manner, while the joint is between the wheels, the pressure is taken by these broad-bearing surfaces, none coming on the apex of the rocker pin except when the joint is passing on or off the sprocket. In the ordinary chain, built up of alternate links on a circular pin, the pressure on the latter in each direction must be carried by one set of links, leaving only half the length of the pin for bearing surface. In the Morse chain, on the other hand, the whole width of the chain, less the outside links, is available in an unbroken line of contact, which nearly doubles the length of the bearing surface for a chain of a given width.

Lubrication has always been a difficulty with drives employing the old type of chain, with its sliding friction at the joints. In such chains efficient and ample oiling is a prime necessity, in order to reduce joint wear and maintenance costs. While this may be effected with comparative ease at low speeds, there is a limit of velocity at which centrifugal force throws off all lubricant and causes the chain to run dry. Therefore, a chain requiring constant lubrication is debarred entirely from high speed use unless enclosed in a bath of oil at a considerable cost and sacrifice of convenience. An important feature of the Morse chain is that as there is no sliding friction, there is no need for lubrication; and hence, the speed limit is not fixed at the point where centrifugal force comes into play, and throws off the oil.

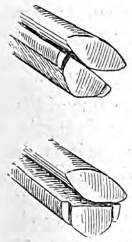


Fig. 1.—Joint in Two Positions.

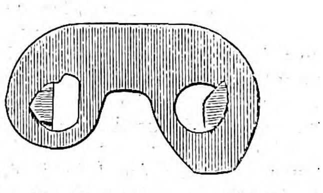


Fig. 2.—Link showing Method of Assembling Two Halves of Joint.

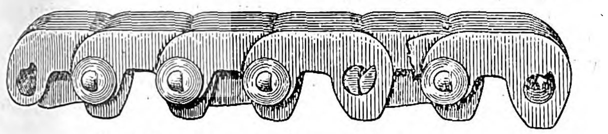


Fig. 3.—Piece of Chain Removed.

Further, grit is not so objectionable in the Morse chain with its rocking joint as it is in the ordinary pin joint, and for this reason it is peculiarly adapted to outdoor work or employment in a dust-laden atmosphere. Whatever grit or dirt gets into the chain does not stay between the rolling surfaces, but finds its way down to the bottom of the joint where it will be noticed the rocking pin is chamfered so as to leave a small space for its reception. An accumulation here does not interfere with the action of the chain, and ultimately works its way out.

In the construction of the chain the outside links are off-set laterally, so that their large ends come under the small ends of the links next adjacent, so that the rocker may extend beyond the last link in which it is fixed, ensuring a good bearing surface in every link. The seat pin being the rivet always extends to the outside of the chain (Fig. 3).

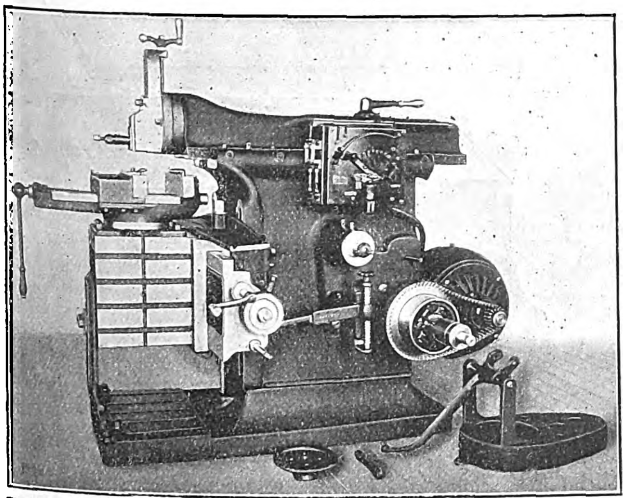


Fig. 4.—3 h.p. Morse Chain Drive. 1,200 revs. per min. on $13\frac{1}{8}$ in. centres; sprockets 16 and 57 teeth; chain $\frac{5}{8}$ in. pitch, $1\frac{3}{4}$ in. wide; speed 1,000 ft. per min.

In order to guide the chain upon the wheels, special links are used in its centre, which, projecting almost level with the ends of the teeth, run in grooves formed in the wheels. The joint pins are made of the best grade of tool steel carefully hardened, the shouldered ends of the seat pins being afterwards softened to permit of riveting into the outside links, or into washers in the larger sizes. The holes in the links are punched to conform in shape to and securely hold the two pins, between which and the link there is no relative motion.

The efficiency of the Morse chain is very high, being 3 to 4 per cent. better than that of the best belt drive running under the most advantageous conditions. The chain will run well in either direction, but it should always be installed in accordance with the specific instructions and as indicated by the stampings on the gear wheels supplied with it. The reason for installing the chain to run in a certain direction is, that if it were to reverse, the small end of the link is made with a different radius than when it is intended to run only one way. This is to prevent the seat pin from sliding across the face of the rocker pin when the chain reverses.

The satisfactory operation of a high-speed chain drive being dependent upon several considerations besides that of strength, it is necessary, in order to attain the best results, to design the drive with a view to the special requirements of the case. With ordinary belting momentary increases of tension are relieved by slipping at the expense both of durability and efficiency. The chain drive, on the other hand, being of a positive nature, must be designed to withstand the severest shock that it may be subjected to. When convenient the drive should be designed with centres as near to the horizontal as possible. The tension side of the chain may be at the bottom with long centres, but for short centres or high-speed driving it is preferable for the tension side to be at the top.

Facilities for adjusting the centres are always desirable, and for vertical drives necessary if the best results are to be obtained.

The longer the pitch the stronger is the chain for a given width; and, generally speaking, as the running speed decreases the pitch of the chain may be increased, or a slightly increased tension may be allowed with a given pitch and width.

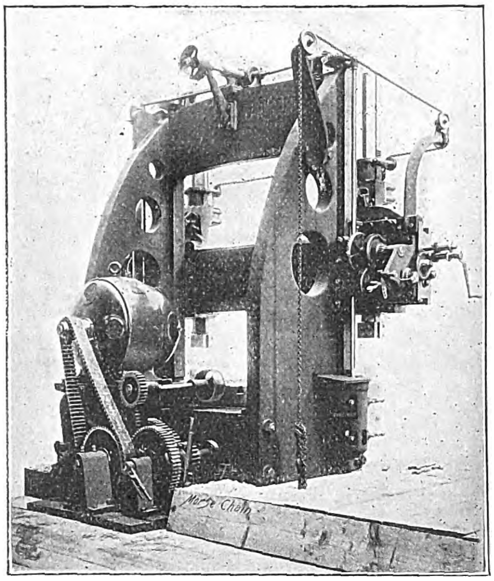


Fig. 5.—17 h.p. Morse Chain Drive. 500–1,000 revs. per min. on $41\frac{1}{4}$ in. centres; sprockets 17 and 55 teeth; chain 1·2 in. pitch, 4 in. wide; speed 850 ft. per min.

Figs. 4 and 5 show the adaptation of a Morse chain to motor-driven machine tools. These chains can be run successfully on wheels with as few as 13 and as many as 130 teeth; and by their use large speed ratios are easily obtainable. They have found considerable favour in the motor-car world, a field for which their high efficiency and durability make them particularly suitable.

## ELECTRICAL EXHIBITION AT OLYMPIA.

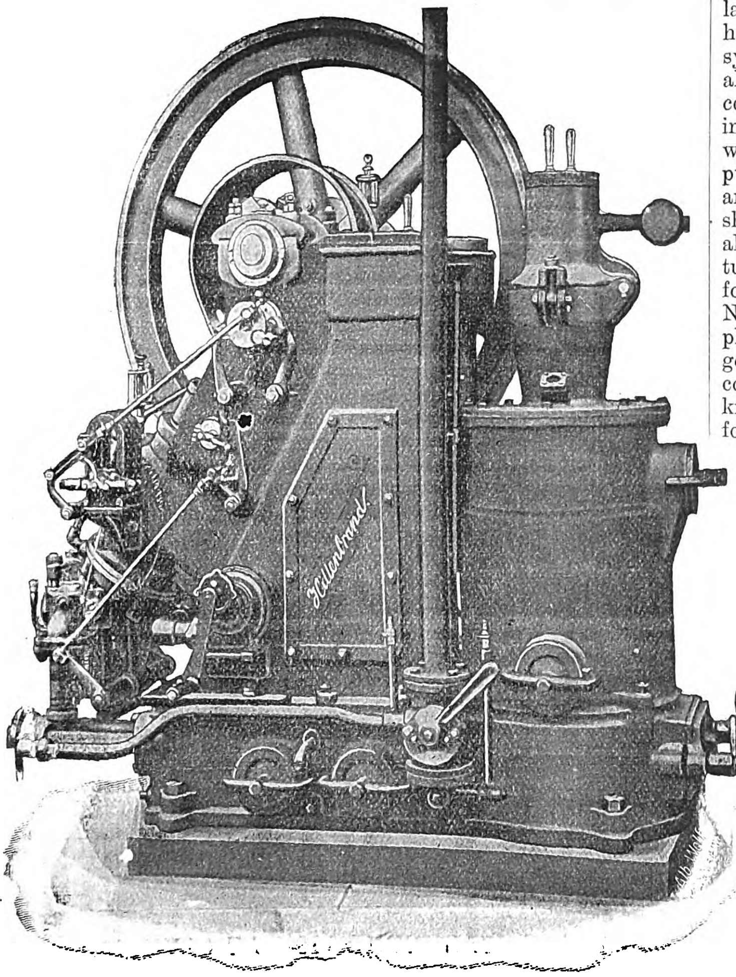
(Ninth Notice.)

Mr. J. G. Statter asks us to state that the 1,000 ampere 400 volt I.T.E. laminated edgewise circuit breaker, an illustration of which appeared in our last issue p. 138, is not made by his firm, but by the Cutter Co. of America, the only part designed by the Switchgear Co. being the time-limit attachment. We understand that since the drawing was prepared, the Cutter Co of America, have taken a general licence under royalty for the manufacture and supply of the "Statter" time-limit in Great Britain, and will, in future, be responsible themselves for the details of the design of the time-limits attached to their circuit breakers.

The Sir Hiram Maxim Electrical Co. made a display of the "Maxim" filament in all its stages. This firm's "Crystolite" lamp has a corrugated bulb instead of the ordinary plain or frosted globe. Another of their lamps is said to give 40 c.p. in the downward direction, while taking only 80 watts. The "Maxim" system of continuous light, it is claimed, utilises the longest tubular filament yet made, but only quite short lengths—12 in. or so—were exhibited. We were informed, however, that there are in process of manufacture filaments 4 ft. long. The "Maxim" semi-enclosed arc lamps, which are now to be seen on practically all the stations of the District Railway, patent locking devices for preventing the removal of incandescent lamps except by an authorised person, and "Huntalite" candle lamps were also shown.

The PICCADILLY PENDANT Co., of Manchester, showed an ingenious adjustable pendant, the lamps being switched on or off when the lamp is pulled down or up. In the case of a lamp suspended from an ordinary ceiling rose, for instance, an ornamental cylinder, about 4 in. in diameter and 4 in. long, is screwed to the ceiling, and the wire from the ceiling rose which is covered by the cylinder is connected to two terminals on the inside. The flexible to which the lamp is connected is wound round a small drum inside the metal cylinder on which are two terminals and brought out through a hole in the bottom. Two projections are screwed to the outside of this drum (which, by the way, is controlled by a spring after the fashion of a spring blind, this spring being balanced by the weight of the lamp), and the action of raising or lowering the position of the lamp brings these pieces into connection with the spring contacts of a double-pole switch. In the action of lowering the lamp the light is switched on, and when the lamp is pushed up the light goes out.

Mr. G. BRAULIK had on view a complete range of telephonic outfits, electrical accessories, testing apparatus, lamps, and some heavier apparatus in the way of electric drills, &c. He also exhibited a Hillenbrand suction gas engine plant coupled by a belt to a small dynamo made by the India Rubber, Gutta Percha & Telegraph Works Co. This supplied 200 volt current for the partial lighting of the stand. The main feature of this suction gas plant is its compactness, the gas generator, scrubber and engine all being combined in one, as will be seen by the illustration above.

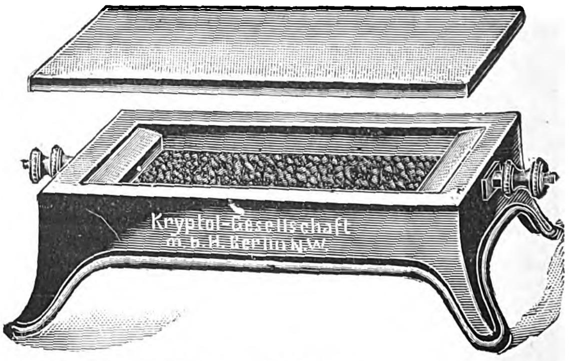


MINIATURE SUCTION GAS PLANT DRIVING SMALL DYNAMO.

The air passing to the gas generator first passes through the cooling water of the cylinder jacket. The air is saturated with steam, and the mixture of air and steam is heated by the exhaust silencer in the bed of the engine before being passed under the firebars of the generator, seen on the right of the illustration. By the sucking action of the motor the air and steam mixture passes through the incandescent fuel where it is decomposed and thus the gas is produced. The hot gas passes from the upper part of the generator into a chamber surrounding and hot-jacketing the working part of the generator. From the generator jacket the gas passes through the engine bed into the scrubber where it is cleaned and cooled in the usual way, and from which it is passed into an expansion chamber in the engine bed. The motor is in a slanting position, but the valves are placed vertically. The air necessary for the combustion in the cylinder is passed through the frame, where it cools the crank shaft; and then, passing through the cylinder cooling water, by means of a system of pipes, it is heated to a degree exceeding the temperature of the gas with which it is to be mixed. This mixing takes place in a regulating cock before entering the inlet valve. The engine which works on the well-known "Otto" principle, is fitted with magneto-electric ignition, and the speed is regulated by a governor acting upon the stroke of the inlet valve. It is claimed that not more than 6 to 10 minutes are required to start the engine from the time of firing. The consumption of fuel is stated to be 1 lb. per B.H.P. hour, and the consumption of water 2 gallons per B.H.P. hour.

The "Kryptol" heating system was also shown at this stand. In this the ordinary method of using a resistance coil as the heating unit is not adopted. The medium in this system is a mixture of graphite, carborundum, silicates and clay in granular form. This material is spread in a layer on an insulating plate between two electrodes, and it will readily be observed that the "Kryptol" may be raked so as to produce thin or thick layers, and thus the heat may be concentrated at any desired spot. The size of the granules varies according to the voltage. For ordinary domestic purposes "Kryptol" is used as described above, but if it is desired for special purposes to use a high voltage and small current, the layer of "Kryptol" is broken up by placing insulating bars half way across, from alternate sides of the insulating plate. The system, of course, is applicable to many purposes, and either alternating or continuous current may be employed. ["Kryptol" cooking appliances were also exhibited by the Dowsing Co., and in Mr. Dowsing's model electric kitchen.] Two other noteworthy exhibits at the stand were an arc lamp for photographic purposes, with an automatic time switch for regulating exposures, and a portable electric drill. The latter is directly driven from the shaft of the motor and the actions of switching on and off, and also of reversing the direction of the drill, are controlled by mere turns of the handle by which the workman holds the drill to his body for securing contact with his work. At Mr. Braulik's other stand, No. 87, is a very complete collection of electrical instruments, telephones, &c. In a portable positive-reading combined ohmmeter and generator for testing purposes, the generator is connected to a moving coil milli-amperemeter, reading as an ohmmeter, through the unknown resistance, and is shunted by a relay. At the critical voltage for which the moving coil instrument is calibrated, the needle of the instrument is fixed by the action of the relay at the reading which it indicates, and is only returned to zero by pressing a button on the face of the instrument.

A useful telephone receiver for use in positions where rough wear is likely, is in the form of a flexible speaking tube, about 2 ft. long, attached to the telephone by a ball socket. The diaphragm is behind this ball socket inside the wooden case, so that injury to the delicate parts of the instrument is avoided. A lamp fitting, which should prove useful in factories, &c., is suspended by a wheel to a live wire drawn across the building, so that the light can be placed at any desired spot. A cheap fire alarm system was also exhibited.

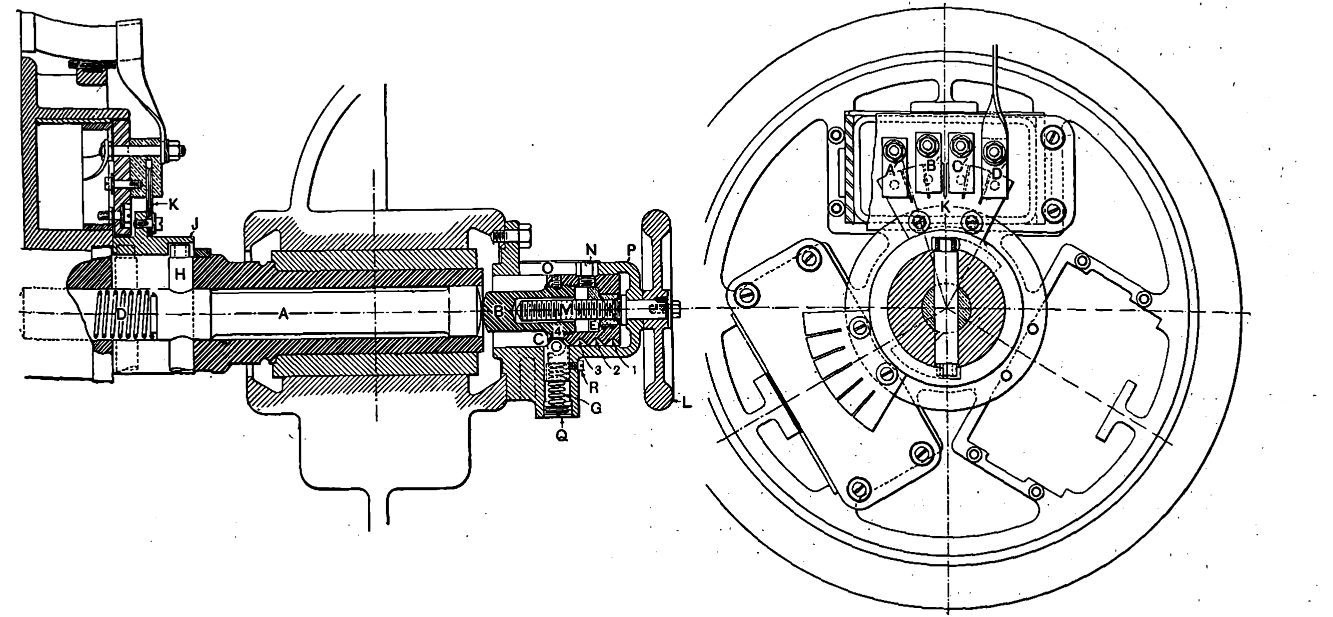


"KRYPTOL" HEATER.

The most prominent exhibit of the BRITISH ELECTRIC PLANT Co. was a duplex double-acting variable-stroke boiler-feed pump, having a capacity of 3,000 gals. per hour against a boiler pressure of 200 lb. per sq. in. The cylinders are 3½ in. by 5 in., and have single outside centre-packed glands, the speed being 85 revs. per min. The stroke is varied by means of simple worm gear, with star wheel and tappet, from 0 in. to 5 in., step by step at each revolution of the crank shaft. A special feature of the design is the care taken to prevent the slightest trace of air lock, and this feature, together with adequate air vessels on both suction and delivery sides, has made it possible, it is said, to obtain a delivery substantially as uniform as that from a three-throw pump. The pump is driven through single-reduction gear—raw-hide pinion and machine-cut cast-iron internal wheel—

by a B.E.P. type 13 four-pole open-protected shunt-wound motor, to develop 12 B.H.P. at 585 revs. per min. at 440 volts. This plant has been built to the order of the Gloucester Corporation. We understand that a 6,000 gallon set of similar design has been ordered by the Glasgow Corporation. A six-pole 230-volt shunt-wound protected motor with ventilating covers, to develop 33 H.P. at 520 revs. per min., was also on view. Keeping in step with the progress in dynamo design, the firm exhibited a variable-speed shunt motor with commutating poles. This motor is wound for 230 volts and able to develop 8½ B.H.P. at a lowest speed of 645 revs. per min., and the same, or slightly more, power at all speeds up to 2,000 revs. per min. The speed is varied by shunt control alone. The other exhibits included several continuous-current motors protected in diverse manners, armatures ready for use, core discs, brush-holders and motor switch gear with and without a regulating rheostat for speed variation. Some of the starters are operated by a worm gearing, the handle of which protrudes at the side of the box. This device, now gaining so much in favour, makes it impossible for the operator to switch in very quickly.

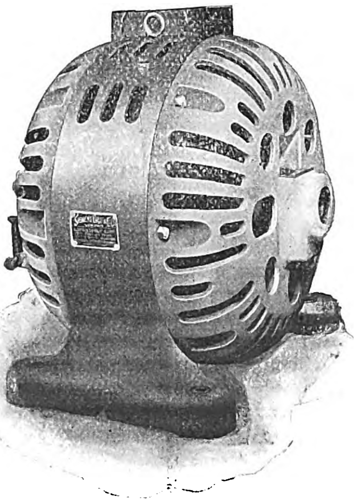
Messrs. SIEMENS BROS. & Co. had things of greater interest to show than the enormous pile of dry batteries that occupied the place of honour in the centre of their stand. The exhibition afforded everyone an opportunity of seeing the tantalum lamp, which when perfected will constitute an enormous advance on the carbon filament lamp for both internal and external lighting. There were 100 of these lamps on the stand, each of 110 volts and 22 c.p., and wired two in series. In addition 10 tantalum lamps were mounted next to 10 carbon filament lamps, and instruments were connected to them to show that they consumed 30 per cent. less current, in spite of the fact that they gave 50 per cent. more light. The efficiency is stated to be 1·7 watts per candle power when the lamp is new, and the life of continuous-current lamps is estimated at 400 to 600 hours. Consumers are not recommended to use the lamp on alternating-current circuits at present. We do not add a description or illustration of the lamp here, as both have appeared in our columns at a comparatively recent date. In addition to the tantalum lamps, some "liliput" continuous-current arc lamps helped to illuminate the stand. These lamps take 2 amperes when connected two in series on the 220 volt mains.



SHAFT OF SIEMENS INDUCTION MOTOR WITH STARTING SWITCH.

Several motors were exhibited, and we select two for description. In the induction motor illustrated in the next column, the end shields have narrow openings, so arranged that the motor is effectively protected from articles falling on it, but with larger openings for inspection and attention in less exposed positions. The stator frame is of cast iron of a ribbed section and the stampings are held in position in the frame by cast-iron collars or bolts. The end shields are as light as is consistent with good mechanical construction, and are bolted to circular facings on the stator frame so arranged that by rotating them the motor may be attached to wall, floor or ceiling without other alteration. Stator coils of the pull-through type are employed, the slots being nearly closed. The rotor is also built up of stampings with nearly closed slots. In the case of short-circuited rotors, the bars are insulated in the slots. They project a considerable distance at each end, and act as ventilating blades. In wound rotors the ends of the winding are opened sufficiently to allow a free circulation of cool air, aided by blades on the end castings. In slip-ring rotors the rings are internal.

Induction motors, in which the rotor-starting resistance is carried on the rotor itself, and is switched out without the assistance of external connections, are not new, but the one shown by Messrs. Siemens Bros. & Co. is a new pattern. The gear for switching out the resistance is shown in the detailed drawing below, in its final position—*i.e.*, with all the resistance in the rotor circuit cut out. In starting up the position of the auxiliary plunger B is such that the roller C engages with Vee slot 1. As the screw M is rotated by means of the handwheel L, it forces the bush E from left to right, and the pull is transmitted to the auxiliary plunger B, causing the latter to force back plunger F against the action of the spring G.



SIEMENS BROS. & CO. VENTILATED ENCLOSED MOTOR, SLIP-RING END.

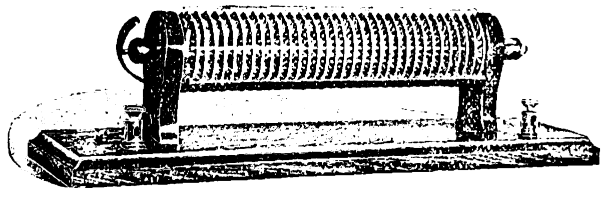
The handwheel is slowly rotated until such a position is reached that the action of spring D overcomes the action of the plunger F, thus causing the plunger B to jump until the roller C occupies Vee slot 2. This movement is immediately taken up by plunger A under the action of plunger B. In moving, the plunger A carries with it the pin H, which, rolling in a spiral slot in the collar J, gives to the latter a rotary motion. The collar J carries the blade K, which intermittently short circuits the contacts A', B', C' and D'. If the handwheel L is still rotated, then the movement of plungers A and B are repeated, and the roller C successively occupies the Vee slots 1, 2, 3 and 4. The number of Vee slots corresponds to the number of resistance contacts, and the blade K occupies a definite position when the roller C is in any one of the Vee slots. N is an indicator working in a slot, O, which reveals to the operator the position of the blade K. The whole of the mechanism for the intermittent motion is entirely enclosed in a cast-iron case, P, and secured to the end of the bearing of the motor. Q is a screwed plug for adjustment of the spring G, and the plunger F is prevented from rotating by the action of the screw R sliding in a keyway.

A large collection of crane controllers were exhibited, and these, as a large number of this firm's exhibits, were made at the Siemens-Schuckert works in Berlin, but we understand that the manufacture of the controllers is shortly to be taken up at the company's dynamo works at Stafford. Samples of cable, pyrometers and measuring instruments were also exhibited, and among the instruments the most prominent was a Ferraris "Universal" wattmeter, over 20 in. in diameter, with three separate pointers indicating kilowatts, volts and amperes respectively.

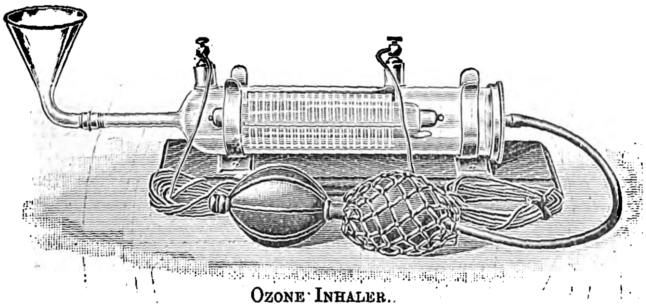
Messrs. Longstreths (Ltd.) showed a number of "Lithanode" storage batteries of various sizes. These cells are so familiar that it is quite unnecessary to enter into a description of them. A feature of interest was the unspillable cell for motor ignition purposes. This cell can be shaken about or even held upside down without a drop of acid being spilt. An auxiliary compartment is provided into which acid, coming out of the cell proper, is deposited. This acid can afterwards be blown back into the cell. Patent oil cups are fitted to prevent the acid "creeping" up the positive terminal and destroying it by corrosion.

Carl Hentschel (Ltd.) showed printed specimens from photo-mechanically engraved blocks, in one, two and three colours, and also specimens of engraving in the half-tone, line and colour processes now used for printing purposes generally. Messrs. Hentschel's exhibit had special reference to high-grade catalogues and advertisements, and was a very excellent display. We would especially refer to the illustrations supplied by this firm for Mrs. Allingham's famous book "Happy England."

Messrs. William McGeoch & Co. showed a large range of electrical accessories, but the centre of attraction was a patent electrical ozoniser, which we illustrate. This apparatus is made by the Electric Ozone Synd., and the principle of it is that invented by the late M. Emile Andreoli. The chief function claimed for this apparatus is the purification of air and water, although there are a number of commercial applications for which it is possible to use the apparatus. The apparatus can be used with an ordinary motor-car coil, or directly from the supply mains through a transformer. Our other illustration shows an ozone tube, 6 in. long, with vulcanite funnel and blower, for medical purposes. A number of these tubes can also be placed around the wire cage of an electric fan, and this method of distributing the ozone has been adopted on board ship. Messrs. McGeoch pay special attention to ships fittings, and a large variety of these were shown.



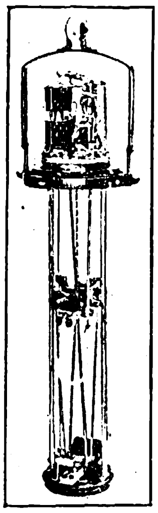
Open Ozone Tube.



Ozone Inhaler.

Messrs. G. Richards & Co. had a heavy 3 ft. boring and turning machine, radial drilling machines, mould drier, sand-blast apparatus, air compressors, compressed air tanks, Richards' "cling-rim" motor pulleys, &c., on view. The boring and turning machine which was exhibited is the smallest of the standard types manufactured, which range, in 12 steps, from 3 ft. to 16 ft. in diameter. The large annular bearing under the table has the special form of the "Schiele" curve, and rotates in a reservoir of oil. This form of bearing gives special rigidity to the table, and permits of the same being rotated without undue friction at suitable speeds for boring. The tables are driven by spur gearing on their periphery, which prevents any tendency to raise the table when taking heavy cuts. Each machine is fitted with a positive feed motion, which is a very compact arrangement, and is claimed to be an advance on the sliding-key system. The whole of the gears are encased in a box containing oil. Twelve rates of feed are provided, and these can be changed instantly. Richards' "Cling Rim" pulleys are ordinary pulleys which, after being bored and turned in the usual way, are passed through a sand-blast machine, by which the rims are given a coarse-grained surface, the effect of which, it is said, more than doubles the adhesive power between the belt and rim. The mould drier exhibited can be moved about by two men. Compressed air is supplied at 20 lb. pressure and the drier requires approximately 10 cubic ft. of free air per minute. The outer casing contains an inner cylindrical fireplace which is lined with gannister. A flat hearth is arranged a short distance from the bottom, to support the gas coke used. When the air is turned on it flows into the casing, part of it going through the top of the inner fireplace, and the other part passing through a perforated adjustable ring and down the annular space between the fireplace and the outer casing. The hot and cold gases are mixed in the chamber below, and by increasing the supply of cold air through the annular space after the drier is well started, the correct supply of hot air to the mould is ensured without the risk of burning. An improvement is effected by causing the air to pass downwards through the fire, the carbon and smoke being consumed, instead of being deposited in the mould, which, when the air is blown up through the fire, is more or less likely to happen.

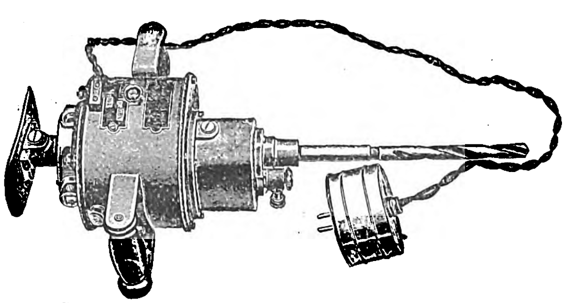
The Armorduct Mfg. Co. exhibited a good collection of tubes and fittings for internal conduit wiring work, and a large assortment of wires and cables, but their most interesting exhibit was a new "flame" arc lamp. This lamp, which we illustrate below, is of the converging carbon type with magnetic blow out, differentially wound and escapement controlled. The magnetic blow out coil has a double winding. One of these windings is in circuit when the lamp is burning, and creates a weak magnetic field in which the flame is maintained. The second winding is brought into use when the carbons are burnt out. This is effected by an automatic switch which serves the dual purpose of cutting out the shunt coil, and at the same time switching in the second winding of the blow-out coil, which effectually blows out the arc. The clockwork mechanism is simple and is actuated by weights to which the carbon holders are fixed, the escapement being released by means of the differential coils and dash pot. The weights and carbon holders are fitted with roller bearings throughout, by which means friction is reduced to a minimum, and the makers state that it is practically impossible for the carbons to stick, so that there is a perfectly steady feed. The whole of the mechanism is protected from the fumes given off by the sodium cored carbons. The lamps are designed for both a continuous and alternating current in the following sizes: D.C. 6, 8, 10 and 12 amperes (burning hours 7 to 19); A.C. 8, 10, 12 and 15 (burning hours 7 to 17). Terminal voltage from 45 to 48. The hemispherical candle-power is stated to be approximately as follows:—



The "Blaze" Flame Arc Lamp.

| | |
|---|---|
| 6 amperes | 1,750 c.p. |
| 8 " | 2,500 " |
| 10 " | 3,600 " |
| 12 " | 4,750 " |

The same firm exhibited a neat little three-speed breast-plate drill, which we illustrate below. It contains a shunt motor, the three speeds being given by change in gearing. To make the tool as light as possible, all non-magnetic mechanical parts are made of an aluminium alloy. As is seen in the illustration, the drill has two strong handles. The switch to start the motor is actuated by the thumb of the right hand. The change of gear is effected simply by pulling out or pushing in two small knobs attached to a locking pin and the intermediate spindle respectively. Enclosed in the plug fitting at the end of the flexible, is a simple form of magnetic cut-out, which opens the circuit if the load is too great and closes it again when the pressure is relaxed.



The "Little Hustler" Breast-plate Drill.

Much interest was evinced in Mr. A. Blackmore's "Dead-Wiring" system shown in operation in a stand on the gallery in the Exhibition. Mr. Blackmore replaces all the branch switches by relays mounted on the distribution board or boards. These relays are controlled by a low-pressure circuit, so arranged that an ordinary bell push occupies the position of the usual switch for each lamp or group of lamps; the first time the push is pressed the lamps light; the second press extinguishes them. It is thus seen that the principle is the same as that on which the modern remote control power-house switchboard is worked. The wiring carrying the main current runs straight from the relays on the distributing board to the lamps, and the push circuit is worked at quite a low voltage and is wired with bell wire. No figures as to cost are yet available.

Power presses, particularly adapted for punching armature discs and for stamping out small parts for switches, brushes, &c., were shown by Messrs. Joseph Rhodes & Sons. These presses are powerfully built, and are provided with a safety clutch motion which, by a simple mechanical device, throws the press out of gear automatically after each stamping. This enables the machine to be run at an exceptionally high speed. The gear is put into action again by depressing the treadle.

The Bat Electrical Co. showed a number of their electricity meters, specimens of the Bardon arc lamps, and "permutators" in operation. These latter are machines with vertical shafts for transforming alternating into continuous current, the only moving part being the brush gear which is driven by a small rotor revolving at synchronous speed.

Messrs. Frank Pearn & Co. had a number of pumps of all descriptions, such as single-acting Manchester donkey pumps, duplex ram pumps, &c., on view, these pumps being operated either by steam or by an electric motor made by Electromotors Limited.

The Sun Electrical Co. had an effective stand in the annexe, showing to advantage all kinds of fittings for electric lighting, electric bell installations, &c. Favourable mention may be made of the series of artistic bell pushes with a flat front plate.

The James Keith & Blackman Co. showed several electrically-driven fans for various purposes. These all exhibited the excellent workmanship that characterises all this Company's electrical work.

Among the gallery exhibits was that of Messrs. Oliver, Clark & Co., who showed a number of tastefully designed electroliers, brackets, pendants, radiators, &c.

The Electrical Corporation (Ltd.) arranged their stand very artistically in form of a room, decorated all over with the company's electric fittings to suit all tastes.

Mr. Albert C. Hands showed a large variety of fittings for electric lighting, artistic radiators and accessories.

Messrs. Cory Bros. had on view samples of Welsh steam and other coals suitable for steam raising in boilers of all descriptions.

Messrs. Rawlings Bros. had a comprehensive display of electrical fittings in various designs which showed considerable artistic merit.

Messrs. G. Strauss & Co. had a good show of standard electrical fittings in brass, porcelain and wood, and cables and cable fittings. The most noticeable exhibit was a portable generating set for country-house lighting, &c., the engine being of the petrol type, directly coupled to a standard dynamo. The engine was manufactured by the Electrical Trades Supply Co.

The Cape Asbestos Co. had an excellent display of their familiar removable and plastic non-conducting coverings for ordinary and superheated steam pipes. They also showed a quantity of fine asbestos yarns for electrical insulation. It may be mentioned that the Cape Asbestos Co. are introducing a new insulating material named "Capyt," for which superior qualities are claimed.

The Howard Conduit Co. showed specimens of their well-known troughing in various shapes, both for their solid system and asphalte conduit for drawing-in systems. Included in the exhibit were specimens of the troughing which is being used for the cables for portions of the Great Western Railway which are now being electrically equipped.

The Virtuoso self-playing piano was exhibited by Messrs. Doremi & Co. and attracted large crowds. It will not only reproduce any melody by means of the familiar perforated roll, but is also capable of recording tunes by perforating a blank roll. The mechanism is worked from a miniature motor by a rope drive, the motor being let into the body of the piano at the back.

Among the exhibits of fittings that of Messrs. Escaré & Denelle was one of the best. Not only were the fittings themselves shown, but three or four workmen were actually engaged in their manufacture. The special point concerning these fittings is the fact that they are first modelled in clay and then cast solid, a large amount of hand labour being subsequently spent in finishing.

Messrs. F. Darton & Co. showed a very large number of small dynamos, motors, ventilating fans, induction coils, accumulators, electric hand lamps, &c., the majority of which were in the nature of working toys or models, some being priced at as low as a shilling or two.

A number of firms exhibited various office appliances, including card-index cabinets, filing cases, letter-filing apparatus, &c. These firms included the Typewriter Co., the Globe Wernicke Co., the Trading & Mfg. Co., Hammond & Stow, Tollit & Harvey, and the Office Appliances Mfg. Co. Among these exhibitors the Typewriter Co. made a bold display of the "Royal Barlock" typewriter and Barlock accessories and sundries. Nowadays the typewriter is as indispensable in business houses as any part of the equipment of the office. The chief requirements of a typewriter are that it should be as little liable as possible to get out of order, and shall stand as much fair wear and tear as can be expected from any piece of mechanism which is sometimes somewhat roughly handled. After an experience extending over more than 16 years we can say that the Barlock typewriter fulfils these requirements. We have ourselves a number of these machines in operation. The latest improvements introduced have strengthened the machine, have amplified the facilities of the operator, and have, we consider, brought the machine to a high degree of perfection on every point where a typewriter should be strong. The Typewriter Co. are responsible for the introduction of many labour-saving devices for the office, and amongst those exhibited we may mention a new rotary letter-copying press. The Office Appliances Mfg. Co. also showed a letter copier, the "Victoria," which can be adapted for working by an electric motor, thereby reducing the whole of the work of the operator to feeding the copier with the matter to be copied.

The Standard Metal Engraving Co. had a very fine collection of attractive metal and composition name plates and designs, many of them of a novel character. They were made in all the metals, in "ivoride," and in flexible metal of various colours.

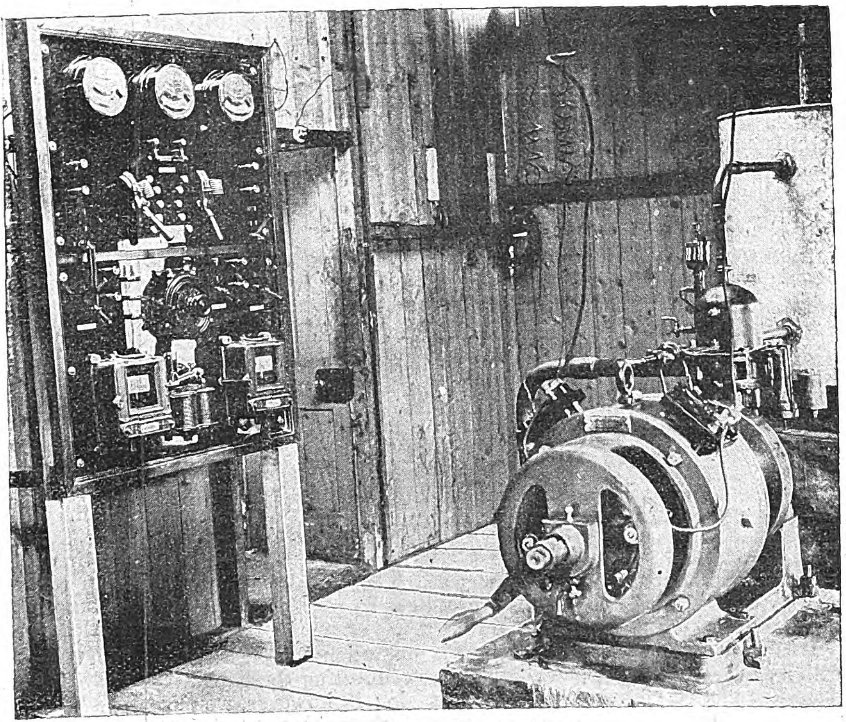
Messrs. J. H. Heathman had their extending ladders on view; these have found considerable application in connection with public arc lamp cleaning and repairs, overhead trolley wire work, &c.

Price's Patent Candle Co. exhibited lubricants for all kinds of machinery, including dynamos, motors, and all electrical apparatus.

The Consolidated Pneumatic Tool Co. exhibited a good collection of portable machine tools.

## COUNTRY HOUSE LIGHTING.

We illustrate herewith a compact little electric light installation recently carried out by Messrs. R. J. Nicholson & Co., of Manchester, at a country house in Cornwall. The plant consists of a 55 cell, 7-plate section storage battery, a directly-coupled dynamo and petrol engine, and a switchboard. The petrol engine is of the two-cycle type giving 4 B.H.P. at 1,000 revs. per min. The switchboard, which was built by Messrs. Nicholson & Co., is specially designed for installations of this description, and in addition to the usual instruments, is mounted with a charge and discharge ampere-hour meter.



Country House Engine Room

## ZINC FUSES.

BY ALFRED SCHWARTZ AND W. H. N. JAMES.

In connection with the recent Paper on "Low-tension Thermal Cut-outs"[*] (*Journal* Institution of Electrical Engineers, Part 174, Vol. XXXV., 1905), we have thought it desirable to extend the examination of zinc and aluminium as materials for fusible cut-outs. Both these metals are in use to a considerable extent at the present time in fuses of large capacity. Zinc cannot be drawn into wire and can only be rolled hot, while aluminium wire, as we have previously shown, particularly when of small diameter, is unreliable as a fuse, owing to the molten metal being held up by the skin of oxide. For example, an aluminium wire 0·7 mm. diameter, when supported between terminals in the ordinary way, will disrupt with 43 amperes, whereas the wire really melts within its oxide skin with 21 amperes, and the wire could be ruptured at this current value by means of the repelling action of a magnet or the tension due to a weak spring. It is evident, then, that only in the form of strip can zinc and aluminium be advantageously employed as fuses. Our examination of copper and lead strip for the purpose of connecting the fusing current with the dimensions of the strip employed showed that this relation was expressed by rather different formulæ in the two cases.

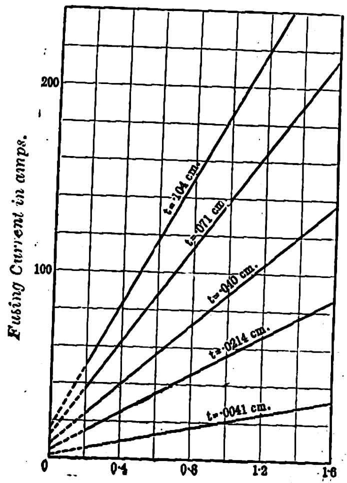


FIG. 1.—Zinc. Curves connecting Fusing Current and Breadth of Strip for Various Thicknesses.

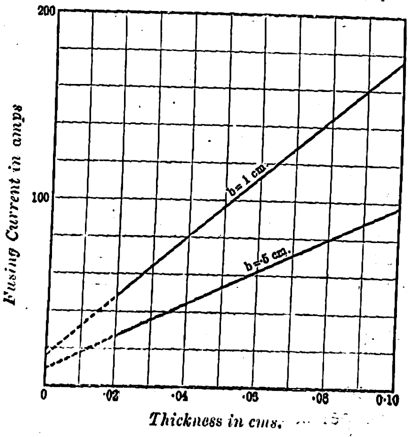


FIG. 2.—Zinc. Curve connecting Fusing Current of Strip and Thickness for Different Breadths.

With copper strip the fusing current is proportional to the breadth with a constant thickness, and the curves connecting these quantities when plotted all pass through the origin; if, however, we plot thickness against fusing current for strips of constant breadth, it will be found that the curves pass through a point on the axis of thickness considerably to the left of the origin due to the increased carrying capacity per unit area in the small strips owing to their relatively greater cooling surface. In the case of lead strip, the curves connecting fusing current and breadth when extended backwards are for a similar reason found to cut the axis of breadth at a point considerably to the left of the origin, while on plotting fusing current against thickness for a constant breadth the curve is found to follow a logarithmic law, that is to say, with a constant breadth the fusing current is not proportional to the thickness $t$ but to $t^n$ (for lead $n = 0{\cdot}74$). We can summarise thus:—

| Breadth. | | Thickness. |
|---|---|---|
| Copper $C \propto b$ | ............ | Copper $C \propto (t+k_1)$ |
| Lead $C \propto (b+k)$ | ............ | Lead $C \propto t^{0{\cdot}74}$ |

Where $C$ = fusing current; $b$ = breadth; $t$ = thickness.

Now the melting point of zinc and its current-density at fusion is intermediate between those of copper and lead and the law connecting its fusing current and dimensions may be regarded as being intermediate between those given above, in fact, for zinc strip $C \propto (b+b_1)$; $C \propto (t+t_1)$; or $C=\kappa(b+b_1)(t+t_1)$; $b_1$ and $t_1$ being constants independent of the length, breadth and thickness of the fuse, and $k$ being a constant dependent upon its length.

For zinc strip the values of the constants $b_1$ and $t_1$ can be determined from Figs. 1 and 2. In centimetre measure $b_1 = 0{\cdot}1$, $t_1 = 0{\cdot}01$. In inch measure $b_1 = 0{\cdot}04$, $t_1 = 0{\cdot}004$.

In Fig. 3 curves are given connecting the constant $\kappa$ with the length $\kappa$( being in inch measure) for zinc strips in a vertical or horizontal position ($\kappa$ in inch measure $=\kappa$ in centimetre measure $\times 6{\cdot}45$). The law indicated above will hold between the following limits:—

$$\text{Thicknesses} \left\{ \begin{array}{l} 0{\cdot}01 \text{ cm. to } 0{\cdot}1 \text{ cm.} \\ 0{\cdot}004 \text{ in. to } 0{\cdot}04 \text{ in.} \end{array} \right.$$

$$\text{Breadths} \;..\left\{ \begin{array}{l} 0{\cdot}4 \text{ cm. to } 1{\cdot}5 \text{ cm.} \\ 0{\cdot}16 \text{ in. to } 0{\cdot}6 \text{ in.} \end{array} \right.$$

In our experiments we did not go beyond 300 amperes on a single strip, but it is probable that by using strips of increased breadth the law would hold good up to 400 or 500 amperes per strip. For fuses of large capacity it is advisable to use a number of strips in parallel and to keep the current per strip as low as possible; by making the spacing between the strips liberal the dissipation of the heat will be facilitated.

Zinc fuses show very little deterioration, even when run continuously at 90 per cent. or even 95 per cent. of their normal fusing current, the oxidation is very slight, and the final resistance of the strip is practically the same as its initial resistance. The metal does not appear to be held up on fusion to any appreciable extent by the skin of oxide. It would be of interest to learn from any of your readers who have had zinc fuses operating under service conditions for any length of time whether they have observed any deterioration due to molecular change or crystallisation taking place in the strip.

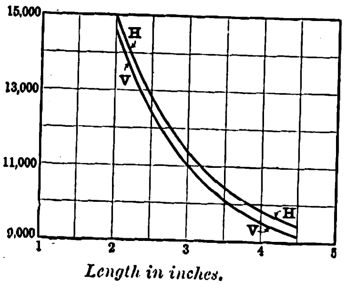


FIG. 3.—Curve connecting the Constant $\kappa$ $(b+b_1)$ in the formula $C=\kappa$ $(t+t_1)$ with the Length of Fuse.

H = Zinc Strip Horizontal.
V = Zinc Strip Vertical.

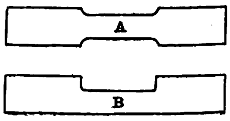


FIG. 4.

This freedom from oxidation when run at high-current density renders zinc a desirable material for fuses which are required to blow with only a slight overload. For circuit fuses of several hundred amperes it is not necessary or desirable that the fuse should be set for as much as 100 per cent. excess current, and in this case zinc possesses considerable advantages over copper, in that the latter becomes red hot with about 75 per cent. of its normal fusing current and above this point oxidises rapidly, whereas zinc only attains red heat just before fusion. It must be borne in mind, however, that for a given fusing current the mass of a zinc fuse is about 3·5 times that of a copper one of the same length, while its volume is approximately 4·4 times that of the copper and this gives a large amount of metal to be disrupted.

Although zinc does not attain so high a temperature on fusion as copper does, yet its greater mass and volume operate unfavourably in connection with its behaviour on short circuit and this defect is further aggravated by the fact that in open-type fuses the metal is disrupted in the form of globules which are not only red hot, but which *continue to burn* in air, and which are accompanied by dense white fumes which deposit heavily on contiguous surfaces. For the above reasons zinc when employed in enclosed fuse-holders would require a larger cartridge than copper if we considered only the damage likely to arise to the case and disregarded the question of cooling.

Mr. Wm. Cramp a few years ago, in some hitherto unpublished experiments on fuses carried out at the Central Technical College, London, found with strip fuses of thin tinfoil which were reduced in breadth at the centre for a short distance of their length, that the length of wire disrupted on short-circuit was confined to the section with reduced breadth, and that the arc did not extend beyond this length towards the terminals. It appeared to us that this might be due to the cooling effect on the arc where the section of the fuse was increased, and zinc, owing to its comparatively low-melting point, and the large section necessary, seemed likely to show the same effect. A zinc strip with a normal fusing current of 100 amperes was, therefore, put directly across a 100 kw. 200 volt generator, with the result that a strip of uniform width throughout was disrupted from terminal to terminal along its whole length, even with lengths of as much as 7 in.; whereas when the end portions of the fuse had a greater breadth than the middle as shown in Fig. 4A and B, the narrower portion only was disrupted provided that it was about 1½ in. or 2 in. in length. At the present time the Peard fuse has a constriction at the centre, but this is for the purpose of securing the fusion of the strip at the centre point so as to free the spring partition, but it no doubt acts also in helping to suppress the arc.

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[*] *The Electrician*, Vol. LV., p. 8.

In the early days when soft alloys were used chiefly for fuse metal, fuses were often shaped with expanded ends as Fig. 4A to give larger contact area under the screw terminals; it is curious to reflect that this practice was given up in favour of using the fuse strip of uniform breadth throughout its length and soldering it to copper lugs in order to avoid the supposed danger of pinching the soft metal under the screws and thus affecting the fusing current, while we have thereby apparently facilitated the extension of the arc from terminal to terminal.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. FOURNIER D'ALBE.]

*Rock Salt as a Screen against Radium Rays.*—J. Elster and H. Geitel have found that rock salt is an effective screen against the Becquerel radiation which is distributed all over the earth. It is impervious to gases, and therefore also to radium emanation. In considerable thickness it absorbs even the very penetrative γ rays. And lastly, its own radioactivity is very slight, owing no doubt to the fact that the natural deposits of rock salt were in a liquid condition for some time after the radium compounds had been precipitated together with the calcium. The authors tested the efficacy of rock salt as a screen by mounting a dissipation apparatus in a salt mine near Wolfenbüttel. They found that at the bottom of the mine the rate of dissipation was reduced by 28 per cent. The residual radioactivity must be ascribed to thorium compounds, which are not so easily precipitated as are radium compounds.

[ELSTER and GEITEL, *Physikalische Zeitschrift*, November 1, 1905.]

*Ultra-Violet Light from the Sun.*—K. Schwarzschild and W. Villiger have measured the distribution of ultra-violet light over the sun's disc by the simple expedient of photographing it by means of a lens of the new Jena ultra-violet glass, thinly silvered, according to Straubel's suggestion, to cut off the visible rays. A lens like that only transmits a narrow band of ultra-violet light extending from 315 to 327 $\mu\mu$, and is, therefore, a highly efficient filter. The photographs show that whereas the red rays only slightly fall off from the centre to the edge of the disc, and the violet rays fall off very rapidly, this increase in the gradient is not maintained on proceeding further into the ultra-violet. Very near the disc the violet is more obliterated than the ultra-violet. The sun's atmosphere, therefore, affects ultra-violet light in a manner quite different from the earth's atmosphere.

[SCHWARZSCHILD & VILLIGER, *Physikalische Zeitschrift*, November 1, 1905.]

*Braun Tube with Slow Cathode Rays.*—A. Wehnelt showed two years ago that comparatively slow cathode rays, generated with about 500 volts, are capable of producing very perceptible phosphorescence when their density, measured by coulombs per square centimetre per second, is considerable. Such slow rays may be obtained by coating the cathode with calcium, barium, or strontium oxides. A patch of a few square millimetres on a platinum cathode suffices. The latter is mounted facing the cathode, which has a small perforation, and the pencil thus picked out is conducted between two condenser plates to a fluorescent screen. A continuous current supply of 220 or 440 volts may be employed, or a few cells of a high-tension battery, since the current is only a few milliamperes. The tube must be highly exhausted, since the rays have great ionising power, and ionisation discharges the condenser. Since the cathode is only feebly red-hot, the light from it does not interfere with observation of the phosphorescent spot. This form of Braun tube, besides being more sensitive to electric forces, is also useful in all cases where the high electrostatic forces of the ordinary Braun tube are undesirable. The cathode is used up very slowly, and the hardness of the rays may be varied within wide limits.

[A. WEHNELT, *Physikalische Zeitschrift*, November 1, 1905.]

*Glow Discharge in Halogens.*—W. Matthies has followed up his work on mercury haloids by studying the glow discharge in the halogens themselves. There is much similarity between the two classes of bodies. As in the case of the mercury haloids, the luminous phenomena are nearly the same as in pure nitrogen. But the potential gradient is very high in the halogens, and increases from the cathode towards the anode. Moreover, it is not a linear function of the pressure, but increases at first more rapidly than the pressure, and afterwards more slowly. The normal cathode fall increases approximately as the molecular weight, and is independent of pressure and current strength.

[W. MATTHIES, *Physikalische Zeitschrift*, November 1, 1905.]

*Ionisation by α-Particles.*—Rutherford recently announced that the α-particle projected from radium ceases ionising when its velocity falls below 60 per cent. of its velocity of projection, when, therefore, it still possesses a velocity of $1{\cdot}6 \times 10^{10}$ cm. per second. Bragg and Kleeman thought, on the other hand, that the velocity becomes almost negligible before the ionisation ceases. W. H. Bragg now reviews the results which formed the basis of that opinion, and finds that whatever the critical velocity may be, it is the same in all gases. The ionisation curve was examined in many gases, including gases of complex molecular structure, as well as mixed gases. Now, if the α-particle were able to ionise in, say, hydrogen at a lower speed than in oxygen or carbon, the ionisation curve in a mixture should be a complex curve, consisting of simple curves overlapping. The entire absence of any effect of this kind shows that the critical speed is invariable. This makes it probable that the act of ionisation is exactly the same in all gases. The author next proceeds to find in what manner the ionisation depends upon the speed, and constructs tables showing the observed ionisations and the corresponding values obtained from a formula in which the ionisation is made to vary inversely as the $n$th power of the velocity. The values 1, 2 and 3 are given to $n$ in three separate columns, and it is evident that $n = 2$ gives the best agreement. This may be connected with the fact that when one particle flies at great speed past another which is relatively at rest, the energy given by the ionising to the stationary particle, in consequence of their mutual attractions or repulsions, is inversely proportional to the square of the velocity of the moving particle.

[W. H BRAGG, *Philosophical Magazine*, November, 1905.]

*Work of Windmills.*—M. Ringelmann has made some determinations of the relation between velocity of wind and speed of revolution of windmills employed for raising water. The experiments extended over two years and were made with a pump having 72 vanes 1·3 metres long, with a total surface of 9·4 square metres. The pump was left to its own working all the time, being self-turning and self-regulating and going out of gear with a wind velocity exceeding 10 metres per second. The ratio between the velocity of the vane-rim and the wind varied from 0·82 at 4 metres per second to 0·75 at 10 metres. The volume of water raised 10 metres was 1,566 litres per hour at the former speed and 3,527 litres at the latter speed.

[RINGELMANN, *Comptes Rendus*, October 30, 1905.]

*Ionisation and Altitude.*—B. Brunhes and A. Baldit find that altitude above the earth's surface is not a very fundamental factor in ionisation. In a plain at 330 m. the ionisation may be the same as on a plateau at 1,200 m., but a peak may show a very decided difference with the same difference of altitude. The increased electric field on the summit of mountains has little effect on the negative dissipation, but it considerably reduces the positive dissipation. Thus at the base of the Puy de Crouel, in the Puy de Dôme district, the negative and positive dissipations were 13 and 12 volts per minute respectively, while at the summit they were 12 and 6.

[BRUNHES and BALDIT, *Comptes Rendus*, October 30, 1905.]

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## ELECTRIC POWER SUPPLY IN LONDON.

Seldom has a Committee of the London County Council presented a more adverse report on a proposal of another Committee of the same body than has been the case with regard to the electric power scheme recommended by the Highways Committee. The report embodying this proposal was published in our issue of November 3rd, and the report upon it by the Finance Committee appears on another page this week. In principle the scheme is a replica of the Administrative County of London and District Electric Power Bill, although apparently it is intended to apply mainly to the County of London. So completely does the Finance Committee condemn the project that it is difficult to realise, in reading the report, that it emanates from a Committee of the London County Council. At the same time one cannot conceive a body of business men, such as a finance committee should consist of, coming to any other conclusion with regard to the vague proposals barely outlined by the Highways Committee. The matter is of such vast importance, and is open to be viewed from so many different aspects, that the superficial manner in which it has been taken up by the Highways Committee well deserves the strong comments which have been made. The whole of the Finance Committee's report is one recurring complaint that no details have been laid before it upon which to base any estimates, and thus the Finance Committee has perforce turned to the figures placed before Parliament last session in connection with Mr. MERZ's scheme. Here again the Committee is beset with difficulty, for these figures related to a much wider area than is suggested now, and no separate estimates for London were given. The fundamental detail of a power scheme—viz., the area—has not even been given to the Finance Committee, whose remarks upon this point are significant in the extreme. They state that "this [the question of area] is an important point, because the existing conditions of electric supply in London, and the extent to which existing Undertakers are providing therefor, appear to us to render it extremely probable that a scheme of supply limited to the county would not allow of a sufficient output for production at the lowest possible price." Assuming, for the moment, that the scheme must necessarily be confined to the County of London, much turns upon the loyalty of the Borough Councils towards the London County Council, and there are indications that a large number of these bodies regard the scheme with disfavour, and have in view an entirely different course of action. We will deal later with the suggestions that are now being made by certain Borough Councils, which, if carried into effect, would render them independent of any scheme fostered by the County Council. Nor will the London County Council be able to point to any suburban railway as a probable or potential consumer, and no long list of power users is forthcoming; the Highways Committee has lost sight of the fact that the low estimates which Mr. MERZ produced were due as much to the even distribution of the prospective load throughout the day (the high "load-factor") as to the mere magnitude of the contemplated operations. A large station to supply in bulk to other municipal undertakings and to the County Council's own tramways would not generate at the extremely low cost with which the London power schemes of last year have made us familiar.

The financial prospects of the proposal as evolved by the Finance Committee reveal in a striking way the peculiar inconsistency of the position of the Highways Committee, and through them of the Council itself, for the very arguments used by the County Council as a body against the power bill last year are now used by one Committee of the Council against another. The Finance Committee doubts whether the estimates of the Power Company as to working expenses could be realised, and, in consequence, it is sceptical as to the estimated profits; yet, being necessarily forced to adopt these figures because no others have been submitted to it, it proves that the Council would do wrong in embarking upon the project. The assumption is made that £3,000,000 would be necessary as the initial capital expenditure, upon which the debt charges at 6 per cent. would be £180,000 per annum (on the supposition that the sinking fund charges are suspended until the works are in operation), and that, to realise this sum, 200,000,000 units per annum would have to be sold at 0·7d. per unit, as adopted by the Power Company, and if the same provision were made for renewals and reserve. Interest on the loan would still have to be paid during the period of construction, and this cannot be paid out of capital, as in the case of a Parliamentary company. In 1903-4, it is pointed out, the total consumption of electrical energy in London reached 113,896,163 units, but the supply of a further 200,000,000 units and a realisation of a high-load factor can never be brought about without some co-operation between the Council on the one hand and the existing Undertakers and power users on the other. There is little likelihood of this on the part of the companies; we have not heard of any power users anxious to become customers of the London County Council; and, to our knowledge, many of the most powerful Borough Councils from the electric supply point of view are strongly antagonistic to any proposals of this nature by the London County Council. Lastly it must not be forgotten that the big private power users in London are also big ratepayers, and that they are more likely to oppose than to be parties to any endeavour of the London County Council to enter into speculative business on a large scale.

Despite the strongly-worded report of the Finance Committee which we have dealt with above, we are surprised to see that the recommendation of the Highways Committee was adopted at Tuesday's meeting of the Council, with the proviso that an opportunity shall be afforded for the discussion of the Bill before it is deposited. The inherent objection to anything in the nature of private enterprise when applied to public service, inevitable through the large Progressive majority upon the County Council, has, we feel, prevented this project being considered in an impartial manner for the general good of Londoners. At the same time, the expense which the promotion of this Bill will involve may be deemed beforehand to be so much added without useful result to the already large sum expended by the Council—£263,836—in Parliamentary fees, a large percentage of which has been in futile opposition to Bills introduced by companies and in the promotion of Bills that have had almost as little chance of receiving Parliamentary sanction as the ridiculous project that is now being evolved.

The suggestion made at a Conference of London Borough Councils a week or two ago is less pretentious, and although at present the intentions of these authorities are somewhat obscure, next week should see matters sorted out somewhat, for the Parliamentary notices will have to be deposited by then. The proposal has been made that the Borough Councils of Islington, Hackney, Shoreditch, Bethnal Green, Stepney and Poplar, the Corporation of West Ham, and the Urban District Councils of Leyton and Walthamstow should secure Parliamentary powers for giving or taking a supply of electrical energy in bulk. That the power to link up existing generating stations both for emergency and for the general equalisation of the load, is necessary and even essential, has been urged by us for a long time, and the principle of this was embodied in the first Electricity Supply Bill three years ago. From this point of view we could almost wish that all the electric supply authorities in London had joined in this movement if only to impress upon the Government that the delay which has characterised its policy as affecting the electrical industry can no longer be tolerated, and that independent powers must be obtained, even though the expense must be great and would eventually fall upon the consumer. Some of the Borough Councils above referred to, however, also have in view the possible erection of a large generating station for the constitution of a power scheme, but on a smaller scale than that proposed by the Administrative County of London Power Co. and the other companies last year, whilst others of them have suggested a petition to the Government to expedite the passage of the Electricity Supply Bill. None of these propositions has yet taken definite shape, but, as we have said, more will be heard of them in a few days' time.

Turning once more to the London County Council scheme, we would express the hope that the final paragraphs of the Finance Committee's report will be yet acted upon, and that, in view of the existing enormous capital commitments of the Council, it will "select from the objects of expenditure which it is being pressed to undertake those which are necessitated by its present statutory duties, in order that its general financial position may not be prejudiced by forcing larger loans on the market than the investing public could readily absorb." Probably the result of the Conference with the Borough Councils which is to be held on Monday will act as an incentive to a change of views on the part of the majority of the Councillors who voted in favour of the scheme on Tuesday.

# HIGH-VOLTAGE CONTINUOUS-CURRENT TRACTION MOTORS.

In a recent issue of *Elektrische Bahnen & Betriebe*, Herr H. Rikli-Kehlstadt describes a 1,500 volt continuous-current experimental traction motor of 90 H.P., built by Messrs. J. J. Rieter & Co., of Winterthur, Switzerland. It may be mentioned that this firm was one of the first to design 750 volt continuous-current traction motors, such motors having been satisfactorily employed since 1901 on the narrow-gauge electric railway connecting Lausanne with Moudon. This line is about 15½ miles long, and the motors are capable of developing 40 H.P. at 400 revs. per min. It is added that the trolley voltage rose occasionally to 900 volts.

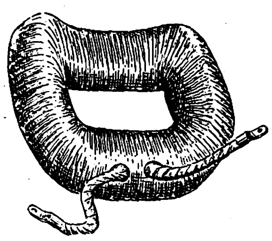

FIG. 1.—SKETCH OF FIELD COIL OF 1,500-VOLT CONTINUOUS-CURRENT TRACTION MOTOR.

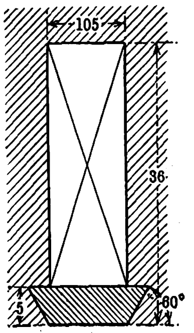

FIG. 2.—DIMENSIONS OF ARMATURE SLOT.

The chief data of the 90 H.P. 1,500 volt experimental motor and the truck to which it was fitted are: Diameter of armature, 440 mm. (1 ft. 5·3 in.); length of armature, including a ventilating duct 1 cm wide, 220 mm. (8·65 in.); number of slots, 53; number of commutator segments, 265; diameter of commutator, 360 mm. (1 ft. 2·2 in.): useful length of commutator, 90 mm. (3½ in.); resistance of motor at 70°C., 2·65 ohms; output at the rim of the wheels at the one hour's rating, 75 H.P.; speed, 430 revs. per min.; weight of motor, including gearing and gear case, 1,750 kg. (3,900 lb.); gauge of truck, 1 m. (3 ft. 3⅜ in.); wheel base, 1·8 m. (5 ft. 11 in.); diameter of wheels, 840 mm. (33 in.).

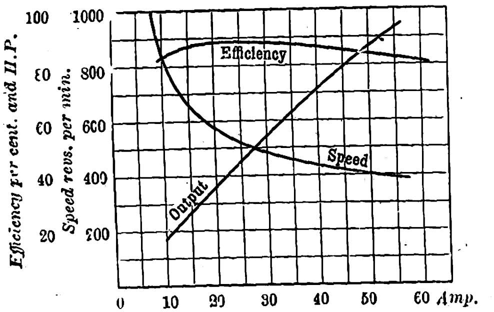

FIG. 3.—CHARACTERISTIC CURVES OF H.T. CONTINUOUS-CURRENT TRACTION MOTOR WHEN FED AT 1,500 VOLTS.

The chief difficulties to be overcome related to commutation and insulation. Auxiliary poles for preventing sparking were considered, but this means was not thought desirable for traction motors for various reasons. Instead, a large neutral zone between the poles was adopted, the ratio of pole-arc to pole-pitch being made equal to 0·67. Besides, the magnetic field was "stiffened" as much as possible by keeping the saturation of the armature teeth high and by curving the field coils so as to embrace the armature as indicated in Fig. 1. The armature coils are substantially insulated and they are protected in the slots by an additional covering of micanite 1 mm. thick. It is stated that all the coils withstood an alternating pressure of 10,000 volts for one hour, one pole of the alternating supply being connected to the armature iron, the other being in connection with the armature copper. The weakest coil broke down after an alternating pressure of 12,500 volts had been applied for 10 minutes. In order to prevent the formation of an arc between the commutator and the motor carcase, the commutator was provided with an end shield in the form of a non-combustible disc of insulating material. Since many breakdowns in traction motors are due to the bursting of the binding wires, it was decided to use such binding wire only for keeping the end connections together and to use wood wedges (see Fig. 2) in the slots. These wedges are of beech boiled in paraffin, and it is said that a pressure of more than 700 kg. was required to force a wedge 10 cm. (3·93 in.) long out of the slot.

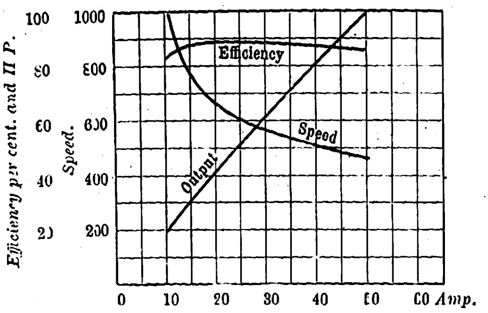

FIG. 4.—CHARACTERISTIC CURVES OF H.T. CONTINUOUS-CURRENT TRACTION MOTOR WHEN FED AT 1,700 VOLTS.

Up to 90 H.P. there is no sparking, but above this output small sparks occur now and again. Figs. 3, 4 and 5 represent the characteristic curves of the motor at 1,500 and 1,700 volts. In the case represented in Fig. 5 the motor speed was increased by connecting a resistance in shunt across the series field. On July 15th the motor was tested for 1¼ hours at a stretch for the purpose of determining the temperature rises in the various parts. The output was kept constant at about 64·3 H.P.; the average speed was 430 revs. per min., the average voltage slightly above 1,500 volts and the mean current 42·7 amperes. At the beginning of the test the temperatures in the testing-room, armature iron, field coils and commutator were 23°C., 46°C., 38°C. and 44°C. respectively, while at the end of the test the corresponding temperatures were 24·5°C., 97°C., 87°C. and 69°C. respectively. Although the motor could only be tested up to 1,700 volts, no higher voltage being available for testing purposes, the designers believe that it would have run well at 2,000 volts or more.

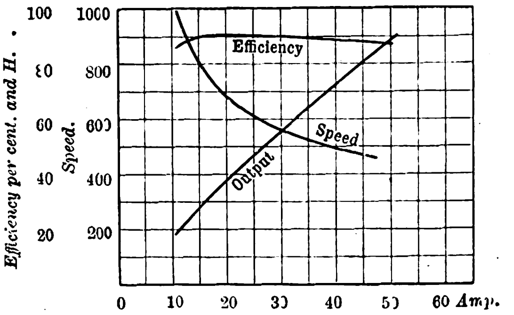

FIG. 5.—CHARACTERISTIC CURVES OF H.T. CONTINUOUS-CURRENT TRACTION MOTOR. SUPPLY VOLTAGE 1,500 VOLTS. A Resistance is connected in Shunt to the Field Winding.

Sixteen motors of this design are now being built for the Bellinzona-Mesocco (Switzerland) electric railway, the trolley voltage being from 1,500 to 1,600 volts.

# ELECTRIC POWER SUPPLY IN LONDON.

Following the report of the Highways Committee of the London County Council on the question of electric power supply in London, given in full on page 109 of our issue for November 3rd, the Finance Committee of the Council has issued a report dealing with the same subject. We give it in full:—

1. The Highways Committee are recommending the Council to promote a bill in the next session of Parliament to enable the Council to supply electrical energy in London and certain surrounding districts, and it devolves upon us under standing order No. A 27 to report upon the financial bearings of the proposal. The authority to be sought includes power (i.) to supply electrical energy in bulk throughout the whole of the area in question, and (ii.) to supply energy to large individual consumers, as, for instance, railway, canal and tramway companies or authorities where these undertakings extend over more than one local government area.

In considering this most important proposal we have found ourselves in a position of great difficulty owing to the absence of any financial data to guide us in advising the Council. Time has not permitted a definite scheme to be worked out by the Highways Committee, and their report to the Council only outlines in very general terms the proposals which they recommend the Council to place before Parliament. We are strongly of opinion that in a matter of this magnitude, raising financial issues of the greatest importance, the Council should, before committing itself to the undertaking, have before it a definite and carefully worked out scheme.

In the absence of any such scheme we have given such consideration to the subject as time and the limited amount of information at our disposal have allowed. The two main questions on which the Council will naturally desire to have our advice, are: (i) Are there reasonable grounds for thinking that the enterprise will be self supporting? and (ii.) can the large sum of capital required be raised without affecting the credit of the Council?

The first of these considerations is one of vital concern, for we cannot suppose that the Council would agree to invest some millions of public money in an undertaking of this kind without substantial reasons for the belief that it would be at least self supporting—in other words, that the profit on working would be sufficient to pay the interest on, and provide for the repayment of, the money borrowed. The credit of the ratepayer would in any case be pledged for the raising of the capital; but the Council will no doubt agree that beyond this no further assistance should be looked for from the rates. The Council will note that the report of the Highways Committee offers no guidance upon this matter beyond the general statement that in the Committee's opinion "it will be quite practicable to put forward a satisfactory scheme." In these circumstances we have endeavoured to assist the Council to a conclusion from a consideration of the estimates and financial data placed by the Power Company before Parliament last session in support of their scheme, with which the Highways Committee's proposals are in a measure comparable. We desire to distinctly disclaim any acceptance of the company's estimates and calculations, but we think it may be useful to the Council to have some of these materials before it.

The Power Company proposed to supply a very large "industrial" and "non industrial" area, of which no less than 75 per cent. was outside the County of London. Capital powers to the extent of £6,600,000 were sought by the bill, and the initial capital expenditure to complete the first station of 60,000 kw., distributing mains and subsidiary works was put down at £2,100,000, the total capital expenditure up to the completion of the undertaking being estimated at £6,600,000, including £100,000 for "preliminary" expenses. The company sought powers to supply existing undertakers (borough councils and companies) and large undertakers—*e.g.*, railways, docks, &c., throughout their area, and also in the "industrial" area manufacturers and other power users *direct* with the consent of the existing authorised undertakers, provided that if that consent were unreasonably withheld an appeal could be made to the Board of Trade. The company estimated that they could generate electricity at the low price of 0·154d. per unit, a figure which, adding general and other expenses, worked out to 0·522d. per unit sold, and that with a sale of 133,500,000 units, by the year 1910, at an average price of 0·7d., there would be a balance after providing for reserve, depreciation, and renewals sufficient to pay 5½ per cent. on a capital of £2,000,000, and, further, that with a sale, by the year 1916, of 600,000,000 units at 0·55d. there would be a balance sufficient to pay —

| | |
|---|---|
| 4½ per cent. on £1,000,000 debenture stock .......... | £45,000 |
| 5 per cent. on £2,000,000 preference stock .......... | 100,000 |
| 8 per cent. on £3,000,000 ordinary stock ............ | 240,000 |
| | £385,000 |

and to carry forward about £38,000.

These figures related to the company's entire area, of which, as above stated, the greater part was outside the County of London; the company gave no figures for the County of London separately. It is, to say the least, doubtful whether the profit estimated by the company could have been obtained.

Whether the above estimates were well founded or not, it appears to us that they are deserving of the Council's attention, particularly in view of the fact that any practical scheme put forward by the Council will inevitably be compared with these figures. The Highways committee do not say what capital would be required, but we have assumed that a sum of about £3,000,000 would be required *in the first instance* for a large generating station with mains and subsidiary works. The expenditure of this money would be spread over five or six years; and it is obvious, therefore, that there must inevitably be a long period during which the capital would be unremunerative, The Power Company proposed to meet this difficulty by obtaining power to pay interest out of capital at the rate of 3 per cent. up to a maximum of £310,000. There is no precedent for a municipal body being given such a power, and we must assume, therefore, that the interest on the capital raised would have to be defrayed out of the rates year by year. We estimate that for interest payable on a sum of £3,000,000 during the construction of the works an aggregate sum of about £380,000 would have to be so provided. This is a consideration which we do not think the Council has sufficiently appreciated in the past. There are precedents for the postponement for a few years of the sinking fund provision, and we have therefore assumed that no charge under this head would fall upon the ratepayers of the earlier years.

The ultimate debt charges, assuming that the expenditure on land and buildings were spread over 60 years, and the cost of machinery, trunk mains, &c., over 25 years, may be taken roughly at about 6 per cent., which, on an initial outlay of £3,000,000, would represent an annual charge of £180,000 a year. What the Council has to consider is the probability or otherwise of the undertaking showing a profit on working sufficient to produce this amount.

The Power Company calculated on a total output for their entire area of 133,500,000 units in five years' time, and on 600,000,000 units in 11 years' time, when the works would be completed.

We find that the output of the existing undertakers in London in 1903-4 was as follows :—

| | | |
|---|---|---|
| Companies ........................... | 85,933,026 | units. |
| Borough Councils .................... | 27,963,137 | ,, |
| Total ........................ | 113,896,163 | ,, |

On the basis of the Power Company's calculations it would be necessary for the Council to sell upwards of 200,000,000 units at an average of 0·7d. per unit in order to realise a profit on working of £180,000 a year, even if the working expenses should prove to be not higher than those estimated by the company, and if the same provision is made for renewals and reserve.

It is difficult to compare the proposals foreshadowed by the Highways Committee with the Power Company's scheme for various reasons. In the first place the proposed area of supply has not yet been determined by the Highways committee; but we gather that it would include a large district outside the County of London. This is an important point, because the existing conditions of the electric supply in London and the extent to which existing undertakers are providing therefor appear to us to render it extremely probable that a scheme of supply limited to the county would not allow of a sufficient output for production at the lowest possible cost. On the other hand, there are obvious difficulties in the way of the Council obtaining powers of supply outside the County of London, and the wider area would largely increase the amount of capital to be provided, and add greatly to the Council's responsibilities, for whatever financial risks there may be in the undertaking would fall entirely on the ratepayers of the County of London.

It is not clear from the proposals outlined in the Committee's report whether the Council would be able to supply power direct to individual manufacturers, or only, with certain exceptions, to supply through existing undertakers. The Council is aware that the Power Company sought powers, with the consent of the Board of Trade, to supply directly to the manufacturers with the object, no doubt, of securing thereby a lever to force the distributing undertakers either themselves to supply the manufacturer at or about the prices offered by the Power Company or to accept a bulk supply from the Power Company. It appears to us that this matter has an important bearing on the probable amount of business for which the Council might look.

Again, the Highways Committee are not yet in a position to estimate the amount of support which the Council would be likely to receive from existing undertakers (companies and borough councils), and until some information on this point is forthcoming it appears to us undesirable for the Council to commit itself.

Turning now to the other consideration which has occupied our attention, we feel it our duty to state to the Council that we view with apprehension the large addition to the Council's capital commitments which this undertaking would necessarily involve. As the Council must be aware, the question of the extent of its commitments, particularly in their bearing on the amount of money which will have to be raised on loan during the next two or three years, has for some time past been a matter of growing concern to us. We desire to impress upon the Council the fact that, however good its credit may be, if it were to force larger loans on the market than the investing public could readily absorb, the Council would inevitably have to be content with a lower price for its issues of stock, and this would particularly be the case when the general conditions of the money market are not altogether favourable for such issues. The effect of such a course would speedily prove detrimental to the Council's credit, and in our opinion the Council should so limit its capital expenditure as to obviate the necessity for making undue demands upon the money market. The time has, in fact, arrived when the Council must, in our judgment, select from the objects of expenditure which it is being pressed to undertake, those which are necessitated by its present statutory duties in order that its general financial position may not be prejudiced.

The Council is at the present time engaged in carrying out several great improvements and works involving a large amount of capital expenditure, and during the present year it has decided upon the immediate electrification of the whole of the Northern system of its tramways, and this with various extensions and other reconstructions will necessitate a far larger capital expenditure on tramways during the next few years than in any past year. Again, the acquisition of a site for the new County Hall has been approved, and provision for this, together with the building, will make a serious addition to its normal requirements on capital account. In these circumstances, and apart altogether from the consideration of the risk which the proposed scheme involves, we think the Council should endeavour to find some solution of the problem which would not involve the raising by the Council of large sums of capital in the near future.

The report of the Highways committee does not discuss any alternative policy by which the evils which might result from the creation of a virtual monopoly with wide powers, might be obviated, as, for example, the introduction in the Power Company's bill of adequate safeguards in the form of a purchase clause, sliding scale of price, and dividend and other similar provisions. We merely refer to this aspect of the subject in order to point out that there are alternative methods of dealing with the difficult situation which has been created by the general recognition of the changed conditions under which electrical energy must in future be generated.

In conclusion, we desire to impress upon the Council the fact that the enterprise to which it is being asked to commit itself is one which, from its nature and from the possible developments of electrical science is of a somewhat uncertain character, and that the Council is being asked to commit itself without any figures before it showing that the undertaking would be made self supporting. We are, moreover, of opinion that the Council should be further guided in this matter by its financial position, and that it should not largely extend its financial engagements during the next few years beyond those already entered into.

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At the meeting of the London County Council on Tuesday the Highways Committee's report, given on p. 109 of our issue for November 3rd, came up for consideration.

Mr. H. P. HARRIS moved an amendment that the Highways Committee's report and its recommendations be referred back or further consideration, with an instruction to the committee,

> "That the Council is unwilling to promote a Bill relative to the supply of electrical energy in London which is not based upon any definite scheme, or upon any agreement with the borough councils or existing companies, or upon any estimates which would enable the Council to judge of the financial responsibilities to be incurred by

the ratepayers; and, further, that it be an instruction to the committee to consider the whole matter, and in particular to report whether, in view of the heavy commitments of the Council, and the speculative nature of the proposed enterprise, the Council's efforts should not be directed to securing the supply of electrical energy by new or existing undertakers on terms and conditions which would safeguard the public interests."

Mr. Harris said that the question of the supply of electricity to London and neighbourhood was one that should not be made a party question. The Council must be careful that in their desire to discharge their duty to their constituents they did not rush into a project which was not demanded by the public interests and which might injure the credit of the Council as a business body. The recommendations of the Highways committee pledged the Council to the policy of undertaking an enterprise of which at present the limits were not defined, of which the cost was unascertainable, and of which the financial results were not at present estimated. The adoption of that policy was a step which it would be hard to retrace. Last year, when opposing the bill of the Administrative Co., the Council alleged that no public necessity existed for the bill; now they were asked to say that there was a necessity, and that the Council was the proper body to meet it. He urged that before the Council committed itself to a trading enterprise of that kind it should be fully informed as to what were the powers it was intended to seek, and what were the financial results likely to ensue from the exercise of those powers. The Finance committee had pointed out in their report [see above] that they had been in a position of great difficulty in considering the scheme because they had no financial data to go upon. It was a leap in the dark they were being asked to take by a committee which was itself in the dark. The field which the Council was asked to enter upon was already largely occupied. There were not only power companies, but there were electric lighting companies and many borough councils who had their own generating plants. The Highways committee were in a dilemma. If it was understood that they should seek the same powers as the Administrative County Co., they would have to interfere with the statutory rights of existing companies, while if, on the other hand, it was not proposed to seek the same powers, then all he could say was that from a financial point of view the scheme stood hopelessly condemned. Members of the Council had received several documents, but they were marked "Private and confidential," and he was not at liberty to refer to them. He had studied them, however, and in his opinion the enterprise would result in a loss for several years without any certainty of ultimate profit. If there was a loss it would fall upon the ratepayers, while if there was a profit it would be received by consumers in the area outside the county. The Administrative Co. only estimated a profit of 5½ per cent., and the Finance committee advised them that it was extremely doubtful whether they would be able to obtain it. The supply of electricity in bulk to London was a business of a speculative nature in which private persons might be allowed to risk their own money. He considered that the Council could do much better for the ratepayers by insisting upon proper safeguards in any private Bill rather than by attempting to set up as rival promoters.

Mr. R. A. ROBINSON seconded the amendment. He had no prejudice against the Council undertaking this work if it could be done with advantage to the ratepayers. One great objection to the scheme was that the conditions of electrical science changed so very rapidly. If there was any risk of a charge falling upon the rates they ought to be very careful before they embarked upon the project. The total debt of London at the present time was £71,500,000, and the commitments of the Council were going on alarmingly. They were committed to a further £21,000,000, of which £11,000,000 had actually been voted. Therefore they had to face a gross debt of £92,500,000. They could not hope to have a monopoly in this business, because there were already companies in London, beside the borough councils, which had the power to supply. He would remind them that during its existence the Council had spent £263,836 upon the promotion of Parliamentary bills, and he asked them to pause before they committed themselves to any further expenditure.

Sir F. MOWATT said that when the scheme was before the Finance committee they felt that they had practically no data to go upon to form a conclusion as to the limitation, the scope, or the cost of the proposed scheme. Speaking with some experience and knowledge on financial matters, he thought it was his duty to say that the financial condition of the Council was such as demanded very serious consideration. If the project were persisted in he should be driven, very reluctantly, to support the amendment. He appealed to the chairman of the Highways Committee to alter the recommendations so that it would commit the Council only to the principle of the introduction of a bill, and before it was introduced opportunity should be afforded for full discussion, especially in regard to the financial consequences of the scheme.

Mr. McKINNON WOOD said that he saw no objection to the words which had been suggested by Sir Francis Mowatt. Mr. Harris had told them that there were no figures showing the financial probabilities of the scheme, but the Finance committee showed that the Administrative Co. produced figures showing a profit of £385,000, or enough to pay 8 per cent. on £3,000,000 ordinary stock, besides paying debentures and preference stock and carrying forward £38,000. It seemed to him that the only alternative to the Council doing the work was to have a private monopoly.

Lord ELCHO said, rather than risk the ratepayers' money he would like to see a private company undertake the work under proper restrictions. He hoped the Council would have nothing to do with the scheme.

Sir MELVILLE BEACHCROFT said electricity was a gigantic industry, and while Germany and America had taken advantage of it Britain had lagged behind. First it was strangled by unwise legislation, which to a large extent had been relaxed, and now it bid fair to be stifled by municipal greed.

Mr. J. BURNS supported the recommendations of the Committee and denied that the scheme was either a risky or a speculative one. If London, Glasgow, and centres like the Tyne and Tees were to improve their positions, it could only be done permanently, commercially, scientifically, and, above all, cheaply, by their putting forward a bulk supply of electricity to traders and manufacturers at 1 per cent. net profit on cost. He hoped they would not imitate New York and put 11 or 12 millions in a bulk supply and then lease it.

The amendment was defeated on a division by 79 votes to 36.

Sir FRANCIS MOWATT then moved that the following be added to the recommendation, "provided that, before the introduction into Parliament of any bill, opportunity shall be afforded for full discussion in the Council of its provisions, especially as they affect the financial consequences of the scheme."

Mr. McKINNON WOOD seconded, and with this addition the recommendation was carried.

## THE MANUFACTURE OF ARC CARBONS.

An interesting Paper on this subject was read before a meeting of the Central Technical College Students' Union on Friday last by Mr. Maurice Solomon, Prof. Ayrton, the Dean of the College, being in the chair. The author commenced by a brief historical sketch, in which he said that the arc-lamp carbon of to-day differed very little from the early forms, and the process of manufacture was also practically the same. Nearly all carbons contained then about 75 per cent. of gas carbon and 25 per cent. of soot, gas tar being employed at present, instead of syrup as formerly. Apart from the original Carré patent there were practically no others, except that of Siemens, which related to cores. Latterly the development of flame lamps and flame carbons might be noticed and the highly expensive investigations which had been carried out were just beginning to bear fruit. A more or less detailed account of the manufacture of carbons, as effected at the General Electric Co.'s Witton works, was then given. The author described the various processes of grinding the retort carbon to pebbles, and finally to dust, by means of an octagonal box containing heavy steel spheres. Tar of the correct quality, although not treated in any way, was exceedingly difficult to obtain. The mixing process was carried out by means of a dough-mixing machine, and the mixture subsequently passed between rollers, so as to distribute the tar evenly. Finally, the material was moulded into large cylinders, forced through a nozzle by means of hydraulic pressure, cut off into lengths of a little over a metre, and then baked. After baking, the rods were cut up into pieces of any desired length, sorted, ground to length, and pointed. The author mentioned that carbons for use in open-type lamps out of doors had a large proportion of retort carbon; those for use in the same lamps indoors would be composed of about equal parts of carbon and soot; while a third class for enclosed lamps would be nearly all soot. It was worth noticing that the materials had to be very pure and clean, and the soot had to be specially made.

In order to show that the carbons made by the General Electric Co. at Witton were high quality carbons, the author gave the average test results for every month since the beginning of the year. The tests were not specially selected, but were the averages for *all* the 18 mm. cored and 12 mm. solid Apostle carbons tested each month, and as these tests were made every day on five lamps in series on 230 volts, each figure represented the average of 80 to 100 pairs of carbons:—

| — | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|---|
| Consumption per hour in mm., upper carbon | 12·6 | 12·4 | 12·3 | 12·4 | 12·1 | 12·2 | 12·2 | 12·1 | 12·0 | 12·2 |
| Do. lower do. | 11·4 | 11·1 | 11·3 | 11·3 | 11·2 | 11·6 | 11·2 | 11·0 | 11·6 | 11·4 |
| Do. total ...... | 24·0 | 23·5 | 23·6 | 24·0 | 23·3 | 23·8 | 23·4 | 23·1 | 23·6 | 23·6 |
| Ash as percentage of weight of carbon burnt | 0·66 | 0·71 | 0·82 | 0·79 | 0·67 | 0·93 | 0·86 | 0·87 | 0·84 | 0·76 |

That these results were quite as good as those obtained with high-grade Continental carbons is shown by the following figures for two of the best Continental makes:—

| — | Conradty (C mark). | Schiff & Co. |
|---|---|---|
| Consumption per hour in mm., upper carbon | 12·8 | 12·1 |
| " " lower " | 11·3 | 12·0 |
| " " total ...... | 24·1 | 24·1 |
| Ash as percentage of weight burnt ........ | 1·86 | 1·45 |

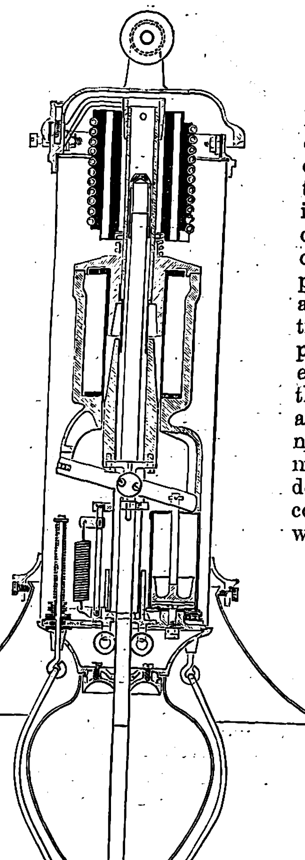
These results obtained from the General Electric Co.'s tests are confirmed by some comparative tests made at the National Physical Laboratory:—

| — | G.E.C. Apostle. | Conradty C. | Schiff & Co. 1 × G. |
|---|---|---|---|
| Consumption per hour in mm. upper carbon | 14 | 13 | 15 |
| " " " lower " | 13 | 12 | 14 |
| " " " total ...... | 27 | 25 | 29 |
| Ash deposited per hour in milligrammes.. | 20 | 172 | 98 |

To show the degree to which foreign competitors had cut prices in order to stifle the industry in this country, Mr. Solomon mentioned that at present carbons cost in Germany approximately 70 per cent. more than in England in spite of the cost of carriage. Before the General Electric Co. started their works the price which a large consumer (such for example as a corporation or a railway) would have to pay was from 50s. to 55s. per 1,000 ft. of carbons. At present the price was about 20s. to 22s. for the same size. Thus they were before paying two and a-half times the present price for carbons of a quality naturally not so good as those manufactured to-day.

## A NEW JANDUS ARC LAMP.

The accompanying illustration shows the latest design of Jandus arc lamp, which, while retaining all the main features of the old pattern that has proved so successful, embodies further improvements, so as to increase the lighting qualities and the already long burning hours of the lamp, and to render all parts of the mechanism easy of access. In the mechanism of the lamp is a compound-wound solenoid, which acts on an armature of nearly 3 lb. weight. The great inertia of this heavy weight, compared with the light mechanism in so many lamps, naturally acts as a flywheel in steadying small fluctuations, and, the pull being vertical, the whole weight of the armature is available for checking small fluctuations. It will be noted that the total weight of the mechanism acts directly as a controlling force, and is therefore able to overcome any friction. A dashpot is mounted on one side, is totally covered in and can be removed for cleaning without disturbing any other part of the lamp. The coils are baked after treatment with a patent composition and rendered thoroughly waterproof. They are tested while hot at eight times the working pressure, and the shunt coils will stand 250 volts across the terminals of the lamp indefinitely without injury. By this arrangement the need for cut-outs or other devices to break the circuit of the shunt coils is not necessary for ordinary series working.



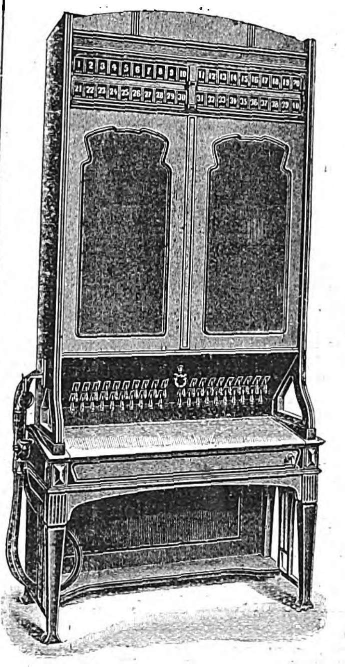
Interior of New Jandus Arc Lamp.

The Jandus Company still adhere to the use of powerful shunt coils for series lamps (these coils balancing the arc voltage within 1 or 2 volts), and do not rely upon the use of series coils only for the regulation of the arc voltage. Series coils, whether assisted by weights or springs, depend only for any balance the lamp may possess upon the latter taking an increasing current as the arc is lengthened, and the lamp can therefore never burn with an absolutely definite current. The series coils, with their attendant springs or weights, regulate only the position of the arc mechanism, and not the length of the arc; it is, therefore, necessary that the lamp should break the circuit and re-strike the arc before each feed to keep even an approximate balance.

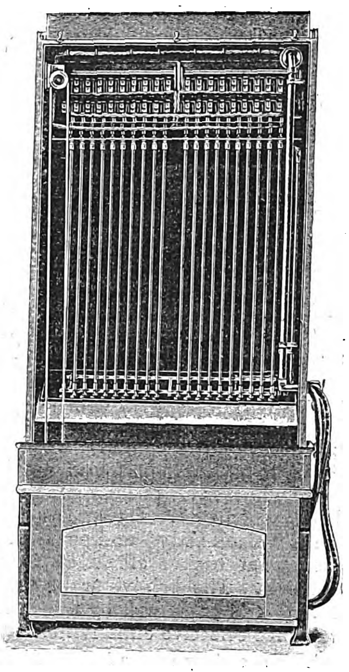
As owners of the Jandus, Howard, Marks and many other enclosure patents, the Jandus Company have devoted considerable attention to long burning hours, it being maintained that the present lamp will burn for 200 hours at one trimming without any blackening of the globe, flickering of the light or explosions. The trimming is at the same time very simple, and only one glass to metal joint is broken; an extremely high arc voltage is employed. A diffuser is fitted above the globe, and to this is added any one of an extensive series of reflectors. These, combined with the cleanliness of the globe due to a nicely designed enclosure, result in a lamp of high light efficiency. The resistances may be either internal or external to the lamp as desired, and a variety of globes, reflectors and cases are stocked, all being interchangeable upon the same lamp body. Current is fed through the patent gravity brush rings, and there is an entire absence of flexible cords or clockwork. The case is removable while the lamp is hanging in position, when the whole of the working parts are accessible and can be inspected without dismantling the lamp.

## A NEW TELEPHONE SWITCHBOARD.

At the invitation of the Sterling Telephone & Electric Co., we recently had the opportunity of inspecting a telephone switchboard of quite a novel design. This board has been specially built for use in connection with the distribution system of the Lancashire Electric Power Co. (*The Electrician*, October 13th.) It will be remembered that the Lancs. Co. have several miles of 10,000 volt overhead transmission lines, and the telephone board has, therefore, been constructed so as to make it impossible for the operator to receive a high-voltage shock, or indeed a shock of any kind. This board is equipped for 40 lines, and does not provide, in the ordinary course, for intercommunication. Most of the lines terminate in sub-stations, many of which are on consumers' premises, and intercommunication is therefore quite unnecessary. Each telephone station is provided with an instrument having a couple of long speaking tubes between the hand set and the receiver and transmitter. These tubes are made of insulating material, and it is impossible for the user to touch any part in metallic connection with the line. To call the power station he uses his magneto, which drops an indicator on the front of the new board. This indicator, in falling, closes a local circuit and rings a bell. The operator then takes the hand set—which is insulated from the receiver and transmitter by long tubes—off the hook, pulls over the key corresponding to the number indicated, and talks with the subscriber. Since intercommunication is not required there is, of course, no ring-off indicator. The replacement of the drop shutters after a call has been attended to is effected by pulling down a handle on the front of the board. This handle communicates, through an insulating rod, with the replacement mechanism, which throws the shutter back to the normal position.



Front of Switchboard.



Back of Switchboard.

As far as the telephonic operations are concerned there is nothing novel about the board, but its great feature is the care which has been taken to guard against shock to the operator. The front of it is entirely closed, and is not made to open, either by lock and key or screws. Means of access is provided at the back, but even here the covering is screwed on, and a number of obstacles have to be overcome before any person can get at parts in metallic connection with the line. The keys themselves, by means of which the operator changes the connections from the ringing to the listening contacts, are separated from metal, which may possibly become charged with high-voltage current, by ebonite rods 1 metre in length. They are so constructed that the necessary connections from the indicator to the operator's set are made by an upward pressure of a small roller of insulated material. The method of applying this upward pressure is as follows: The small rollers are fitted on one arm of a pivoted crank, the other arm being connected to the ebonite rod; at its bottom extremity this rod terminates on one arm of a second crank, the other arm of which projects through to the front of the board, and terminates in an ebonite handle, numbered to correspond to the station it represents. At the bottom part of the board there is arranged an ingenious interlocking bar. When any handle is pulled forward it has the effect of pulling the ebonite rod downwards and, through the top crank, lifting the small roller above referred to up towards the key. When the limit is reached, a small projection on the bottom crank engages with the interlocking bar, by which it is retained in position, leaving the operator's telephone connected to the line of the party calling or required. On the top of the board are the heat coils, and a separate fuse board is provided. By pulling over two keys at the same time a triangular conversation may be carried on, but there is no intention of doing this as a rule. If one key is already pulled over, then the pulling over of a second automatically releases the first. The replacement of the hand set on the hook breaks the speaking circuit connections and restores those for ringing.

## PHYSICAL SOCIETY.

At the meeting held November 10, 1905, Dr. C. Chree, F.R.S., Vice-President, in the chair, a Paper on

### The Question of Temperature and Efficiency of Thermal Radiation

was read by Mr. James Swinburne.

It has long been known that various surfaces have different emissivities, and it is generally held that at a given temperature some bodies radiate a larger percentage of their total radiation in the form of light. This view is largely based on some experiments by Evans and Bottomley. Evans's experiments really show that if two filaments, A and B, of the same area, but of low and high emissivities respectively, are run to give the same light, the filament A of lower emissivity will give a higher efficiency, and it will give a still higher efficiency if run so as to use the same power as B. This is a natural consequence of the different emissivities, and does not at all show that A gives a higher efficiency at the same temperature as B. Prof. Bottomley's experiments are criticised on the ground that he used no photometer, and his reasoning attacked on the ground that he makes the same slip as Evans in confusing difference of emissivity with difference of efficiency at the same temperature. It is urged that a body, A, at the same temperature as B cannot give out radiation corresponding to a higher temperature of B; for if it could, and A and B were enclosed in a perfectly reflecting space, A would heat B to a higher temperature than A. It may be said that A can have a higher efficiency than B, not by giving out rays corresponding to B at a higher temperature, but by omitting to give some of the longer radiations that B gives. If this were true, a hot body might be surrounded by a thin case of A lined inside with a substance which only emitted and absorbed long waves. The case would then take in long and give out short waves, though colder than the source. High efficiency or selective emissivity are always sought in polished, grey, or white surfaces like flashed filaments, platinum and other metal wires and rare earths. If there were such a thing, it should be found not in white, but in black bodies, as a body which is a specially good radiator of light when hot should be black when cold. Lummer's curves of the distribution of energy for a "black body" and polished platinum are compared, and show somewhat higher efficiency for platinum; but the comparison is difficult. The behaviour of flashed lamps and incandescent gas-mantles is explained by the difference of emissivity, without any need for selective emissivities.

The Secretary read a letter from Dr. J. T. BOTTOMLEY, in which he stated that the author's Paper seemed to be to a large extent an attack on his work on radiation. He could not see that Mr. Swinburne had made a single experiment in support of his proposition that "In the case of pure temperature-radiation the light efficiency is a function of the surface temperature only." No amount of discussion such as the author asked for could do anything to prove or disprove this proposition. He failed to see that the author had worked out any logical proof of the proposition. The author had assumed that he (Dr. Bottomley) was incapable of matching the light-giving properties of two platinum strips placed side by side and properly arranged for this sort of comparison. The matching is exactly the same in principle as in shadow photometry, and in all the cases cited in the Paper to which Mr. Swinburne takes exception, Dr. Bottomley's determinations agreed with those of his assistant, Mr. Evans.

Dr. J. A. HARKER expressed his interest in the Paper, and said that the question of radiation was of practical importance in the measurement of high temperatures by electrical resistance methods. He asked if two platinum thermometers, one bright and the other blackened, but identical in other respects, were transferred from an ice bath into a sulphur bath, would the final temperatures of the two thermometers be the same, and also would the thermometers approach their final temperatures at the same rate?

Prof. H. L. CALLENDAR, referring to Dr. Harker's questions, stated that if the sulphur bath was in an isothermal enclosure the two wires would reach the same ultimate temperature, although the blackened one would reach it quicker. The difference, however, would be small. With fine wires the loss of heat by conduction through the gas is more important than the radiation loss. The loss by radiation is proportional to the surface, but the loss by conduction is not, and it therefore becomes relatively more and more important with the fineness of the wire. With regard to the action of incandescent mantles, he thought the author's theory was reasonable and satisfactory.

Mr. MAURICE SOLOMON said he did not agree with Mr. Swinburne's contention that in the case of solids there was no such thing as selective emissivity, but that all bodies at the same temperature radiated light of the same efficiency. Selective emissivity existed in the case of incandescent vapours, and if it was consistent with the laws of thermodynamics in such a case, it could not be inconsistent in the case of an incandescent solid. With reference to the incandescent mantle, the explanation put forward by the author did not seem satisfactory. It was difficult to believe that the very small differences in colour between a thoria, a thoria-ceria and a ceria mantle could account for the enormous differences in their candle-powers.

Prof. W. E. AYRTON referred to experiments which he had carried out which tended to show that the temperature of a Bunsen flame was lowered by an incandescent mantle. He had also found that small pieces of mantle heated in a platinum boat to various temperatures just below the melting-point of platinum never looked brighter than the platinum. If, however, a small hole was made in the bottom of the boat and coal-gas passed in, the mantle immediately became brilliant.

Mr. SWINBURNE, replying to Dr. Bottomley, said that his main argument was that he had not made experiments. In the investigation of a question such as that considered in the Paper, it was possible to prove much by means of experiment, but it was also possible to attack the problem by thermodynamic reasoning. He expressed his interest in the fact that Prof. Callendar had referred to his views as reasonable.

## CORRESPONDENCE.

### TRAIN-WEIGHT AND ACCELERATION UNITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The English-speaking race is doing incalculable harm in opposing progress in the internationalisation of engineering units. Its attitude is commonly ascribed to a conservative dread of the consequences of altering the existing units. This, however, is not the case. Thus Mr. Parker, speaking for the British Weights and Measures Association, an Association formed with the object of preserving British units of weights and measures, which is tantamount to opposing the extension of the metric system of weights and measures, proposes to "increase the grain-weight by 1 per cent. and to recognise the weight of a cubic inch of water, which would then be 250 grains, and which might be called the imperial unit of weight or the ounce weight."

Mr. Parker professes to see no objection in the circumstance that this imperial ounce has a value altogether different from the British ounce. The proposed imperial ounce would have some 57 per cent. of the weight of the British ounce; certainly a very considerable change in order to secure the slight alleged advantage that $\frac{1}{1000}$ part of an ounce should be equal to $\frac{1}{4}$ of a grain.

In America we also find among young engineers a growing willingness to change. Thus, writing from New York (*The Electrician*, October 20, 1905, p. 33), Mr. Mailloux advocates a ton of 2,000 lb., owing to the advantage of having $\frac{1}{1000}$ part of a ton equal to 2 lb. The logical outcome of Mr. Mailloux's guerilla reform would lead to accompanying his "short" ton of 2,000 lb. with a "long" mile of 6,000 ft. (or 2,000 yds.) in order that $\frac{1}{1000}$ of a mile should equal 2 yds. Mr. Mailloux's admiration for the 2,000 lb. ton (or, as it is sometimes called, the "short" ton) appears to have been intensified by the discovery that $\frac{1}{160}$ of the British ton of 2,240 lb., in addition to being so unfortunate as to be equal in weight to 14 lb., is dignified with the privilege of being known as 1 stone.

In the same communication Mr. Mailloux champions the use of 1 mile per hour per second as unit of rate of acceleration. It appears to have escaped Mr. Mailloux's attention that a tractive force of 102 lb. (or 100 lb. approx.) per British ton produces a rate of acceleration of 1 mile per hour per second on a level, frictionless track. This admirable relation to his chosen unit of rate of acceleration ought to have appealed to Mr. Mailloux as an extenuating circumstance for the crime of being equal to 160 stone and to 160 × 14 lb.

The British ton of 2,240 lb. has the immensely important advantage of being but 1·5 per cent. greater than the weight of the metric ton of 1,000 kgs.—*i.e*, than the weight of 1 cubic meter of water, and thus through the medium of the British ton (the ton of 2,240 lb.) we are brought far nearer to the metric system than by means of any other British measure. It is for this reason that it is highly important to use it in preference to the 2,000 lb. ton. In the case of a vast majority of the problems with which engineers have to deal, an exactness of 1½ per cent. is amply sufficient, and it becomes practicable to ignore the 1½ per cent. difference between the metric ton and the British ton, and simply to refer to the ton. To do so involves no uncertainty of any consequence, if only the "short" ton of 2,000 lb. could be disqualified. It is also amply accurate to employ the rule that a tractive force of 100 lbs. per ton produces an acceleration of one mile per hour per second. This is close to the truth for the metric ton, and is only 2 per cent. low for the British ton.

The note in Messrs. Ashe & Keiley's book on "Electric Railways" may not, perhaps, have been in vain should it lead to a clearer perception of the importance at this juncture of resisting any inroads by the "short" ton. The 2,000 lb. ton should be carefully quarantined in the only country in which it is prevalent till progress in the internationalisation of the metric ton shall have removed all danger of its becoming epidemic elsewhere.

The convenient rule that an accelerating rate of 1 mile per hour per second is produced by a tractive force of 102 lb. (100 lb. approx.) per ton (of 2,240 lb.), is nothing but one of a number of useful coincidences which always emerge, however mixed a systems of units may be. It is, of course, perfectly legitimate to make use of such relations in the transition stage to the internationalisation of the metric system. That this end will be accomplished in a far shorter time than is generally believed, is a fair conclusion in view of the fact that in neither of the two great English-speaking countries is there such opposition to change as is customarily assumed. This fact becomes clear from a study of the proposals of Messrs. Parker and Mailloux. These gentlemen have thus given a personal demonstration which should be very useful to the Decimal Association and to all interested in the internationalisation of the metric system.

The accomplishment of this internationalisation will contribute far more greatly to the progress of technical education in America and England than all the millions which the Rothschilds, Carnegies and Rockefellers may condescend to donate to universities and libraries; and anyone who lends a hand in this cause may rightly feel that the results which accrue to his efforts, if capitalised on this basis, will be of a value to his fellow-men quite commensurate with the results accomplished by a millionaire in endowing institutions for the promotion of the welfare of mankind.—Yours, &c.,

INTERNATIONAL.

## THE NATIONAL PHYSICAL LABORATORY.

### TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is most interesting to observe, from the leaders and letters which have appeared in your issues of October 27th and November 3rd and in the engineering supplement to *The Times*, that the undiscriminating application of "business methods" to Government Departments—for which the business world has called so loudly—may lead to results against which business men protest with no less loudness. Fortunately they are not in this particular instance restricted to mere protest, but are able to bring into use the much more effective weapon of "refusal of supplies" through the industrial and technical societies which, I believe, at present give some measure of pecuniary support to the National Physical Laboratory.

The broad fact, however, remains that "business methods," including businesslike touting for business, are inapplicable to most Government Departments, certainly to such a one as the National Physical Laboratory. If the powers that be had not been inoculated with the "self-supporting" fever, we may be sure the departure so justly complained of would never have been attempted. A State institution is bound to come into collision with innumerable industrial and professional interests the instant it begins to trade "on its own," but the accurate definition of "trading" need never trouble such an Institution if it will but keep two cardinal principles well in view—viz., (1) To publish fully and freely *all* its investigations and *all* its results. (2) To restrict itself to "unprofitable" researches. A properly-managed State Department, working on these lines for the good of the community at large and of certain industries in particular, may be sure, in any tolerably enlightened land, of securing sufficient support from the taxpayer and liberal donations from the industries more directly interested. For a public institution to compete for remunerative work and aim at being self-supporting is "to hunt with the hounds and run with the hare," an achievement only feasible in space of four dimensions.—Yours, &c.,

W. G. BOND.

Nov. 14.

## HARMONIC TERMINOLOGY.

### TO THE EDITOR OF THE ELECTRICIAN.

SIR: Perhaps you will kindly allow me to offer a few remarks on your criticism of Mr. Clinker's article. In speaking of the term $E_3 \sin 3pt$ as the "third harmonic," Mr. Clinker is only following the new and rational terminology which has been universally (so far as I am aware) adopted by all the leading writers on the subject. The bad old way which you uphold is redolent of physics text-books half-a-century old, but has no place in a first-class modern text-book. As an example, I may cite Poynting and Thomson's *Sound* (p. 67; also pp. 102 and 103, where "even" and "odd" are used in the sense in which Mr. Clinker uses them).

Quite apart from the confusion to which the absurd terminology upheld by you is liable to give rise, there is absolutely no justification for differentiating the first term of a Fourier's series from all the others, and speaking of it as the *fundamental*, while all the others are termed *harmonics*. Is not the fundamental as much of a harmonic (*i.e.*, a simple sine function) as all the others? And I fail to see why the "fundamental" should not be spoken of as the first harmonic, or fundamental harmonic. The question, however, is, as I have already stated, settled for us by the prevailing practice of modern writers on the subject, and I can only regret that you should use your influence in an attempt to revive an anomaly which is already virtually dead.—Yours, &c.,

London, N.W., Nov. 11. ALFRED HAY.

[Then according to Dr. Hay, Clerk Maxwell had "absolutely no justification" for the following passage :—

> The term Harmonic Analysis was suggested by the study of the vibrations of strings *and the analysis of these vibrations into their fundamental tone and its harmonics or overtones.*

The italics are ours. Perhaps Dr. Hay, with his characteristic assertiveness, will reply that Clerk Maxwell's way is bad and absurd, and that he was not a leading writer on the subject. Of course the terminology employed by Mr. Clinker, and we admit frequently used by other writers, may be more convenient, but it may introduce an element of uncertainty, and for that reason we preferred to use the term triple-frequency component in our editorial note last week.—ED. *E.*]

## LEGAL INTELLIGENCE.

### Ingleton Electric Lighting & Power Co. v. Ingleton Gas Co.

This case (briefly referred to in our last issue) was heard by Mr. Justice Warrington on Wednesday, Thursday and Friday last week.

Mr. McMORRAN (for plaintiffs) said the plaintiff company was registered in 1899, obtained a licence from the Board of Trade, and in 1903 obtained a provisional order. The defendant Gas Co. was formed in 1886 and had no statutory powers to supply gas or lay mains and service pipes, but proceeded to lay them and supply gas. The business of the Gas Co. was purchased in 1899 by defendants, who registered it several months after the plaintiff company, but still it had no statutory powers whatever. In January, 1905, defendants dug a trench in a street, and whilst doing so seriously injured a feeder cable belonging to plaintiffs, and the village was thrown into darkness for a night and a day, and the supply of electricity was seriously incommoded for some time. The actual fault was only found after some difficulty at great expense. The defendants had laid a gas pipe above plaintiffs' cable, thus preventing them from having free access thereto. The injury was caused through negligence, but he went further than that, and said the damage was caused in the course of performing an illegal act, the opening of trenches in the street being a public nuisance and unlawful. This was not an isolated act on defendants' part, but one which had occurred at intervals, which must occur in the future, and which might lead to further damage.

Mr. DAVID TATTERSALL, resident engineer of plaintiff company, explained that supply was not immediately interrupted on the assumption that the pick pierced the sheathing of the cable and touched the neutral conductor. It left a hole in the cable which admitted moisture, and a gradual leakage was set up tending to carbonise the insulator, which would go on increasing until it burnt out. The cable was 4 in. below the gas pipe, and the lateral distance between the two was less than 2 ft. He had seen the cable laid from a big drum without an inner roller, but it was not true that a kink was caused by straining by which moisture would be admitted, thus eventually causing a short-circuit. He denied that if, in seeking for the fault, full power was put on it would make a small hole bigger, or that the fault could have been caused in testing.

E. TOMLINSON, stonemason, said he was employed to dig a trench for relaying the gas main. He was also employed by the Electric Co. in February to open the trench for them. When getting near the cable he noticed that the earth was black, showing that the cable had been fused. The sheathing of the cable was burnt. An employé of the Gas Co. noticed the hole in the sheathing, and remarked to witness that it was a pick hole.

Mr. WM. F. PRICE, M.I.M.E., M.I.E.E., said he was a member of the firm that laid the cable. The injury to the cable was undoubtedly from the outside by some sharp instrument, the hole being more or less regular in shape. The interval between the injury being done and the breaking down of the cable depended on the rate at which the insulation absorbed moisture. The cable might break down almost immediately; on moderate soil it might take two or three months, and in sandy soil it might never break down at all.

For the defence evidence was given by a foreman and workmen employed by defendants and by the contractor who laid the pipe. They denied that they uncovered the cable or touched it with their picks.

Mr. M. ADAM, consulting electrical engineer, said that having regard to the proximity of gas and water mains and frequent necessity of opening the road, it would have been a reasonable precaution to put a board in the earth above the cable. It was a practice which he always recommended. He was of opinion that the injury was caused from the outside, and probably by a pick.

In the result his LORDSHIP, in giving judgment, said plaintiffs' theory was consistent with the injury having been caused during the opening of the trench, but they had not, in his opinion, discharged the onus which was upon them of establishing that the injury was caused by defendants' workmen, and he thought if he was to accept the description of what was done by the defendants he must come to the conclusion that the injury was not done by them. He did not think it was consistent with the facts that the injury should have been occasioned by a pick used by their workmen. There was a hole, admittedly made by external agency and by a blow of such an instrument as a pick, but no explanation was offered as to how the injury could have been occasioned. There would be judgment for defendants, with costs.

## Re L. Maxwell Waterhouse and Patent No. 28,632 of 1903.

This matter came before Mr. Justice Buckley on Wednesday and yesterday on the petition of the Metallic Seamless Tube Co. (Ltd.) to revoke letters patent No. 28,632 of 1903 granted to Mr. S. Maxwell Waterhouse. The letters patent in question granted to Mr. Waterhouse and the Simplex Steel Conduit Co. was for an alleged invention for improvements in metallic conduits for electric light cables and the like, and the petitioners said that the letters patent were invalid by reason of the following anticipations: Richardson 1884, Lorinz 1889, Souter 1890, Davis and Baldwin 1891, Parlour 1893, Hill 1893, Braham 1894, Lake 1896, Granger 1900, Lindsey 1902 and Bayliss & Brown 1903. Petitioners said that having regard to these specifications and the state of public knowledge no invention was required to produce the method of connecting plain conduit to couplings and other fittings by means of a split screwed lashing described and claimed in respondent's patent, and that the letters patent were invalid for want of subject matter. They also said that the letters patent were unvalid for the reason that the devices shown in Figs. 4, 5 and 6 and claimed in claims 1, 2, 4 and 5 were of no utility and did not affect the objects pointed out in the specification.

Mr. FLETCHER MOULTON, K.C., having opened respondent's case,

Mr. JAMES SWINBURNE, said he was familiar with all kinds of electrical apparatus. In certain installations it was desirable that the conduit should be capable of being in electrical contact throughout. There were various methods of forming contact with the earth by casing, but the present invention had nothing to do with that. This had to do only with a system in which the conduit was contained in thin metallic tubing. In an electrical conduit of that kind the continuity of the inner surface was a matter of importance. The various conducting parts of the conduit should be of the same size. The invention consisted of a ferrule which was screwed at one end to go into the socket and was always screwed. The other end was larger and a plain socket which fitted an unscrewed pipe and the same size was the screwed end of the socket. The ferrule was split, so that when it was screwed up it gripped enough on the plain tube to make an electrical contact. In Figs. 1, 2 and 3 the screwing was attained by the ferrule being split along one side. Taking the instructions contained in the text of the specification, he thought any person desirous of working the apparatus shown in Figs. 4, 5 and 6 would not have any difficulty in making them work. He had perused the specifications referred to in the particulars of objections, and he did not find in any of them the invention in question. As to the suggestion that no invention was required to arrive at that, he said it was an ingenious invention. It was obviously a good thing. He believed it had been superseded by some other invention of the same inventor's, but it was all right, and was quite good.

Mr. J. E. LLOYD BARNES said his firm were responsible for the specifications. His recollection was that there was nothing in any of the anticipations which would enable one to couple what he, as a practical man, called an inch conduit to what he would get from the Simplex Company, an inch fitting. He was acquainted with all the terms of the article at the date of the specification.

On behalf of petitioners, Mr. DUGALD CLERK and Mr. C. E. LUGARD gave evidence to the effect that there was no novelty or utility in the invention in question.

Counsel having addressed his Lordship, judgment was reserved.

## Krauss and Others v. South Lancashire Electric Traction & Power Co. (Ltd.)

In the Chancery of Lancashire, Liverpool, on Monday, a debenture-holder's action came on for further consideration before the Vice-Chancellor (Mr. O. Leigh Clare, M.P.). Judgment was given on Aug. 16 last, and the order was in the usual form, certain inquiries being directed as to trustees' remuneration, &c. The property consisted of the whole of the shares in the South Lancashire Tramways Co., the South Lancashire Light Railway Co., the generating station and other items. There were certain prior incumbrances which took priority over the debenture stock—two in particular, one being a claim by Parr's Bank for £37,500, advanced for the completion of the undertaking, and another an action for damages by the Electric Conversion Synd., now pending. If the plaintiffs were successful in that action there might be a claim prior to the debenture stock. Leave had been given to sell the property, and it would now be sold free from incumbrances, the incumbrances being paid out of the purchase money. The purchase money was £150,000, and the prior incumbrances did not amount to anything like so much. The property was sold to the Hon. Arthur Stanley, and in the order giving receivers liberty to sell there was a direction that the purchaser should be at liberty to set off against the debenture holder the actual value of any amount of debenture stock held by him. It was agreed that the costs of other debenture holders who had commenced actions should be allowed, but the Vice-Chancellor could not allow the defendant company any costs or the liquidator any costs beyond certain specific allowances which his predecessors had made.

## Dotchin v. N.E. Railway Co.

At North Shields County Court last week Mr. S. Dotchin sued the N.E. Railway Co. for £10 damages for loss of a beast which was killed by contact with the live wire on defendants' line at Cullercoats.

Mr. MEYNELL, for plaintiff, said the beast (with other animals) arrived at the cattle dock after nightfall. Three hurdles had been sent by the company, and were placed end to end to prevent cattle straying on to the line. Plaintiff's beast knocked down one of the hurdles, walked through the gap and was killed by the live rail.

Mr. SMITH, for defendants, said the company, in providing a movable fence, had done all that could reasonably be expected of them.

Ultimately Judge Greenwell gave judgment for plaintiff for the amount claimed and costs.

## Atkinson v. Schmahl.

Yesterday, Mr. Justice Swinfen Eady had before him a partnership action brought by Mr. S. J. Atkinson, electrical engineer, Newcastle-on-Tyne, against Wilheim Schmahl.

Mr. MICKLEM, K.C., for plaintiff said the claim was brought under certain articles of partnership entered into between the parties in 1900 in connection with the business of dealing in electrical fittings, &c. Plaintiff's case was that his partnership with defendant still subsisted, while the defendant said it was dissolved by an agreement.

Mr. EVE, K.C., for defendant, said both parties were agreed that there was a verbal agreement come to at the same time as the written agreement, and his case was that the verbal agreement, coupled with the document, made a complete dissolution. The parties were now agreed that plaintiff should have his capital. Defendant would pay him £510 in two instalments.

His LORDSHIP granted a stay of proceedings, without costs, as desired by the parties.

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Proceedings of the Royal Society." Series B. No. B 513. November. (London: Harrison & Sons.) 3s.

"Proceedings of the American Institute of Electrical Engineers." October, 1905. (New York: The Institute.) 50c.

"Physics." By C. R. Mann and G. R. Twiss. (Chicago: Scott, Foresman & Co.).

"Synchronmaschinen für Wechsel-und Drehstrom: Ihre Wirkungsweise, Berechnung und Konstruktion." By W. Winkelmann. (Hanover: Dr. Max Jänecke). 3.40m.

"Traité de Physique." In four volumes. By O. D. E. Chwolson. Translated from the Russian and German editions by E. Davaux. With notes on Physical Theory by E. & F. Cosserat. Vol. I.: Introduction, Mécanique, Méthodes et Instruments de Mesure. Vol. II. Emission et Absorption de l'Energie rayonnante, Vitesse de Propagation, Réflexion et Réfraction. (Paris: A. Hermann.) Vol. I., 16fr. Vol. II., 6fr.

"Handbuch der Physik." Edited by Prof. Dr. A. Winkelmann. Vol. V. (first half): Elektrizität und Magnetismus. II. By Prof. Dr. F. Auerbach. (Leipzig: J. A. Barth.) 16m.

"Die Elektrolyse geschmolzener Salze." Part II. "Das Gesetz von Faraday; die Uberfuhrung und Wanderung der Ionen; das Leitvermogen." By Prof. R. Lorenz. (Halle-a.s.: W. Knapp.) 8m.

# MUNICIPAL, FOREIGN & GENERAL NOTES.

## APPOINTMENTS VACANT AND FILLED.

Vickers, Sons & Maxim, River Don Works, Sheffield, require a thoroughly capable and experienced superintendent for their electrical manufacturing shops. See an advertisement.

At the University of Birmingham a mechanical draughtsman is required, thoroughly conversant with best English practice in the design of dynamos, transformers and accessory apparatus. Salary £250 per annum. Applications to the Secretary by Nov. 27. See an advertisement.

Mr. R. L. Pearson is resigning his position as assistant editor of *The Electrician* on his appointment to the post of assistant lecturer in physics at University College, Reading.

Mr. Hugh Stevenson has been appointed general manager of Crompton & Co. (Ltd.), Chelmsford and London, in succession to Mr. F. R. Reeves, who will now act as financial adviser to the board of directors.

South Shields Town Council have appointed Mr. John Wilson general manager of the Corporation electric tramways at £250 per annum. Mr. Wilson has been general manager of the old South Shields horse lines for 20 years, and prior to that he was traffic manager for three years of the steam tramways at Gateshead.

## EDUCATIONAL NOTICES

**Motor Construction Lectures.**—Prof. C. A. Carus-Wilson, M.A., M.I.E.E., commenced a special course of lectures to the senior students of the Electrical Standardising, Testing and Training Institution yesterday (Thursday) on "Direct-current Motor Construction." The lectures will be delivered on every subsequent Monday and Thursday for the remainder of the term.

**Birkbeck College, London.**—The Lord Chief Justice (Lord Alverstone) presided on Tuesday at the 82nd anniversary of the foundation of this college, when Sir William Preece presented the prizes. The total number of students for the past year was 2,502, of whom 686 were women. Day students numbered 810 and evening 3,401.

**Technological Scholarships.**—The Education Committee of Cheshire County Council have decided to offer two scholarships, tenable at Manchester School of Technology or other institution approved by the committee, to Cheshire boys not under 15 years of age, to enable them to take up a course of study and practical work in mechanical or electrical engineering, sanitary engineering and plumbing, pure and applied chemistry, or textile fabrics. The scholarships will be for one year, but will be renewable for a second and third year at the discretion of the Committee.

**Alleged Frauds on Electrical Firms.**—At the Central Criminal Court yesterday the Recorder commenced the trial of G. Webber, R. Rosenberg, W. Leslie and Frances Cheesman for conspiring to defraud certain electrical firms of large sums of money. After evidence had been called for the prosecution the case was adjourned until to-day (Friday).

**Argentina.**—The "Review of the River Plate" says Rosario Municipality will shortly invite tenders for electric or gas lighting, as the contract with Rosario Electric Co. will expire.

A further attempt is being made to form a co-operative Telephone Co. at Rosario, and a large number of shares has, it is said, been taken up.

In the last issue of the Argentine Postal Regulations a clause was inserted prohibiting the telephone companies from receiving telephonic messages for delivery. The matter was, however, recently brought before the Senate and the restriction removed.

The Public Works committee of Buenos Ayres City Council have considered a project for a system of electric tramways to some of the suburbs of the city, which has been presented by R. Von Wentzky & Co. The committee's report is said to be favourable to the scheme.

**Australasia.**—The "Australian Mining Standard" states that Wellington (N.Z.) City Council have let a contract for the construction of a tunnel for an electric tramway through Mt. Victoria at £16,000.

The Commonwealth Postmaster-General has ordered preparations to be made for the erection of the telephone line from Sydney to Melbourne.

Perth (W.A.) Electric Tramways (Ltd.) have decided to discontinue the tramway service on the Wellington-street route, which has been unremunerative, and the Corporation, who wish the service continued, have been informed that the agreement with the Council empowers the company to lay the lines, but does not bind them to run cars, and therefore that the company are within their rights.

The Waihi Gold Mining Co., N.Z., are taking steps for the transmission of electric power to Waihi from the Waikato. The management is making exhaustive investigation and working out the scheme for augmenting existing power with electrical energy. The present steam power being inadequate for the increasing operations of the company, it has been decided to adopt electricity as a means of supplementing the power, and application has been made to the Government for water rights on the Waikato river, near Matamata. If the company succeed in their application electric power will be generated there and transmitted across to the reduction works at Waikino and Waihi.

**Ayr.**—The Council are to consider a proposal to extend the electric tramways to Hawkhill and Whitletts.

**Bettwsycoed.**—The Council have assented to the application of a local syndicate for a provisional electric lighting order.

**Birmingham.**—An interesting ceremony took place on the 6th inst. at the new Corporation electric generating station in Summer-lane, now in course of erection. The chairman of the Electric Supply committee (Mr. Councillor Ellaway), accompanied by the committee, proceeded to the top of the chimney stack where he laid the last brick and completed the chimney.

The chimney has been designed to deal with the flue gases produced by boilers having a capacity of about 20,000 H.P., and is the first of two similar chimneys that will be required for the ultimate capacity of the station. The chimney has been built by W. Sapcote & Sons, the first brick having been laid on Dec. 14, 1904, but the work was delayed for some time on account of bad weather. The leading dimensions of the new chimney are: Height from base 249 ft., from floor level 225 ft.; internal diameter 15 ft., external diameter at bottom 24 ft., at top 17 ft. 4 in.; total weight 2,750 tons; approximate number of bricks 500,000. As regards capacity the chimney is the largest in Birmingham.

**Bradford-Huddersfield Tramways.**—The National Electric Construction Co. are applying for powers to construct and work tramways in the Brighouse and Elland districts which will give these towns additional facilities for inter-communication.

The company also seek powers to include the running over the Halifax tramways to West Vale, thence to Elland by a route to be constructed, and out to Rastrick. At Brighouse it is intended to lay down a line to Huddersfield, the promoters taking over the powers obtained by the latter Corporation, which is willing to concede them on payment of promotion expenses. The company also seek authority to join up the proposed line from Rastrick to Halifax Corporation system at Bailiffe Bridge, and to extend the system to the termination of the Bradford lines at Wyke.

**Brazil.**—The contract between the Brazilian Government and the Companhia Cantareira for a tramway service at Nictheroy has been renewed, on the condition that the company substitutes electric for animal traction, that they extend the existing lines and construct certain new lines, all worked by electricity. The works in connection with this concession represent, it is said, an expenditure of over £330,000. Under the renewed contract the company are allowed to purchase electricity in bulk.

**British Columbia.**—The electricity supply undertaking of the Kamloops Municipality, which commenced operations in February last, has now 340 consumers with an equivalent lamp connection of about 8,000 8 c.p.

**Buxton.**—An unopposed inquiry was held on Tuesday into the application of the Council for sanction to borrow £4,000 for electricity supply.

**Canada.**—The Sherbrooke (Quebec) Power, Light & Heat Co., which has supplied electric current since 1888 and has 1,500 consumers on its books, will shortly take out a 360 kw. set and replace it by two of 500 kw. capacity each. Two new water wheel equipments are also to be put down.

The Corporation of the town of Joliette (Quebec), which has supplied current for lighting since 1889, and has a main connection equivalent to 4,000 8 c.p. lamps and 250 consumers, is connected up to the full extent of the plant capacity of the station. Consumers have a free supply of 16 c.p. lamps.

**Cannock.**—The Council have decided to take current in bulk from the Staffs., Shropshire and Worcestershire Electric Supply Co. at 2½d. or at ¾d. if the Council undertake the distribution and provides a storage battery. A loan of £3,000 to carry out the scheme has been applied for.

**Castleford (Yorks.)**—As the Board of Trade threaten to revoke the Council's provisional electric lighting order, 1899, an application to further extend the period of the order has been made.

**Colwyn Bay.**—The Council will apply for sanction to a loan of £10,500 for extensions of the electricity undertaking.

**Cost of Running Electric Tramways.**—In the Sydney (N.S.W.) "Daily Telegraph" a series of contributions is appearing from the pen of Mr. E. Kilburn-Scott on the subject of the cost of running the Sydney tramways and other subjects. In the issue of that journal for Oct. 6 an interesting contribution on the subject appears, in which a table is given showing the results of electric tramway working in many of the principal towns of the United Kingdom.

**Coventry.**—At the last meeting of the Council the chairman of the Electric lighting committee (Ald. West) moved a recommendation that any consumer of not less than 250,000 units of electric energy per annum should be supplied in bulk at ¾d. per unit.

Ald. West said all the charges had been included in that special rate, and a profit would be made. At the present time large consumers of electricity received the light at 1d. and a fraction per unit.

Councillor Bettman moved an amendment that a special committee be appointed from the chairmen and vice-chairmen of the trading committees to consider the whole question of supplying gas and electric light and power to large consumers.

After discussion, the amendment was carried and the sub-committee constituted.

**Crediton.**—The Crediton Gas Co. intend to promote a bill for the incorporation of a new company, and notify that they are also willing to apply for powers to lay within three years electric lighting mains in the streets of the town as specified in the electric lighting order obtained by Christy Bros. and Middleton last year. The charges for current to be those specified in the order.

**Cumberland.**—The Brush Co. have decided to apply for powers to supply electricity in Maryport, Workington and Whitehaven.

**Curtis Turbine Contracts.**—We are informed that the British Thomson-Houston Co.'s sales to date of Curtis turbo-generators amount to a total of 24,000 kw., of which 11,750 kw. have been delivered and put in service in various stations in the United Kingdom.

The principal orders show a total of ten 1,500 kw. sets, four 1,000 kw. sets, and four 750 kw. sets. Curtis turbine rights in America are owned by the General Electric Co., who have received orders to date for 472 machines, aggregating 454,886 kw., of which 282 machines, aggregating 237,775 kw. have been delivered and are in use or in course of erection. Four sets of 8,000 kw. are under construction, and it is interesting to note that these will be the largest steam turbo-generators in the world. The list of orders includes thirty 5,000 kw. sets, eleven 3,000 kw., thirty-one 2,000 kw., and thirty-one 1,500 kw. sets, of which fifteen 5,000 kw., seven 3,000 kw., sixteen 2,000 kw., and twenty-three 1,500 kw. sets have been delivered.

**Customs Decisions.**—Certain amendments have been made in the customs tariff of the Philippine Islands some of which affect the imports of electrical machinery and apparatus. Dynamos and all other machinery for the generation of electricity, for lighting or for power, including transformers, electric motors and electric fans, which were formerly charged 5 pesos per 100 kilos, are now charged at 5 per cent. ad val.; storage batteries 5 per cent. ad val ; apparatus and appliances employed in the generation, distribution, testing, measuring and installation of electricity, dry and wet batteries, carbon brushes arc lamps and fittings, insulating materials used exclusively for electrical purposes, bells, annunciators, telephones and apparatus pertaining thereto, galvanometers, ampere, volt and wattmeters and all and every part of apparatus, including insulators, which formerly bore a duty of 2 pesos per 100 kilos. now bear a duty of 5 per cent. ad val. Steam boilers pay 15 per cent. ad val. Tramway carriages of all kinds were formerly charged at 45 pesos each complete, the new tariff is 35 pesos for the car bodies and 10 pesos per set of trucks for same.

The customs authorities of New Zealand have decided that imported electric arc lamps are classed as electric machinery and appliances, and pay a duty of 10 per cent. ad. val.

Insulators (telegraphic and telephonic) of all kinds imported into Norway, which were formerly admitted free, now pay a duty of 6 ore per kilog.

**Devizes.**—The Town Council, having failed to obtain a satisfactory tender for the transfer of their provincial electric lighting order, have decided to permit it to lapse.

**Dublin.**—It was announced at the last meeting of Pembroke (Dublin) Council that the Board of Trade had, wherever the roads were sufficiently wide, allowed an increase of speed of two miles per hour in the case of the cars of the Dublin United Tramways Co., but in some instances, as at turnings, the speed has been lessened. At one place the Board had allowed 12 miles an hour, and at another 14 miles an hour.

**Dundee.**—The Council have decided to extend the tramways to the borough boundary. An agreement has been entered into with Gourlay Bros. for the supply of electric energy for power to the Camperdown shipyard.

**Dunfermline Tramways.**—There is, we understand, a fair prospect of an agreement upon certain outstanding points between the parties concerned in carrying out this project—Dunfermline District Committee and the promoters of the W. Fife tramway scheme.

**Electrical Contractors' Association.**—At Bristol on Monday a deputation from the Electrical Contractors Association met several local electrical contractors with reference to the formation of a western section of the association. The president (Mr. J. McDermott, J.P.) was in the chair, and after discussion it was decided to hold another meeting of local contractors at an early date.

**Electric Lighting Notices.**—The following official notices of intention to apply for provisional electric lighting orders have appeared in the "London Gazette":—

*Wisbech* Corporation, to amend existing order by extending the period for laying mains and authorising the transfer or lease to the National Electric Construction Co. or a company to be formed.

*Frome* District Council, to authorise transfer of rights under 1901 electric lighting order to Edmundson's Electricity Corpn.

*Barton-upon-Irwell* Rural District Council, to obtain an order which shall authorise (inter alia) the transfer of said order to a company, the taking of supply of electricity in bulk and the purchase and sale of electric light fittings, switches, lamps, dynamos, &c., and other apparatus incidental to the consumption of electricity.

**Elgin.**—The Council have deferred consideration of a report by Messrs. M. Buchan & Hogarth recommending application for a provisional order and the erection of electricity works.

**Exhibitions.**—A trades and electrical exhibition, promoted by the Ramsgate & District Electric Supply Co. and a syndicate of local firms, was opened last week by the mayor.

An exhibition, organised by the Southport Electricity committee, was opened on Friday last. In addition to the Corporation Electricity department, which had a large display of fittings, motors, lamps, &c., a number of local firms made interesting exhibits.

On Monday, Provost Melvin formally opened, at Montrose, an electrical exhibition organised by the North of Scotland Electric Light & Power Co.

**Falkirk.**—The Falkirk & District Tramways Co. intend to apply for a provisional order to extend their tramway system to Laurieston and Grangemouth.

**Fire Inquest.**—It is the custom in the City of London to hold an inquiry by the City coroner into the circumstances attending an outbreak of fire within the City area. A fire occurred on Nov. 5 on the premises known as Albert-buildings, 49, Queen Victoria-street, London, E.C., and Dr. F. J. Waldo, J.P., the City coroner, on Nov. 10, held an inquest on the circumstances attending the outbreak. There are about 120 persons using the range of premises upon which the fire took place, as offices, &c., including five residents. The fire occurred at 9:55 p.m. on Sunday evening, Nov. 5, the housekeeper and his wife being on the premises at the time. The fire broke out in the basement, which was occupied by the Photo Printing Co., and there was also a cellar in which waste paper was stored. A quantity of wood was kept in the basement, which was lighted by both electricity and gas. The housekeeper gave evidence at the inquiry, and said he thought the fire was due to a short-circuit of the electric current. Mr. Gamble, second officer of the London Fire Brigade, also ascribed the fire to this cause "or from a light being thrown on to the collection of rubbish in the basement," which, according to the evidence of Col. Fox, chief officer of the London Salvage Corps, "was littered with rubbish which might smoulder for hours." This officer also thought the fire was due to a short-circuit. There was, however, no direct evidence given at the inquest on this point. The jury found "that the cause of the fire was in all probability due to a short-circuit of the electric current," and added a rider recommending that all electrical wires throughout the building in which the fire occurred should be encased in metallic tubing.

**Frimney.**—The Lighting committee last week recommended the Council not to assent to the Camberley Electric Supply Co.'s application for a provisional electric lighting order, but by the casting vote of the chairman it was decided to refer the recommendation back.

**Gravesend.**—The Council have applied for sanction to a loan of £7,000 for extensions of the plant at the electricity works.

**Hamilton.**—On Wednesday last Major-Gen. Hutchinson held a Board of Trade inquiry into the dispute between the Council and Clyde Valley Electric Power Co. as to the most suitable route for laying the company's electricity mains.—Decision reserved.

**Hammersmith (London).**—The Council on Wednesday decided to apply to London County Council for sanction to a loan of £15,570 for mains and sub-stations (£7,898. 12s. 8d.), consumers' services (£3,569. 4s. 9d.) and buildings (£4,103).

**Hampstead (London).**—The income from electricity supply for the half year ended Michaelmas was £23,189. 18s. 2d., against £21,569. 0s. 8d. in the corresponding period last year.

**Hayward's Heath.**—As the Council would only assent to the Hayward's Heath Electric Supply Co. application for a provisional electric lighting order on condition that the Council could purchase at end of 21 years, without payment for goodwill, the company have abandoned their application.

**Hexham.**—Hexham & District Electric Supply Co. is distributing an illustrated pamphlet which sets out in clear terms the advantages of electricity for lighting, power, heating, &c. Current is supplied at 5d. per unit for incandescent lighting, 2½d. for arc lighting, 2d. for first 1,000 units and 1½d. after for power, and 2d. for heating and cooking and ventilating.

**Inquest.**—At Wednesbury on Saturday, Mr. A. A. Betham held an inquest concerning the death of Samuel Mansell, boiler maker, who was fatally injured at the Brunswick Works of the Patent Shaft and Axle-tree Co. on 9th inst.

Deceased was sent to drill holes in an overhead electric travelling crane, and was instructed to keep on the outer side. Subsequently he was found unconscious lying across some roofing principals, and from his position it was conjectured that he had fallen whilst trying to get to the other side of the crane.

The jury returned a verdict of accidental death, adding a rider recommending that the company should have printed regulations with respect to the control of electric current, and that a responsible person should be appointed to see that they were carried out.

**Japan.**—Sir W. G. Armstrong, Whitworth & Co. have sent out engineers to prepare plans for the branch works which they have been invited to establish in Japan by the Japanese Government.

The Yokosuka Electric Light Co. has recently been formed, with a capital of 250,000 yen.

**King's College.**—The annual dinner of past and present students and friends of King's College engineering faculty will take place on Nov. 25 at the Hotel Cecil, Strand, London. Sir A. Binnie, President of the Institution of Civil Engineers, and Sir A. Rücker, Principal of the University of London, have promised to attend, and Prof. A. K. Huntington will take the chair. This is the 12th annual dinner, and as the numbers attending have steadily grown each year, it is hoped that all past students will write to the hon. secs. at the college and will endeavour to attend. There will be a special souvenir menu, which will remind visitors of the work of Wheatstone, Daniell, Clerk-Maxwell and Dr. John Hopkinson at King's College.

**Kirkcaldy.**—The report of the burgh electrical engineer (Mr. O. F. Francis) on the working of the electricity department between May 15 and Sept. 30 last shows that 17,108 units have been sold for private lighting (an increase of 5,772 over the corresponding period of last year) and 28,100 units for power (increase 18,773). 26 new consumers have been connected. The works costs show a decrease, and Mr. Francis expects a net profit on the current year in place of the deficit of £397 originally estimated.

**Ledbury.**—The Council have assented to the application of Foote and Milne for a provisional electric lighting order and to the use of overhead wires.

**Liege International Exhibition, 1905.**—We give below a list of the awards to British exhibitors at the recent Liège Exhibition so far as they affect the electrical and engineering industries, &c. We understand that there are still some cases on appeal before the Superior Jury, and that diplomas will not be awarded until after the New Year.

Machine Tools.—*Grand Prix*: Sir W. G. Armstrong, Whitworth & Co., Alfred Herbert (Ltd.) and Thos. Robinson & Son. *Gold Medals*: Consolidated Pneumatic Tool Co. and John Lang & Sons.

Generation and Mechanical Utilisation of Electricity.—*Silver Medals*: F. Darton & Co. and United Flexible Metallic Tubing Co.

Telegraphy.—*Grand Prix*: Marconi's Wireless Telegraph Co.

Methods of Transport.—*Bronze Medal*: Wallach Bros.

Instruments of Precision.—*Grand Prix*: Sir W. G. Armstrong, Whitworth & Co. *Diploma of Honour*: F. Darton & Co.

Steam Engines.—*Diploma of Honour*: E. Green & Sons. *Bronze Medals*: Rd. Klinger & Co. and Premier Boiler Tubes (Ltd.) *Silver Medal*: Frictionless Engine Packing Co.

Various Mechanical Apparatus.—*Diploma of Honour*: United Flexible Metallic Tubing Co. *Gold Medals*: W. & T. Avery and Reavell & Co.

Chemicals.—*Grand Prix*: United Alkali Co.

**Light Railways.**—The Grimsby District Light Railways Order has been submitted for confirmation. Objections by Dec. 5.

It has been decided to proceed with the scheme for a line from Bournemouth to Swanage, which is estimated to cost £200,000.

**Liversedge.**—An agreement has been made between the Council and the Yorkshire Electric Power Co. for the supply of electric energy by the latter. One of the company's engineers is advising the Council on the subject of laying mains.

**London County Council.**—At Tuesday's meeting it was recommended that the tender of the Brush Co., amounting to £14,280, be accepted for 34 single-deck street tramway bodies for the subway tramways, and the tender of the British Westinghouse Co. for 34 tramcar trucks and electrical equipment and the assembly of the cars at £13,481 be also accepted, but the decision was postponed.

Poplar Council received sanction for a loan of £2,497 for electric lighting.

*Tramways.*—Supplemental estimates for £19,780 for additional tramways on the southern system were adopted.

The adjourned report of the Highways committee was submitted recommending that Parliamentary sanction be sought for the acquisition of certain sites for the erection of car sheds and sub-stations in connection with the electrification of the northern system of tramways. The estimated cost of the site was £53,750.—Agreed.

The same committee recommended that Parliamentary sanction be obtained for the acquisition of property at Wellington-street, Strand, to enable a station to be constructed underground in connection with the subway tramways. The Finance committee reported that the cost would be about £37,000.—Agreed.

*Electric Lighting.*—It was recommended by the Housing committee that electric light be installed at Kemble-street lodging house, and that the committee be authorised to purchase the materials and employ the labour required for the execution of the work.—Agreed.

*Electric Power Supply.*—This matter is dealt with on p. 188 of this issue.

**Lowestoft.**—The Council have refused to entertain an offer by a syndicate to take over the electricity supply and electric tramway undertakings.

**Manchester District Tramways.**—Manchester Corporation propose to obtain powers to construct tramways in Urmston, and the Council of the latter district are considering the project.

**Municipal Honours.**—Mr. Alfred Cleaver, member of the Nottingham Guild of Electrical and Mechanical Engineers, has been elected mayor of Nottingham.

**Municipal Telephony.**—It is announced that Swansea municipal telephone department are now in a position to connect up with the National Co.'s system for intercommunication.

**Newcastle-on-Tyne.**—It is announced that the tramway employés of the Corporation have decided to go out on strike at midnight this (Friday) night unless a notice reducing the working days from 12 to 11 per fortnight be withdrawn.

**Newport (Mon.).**—In an omnibus bill the Corporation are seeking powers to undertake the wiring of consumers' premises, to let motors on hire, &c.

**Newquay.**—Arrangements have been made by the Electric Supply Corpn. for the erection of electricity works and for the laying of mains, &c.

**Nova Scotia.**—The telephone service on Cape Breton Island is owned and worked by the Eastern Telephone Co., of Sydney, C.B., and has been working for 16 years. There are now eight exchanges with nearly 1,000 subscribers.

**Obituary.**—The death took place last week of Mr. J. H. Wurtzburg, director of Greenwood & Batley, of Leeds.

**Paraguay.**—The "Review of the River Plate" says Assuncion Municipality have granted to Agatti & Co. a five years' concession for electricity supply.

**Philippine Islands.**—An electric tramway has been constructed and is working in Manila, cars running through the principal thoroughfares of the city. The total length of line is about 45 miles. 55 cars have been imported in parts from different countries, the bodies from Belgium, the axles and steel tyres from Great Britain, and the trucks and electrical equipment from the United States. Some larger double-deck vestibule cars have been ordered from Great Britain, and several of these have already arrived.

Numerous projects for extensions of existing lines of railways and for the construction and working of new lines have either been decided upon or are under consideration. In July last a general scheme for the construction of lines of railway in the different islands was published granting special facilities under a guarantee by the Philippine Commission. Several offers from contractors in connection with these construction works have been received. Telegraph lines will be constructed along the railway routes to be used for commercial as well as railway purposes.

**Poplar (London).**—In the course of his report on the year's work, the retiring mayor (Ald. M. Dalton) said, with regard to the Council's electricity undertaking, that the number of units sold for private supply for the half-year to September was 831,267, against 596,885 for the corresponding period last year. The new turbine plant of 2,000 kw. capacity was running satisfactorily and was taking the major portion of the present load. The capital invested in the undertaking now stood at £239,874. The financial success of the undertaking was fully assured.

**Presentations.**—On behalf of the staff of Ilford electricity department, the chief engineer (Mr. A. H. Shaw) recently presented a marble clock to Mr. S. Watskow, meter fixer and installation inspector, who is leaving to take up an appointment in West Africa.

The indoor staff at Plymouth of the National Telephone Co. have presented a service of plate to Mr. C. S. Weston, who is leaving for Swansea.

**Railway Electrification.**—It is stated that the L. & N.W. Railway Co. are about to convert the line from the Manchester Exchange station to Eccles and Patricroft, about 6 miles in length, to electric traction.

**Railway Electrification in New South Wales.**—Mr. Hy. Deane, late engineer-in-chief for railway and tramway construction, recently prepared a lengthy report upon inter-urban railways and the electrification of steam railroads for the Legislative Assembly of New South Wales.

Mr. Deane stated that in America, up to the present time, there were only a few instances where the electrification of existing steam lines had been taken in hand. The three most notable cases where electrification had been put in hand were the following: (1) The tunnel section of the Baltimore & Ohio Railroad, under the city of Baltimore (about 2½ miles); (2) the end sections of the New York Central & Hudson River Railroad, and of the New York, Newhaven & Hartford Railroad (25 and 35 miles respectively) included a considerable amount of covered way under the city at the approach to the combined terminal station in New York, and these were to be worked by electric locomotives instead of steam; and (3) the tunnel section of the extension of the Pennsylvania Railroad from New Jersey, under the Hudson River, New York, East River and Long Island, now in process of construction. A change was also contemplated on the West Shore line of the New York Central Railroad. Although so few cases had occurred of electrifying existing lines a vast system of independent interurban railways had sprung up. The interurban railways in the United States were said to total over 3,000 miles. Interurban railways were for the most part as well laid as any steam road with heavy rails, close sleepered, and well ballasted, and possessed all the advantages afforded by high speed and frequent stops. A high speed could be maintained even when the stops were frequent, and the electric railway must be considered, with the superior advantages offered, to be the ideal system for passenger traffic. The speed on some of the lines radiating from Detroit was about 25 miles per hour, on others 35 miles per hour was the scheduled rate. The cars were heavy, and designed to insure stability under high speed. They were from 40 ft. to 50 ft. in length, and were provided mostly with two 150 H.P. motors. On the line from Los Angeles to Long Beach a car with a seating capacity of 48 was often moved along with a speed of 50 miles per hour. The lines employing the third rail system included the North Shore line opposite San Francisco, with a speed often over 40 miles an hour; the Chicago, Aurora and Elgin railway, on which a speed of 65 miles per hour was often attained. Strong objections had been urged against the use of the third rail on the score of danger, but as satisfactory safeguards could be introduced, Mr. Deane thought they were overestimated. The overhead conductor answered very well when it was not heavily drawn upon for current, but when trains consisting of several cars were run, recourse had to be made to the third rail.

Those remarks applied to the use of direct current of 500 to 600 volts. There were some points of difference in practice on the continent of Europe. While in America and Great Britain the rotary converter was used, on the Continent the motor generator was adopted. On the Continent, too, pillars were used for carrying power-house recording instruments, by which the main switchboard was much reduced in size or almost dispensed with. . . . In New South Wales the time had not arrived when the necessity of starting a new system of interurban railways outside the existing railway system had become urgent. The question of electrifying the suburban and the North Shore lines would sooner or later have to be considered and probably after that had taken place and all the advantages of electric traction felt, the wonder would be expressed that the change had been so long deferred. The question of the desirability of introducing electric traction on any portion of the main lines was a different matter. Except where the traffic was very heavy and continuous, so as to give a fairly constant load on the generators, the use of simple moving self-contained units like steam locomotives was far more practicable, and probably much cheaper. There were, of course, cases where a change to electric traction might prove actually economical. He believed it had been suggested that the Blue Mountains line might be thus worked. It appeared to him that if it were desired to make an experiment on any portion of the New South Wales system, outside the suburbs, the ascent from Lithgow to Bell or Mount Victoria would afford opportunity. Coal for generating purposes was handy and cheap at Lithgow, and the adoption of electric traction would allow of shortening and cheapening of the project to cut out the great zigzag, which had already been investigated by the Public Works committee, by allowing the introduction of steeper grades. When the site for the Federal capital had been decided upon, and steps had to be taken to mark out the details of water supply and communications, there would be opportunities for economically laying out electric railways. The power at present running away in the Snowy River and its tributaries might come to be utilised if the site adopted was at Dalgety or in the neigbourhood of Bombala. A lengthy transmission was no bar at present, and a distance of 50, 100 or even 200 miles was quite within the limit of economical transmission. Thus the connection with the capital and the coast might come to be worked by electric current generated cheaply by water power, and an expenditure that would be extremely heavy if a railway suitable for steam trains had to be built might be very materially reduced when the sharper curves and steeper grades permissible on an electric line were taken into consideration, and the line located accordingly. If neither of those sites was selected, but some other, such as Tumut or Yass, or any other where the water supply was not so abundant there seemed to be no reason why a portion of the water supply intended for the capital, under a gravity scheme, should not be intercepted on its way and used for the generation of tractive power, &c. The proposition that the Bombala or Dalgety-Bega connection might be best effected by the construction of an electric line supplied by current generated by water power, led to a further suggestion, that the problem of connecting the main northern line with the coast from Guyra, Glen Innes or Tenterfield, might also be solved by adopting electric traction, in this case, however, the requisite energy being derived primarily from the consumption of coal. The advantage of the use of electricity would be, as in the other case mentioned, that as electric motors would be better adapted to pass round sharp curves than steam locomotives, and would be able to negotiate steeper gradients than those which were considered requisite for a steam line, a much closer approximation to the surface of the ground could be attained when laying out the line. Heavy cuttings and embankments would thereby be avoided, bridges and culverts reduced in cost, and a very considerable cheapening would result. The subject seemed to him to be well worthy of further investigation.

**Scunthorpe.**—An inquiry was held on Tuesday into the application of the Council for sanction to borrow £4,500 for electricity supply.

The clerk (Mr. H. M. HETT) said the contract for the work had been provisionally let to the British Westinghouse Co., and he asked for a 40 years' loan.

Particulars of the area, assessable value, &c., having been given, Mr. COBBAN, engineer for the scheme, said a profit of £41. 6s. 7d. was expected on the first year's working. It was intended to light the principal streets with 16 c.p. incandescent lamps.

There was no opposition.

**South Africa.**—The "British and South African Export Gazette" says:—

*Bloemfontein* Corporation are about to extend their generating plant, &c., at an estimated cost of £21,877, and mains, extensions, &c., at £16,924. The consulting engineer (Mr. Robert Hammond) has approved the extension scheme.

The *Umtata* (Cape Colony) Municipality have invited tenders for electric, acetylene gas or other system of lighting, and plans for an electric lighting scheme have been prepared by Messrs. Clifford, Jones & Olive.

*Kingwilliamstown* Council, who find their recent purchase of the electricity works a profitable investment, have reduced the monthly minimum charge for current from 10s. to 7s. 6d.

*Klerksdorp* electricity supply scheme, prepared by Mr. Dagnall, has been approved by the Government Electrical Engineer and will shortly be carried into effect.

**Southern Nigeria.**—The first land telegraph lines erected in Southern Nigeria were opened for traffic during 1904, and have proved a great boon both to the Government and to the public, despite the fact that some sections of the lines have been frequently interrupted. With the object of developing the traffic a low tariff of 1d. per word with a minimum charge of 1s. has been fixed. This route is, of course, not remunerative. Amongst the stations at which the telegraph is working are Benin, Bonny, Calabar, Egwanga, Eket, and Forcados. The capital expenditure on telegraphs during 1904 was £27,734. 14s. 7d., the total length of lines opened being 181¼ miles. The principal line is from Calabar to Bonny, 117¼ miles in length. The character of the land, the climatic conditions, the action on the ærial lines of the sea, and other causes make some parts of the service extremely unreliable, but large inland extensions are being made which it is hoped will remedy these defects. These extensions will connect Calabar with the inland stations in the Eastern, Central and Western divisions of the territory, and other extensions will connect Warri with Forcados by an ærial and cable line, while yet another line will connect Calabar with Onitsha, the headquarters of the Central division and an important commercial centre. The river Niger is to be crossed by a subaqueous cable, from which place an ærial line is to be constructed to Benin City, thus linking up Lagos and Calabar with all the important stations of the Protectorate, with the exception of those in the Cross River division.

**Southwark.**—In view of the electric power supply scheme of the London County Council, the Borough Council have decided to defer consideration of offers made by the County of London Electric Supply Co. and the London Electric Supply Corpn. for the purchase of the municipal electricity works and for the supply of electricity in bulk in the district.

**Spain.**—A correspondent writes us calling attention to the development of German and Belgian enterprise in Spain. We have already announced that the Barcelona Tramways Co. have passed into the hands of a Belgian syndicate, and throughout Spain it is the subject of general remark that the Belgians and Germans are acquiring, or endeavouring to acquire, the control of electrical undertakings wherever possible. The magnitude of British commercial interests in Spain justifies the hope that an endeavour will be made by British capitalists and contractors to maintain these interests in Spanish electrical enterprises.

**Stalybridge.**—The Stalybridge, Hyde, Mossley & Dukinfield Joint Tramways and Electricity Board have applied for sanction to a further loan of £40,000.

**Steam Turbines for Hungary.**—Our Hungarian correspondent expresses the opinion that a good firm of steam turbine manufacturers would do well to establish an agency in Hungary, as the making of steam turbines has not so far been undertaken there, and all such machinery is imported. Our correspondent would give all desired information and all assistance possible.

**Straits Settlements.**—Increases in the imports of electric lighting materials into the Straits Settlements in 1904 are recorded to the extent of $145,000. Tramway and railway materials increased by nearly $880,000. Increased quantities of tramway and railway materials are being sent in by Belgium.

Singapore Tramways (Ltd.) have now completed the construction and electrical equipment of their tramways, and the power station at Mackenzie-road being near completion the electrical service is about to be inaugurated.

At Penang a new iron pier has been completed, and is lighted by electricity, current being taken from the power station owned by Penang Municipality, whose electrical department has now also in hand the lighting of the principal streets. The demand for current for private lighting, &c., is making satisfactory progress, and the tramway system in Penang, which has been tranferred to the Municipality, is to be electrified.

**Torquay.**—At the meeting of the Council last week a report was presented as to the result of the recent conference between representatives of the Council and Dolter Electric Traction Co. (Ltd.).

The company agreed to waive the question of feeder cables and of the Corporation providing a site for the car-shed; also they were prepared to extend the time for providing current from Dec. 14, 1905, to March 31, 1906. These concessions were made in consideration of the Council's accepting the plans sent in to the Electric Lighting committee, and their also agreeing to the construction by the company of the Torbay-road route, after the completion of the other routes and the satisfactory running of the cars. The committee recommended that the proposals of the company be agreed to.

The committee's report and recommendation were adopted.

**Tramcar Speeds.**—The Automobile Club has issued the following table of speeds (of course, compiled by their own timekeepers) of electric tramcars in various towns in the United Kingdom. The meagre information given in the first column limits the value of the figures:—

| Town. | Distance over which timed. Yards. | No. of cars. | Average speed of— | | Speed of fastest car. Miles. |
|---|---|---|---|---|---|
| | | | All cars timed. Miles. | Six fastest cars. Miles. | |
| London (Streatham Hill) | 110 | 22 | 18·95 | 20·45 | 21·22 |
| Ealing | 88 and 110 | 84 | 13·52 | 17·44 | 18·44 |
| Newport | 110 and 44 | 56 | 12·94 | 16·16 | 17·25 |
| Manchester | 162, 148<br>144, 158 | 20 | 17·91 | 20·36 | 21·25 |
| Leeds | 88 | 34 | 16·41 | 22·00 | 22·70 |
| Cardiff | 88 | 30 | 14·18 | 16·58 | 17·30 |
| Derby | 100 | 10 | 15·75 | 17·06 | 18·00 |
| Cheltenham | 88 | 20 | 12·46 | 13·50 | 14·06 |
| Bath | 88 | 27 | 13·28 | 15·27 | 16·07 |
| Bristol | 88 | 38 | 12·91 | 14·76 | 15·00 |
| Sunderland | — | — | — | — | 17·00 |
| Ayr | — | — | — | — | 16·40 |
| Pollockshaws | — | — | — | — | 16·40 |
| Huddersfield | — | — | — | — | 15·00 |

**Uruguay.**—Despite revolutions and strikes and other political and industrial upheavals the electrification of the existing tramway lines in Uruguay is proceeding. Concessions have been obtained by the Commercial Society of Montevideo for the reconstruction of several existing tramway routes to electric traction, and the company has carried out a large quantity of work for four of the tramway companies. Electric tramcars will be running over these lines it is expected in the early part of next year. There still remain three tramway routes whose owners have not yet applied for permission to convert their systems.

The Compania Alemana Transatlantica de Electricidad have acquired the Tranvia del Paso del Molino of Montevideo and will shortly convert the system to electric traction.

**West Indies.**—During 1904 an extension of the telephone system at Grenada was carried out to Carriacou, and other extension work is being pushed on. The telephone revenue shows a steady increase.

At St. Vincent there was also an improved revenue from the telephone service for 1904-5.

**Westminster.**—The Westminster Electric Supply Corpn. has withdrawn its appeal to the Board of Trade in regard to the condition imposed by the Council as to filling of covers of surface boxes, the Works committee having resolved, that (subject to filling of covers of 395 boxes the company has in stock being composed of hard, durable and non-slipping material to the satisfaction of the City engineer) the condition that box covers shall be filled with material similar to the surrounding pavement will be waived.

**Whitby.**—The Council have voted an honorarium of 90 guineas to the electrical engineer (Mr. L. H. King) for services in connection with the erection of additional generating plant at the electricity works.

**Willesden.**—Main extensions are to be carried out at an estimated cost of £403.

**Wolverhampton.**—On Thursday last a through tramcar service between Wolverhampton and Bilston was commenced.

**Woolwich.**—It was reported to the Council by the Electricity committee last week that the parish of Eltham was now receiving a supply of electricity direct from the Plumstead station, and that the agreement with the South Metropolitan Electric Light and Power Co. for the supply of electricity in bulk at 4d. per unit had been determined. It was decided to make the charges for electricity in Eltham uniform with those in the parishes of Woolwich and Plumstead, and to abolish meter rents.

**Workhouse Lighting.**—As the Brompton & Kensington Electricity Supply Co. have reduced their charges for electricity supply, Kensington Guardians are to again consider the expediency of installing the electric light in their institutions.

Stonehaven guardians are considering the advisability of adopting electric lighting.

**Dinner.**—The sixth annual dinner of the Newcastle Local Section of the Institution of Electrical Engineers took place at Newcastle on Wednesday evening. There were about 90 members and guests present.

Dr. W. M. Thornton (chairman of the Newcastle Section) presided, and among those present were the Hon. G. L. Parsons, Sir Isambard Owen, the Mayor of Newcastle (Ald. J. Baxter Ellis), Mr. A. W. Heaviside, Mr. W. D. Hunter, Mr. J. H. Holmes, Mr. Ernest Hatton, Mr. Gerald Stoney, Mr. G. C. Lloyd (secretary of the Institution of Electrical Engineers), Mr. C. Faraday Proctor (secretary Newcastle Section), Mr. A. L. E. Drummond, Mr. C. S. Vesey-Brown, Mr. H. L. Riseley (vice-chairman, Newcastle Section), Dr. Farquharson, &c. After the usual loyal toasts,

Mr. A. L. E. DRUMMOND proposed: "The Mayor and Corporation of Newcastle-on-Tyne," and the MAYOR replied. He said he was interested in the profession of electrical engineering, but only as a commercial man. It had been his lot to be called upon to take charge of the Newcastle tramways (through the Tramways committee) over 18 months ago. He and his colleagues could claim that they had succeeded in reorganising their system, bringing it up-to-date, making it a commercial success, and in securing an able manager. They were working the system now with less than 1,000 men, equal in every way to the working of the system 18 months ago with 1,500 men. They still felt that further economies were necessary.

Dr. Farquharson proposed: "The Institution of Electrical Engineers." Mr. G. C. Lloyd and the Chairman briefly responded.

Mr. G. Stoney proposed: "Armstrong College and the Learned Societies," to which Sir Isambard Owen and Mr. James Walker replied.

"The Guests" was proposed by Mr. C. S. Vesey-Brown, and responded to by Mr. A. W. Heaviside.

**Electro-Harmonic Society.**—A Ladies' Night concert will be given this (Friday) evening in the King's Hall, Holborn Restaurant, at eight o'clock, Mr. W. E. L. Gaine presiding. An excellent programme of vocal and instrumental music will be provided for the occasion, and the entertainment will include several humorous sketches and recitations.

## TRADE NOTES AND NOTICES.

### TENDERS INVITED.

The Guardians of *Poplar* (London) Union invite tenders for supply and erection at the Children's Home and Schools (now in course of erection at Hutton, Essex) of steam engines, dynamos, pipework, &c.; main switchboard, wiring, motors, &c.; fire alarms, telephones and electric bells. Persons desirous of tendering may obtain general conditions, specifications, &c., and inspect plans at the offices of the consulting engineer (Mr. Albion T. Snell, M.Inst.C.E.), Suffolk House, Laurence Pountney hill, Cannon-street, London, E.C., on and after 21st inst. Tenders, addressed to the clerk to the guardians (Mr. G. Herbert Lough), Guardians Offices, 45, Upper North-street, Poplar, before 6 p.m. Dec. 13. See an advertisement.

*Beckenham* District Council invite tenders for supply, delivery and erection of two 250 kw. direct-current railway generators direct-coupled to two high-speed vertical enclosed engines. Particulars from the consulting engineer (Mr. Reginald P. Wilson), 66, Victoria-street, Westminster, S.W., or from Mr. John Angell, surveyor, Council offices, Beckenham. Tenders to the clerk (Mr. S. Stevens) by noon, Nov. 23. See also an advertisement.

*Salford* Corporation invite tenders for wiring the Higher Grade Council School for Girls, Victor-street, Salford. Specifications, &c., from the borough electrical engineer (Mr. C. D. Taite), Electricity Works, Frederick-road, Pendleton. Tenders to the Director of Education, Chapel-street, Salford, by Nov. 30. See also an advertisement.

The Mayor and Aldermen of the City of *Launceston* (*Tasmania*) invite tenders for supply of 500 or more electric meters and of maximum demand indicators. Specifications, &c., from the city electrical engineer (Mr. Wm. Corin), Launceston, Tasmania, or from Messrs. John Terry & Co., 7, Great Winchester-street, London, E.C. Tenders to the town clerk (Mr. C. W. Rocher), Town Hall, Launceston, by noon Jan. 15. See also an advertisement.

The Directors of the *Caledonian Railway Co.* invite tenders for stores for the 12 months from Jan. 1, 1906, including telegraph appliances, telephones, &c., electric lighting material and fittings, asbestos and guttapercha goods, balata belting, packings, galvanised wire, oils and grease, screws, copper rivets, cotton waste, malleable iron pipes and fittings, tools, time-pieces, &c. Tenders to the secretary (Mr. J. Blackburn), 302, Buchanan-street, Glasgow, by Nov. 20.

*Torquay* Town Council invite tenders for one combined 250 kw. d.c. traction and 75 kw. a.c. steam generator set, one 200 kw. motor generator, one automatic reversible booster, one traction battery, and one traction switchboard. Applications for specifications to the town clerk (Mr. F. S. Hex), Town Hall, Torquay, before Nov. 20.

*Dublin United Tramways Co.* (*Ltd.*) invite tenders for supply of general stores, including car fittings, iron and steel castings, oil, electrical supplies, timber, &c., for the year ended Dec. 31, 1906. Forms of tender (after Nov. 22) from the Secretary's office, 9, Upper Sackville-street. Tenders to Chairman by Nov. 27.

*Rawtenstall* Corporation invite tenders for electric light wiring and fittings to new free library. Tenders to Messrs. Lacey, Sillar & Leigh, 78, King-street, Manchester, by 20th inst.

*Ebbw Vale* Urban District Council invite tenders for free wiring and for the supply of incandescent lamps. Tenders to the clerk (Mr. Thomas Hughes), Council Offices, Ebbw Vale, by noon Nov. 25.

*Chatham* Corporation want tenders by noon 30th inst for 12 months' supply of stores, including incandescent elecric lamps, coal, ironmongery, &c.

*Aston Manor* Public Works committee want tenders by noon 24th inst. for maintenance of a portion of their tramway system for 12 months.

*London* County Council require tenders by 10 a.m. 28th inst. for erection of a tramcar shed in Leven-road, Poplar.

*Sheffield* Tramways committee want tenders, by 6 p.m., 23rd inst., for erection of car-shed roof, &c., at Queen's-road, Sheffield.

Insulators, phosphor bronze wire, copper sleeves, binders and tapes are required by the Postal Telegraph Department of the Australian Commonwealth, and tenders will be received at the office of the Deputy Postmaster-General, *Brisbane*, up to noon, Dec. 18. Tender forms, &c., can be obtained from and samples seen at the stores branches of the Postmaster-General's Department at Sydney, Melbourne, Adelaide and Brisbane. The usual Commonwealth conditions apply.

Telephone cable and insulators are required by the Deputy Postmaster-General, *Melbourne*. Tenders will be received until noon Dec. 19. These supplies include delivery at Melbourne of (1) 10 miles of 26 pair lead-covered paper-insulated telephone cable; (2) 1 mile of 156-pair lead-covered paper-insulated telephone cable (12½ lb. conductors); and (3) 5,000 barrel insulators (delivery within three months from date of acceptance of tender). A sample of the insulator and tender forms, &c., at the General Post Offices at Melbourne, Sydney, Brisbane, Adelaide, Perth and Hobart.

The *Norwegian* Telegraph department are inviting tenders for 3,000 kg. of bronze wire. Tenders from British firms must be lodged by their agents in Christiania by mid-day Dec. 1. Conditions, &c., on application to the Telegraph authorities at Christiania, Bergen, Stavanger and Orendal.

*Zagrab* (*Hungary*) Municipality want offers for erection of electric light and power works with plant of 5,000 H.P. The water power of the river Kulpa is to be used. Further information may be obtained from the Ingenieuramt.

## TENDERS RECEIVED AND ACCEPTED.

London County Council received the following tenders for wiring and fitting for electric light at Lee Green fire station:—

| | | | | | |
|---|---|---|---|---|---|
| Hooper, Neary & Co. (*acc.*) | £141 | 10 | F. J. Coleby & Co. | £164 | 10 |
| J. Defries & Sons | 155 | 0 | Oliver Clark & Co. | 170 | 0 |
| Nat. Elec. Construction Co. | 157 | 0 | J. O. Grant & Taylor | 175 | 0 |
| Durell & Co. | 160 | 0 | W. H. Johnson | 183 | 15 |
| Roger Dawson (Ltd.) | 160 | 0 | Barlow & Young | 240 | 0 |

The Tudor Storage Battery Export Synd., 35, Surrey-street, London, W.C., have recently received orders for one battery of 240 cells, 145 ampere hour capacity; one ditto, 218 ampere hour capacity; and one ditto 290 ampere hour capacity, complete with reversible booster equipment, for India; one battery of 200 cells, 500 ampere hour capacity, for Egypt; and 38 cells, of 430 ampere hour capacity, for Natal.

Glasgow Tramways committee have let the following contracts:—

India Rubber Co., insulated cable; P. & W. McLellan, special track work; Alfred Herbert (Ltd.), machine dies; B. & S. Massey, pneumatic power hammers; Estler Bros., trolley standards and poles; Fleming, Birby & Goodall, graphite bushings; Lorain Steel Co., special track work for Albert-road; Craig Sharp (Ltd.), bitumen; Currie & Co., rock asphalte; Howard Conduit Co., conduits; Dempster, Moore & Co., anvils, &c.; Spear & Jackson, cold saws.

Among the orders recently received for Paterson purifiers for power plants are the following:—

One Paterson condensation water purifier of 70,000 lb. hourly capacity for Cleveland & Durham County Electric Power Co. (through Willans & Robinson); two Paterson, type A, water softeners and heaters with quartz sand filters, each of 25,000 lb. hourly capacity, for G.W.R. electric power station at Park Royal (through Aiton & Co.); two Paterson greasy condensation water purifiers and make-up softeners, each of 30,000 lb. hourly capacity (to order of J. G. White & Co.), for Buenos Aires and Montevideo; one Paterson softener and heater of 30,000 lb. hourly capacity for Southwark Borough electricity works.

It is reported that the N.E. Railway Co., who intend to employ electricity on a greatly-increased scale, not only for power and signalling, but also for lighting their largest passenger stations, goods warehouses and marshalling yards, have placed an order with the British Thomson-Houston Co. for 285 5-ampere direct-current and 600 7½-ampere alternating-current arc lamps. The former pattern are for 110 volt circuits and burn for 150 hours, and the latter are for 110 volt (40 cycle) circuits.

Coventry Council have accepted the tender of the Harris Patent Feedwater Filter (Ltd.), Greenock and 82, Victoria-street, London, S.W., for a chemical oil separator for the electricity works at £840. In recommending the acceptance of the tender at the meeting on Thursday the chairman of the Electric Light committee said that considerable trouble had been experienced from oil getting into the boilers. It had been found that the separator recommended was one of the best.

The Metropolitan Asylums Board received 16 tenders for an electric motor, &c., for the Western Hospital, and the lowest, that of H. Greene & Co., at £189. 9s. 4d., was accepted. The highest tender was £406. 3s. 7d. and the engineer-in-chief's revised estimate was £195.

Wellington (N.Z.) Corporation tramways department have placed an order with Belliss & Morcom for a high-speed triple-expansion 1,000 B.H.P. steam engine. This is the sixth Belliss engine supplied for the Wellington tramway power station.

Subiaco (W. Australia) Municipality have placed an order amounting to £3,991. 8s. with Kidston & Co. for duplication of plant at the local electricity works.

The Metropolitan Asylums Board have placed an order with Pritchetts & Gold, at £71, for renewing, &c., the storage battery at Grove Hospital.

Stalybridge, Hyde, Mossley and Dukinfield Tramways and Electricity Board have accepted the tender of W. T. Glover & Co. for supply of cable.

Stoke Guardians have accepted the tender of Blackburn, Starling & Co. for re-wiring the Cottage Homes and portions of the Workhouse at £266.

Dartford Council have accepted the tender of the Electric Power Storage Co. for cleaning the cells of the storage battery at the electricity works and installing 32 new sections at £75. 16s. 9d.

Norwich Council have accepted the tender of the Corporation Electricity committee for the supply of electric light fittings for the Asylum at £134. 6s.

Poplar (London) Public Health committee has provisionally accepted the tender of Geipel & Lange at £325, for plant for manufacturing by electrolysis disinfectants from salt water.

Yarmouth Corporation have accepted the tender of the Brush Co. for two electric tramcars at £1,014.

Burslem Council have accepted the tender of Cross & Cross for wiring and installing arc lamps in St. John's market at £82.

Hereford Council have placed an order with Callender's Co. for electric light cable.

Hubert Davies & Spain have secured a contract for the construction of 4½ miles single-track tramway for Durban Corporation.

## BUSINESS NOTICES.

Rhodes Electrical Mfg. Co. (Ltd.), 70 and 71, Bishopsgate-street Within, E.C., and Sunbridge-road, Bradford, have appointed R. A. Fullerton & Co., 116, Hope-street, Glasgow, as their sole agents for Scotland.

Joseph Frain, sen., and Percy Hopper (trading as Frain & Co.), electrical accessory dealer, &c., 92, Northumberland-street, Newcastle-on-Tyne, have dissolved partnership. Debts by Mr. Hopper, who continues.

## BANKRUPTCIES, LIQUIDATIONS, &c.

Robt. Pries (trading as Durtnall & Pries), electrical sundriesman, 75, City-road, London, E.C., has been adjudicated bankrupt.

An application for the discharge of Arthur Edgar Brooks (trading as Brooks & Brooks), electrical engineer, 110, Cheapside, London, E.C., will be heard at Bankruptcy-buildings, London, W.C., on 29th inst.

The Anti-Collision Alarm Telegraph Co. (Ltd.) is being wound up voluntarily. Mr. P. R. Kepple, 32, Strand street, Liverpool, is liquidator.

**Premises to Let.**—A substantial brick-built and slated building of three floors, each 4,200 sq. ft., is advertised to be let in another column.

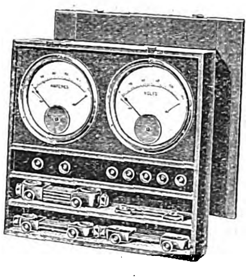
**Plant, &c., for Sale.**—Mr. R. Archer, Horsforth, Leeds, advertises for sale Evershed testing sets.

**"Osmi" Lamp Developments.**—The General Electric Co. announce that the prices previously made for "Osmi" lamps from 2½ c.p. to 32 c.p. have been considerably reduced. The 2½ c.p. lamp is reduced from 4s. to 2s. 6d., and the 32 c.p. lamp from 7s. 6d. to 5s., with corresponding decreases in the intermediate candle-powers.

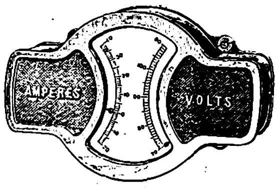
**New York Waterside Electricity Station.**—In reference to the illustrated description of the Waterside Station of the New York

Edison Co., which appeared in our issues of Oct. 6 and 27, the Chloride Electrical Storage Co., of Clifton Junction, points out that the Edison Co. employs the Chloride accumulator on a very extensive scale. There are in connection with the New York supply 31 batteries of chloride cells, situated in various parts of the city, or an order for early delivery. The batteries consist of 150 cells each and are capable of giving, at the one-hour rate of discharge, about 2,000 amperes on each side.

**Catalogues, &c.**—A new price list of ammeters, voltmeters and recorders has been issued by James Pitkin & Co., 56, Red Lion-street, Clerkenwell, London, E.C. Our readers will remember the name of James Pitkin in connection with the electrical measuring instrument industry as long as that industry has been in existence. This firm was established in 1855, and has always made a speciality of these instruments. In 1902 Mr. Pitkin was joined in business by Mr. H. B. White, who has the electrical instrument department under his direct supervision. Within the last two years many important Government contracts have been secured and completed by the firm of James Pitkin & Co., who number amongst their clients nearly all the electricity undertakings, technical colleges and switchboard makers and dealers in the country. The list before us calls attention to the fact that the large number of instruments now being turned out by the company enables them to supply at the most moderate prices, and the attention of switchboard makers and contractors is directed to the fact that James Pitkin & Co. do not make switchboards, but devote their attention exclusively to the manufacture and supply of electrical and scientific instruments. One of the Pitkin combined testing sets is shown in the adjoining illustration. These instruments consist of two distinct moving-coil dead-beat movements, one arranged as an ammeter and the other as a voltmeter, the resistances and shunts being designed to facilitate accurate tests with ease and rapidity. A type K motor-car current-measuring instrument is shown in Fig. 2.

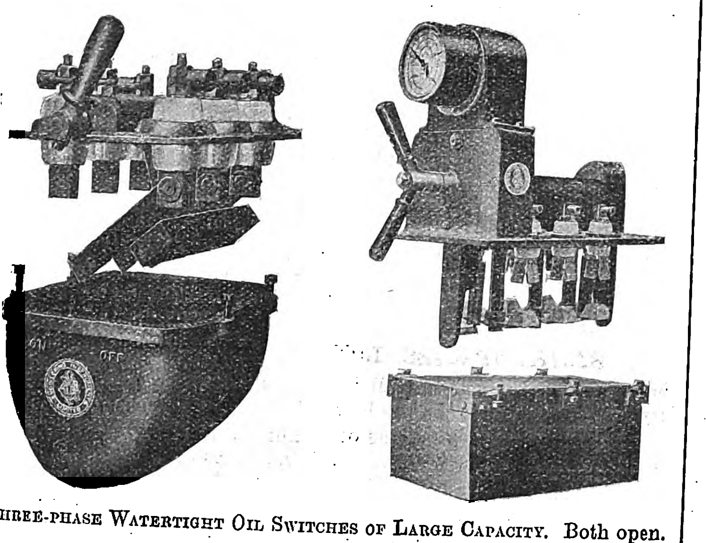


Pitkin Combined Testing Set.



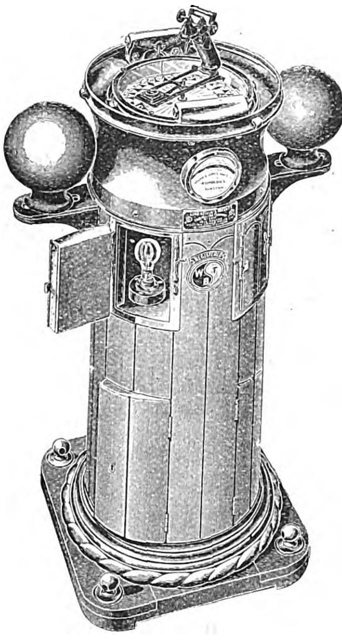
Pitkin Type K Motor Car Instrument.

A new list of motor-control gear of all descriptions, including oil switch gears, enclosed switches and fuses, measuring instruments and general specialties dealing with continuous-current and three-phase motor control has been issued by Engineering Instruments (Ltd.), 272B, Upper-street, London, N. The gear is of the enclosed watertight type, specially designed for use in workshops and mines to comply with the new rules and conditions relating to these installations. The illustrations herewith show two patterns of enclosed three-phase watertight oil switches of large capacity. The apparatus is designed especially for use in exposed situations in collieries, workshops, &c. A time lag overload release (with ammeter) is also listed, in which the release mechanism consists of two contacts mounted in a chamber filled with oil; one of these contacts is fixed in position, while the other is carried on a flexible support. The movable contact is fitted with a mica vane which damps its movement. At one side of this chamber a tubular extension is mounted which carries a metal ball, free to roll from end to end of the tube; this tube is also filled with oil. Under normal conditions the tube is inclined, so that the ball rests at the end remote from the contact chamber, but when the predetermined load is exceeded, the tube becomes inclined till the ball starts to roll along it. When the ball reaches the contact chamber it presses the flexible contact against the fixed contact and operates the release. The time taken for the ball to roll from end to end of the tube can be adjusted between the limits of 3 min. and 60 min., while the current at which the ball starts to roll can be set between the limits of 60 per cent. and 100 per cent. of the maximum reading of the ammeter. In the event of the instrument being subjected to a heavy overload or a short circuit, the operating tube is inclined so much that the weight of the flexible contact is sufficient to make contact with the fixed contact without the assistance of the ball, and the release operates at once.



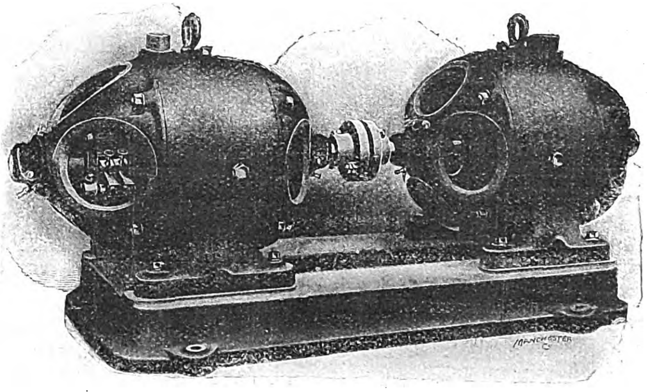
Three-phase Watertight Oil Switches of Large Capacity. Both open.

A new list of ships' compasses, &c., has been issued by the nautical branch of Kelvin & James White (Ltd.), which has recently been established in London under the title of Kelvin & James White (Ltd.) & Hutton. Amongst the items listed in the new catalogue is the latest type of Lord Kelvin's patent standard compass (merchant service pattern). It will be seen from the accompanying illustration that this compass can be lighted from below by means of an electric light, the illustration showing the electric lamp beneath and the new method of suspension. The illumination of the compass at night is now entirely effected from underneath the bowl, the underpart of the bowl being of strong annealed thick glass through which the light is refracted on to the card. An arrangement is fitted by means of which the intensity of the light can be increased or diminished. Many other improvements have been fitted to the latest type of this compass.



Lord Kelvin's Merchant Service Pattern Compass, showing New Suspension and Electric Light under.

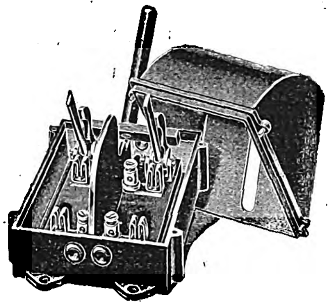
A neat and well-arranged list of Rhodes motors and dynamos, manufactured at the Bradford Works of the Rhodes Electrical Manufacturing Co., of 70 and 71, Bishopsgate-street Within, London, E.C., has been issued, the illustrations including examples of several of the company's standard lines of continuous and alternating-current motors, which have been entirely re-designed. In the process of revision the company have also somewhat modified the system of manufacture in the light of experience, and now offer their R.E. motor as beyond criticism as regards workmanship, quality of material and commercial practicability. The accompanying illustration shows a R.E. type motor-generator of this company's manufacture. Standard high-speed motors can be fitted with a spur reduction gear, consisting of a raw hide pinion engaging in a machine-cut cast-iron gear wheel, the latter being mounted on a substantial back shaft supported by two bearings fixed on the top of the motor. The gearing can be arranged at the side of the motor instead of at the top if specially required and ordered. All motor bearings are of the self-aligning type, and every motor is tested in the works at full load for not less than four to six hours, at the end of which time a breakdown strain of 1,500 volts alternating is applied between the windings and the frame. The firm's single-phase motors are stated



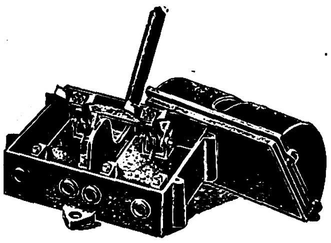
Rhodes R.E. Type Motor-Generator.

to be capable of starting against full load with a starting current not more than 25 per cent. above the normal. Motors for lift and crane work, having a torque of not less than twice full-load value, and with an additional reversing winding to reverse the motor without moving the brushes, can be supplied.

Double pole "Glasgow" and "Y" switches, for pressures up to 600 and 400 volts respectively, are described and illustrated in two circular lists issued by A. Seage & Co., Cambridge Works, Hammersmith, London, W. The "Glasgow" type of switch has been designed to conform with the rules of Glasgow Corporation for 500-volt circuits, and generally to meet the requirements of consulting and station engineers for pressures up to 600 volts. From the illustration it will be seen that a neatly-cast box is fitted with insulation bushes for receiving cable, or can be screwed any special size for barrel, &c. Suitable means for earthing is provided, and being lined with stout asbestos, the box is fireproof. The connecting bar for the poles is of substantial hard black vulcanised fibre, the handle being of the same material. The switch has a very long and extremely rapid break. No iron parts are used in the construction of the switch, only copper, gun metal and brass. The "Y" type switch is supplied in a similar case, and each pole is carried on a separate paraffin slate and insulated from the case by ebonite brushes, a stout fibre dividing fillet protects the adjoining poles, and extends almost to the top of the case. Similar methods of construction are adopted with both switches.

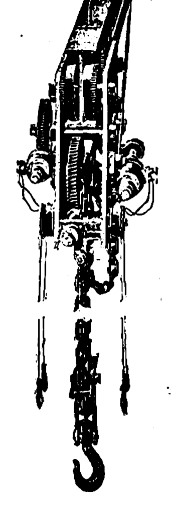


SEAGE DOUBLE-POLE "GLASGOW" SWITCH.



SEAGE DOUBLE-POLE LAMINATED "Y" SWITCH.

Overhead liftways for use in works and factories are described and fully illustrated in a list just issued by Arnold Goodwin & Son, Sumner-street, London, S.E., makers of liftways operated by electricity, hand or compressed air. Numerous examples of the application of these suspended liftways are given. An improved form of electrical transporter for liftways is shown in the illustration herewith. This type of apparatus has been found very serviceable for transporting passengers' parcels and luggage from railway station platforms, a development for which a considerable extension is desirable. Owing to the small head-room required and other advantages of this method of transportation, this much-needed development should be facilitated. These electrical transporters are made on three principles (1) to hoist electrically and travel by hand; (2) to work semi-automatically; (3) to work automatically; and combinations of the three principles can also be adapted. The electrical transporter is made to lift and traverse up to 10 tons.



ELECTRICAL TRANSPORTER FOR LIFTWAYS.

**Reyrolle Supplies.**—In connection with the recent exhibition at Olympia, Messrs. A. Reyrolle & Co., of Hebburn-on-Tyne, have prepared a souvenir, copies of which can be obtained by anyone interested in the use of electric power. The souvenir takes the form of some "suggestions to those about to instal electrical motors," and points out the merits of the Reyrolle motor starter, which is provided with a starting resistance which has a special valve characteristic enabling the motor to be started at all loads while the handle of the starter is held at the first stop. Several examples of these starters are shown, and particulars are given which will be of interest to all who have the work of motor installation to do There are also two small installations given on the last page of the souvenir which are not uninteresting to those who have been long enough associated with the electrical industry to remember the small Reyrolle beginnings in London. These (and we are among the number) will congratulate the firm upon the extension that has taken place and which has necessitated the erection of large premises at Hebburn-on-Tyne for the manufacture of Reyrolle supplies. Practical designs and good workmanship have secured their due recognition, and have had the inevitable result of keeping the company's order books filled and the works well occupied.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Nov. 8 to 14, with the ports of destination:—

*Africa.*—Alexandria, £423; Cape Town, £218; Delagoa Bay, £934 (including £365 telegraph cable); Durban, £664 (including £136 telegraph material); East London, £1,751 (including £821 telegraph material); Mombasa, £40; Mossel Bay, £11; Port Elizabeth, £662. *Argentina*—Buenos Ayres, £2,812 (including £1,182 telegraph material); Rosario, £330 (telegraph material). *Australasia*—Adelaide, £116; Auckland, £192; Hawera, £30; Lyttelton, £167; Melbourne, £8; Napier, £40; Otago, £18; Perth, £25; Sydney, £1,885 (including £40 telegraph material); Wellington, £95. *Belgium*—Ostend, £75. *Canada*—Halifax, £211. *Ceylon*—Colombo, £166. *Channel Islands*, £1,007. *China*—Shanghai, £334; Tientsin, £42. *Colastine*, £748. *Denmark*—Copenhagen, £575 (telegraph material). *Germany*—Cologne, £15. *Gibraltar*, £533. *Greece*—Piræus, £8. *Holland*—Amsterdam, £167 (including £124 telegraph material). *Hong Kong*, £1,531 (including £125 telegraph material). *India*—Bombay, £1,892 (including £340 telegraph material); Calcutta, £1,537; Karachi, £190; Madras, £253. *Japan*—Kobe, £23 (telegraph material); Tokyo, £20. *Mexico*—Coatzacoalcos, £2,134 (including £1,216 telegraph material). *Portugal*—Lisbon, £75. *Siam*—Bangkok, £18. *Straits Settlements*—Penang, £34; Singapore, £89; *Sweden*—Gothenburg, £840 (telegraph cable); Stockholm, £1,604 (telegraph material). *United States*—New Plymouth, £50. Total, £24,592, against £24,231 in the corresponding week last year (Nov. 9 to 15).

# PATENT RECORD.

## APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked* †) *are not open to public inspection until after acceptance of Complete Specification. Those marked* † *are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

October, 4, 1905.

20,024 HARRIS. Electro-deposition apparatus.
20,040 WILD. Electric railway and tramway points.
20,051 HAWTHORN. Automatic transmitters for electric fire alarms or other signals.
20,058 SIEMENS-SCHUCKERT WERKE G.M.B.H. Mounting field coils of dynamo electric machines. (Date applied for, Nov. 12, 1904.)*†
20,068 POULSEN. Receiving systems for wireless telegraphy. (Date applied for, Oct. 8, 1904.)*†
20,077 WILLANS & ROBINSON & PEACHE. Steam turbines.
20,099 CRAWLEY. Alternating current switches.
20,100 "POLYPHOS" ELEKTRIZITÄTS-GESELLSCHAFT. Röntgen-ray tubes. (Date applied for, Oct. 5, 1904.)*†
20,102 B.T.-H. CO. (G.E. Co., U.S.) Electric carrier systems.

October 5, 1905.

20,104 INGLEBY. Brushes for turbo-generators.
20,106 SIMMONS. High tension distributor for electric ignition of internal combustion engines of more than one cylinder worked by one induction coil.
20,143 WHITEHEAD & MARINON. Accumulators.
20,152 RIZZO. Electric ship log and indicator.
20,155 TRIPPE & STANILAND. Automatic control of arc and incandescent lighting circuits.
20,158 WRIGHT. Switch.
20,169 BRAUN. Systems of electrical distribution.
20,175 JUST, HANAMAN, LANDESBERGER SALZMANN & VEREINIGTE ELECTRICITÄTS ACTIEN-GESELLSCHAFT. Incandescing bodies for electric lamps.*
20,184 WOODYER & WOODYER. Electric mechanism for advertisements.

October 6, 1905.

20,197 ROBERTSON & PARRY. Making talking machine "records" by electricity.
20,217 VAREILLE. Electrolysis of water.*
20,231 OPPENHEIMER. (A.-G. Mix & Genest, Germany.) Buzzers for telephone stations.

October 7, 1905.

11,036A & 11,036B CONRAD & BRADSHAW. Alternating current measuring instruments. (Date applied for, May 27, 1904.)*†
20,269 CARR. Electric mains telephone and fault detector.

October 9, 1905.

20,330 B.T.-H. CO. (A.E.G., Germany.) Arc lamp electrodes.
20,335 ROBSON. Protective devices for use in distribution by overhead wires.
20,344 BARTER. High-tension distributor for internal combustion motors.
20,347 LUSTGARTEN & JONES. Apparatus for mechanically and electrically controlling the working of overhead and rail points on electric railways and tramways.
20,368 FYNN. Single-phase commutator motors.
20,371 SIEMENS BROS. & CO. (Siemens-Schuckert Werke G.m.b.H., Germany.) Sound transmission by electrically-produced light and heat rays.*
20,392 PIEPER. Electric motors.*
20,394 BELLISS & MORCOM & JUDE. Turbines.*

### October 10, 1905.

20,402 Midgley & Reed. Direct-current dynamo-electric machines and motors.
20,435 Veritys Limited & Worsley. Flame carbon arc lamps.*
20,441 Veritys Limited & Worsley. Inclined-carbon arc lamps.*
20,467 Abel. (Siemens Schuckertwerke G.m.b.H., Germany.) Signalling apparatus for single-line sections of electric railways and tramways.*
20,496 Boult. (Egan, U.S.) Telephones and telephone systems.*
20,500 Hatfield & Reason Mfg. Co. Mercury electrolytes.
20,512 Favero. Caps and contacts of incandescent lamps.
20,515 Davy. Arc lamps.

### October 11, 1905.

20,542 Bevis & Archer. Electric cooking apparatus.
20,547 Kitsee. System for transmission of electric currents.*
20,548 Kitsee. Transmission of intelligence by aid of electric energy.*
20,593 Peterson. Annunciators for telephones.*
20,595 Atkinson & Garside. Switch fuses.
20,599 B.T.-H. Co. (G.E. Co., U.S.) Switches.
20,609 Lewis. Arc lamps.

### October 12, 1905.

20,657 Minkley & Bakewell. Duplex telegraphy.
20,666 Marks. (Roberts, Cape Colony.) Electrical distributing systems.
20,687 Giraud. Safety devices for overhead conductors. (Date applied for, Oct. 31, 1904.)*†
20,690 McIlwain & Bennett. Electrical block signalling apparatus.

### October 13, 1905.

20,737 Markus & Barnwell Machine Co. Insulating materials.
20,742 Roose. Hand-operated brakes on electrical cars.
20,749 Siemens-Schuckertwerke G.m.b.H. Overhead current collectors for electric railways and tramways. (Date applied for, 10/27/04.)*
20,769 Mitkevitch. Application of alternating current to electrometallurgy.*
20,770 Hatfield & Reason Mfg. Co. Cathodes.
20,772 Aktiengesellschaft Brown, Boveri & Cie. Alternating-current collector motors. (Date applied for, Oct. 17, 1904.)*†

## SPECIFICATIONS PUBLISHED.

These may be obtained at the Sales Department of the Patent Office, Quality-court, Chancery-lane, London, W.C., at a uniform price of 8d.

### PUBLISHED OCTOBER 19, 1905.

### 1904 Specifications.

21,902 B.T.-H. Co. & Clinker. Dynamo-electric machines.
23,097 Fricker. Electrical measuring instruments.
23,109 Armstrong & Orling. Electro-capillary apparatus.
23,816 B.T.-H. Co. (G.E. Co., U.S.) Electric control systems.
23,971 Anders & Byng. Electric device for circuit closing and other purposes.
24,030 Jones. Electric time switch or contactor.
24,432 Bonniksen. Electro-mechanical synchronisation apparatus.
24,900 Davis. Electric breaks or interrupters.
25,235 Taylor & Lawson. Ignition plugs for internal-combustion engines.
25,276 B.T.-H. Co. (G.E. Co., U.S.) Vapour electric lamps, rectifiers and the like.
25,524 Imray. (Denham.) Electric lighting of railway carriages.
25,630 B.T.-H. Co. (G.E. Co., U.S.) Control for electrically-operated doors.
25,634 B.T.-H. Co. (G.E. Co., U.S.) Seals for vacuum tubes.
25,708 Kamm. Electric projecting lamps.
25,730 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.
25,903 Atkinson. Distribution of electric current.
28,889 Abrahamson. Electric fire alarm and like circuits.

### 1905 Specifications.

424 Jacobs. Working single lines of railway by electric systems.
1,281 Siemens Bros. & Co. & Berry. Controlling polyphase and monophase alternating-current motors.
1,590 B.T.-H. Co. & Samuelson. Governing mechanism for turbines.
2,190 Catworthy, Holmes, Holmes, Holmes, & Holmes. Starting switches.
2,995 Maclean. Electrically-heated curling tongs.
10,047 Smith & Granville. Cables.
10,304 Allmänna Svenska Elektriska Aktiebolaget. Single-phase alternating-current motors. (Date applied for, Sept. 15, 1904.)
10,553 Weedon. Arc lamps. Date applied for, May 20, 1904.)
11,169 Siemens Bros. & Co. (Siemens Schuckertwerke, G.m.b.H.). Carbon holders for arc lamps.
11,829 Cossor. Lowering the vacuum of X-ray and other vacuum tubes.
11,861 Hubbell. Secondary battery plates.
12,505 Hodgkinson. Electric hair brush.
12,506 Hodgkinson. Electrical massage apparatus.
13,381 B.T.-H. Co. (G.E. Co., U.S.) Electrodes for arc lamps.
13,679 Fessenden. Aerials for transmission and receipt of electro-magnetic wave energy.
14,486 Gasmotoren Fabrik Deutz. Regulating turbines. (Date applied for, July 14, 1904.)
15,658 Damico. Telephone attachments.
15,673 McDonnell. Electric lamp bulb and finishing same. (Date applied for, Nov. 2, 1904.)
16,075 Siemens Schuckertwerke G.m.b.H. Supplying and cutting off currents of high potential. (Date applied for, Feb. 23, 1905.)
17,800 Hartig. Safety fuse apparatus for electrical installations.

### PUBLISHED October 26, 1905.

### 1904 Specifications.

20,968 Highfield. Central station electric installations.
25,478 James. Single and double-pole fuse boxes.
25,729 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.
26,082 Leitner & Lucas. Dynamo-electric generators.
26,171 B.T.-H. Co. (G.E. Co., U.S.) Armature windings.
26,288 Vickers, Sons & Maxim, Williamson & Sumpter. Electrical apparatus for heavy guns.
26,327 Large. Switches.
26,374 Leitner, Lucas & Hill. Automatic switches for charging accumulators.
26,445 Feeny. (Wirt.) Brushes for dynamo-electric machines.
26,593 Warwick Machinery Co. (G.E. Co., U.S.) Brakes for turbines.
26,596 Warwick Machinery Co. (G.E. Co., U.S.) Turbines.
26,602 Johnson. (Badische Anilin & Soda Fabrik.) Production of reactions in gases by electric arcs.

### 1905 Specifications.

209 Malan. Electro-magnetically controlled fluid pressure motors.
1,136 Rymer-Jones. Condensers.
1,732 Russell & Ford. Controller and brake for electric road vehicles.
2,631 Lynch. Ships' telegraphs.
2,890 Scott. Electrically-operating gas valves.
3,076 Evershed & Vignoles, & Evershed. Electric signalling.
3,265 Tyer. Switches.
5,866 Howorth. (Moore Electrical Co.) Electrically-operated tubes or bulbs containing rarefied gas or vapour.
6,053 Vickery. Electric lamps for time-pieces and other uses.
8,127 Carter. Gas proof and disconnecting plug for switches.
12,406 Knoll. Telephone mouth-pieces.
13,093 Boult. (Duntley.) Electric drills.
13,586 Siemens Bros. & Co. (Siemens & Halske, A.-G.) Supplying current to branch telephone exchanges.
14,210 Siemens Bros. & Co. (Siemens Schuckertwerke G.m.b.H.) Regulating switch apparatus for increasing or decreasing pressure of a finely-divided network.
14,780 Lake. (Clinton Wire Cloth Co.) Apparatus for electric welding.

## COMPANIES' MEETINGS AND REPORTS.

◆

### Amazon Telegraph Co. (Ltd.)

The eleventh ordinary general meeting was held on Tuesday, under the presidency of George Keith, Esq.

The SECRETARY (Mr. Edmund Petley) read the notice calling the meeting and the auditors' certificate.

The CHAIRMAN: Gentlemen, the past year, ended June, has been a very favourable one for successful business on the Amazon. The price of rubber has been abnormally high, and commercial activity greatly on the increase. The progress of the Amazonas is shown by the increasing traffic on the river, and our Company's communication is also assisting materially in that progress. Every year our cables are working better and carrying more traffic. They still suffer somewhat from the forces of the river, especially from landslips on the banks, which are most prevalent when the river is falling during the months from June to October after it has been in full flood. But the process of repair is gradually moving the cables into better position, and rendering them less liable to damage from these causes. Fortunately for the service, our cables stand better in the busy season than in the slack, which corresponds very much with the rise and fall of the river. The traffic receipts for the past year amount to £67,253, showing an increase of £26,702 as compared with those for the preceding year. This gain was due partly to the larger volume of traffic transmitted, and partly to the increased rates, which came into effect on Jan. 1. The rise in the value of the currency in which our receipts are collected for some time also added to their sterling value, although, owing to our rates being fixed on a gold basis, the continued rise made the gold basis operative, and took away the advantage from this source, which was covering the corresponding increase of local expenses in Brazil due to the same cause. The expenditure amounts to £52,883, showing an increase for the year of £8,840. Station expenses are £949 more, owing to the higher value of the currency. Ship's expenses are £1,918 less, owing to the fewer repairs required during the year. The other items of expenditure are, as a whole, more or less the same as last year. The cost of cable, however, has been very heavy, owing to the large amount used for the restoration of the three remaining branch cables. The Alemquer section was relaid in January at a cost of some 34 miles of cable, and about 100 miles were expended in restoring the two Macapa Chaves sections. The work of restoring these two cables was finished in July last, and since then the whole of the Company's system has been complete and in working order. The successful restoration of our cables has been a work of great difficulty. For several years it was greatly handicapped by the imperfect knowledge of the river and its side waters, but this was gradually overcome, and a great part of our cables now lie comparatively free from interference. Altogether about three-fourths of the entire system have been relaid. The subsidy for the past year amounts to £13,654, and altogether the revenue of the year comes out at £80,911. After meeting the expenditure and providing for all charges, there remains a credit balance for the year of £9,836, as compared with the deficit of £7,130 for the preceding year. The increased earnings of the business have made it practicable to readjust the finances of the Company on a more permanent basis. The temporary loans have been paid off by the issue of £100,000 6 per cent. preference debentures and by the sale of the State of Amazonas gold bonds. The arrears of interest due on the 5 per cent. ordinary debentures, amounting to £35,900, have been funded by a further issue of the same debentures. This transaction has now been completed and will appear in the current year's accounts. Altogether the position of the Company has been greatly improved, and, if all goes well, I hope that the current year may produce as good, if not better results. I now move the adoption of the report and accounts.

Mr. E. B. ELLICE-CLARK seconded the motion, and said he thought Mr. Keith had drawn a somewhat conservative estimate of the prospects of the Company. He considered the Company had a very bright future.

The motion was carried unanimously, and the retiring director (Mr. Keith) and the auditors having been re-elected, the proceedings terminated with a hearty vote of thanks to the chairman and directors.

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**WEST INDIA & PANAMA TELEGRAPH CO. (LTD.)**—The report of the directors for the half-year ended June 30 last states that the amount to credit of revenue is £32,773. 13s. 11d., against £34,581. 11s. 7d. for the corresponding half-year of 1904. Expenses have been £23,230. 9s. 8d., against £23,437. 14s. 3d., leaving a balance of £9,543. 4s. 3d., to which is added £1,756. 0s. 11d. interest on investments, and £494. 9s. 3d. brought forward, making £11,793. 14s. 5d. It is proposed to pay 6s. per share on account of arrears of dividends to June 30 on the first preference shares (£10,368. 18s.), and to carry forward £1,424. 16s. 5d. This will leave dividends in arrear on first preference shares £3,456. 6s., on second preference shares £14,007. The decrease referred to in the last report continued for the remainder of the half-year, and amounted to £993 compared with the corresponding period of 1904. The traffic receipts for the current half-year also show a decline.

The British Guiana subsidy of £4,500 per annum, voted for 10 years from Jan. 1, 1892, in consideration of the company's laying a new cable between that colony and Trinidad, and continued at that rate up to March 31 last, has from that date been reduced to £3,000 per annum.

**WESTERN UNION TELEGRAPH CO.**—The report of the president for the year ended June 30 states that the amount of capital stock is unchanged—viz., $97,370,000, of which $29,394 is in the company's treasury. The bonded debt is $28,504,000, including $3,000,000 funding and real estate mortgage bonds issued during the year. The revenue was $29,033,635.04 ($215,755.40 decrease compared with preceding 12 months), and the expenditure $21,845,570.32 (increase $483,654.86). Interest on bonds absorbed $1,227,200.00 (increase $69,500.00), leaving net profit $5,960,864.72 (decrease $768,910.26), of which $4,868,083.75 was appropriated for dividends, leaving $1,092,780.97 surplus (compared with $1,861,703.73 from previous year), making the total surplus $15,974,209.25. 200,244 miles of poles and cables were erected (compared with 199,350 in previous year) and 1,184,557 miles of wires (against 1,155,405), and messages transmitted, not including messages over leased wires or under railroad contracts, numbered 67,477,320 (against 67,903,973). The average toll per message was 31.6 cent (against 31.7 cent), and the average cost per message 27.3 cent (against 26.1 cent). The substitution of dynamo current or storage batteries for chemical main batteries has been authorised at 13 important centres during the year. Contracts covering 3,474 miles of railroad have been closed during the year with 22 railway companies.

**WESTMINSTER ELECTRIC SUPPLY CORPN. (LTD.)**—At an extraordinary meeting on Wednesday the resolutions passed at the meeting on Oct. 31 for increasing the capital of the company from £800,000 to £2,000,000, by the creation of 240,000 new shares of £5 each, of which 90,000 are to be issued as ordinary and 150,000 as preference shares, carrying a cumulative preferential dividend at the rate of 4½ per cent. per annum, and ranking pari passu with 50,000 preference shares authorised by special resolution in December, 1901, and that any such preference shares unissued shall be issued upon the terms of carrying dividend at the rate of 4½ per cent., instead of 5 per cent. per annum, were unanimously confirmed.

## NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

### NEW COMPANIES.

**ASTER ENGINEERING CO. (LTD.)** (86,199.)—Reg. Oct. 20, capital £50,000 in £1 shares, to adopt two agreements and to carry on the business of manufacturers of motor cars, omnibuses, cabs, and motor conveyances, makers of chasses, machinery and fittings of all kinds, mechanical engineers, electricians, manufacturers of and dealers in gas, oil and electric engines, &c. First directors are M. Cheronnet (chairman) A. Monard, L. C. Getti, G. M. Bertault and S. D. Begbie.

**BRITISH HOSIERY & ELECTROLYTIC BLEACHING CO. (LTD.)** (86,337.)—Reg. Nov. 2, capital £60,000 in £1 shares, to acquire certain patents relating to the Vogelsang Electric bleaching process, belonging to the Foreign Electrical Bleaching Patents (Ltd.), &c. Reg. office, 6, Eastcheap, London, E.C.

**CREMORNE MOTORS (LTD.)** (86,325.)—Reg. Nov. 1, capital £30,000 in £5 shares (2,000 6 per cent. cumulative preference), to carry on the business of builders and sellers of motor omnibuses, motor cars, motors, &c., manufacturers of and dealers in motors or engines for electric lighting or power, mechanical and electrical engineers, &c. First directors, A. E. Dobbs (permanent), W. East, J.P., and A. F. Dobbs. Reg. office, Lots-road, Chelsea, S.W.

**J. S. FAIRFAX & CO. (LTD.)** (86,317.)—Reg. Oct. 31, capital £12,500 in £1 shares, to adopt an agreement with J. S. Fairfax for acquisition of certain patents, and to carry on the business of mechanical, hydraulic, electrical, traction and general engineers, builders of motor and other vehicles, generators, users and suppliers of electric energy, &c. Reg. office, Kew Bridge Engineering Works, Strand-on-the-Green, Chiswick, W.

**WEMYSS & DISTRICT TRAMWAYS CO. (LTD.)** (6,008.)—Reg. in Edinburgh on Nov. 8, capital £55,000 in 9,000 preference shares of £5 each and 10,000 ordinary shares of £1 each, to carry on business as financiers, promoters, contractors, &c., and to purchase the control of statutory rights and powers for the construction and working of tramways and tramroads in the parishes of Kirkcaldy, Dysart, Wemyss and Scoonie, Fifeshire. First directors: J. Oswald, J. Budge, A. Bowman, W. Shepherd and S. Sellon, C.E. Reg. Office, Royal Bank-buildings, High-street, Leven.

### STATUTORY RETURNS.

**BRITISH CONTINENTAL ELECTRICITY CO. (LTD.)**—Return to Aug. 12 gives capital as £20,000 in 1,000 ordinary and 1,000 preference shares of £10 each, of which 906 ordinary and 1,000 preference have been taken up. £10 per share has been called up on 790 preference and 756 ordinary, and £15,460 has been received. £3,600 is considered as paid on 116 preference and 244 ordinary. Mortgages and charges: Nil.

**EDISON & SWAN UNITED ELECTRIC LIGHT CO. (LTD.)**—In return to Oct. 26 capital is £941,090 in 150,000 A and 24,436 B shares of £5 each, and 23,564 B shares of £2. 10s. each, of which 116,400 A and 23,564 £2. 10s. B shares have been taken up. 10s. per share has been called up on 89,261 A and £44,630. 10s. has been received. £2. 10s. per share is considered as paid on 89,261 A, £3 per share on 10,000 A, £5 per share on 17,139 A and £2. 10s. per share on 23,564 £2. 10s. B shares, making a total of £397,757. 10s. considered as paid. Mortgages and charges, £399,576.

**OXFORD ELECTRIC CO. (LTD.)**—On Oct. 2, 1,358 ordinary shares of £5 each had been allotted for cash in addition to 18,500 shown issued by return of March 17th last, when £60,050 had been received in cash, including £1,550 paid on 310 forfeited shares, and £34,000 was considered as paid. Mortgages and charges, £50,000.

### MORTGAGES AND CHARGES.

**SCOTTISH HOUSE-TO-HOUSE ELECTRICITY CO. (LTD.)**—A charge for £500, dated Oct. 24, 1905 (supplemental to charge of March 31, 1904), has been registered. Holders, County of London Electric Supply Co. Property charged, company's undertaking and property, present and future.

**NORTHAMPTON ELECTRIC LIGHT & POWER CO. (LTD.)**—Issue on Nov. 4 of £300 debenture, part of a series created June 3, 1896, to secure not more than two-thirds of paid-up capital for time being, charged on company's undertaking and property. No trustees. Previously issued of same series, £33,200.

**NORTHALLERTON ELECTRIC LIGHT & POWER CO. (LTD.)**—Issue on Oct. 27 of a £1,000 debentures, part of series created Nov. 30, 1900, to secure £5,000, charged on company's property, present and future, including uncalled capital. No trustees. Previously issued of same series, £3,740.

**LLANRWST ELECTRICITY SUPPLY CO. (LTD.)**—Four debentures, dated Oct. 30, 1905, securing in all £1,000, charged on company's undertaking and property, present and future, including uncalled capital, have been registered. Holders: A. P. Elworth, R. Conway, and O. I. Jones.

## CITY NOTES.

**MEMORANDA** (Nov. 16).—Bank rate 4 per cent. (since Sept. 28, 1905) Price of silver 29$\frac{9}{16}$d. per oz. Consols 88$\frac{7}{16}$—88$\frac{9}{16}$ for money, 88$\frac{9}{16}$—88$\frac{11}{16}$ for account; 2½ per cent. annuities 87½—87¾. Consols Pay Day, Dec. 1; Stocks and Shares Continuation Day, Nov. 28; Ticket Day, Nov. 29; Pay Day, Nov. 30; Mining Share Carry-over Day, Nov. 27.

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**ALLGEMEINE ELEKTRICITATS GESELLSCHAFT.**—The net profit for the past year was 10,954,000m. (£547,700), against 8,556,000m. (£427,800) in 1904, and a dividend of 10 per cent. has been declared, against 9 per cent. in the previous year. It is proposed to increase the capital of the company from 86,000,000m. to 100,000,000m., £4,300,000 to £5,000,000.

**BRITISH ALUMINIUM CO. (LTD.)**—The directors have declared an interim dividend for the half-year ended June 30 at the rate of 6 per cent. on the A and 7 per cent. on the 7 per cent. preference shares.

**COMPAGNIE BELGE POUR LES TRAMWAYS ET L'ECLAIRAGE ELECTRIQUES DE SARATOFF.**—This company has been formed in Brussels to acquire the undertaking of the Compagnie Mutuelle de Tramways and to convert its lines in Saratoff to electric traction; also to establish works for the supply of electricity for light and power. The capital is fixed at 10,000,000 fr., in addition to 100,000 shares allotted without subscription.

**COMPANIES TO BE STRUCK OFF REGISTER.**—The "London Gazette" for Nov. 10 announces that the following, among other joint stock companies, will be struck off the register in three months, unless cause is shown to the contrary:—

Dumont Electric Ignition & Self-Starter Co.
General Fire Alarm & Automatic Sprinkler Synd.
Great Western Electric Light & Power Co.
King Arc Lamp Co.
Lancashire & Yorkshire Electric Tramways.
London Mica Co.
Snelgrove Electric Cash Register Till Synd.
Taipo Accumulator Co.
United Electric Tramways.
West Riding Tramways & Electricity Supply Co.
World's New Accumulator Co.

**EDISON & SWAN UNITED ELECTRIC LIGHT CO. (LTD.)**—Yesterday the shareholders confirmed the resolution passed on Oct. 30 to pay the directors an additional 750 guineas for their services during the year ended June last, beyond the remuneration to which they might be entitled.

**ELECTRIC TRACTION CO. OF HONG KONG (LTD.)**—At the meeting yesterday (Thursday) resolutions for the adoption of the report and accounts and the re-election of directors and auditors were passed.

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (*a*) | Aggregate. No. of weeks. | Aggregate. Amount. | Aggregate. Inc. or Dec. (*a*) |
|---|---|---|---|---|---|---|
| | | £ | £ | | £ | £ |
| Aberdeen Corporation | Nov. 11 | 1,174 | + 18 | 24 | 35,347 | – 1,548 |
| Airdrie | „ 8 | 209 | + 4 | 44 | 9,051 | + 126 |
| Anglo-Argentine | „ 11 | 14,993 | + 1,697 | 44 | 600,892 | + 38,029 |
| Ayr Corporation | „ 11 | 178 | – 7 | 26 | 9,287 | – 158 |
| Barcelona Trams Co. | ... | ... | ... | ... | ... | ... |
| Barcelona, Ensanche, Gracia | ... | ... | ... | ... | ... | ... |
| Barnsley | „ 8 | 156 | – 4 | 44 | 7,108 | – 318 |
| *Barrow | „ 8 | 218 | + 23 | 44 | 10,743 | + 2,145 |
| Bath Electric Trams, Ltd. | „ 8 | 659 | + 106 | 45 | 31,025 | + 1,920 |
| Birkenhead | „ 5 | 987 | – 34 | 6 | 5,796 | – 218 |
| | „ 12 | 953 | – 24 | | | |
| Birmingham Corporation | „ 11 | 875 | + 44 | 32 | 11,595 | + 1,882 |
| *Birmingham & Mid. | „ 8 | 1,397 | – 115 | 44 | 70,350 | + 280 |
| Blackpool Corporation | ... | ... | ... | ... | ... | ... |
| Blackpool and Fleetwood | „ 11 | 167 | – 19 | 19 | 19,028 | + 1,081 |
| Bolton Corporation | „ 12 | 1,825 | + 81 | 33 | 64,057 | + 2,863 |
| Bournemouth Corporation | „ 8 | 1,404 | + 318 | †31 | 48,515 | + 8,426 |
| Bradford Corporation | „ 11 | 4,001 | + 140 | 32 | 143,871 | – 7,184 |
| Brighton Corporation | „ 12 | 814 | – 20 | 33 | 85,321 | + 455 |
| Bristol Trams & Carriage | „ 10 | 4,643 | + 9 | 14 | 70,020 | + 911 |
| Buenos Ayres & Belgrano | „ 12 | 3,667 | + 165 | 45 | 156,151 | + 7,548 |
| Buenos Ayres Elec. Trams | Oct. 14 | 1,324 | ... | 41 | 47,550 | ... |
| Burnley Corporation | Nov. 11 | 1,021 | + 18 | 32 | 46,160 | + 2,100 |
| Burton Corporation | „ 12 | 276 | – 41 | §32 | 10,410 | – 1,331 |
| Bury Corporation | „ 5 | 658 | ... | §31 | 28,805 | ... |
| Calcutta Tramways Co. | „ 11 | R13,627 | + R5,752 | 19 | R809,549 | + 102,391 |
| Camborne-Redruth | „ 11 | 99 | – 28 | 2 | 204 | – 39 |
| Cardiff Corporation | „ 11 | 1,805 | – 98 | 32 | 67,785 | + 134 |
| Carlisle Tramways Co. | „ 13 | 164 | – 28 | 45 | 8,353 | – 576 |
| Cavehill | ... | ... | ... | ... | ... | ... |
| Central London Railway | „ 11 | 7,112 | + 110 | 19 | 116,763 | – 1,098 |
| Chatham & Dist. Lt. Rys. | „ 9 | 584 | + 58 | 45 | 29,875 | + 3,148 |
| *City of Birm'gh'm Tram Co. | „ 3 | 5,193 | – 194 | 44 | 237,045 | + 909 |
| City & South London Rly. | „ 12 | 3,061 | + 220 | 19 | 47,450 | + 149 |
| Colchester Corporation | „ 9 | 143 | – 46 | 15 | 4,485 | – 1,260 |
| Cork Electric Trams Co. | „ 9 | 409 | – 17 | 45 | 21,976 | + 658 |
| Devonport & Dist. Trams. | „ 3 | 414 | – 82 | 44 | 20,456 | – 3,134 |
| Dover Corporation | „ 11 | 192 | + 11 | 32 | 7,726 | – 100 |
| Dublin & Lucan Railway | „ 10 | 77 | – 13 | 19 | 2,580 | – 31 |
| Dublin Southern District | „ 10 | 747 | – 48 | 19 | 98,627 | – 1,124 |
| Dublin United | „ 10 | 3,624 | – 126 | | | |
| Dudley—Stourbridge | „ 8 | 818 | + 37 | 44 | 39,864 | + 1,363 |
| Dundee Corporation | „ 8 | 914 | + 88 | §25 | 23,237 | + 1,197 |
| East Ham Council | „ 11 | 704 | + 86 | 32 | 27,116 | + 2,853 |
| Gateshead & Dist. Trams. | „ 3 | 969 | + 76 | 44 | 40,625 | + 728 |
| Glasgow Corporation | „ 11 | 14,976 | + 662 | 24 | 862,635 | + 17,775 |
| Glossop | „ 4 | 125 | + 22 | 45 | 5,520 | + 4.8 |
| | „ 12 | 118 | + 7 | | | |
| Gloucester Corporation | „ 8 | 235 | + 6 | 32 | 10,005 | ... |
| Gravesend—Northfleet | „ 8 | 2.3 | + 10 | 44 | 10,314 | – 943 |
| Gt. Northern & City Rly. | „ 11 | 1,730 | + 302 | 19 | 28,748 | + 6,780 |
| Greenock & Port Glasgow | „ 3 | 513 | + 20 | 44 | 28,586 | + 3,060 |
| Halifax Corporation | „ 1 | 1,463 | + 204 | 31 | 51,158 | + 2,798 |
| Hartlepool Tramways | „ 3 | 2,525 | – 11 | 44 | 11,844 | – 1,207 |
| Hastings Elec. Trams Co. | „ 9 | 388 | ... | 14 | 8,349 | ... |
| Huddersfield | „ 11 | 1,289 | + 27 | 32 | 44,293 | + 1,400 |
| Hull Corporation | „ 11 | 2,112 | – 41 | 32 | 71,922 | + 503 |
| Ilford Dist. Coun. | „ 11 | 386 | + 16 | 32 | 15,875 | + 282 |
| Ipswich Corporation | „ 11 | 326 | – 47 | 32 | 14,823 | – 1,844 |
| Isle of Thanet Co. | „ 11 | 289 | – 32 | 6 | 1,904 | – 444 |
| Kidderminster & District | „ 3 | 99 | + 1 | 44 | 5,449 | – 311 |
| Kilmarnock Corporation | ... | ... | ... | ... | ... | ... |
| Kirkcaldy Corporation | „ 8 | 196 | – 8 | 10 | 2,052 | – 64 |
| Lanarkshire Trams Co. | „ 9 | 838 | + 169 | 45 | 83,634 | + 4,096 |
| Leamington | „ 3 | 128 | + 26 | 16 | 3,168 | + 1,218 |
| Leeds Corporation | „ 11 | 5,377 | – 25 | 32 | 197,305 | + 3,855 |
| Leicester Corporation | „ 11 | 1,888 | + 71 | 45 | 93,649 | + 28,744 |
| Liverpool Corporation | „ 4 | 10,331 | + 188 | 44 | 466,242 | + 8,732 |
| Liverpool Overhead Rly. | „ 12 | 1,352 | – 57 | 19 | 30,653 | – 1,329 |
| *London County Council | „ 4 | 14,038 | – 1,136 | 31 | 469,617 | + 66,588 |
| Lowestoft | „ 11 | 150 | + 2 | 6 | 982 | – 81 |
| Maidstone Corporation | „ 9 | 92 | – 21 | 32 | 4,315 | ... |
| Manchester Corporation | „ 11 | 12,218 | + 430 | 32 | 418,443 | + 16,708 |
| Mersey Railway | „ 11 | 1,591 | + 121 | 19 | 29,706 | + 1,835 |
| Merthyr | „ 3 | 182 | – 4 | 44 | 8,395 | – 459 |
| *Metropolitan Elec. Trams | „ 3 | 2,526 | + 80 | 44 | 118,051 | + 51,142 |
| Middleton | „ 3 | 800 | + 14 | 44 | 15,106 | + 614 |
| Musselburgh | „ 2 | 185 | ... | 46 | 10,519 | ... |
| Nelson Corporation | „ 11 | 120 | + 5 | 33 | 4,401 | + 405 |
| Newcastle-on-Tyne Corp. | „ 11 | 3,700 | + 61 | 32 | 123,975 | + 3,648 |
| Newport (Mon.) | „ 11 | 547 | + 2 | 6 | 3,251 | + 270 |
| Northampton Corporation | „ 10 | 363 | – 15 | 31 | 13,621 | + 4,775 |
| Oldham, Ashton & Hyde | „ 3 | 571 | + 46 | 41 | 24,661 | + 502 |
| Oldham Corporation | „ 12 | 1,588 | + 259 | 33 | 54,686 | + 14,508 |
| Perth (W. A.) Elec. Trams. | „ 10 | 1,338 | + 59 | 45 | 61,667 | + 3,659 |
| Peterborough | „ 3 | 101 | – 18 | 44 | 6,094 | – 640 |
| Pontypridd Dist. Council | „ 11 | 136 | ... | 32 | 5,337 | ... |
| Portsmouth Corporation | „ 11 | 1,431 | – 123 | 32 | 68,708 | + 999 |
| Potteries | „ 3 | 1,843 | + 109 | 44 | 75,098 | + 572 |
| Preston Corporation | „ 8 | 602 | ... | 6 | 3,624 | ... |
| Reading Corporation | „ 9 | 561 | – 69 | 6 | 8,460 | – 265 |
| Rotherham Corporation | „ 9 | 534 | + 37 | 32 | 14,761 | – 185 |
| Rothesay | „ 3 | 41 | + 5 | 44 | 9,339 | + 2,653 |
| Salford Corporation | „ 13 | 4,169 | + 203 | 33 | 142,162 | + 6,975 |
| Sheerness | „ 1 | 54 | – 2 | 44 | 3,147 | + 298 |
| Sheffield Corporation | „ 12 | 4,819 | + 275 | 33 | 163,480 | + 7,347 |
| Southampton Corporation | „ 8 | 897 | – 12 | †6 | 4,923 | – 450 |
| Southend Corporation | ... | ... | ... | ... | ... | ... |
| Southport Tramways | „ 3 | 246 | – 14 | 44 | 14,059 | – 512 |
| S. Staffordshire Trams. | „ 3 | 834 | + 148 | 44 | 32,443 | + 1,178 |
| Stockport Corporation | „ 10 | 736 | + 280 | 32 | 24,697 | + 5,458 |
| Swansea Trams | „ 3 | 763 | + 279 | 44 | 31,783 | + 7,793 |
| Swindon Corporation | „ 8 | 107 | ... | 32 | 6,501 | ... |
| Tynemouth and District | „ 3 | 182 | – 6 | 44 | 11,717 | – 1,561 |
| Tyneside Trams Co. | „ 8 | 350 | + 15 | 45 | 18,767 | + 1,042 |
| Wallasey District Council | „ 11 | 671 | + 13 | 32 | 25,885 | + 682 |
| Walsall | „ 11 | 484 | + 13 | 44 | 22,123 | + 278 |
| Warrington Corporation | „ 9 | 328 | + 7 | 32 | 10,984 | + 532 |
| West Ham Corporation | „ 9 | 1,804 | + 757 | 82 | 57,742 | + 24,231 |
| Weston-super-Mare | „ 1 | 32 | – 8 | 44 | 6,645 | + 610 |
| Wolverhampton Corpn. | „ 8 | 736 | ... | 6 | 4,577 | ... |
| Wolverhampton District | „ 3 | 339 | + 36 | 44 | 17,507 | + 208 |
| *Worcester | „ 8 | 261 | – 13 | 44 | 13,575 | + 472 |
| Wrexham | „ 8 | 91 | + 8 | 44 | 4,488 | – 385 |
| Yorkshire Woollen District | „ 8 | 759 | + 246 | 44 | 29,044 | + 3,143 |

(*a*) These comparisons are with the corresponding period last year. † Minus 8 days. § Plus 2 days. * Partly electrical.

**ELMORE'S GERMAN & AUSTRO-HUNGARIAN METAL CO. (LTD.)**—Meetings will be held on 23rd inst. for the purpose of re-arranging and reducing the capital of this company. The directors state that the Metal Co. is continuing to make good progress. Sales show a considerable increase, while cost of production has been lowered.

**GENERAL ELECTRIC CO. (NEW YORK).**—On 5th prox. a meeting will be held to consider a proposal for largely increasing the capital. The new capital is said to be required for acquiring the control of the American Locomotive Co.

**W. T. HENLEY'S TELEGRAPH WORKS CO. (LTD.)**—In consequence of the very large over-subscription of the issue of £150,000 debenture stock in this company, the list of applications, which was only opened on Monday, was closed on that day for London and by first post on the following morning for the country. As the date for the closing of the list fixed by the prospectus was four o'clock on Thursday (yesterday), the over-subscription of the issue immediately upon the publication of the prospectus clearly indicates the confidence of the investing public in this class of investment.

**SUNDERLAND DISTRICT ELECTRIC TRAMWAYS (LTD.)**—The greater part of this company's system is now in working order. The first section of about 11 miles, from Grangetown to Houghton-le-Spring, was opened for traffic on June 10 last, and a further section, from Houghton to Hetton, of nearly 2 miles, on Oct. 20. With an average of only 10 cars (one-third the total number) the traffic receipts to the end of October were £6,957. At present 18 cars are in operation, and this number will be increased.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Nov. 15. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Nov. 15. Highest. | Business, Week to Nov. 15. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | £ s. d. | | | |
| 5 | 8/0 | Anglo-Argentine Ord. Shares | 8⅝–8⅞ | 4 10 5 | Ap, Oct | 8$\frac{11}{16}$ | 8$\frac{23}{32}$ |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞–6⅛ | 4 9 8 | — | 6$\frac{1}{16}$ | 5$\frac{15}{16}$ |
| St. | 6% | Do. Permanent 6% Deb. Stock | 141 –144 | 4 3 3 | — | .. | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 105 –107 | 4 13 5 | — | .. | .. |
| 10 | 12/0 | Barcelona Tramways Ord. | 13¾–14¼ | 4 4 0 | — | .. | .. |
| 10 | 5/0 | Do. 5% Cum. Pref. | 9½–10 | 5 0 0 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock (red.) | 97 –102 | 4 8 3 | — | .. | .. |
| 100 | 5% | Do. 5 per Cent. Debs. | 93 –101 | 4 19 0 | — | .. | .. |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1 –1½ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 4 –4½ | 5 18 3 | — | 4$\frac{3}{16}$ | 4⅛ |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 95 –98 | 4 12 0 | — | 98 | .. |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 124 –127 | 4 14 6 | — | 126 | 25 |
| St. | 5% | Do. Pref. Ord. Stock | 113 –116 | 4 7 9 | — | 115 | 114 |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock | 103 –109 | 4 11 8 | — | .. | .. |
| 40 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%–105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 102 –105 | 4 5 9 | — | .. | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | 3⅝–3⅞ | 5 2 0 | — | 3$\frac{23}{32}$ | 3$\frac{11}{16}$ |
| 5 | 8/0 | Do. 6 per Cent. "A" Cm. Pref. | 5$\frac{11}{16}$–5$\frac{15}{16}$ | 5 2 0 | — | .. | .. |
| 5 | 8/0 | Do. "B" | 5 –5½ | 5 9 1 | — | .. | .. |
| St. | 5% | Do. 5 per Cent. Debs. | 106 –108 | 4 12 6 | — | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102 –105 | 4 16 3 | — | 104 | 103½ |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 98 –100 | 5 0 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 101 –105 | 5 4 9 | .. | .. | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 101 –108 | 5 11 1 | .. | .. | .. |
| 5 | 8/6 | Calcutta Tramways (Nos. 1 to 105) | 9¼–9¾ | 4 7 2 | — | 9$\frac{3}{16}$ | 9⅜ |
| 5 | 0/3 | Do. Nos. 105,001 to 137,610 | 8½–9 | .. | .. | 8$\frac{9}{16}$ | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 107 –109 | 4 2 7 | — | .. | .. |
| 1 | 0/6 | Cape Electric Tram Shares | 1 –1¼ | 4 0 0 | — | 1$\frac{3}{16}$ | 1$\frac{3}{16}$ |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 101 –103 | 4 17 2 | — | — | — |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 97 –99% | .. | .. | 98¼ | .. |
| 1 | .. | Lisbon Elec. Trams Ord. | 1$\frac{5}{16}$–1⅜ | .. | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛–1¼ | 4 13 0 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 100 –103 | 4 17 0 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 103 –105 | 4 15 3 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101 –104 | 4 16 2 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102 –104 | 4 6 7 | — | — | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 104 –107 | 4 18 5 | .. | .. | — |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 142 –145 | 5 10 3 | .. | .. | .. |
| .. | .. | Do. 5% 1st Mt. $500 Dbs. | 99 –101 | .. | .. | 100 | .. |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | 3/3 | †Calcutta Elec. (1-60,000) ex new | 9 –9½ | 4 4 2 | — | 9½ | [illegible] |
| 5 | 2/3 | † Do. (60,001-80,000) ex new | 9 –9½ | 4 11 9 | .. | .. | .. |
| 10 | 5% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50 –52 | 4 16 1 | .. | .. | — |
| .. | .. | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 96 –98 | .. | .. | 97½ | 97 |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½–3 | .. | .. | .. | — |
| St. | 5% | Do. 5% Debs. | 85 –90 | 5 11 1 | — | .. | — |
| 10 | .. | Havana Electricity Co. Shares | 9 –10 | — | — | .. | .. |
| 100 | 15/6 | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 94 –96 | 5 4 2 | .. | .. | .. |
| St. | .. | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. 50% pd. | 60 –62 | .. | .. | — | .. |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞–1$\frac{1}{16}$ | 5 18 0 | — | .. | — |
| 1 | 1/0 | Rand Electric | 1$\frac{5}{16}$–1$\frac{7}{16}$ | .. | — | .. | — |
| 1 | .. | River Plate Electricity Co. Ord. | ⅝–¾ | .. | .. | .. | .. |
| 1 | 1/2⅜ | Do. 6% Non. Cum. Pref. | ⅞–1$\frac{1}{16}$ | .. | .. | .. | .. |
| St. | 5% | Do. 5% Deb. Stock | 103 –105 | 4 15 0 | .. | .. | .. |
| 5 | 6/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5⅛–5⅝ | 5 6 8 | .. | .. | .. |
| 5 | 3·23d | Do. (12,001-20,000) | 5 –5½ | 3 8 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100 –103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 10/9 | Shawinigan Water and Power 5% Bds., Scrip | 99 –101 | 4 19 0 | .. | 100⅛ | 99⅞ |

* In calculating the yield, allowance has been made for accrued interest but not for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Share. | Last Dividend | Name. | Price Wed., Nov. 15. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business, Week to Nov. 15. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| 1 | .. | Bath Elec. Trams Pref. Ord. | 15/16—1 | .. | .. | 31/32 | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16—1 1/16 | 4 14 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 103—105 | 4 5 9 | .. | 104½ | 103½ |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 104—106 | 4 5 9 | .. | 105 | 104½ |
| 10 | 9% | Bristol Tramways and Carriage Ord. | 17—17½ | 5 2 11 | Feb, Aug | .. | .. |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10—10½ | 3 18 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Debs. | 105—107 | 3 14 10 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 9¾—10½ | 5 17 0 | .. | 10¼ | 9 15/16 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 11—11½ | 5 4 4 | Feb, Aug | 11 5/16 | 11 1/16 |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 121—123 | 4 1 0 | .. | 122½ | 121½ |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 98—100 | 4 10 0 | .. | 99½ | 98¾ |
| St. | 4% | Central London Ordinary Stock | 92—94 | 4 5 1 | June, Dec | 93½ | 93¼ |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 101—103 | 3 17 8 | .. | .. | .. |
| St. | 4% | Do. Deferred Stock | 85—86 | 4 13 1 | .. | 85½ | 85 |
| 100 | 4% | Do. 4 per Cent. Debs. | 110—112 | 3 11 5 | .. | 111¾ | 111½ |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 4⅞—5⅛ | 4 17 6 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 100—103 | 3 17 8 | .. | .. | .. |
| St. | 2% | City and South London Rly. Con. Ord. | 44—46 | 4 2 6 | Feb, Aug | 45½ | 44¾ |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 119—122 | 4 2 0 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 117—120 | 4 3 4 | .. | .. | .. |
| St. | 5% | Do. (1901) | 114—117 | 4 5 6 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 105—108 | 3 14 1 | May, Nov | 107 | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13½—14½ | 4 2 8 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½—15½ | 3 17 8 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5¼—5¾ | 6 19 2 | .. | 5¾ | 5 17/32 |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8—9 | 4 8 11 | .. | .. | .. |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 100—102 | 4 8 3 | .. | 102⅛ | 102 |
| 10 | 9% | ‡ Imperial Tramways Ord | 17—18 | 5 0 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 13¾—14¼ | 4 4 2 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 108—110 | 4 1 10 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2½—2¾ | 9 8 6 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 83—88 | 4 10 11 | .. | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8 11/16—8 13/16 | 3 18 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾—10¼ | 4 15 3 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99—102 | 3 19 3 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9¾—10¼ | 4 17 6 | .. | 10⅛ | .. |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 100—103 | 3 17 8 | .. | 101¼ | 100½ |
| St. | .. | Mersey Con. Ord. Stock | 7—9 | .. | .. | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8—11 | .. | .. | .. | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32—9/32 | .. | .. | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1—1 1/16 | 4 14 1 | .. | 1 1/32 | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106—108 | 4 3 3 | .. | 106¾ | 106¼ |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½—1½ | .. | May | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾—9¼ | 5 5 8 | .. | 9 3/16 | 9⅛ |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9½—10 | 5 0 0 | Feb, Aug | .. | .. |
| St. | 4½% | † Do. 4½ per Cent. Deb. Stock | 101—104 | 4 6 4 | .. | .. | .. |
| 1 | .. | South Lancs. Elec. Trac. & Power Ord. | .. | .. | .. | .. | .. |
| 1 | .. | Do. 6% Pref. (£1 paid) | .. | .. | April, Oct | .. | .. |
| St. | .. | Do. 4½% Deb. Stock (100% paid) | .. | .. | Jan, July | .. | .. |
| 100 | .. | Sunderland Dist. Elec. Trams. 5% 1st Mort. Debs. | 95—99 | .. | .. | 98½ | .. |
| .. | 5% | Underground Elec. Rys. Co. of London | 99½—100½ | 4 19 6 | .. | 100½ | .. |
| St. | 3% | Waterloo and City Ord. | 87—89 | 3 7 5 | June, Dec | 88 | .. |
| St. | 12/11 | Yorkshire W. R. Elec. Trams Co. 4% 1st Debs. | 95—97 | 4 2 6 | .. | 96¼ | 96 |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | * African Direct Tel. 4% Mrt. Deb. (red.) | 99—102 | 3 13 5 | Jan, July | .. | .. |
| 10 | .. | Amazon Telegraph | 4—4½ | .. | Jn, Dec | .. | .. |
| 100 | .. | Do. 5% Debs. (red.) | 85—90 | 5 11 0 | .. | 88¾ | .. |
| St. | 15/0 | Anglo-American | 61—63 | 4 15 0 | F,My,Ag,N | 61½ | 61 |
| St. | 30/0 | Do. Preferred | 108½—109½ | 5 6 7 | F,My,Ag,N | 108¾ | 107½ |
| St. | 2/0 | Do. Deferred | 17¼—17¾ | .. | F,My Ag,N | 17⅜ | 16 15/16 |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 96—98 | 4 1 8 | Jn Ap,Jy,O | 97¾ | 97½ |
| 10 | 5/0 | Cuba Submarine Ord. | 8¾—9¼ | 5 8 8 | Feb, Aug | 9 3/32 | .. |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17—18 | 5 11 2 | Feb, Aug | .. | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅝—3⅞ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 9½—9¾ | 5 2 6 | April, Oct | .. | .. |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 100%—103% | 4 7 5 | Jan, July | .. | .. |
| 20 | 3/0 | Direct United States Cable | 13½—14 | 4 9 8 | Ja,Ap,Jy,O | 14⅛ | 13 15/16 |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 100—102 | 4 8 8 | Jn, Dec | .. | .. |
| St. | 25/0 | Eastern Ordinary | 144—147 | 4 15 8 | Ja,Ap,Jy,O | 146 | 144½ |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 89—91 | 3 16 11 | Ja Ap,Jy,O | 90½ | 89 |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 106—108 | 3 14 1 | May, Nov | 107 | .. |
| 10 | 2/6 | Eastern Extension | 14½—15 | 4 13 4 | Ja,Ap,Jy,O | 14 13/16 | 14 9/16 |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 106—108 | 3 14 1 | Feb, Aug | .. | .. |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 99—101 | 3 19 2 | Feb, Aug | .. | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 99½%—101½% | 3 18 9 | May, Nov | 99½ | .. |
| 10 | 5/0 | G. N. (of Copenhagen) | 35—36 | 6 17 6 | Jan, July | 35 | .. |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 100—102 | 4 8 3 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57—59 | 5 10 0 | May, Nov | 57½ | .. |
| 100 | $1 | Mackay Companies Common | 49 11/16 | 4 0 6 | Jan, July | .. | .. |
| 100 | 4% | Do. Preference | 74⅛ | 5 8 0 | Ja,Ap,Jy,O | .. | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1 5/16—1 7/16 | .. | .. | .. | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 100—103 | 3 17 8 | June, Dec | 100¼ | .. |
| 10 | 5/0 | West African Telegraph Shares | 10—10½ | 4 15 8 | .. | .. | .. |
| 2½ | .. | West Coast of America | 9/16—11/16 | .. | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100—102 | 3 18 5 | Jan, July | .. | .. |
| 10 | .. | West India and Panama | ⅝—⅞ | .. | May, Nov | .. | .. |
| 10 | 5/0 | Do. 6% 1st Pref. | 8¾—9¼ | 6 11 0 | May, Nov | 8⅞ | .. |
| 10 | .. | Do. 6 per Cent. 2nd Pref. | 6½—7½ | .. | May, Nov | 7 | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 101—104 | 4 16 2 | Jan, July | 101 | .. |
| 10 | 5/0 | Western Telegraph ........xd & bonus | 14—14½ | 4 16 7 | Mr,Jn,O,D | 14¼ | 14 |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 102—104 | 4 16 0 | June, Dec | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 103—105 | 3 16 0 | .. | 104½ | 103⅞ |
| | | **TELEPHONES.** | | | | | |
| 5 | 5/0 | Chili Telephone (fully paid) | 7½—7¾ | 5 3 8 | August | .. | .. |
| 1 | 0/9¾ | Monte Video Telephone Ord. | 13/16—15/16 | 3 14 5 | .. | .. | .. |
| 1 | 1/0 | Do. 5% Pref. | ⅞—1 | 5 0 0 | .. | .. | .. |
| St. | 6% | National Co. Pref. Stock | 111½—112½ | 5 6 8 | .. | 112⅜ | 111 |
| St. | 5% | Do. Def. Stock | 107—108 | 4 12 6 | .. | 107½ | 106¾ |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13—15 | 4 0 0 | Feb, Aug | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 12—13 | 4 12 4 | Feb, Aug | 12 11/16 | 12½ |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅜—5⅞ | 4 5 2 | Feb, Aug | 5⅞ | 5⅝ |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 97—99 | 3 10 8 | June, Dec | 98⅛ | 97½ |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 104—106 | 3 15 6 | .. | 105½ | .. |
| 1 | 0/7½ | Oriental | 1¼—1⅜ | 3 12 9 | April, Oct | 1 9/32 | .. |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1 3/16—1 5/16 | 4 11 6 | .. | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 102—105 | 4 5 9 | .. | .. | .. |
| 5 | 5/0 | United River Plate | 7—7½ | 5 6 8 | July | 7 5/16 | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅜—5⅝ | 4 8 10 | June, Dec | .. | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 110—112 | 4 10 3 | June, Dec | .. | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 4¾—5¼ | 5 14 4 | .. | .. | .. |
| 10 | 2/0 | Globe Telegraph and Trust | 10½—10¾ | 5 0 8 | Ja,Ap,Jy,O | 10¾ | 10½ |
| 10 | 2/0 | Do. 6 per Cent. Pref | 14⅛—14⅜ | 4 8 0 | Ja,Ap,Jy,O | 14¼ | 14 1/16 |
| 10 | 6% | Submarine Cables Trust (Cert.) | 125—128 | 4 13 9 | April, Oct | 125 | .. |

| Share. | Last Dividend | Name | Price Wed., Nov. 15. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Week to Nov. 15. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12¼—12¾ | 5 9 10 | .. | .. | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10⅜—10⅝ | 4 4 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11¼—11¾ | 4 18 0 | .. | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 107—109 | 4 2 6 | .. | .. | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 102—105 | 4 5 9 | .. | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 9½—10 | 5 0 0 | .. | 9¾ | 9½ |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 9½—9¾ | 3 11 9 | Mar, Sept | .. | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 105—108 | 3 14 1 | .. | .. | .. |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 6⅞—7⅜ | 4 8 0 | Feb, Aug | 7⅛ | 7 1/16 |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5½—5¾ | 3 18 3 | Feb, Aug | 5 25/32 | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 103—105 | 3 16 2 | .. | 104½ | 103⅝ |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4¾—5 | 4 10 0 | .. | .. | .. |
| 5 | 2/3 | Do. Do. (1908) | 4¾—5 | 4 10 0 | .. | 4 15/16 | .. |
| 5 | 2/8 | Chelsea Electric Supply Ord. | 6—6½ | 4 12 0 | March | 6⅛ | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 110—112 | 4 0 4 | Jn, Dec | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 11¾—12¼ | 4 18 0 | Feb, Aug | 12⅛ | 11 15/16 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13¾—14¼ | 4 4 2 | Jan, July | 13 9/16 | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 124—128 | 3 18 1 | Jn, Dec | .. | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 104—106 | 4 4 10 | .. | .. | .. |
| 5 | .. | County of Durham Elec. P.D. Ord. £2 pd. | 2 3/16—2¼ | .. | April, Oct | .. | .. |
| 5 | 6¾d. | Do. Do. 5% non cum. pref. | 5¼—5½ | .. | April, Oct | .. | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 9¾—10¼ | 4 7 10 | .. | 10 | 9 13/16 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅜—12⅞ | 4 13 2 | Mar, Sept | 12 11/16 | 12½ |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 111—114 | 3 18 11 | .. | .. | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 102—104 | 4 6 7 | .. | .. | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5—5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101—104 | 4 6 6 | .. | .. | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8¼—8¾ | 4 17 2 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100—103 | 4 7 5 | .. | .. | .. |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 11¼—12 | 5 0 0 | .. | 11⅝ | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½—7 | 4 5 9 | Jan, July | .. | .. |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98—101 | 3 19 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101—103 | 3 17 8 | .. | .. | .. |
| 3 | 1/9⅜ | London Electric Supply Ord. | 1¾—2¼ | 4 0 0 | .. | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5—5¼ | 5 14 4 | .. | 5 3/16 | 5 1/16 |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 99—102 | 3 18 5 | Mr,Jn,S,D | .. | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 10—10½ | 5 4 9 | April, Oct | 10¼ | 10⅛ |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5⅝—5⅞ | 3 16 8 | Jan. July | 5 23/32 | 5 21/32 |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 109—113 | 3 19 7 | Jn, Dec | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 97—99 | 3 10 8 | .. | .. | .. |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 101—103% | 4 7 5 | .. | 102¼ | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 12½—12¾ | 5 19 1 | Feb, Aug | .. | .. |
| 100 | .. | Do. 4½% Deb. | 104½—106½ | .. | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8⅛—8¼ | 4 18 2 | Feb, Aug | 8¼ | 8⅛ |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6¼—6½ | 3 18 6 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99—100 | 4 0 0 | Jan, July | .. | .. |
| 1 | 3% | Northern Counties Elec. Sup. 17/- paid | 13/16—27/32 | 3 1 1 | Mar, Aug | .. | .. |
| 100 | .. | Do. 4½% Deb. | 100½—101½ | .. | Jan, July | .. | .. |
| 10 | 6/0 | Notting Hill Electric Ord. | 14—15 | 4 0 0 | March | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98—100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅜—6⅞ | 5 1 6 | March | .. | .. |
| St. | 4% | Do. 4% Deb. Stock | 100—102 | 3 18 5 | .. | .. | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 13¾—14¼ | 5 1 9 | Feb, Aug | 13¾ | 13½ |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 8¼—8¾ | 3 16 0 | Feb, Aug | 8⅝ | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 98—100 | 3 10 0 | .. | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2—2½ | 8 0 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76—80 | 5 0 0 | .. | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 3½—4 | 6 0 0 | .. | .. | .. |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | 1⅜—1⅝ | .. | .. | .. | .. |
| 1 | 0/8¾ | Do. 7% Cum. Pref. | 1 5/16—1 7/16 | 4 17 2 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105—108 | 4 3 8 | .. | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4½—4¾ | 5 5 3 | .. | .. | .. |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5—5¼ | 4 15 3 | .. | 5⅛ | 5 3/32 |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 104—106 | 4 4 10 | .. | .. | .. |
| 5 | 6/6 | Westminster Electric Supply Ord. | 12¼—12¾ | 5 8 4 | Mar, Sept | 12¾ | 12½ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 6—6½ | 3 16 11 | .. | 6½ | 6⅛ |
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝—⅞ | 5 6 6 | .. | .. | .. |
| 1 | 6d. | Aron Elec. Meter 6% Cum. Pref. | ½—⅝ | .. | .. | 9/16 | .. |
| 1 | 1/7⅛ | Babcock & Wilcox Ord. | 1¾—2 | 5 0 0 | .. | .. | .. |
| 1 | 7½d. | Do. Pref | 1 7/16—1 9/16 | 3 16 10 | .. | .. | .. |
| 5 | 4/0 | British Insulated & Helsby Cables Ord. | 6¾—7¼ | 5 10 3 | July, Feb | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾—6¼ | 4 16 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103—106 | 4 4 11 | .. | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98—100 | 4 10 0 | .. | .. | .. |
| 5 | 3/0 | British Westinghouse 6% Pref. | 2¼—2⅝ | 11 4 6 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 85—89 | 4 9 11 | .. | 86½ | .. |
| 2 | .. | Brush Electrical Engineering | ½—¾ | .. | March | ⅝ | .. |
| 2 | 2/4½ | Do. 6 per Cent. Pref. Non-Cum. | 1½—1¾ | 6 17 2 | Mar, Sept | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 93—97 | 4 12 10 | Mar, Sept | .. | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 77—80 | 5 12 6 | Jan, July | .. | .. |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11—12 | 5 0 0 | Jan, July | 11⅝ | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅜—5⅞ | 4 5 2 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 109—111 | 4 1 1 | Nov, May | .. | .. |
| 1 | 4¾d. | Castner-Kellner Alkali Co. | 1—1⅛ | 5 7 0 | .. | 1 1/32 | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 97—102 | 4 8 3 | .. | 100 | .. |
| 1 | 9⅛d. | Chadburn's (Ship) Telegraph Ord. | 1 3/16—1 5/16 | 4 10 6 | .. | .. | .. |
| 1 | 7⅛d. | Do. 6% Cum. Pref. | 1 1/16—1 3/16 | 5 2 7 | .. | .. | .. |
| 3 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 1⅝—1⅞ | 3 15 8 | Jan, July | 1¾ | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 94—99 | 5 1 0 | Jan, July | .. | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord | 8½—9 | 5 11 1 | Sept | 8 23/32 | .. |
| 5 | 3/0 | Do. 6% Cum. Pref. | 5¾—6¼ | 4 18 0 | Sept | 6 1/16 | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106—108 | 4 4 1 | .. | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅜—1⅝ | .. | Feb, Aug | .. | .. |
| 5 | 2/6 | Do. (£5 paid) | 2—2½ | .. | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 85—90 | 4 8 11 | June, Dec | .. | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92—97 | 5 3 1 | .. | .. | .. |
| 5 | 4/6 | Edmundson's Elec. Corp. Ord. | 5½—6 | 5 16 8 | H'lf-yearly | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 6—6¼ | 4 16 0 | .. | 6 3/32 | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 108—110 | 4 1 6 | .. | 109 | .. |
| 2 | 1/7½ | Electric Construction Co. | ⅝—⅞ | 8 0 0 | July | .. | .. |
| 2 | 2/9⅜ | Do. 7 per Cent. Cum. Pref | 1⅞—2⅜ | 5 18 8 | July | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 92—95 | 4 4 2 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9½—10 | 5 0 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96—100 | 4 0 0 | .. | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 12—13 | 5 15 5 | Feb, Aug | 12⅝ | .. |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5—5¼ | 4 4 6 | Feb, Aug | 5¼ | .. |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | 109—111 | 4 1 1 | Feb, Aug | .. | .. |
| 10 | 5/0 | India Rubber, Gutta Percha, &c., Wrks. | 16—17 | 2 18 9 | Feb, Aug | 16⅜ | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99—102 | 3 18 5 | Mar, Sept | .. | .. |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¼—11¾ | 4 5 1 | Mar, Sept | .. | .. |
| 15 | 12/0 | Telegraph Construction & Mainten'ce. | 32—34 | 5 5 10 | Mar, July | 33½ | .. |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 102—104 | 3 16 11 | Jan, July | .. | .. |
| 5 | — | Willans and Robinson Ord. | 1¼—2 | .. | Apr, Oct | 1⅞ | .. |
| 5 | — | Do. 6 per Cent. Cum. Pref. | 2½—3½ | .. | Apr, Oct | 3¼ | .. |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 85—90 | 5 0 0 | May Nov | .. | .. |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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In Plates
In Cubes
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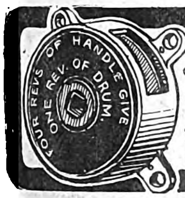
**EDUARD ELBOGEN,**
*Proprietor of Steatite Mines,*
**VIENNA 3/2, AUSTRIA.**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AN IMPROVED WINCH FOR ARC LAMPS OR OTHER LIGHT WEIGHTS. CONTAINS A NEW MECHANICAL MOVEMENT

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SELF SUSTAINING.
NO GEARWHEELS
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ALWAYS LOCKED.

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Sole Manufacturers of FRANKLIN'S
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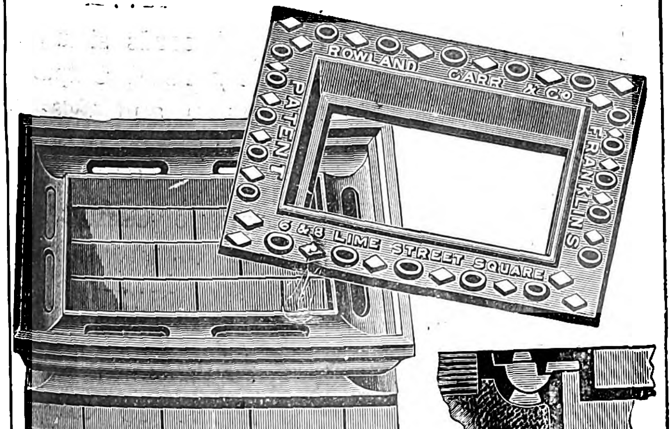

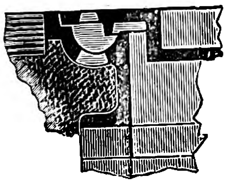

IMPORTANT to Consulting and Electrical Engineers. The FRANKLIN FRAME and COVER ensures a perfectly ventilated pit, excludes all water therefrom, prevents gas, or other explosions.

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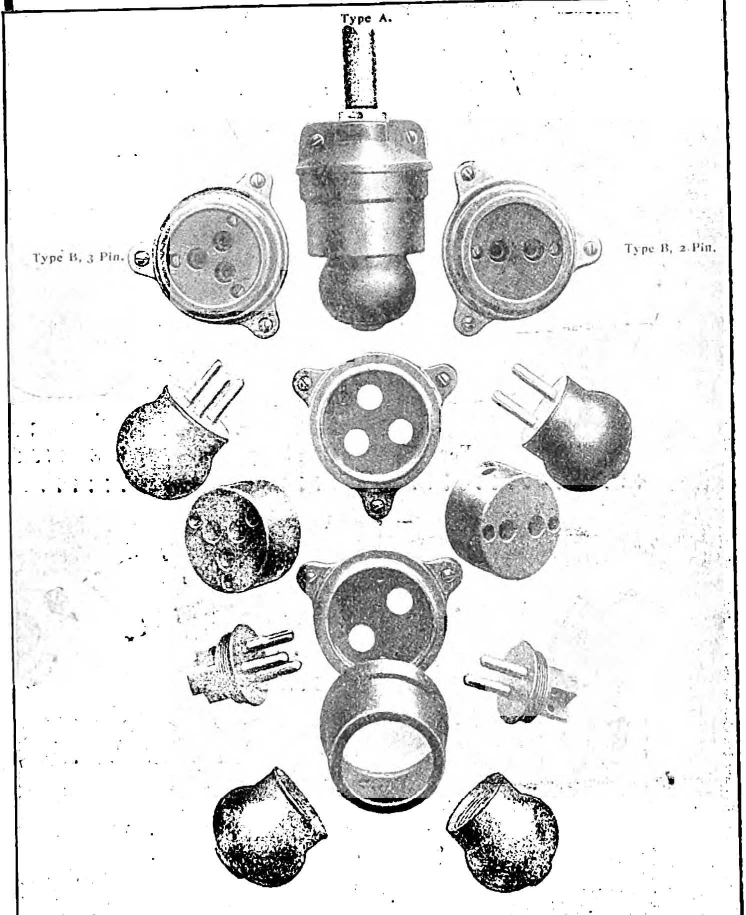

The strength of these Wall Plugs attracted considerable attention at the recent Electrical Exhibition. We threw them up into the air and let them fall heavily upon the bare and hard floor of the Hall without fear of injury—to the plugs.

Many Engineers expressed very decided opinions in favour of these designs for use in shipyards, theatres, workshops, and other places, where such apparatus is subjected to very rough usage; the prices were also discussed, and were considered by the majority to be exceedingly LOW.

**A. REYROLLE & CO., LTD.,**
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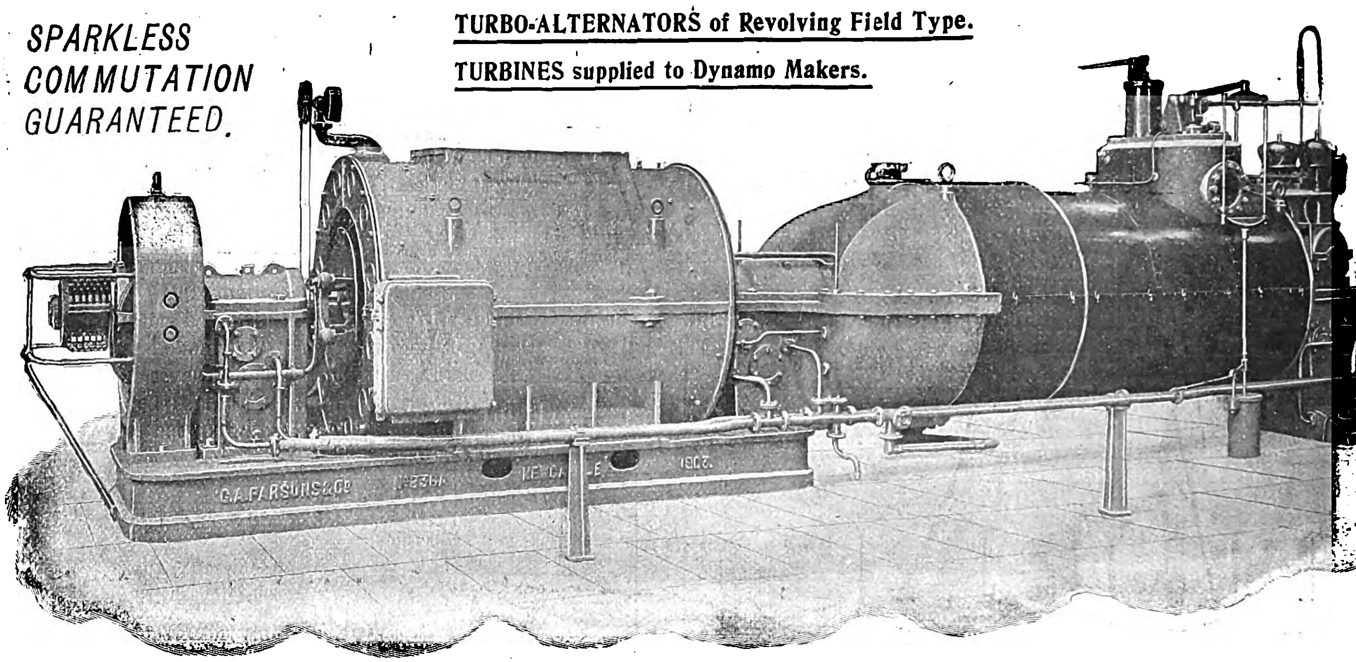
**STEAM TURBO-DYNAMOS** FOR CONTINUOUS CURRENT.

TURBO-ALTERNATORS of Revolving Field Type.

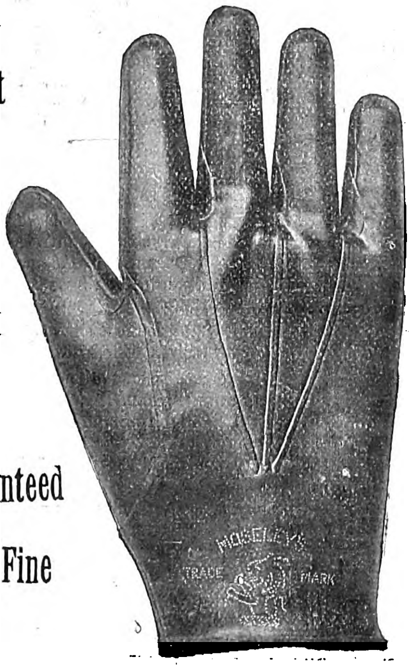
TURBINES supplied to Dynamo Makers.

SPARKLESS COMMUTATION GUARANTEED.



2,000kw. THREE-PHASE ALTERNATOR, 40 Periods 6.000 Volts.
For the NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY COMPANY'S CARVILLE POWER STATION.

**MOSELEY'S**
SPECIALLY ADAPTED FOR ELECTRICIANS.
**RUBBER GLOVES.**



Perfect Fine Soft Finish.
Never Harden.
Stand any Climate
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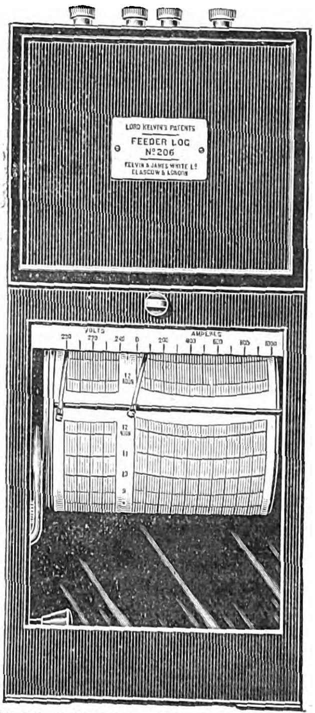
SPECIALLY ADAPTED FOR USE ON B.O.T. TRACTION PANELS.



Records simultaneously Total Output of Station and 'Bus bar Volts; or Leakage Current, and Rail Volt Drop.

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WANTED, THREE DYNAMOS, one 100 volts, two 200 volts, about 4 H.P.—Write, X. Y. Z., at Horncastle's, Cheapside, E.C.

WANTED, 20 kw. ALTERNATING SET, 100 periods, 2,000 volts, fixed armature.—J. G. Childs & Co., Ltd., Willesden Green, London, N.W.

WANTED, good second-hand Enclosed HIGH-SPEED ENGINE, forced lubrication, 200 kw.—State lowest price, age and history, to C. P. G., *Electrician* Office, Salisbury-court, Fleet-street, London.

WANTED.—LIGHTING BATTERY for 110-volt circuit and REGULATING SWITCHBOARD.—Particulars to Rose Bros., Albion Works, Gainsborough

GENERATING SET, second-hand, WANTED, about 100 H.P., two-phase, 200-250 volts, or engine only, suitable for attaching alternator.—Full particulars, measurements, age, price, &c., to K. X., care of J. W. Vickers, 5, Nicholas-lane, London, E.C.

WANTED, OLD COPPER and other METALS and ASHES. Good prices given.—Daw, Tudor Refinery, Llanelly.

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## MISCELLANEOUS PLANT, &c., FOR SALE.

DYNAMO for SALE (unused), 208 amperes, 120 volts, 900 revs., by Kummer & Co., Dresden.—Offers to the Director, Salvation Army Printing Works, St. Albans.

2 KW. Shunt-wound DYNAMO ALTERNATOR, by A. H. Avery, slotted drum, armature wound for 50 volts, 40 amperes; continuous-current shunt RHEOSTAT, slide rails complete.—Barrington, 17, Stoke Newington Common, London, N.

FOR SALE.—Good CABLE FLOAT, with pole and shaves; carry 4 tons. Excellent repair.—T. Mansell, Contractor, Electricity Works, Weybridge.

EVERSHED TESTING SETS, 200 volts, in perfect condition. £13 each net.—R. Archer, Horsforth, Leeds. Telephone 086.

FOR SALE or HIRE, high-class Dynamos, Motors, Alternators, Cable and Electrical Apparatus.—Percy Huddleston & Co., 72, Finsbury Pavement, London, E.C.

**GLASS SHADES for Electric Lighting in every variety of design and colour.—JOHN WALSH WALSH, Glass Manufacturer, Birmingham.**

INSTRUMENTS ON HIRE. Write for Scale of Fees.—Westminster Electrical Testing Laboratory, York Mansion, York-street, Westminster, London, S.W.

NOW READY.—The "Practical Engineer" ELECTRICAL POCKET BOOK AND DIARY for 1906. Price 1s. 6d., postage 2d. Contains 440 pages of valuable data, tables, &c., in handsome binding with gilt edges, pocket and elastic band.—Technical Publishing Co., Limited, 287, Deansgate, Manchester, and all Booksellers.

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## TENDERS INVITED.

### BOROUGH COUNCIL OF ST. PANCRAS.

TENDERS are invited for Supplying **LEAD-COVERED** and **ARMOURED CABLES.**

Copy of Specification, Conditions of Contract and Form of Tender to be obtained upon application to the Chief Clerk, Electricity Department Offices, No. 57, Pratt-street, N.W., on payment of a deposit of £2, which will be returnable only on receipt of a bona fide Tender.

Tenders to be sent to the undersigned, endorsed "Tender for Cables," by 12 o'clock noon on THURSDAY, the 30th November, 1905.

The Council do not bind themselves to accept the lowest or any Tender.

Town Hall, Pancras-road, London, N.W., C. H. F. BARRETT, Town Clerk.
21st November, 1905.

### ILFORD URBAN DISTRICT COUNCIL.

The Council is prepared to receive TENDERS for the Supply of **·5 in. TRIPLE-CONCENTRIC ARMOURED CABLE.**

Copies of the Specification, Conditions and Form of Tender may be obtained on application to Mr. Arthur H. Shaw, M.I.E.E., Electrical Engineer to the Council, Electricity Works, Ley-street, Ilford, on and after Monday next, the 27th instant.

Tenders, addressed to the Chairman, and endorsed "Tender for Cable," must be sent to the undersigned on or before TUESDAY, the 12th day of December, 1905, at 4 p.m.

The Council does not bind itself to accept the lowest or any Tender.

Town Hall, Ilford, Essex, JOHN. W. BENTON, Clerk to the Council.
23rd November, 1905.

### GLASGOW CORPORATION.

ELECTRICITY DEPARTMENT.

**MOTOR GENERATORS AND SWITCH GEAR.**

The Corporation invite TENDERS for the Supply of (1) 1,000 kw. MOTOR GENERATORS, and (2) HIGH and LOW-TENSION SUB-STATION SWITCH GEAR. Offerers must be able to show plant similar to that for which they tender.

Copies of the Specifications and Forms of Tender may be obtained on application to Mr W. W. Lackie, Engineer, 75, Waterloo-street, Glasgow, on payment of a deposit of One Guinea for each Specification. Deposits will be returned on receipt of a bona fide Tender.

Sealed Offers, marked "Electricity Department, Tender for.........," must be lodged with the Subscriber on or before MONDAY, the 4th December, 1905.

The Corporation do not bind themselves to accept the lowest or any offer.

City Chambers, Glasgow, JOHN BOWERS, Town Clerk.
21st November, 1905.

NORTH EASTERN RAILWAY.—TENDERS FOR TELEGRAPH STORES.—The Directors are prepared to receive TENDERS for the undermentioned **ARTICLES**, in such quantities as they may require, during the 6 or 12 months from 1st January, 1906, delivered carriage paid at the Company's Telegraph Stores at York:—1. Telegraph Apparatus. 2. Telegraph Wire and Line Stores. Payment for each month's delivery will be made at the end of three clear months, or in cash less 2½ per cent. discount. Forms of Tender may be obtained on application to Mr. C. H. Ellison, the Company's Telegraph Superintendent. York, and Tenders must be sent in to the Secretary at York, sealed and marked "Tender for Telegraph Stores," not later than 9 a.m. on SATURDAY, 2nd December. The Directors do not bind themselves to accept the lowest or any Tender.

York, 16th November, 1905. R. F. DUNNELL, Secretary.

**Royal Doulton Potteries.**

**INSULATORS**

AND ALL KINDS OF

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MANUFACTURING PREMISES, recently erected to meet the requirements of the L C. Council. Basement and four floors. Fitted crane and loop doors.—TILLEY, 87, Forest-road, Dalston, London, N.E.

TO BE LET, FACTORY PREMISES, substantially-built brick and slated building of three floors, each 4,200 super ft. Lift, water and gas each floor. Chimney shaft in engine house, adjoining, on ground floor. Lease about 17 years, £250 per annum. Also long iron-roofed Shed, 150 ft. by 30 ft., suitable for storage, motor garage, or repairing factory, &c. Lease about 17 years, £100 per annum. Also large open Space, 81 ft. frontage to Bow Common-lane, about 6,000 super ft. Lease about 17 years, £60 per annum. Can be seen any time.—Apply on Premises, Invicta Mills, Bow Common-lane, London, E.

MANUFACTURING PREMISES.—Ground and first floor, 56 ft. by 14 ft., very light, and yard 14 ft. by 32 ft.; gateway in main road; near railway goods yard; also two rooms, suitable for office or living rooms, if required; every convenience.—Apply FRED COUSINS, Wedmore-street, Upper Holloway, London, N.

WAREHOUSE (31 and 32, Eagle-street, Holborn), large, modern, just built, comprising basement and four floors, to be LET, in floors or as a whole, on lease or agreement. Well lighted Concrete floors throughout; crane each floor. Latest sanitary improvements. Situated between Kingsway and Red Lion-street. Suitable for light or heavy trade For full particulars and keys, write the OWNER, Mr. Skivington, 34 and 35, Norfolk-street, Strand, London, W.C.

MOTOR MANUFACTURING WORKS, situated in the S.E. of London, in busy and high-class neighbourhood. Complete plant, suitable for the building of small cars, consisting of the latest American automatic machinery, driven by 11 H.P gas engine. Patterns and castings for building up-to-date, light car, electric light and charging plant The premises consist of 4,860 sq. ft floor space. On the ground floor machine shop and erecting and smiths' shops. On first floor fitting and pattern shops, drawing and other offices. Rent £65 per annum —Address, C. P. L., *Electrician* Office, Salisbury-court, Fleet-street, London.

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SOLE AGENT FOR **E.P.S. SMALL STORAGE BATTERIES** FOR Sale or Hire.
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Battery Makers by appointment to His Majesty the King.

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Manufacturer of
ELECTRICAL AND PHYSICAL INSTRUMENTS.
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Age of applicants must not exceed 35 years.

Commencing salary £600 per annum.

Applications, with six copies of testimonials and health certificate must be sent not later than 15th DECEMBER, 1905, to the AGENT-GENERAL FOR CAPE COLONY, 100, Victoria-street, London, S.W., from whom further particulars can be obtained.

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ELECTRIC FITTINGS.—SOLE AGENCY WANTED in London for up-to-date house. City office and showrooms. First-class connection, highest references.—Address 5964, *Electrician* Office, Salisbury-court, Fleet-street, London.

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*Three Lines and under (Minimum)* ... — — 1s. 6d.
*Per Line after* ... ... ... — — — 6d.

Ten Words to the Line.

### SITUATIONS WANTED.

*Sixpence per Line of Ten Words, minimum One Shilling.*

Where answers to any of the above Advertisements are to be sent to the Publishing Offices to be forwarded, the sum of 3d. must be sent with the order to pay for postage of these replies. Six Words must be allowed for the address of the Publishing Offices.

## SITUATIONS, &c., VACANT.

SHOP SUPERINTENDENT.—Messrs. VICKERS, SONS & MAXIM, LIMITED, River Don Works, Sheffield, require the services of a thoroughly capable and experienced Superintendent for their electrical manufacturing shops. Applications only considered from persons who have held a similar position in a modern shop manufacturing large and small generators and motors, both A.C. and D.C., preferably with turbo-generator experience. Duties: to control the foremen and labour, tool room, and all mechanical work, but not the winding and insulating department.—Apply, as above, stating age, past experience, salary required and when at liberty, giving at least one reference.

MANAGER WANTED for an Electrical Manufacturing Firm, who are full up with orders; strictest investigation allowed; will require to take entire charge of works; must be thoroughly capable and preference will be given to one able to invest capital.—Letters, B. S. R., 5,952, *Electrician* Office, Salisbury-court, Fleet-street, London.

MAINS ENGINEER REQUIRED for Power Co. in the North of England. Must have had thorough experience in high-tension, three-phase work. Apply, stating age, experience and salary required, and also copies of testimonials, by letter, to C. P. B., *Electrician* Office, Salisbury-court, Fleet-street, London.

ELECTRICAL TESTER and INSPECTOR REQUIRED for Switch Gear. Must be accustomed to general testing (high and low-tension).—Send details of previous experience, wages expected and testimonials, to C. P C., *Electrician* Office, Salisbury-court, Fleet-street, London.

SUB-STATION ATTENDANTS.—WANTED immediately, a few charge hands for sub-stations, preferably used to three-phase rotaries and high-tension work. London district. State age, experience, money required and whether free to join at once.—5,959, *Electrician* Office, Salisbury-court, Fleet-street, London.

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WANTED, a few good ELECTRICIANS, accustomed to motor work; permanent situations for suitable men.—Applications to the EBBW VALE STEEL, IRON AND COAL COMPANY, LTD., Ebbw Vale, R.S.O., Mon.

ELECTRICAL ENGINEER.—Thoroughly capable man WANTED to manage branch office of first-class firm of lighting and power contractors. Excellent opening for energetic man.—K 79, Keith's, 59, George-street, Edinburgh.

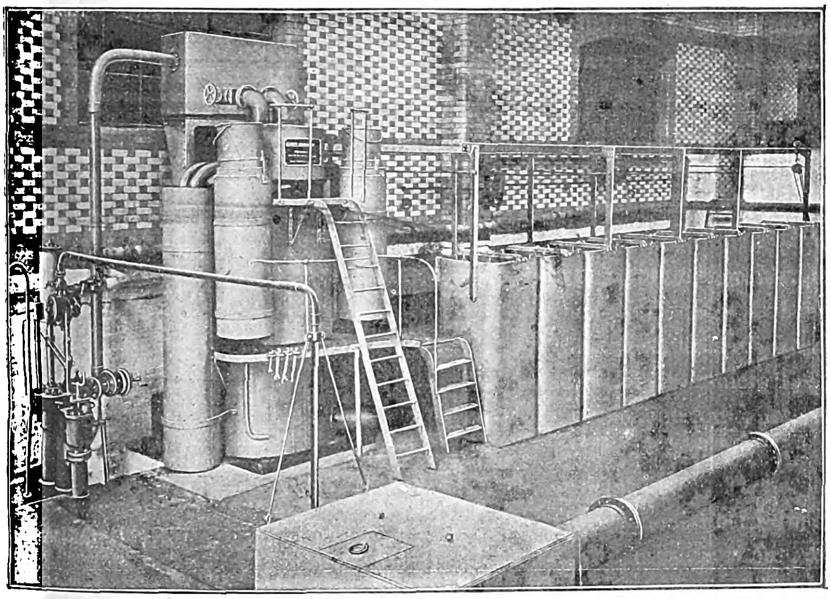
SITUATIONS VACANT, &c., continued on page xvi.

**NO MORE COLLAPSED FURNACES OR BUCKLED TUBES**

THROUGH GREASE

IF YOU PURIFY THE CONDENSED WATER

WITH THE "HARRIS-ANDERSON" PURIFIER.



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Telegrams: WINDTIGHT SUNDERLAND. Telephone 569

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Telegrams:
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MAKERS OF
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FOR
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COMPLETE EQUIPMENTS
FOR
ELECTRIC DRIVING
OF
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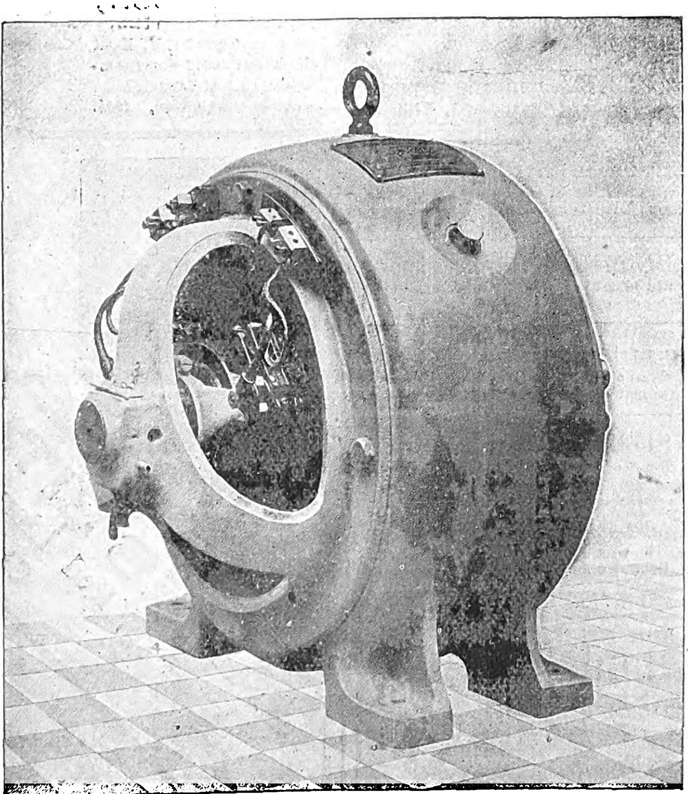

STANDARD SEMI-ENCLOSED MOTOR.

VICKERS' VARIABLE SPEED MOTORS.

SPEED RANGE,
UP TO 6 : 1.

BY SHUNT REGULATION ONLY

FULL POWER at ALL SPEEDS.

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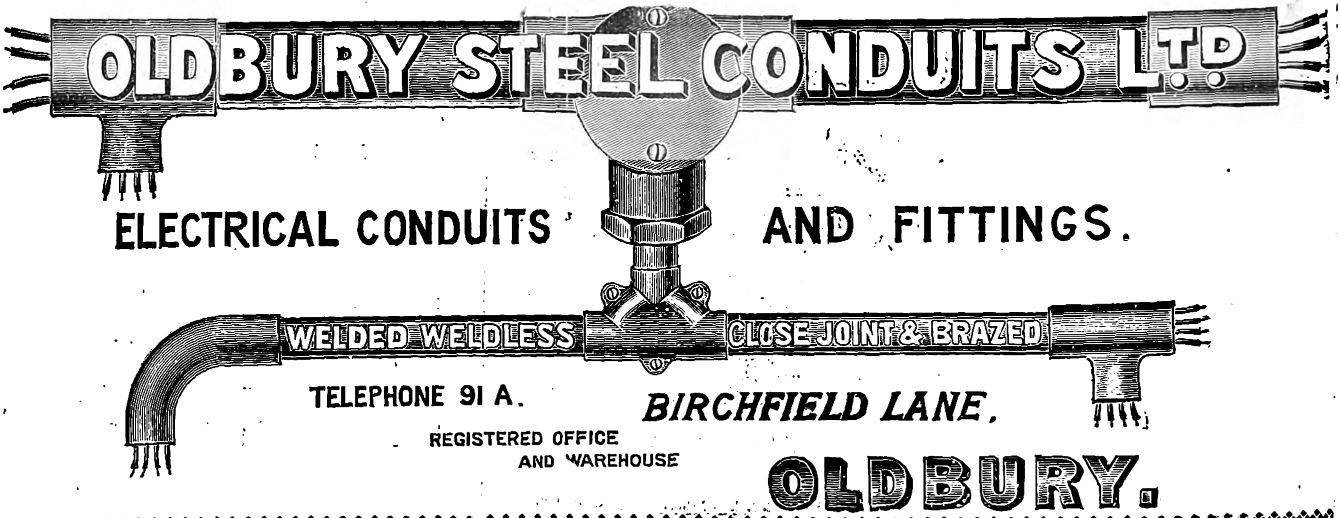

**OLDBURY STEEL CONDUITS LTD**

ELECTRICAL CONDUITS AND FITTINGS.

WELDED WELDLESS CLOSE JOINT & BRAZED

TELEPHONE 91 A.

REGISTERED OFFICE AND WAREHOUSE

BIRCHFIELD LANE, OLDBURY.

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### SITUATIONS, &c., VACANT—*continued.*

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WANTED, at once, young MAN, thoroughly competent to carry out repairs to electric meters.—Application to be made by letter, stating age, full particulars of experience and wages expected, to Box 596, Judd's Advertising Offices, 5, Queen Victoria-street, London, E.C.

### SITUATIONS WANTED.

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YOUNG MAN (20) desires SITUATION in electrical engineer's office, 14 months in charge 28 motors and lights.—Address, S. P., 23, Crouch Hall-road, Crouch End, London, N.

ADVERTISER, young, incandescent lamp maker, cellulose to finished article; capable; alive; would go abroad. Strictest confidence.—Address, 5,961, *Electrician* Office, Salisbury-court, Fleet-street, London.

"The Electric Accumulator." No. 1, Vol. I.

**The ONLY Storage Battery Paper.** Jan. '06.

*Particulars:*—8, St. Ann's Road,
Telegrams: ELECTROLYT. WANDSWORTH, LONDON, S.W.

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**MOTHERWELL, N.B.**
— *See Illustrated Advertisement last week.* —

**VACUUM TUBE DETECTOR for HIGH-TENSION MAINS**
Works on any Voltage above 2,000. **Price 10s. 6d.**

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**54, Farringdon Rd., LONDON, E.C.**
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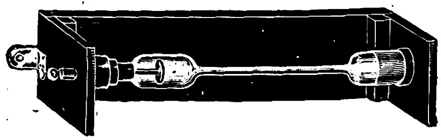
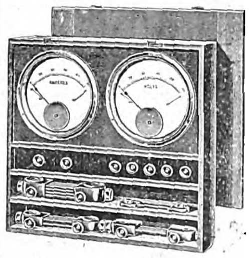
*GOLD MEDAL,*
*St. Louis Exhibition, 1904.*





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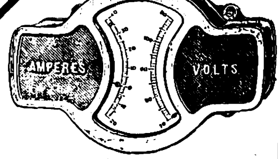
**56, Red Lion Street,**
**CLERKENWELL, LONDON.**



**AUTOMOBILE TYPE.**
*As described in last week's "ELECTRICIAN."*

**Write for Lists.**

# THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,436. [No. 6. Vol. LVI.] FRIDAY, NOVEMBER 24, 1905. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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## NOTES.

THE Inaugural Addresses delivered by the various Chairmen of the Local Sections of the Institution of Electrical Engineers this year make most interesting reading. The Leeds and Dublin addresses have already appeared in our columns, and we publish this week those read at Manchester, Glasgow, and Newcastle. In Birmingham Prof. THRELFALL put his address in the form of an interesting Paper "On Some Problems of Electro- and Electro-Thermal Chemistry," the publication of which we reserve for our next issue. No fault can be found with his choice of a special subject, but Mr. PEARCE'S general survey of the year's work and Mr. MUNRO'S polemical, historical and speculative discourse deserve equal commendation. The shorter addresses of Mr. MOUNTAIN and Dr. THORNTON are valuable as giving the views of the respective authors on matters upon which they are in a position to speak with authority, and Mr. SHEARDOWN opened the session in Dublin in a useful way by calling attention to those Papers read before the International Electrical Congress at St. Louis which were issued too late to receive, at the time, the general notice they deserved. The home centre of the Institution is equally fortunate in its Presidential Address and in the first Paper read yesterday and partly published in our present issue, and we have good reason to hope that the new session, so happily inaugurated all over the country, will continue to be productive of good work.

AN interesting situation has arisen at Belfast in connection with the new tramways undertaking there. It appears that everything is in order for the opening of the service, with the sole exception of the condensing plant in the generating station. A proposal was therefore made by Mr. V. A. H. M'COWEN, the city electrical engineer, to conduct 12-hour trial runs of the new 1,000 kw. engines when running at full load, non-condensing. This brought a protest from the engine builders, who maintained that the specification did not call for engines capable of developing full load for a lengthy period when running non-condensing. Mr. M'COWEN holds that the engines must be capable of doing this. If the engines are designed to run under the most economical conditions at full load and condensing, then full load will not be their most economical load under non-condensing conditions, and it may be, as it would appear to be in this case, that their rating would not be sufficiently high to run continuously at full load without condensers. In some cases arrangements are provided by which live steam is admitted to the intermediate cylinder in the event of a breakdown of the condensing plant, but, as the makers point out, this is not a condition for permanent running, and must only be regarded as an emergency measure. On the other hand, if the engines, when condensing, will run on their overload rating for long periods at a time, there should be no reason why they should not supply full load non-condensing for similar periods. These matters are all so well known that there should not be room for any doubt in a properly-worded specification; and, if there are two possible interpretations of the specification, the engine-builders or contractors should, when they tender, make it clear what they propose to supply. We trust that an amicable understanding will be come to between the two parties without an endeavour to enforce compulsory measures, in spite of the correspondence and reports, extracts from which we publish elsewhere in this issue.

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IN an article on "Parker" dynamos on p. 214 of this issue, attention is drawn to the possibility of varying the speed of continuous-current motors fitted with auxiliary poles by simply shifting the brushes, the commutation remaining sparkless all the time. Too much stress need not be laid on this property, however, for it must not be forgotten that a shifting of the brushes out of their "best" position always leads to a reduction of the efficiency. As soon as the brushes are given a lead or a lag relative to the best position, the motor is no longer running at its best, for the current density in the contact area between brush and commutator is now not uniform, and the commutator losses have increased accordingly. The actual increase in $C^2R$ losses under the brushes is a function of many variables, but may be readily calculated when all the data of the machine are known. It is safe to say, however, that the usual methods of speed regulation are more economical, and of course they admit of being applied over a far greater range of speed. In fact, one of the reasons for the adoption of auxiliary poles is to enable wide speed variation to be effected with the ordinary field rheostat without its being necessary to shift the brushes to avoid sparking. The other reason for this special construction, applicable in the case of generators as well as motors, is to diminish the size and cost of those machines which have hitherto had to be designed on the basis of the limit due to sparking instead of that due to temperature rise only.

◆

A LETTER from Mr. J. B. CLARKE, late electrical engineer to the Stourbridge Urban District Council, recalls one of the earliest refusals of the Local Government Board to sanction a loan for a municipal electric supply undertaking where the circumstances did not warrant a large capital outlay. In 1904 an application by the Stourbridge Council for a loan with which to erect a generating station was adjourned by the Local Government Board Inspector in order to give the Council an opportunity to ruminate upon the advantages of a bulk supply from the Midland Electric Corporation for Power Distribution. This was a course which we approved, but when the Council came for a loan for distributing mains and sub-station plant, the Local Government Board discovered that the Midland Electric Corporation had no statutory powers to supply in Stourbridge. Subsequently the Council opened negotiations with the Shropshire, Worcestershire & Staffordshire Electric Power Co., which has powers to supply in bulk in the area. A draft agreement had been drawn up in which the price was stated at 2·5d. per unit for lighting and 1d. per unit for power, and it was this agreement which was referred back at the Council meeting on Monday. The wording of the amendment is mysterious, for very detailed estimates were prepared by Mr. CLARKE in April and June, 1904, for a generating station erected by the Council, and with regard to distributing a bulk supply. However, local circumstances have determined the issue, and we will neither congratulate, nor sympathise with, the ratepayers of Stourbridge. Unless the Board of Trade grants an extension of time, the Stourbridge Provisional Order will expire on December 31, 1905. In any case the Shropshire, Worcestershire & Staffordshire Power Co. would hardly have been ready to supply by that date.

◆

THE motor car show now being held at Olympia is not very encouraging so far as electrically-driven cars are concerned. Indeed, the number of such vehicles exhibited is extremely small, and appears quite insignificant compared with the huge number of petrol cars. Moreover, there are no more—probably less—than there were at last year's exhibition, while two or three years ago there was a greater number exhibited at other shows. Two possible reasons exist for this lamentable shortage; one is that manufacturers are too busy, and the other is that they are not. Either they cannot spare the time to exhibit, or they cannot afford the money. We hope the former explanation is the correct one. It is excessively disappointing to find that the electric motor car industry is in the condition that it is, after the prognostications of a brilliant future which were made a few years ago. Apparently, the hopes so frequently expressed were forlorn ones, and it does not seem that their consummation is much nearer now than it was twelve months ago. It is true that the industry has much to contend with, not the least obstacle being the absurd and vindictive order prohibiting all motor cars, including those driven by electricity, from entering Hyde Park between the hours of 4 p.m. and 7 p.m. during the months of May, June and July. Even if there had been any justification for this order as applied to petrol cars, it was a sheer injustice to shut out the "harmless necessary" electric car, and we are glad to announce that this order no longer applies to electric carriages.

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WE are glad to note that the London County Council is at last about to consider the expediency of diminishing the period for electric lighting loans to London Borough Councils. The Local Government Board has for some time past realised that it was wrong to allow a full 42 years period for the repayment of loans on plant whose life was a far shorter one. The period would not be too long if proper sums were set aside for depreciation, but this is not done in the majority of cases.

◆

**Royal Society.**—Among the Papers down for reading yesterday was the following: "On the Nature of the Galvanotropic Irritability of Roots," by Dr. A. J. Ewart and Miss Bayliss, communicated by Francis Darwin.

**Royal Meteorological Society.**—The Council of the Royal Meteorological Society have awarded the Symons Gold Medal to Lieut.-Gen. Sir Richard Strachey, R.E., G.C.S.I., F.R.S., in recognition of the valuable work which he has done in connection with meteorological science. The medal will be presented at the annual general meeting of the society on January 17, 1906.

**Cable Interruptions and Repairs.**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Tarifa—Tangier | Jan. 18, 1904 | — |
| Jamaica—Colon | Jan. 10, 1905 | — |
| Cadiz—Teneriffe | July 20, 1905 | — |
| Kotonou—Grand Bassam | Oct. 4, 1905 | Nov. 18, 1905 |
| Oran—Tangier | Oct. 30, 1905 | Nov. 22, 1905 |
| Tangier—Cadiz | Oct. 30, 1905 | — |

**London Electrical Contractors' Association.**—Mr. J. McDermott, as announced in the "Arrangements for the Week" in our last issue, was down to read a Paper on "Workmen's Cards" before the London Electrical Contractors' Association on Tuesday. At the last moment Mr. McDermott was called upon to fulfil an important engagement, and was unable to read his Paper. The meeting was therefore postponed until a future date, notice of which will be given in due course.

**The Pacific Cable.**—A Reuter telegram from Melbourne on November 16th, published in last Friday's *Times*, reports that in reply to a question in the Commonwealth Senate on that day, the Australian Postmaster-General stated that negotiations were proceeding with the Pacific Cable Board and the Eastern Extension Telegraph Co. with a view to pooling the receipts. The Government would not consent to any agreement until Parliament had been afforded an opportunity of considering the matter.

**Telephonic Communication with the Continent.**—A copy of a resolution passed by the Association of Chambers of Commerce, at its Liège meeting this year, dealing with the question of increased telephonic communication with the Continent, having been sent to Lord Stanley, the Postmaster-General, a reply has been forwarded in the following terms. Whilst fully appreciating the importance to the mercantile community of direct and more efficient telephonic communication with the Continent, the Postmaster-General points out that he fears that the difficulties in connection with long-distance telephony are not fully understood. In the telephone service there is a limit beyond which it is at present impossible to carry on conversation. Before arrangements were concluded for the use of Anglo-French and Anglo-Belgian telephone lines by subscribers outside the respective capitals, careful experiments were made to determine the *maximum* limits within which it was practicable to afford a reliable service between this country and France and Belgium. Since then many extensions have taken place and it is now possible for communication to be obtained from Liverpool with over 100 places in France and between Liverpool and Brussels and other places in Belgium. Communication between Liverpool and Antwerp and between this country and Holland, however, was not practicable. Lord Stanley regrets that at present it does not seem possible for him to hold out the hope of any material extension of existing facilities; but further experiments will, from time to time, be made, and he will be glad if, by the advance of science and invention, he is able to meet the views expressed by the Association.

**Petrol Electric Omnibuses in New York.**—The difficult problem of placing automobile vehicles on the famous Fifth Avenue thoroughfare, New York City, as substitutes for the horse omnibuses, has again been attempted recently. The vehicle employed is equipped with two electric motors, current for which is obtained from a generator directly connected to a 40 H.P. gasoline engine. The motors, hung under the frame, drive the rear road wheels by means of sprockets and chains. Beneath the body is a battery box which carries two 10-cell sets of storage batteries. These batteries can be used for starting the engine as a matter of convenience by connecting them with the generator, which can then be used as a motor to rotate the crank shaft. As a matter of fact, however, the function of the batteries is to furnish current for the five incandescent lamps in the interior of the coach and for the outside lights. The battery is not used for driving the motors nor for equalising the generator load in any way. In addition to the lights, the car has an electric attachment of a disc character, which shows a red sign automatically by day and a red light at night. This is set just above the rear platform and cuts in and out as the car starts and stops. The speed is 15 miles an hour on the level and 8 miles an hour on 8 per cent. grades. When complete the vehicle weighs about 7 tons. The wheels are equipped with solid rubber tyres. Seating capacity is provided for from 28 to 30 passengers, and the body is of the street car type, conforming to the latest approved practice in being semi-convertible, so that in summer time the windows can be lifted entirely out of sight and stored in the roof of the car. The interior is finished in oak and bird's eye maple, and furnished with cane-covered seats for two persons, each extending cross-wise, with an aisle down the centre. The vehicle has a regular street-car step and platform, and a gate, which can be closed when all the seating space is occupied, so as to prevent the occupancy of standing room. No data are yet obtainable as to the results with this vehicle, which, being the first of its kind, is likely to be materially improved as changes are suggested from practice. It is understood that the succeeding vehicles will be somewhat lighter, this being unnecessarily strong and substantial.

**A High Mountain Lift.**—A fine view of Swiss lakes and mountains may be obtained from the summit of Mont Hammetschwand, one side of which rises nearly perpendicularly from Lake Lucerne, but hitherto access has been rendered very difficult by the nature of the mountain. An electric lift has now been constructed, however, and this greatly facilitates matters. It is no less than 158 metres (518 ft.) high, and its lower end is some 3,180 ft. above sea level, being reached from the top of the Bürgenstock mountain by a footpath hewn out of the solid rock. By far the greater part of the lift is of girder construction, anchored at intervals to the perpendicular side of the mountain in such a way that the iron structure is free to expand and contract, but the bottom part of the lift pit had to be cut in a projecting part of the rock, and is reached by a horizontal shaft through the rock, 11½ ft. high and 37 ft. long, this shaft also being made use of for accommodating the lift machinery. The foundations of the girder work are placed within the rock at a considerable depth, so as not to jeopardise the structure should the rock disintegrate. It is designed to carry 500 kg. (equivalent to the weight of about seven persons) and the speed is to be 1 metre (3 ft. 3⅓ in.) per second. Should the rope break or the speed exceed 1·2 metres (3 ft. 11 in.) per second, a safety device comes into operation. The lift cage is of wood with glass panels, being protected from the weather on the outside by a covering of zinc. In order to ensure safety two steel ropes are used, each being 16 mm. (0·83 in.) in diameter. The balance weight exceeds the weight of the lift by half the carrying capacity. Motive power is obtained from a 15 H.P. shunt-wound motor with Gramme armature, running at 900 revs. per min., when fed with current at 1,200 volts. Double reduction gearing is interposed between the motor and the rope drum, the diameter of which is 2 metres (6 ft. 6⅔ in.). The other apparatus in the horizontal shaft includes a depth-indicator (which automatically switches off the controller when the cage has reached its upper limit), a centrifugal device on the motor shaft for interrupting the current when the motor speed exceeds a predetermined value, an automatic brake and a small switchboard. All operations of starting and stopping are done by the operator at the bottom of the lift, but it is not clear from the description in *Elektrische Bahnen & Betriebe*, from which these notes are taken, whether there is also an attendant in the cage or not. It is stated that the voltage of the continuous-current supply varies between 700 and 1,500 volts.

**The Effect of the Eruption of Mount Pelée on Atmospheric Electricity.**—According to the *Western Electrician* of Chicago at the Sloane Physical Laboratory, New Haven, Connecticut, observations of the phenomena of atmospheric electricity are among the daily exercises of the students attending the institution, the work being generally taken up during the months of April, May and June. Prof. Arthur W. Wright, in an article in the *Monthly Weather Review*, describes the results of the laboratory observations of several students on May 8 and 9, 1902, the day of and the day following the eruption of Mount Pelée in the West Indies. The students assigned to the work on those days preserved the records of their observations, which were plotted in the form of curves and show some remarkable results. One curve represents the observations of May 8, 1892, and does not show very marked deviation from the normal or the average of those generally observed, except that the changes are somewhat more rapid and abrupt than usual. A second curve was drawn from observations made on the morning of May 9, 1902, the day following the eruption. This curve is remarkable from the fact that it indicates a considerable negative potential for the greater part of the observation. This is more unusual for the reason that the atmosphere was perfectly clear and there were no signs whatever of thunderstorms. During the last 20 years that observations have been carried on the atmosphere has uniformly shown a positive charge in fair weather, except, perhaps, a mere momentary dipping below the zero line in a few instances. Strong and sustained negative potential had never before been observed except on occasions of heavy rain or snowfall. The result obtained on the morning of May 9th was so striking and unusual that several observations were made later in the day. The potential remained strongly negative during most of the afternoon, though apparently diminishing slowly. The next day it was found to be positive again and did not depart from the normal conditions. Another peculiarity of the record of May 9th is the vacillating character of the charge observed, the larger variations of the curve having superposed upon them a number of small and rather rapid fluctuations, whereas, in general, the variation of potential occurs gradually and rather slowly. These results appear to indicate an abnormal electrical condition of the atmosphere, and the influence of some energetic disturbing agency. It seems not at all improbable that the immense volumes of gas and other eruptive products ejected from the crater of the vulcano, which were manifestly the seat of intense electrical charges, may have made their influence felt, gradually and progressively, at great distances from their point of origin.

and so have produced a widespread disturbance of the electrical condition of the atmosphere. This would naturally accord with the absence of any immediate and radical departure from the normal in the observation of May 8th, made within about two hours after the great eruption, the minor peculiarities observed being such as might be due simply to inductive effects at a distance.

**The Sanitary Conditions of the New York Subway.**—The following is a brief summary of a preliminary official report, made to the New York Rapid Transit Commission respecting the sanitary condition of the subway, by Dr. Geo. A. Soper. It is stated that during the period of observations the air was renewed with sufficient frequency to ensure an ample supply of oxygen and prevent the detection of unpleasant odours due to the large number of people present in the subway. Odours from other causes were present, however. The principal objection to the air had been its high temperature. Throughout the period of investigation the subway had been decidedly warmer than the outside air. On an average the temperature during the daytime for three months had been for the subway 79·8°F., and for the air in the streets 72·8°F.; difference 70°F. The highest temperature observed in the subway wac 90·6°F. The hottest week had been that of August 4th to 10th inclusive, when the average daily temperature for the subway was 83·1°F. For the outside air it was 73·2°F., the difference being 9·9°F. The maximum temperature observed in the subway had amounted to 88·5°F.; in the streets 88·2°F. As a rule the air of the subway was less humid than the air of the streets, the average humidity during the three months being 56·2 per cent. The hottest week was also the most humid in the subway, the percentage of relative humidity having been 75·2 per cent. The high temperature of the subway was due chiefly to the amount of power operating the road, which in one way or another was converted into heat. Most of it came from the motors and brakes on the cars. This loss of energy might be reduced by adopting regenerative control. Again, a lower speed from station to station would also prevent the production of so much heat from the motors and brake shoes. This should be possible without sacrificing the actual running time, by improved means of loading and unloading the cars. The average of 721 analyses gave for the air of the subway 4·58, and for the air of the streets 3·45 parts of carbon dioxide per 10,000 volumes of air, the largest amount found on any occasion in the subway being 7·81. Chemical analysis of black dust found in the air showed that it contained 62·78 per cent. of metallic iron. Microscopic analysis showed that the particles ranged from fragments which could almost be seen with the naked eye to pieces less than $\frac{1}{25000}$th of an inch in diameter. Most of this pulverised iron was due to the grinding up of brake shoes, the daily loss in weight of which was surprisingly large. It was important to take notice of the presence of this iron dust, both because of the possibility of its affecting the health of persons who continually breathed it and on account of the black stain which it imparted to the light-coloured portions of the subway structure, cars, booths and other furniture, and the employés and passengers. Because of the presence of about 1 per cent. of oil which the dust contained it gained secure lodgment upon all surfaces. There had generally been fewer bacteria in the air of the subway than in the air of the streets, but occasionally there had been more. A study of the results of 2,600 tests showed that the average number of bacteria which were deposited per minute upon a square foot of surface and were subsequently capable of growing at the temperature of the human body was, for the subway, 750, and for the air of the streets 1,200.

**A New System of Ventilation and Warming at Drury Lane Theatre.**—The management of the Theatre Royal Drury Lane have adopted a system of warming and ventilation on the most approved lines. The component parts of the plant are as follows: A boiler, 14 ft. long by 5 ft. diameter, requiring about 5 cwt. of coal per hour; four large centrifugal fans, the aggregate weight of which amounts to about 3 tons; four electric motors, representing a total of 33 H.P.; two air-filtering screens revolving in water and having a total filtering area of about 400 sq. ft.; two separate sets of heating apparatus for raising the temperature of the air to the required degree, and consisting of between 3 and 4 tons of cast-iron and steel tubing; and combined with these a large number of ducts for conveying the warm air. These ducts are very capacious, and are constructed so that every part of them can be periodically examined and kept absolutely clean. The plant has been so arranged about the building that the temperature maintained may be as uniform as possible throughout the theatre. The modus operandi is as follows: Fresh air in large volumes is continuously being drawn through the filter screens, and over the heating apparatus by means of the electrically-driven fans, which discharge the warmed and filtered air through the various ducts into the theatre in such a way that it has the effect of raising the temperature of the whole house, thus securing the comfort of visitors without subjecting them to direct currents of air. One great feature of the system to be borne in mind is that fresh air—warm or cold, according to requirements—is being continually pumped into the theatre by one set of fans, whilst another large and powerful set are employed in extracting air from the building, the result being that within a very short time the whole of the air in the theatre is entirely replaced by fresh, filtered, warmed or cooled air. One of the chief causes of the difficulties in connection with warming this house was that, owing to the enormous area of the stage and its free access to the outside atmosphere by many large doors, and the capacious space under the stage, filled with machinery of all descriptions for the manipulations of the various scenic arrangements, this part of the building was excessively cold; whilst the auditorium for obvious reasons was of a much higher temperature. The result was a strong current of cold air passing from the stage to the stalls and other parts of the house, to the discomfort of the audience. This trouble has now entirely disappeared, owing to the fact that the space under the stage is thoroughly warmed, and warm air is being continually delivered at the stage level in such positions that any connections to the outside air through doors, &c., is immediately met by a large volume of warm air. Indeed, the stage is now thoroughly warm and comfortable in every part, when the plant is running, and can in no way be a cause of discomfort to the audience. To make matters doubly sure, however, a large extraction fan has been arranged over the stage so that the whole of the air in the stage space may be be extracted at will through the same, without being allowed to pass into the auditorium, the air extraction from this latter part of the house being effected by means of a separate large fan fixed to the side of the building. All this work has been carried out in accordance with the London County Council requirements by Mr. R. Hancock.

**The Alexandria-Ramleh Electric Railway.**—Up to last year the line between Alexandria and Ramleh was worked by steam. It is a straight double track from Alexandria to Bulkeley, where it branches off in two directions through the city, joining again at S. Stefano. In order to deal with the growing passenger traffic, the board of the railway company decided some time ago to "electrify" the system, and they finally accepted the tender of Messrs. Brown, Boveri & Co., who proposed to instal at the power station at Karmous two 600 kw. three-phase 6,500-volt, 25 ~ generators of the revolving field type, to run at 107 revs. per min. A 350 kw. rotary converter was also to be provided for converting the three-phase current to continuous-current or *vice versâ*. The steam generating equipment of the plant consists of 10 boilers to supply steam at 135 lb. per square inch. They are hand-fired, using bituminous coal, and are equipped with Green economisers. The engine plant consists of two 750 H.P. horizontal tandem compound condensing engines, built by Franco Tosi, Legnano (Italy). Their cylinders are 600 mm. (23·6 in.) and 1,050 mm. (42 in.) in diameter respectively, the common stroke being 1,200 mm. (47·3 in.). In order to get satisfactory running with the rotary converter, the fly wheel of the steam engines was designed so that the cyclic irregularity should not exceed $\frac{1}{100}$. The magnet wheel of the alternator is connected to the fly-wheel by means of a flanged coupling. Two belt-driven 35 kw. 100-volt continuous-current machines are used for exciting the alternators. The switchboard is divided into one panel for the exciters, two panels for the alternators and two panels for the feeders. Of the latter, one is at present in service and the other is kept in reserve for future extensions of the plant. All the H.T. panels are provided with oil switches, and those for the feeders are further equipped with overload circuit breakers. Current is conveyed from the power house towards the sub-station at Bulkeley for a distance of about 6½ miles by two three-core cables with conductors each 50 mm. (1·97 in.) in diameter. In order to avoid crossing the inhabited quarter with a H.T. line, two underground cables are employed on the first portion of the line. These cables are of the paper-insulated type by the British Insulated and Helsby Cables Co. They have metallic sheaths and are laid at a depth of 70 cm. (27·6 in.) below the surface. At a point near Ramleh, connection is made with an aerial line, the H.T. feeders being carried to the Bulkeley sub-station on the centre poles of the system, which also carry the trolley brackets. The feeders are mounted on porcelain insulators fixed on cross-arms and pole tops. A notable feature of this H.T. line is the provision of automatic earthing forks under each line wire upon both sides of each insulator. If a high voltage wire breaks it drops into the fork and is immediately earthed. Bulkeley sub-station is situated in the centre of Ramleh, about 8 miles from the power station, and contains three three-phase tranformer sets, each set consisting of three single-phase transformers of 110 kw. connected up in delta and designed to reduce the tension from 6,500 to 350 volts. Current at this voltage is fed to three 300 kw. rotary converters which transform the alternating current into continuous current at 560 volts. The converters are started from the continuous-current side, the current for this purpose being generated by a 50 H.P. motor-generator, the motor being of the induction type. Besides having a shunt winding, the converters are provided with two compound windings which can be put in series or in parallel. The object of this is to obtain, in conjunction with choking coils in the alternating-current circuit, a variation in voltage from 500 volts at no load to 525 volts at full load. The rolling stock consists of first and second-class cars, all of which are of the double-deck type. Only the first-class cars are equipped with motors, the second-class cars being used as trailers. The main car shed is situated at Mustafa near the Bulkeley sub-station, and can accommodate 70 cars. A general repair shop and car shed has been built at Karmous, adjacent to the power plant, where all heavy repairs are carried out.

**Obituary.**—It is with great regret that we record the death of Mr. G. A. Grindle, who was lost in the wreck of the "Hilda," off St. Malo, on Sunday morning. Mr. Grindle has been rightly described as one of the pioneers of the electrical engineering industry in this country, for he was intimately associated with the early events. For some time he was on the staff of the Brush Company, and in 1881 he had charge of the first electric lighting of the City of London. Subsequently he went to India to look after the affairs of the Eastern Electric Light & Power Companies, and on his return to England he commenced practice as a consulting engineer. In 1889 he was appointed resident engineer to the electrical department of the City & South London Railway, and in 1893 he became works manager of the Chloride Electrical Storage Co. Three years later Mr. Grindle was appointed general manager to the same company, but he retired in 1903, still retaining connection with the firm in the capacity of consulting manager. The extension of the Chloride Company's business has been largely due to Mr. Grindle's perseverance, and he had no small share in developing the works from a few small huts in 1894 to the present extensive and well-appointed shops at Clifton Junction. Mrs. Grindle and her three children, who reside at St. Malo, have the sympathy of the entire electrical profession and industry in their sad bereavement.

Another prominent name is lost to the electrical world by the death of Mr. Charles Cuttriss, electrician of the Commercial Cable Co., which took place suddenly at New York. Mr. Cuttriss had been suffering from ill-health for three or four years. He was born at Bedford 56 years ago. On entering the University of Glasgow he received his electrical instruction under Lord Kelvin, and on the laying of the French Atlantic cable in 1869 he was selected as a member of the electrical staff and was sent to Duxbury, Massachusetts, at which station he successfully introduced the siphon recorder just invented by Lord Kelvin. He remained at Duxbury until 1884, when he joined the Commercial Cable Co. as its chief electrician at New York. Mr. Cuttriss was a man of much ability. He introduced several improvements in the siphon recorder, one of which was the electromagnetic vibrator, and he devised an arrangement for neutralising earth currents on cables. He invented a system of automatic transmission which has proved most successful, and he was also the inventor of an automatic fire alarm which gave warning of the rise of temperature in a room and also of the escape of gas. Mr. Cuttriss leaves a widow and four children.

The death occurred at Bournemouth on Monday morning of Mr. G. H. Comport, until two years ago superintendent engineer of the Post Office telegraphs for the North Midland District. Mr. Comport, who was born at Rochester 69 years ago, joined the telegraphic service when quite young, and was associated with it for 51 years. Originally connected with the old Electric Telegraph Co. at Leicester, he acted as superintendent at Nottingham until 1868, when upon the passing of the Telegraph Act, he was appointed superintending engineer for the district, a post which he held until his retirement in 1903. Mr. Comport became responsible for a great deal of intricate and heavy work, and in May, 1903, he was created a Companion of the Imperial Service Order, being the first man in the telegraph service to receive the honour. In the same month he retired, but just prior to his severance with the duties of his office, Mr. Comport was engaged in the installation of important new telephone trunk wires between London and the North.

## ARRANGEMENTS FOR THE WEEK.

**(To-day) FRIDAY, November 24th.**

PHYSICAL SOCIETY.

*5 p.m.* Meeting at the Royal College of Science, Exhibition-road, South Kensington. Agenda.—(1) "The Dielectric Strength of Air," by A. Russell. (2) "On the Electrical Conductivity of Flames containing Salt Vapours, for Rapidly Alternating Currents," by Dr. H. A. Wilson. (3) "On the Lateral Vibration of Loaded and Unloaded Bars," by J. Morrow.

MANCHESTER STUDENTS' SECTION: INSTITUTION OF ELECTRICAL ENGINEERS.

*7:30 p.m.* Meeting in the Municipal School of Technology, Sackville-street, when Mr. James Swinburne will deliver an Address.

**SATURDAY, November 25th.**

INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.

*10 a.m.* Visit to the tube railway tunnelling works, Edgware-road site. Meet at corner of Bell-street. (List full.)

**MONDAY, November 27th.**

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture I.: "The Measurement of High-Frequency Currents and Electric Waves," by Dr. J. A. Fleming, F.R.S. (In continuation of previous courses on "Electric Oscillations and Electric Waves" and on "Hertzian Wave Telegraphy.")

**TUESDAY, November 28th.**

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER LOCAL SECTION.

*7:30 p.m.* Meeting at the University, when the following Papers will be read: (1) "Theoretical Considerations of Feeder Systems," by Dr. W. G. Rhodes; (2) "Street Cable Systems," by S. J. Watson.

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be further discussed: "On Waterways in Great Britain," by J. A. Saner. Time permitting, the following Paper will also be read: "The Steam Turbine," by the Hon. C. A. Parsons, F.R.S., and G. G. Stoney.

**WEDNESDAY, November 29th.**

INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.

*7:30 p.m.* Meeting at 92, Victoria-street, Westminster, S.W. Paper to be read: "Automatic Train Control," by H. G. Trust.

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. Paper to be read: "The British Association in South Africa," by Sir William Preece, K.C.B., F.R.S.

**THURSDAY, November 30th.**

RUGBY ENGINEERING SOCIETY.

*8 p.m.* Meeting in the Benn Building, High-street, Rugby. Paper to be read: "The Conversion of Steam Energy into Mechanical Energy," by E. R. Briggs and E. A. Reynolds.

**FRIDAY, December 1st.**

INSTITUTION OF CIVIL ENGINEERS: STUDENTS' SECTION.

*8 p.m.* Meeting at 25, Great George-street, Westminster, S.W., when the following Paper will be read: "An Installation for the Bacterial Treatment of Sewage at Neath," by W. L. Jenkins.

**SATURDAY, December 2nd.**

GLASGOW TECHNICAL COLLEGE SCIENTIFIC SOCIETY.

*7:30 p.m.* Meeting at the Glasgow and West of Scotland Technical College, George-street, Glasgow. Paper to be read: "Metallography," by James Muir.

## ELECTRICITY AND SEWAGE DISPOSAL.

High-tension overhead transmission lines are so rare in this country that the opening of a new one is an event of more than usual importance. As a matter of fact, the undertakings now working with anything higher than trolley voltage on bare overhead wires can be counted on the fingers of one hand.

An exceedingly interesting electrical power transmission scheme has just been completed in the neighbourhood of Birmingham. It extends down the valley of the Tame for a distance of about 6 miles, and has been designed by the Birmingham, Tame and Rea District Drainage Board for the purpose of enabling them to pump sewage on to land adjacent to and situated at a higher level than the main conduit which conveys the sewage from the outfall works situated within the City of Birmingham to the sewage farm, located in the Tame Valley, and extending from Birmingham to Curdworth.

In 1901 an agreement was entered into between the City of Birmingham and the Drainage Board by which the Health Committee obtained 2 acres of land at Saltley, excellently disposed for the purpose; further, the Drainage Board agreed to build the required boiler house, to provide three Lancashire boilers, boiler covering, economiser, steam lay-out, two feed-pumps, and one feed-heater, and to pay 10s. per horse-power per annum, nearly all of which work would have had to be done even if the heat had gone up the chimney almost entirely unused, as in the other city destructors. The Drainage Board, on the other hand, having the prospect of obtaining relief to their land by the construction of bacteria beds, felt they could afford to part with the 2 acres referred to, and, by obtaining steam for the sum named, were in a position to dispense with five exceedingly wasteful portable engines and pumps, two gas engines, and certain farmyard machinery, besides getting rid of gas and water bills amounting to nearly £400 per annum. Altogether the Drainage Board will save more than £1,000 per annum by substituting electricity for steam, and that after making allowance for repayment of principal and interest on the loan sanctioned by the Local Government Board.

The Health committee felt that it was a most important matter to provide a destructor of proved capabilities for steam raising, and decided to adopt the Heenan patent top feed type of destructor; the engineer to the Drainage Board (Mr. John D. Watson) was entrusted with the preparation of the plans for the combined scheme.

Immediately on the right of the destructor buildings is a weigh office, where all the refuse is weighed prior to its being taken to the furnace hopper. In front of the weigh office is the approach to the inclined roadway, leading to the tipping floor. This is 150 ft. long and 32 ft. wide, and has a gradient of 1 in 18. At right angles to the approach is the inclined road proper, which is 242 ft. long and 20 ft. 2 in. wide, with two cart tracks, one for ingoing carts and the other for outgoing carts, having a gradient of 1 in 19. At the head of the inclined roadway is the tipping floor; here the carts are emptied of their contents directly into two large refuse hoppers. At the bottom of each of these hoppers are circular openings; these are for the purpose of charging the furnaces below, there being one opening immediately over each furnace.

Between the two hoppers are two engines driving enclosed fans. By placing the fans on this floor they greatly assist the circulation and the removal of foul air. They are connected down to the air heaters by means of square steel tubes. Each fan is 66 in. diameter, and it may thus be run at a comparatively low speed, so that differences in volume can be obtained without much fluctuation in wind speed. The fans are driven by entirely enclosed self-oiling Belliss engines of 12 B.H.P. each, and are of sufficient capacity to enable 60 tons of ordinary house and shop refuse to be burned in 24 hours by one set of four furnaces, which is equal to 56 lb. per square foot of grate per hour. The makers guarantee that when eight furnaces and two boilers are in use under ordinary conditions the plant will evaporate not less than 9,000 lb. of water when the furnaces are fed at the rate of 8,000 lb. of refuse per hour. Each furnace has a grate area of 25 sq. ft. There are eight of these arranged in two distinct sets, each set consisting of four furnaces, one air heater and fan, and one settling chamber, connected to one boiler and forming one unit plant.

The furnaces and settling chambers internally are entirely lined with 9 in. of fire-brickwork, and externally with common hard brickwork 14 in. thick, and between this outer and inner lining of brickwork there is a $1\frac{1}{2}$ in. cavity filled up with silicate of cotton. The whole of the brickwork is braced together by means of double channels placed vertically at intervals; these in turn are secured to horizontal channels let in flush with the brickwork and fixed in such a position as to take the thrust of the arched covers of the furnaces. The fronts of the furnaces are of very heavy construction, each weighing something like 45 cwt. Each front is fitted with regulating valves to adjust the admission of heated air from the heaters both above and below the grates. The hot air is conveyed from the heaters to the furnaces below the floor in brick ducts, running under the entire length of each set of furnaces, immediately under the fire grates.

Between the two sets of furnaces are the two air-heating apparatus, each of which provides about 1,500 sq. ft. of heating surface. They each consist of a series of 3 in. tubes fixed vertically and secured at their upper and lower extremities to horizontal plates. The hot gases, after passing through the boiler flues, are made to pass through these tubes on their way to the economiser and chimney, thereby heating the forced air which is made to circulate around the outer surface of the tubes on its way from the fans to the furnaces. It is claimed by the makers that the introduction of hot forced air into the furnaces gives an initial temperature of from 300 to 350 deg.

Immediately opposite the air-heater, and in the centre of the clinkering floor, is the pump room, in which are placed two boiler-feed pumps. These pumps are of the Mumford vertical type with 6 in. diameter steam cylinders and 4 in. diameter water cylinders with 6 in. stroke, each capable of delivering 2,400 gallons per hour, against a pressure of 160 lb. per square inch. On the other side of the pump room are a workshop and a general store room.

The boiler house measures internally 73 ft. 6 in. long and 24 ft. 6 in. wide, and is 13 ft. high from the top of the flues to tie rods. Accommodation is here provided for three boilers, one economiser (with provision for adding another 64 tubes) and the necessary flues. In the centre of the building is the main flue running across at a low level from the heater in the destructor house to the economiser. On one side of the flue are placed two boilers side by side, and on the opposite side are one boiler and the economiser with a bye-pass flue between. Openings covered with portable firebrick slabs in chases are provided between the lower boiler flues and the above main low-level flue from the heater for the purpose of sweeping the soot or dust from the boiler flues into the main flue and thence to a point in this flue under the destructor house floor where it can be hoisted up by means of a small permanent winch and deposited into the clinkering trucks close at hand. The three boilers, which were supplied by Messrs. Taylor & Sons, are of the Lancashire type, each measuring internally 30 ft. long and 8 ft. diameter, and are constructed for a working pressure of 160 lb. per square inch. Two of these boilers are gas fired—that is, they are connected with the furnaces—while the other is adapted for coal firing, and is therefore considered a stand-by. The gas-fired boilers are connected to the settling chambers by means of steel rings lined internally with firebricks.

The pressure and water gauges on the gas-fired boilers are fixed on the sides on Hopkinson's columns with guards near the back ends of the boilers facing the destructor house so that they can be seen from the clinkering area. The feed inlets are at the top near the back ends, and the valves are Hopkinson's patent accessible feed valves worked from the clinkering area by means of rods and hand wheels, the hand wheel being arranged to be worked adjoining the pressure and water gauges. From this position it is also arranged to work the flue dampers in connection with the gas-fired boilers. The economiser was supplied by the Clay Cross Co., and consists of 128 tubes 9 ft. long, $4\frac{9}{16}$ in. diameter, fixed vertically, and forced into longitudinal top and bottom boxes in sections, forming metal to metal joints. The tubes are arranged in two groups of 64 each, and connected together with cast-iron expansion elbows.

Each tube is fitted with triple scrapers, which are drawn up and down the tubes by means of a small 1½ H.P. alternating-current B.T.-H. motor. The furnace chimney, which is at the end of the boiler house next the canal, is 165 ft. high from the present ground level, and is lined with firebrick for 130 ft. The internal diameter at the top is 7 ft., and is finished with a cast-iron casing 5 ft. high, filled in on the inside with brickwork.

The generating plant in the engine room consists of two B.T.-H. 115 kw. revolving-field alternating-current generators, each of which is coupled to a high-speed Belliss & Morcom compound two-crank engine. Each gives its full output at 2,250 volts and a frequency of 50 ~ per second. On an extension of the main shaft is fitted a 220 volt exciter, so that the unit is self-contained. A small continuous-current steam set of 15 kw., generating at 220 volts is also installed in this station. This latter set supplies a number of B.T.-H. enclosed arc lamps in the middle of the roughing tanks at Saltley; it also lights the station, and, in case of necessity, excites the alternating-current generators. There are two alternative systems of lighting the generating station, one from the continuous current side and one from the alternating system of supply from the main generators. In the latter case suitable transformers are provided in a transformer chamber under the generating station to reduce the pressure from the primary 2,250 volts to 220 volts, which is the pressure of the lighting circuits.

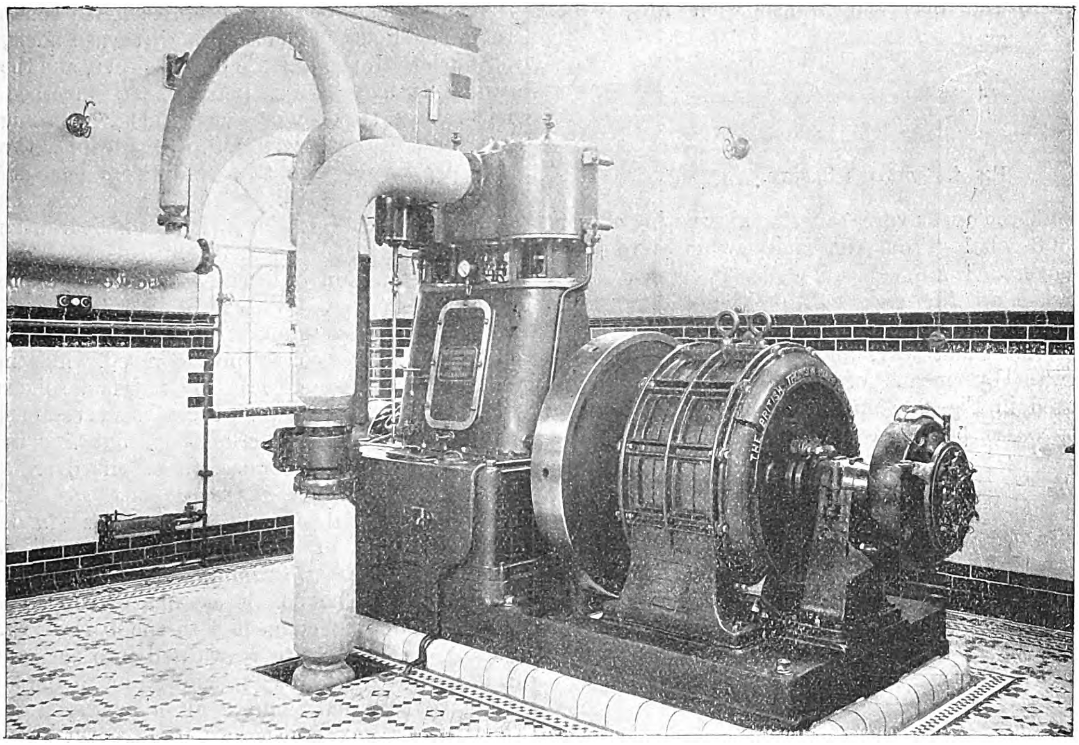


FIG. 1.—115 KW. BELLISS–B.T.-H. SET.

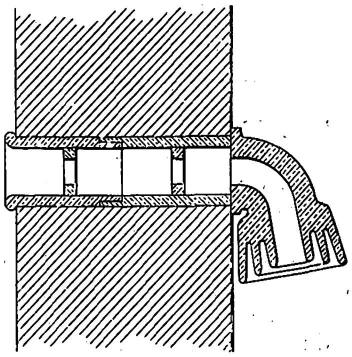


FIG. 2.—PORCELAIN TUBE FOR CARRYING OVERHEAD CONDUCTOR THROUGH WALL.

The main switchboard contains two generator panels, each of which carries complete apparatus for one of the alternators, including the main switch, which is of the British Thomson-Houston Co.'s oilbreak type, ammeter and voltmeter, together with the field rheostat for varying the excitation of the alternator. There is also one feeder panel controlling the supply to the overhead line and to the station power and lighting transformers, one meter panel containing a B.T.-H. three-phase wattmeter for measuring the total output of the alternators, and a B.T.-H. continuous-current wattmeter measuring the output of the small continuous-current set.

From the main generators three 19/16 cables are taken to the hand-operated three-phase oil switches, just previous to which tappings are taken off to the potential transformers, the secondaries of which are connected to the synchronisers voltmeters and wattmeters. The main cables are then connected to the 'bus bars through H.T. fuses. Regarding the 'bus bars, these consist simply of bare copper rod supported overhead by means of porcelain petticoated insulators. An

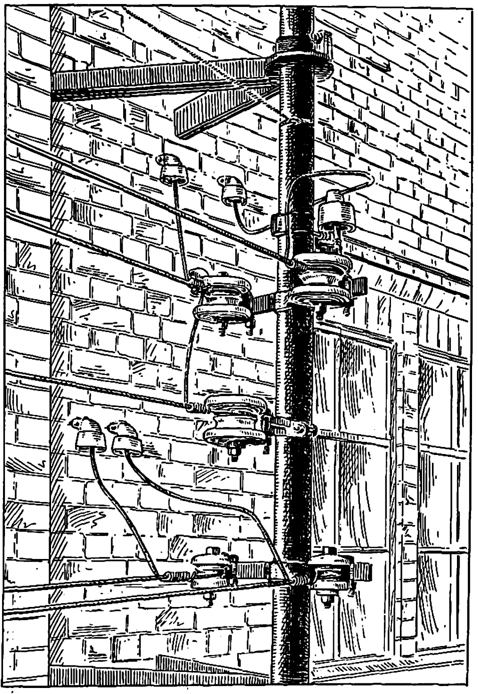


FIG. 3.—FEEDER LEAVING THE STATION.

expanded metal screen is provided to prevent access of unauthorised persons to the back of the board, and a further screen, locked and hinged, is fitted immediately over the 'bus bars, so that the hook of the overhead crane cannot come into contact with live parts. There are two H.T. feeders, one of which supplies the two 4 kw. single-phase transformers in the basement, for station purposes, while the other is connected to the overhead line. Each of these feeders is provided with H.T. fuses and a hand-operated oil-break switch.

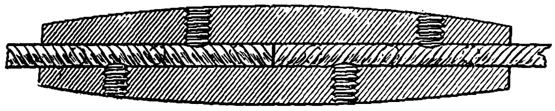
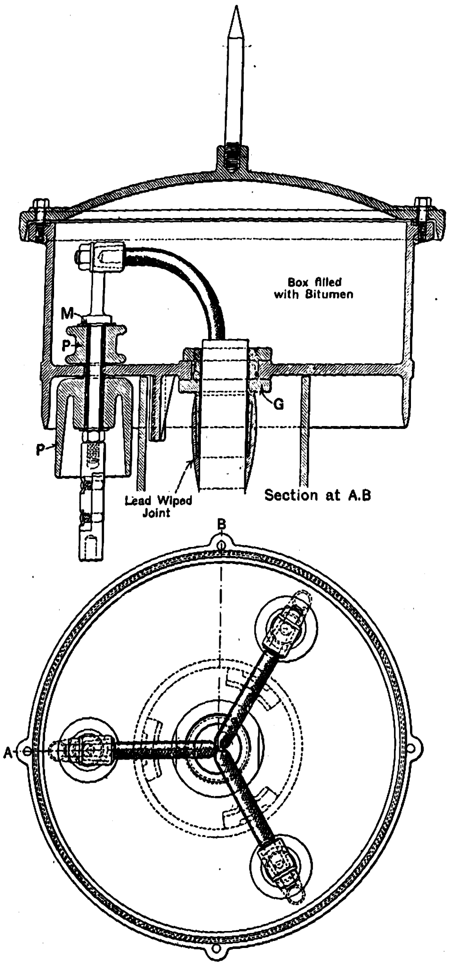


FIG. 4.—JOINTING SLEEVE.



⅙th full size.

FIG. 5.—TERMINAL HEAD.

G=Gunmetal Gland. M=Mica Tube. P=Porcelain.

While inspecting the scheme last week, we naturally devoted most attention to the overhead transmission line, which consists of three bare copper wires carrying alternating current at 2,000 to 2,500 volts. From the main switchboard three single rubber-covered 19/16 cables by Messrs. W. T. Glover & Co. are carried up the end wall of the engine room. Tappings are taken off to the lightning arresters, which are earthed in the usual way, and the cables then pass through the wall by means of porcelain tubes, in the manner illustrated in Fig. 2. On the outside of the wall a bell-shaped petticoated porcelain mouthpiece is fitted, and a couple of porcelain rings with a circular aperture are fixed within the tubes. In the case of thinner walls, such as those at sub-stations, two lengths of tube are not required for each cable. When the cables have reached the outside of the wall they are no longer insulated, and at a point about a foot from the bell-shaped mouthpiece they are connected to the overhead line proper. This latter consists of three single strands of No. 1 trolley wire, hard drawn. The methods of bringing the feeder out of the generating station is well illustrated by Fig. 3. It will be seen that a vertical steel tube is supported by stays at the top and bottom, the shackle insulators being attached by steel collars. For connecting the cable to the trolley wire a solid brass sleeve is employed, as shown in Fig. 4. The ends of this sleeve are tapered off, and 10 holes drilled in it. Six of these holes are for the admittance of solder, and the other four for grub screws. First of all, the sleeve is tinned, inside and out, as are also the cable end and trolley-wire end. The two latter are then inserted and butted hard together. By means of a drill each is slightly countersunk opposite the screw holes. The screws are turned home, their ends filed off flush with the outside of the sleeve, and the whole sweated solid. It may be mentioned that this method produces excellent results, the only precaution necessary being that care must be exercised in soldering the solid copper wire, as it is easily split by heat. The two conductors seen at the bottom of Fig. 3 are No. 00 trolley wire, and convey continuous current to the Saltley sub-station, which is not far distant. Above the H.T. conductors is a barbed wire earthed at every fifth pole, and the function of this is to serve as a protection against lightning strokes. Where the line has to cross roads or railways, it is taken underground, the cable running down the poles being three-core rubber covered, while that underground is paper-insulated and lead-covered, laid solid in wood troughing. Connection between the cables is established by an ordinary underground junction box, but this is, of course, not the case with the connection of the overhead wire to the rubber cable. As a matter of fact, a special terminal pole head has been designed, and is shown in detail in Fig. 5. This head is of cast iron, and is kept water-tight by means of a rubber grummet between the box and the lid. On the lid of the box is a spike of copper, which, together with the box, is connected to the barbed wire and thus to earth. The bare wire is sweated into the split sleeve, shown in Fig. 5, and the latter is screwed on to the lower end of the Γ-shaped terminal. The shank of this terminal passes through the cast-iron box, and is insulated from it by means of a mica tube $\frac{3}{16}$ in. thick. Inside the box, and directly beneath the shoulder of the terminal, is a reel insulator, while outside the box is an ordinary single petticoat insulator, both insulators being held away from the box by rubber washers. The whole device is held firmly in position by a nut on the lower end of the terminal shank, and a second nut is screwed on for locking. A tapered hole is bored in the top of the terminal, and into this a tapered piece of brass is fitted. One end of this brass is screwed and the other is drilled to receive the core of the rubber cable. Thus, it will be observed that excellent electrical contact is secured, and it is practically impossible for anything to become loose by accident. Finally, the box is filled with insulating compound to a level above that of the terminal heads.

*(To be concluded.)*

## "PARKER" DYNAMOS WITH AUXILIARY POLES.

In those types of dynamos and motors in which the output is limited by questions of sparking and not by considerations of temperature, auxiliary poles suggest themselves as a means for minimising or preventing sparking and for increasing, consequently, the capacity of a machine belonging to this category. Formerly the field for such auxiliary devices was more or less restricted, but during the last few years the extent to which the temperature of open and semi-enclosed dynamos and motors could be kept down by the employment of ample ventilating ducts and other suitable means has become fully recognised, and the field of application of auxiliary poles has grown considerably in consequence.

Moving with the times, Messrs. Thomas Parker (Ltd.), of Wolverhampton, began about a year ago to fit auxiliary poles to all classes of their machines, including a 2,000-volt 500 kw. dynamo with a smooth core and a fixed brush position from no load to full load. Figs. 1 and 2 represent one of the firm's most recent machines, a standard 210 kw. 525-volt dynamo driven at 210 revs. per min. Motors, down to 10 H.P.

in size, are also fitted by the firm with auxiliary poles, but below this size the application is stated to offer no advantage except in motors having a large range of speed variation. Of course, auxiliary poles are not fitted to all standard machines, but only to those in which the inductance of the armature coils is high. Since it is not necessary to shift the brushes of machines with auxiliary poles, it is customary to omit the usual brush-rocking devices, the brush gear being "pegged" in one position after the test. The section of the auxiliary poles is made larger or smaller according to the reactance of the armature coils to be balanced. In the case of the 210 kw. machine illustrated, the reactance of the armature coils was high, and the auxiliary poles extend for this reason the whole length of the armature, so as to obtain the necessary section.

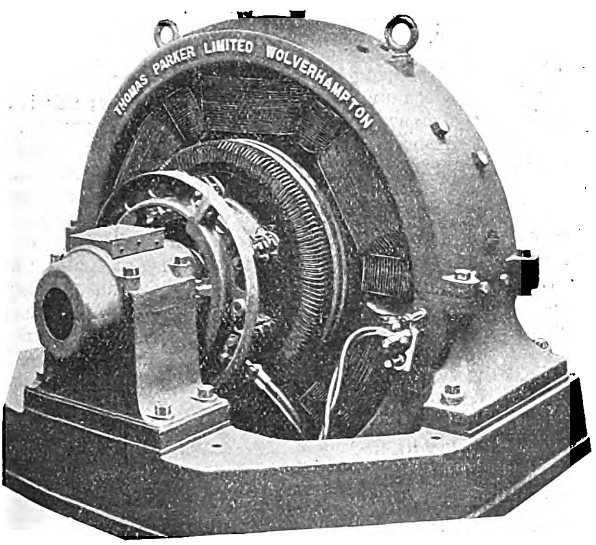


Fig. 1.—View of "Parker" 210 kw. 525-volt Dynamo with Auxiliary Poles.

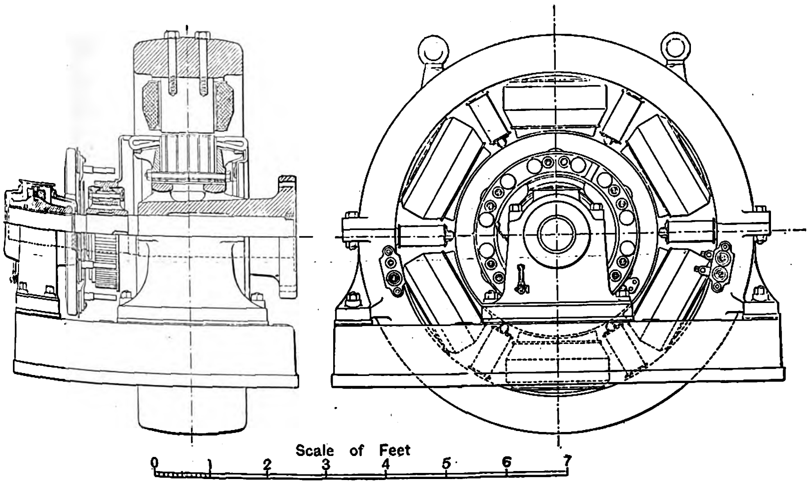


Fig. 2.—Parker Slow-speed Direct-coupled Dynamo, with Auxiliary Poles. 210 kw. 525 volts. 210 revs. per min.

The straight lines in Figs. 3 and 4 indicate the sparking limits of "Parker" machines fitted with auxiliary poles. Fig. 3 relates to a 200-volt 500-ampere four-pole dynamo designed to run at 450 revs. per min., while Fig. 4 refers to a 20 h.p. 400-volt four-pole motor to run at 650 revs. per min. It will be noticed (Fig. 3) that the armature ampere-turns per pair of poles in the 100 kw. dynamo may be varied at any load by about 3,500 ampere-turns without producing sparking. In the case of the 20 h.p. motor, the corresponding range of armature ampere-turns per pair of poles is 1,100 ampere-turns. The greater the distance between the two parallel lines, the larger the over-load capacity and the greater the movement of the brushes around the commutator without sparking. The latter possibility may be utilised for varying the speed of motors, and, in dynamos, for making use of the compounding effect of the armature ampere-turns. We are informed, for instance, that the speed of a 250-volt 30 h.p. motor could be varied between 980 and 1,180 revs. per min. by shifting the brushes only. In another case, the speed of a 20 h.p. 460-volt motor could be varied by 120 revs. per min., the normal speed being 800 revs. per min.

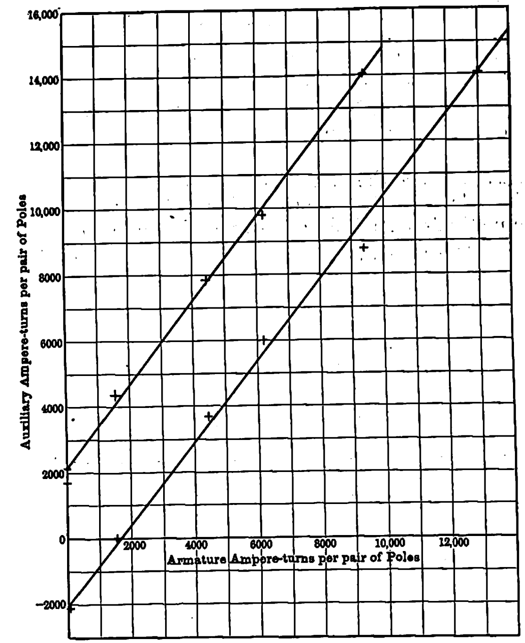


Fig. 3.—Diagram illustrating the extent to which the Armature Ampere-turns of a 100 kw. Four-pole "Parker" Dynamo running at 450 revs. per min. may be Varied without Causing Sparking.

Amongst the many places to which "Parker" machines with auxiliary poles have been supplied, we may mention Hull, Mansfield and Alderley Edge. Machines are at present under construction for the Shrewsbury and Newbury electricity works and other customers.

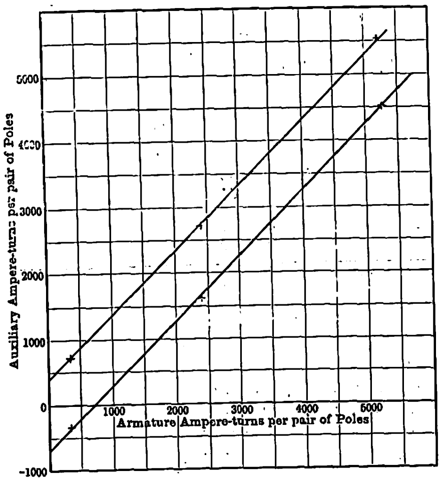


Fig. 4.—Diagram showing the Sparking Limits of "Parker" 20 h.p. 400-volt Four-pole Motor running at 650 revs. per min.

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**9,000 H.P. Steam Turbine for Brooklyn.**—According to the *Street Railway Journal*, the Brooklyn Rapid Transit Co.'s new Williamsburg station has been designed to accommodate a total of nine turbo-generator units, three of which are now being installed. One of the most interesting of these is the Allis-Chalmers 9,000 h.p. unit. The turbine is of the Parsons type, running at 750 revs. per min., and is coupled to a Bullock alternator. The turbo-generating unit measures approximately 47 ft. in length over all, 13 ft. 3 in. in width and 11 ft. 6 in. in height above the engine-room floor.

# APPLICATIONS OF ELECTRICITY IN THE ROYAL GUN FACTORY, WOOLWICH ARSENAL.*

BY COL. H. C. L. HOLDEN, R.A., F.R.S.

When it was suggested to me that I should put before the Institution, in the form of a Paper, a description of what had been done in the matter of electric driving in the Royal Gun Factory, with which I have been associated since 1899, I felt some diffidence in complying with the request, because it did not appear that a mere description of what had been done in this direction would possess sufficient interest unless there was some notable departure from ordinary practice, since the electric driving of factories is now fast becoming the rule instead of the exception. As far as I am aware, some of the methods I shall describe and illustrate to you are departures from the ordinary methods in vogue, and on that account I am in hopes they may be of interest, and this must be my excuse for bringing them to your notice. I do not, however, intend to confine myself entirely to methods of electrical driving, but will describe more or less briefly other applications of electricity which have been found to be of use in this particular factory.

The question of the relative merits of individual motors for driving machine tools versus motors driving groups of tools has often been discussed, but no hard-and-fast line can be laid down as to when either system should be used, except, perhaps, for tools which require a large amount of power, certainly not less than 10 H.P. or 15 H.P. as a minimum; but the converse of this is not true, because it may often be expedient to employ a motor of even a fraction of a horse-power for an individual machine. It comes to this, therefore, that each individual case must be considered on its own merits, and this is the principle on which I have worked. In the case of a great many conversions of workshops to electric driving all that has been done has been to substitute an electromotor for the prime mover previously used, be it steam, gas, or other engine, and though this may have effected an improvement in economy and other ways, it is not by any means as good as if the whole system had been remodelled with a view to electric driving throughout. I may here explain, for the benefit of the few of those present who do not already know it, that the work of the Royal Gun Factory consists of the manufacture of guns ranging from 3 cwt. up to 60 tons or even more, and also in the manufacture of the breech mechanisms and other adjuncts and appurtances of the guns themselves. This work necessitates a very large range of machine tools, from boring machines 50 yds. in length, and lathes of 100 ft. bed, down to the smallest milling machines and lathes. There is, therefore, plenty of scope and opportunity for the employment of different descriptions of electrical drives.

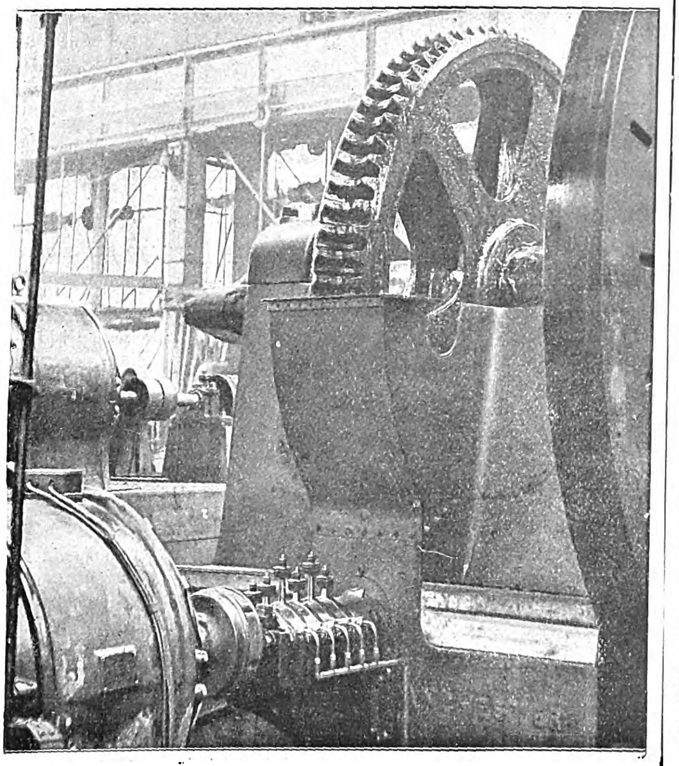

FIG. 1.

Although there were previously several instances where in the Factory electromotors had been substituted for steam engines, it was only in 1900 that I converted the first of two large boring machines to a direct electric drive by means of a variable speed Schuckert four-pole motor of 25 B.H.P. (Fig. 1). The variation of speed was obtained by the now well-known method of varying the excitation of the fields, and the ratio in this case was 1 to 3·5 or so, giving speeds of from 250 to 880 revs. per min., which is amply sufficient range, without any further gear, for the work that is put into these machines.

The machines themselves are of the simplest possible description. The headstock which revolves the work carries between its bearings a large worm wheel (Fig. 1), which is driven by a worm shaft forming a continuation of that of the motor, but connected to it by a flexible coupling; the thrust of the worm shaft, which in such large machines is very considerable, amounting to tons in some cases, is taken by a thrust bearing of marine type, and through this the cutting lubricant passes on its way to the boring bar; this is only a precautionary measure, but, nevertheless, a necessary one, as not only is it very important that the machine should not stop during a boring operation, but also, as they have to run from early on Monday morning till late on the Saturday night, and are only stopped for shifting or adjusting the work or tools, it is imperative that any trouble that could arise from a heated bearing should be guarded against; and I am happy to say that so far there has not been a single machine stopped from this cause. They run absolutely silently and without jar or vibration; indeed, in this respect the worm and worm wheel, together with the electro-motor drive, is ideal; and even if it have the defect that it is slightly less economical than spur gear, this loss is more than compensated for by the extra accuracy of the work done and the freedom from breakage of tools. It would be impossible in a spur-gear-driven machine, I believe, to fine-bore a hole 12 in. to 20 in. in diameter and up to 50 ft. in length without a variation of 0·004 in. in diameter, which is what these boring machines are called upon to do, and do to perfection, daily.

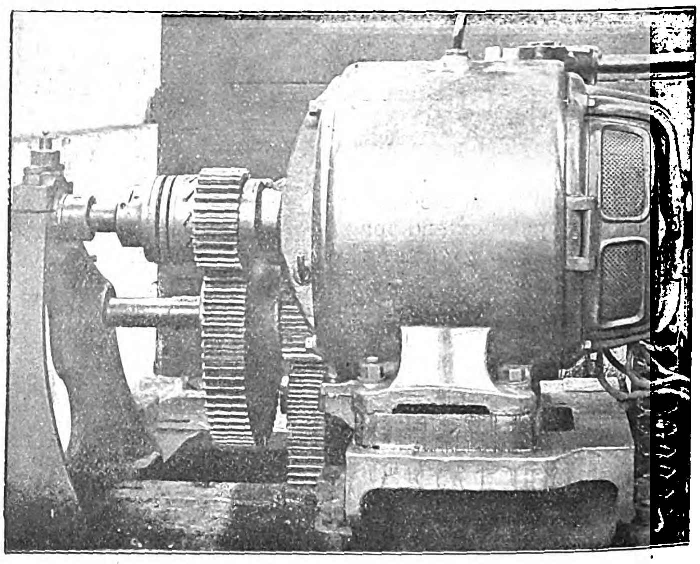

FIG. 2.

The feed of the boring bar in the machines described is worked from the motor by means of a shaft, which connects it with change gear, similar to that of a lathe, at the other end of the bed, 150 ft. away. At this end there is also a 15 H.P. series motor, which can be mechanically coupled to the screw shaft moving the boring head and saddle, with the object of withdrawing or advancing one or both rapidly in either direction as required; in this case I have introduced a slip coupling (Fig. 2), which in the event of an overload not only slips, but also draws attention to the fact by making a hideous noise; this is, I think, better in many ways than the overload release, and much more convenient, of course, than a fuse which has to be replaced. It may be interesting to you to know that the change to motor driving, and the improved control of the speed, enabled us to turn out at once more than double the former amount of work done per week. It was considered necessary at first to put the control of the speed in the hands of the foreman only, and for him to lock up the shunt regulator; this is now found to be an unnecessary precaution.

A later development of this method of driving is one whereby the driving shaft, just mentioned as running the whole length of the bed, is entirely done away with, and the one motor, now a variable-speed shunt motor, does all the feeding of the boring bar, as well as the rapid advancement and withdrawal of it and the saddle, the latter weighing 10 to 12 tons or more. How this is effected is shown in the diagram of this feed gear in Fig. 3.

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* Paper read last night before the Institution of Electrical Engineers.

The action of the gear is as follows: The motor drives the shaft through a flexible coupling H. This shaft carries on it the magnetic clutch B, and beyond the clutch the worm C. It also carries on a sleeve a pinion, and the overload clutch G and an armature. The worm gears into the worm wheel above it, from which the change gear D, similar to that of a screw-cutting lathe, and situate behind the worm wheel, drives a horizontal shaft on which another worm engages with a second worm wheel, E. This latter can be clutched mechanically by the claw clutch A to the screw shaft I actuating the saddle. The claw clutch A is moved by a hand-wheel in and out of position, and the lever F that moves carries a contact which only allows of the magnetic clutch B being in action when the claw clutch is disengaged. Thus normally the drive is through the worm wheels and the change gear, but when it is desired to move the saddle quickly the magnetic clutch is energised and the pinion on the motor shaft then drives a spur wheel which is keyed to the screw shaft I, the latter being thus driven direct. The feed can be varied practically to any extent required between the extreme limits by the combination of change gears and the varying speed of the motor. This gear is worked entirely from the main switchboard by which the man starts and stops and controls the speed of the headstock carrying the gun tube, and the switches are so interlocked electrically that it is impossible either to start the feed gear or to leave it running unless the main motor is running.

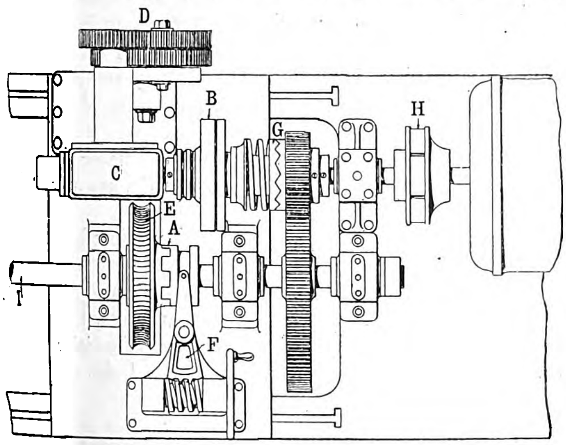

Fig. 3.

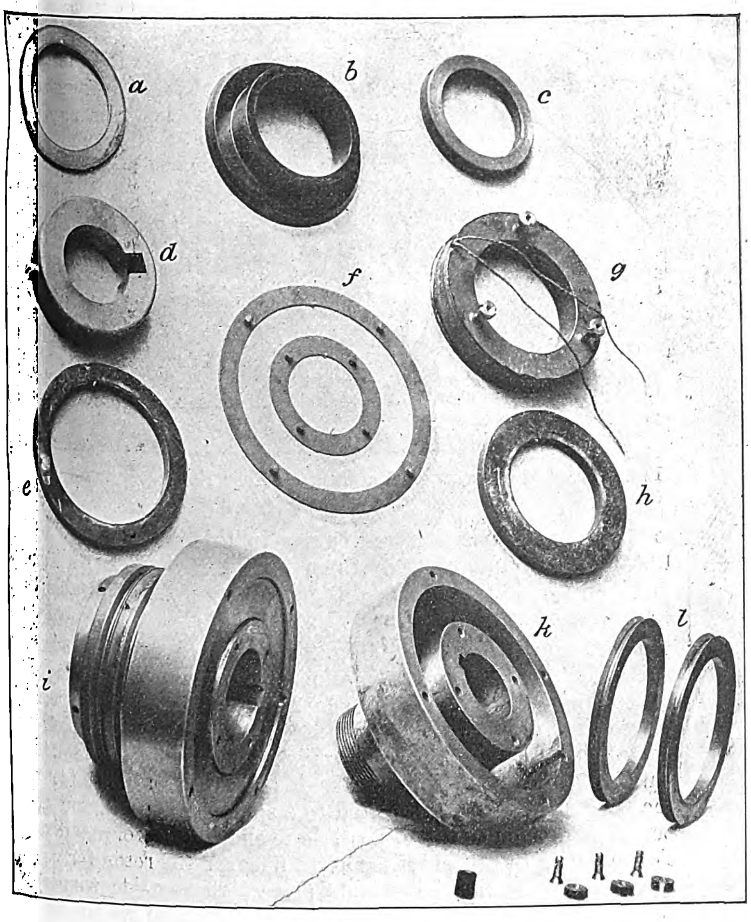

Fig. 4.

It will be seen that there is a magnetic clutch employed in connection with this gear, and as such clutches appear in a good many of the illustrations in the Paper, I may as well describe it in more or less detail now.

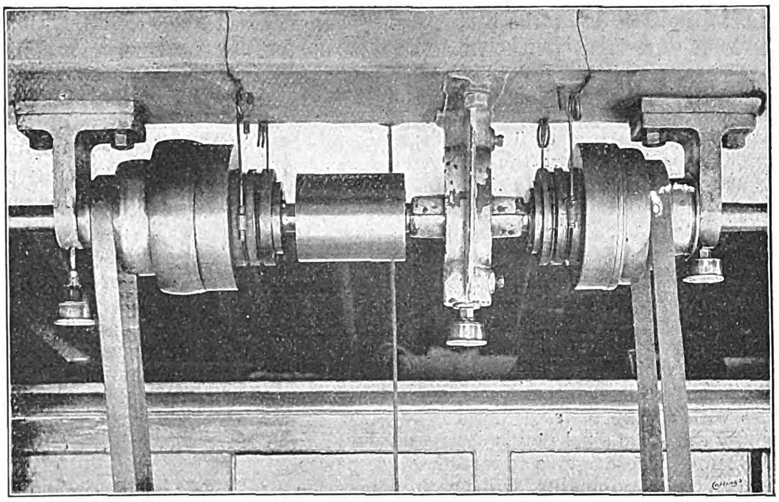

Fig. 5.

This magnetic clutch is, of course, only a variety of a friction clutch, but it has advantages over the latter in that it can be used under conditions which would be impracticable, and in many instances impossible, for an ordinary friction clutch, owing to the fact that it can be as readily worked from a distance as from close at hand, whilst its action is quicker and more definite as to holding power, and it cannot possibly stick or seize.

As will be seen from the accompanying illustration (Fig. 4), the clutch consists of five essential parts, the slip rings *l*, for conveying the current to the coil *g*, the circular magnet *k*, the demagnetising rings, so-called, *f*, and the armature, which is merely a plain disc of Swedish iron or a piece of high permeability steel. The remaining portions shown in the block are merely insulating rings, screws and nut for building the parts into the complete clutch which is shown at *i*.

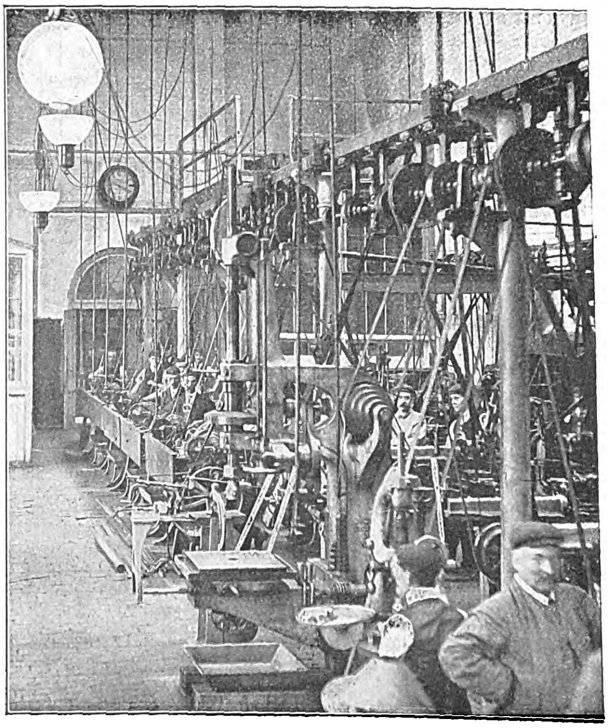

Fig. 6

Two of the first clutches made over 15 years ago are shown in Fig. 5, and these are still in perfect condition. I am at present only using two types of these clutches, one rated at 6 H.P. and the other at 25 H.P. at 300 revs. per min. Owing to the fact that the voltage of the supply circuit was 300, and also to the difficulty that there is in winding bobbins with a finer gauge of wire than No. 36 S.W.G. or 0·0076 in. diameter, it was not practicable to make a smaller clutch than the size named, which is only 7·5 in. in diameter; indeed, in this case even it is necessary to add 1,000 ohms resistance to that of the bobbin in order to reduce the current and prevent heating of the coil. 8,000 turns of wire are employed in either case, the sectional area of the bobbin being 1 sq. in., and the total capacity of the bobbing being 15·7 cubic in. for the 6 H.P. and 32 cubic in. for the 25 H.P. clutch. 21 watts are absorbed in the magnetising coil of the 6 H.P. clutch and about 42 in the coil of the 25 H.P. clutch. This gives an efficiency of under 1·5 watts per horse-power in the case of the 6 H.P., which actually transmits 14·36 H.P. at 300 revs. per min.; the 25 H.P. clutch is still more efficient It will no doubt be readily seen that the diameter of the clutch has a more important effect upon the number of watts per horse-power transmitted than any other factor, and that it is quite feasible to transmit 1 H.P. for quarter of a watt or even less. The original pattern of demagnetising ring was a complete disc, which is simpler and not impracticable; but obviously some of the lines of force are uselessly diverted by it, and where high efficiency is desirable it should not be used. In the case of the clutch rated at 6 H.P., the horse-power transmitted at 300 revolutions is 12·73 with the complete disc, as against 14·36, with the two rings—by perforating the disc with a ring of large holes concentric with the bobbin very nearly the same efficiency is obtainable as with the rings—namely, 14·32 H.P. These figures as regards horse-power transmitted were obtained with the surface of the clutches dry and free from oil, and it seems hardly necessary to point out that the horse-power which can be transmitted, if they are well oiled, is considerably reduced; it is therefore necessary to arrange in designing the mounting of these clutches that oil shall not by any possibility work itself between the acting surfaces. I have not found any great difficulty in this respect. Where it is impossible or undesirable to prevent the adhering surfaces from becoming oiled, then the clutch must be rated 50 per cent. lower, or else made larger in diameter to transmit the same power as when kept free from oil. Some 117 of these clutches are in daily work at the Gun Factory, and are applied to a variety of purposes, some of which are illustrated in this Paper.

A view of the Gauge-room, Royal Gun Factory (Fig. 6), shows the method of driving the lathes and other machine tools which was introduced when the shop was remodelled some four or five years ago; I have also some views of existing shops in which the old system of driving is still employed, so that anyone who wishes may be able to appreciate the simplicity of the later system, as compared with the former. In the new arrangement, the motor, a 15 H.P., is attached to the wall and drives the main shaft, which runs down the centre of the shop, by means of a belt at a point about midway in its length at a speed of 450 revs. per min.

There is none of the usual countershafting and its multiplicity of belts; instead there is one cone pulley over each machine, driving the machine in the usual manner with a belt. These cone pulleys are, however, not carried on the main shaft, but on tubular bearings through which the main shaft passes quite clear, while the bearings themselves are supported on brackets; the pull of the belt thus does not come upon the shaft when the cone pulley is not running and the machine is idle; the cone pulley carries the armature of the clutch at one end of it, and against this end the electromagnet with its collecting rings is keyed or otherwise fixed to the shaft. The pins of the demagnetising rings enter holes in its face, and keep this part of the apparatus in position. Very slight longitudinal play in its bearing is given to the cone pulley, and a slight bias is given to the belt drive, so that the tendency of the pulley is to run from the magnet when the latter is de-energised. It is found that by adopting this simple method no spring or other device is required to keep the surface from contact or rubbing when the clutch is not in action. The extent to which frictional losses are reduced can be imagined when it is explained that when the motor-driving belt is thrown off and there is no current on the clutches, the main shaft can be revolved between the fingers. The switches used to actuate the clutches are of a selective type—that is, when the current is off, a pull at the switch rope puts it on, and a second pull cuts the current off again; this appears from practical experience to be more convenient than the ordinary belt-shifting method in which two ropes are employed, one to put the power on and another one to cut it off. The base of the switch contains a condenser to render the extra current innocuous on breaking the circuit.

(*To be continued.*)

## THE DICK KERR ALTERNATOR FOR STEAM-TURBINE DRIVE.

Manufacturers of electric generators are now obliged to turn their attention to the design of a machine differing so much from their existing types as to involve practically the establishment of new standard patterns. We refer to the generators of large capacity which are to be driven by steam turbines, and whose speed is such that the number of poles on the machines is greatly diminished, both the stationary and rotating parts become much smaller, and the whole lines of the design are altered.

In the present article we describe the new alternator for steam-turbine speeds which Messrs. Dick, Kerr & Co. are now manufacturing.

Two of these machines of 3,000 kw. capacity have just been installed at the Port Dundas electricity supply station at Glasgow. The turbines driving these are of the Parsons type, manufactured by Messrs. Willans & Robinson, and they have already been described in these columns (*The Electrician*, Vol. LV., pp. 211 and 895). It may be mentioned also that some of the particulars and curves in this article relate to a 1,000 kw. machine built by them for the Bristol Corporation. The general details of the design, however, are applicable to both sizes of machine.

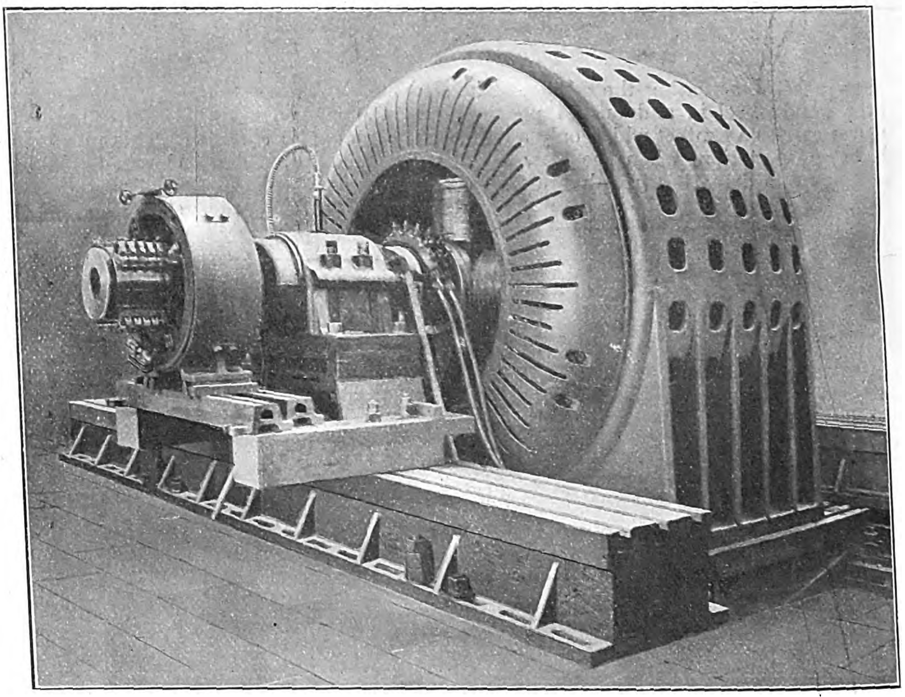

FIG. 1.—ALTERNATOR, WITH EXCITER, ON TEST BED.

The frame of the stator (Fig. 2) is made of strong cast-iron, and supports the stator laminations. Slot winding is employed, the conductors being insulated by means of pure mica. Special ventilating ducts are provided in the frame, and stiffening fingers are clamped on to the outside of the laminations for the purpose of obviating any danger due to vibration. The feet of the alternator frame are bolted to a special sole plate, and the bed plate is such that it is possible to slide the stator in a direction parallel to the shaft, so as to uncover the rotor for easy inspection. Perforated shields protect the outside windings from accidental contact or mechanical injury, and are furnished with open spaces for ventilation. All external parts of the high tension windings are covered with sufficient insulation for the full voltage.

The rotor body (Fig. 8) is built up of a central solid steel casting A (Fig. 7), cast under pressure, with four projecting poles. This central body is machined and bored out to a diameter larger than the shaft. Two cross-shaped pieces, B, are built at each end of the central body and carry the rotor on the shaft. These parts are so arranged with reference to the shaft as to leave an annular space all round for ventilation, the openings being shown at K. On the central body A radially drilled passages L are provided, which correspond to air ducts in the laminated pole tips, these being in line with openings left in the stator iron. The pole tips are laminated and are dovetailed on to the steel casting of the central body. Special end pieces, shown at C, also dovetailed on to the steel casting, retain the laminated tips in position, and at the same time act as checks against centrifugal force to keep the spools in position. The dovetails on the central body A and on the end pieces B are of such a dimension as to allow the

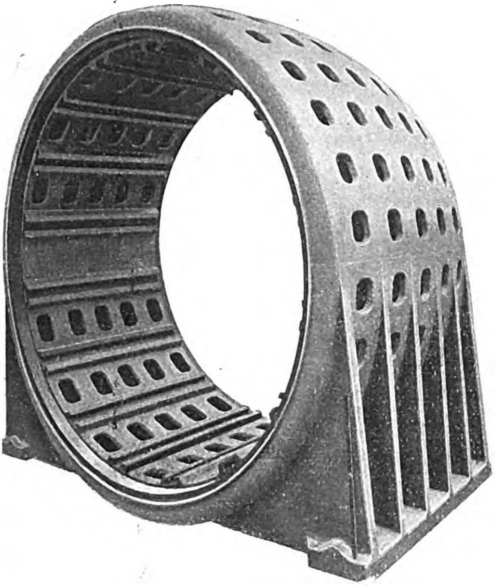

Fig. 2.—Stator Casting.

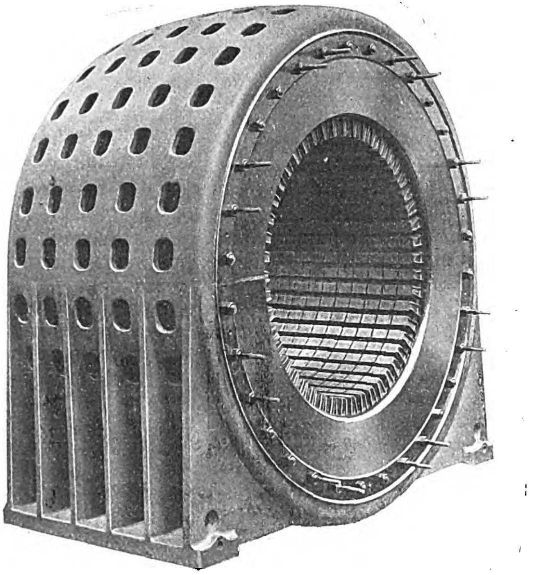

Fig. 3.—Laminations assembled in Stator.

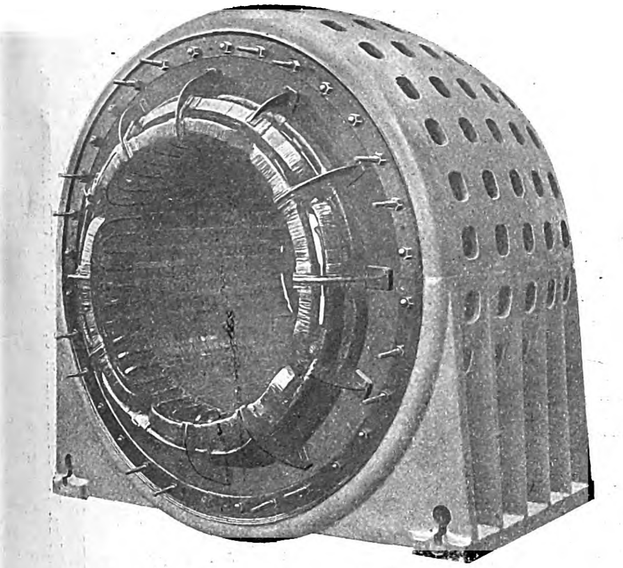

Fig. 4.—View of Stator, showing Windings.

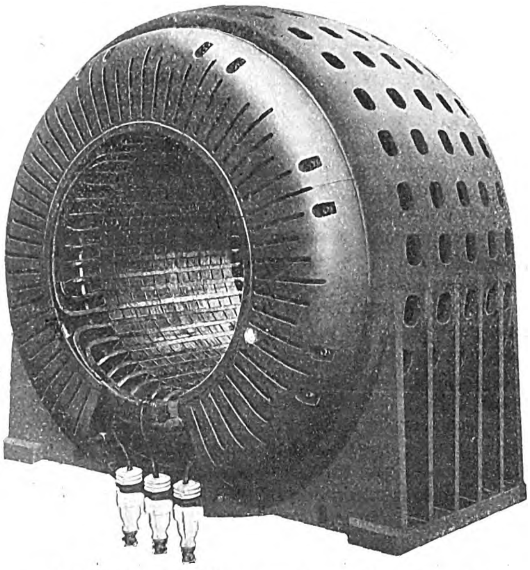

Fig. 5.—Stator Complete with End Shields.

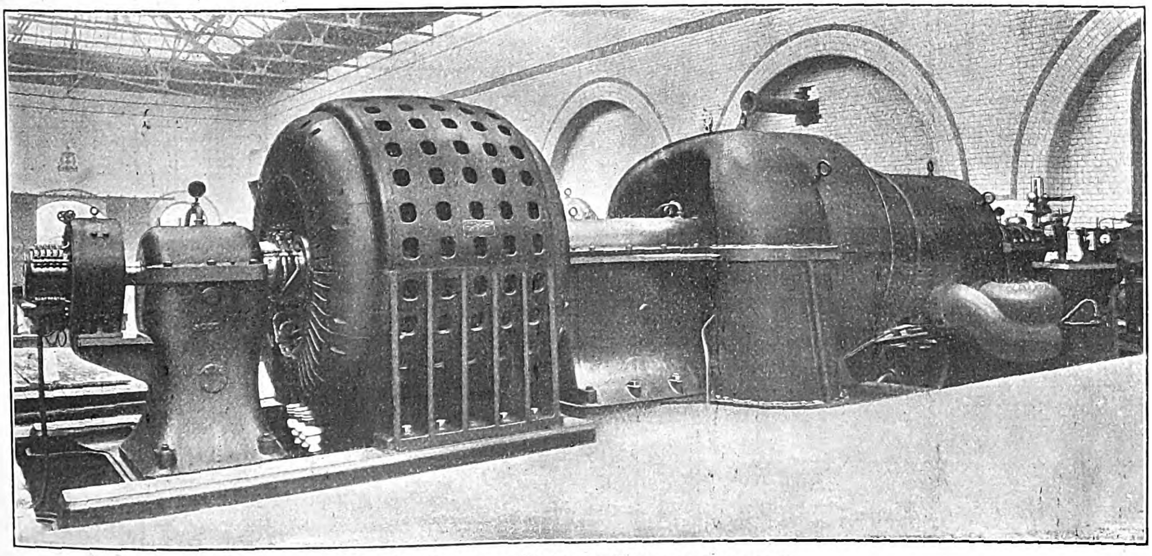

Fig. 6.—General View of Turbo-alternator.

steel tips C to be put into position by sliding in on the dovetail of the central body A. It will be seen that when the laminated pole tips have been inserted in position and pressed together by means of the steel tips C, they are all interlocked and cannot shift. To guard against centrifugal force which would tend to spread the field coils laterally, wedge pieces F are inserted between adjacent coils, pressing against them and the laminated pole tips.

The field winding is built up of solid copper strip wound on edge, insulated between turns by means of paper and mica and supported in a special copper spool with heavy insulated flanges. The spools, after being formed and insulated, are subjected to hydraulic pressure in the axial direction of about 50 per cent. over the pressure to which they would be subjected from centrifugal action in normal running. The copper winding of the field bears flat on the insulation, thus avoiding any danger of cutting. The terminal leads of each spool are carried out on the bottom of the spool, and are composed of very thin and flexible copper strips. Between the spools special wedges, already indicated at F, are provided to withstand the horizontal component of the centrifugal force, which tends to open the spools. The spools, after being assembled and connected up, are finished on the outside surface, where otherwise the copper would be bare, by means of a special varnish, which is oil and waterproof, thus presenting a very hard and glossy surface, making it easier to clean the machine.

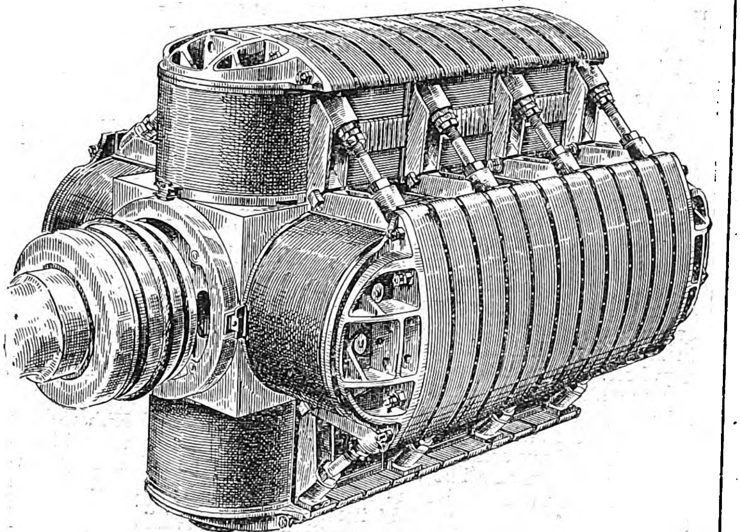

FIG. 8.—REVOLVING FIELDS OF ALTERNATOR.

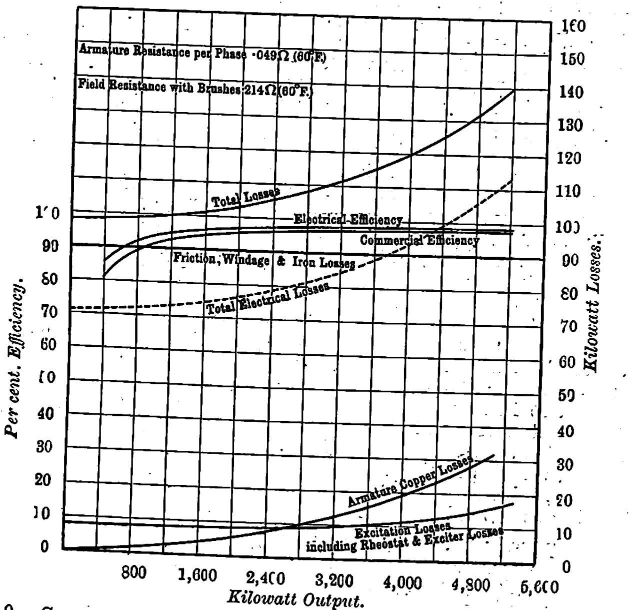

FIG. 9.—CURVES SHOWING LOSSES, COMMERCIAL EFFICIENCY AND ELECTRICAL EFFICIENCY OF GLASGOW THREE-PHASE TURBO-ALTERNATOR.
Four poles., 750 revs. per min., 3,000 kw., 6,700 volts, 25 ∽.

Special pressed steel is employed for the shaft, which is finished all over; the rotor is pressed over it with about 100 tons pressure.

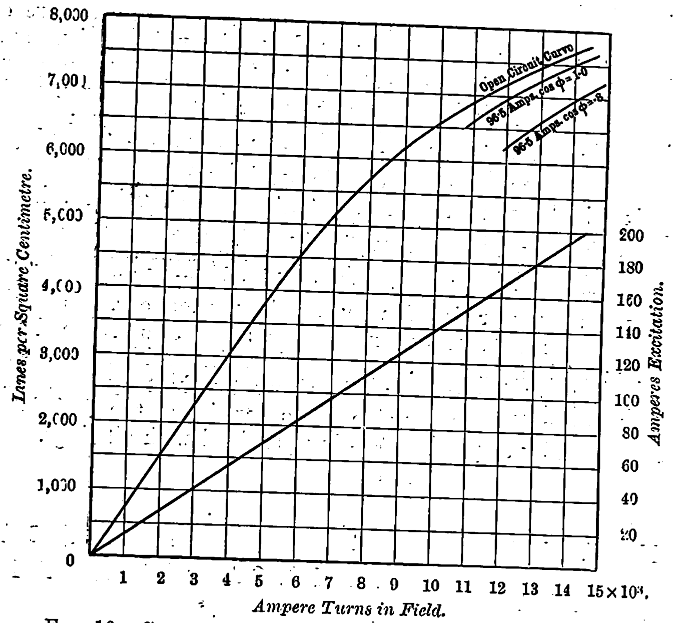

FIG. 10.—SATURATION CURVES OF THREE-PHASE ALTERNATOR.
Four poles, 1,500 revs. per min., 1,000 kw., 6,000-6,600 volts, 50 ∿.

The collector rings are of manganese bronze, fixed over a solid steel sleeve, and of a special construction which prevents deformation under working conditions, the rings being shrunk hot over special micanite rings, which are built up directly on the steel shell of the collector ring. From the field coils leads are carried to the collector rings, and are protected by means of special metallic caps, which are fitted over the shaft and to the end of the rotor body. The connection of the leads to the collector rings is also protected by a special cap, which is easily

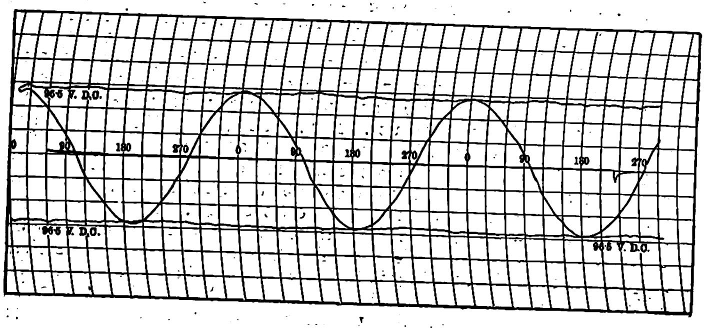

FIG. 11.—BRISTOL 1,000 KW. TURBO-ALTERNATOR. ONDOGRAPH CURVE TAKEN ON OPEN CIRCUIT.
A.C. volts, 6,000; speed, 1,520 revs. per min.; A.C. volts across instrument, 69; D.C. volts, 96·5.

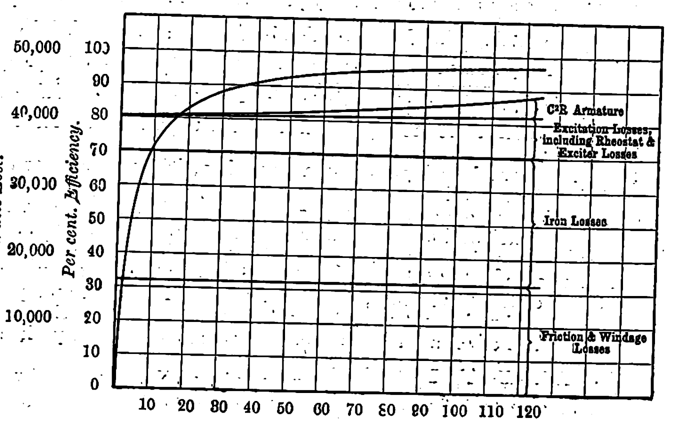

FIG. 12.—CURVES SHOWING EFFICIENCY AND DETAILED LOSSES OF THREE PHASE ALTERNATOR.
Four poles, 1,500 revs., 1,000 kw., 6,000-6,600 volts, 50 ∿.

removable for inspection if necessary, the finished appearance of the collector rings and rotor body being such as not to have any loose connection or projecting part, making it possible to keep the machine clean when running. The brushes are of special graphite copper of very low friction coefficient and high conductivity. Those belonging to one collector ring are kept separate from the brushes belonging to the other. Ample contact area is provided on the brushes, and they may be adjusted and replaced if necessary when the machine is running, without interfering with its working.

It will be seen from Fig. 6 that the exciter is overhung, being carried on an extension of the main shaft. It is designed to give its full load continuously, with a rise in temperature not exceeding 65°F. above the surrounding atmosphere. The commutator is of very ample proportions, while the brushes are made of carbon graphite, and are so arranged that they may be adjusted or replaced when the machine is running. The exciter is connected to the alternator shaft by means of a flexible coupling on one side, the other side of the shaft being supported by a spherical bearing provided with oil rings.

## MR. J. M. M. MUNRO'S INAUGURAL ADDRESS TO THE GLASGOW SECTION OF THE INSTITUTION OF ELECTRICAL ENGINEERS.*

Your choice of a chairman has been somewhat influenced, I believe, by a desire to recognise the early work of the pioneers of the electrical engineering industry in Scotland. Therefore, in choosing a subject on which to address you this evening, my thoughts first turned naturally towards these earlier days of our industry. We had then great faith in ourselves, and would have accepted an order to plan and do anything if only it were to be done by electricity. Thus the early work, although small, presented great variety of problem. Everything which is now commonplace routine had to be designed anew for each little undertaking. So it has come to pass that many of us who were privileged to take a part in the work of these early eager days are each of the opinion that we were the first to invent and utilise a surprisingly large number of the electrical appliances now in common use. Between 1877 and 1882 almost every development of the next 15 years was foreshadowed.

Glasgow has a world-wide reputation for enlightened and successful corporate enterprise. It may therefore be apt and useful to make some general remarks anent electricity in civic service. Few subjects have awakened controversy more heated than the policy of municipal trading. To the greater part of the electrical Press, and to many members of this Institution, municipal trading is the embodiment of all evil. Where there is smoke there is fire, and hostility so vehement has not arisen without cause. The chief points against municipal trading may be stated thus:—

1. Those countries which are soonest willing to spend money freely in extensive trial of great inventions long retain the manufacturing trade for which their experience pre-eminently fits them. Thus, steam engine making, shipbuilding and railway work were secured and held by Britain. So also America, and Germany later, got a good grip of heavy electrical engineering. Public opinion does not yet permit towns to undertake venturesome pioneer projects. Therefore, it is not good policy to discourage private enterprise, either by direct veto or by the knowledge that its future may be limited by the formidable competition of the towns. By the time towns are ready to act heavy plant is best made abroad.

2. After a city has entered upon a scheme, suggestions from elsewhere are frequently unwelcome and their adoption often inconvenient. With a free field every new minor device and suggestion would find ready trial somewhere, and young engineers get work, experience and stimulus. Therefore, town monopoly here again hinders the advance of our national industries. Then there are arguments founded upon the local results of civic trading.

3. As the towns, by a dog-in-the-manger policy, delayed the progress of electric lighting, so will their formidable trading rights frequently debar their inhabitants from getting early use of many modern inventions. For, as already pointed out, under existing conditions, a town may not touch a trade for the supply of something not yet in general demand, and private enterprise dare not, lest it be robbed later of its fruits by civic competition.

4. Great civic undertakings, founded by men of wisdom and public spirit, may in time be controlled by weaker men or even by self-seeking demagogues, who will use these undertakings to furnish their pockets or enrich their friends and supporters.

5. A vast number of workmen in town service would, by compact voting power, be able to influence elections and advance their own wage and status at the expense of other citizens.

6. Imperial and local politics develop burning questions and the patronage of city undertakings may be used as counters in the political game.

7. Civic trading accentuates the evil attributed to all concentration of business into few hands—it tends towards a condition in which there are a few highly paid men and all others are slaves of system and routine.

8. A crowd of officials and servants may not all be citizens so desirable as numerous master-traders with their workmen. Independence develops character and promotes diversity. Variation, struggle for existence and survival of the fittest are essential to progress.

9. Where a number of citizens are engaged in a trade it is unfair for the others to use common capital to crush them by entering upon a like trade. Those displaced ought at least to be generously treated. Too often towns adopt the tactics of unscrupulous traders who, by opposition or threat of it, endeavour to ruin a rival that they may buy him up cheaply.

10. A group of gentlemen attending periodic meetings cannot be expected to exercise useful control over a business to which they have not devoted their lives. So soon as they begin to understand it, they are apt, for other reasons, to lose their seat on council or committee.

11. Each committee is eager to show improved results under its management, yet its members do not suffer financially through mistakes made. Thus arises risk of rash extensions followed by deceptive financing. The like cause may delay development.

12. When municipalism is triumphant a town will be engaged chiefly in providing and distributing the necessities and luxuries of life. But a town cannot live permanently on "taking in each others washing." It must do work for those outside to obtain its supplies of food and raw materials. The town will be forced to undertake much such work also. For in many trades an external business cannot be built up and sustained by private traders who are cut off from a local market.

13. If a town decay and fall off in population, those who remain will be forced to flee to escape the burden of taxation consequent on reduced income from elaborate undertakings.

As 13 is deemed an unlucky number, I will add one more of the arguments which suggest themselves.

14. The element of personal trust in trading is healthy. But to avoid even the suspicion of favouritism and corrupt practice, town committees, in accepting contracts, are also forced to accept the lowest tenders from anywhere. This tends to the extinction of the small trader and (notwithstanding all possible specification and inspection) it leads inevitably to inferiority of workmanship and the degradation of labour.

Many of the evils prophesied have not yet come to pass. Hitherto city undertakings have conferred more benefits than injuries upon the citizens generally. Arguments like those of 3 and 9 may be reversed by compelling towns to treat pioneers liberally. We note, also, that the free competition of private trade is of itself tending towards a centralisation productive of evils worse than those of municipal undertakings. Meantime, we must play the game in the field as we find it. City Corporations have powers: many of them are eager for more. Let us see, then, what limits, if any, may be agreed upon for town trading, and then go on to review what has been and what may be done within these limits by electricity as a civic servant.

The best known statement of the legitimate scope of town trading is that made by our own ex-Lord Provost Chisholm while under examination before a Parliamentary Committee. I have not the report by me, but it was (if I remember aright) to the effect that a town ought not to undertake the supply of a commodity or convenience unless—1st, such service would be beneficial to the citizens generally—not a mere section of them; 2nd, the service to be efficient needed somewhat of the nature of a monopoly; and 3rd, the operations connected with it involved structural interference with streets or other public property. These conditions together have the merit that they may be accepted by those who approve and by those who disapprove of town trading.

Electricity, I think, first formally entered the service of St. Mungo to do fire alarm work. The subject was before the magistrates in 1872. Mr. Symington, already well known by his telegraph exchange, was engineer and contractor for the street fire alarm installation of 1877. It was designed after the fashion of the common electric bell arrangements, but strengthened and encased to suit the exposed conditions, and it usefully served its day. This was succeeded by 1885 by another, the present system, designed by one of the members of this section of our Institution. It retained the direct point to point circuit, but transferred the batteries from the street boxes to the central fire stations, made the action of the push more certain and less under the continued control of the sender, provided terminals for portable telephones, and provided also, among other things, for a ready instantaneous distinction between a fire call and the result of an accidental contact on overhead wires. These, with improvements on the indoor fireman's call arrangements, permitted the committee in charge to report, after a visit to the chief stations in America and Britain, that the Glasgow fire alarms were in their opinion the most efficient and reliable of any. Under the able control of the firemaster, who has further strengthened the mechanism where experience dictated, this favourable comparison yet holds good, I believe. There are in Glasgow 239 public and 50 private street fire alarm boxes besides 34 May-Oatway installations. During the last 10 years about 5,000 fire calls were received, of which less than 1 per cent. were imputed to faults in the apparatus. If private automatic fire alarms are made sufficiently reliable with a small visual or continuously audible signal outside of the building protected by them, I do not see any fatal objection to these being coupled up to the nearest street fire circuit so as to signal there own message—although I daresay the Fire Brigade would prefer their wires kept apart as now.

When dealing with fire brigade affairs it may be of interest to state that there is now under construction for Glasgow an 80 ft. fire escape driven by two electric motors pivoted on the front axle, and having pinion wheels gearing into teeth on inner circumference of front wheels. Motors get current from a dynamo driven by a 30 B.H.P. petrol engine on the car frame of the fire escape. This electrical arrangement is being tried not merely because it permits the motor to run at full speed and power at starting and at any speed of car, but chiefly because the electric motors do not interfere with steering. The petrol engine could not be applied to rear wheels, for the rear wheels have to be canted up when the ladder is extended.

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* Delivered November 14th. Slightly abridged.

Firemaster Paterson's police telephone communication boxes, by which a policeman on his beat may call, or be called from the police office by electrically turning on a coloured light, is also worthy of honourable mention. Small and numerous street boxes as well as kiosks, telephonic or other, from which the public could call police or ambulance, would be useful, especially at night, when ordinary telephone call offices are shut. Were this done it would be desirable to keep the fire alarm signal as it is, a distinct apparatus on its own circuit, not combined, as some other towns have them. Various towns, both at home and abroad, have made extensive trial of police kiosks.

In 1875 or thereby, a number of town clocks were hourly controlled by electric current by a device due to Mr. Brockie, of arc lamp fame. The controlling and the sending mechanism were situated in the premises of a well-known clockmaker, the controlling clock being governed in turn by electric pulses second-by-second from Glasgow Observatory. In 1880 the sending apparatus was greatly simplified and made more reliable by one of your members, whose firm held for a time the sub-contract for the overhead wiring also. The principal of these clocks was a very simple one. They were ordinary clocks of good make, having the minute hand (with the hour-hand gear) spring-tight on the axle. A current, sent hourly round all the clocks of a district in series, actuated an electric magnet on each, whose armature, by means of two projecting pins, set the hands exactly to the hour. Such a system, if fitted to-day, with underground wires, would equal any system in simplicity; therefore, perhaps, in certainty. They gave trouble after a time because the overhead wires were constantly being broken or put in contact, and partly also, I think, because the electric control was on the whole so good that ordinary care was not taken with the common clock mechanism. I believe the price charged to the town did not permit of it. All went well, as a rule, unless the clock went over three minutes or so wrong per hour—an ample margin surely. Yet even then they had one good point: when they did go wrong at all they went so far wrong that nobody was in doubt of the fact. After many years' use this system died of exhaustion, and was buried to await resurrection in a glorified form. Of late new proposals for keeping the city up to time have been under consideration and trial. One of the best of these—Prof. Becker's second-by-second escapement drive—has given promising results, as also have other competing systems.

The so-called Normal Zeit clocks, popular in Germany, have been well spoken of. This system more resembles the old Glasgow system with useful additions. The clocks on a circuit are not in series, but in parallel, and are electrically wound and regulated, not together, but in succession, so that it is possible to get in the control office an automatic record of the accuracy of each clock. Perhaps, when aerial power transmission is a little further on, the city will provide aerial power impulses able to synchronise not only all public but all private clocks and perhaps our watches also. I understand that Vienna has made some experiments in this direction.

Early in the year 1880 the present writer issued, in Glasgow, several thousand circulars regarding a proposed telephone exchange at a £5 annual rental. With the limited number of subscribers then possible such a rental would have been remunerative. This circular met with an encouraging response, but the private firm who fathered it shrank from the added cost of a law fight with rival telephone patentees not then united. Early in 1880 the Bell Telephone Central Exchange was opened in Queen-street. Mr. David Graham about this time founded, in Douglas-street, the Glasgow Medical Telephone Exchange, to which was soon added the Legal, the Stockbrokers, and the Commercial Exchanges at the same centre, and these were soon followed by the Edison Exchange in South Exchange-place. These, in time, became the nuclei of what is now the great local undertaking of the National Telephone Co. The Corporation Telephone Exchange, first discussed by the Council in 1892, licensed and begun in 1900, was opened in 1901, and the present speaker had the satisfaction of filling in the first application form—having been at hand when the printer's proof copy arrived. I am informed that the exchange has now 10,231 names on its directory.

We can, however, unite in hoping that, if the Government do not extend the period of the telephone licence of the Corporation, they will pay such a price for our exchange as will obviate loss to the city. If so, the citizens will have benefited by their venture. In April, 1900, after 20 years' operation, the subscribers in the directory were 6,590. This year in April the combined directory numbers are 25,224.

The Corporation Gas Bill of 1882 proposed to take power to supply electric light in Glasgow, but the clauses were deleted before going to Parliament. In 1890, however, a provisional order was applied for and obtained, and on February 25, 1893, Waterloo-street supply station began to supply the street arcs, and a few months later private consumers were connected up. In March, 1892, the town bought the pioneer undertaking of Messrs. Muir, Mavor & Coulson (Ltd.), in John-street and Miller-street. At that time the undertakers were from John-street supplying current mainly through overhead wires at 2,400 volts single-phase alternating, with transformers in the consumers' premises. Their Miller-street 100-volt station, opened in 1884, chiefly, I believe, for supply to the General Post Office, was the successor of the earlier temporary plant of 1879-80 in George-square. I forbear to revive old controversies by discussing whether No. 9 of the objections to civic trading was cancelled by the price paid for this early and praiseworthy enterprise. Several not unimportant supply stations were early fitted by private firms for railway and other lighting, but these did not pass into the hands of the city.

In 1889 the Kelvinside Electricity Co. was incorporated, and a prospectus issued and notice given to the local authority of intention to apply for a provisional order for the supply of electricity to that district—the plans, specifications and estimates for a 10,000 10 c.p. lamp station having been previously prepared. The second prospectus of this company, and plans of a similar 30,000 lamp station were issued in 1890, after the bill confirming the Glasgow and the Kelvinside and other provisional orders had received the Royal assent. Owing to various circumstances, into which I need not enter, it was August, 1893, before the first section of this station was opened for public supply. It was purchased by Glasgow Corporation in 1899.

By 1897-98 the scheme for the large supply stations at Port Dundas and Eglinton Toll, with certain other sub-stations, was well under way. The energy generated at the various Corporation generating stations has increased from about 408,000 units in 1893 to over 44,000,000 units in 1905.

The Private Tramway Company's lease of the 60 miles (counted as single track) of Glasgow tramways expired in 1894, and the city then took up their operation. On October 13, 1898, Springburn line was opened with overhead-wire electric traction. The 13th was not in this case an unlucky number. The whole Glasgow tramway system was similarly operated by 1901-2. There are now fully 700 cars and some 150 miles of track. The number of passengers carried in year ending May, 1905, was nearly 200 millions. The total capital expenditure equals about £2. 15s. per inhabitant of Glasgow, and every man, woman and child takes about 200 journeys a year, spending about 15s. each in doing so.

Some city routes are yet unserved with cars, and others, when most needed—at busy hours of wet or cold days—are very badly served. The double deckers come slowly, probably that their safety may have adequate trial. Larger cars are advocated—trailers would be more economical, perhaps, but they occupy room. The rapid growth of demand portends congestion of street traffic. Underground or overhead routes must come. Perhaps it would pay the town to buy and electrify the existing subway to begin with. The Finnieston tunnel also may yet be useful as part of a relief north to south line.

There is some 21,800 B.H.P. installed for tramway purposes—a very ample allowance hitherto. The capacity of the electricity department plant in May this year was 10,993 kw.; but important additions are being made in the form of 3,000 kw. turbines coupled to generators of 6,500 volts and frequency 25. This brings me to the subject of the production and supply of electrical energy in bulk for all civic purposes. This problem differs in many respects from that of the now familiar or district supply. The common city electricity generating station is, so far, a solution.

The following figures refer to the year 1904-5. Gas figures are added mainly because they affect the question of coal, and may yet be otherwise closely related to the subject in hand. By useful units I mean the kilowatt-hours sold by electricity department, or issued from tramway sub-stations for traction purposes and lighting of cars.

| | Units generated. | Useful units. | Operative and incidental losses. | Kw. Max. load. | Tons coal. |
|---|---|---|---|---|---|
| E = Electrical dept. = | 20,340,556 | — | — | — | 47,356 |
| E bought from T = | 1,243,532 | — | — | — | — |
| | 21,584,088 | 18,248,468 | 15½% | 13,437 | — |
| T = Tramway dept. = | 23,918,863 | — | — | 8,517 | 35,267 |
| T sold to E ...... = | 1,243,532 | — | — | or | — |
| | 22,675,331 | 17,951,961 | 20½% | 6,300 | — |
| Combined totals .... | 44,259,419 | 36,200,429 | — | 19,737 | 82,623 |

In Montreal, I have been told, a population of one fourth of Glasgow uses nearly three times the electrical energy.

Cubic feet of gas generated .......... 6,449,539,000 ........ 680,235

Total tons of coal............ 762,858

The load factors work out at, for tramways, 41 per cent. excluding current sold to E, or, including this, at 30·8 per cent., and for the electrical department on total amount generated, including current bought = 18·3 per cent. Coal per useful unit (plus and minus amount sold by T to E) comes out at, for tramway department 4·1 lb. coal per useful unit, and for electricity department 6·2 lb.—a coal difference doubtless due to such factors as larger plant units, smaller stand-by losses, more regular hours of load and, in smaller degree, to other points of difference of load factor. For, of course, the chief effects of load factor come in in the standing charges. The effect of the use of electric lighting secondary batteries on this coal rate would be of interest to study.

I made out the probable corresponding figures for the year 1915. As no two men would quite agree on the effect of the various factors which may and must influence a prolongation into the future of the curves of rate of past increase, I do not give the resulting figures. Improvements in generating methods and in the efficient use of the energy tend to lower the total consumption. Increase of population, of trade, of money and of new applications of electrical energy tend towards increase. The figures seem to suggest, however, a total consumption in 1915 for electrical purposes of some 200,000 tons, and for gas of 560,000 tons—a figure which might be much increased if a very cheap gas were greatly used for heating purposes. Much of the gas coal is necessarily derived from special sources, but it may be of interest to state that the annual output of coal of the Lanarkshire coalfields is 17,000,000 tons. It has been estimated by some that this rate of output could be continued for 100 years or thereby.

These figures raise several questions of policy primarily applicable to large cities.

(*a*) Ought the production of electrical energy to be combined under one management distinct from the great departments which have to do with its sale, general distribution, and use for traction, light, power, &c.

(*b*) Ought these great coal burning undertakings to have their works outside the city proper.

(*c*) Ought a great city to do with coal as most have done with water—that other great necessity of life—acquire their own coal fields as they have acquired their mountain lochs and water-gathering areas.

In the smaller towns, and in early electrical stages of all towns it is economical to combine everything as one undertaking. In our own city there were special reasons for providing a generating station for traction purposes alone. The then existing electric lighting generating units were deemed too small and too slim for anticipated, if not quite realised, sudden overloads; the extended area to be served with traction demanded pressures and forms of current quite unlike those hitherto preferred for moderate-sized electric lighting areas; and the traction engineer also naturally wished to gain for the department for which he was responsible every possible modern advantage. In the largest cities—and for convenience we shall still speak of Glasgow as representative—the work is rapidly becoming so great and varied that, in this age of specialists, it may be found advantageous to subdivide and put each department under management which bestows all its study and attention upon one great branch. It is obvious that a power department would have to be in close touch with its primary customers, the distributing and traction departments. Arrangements would have to be made, therefore, for interchange of information, if not, indeed, for a certain amount of combined meeting and action. Possibly a supreme electrical adviser, continuously or occasionally employed, might be necessary, but probably regular consultation between the various chief departmental experts, and a periodic union of the committees for important joint decisions would serve all purposes and prevent injurious interfriction.

Passing from this question, the first point to be settled is: where could dividing lines between power and consuming departments be best drawn? Already the rudiments of subdivision exist. The prime duty of a power department would be to generate all the electrical energy required for all purposes, and deliver it in bulk at a uniform price to the other departments. The phrase "uniform price" does not necessarily forbid that each department might benefit by its specific load-factor; that is a matter for consideration in the interests of the citizens as a whole.

Were this settled so far other questions emerge. To-night I may be permitted some running observations on one or two points only. The use of one uniform pressure for generating in bulk would mean the abandonment of such economy as is to be obtained by direct production of continuous current at 250 and 500 volts or thereby for areas near to the present generating centres. It appears to me that the various economies of uniformity, concentration and distribution would more than recompense for this. Yet, unless indeed the generating station were removed to the coalfield, there would be no immediate need to cease generating at low tension for supplying the area near the station or stations. The capital loss on some existing plant would be in Glasgow an important factor to consider.

A power department would, I think, undertake to deliver its energy at the sub-station terminals. As to the care of feeder and distribution cables, I suggest that the city department, which now makes and maintains the streets, should act as contractors to all electrical and other departments for all work connected with the opening and closing of streets and everything but actual conduits, cast-iron boxes and cables. Subways, when made for all sorts of pipes and cables, would, of course, be constructed by the Street Works Department referred to. It may save some discussion and delays for each electrical department, including the telephonic, and for gas and water departments to send each their own men to open and close streets where and when they will. The method has its advantages, but is unpopular with those who use the streets and find them so often up. Already in Glasgow this trouble is much reduced by having the Street Works Department to permanently restore the streets. With an arrangement such as that proposed, the power department without a special street staff could be responsible for its feeders up to the substations. Other departments could adopt the method so far as they found it beneficial.

I set out to consider this question of power generation and distribution with some bias in favour of sites at coalfields owned by the Corporation. So far as I got with the matter, however, I have not been able to convince myself, and therefore will not attempt to convince others, that the removal of electricity generating stations outwith the city would be financially advantageous. The profit-margins of coalmasters, the cost of conveying coal to and ashes from the city and the cheaper sites together amounted to very little per unit generated; and the interest and depreciation on cables, and the 5 to 10 per cent. loss in the long main feeders, and the reconversion of all instead of only the greater part of the energy more than swallowed up the savings. Then the fact that gas took so much more coal than electricity, and that coal of varied kinds not all obtainable to advantage near Glasgow, and the possibility of special coals being preferred for producer-gas plants were difficult facts to work into a coalfield purchase scheme. If the city relied for light and locomotion on plants in isolated situations—possibly also on overhead feeder lines—it might be suddenly deprived of both in time of war or civil commotion. The chief remaining point—the improved amenity—was partially discounted by the promise of gas engines. For the large power "producer-gas" engine, if not the gas turbine, is sure to arrive. The temperature inside gas engines is some 1,500°C, often more, and steel turbine plates corrode rapidly at 600°C. But the ingenuity of gas engineers will doubtless find means to avoid this trouble.

W. C. Unwin has recently given to the Institution of Gas Engineers, as an approximation to a working formula for coefficient of friction in flow of gas, $\zeta = 0{\cdot}0044\ (1+\frac{1}{7}d.)$ : d being diameter of pipe in feet (not inches, as stated in *Science Abstract* No. 2,125). He supplements this also by a more exact formula. He also gives figures for transmission through 1 mile of 6 in. pipe, of gas (free density 0·55 of air) sufficient to yield fully 2,000 H.P. in a gas engine. The initial pressure at pipe entrance is 34·7 lb. per square inch and 14·7 (atmospheric pressure) at outlet—a loss of 20 lb. These figures are apparently based on isothermal compression and transmission. Of course, they do not mean that the head required for 2 miles would be $20 \times 2 + 14{\cdot}7$, and so on, for the gas compresses as the pressure rises, and the frictional resistance, while it increases somewhat with the density, increases more rapidly with the velocity, and is, therefore, greater at the lower end of pipe line where the bulk of gas is greater. Schemes for such supply are being promoted in Britain—one in Lancashire, I think. The subject has been having some attention of late. I commend to some of you familiar with air and gas-transmission problems, as the basis of a useful Paper, a comparison of "electrical" and "fuel gas" transmission of power giving the horse-power and conditions required for compressing, delivering to pipe, and transmitting through pipes of 10, 20 or more miles in length a supply of producer or other gases sufficient to feed the engines of large electricity generating stations. It would involve consideration of many side problems of site of gas works, compression, high and low-temperature troubles, best pipe sizes, pipe joints, &c. For such distances the power spent in initial compression is very considerable—if economical sizes of pipes are used. The compression to 100 lb. of 2,000 cubic ft. of free gas per minute would, with mechanical losses, absorb nearly 400 H.P. This gas would only give about 2,000 B.H.P. in gas engine after its arrival at atmospheric pressure. Perhaps it may be possible to generate the gas under a high constant pressure; the power required to compress the gas would still be derived from the thermal units of the fuel or their equivalent, but such a process might avoid the heavy outlays, expenses and losses of steam boilers and compressing engines. But I may be suggesting here what is already familiar to, or found impossible by, gas experts. Pressure in existing gas-making apparatus leads to leakage and also impoverishes the gas. If, however, transmission of compressed gas were found as economical as electrical transmission, we would have yet another department working in unison upon electricity supply—the gas department, responsible for supply of fuel to the power stations. If so, it is by no means certain that the gas generating works would be best placed at or near coal mines. Perhaps the gas could be *delivered* to the power station at high pressure, if it can be so generated, and thus simplify the gas engines as well as reduce transmission losses and return a part of the compression power.

Refuse destructors are most useful sanitary appliances. In much smaller towns than Glasgow it is, doubtless, wise to use their heat to raise steam for electric lighting if no other sufficient outlet for the steam can be found. I do not refer to the purchase of an exhaust pipe, but to baths, hot water supply, and rough power purposes, such as making clinker bricks, &c. In large cities the site of electricity generating station and its arrangement could only be affected disadvantageously by adapting these to the requirements of refuse destruction. Yet the best destructor economies may be obtained where the electricity demand is large enough to absorb the day and night output of the destructor—ready, in fact, to take all it can give and large enough not to miss it much when the destructor stops for cleaning or from exhaustion of the day's supply. The peak figures at Hackney are 105 units per ton of refuse, which, at 30lb. water per unit, works out at 1·4lb. steam per pound of refuse. As our tramway coal cost is ·12d. per kw. hour, the fuel value of refuse appears as if about 1s. per ton. But it would not pay an electricity station to buy it at that price, as the total costs of burning it, including interest, depreciation, taxes, labour, &c., vary from 3s. 6d. to 6s. 6d. per ton destroyed. Mr. Maxwell has kindly given me some Partick figures from which I deduce the following as actual or possible. Three tons refuse per day used for banking fires are included throughout. Sundays are excluded. The population of the area from which refuse is drawn is about 64,000.

*Efficiency of Destructor Boilers—1·82 lb. of Water evaporated per pound of Refuse Usefully Burned.*

| | Per day. | Per hour for 18 hours daily. |
|---|---|---|
| Tons of refuse, summer | 35 | .... |
| ,, ,, ,, winter | 65 | .... |
| ,, ,, ,, average (say) | 50 | (Actual av. 47) |
| Units generated per ton of refuse ........ 88 | | .... |
| B.H.P.-hours ,, ,, ,, ..........130 | | .... |

Fuel value (at 0·12d. per kw.-hour for coal
$0{\cdot}12 \times 88 =$ per ton $10\frac{1}{2}$d.)

*Quantities per 1,000 People.*

| | Per day. | Per hour for 18 hours daily. |
|---|---|---|
| Average tons refuse | 0·781 | 0·043 |
| Units generated | 68·728 | 3·820 |
| B.H.P.-hours | 101·530 | 5·640 |

*Quantities per population of Glasgow (1,000,000).*

| | Per day. | Per hour for 18 hours daily. |
|---|---|---|
| Average tons refuse | 781·0 | 43 |
| Units generated | 68,728·0 | 3,820 |
| B.H.P.-hours | 101,530·0 | 5,640 |

Unless I spoke of peat and paraffin there are no other sources of power left to discuss. I have a note by me—I do not know its source—that 3 square miles of peat moss of average depth might supply 10,000 H.P. for 60 years. Mr. A. Dal, in the *Engineering Magazine* of November, 1902, points out that the water in peat (in pressed peat, I suppose) makes it suitable for generating power gas, and ranks it with coal slack containing 60 per cent. carbon. The future may see a power station on Rannoch Moor. To the still more distant future I refer the direct utilisation of the sun's rays or of the internal compression heat of the earth. A more likely source of energy is the momentum of the electrons in the atoms of matter—a source of unbounded energy yet practically inaccessible.

But returning to more familiar things, we have not yet spoken of the ex-urban electricity demand. The spread of car lines outwith the city is pregnant with suggestions of coming change. If city cars run to Paisley and Johnstone, why not to Edinburgh or Kilmarnock. Express cars on a ten minute service between Glasgow and Edinburgh would be useful and popular. If the Imperial Government found it necessary to take over all civic telephony because towns needed interconnection, and country districts wanted telephonic facilities, how much more will they on the same principle desire to take control of traction in and between towns. Will the electrification of main line railways too be after all a Government undertaking. Again, if the great District Electricity Supply Companies prosper as they hope, will not the time come when their power over trade-in-general may be too great, and agitation arise for their absorption by county, if not by Imperial Government. But this line of thought is too tempting and suggests too many possibilities, and we turn again to present day affairs. I have been compelled also to omit reference to many points related to the subject in hand—some of them important—like street lighting. I hear, by the way, that a northern town is making trial of mercury vapour lamps for the lighting of unimportant streets. They are at work and are found useful, I understand, in Oban and elsewhere. We have heard a good deal about the substitution of gas for electricity in Queen Victoria Street, London. We all know several reasons which conduced to this result. In street lighting, however, I think the best test is not a general look round, nor even photometric measurements. Let any one go to the street referred to, and take out a pocket timetable or other small print book containing unfamiliar names or figures, and see whether he can read at any part of the street. In Queen Victoria-street I found the diary unreadable 15 yards from the new gas lamp posts. At the end of the street, at Blackfriars Bridge, where there are modern flame arc lamps, it was possible to read by the light of one of them at a distance of over 100 yards. It must be admitted, however, that the displaced arc lamps were in lanterns of a singularly inefficient and hopelessly antiquated pattern.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

*Deflection of α-Rays.*—A. S. Mackenzie has measured from the deviations of a beam of α-rays in a magnetic and in an electrostatic field the value of the velocity $v$, and of the ratio $e/m$ for the rays from radium and polonium, in order to search for evidence of a change in any of the quantities $v$, $e$, or $m$ as the rays travel in an ordinarily good vacuum. To be able to take both eye observations and photographic records, the author used a "scintilloscope" consisting of a zinc sulphide screen of thin glass, against which the film of the photographic plate could be pressed from the outside. He found the electric dispersion of the beam much smaller than the magnetic dispersion, and amounting to only 10 per cent. of the deviation. If there were different kinds of particles sent out by the radium, the lesser dispersion in the electric field would be explained if the energies of the different kinds of particles were much more nearly the same than their momenta, as these are the physical quantities involved in the electric and magnetic deviation respectively. The slowest rays from the radium examined have a velocity of $1{\cdot}18 \times 10^9$ cm. per second, and the fastest $1{\cdot}74 \times 10^9$. The average is about one-twentieth of the velocity of light. The ratio $e/m$ is $4{\cdot}6 \times 10^3$, instead of the $6{\cdot}2 \times 10^3$ of Rutherford and the $10^4$ of the hydrogen atom. If the charge is the same as that of the hydrogen atom, the mass of the α-particle must be about 2·2 hydrogen atoms, or something like the hydrogen molecule. Since molecules can hardly be assumed to be present, it is most likely that both hydrogen and helium atoms are given out by the radium, and that their energies are about the same, so as to give a small electric dispersion. As regards polonium, the average velocity of the α-particles expelled by it is greater than that of the same particles from radium, but none of them attain the high maximum velocity of the radium particles.

[A. S. Mackenzie, *Philosophical Magazine*, November, 1905.]

*Heusler's Magnetic Alloys.*—B. V. Hill has made some further discoveries in connection with the magnetic alloys of non-magnetic metals discovered by Heusler. He finds that they show an irreversibility with regard to high temperatures, just as the nickel steels show an irreversibility with regard to low temperatures. He worked with an alloy containing 60 por cent. copper, 25 per cent. manganese, and 15 per cent. aluminium, and another alloy containing more aluminium. The latter showed an induction $B = 5{,}750$ c.g.s. in a field $H = 87$ c.g.s., with a comparatively large hysteresis. It was then subjected to repeated heating and cooling. Starting with a magnetic intensity of 311 units, the curve fell till it reached the axis at 320 deg. On cooling, the magnetisation was found to be only 267 units. On heating again, the magnetisation did not disappear completely, but remained as high as 7 up to 500 deg. On cooling, it appeared much diminished, being only 27 deg. at ordinary temperatures and 36 deg. at the temperature of liquid air. The author attempted to restore the magnetisation by heating to dull redness, but only attained an intensity of magnetisation of 90 units. Heating to a bright red made this 155 units, and subsequent exposure to liquid air 165 units. The other alloy, heated to 950 deg., lost its magnetism permanently and became 14 per cent. lighter. The nickel steels are heavier in the non-magnetic state.

[B. V. Hill, *Physical Review*, November, 1905.]

*Very Soft Röntgen Rays.*—When the vacuum in a Röntgen tube is successively reduced, the velocity of the cathode rays and the intensity of the Röntgen rays diminish simultaneously. When the E.M.F. falls below 30,000 volts the fluorescent screen and the photographic plate cease to show any effect. W. Seitz has inquired whether this is due to a cessation of production of X-rays or to a cessation of their penetrating power, thus preventing them from traversing the glass wall of the tube. To decide this question, he replaced a portion of the glass wall by an aluminium partition, and found a vigorous production of X-rays down to voltages as low as 600. So long as the glow-light reaches the anti-cathode, X-rays pass through the aluminium window. Their photographic action is particularly strong. Probably they are more freely absorbed by the film than the harder rays, and are thus more fully utilised. Action upon bacteria is also very strong, but it is correspondingly superficial. Between 1,500 and 6,000 volts, an aluminium film of 0·00075 cm. thickness absorbs more than half the rays. The difference in the penetration through the various metals is less marked than in the harder rays. There is no magnetic deflection.

[W. Seitz, *Physikalische Zeitschrift*, November 9, 1905.]

*The Electron Theory.*—W. Wien reviews the present position of the electron theory, and touches upon some outstanding difficulties which have yet to be overcome. One of these lies in the constitution of the electron itself, which may possibly never be elucidated. The theory is bound to ascribe a definite size to it. If its shape is spherical that size may be calculated, and it comes out as about a billionth of a millimetre. The concentration of an electric charge upon so small a volume would, according to our ordinary conceptions, bring enormous forces into play, which would tend to destroy the electron. It is, of course, hardly admissible to assume the existence of parts and forces within a particle that is supposed to be indivisible. Another difficulty lies in the permanence of the spectrum lines—*i.e.*, the periods of vibration or revolution of the electrons in the atom. The radiation emitted by them must damp these vibrations in the course of time, and it remains to be explained how the energy received from external radiations is utilised to maintain the standard rates of revolution. Gravitation, also, is not yet reduced to E.M.F.s, though several ingenious attempts in this direction have been made. They all, however, require new assumptions of a somewhat artificial kind.

[W. Wien, *Physikalische Zeitschrift*, November 9, 1905.]

*A New Heat Engine.*—M. Cantor makes an interesting communication with regard to a new principle in heat engines. It is well known that the efficiency of a heat engine depends upon the amount of expansion of the gases employed, that is to say, upon the ratio of the final to the initial volume. Successive expansions extend this ratio in one direction, and initial pressure extends it in the other. But no initial pressure capable of solidifying the gas and thus reducing it to the smallest possible initial volume, has yet been employed. The author indicates a theoretical method of doing this. The engine contains incandescent oxide of copper, and it is worked by blowing some liquid fuel, say petroleum, through the incandescent mass. The liquid fuel and the solid oxygen have therefore a very small initial volume, the oxygen being reduced to $\frac{1}{7000}$th of its ordinary volume. The metallic copper is re-oxidised by a current of oxygen, and the heat gained in this oxidation may be also utilised. The method as proposed may, of course, not be practicable, but it indicates a path along which further great improvements in the efficiency of heat engines are theoretically possible.

[M. Cantor, *Physikalische Zeitschrift*, November 9, 1905.]

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## THE STANDARDISATION OF GLOW LAMPS.

Those who read the yearly report of the Council of the Incorporated Municipal Association last summer will remember that mention was made of the report of a sub-committee deputed to consider the question of the testing and certification of carbon filament incandescent lamps. The report on this matter was not made public, however, pending the consideration of the subject by the Engineering Standards Committee. Although the actual report of the Municipal Association sub-committee is not yet available for publication, it is common property that its recommendations cover almost all the points of a lamp specification. Standards of candle-power and wattage are proposed (as well as standard pressures), even such detail as the marking of lamps is considered, the method to be employed for making the tests is discussed, and finally certain limits for the allowable variation from the specification are recommended. As reported in our last issue, the Engineering Standards Committee, or rather the Sub-committee on Physical Standards, has convened a conference on the matter to-day at which the lamp manufacturers have been invited to attend as well as the two delegates nominated by the Municipal Electrical Association. The proceedings at this conference, and also a circular containing facts collected for the purpose by the Engineering Standards Sub-committee, are, we regret to say, private.

We can only hope that, if any agreement be arrived at during to-day's meeting, it will not be regarded as final until an opportunity has been given for open discussion of the questions involved. At present it is by no means certain, for instance that the standardisation of incandescent lamps is really necessary at present, or that it would be advantageous to the electricity supply industry generally. Presumably standard candle-powers can be agreed on, as well as a series of standard wattages which would fulfil the various requirements of different consumers—a range possibly of from 2½ or 2¾ to 4 watts per candle, for it is only carbon filament lamps that are under discussion. But these wattages are absolutely useless as a specification unless some sort of life curve is specified also. And then again the loss in candle power with time cannot be stated for any given lamp except under the assumption that the voltage is constant. And now let us assume that we have two lamps by different makers which, when supplied with a certain number of watts at an absolutely constant specified voltage, will give a certain initial candle power and definite candle powers after 100, 200 . . . . 800 hours of life. It may just be possible that two lamps of different manufacture can be made so far identical: but that is not all. Take these two lamps and connect them to the same supply main, the pressure of which varies from the standard pressure to a certain percentage above that pressure, and then take their life curves. Without a doubt they will be widely different, and yet this is the one test which is important from the consumer's and supply station engineer's point of view.

It is more than probable, in fact it may be regarded as certain, that these difficulties are being discussed by the lamp manufacturers, and that the other members attending the conference are also cognisant of them, but this is not sufficient. The subject must be discussed openly if any useful results are to be arrived at; it should be considered at a conference more widely representative than the present one, and the services of the technical press should be called in so that the opinions of all classes interested may be invited, and so that the views expressed by each individual representative at the conference may receive publicity. A grave mistake has been made by not inviting representatives of the electricity supply companies in the first instance, as well as representatives of the municipal authorities, and the large lamp buyers who are equally free to buy in the British or foreign lamp markets are not represented at all, nor are those makers of lamp-holders and fittings who do not manufacture lamps themselves. Until an opportunity has been given to discuss the matter in all its bearings, the necessity for the standardisation of lamps will not have been proved, and the actual fixing of standards is premature until this main question has been settled. It is an open question whether the time and energy which would be expended by the lamp manufacturers in modifying their processes so as to enable each lamp to comply with a close specification, would not be better devoted to experimental research in the direction of improving the existing lamp rather than standardising it in its present form.

## THE NEW POWER BILLS FOR LONDON.

The most interesting feature in the Power Bill fight which is to take place in Parliament next session is the introduction of an entirely new scheme involving the establishment of a generating station at St. Neots, in Huntingdonshire, and the transmission of current at 20,000 volts, partly on overhead lines and partly through underground cable, to London. The 40 miles between St. Neots and Enfield will be traversed by overhead cables, and from Enfield onwards it is proposed to run underground cables along the River Lea to the Commercial Docks and the Regent's Canal, and also along the Great Northern Railway to Finsbury Park and through streets to the Regent's Canal and King's Cross. The difficulty of negotiating wayleaves with local authorities and private people is largely overcome by running overhead lines along the railway on a private right of way. The Great Northern Railway Co. has agreed to give the power company, free of charge, the use of land 1 chain in width along its line from St. Neots to Enfield; the railway company realises the enormous advantages that will accrue to it by the conveyance of coal along its lines to the power company's works, the possibility of buying cheap power for running its own lines, and also the fact that this possibility of obtaining cheap power will doubtless tempt manufacturers to establish works in the neighbourhood of the power station. Detailed surveys of the routes have, of course, been taken; powers have to be obtained for crossing roads and in some cases compulsory powers for land have also to be obtained where the railway company does not own land of sufficient width.

Another feature of the scheme is that the company does not propose to supply power in London direct to any power consumer except railways. Local Authorities and companies already supplying will be invited to take power in bulk from the company for redistribution to their consumers, and there is to be a clause in the bill by which local authorities will only be allowed to make a certain definite percentage of profit on these sales. We understand that negotiations have already been entered into with some local authorities with regard to this, and that, as regards companies, similar negotiations are, in one case at least, in a forward state. In all probability there will be no serious opposition from any companies, except those which are promoting similar schemes. From the details which we have given, it is seen that the North Metropolitan Electric Power Supply Co. might possibly be affected, as the country around Enfield is included in its area; but we trust that some agreement will be arrived at between the present promoters and the North Metropolitan Company, for the policy of power companies not to fight with those which have already obtained powers is one to be commended. In addition to the Great Northern Railway Co., it is more than probable that, if the scheme passes, the L.B. & S.C. Railway will also take power from the company for supply to the suburban lines which it is about to equip electrically, and there is ample reason to believe that other companies running to the north of London might find it advantageous to enter into similar arrangements.

As regards the technical and engineering details of the scheme, the particulars published in our last issue may be taken to be substantially correct until further details are disclosed when the bills themselves are available. The pressure at which it is proposed to transmit electricity will be initially 20,000 volts, but the overhead lines will be constructed in such a manner that the pressure could be increased to 40,000 volts if found necessary later. At present it is not intended that there shall be any transforming stations at all except at the points of delivery to the various bulk consumers and railways. We are informed by the consulting engineers, Messrs. Kincaid, Waller, Manville & Dawson, from whom we have obtained the above particulars, that the price at which it is proposed to supply will be considerably less than that given in Mr. Merz's scheme last year. As is usual in such cases, a sliding scale has been drawn up depending on the load factor, and the estimates of generating costs are extremely low. There will, we are informed, be no difficulty in obtaining coal at about 6s. per ton, and the enormous reduction in generating costs due to the lower rates and similar other expenses outside London can only be realised when the actual figures are before one.

The notices regarding this bill have now been published, and they are in quite general terms. The name of the bill is the Additional Electric Power Supply (London) and its objects are to "incorporate a company for the general purposes of producing and supplying electrical energy and constructing generating stations and conveying electrical energy and of supplying and distributing the same to any companies or bodies authorised to supply electrical energy and to any companies, bodies or persons owning, working or using railways, tramways, docks, canals or navigations, and of distributing and supplying energy, either in bulk or for manufacturing or other purposes, and generally of carrying on an electrical undertaking. . . ." Powers are also sought to enter into agreements to supply "any local authority, company, body or person whose premises are situate outside the Administrative County of London" and to erect overhead lines for such purposes. The main provisions of the notice, however, apply to the County of London. In spite of what has been told us with regard to the intentions of the promotors to supply directly to their "bulk" consumers at extra high pressure, we notice that a good deal of land is scheduled for compulsory purchase in various parts of London. This, we presume, may be for sub-stations in the event of the supply directly at high pressure not being sanctioned—or it may simply be for switching or distributing stations or to facilitate the obtaining of wayleaves for mains.

The London Electric Supply Co. seeks powers for the whole of the Administrative County of London with the exception of St. Pancras, Holborn and Westminster, for the supply of electrical energy in bulk or for power purposes, such supply being also given in contiguous areas. The borough of Holborn is included, however, for the purpose of laying mains only. Powers are also sought for amalgamation, &c., with other companies. We notice that this bill bears the name of the same Parliamentary agents as does the Additional Electric Power Supply Bill.

With regard to the other power schemes for London, so far as the notices at present go, it appears that bills will be deposited by the Administrative County of London & District Electric Power Co., the Charing Cross, West End & City Electricity Supply Co., and the City of London Electric Lighting Co. The Administrative County of London Company has introduced its bill much in the same form that it was left last session so far as area and general provisions are concerned, but an additional provision is added that the company shall pay back the expenses of last year's bill to the promoters of that measure. The area specified includes the whole Administrative County of London and adjacent areas, except the western portion north of the Thames, which was allotted to the Metropolitan Electric Supply Co. last year. Sanction will be sought to supply power direct to consumers in the "industrial" part of the area as before, and no announcement has been made as to agreements with any of the existing companies. It may be noted, however, that up to the time of our going to press, no notice has been made public as to the re-introduction of the County of London Electric Supply Company's Bill of last year.

The Charing Cross Company's Bill schedules an area almost identical with that of the Administrative County of London Company north of the Thames, taking in all districts below the boundary of the North Metropolitan Electric Power Supply Co. between Kensington on the west and Orsett on the east. The company proposes to supply in bulk directly to consumers for power purposes, and to tramways, railways, canals, &c. The undertaking authorised by this bill is to be kept separate from the company's existing provisional order area.

The City of London Co. seeks power to supply railways, tramways, canals, premises, &c., whether partly within and partly without its present area, and also to enter into agreements with other companies, bodies or persons authorised to give a supply of electricity, as to a supply of electrical energy in bulk or otherwise. Authority is also sought to lay mains in any area intervening between the areas of the City Company and any such authorised distributor desiring a supply.

As regards the London County Council scheme, a conference was held on Monday to which the press was not admitted, and at which the following resolution was passed: "That this conference of borough councils approves of the introduction by the London County Council of a Bill for enabling it to supply electricity in bulk, subject to the interests of borough councils' existing undertakings being safeguarded and the details of the measure proving to be otherwise satisfactory."

We are given to understand that, in addition to the City Corporation, 25 borough councils were represented, and that 14 voted for the scheme, six voted against it, and six (including the City) remained neutral. Chelsea, Poplar and Finsbury were not represented. It will thus be seen that the resolution has not been sanctioned by an absolute majority, as only 14 of the 29 Local Authorities interested voted in favour of it. The voting was as follows:—

*For the Resolution:* Battersea, Bermondsey, Bethnal-green, Camberwell, Fulham, Greenwich, Hackney, Islington, Lewisham, St. Marylebone, St. Pancras, Shoreditch, Southwark, Woolwich.

*Against:* Hammersmith, Hampstead, Kensington, Paddington, Wandsworth, Westminster.

*Not Voting:* Deptford, Holborn, Lambeth, City, Stepney, Stoke Newington.

In addition, a number of borough councils are advertising their intention to apply for powers for bulk supply, &c. Thus the Shoreditch and Stepney Councils seek powers for the supply of electrical energy by or to one another, and to and by any authorised distributor in Bermondsey, Bethnal Green, Hackney, Islington and Poplar. Already Stepney has issued a similar notice, and the others will doubtless follow. The powers sought include the acquisition of land and the erection of additional generating stations in Stepney and Hackney.

## ELECTRICITY METERS.[*]

BY C. H. W. GERHARDI.

(*Continued from page 134.*)

*Resistances.*—When the testing is done on a supply at 100 or 50 volts, it is necessary to provide resistance frames to dissipate the energy, and for alternating-current work these must be practically inductionless. They must also be capable of regulation in small steps in order that varying strengths of current may be obtained. Banks of Sunbeam lamps with 32, 16 and 8 c.p. incandescent lamps answer the purpose, but in order to avoid the glare, it would be almost necessary to keep them out of the test rooms. With water resistances, unless they are made very large in order to be worked at a low-current density, it is difficult to obtain a steady current owing to the great alteration of the resistance with temperature. The most suitable form of resistance for meter testing is the Fleming non-inductive "cage." For the purpose of finally regulating the current and keeping it steady during testing, rheostats will be necessary.

A very good one for the purpose is a carbon-plate rheostat, in which the regulation is obtained by altering the contact resistance between some 40 plates, of roughened battery carbon, by tightening or loosening a screw which clamps them together. Another form of rheostat most useful for meter testing is the Wirt rheostat.

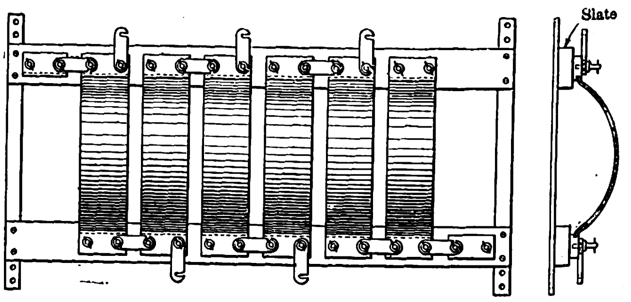

Fig. 143.—Heavy Current Rheostat.

For the regulation of large currents up to 500 or 800 amperes such as would be used for testing station meters the author has designed and found useful the adjustable resistance shown in Fig. 143. It consists of six sets of six strips in parallel, of german-silver soldered at each end into brass blocks which are mounted on slate strips, these latter being screwed to two iron bars at each end, which also serve for fixing the apparatus. Each brass block has two thumbscrews for clamping a connecting piece which is hooked at one end, so as to fall on to the thumbscrew of the next block. By this arrangement the resistance can be connected up all in series, or in any combination, to all in parallel, such as two in parallel, three in series; four in parallel, two in series; and so on. It is found that final regulation can be made by tightening or loosening slightly the thumbscrews.

When the strips are all in series such a resistance will carry about 300 amperes without getting overheated for about half to one hour. All six in parallel will take 1,500 amperes quite comfortably for a short time. The resistance of each unit is approximately 0·000925 ohm at 270°F. The approximate length of each strip is 15¼ in., width 3 in., and thickness of each individual strip 0·018 in. It is used with one or two large secondary cells for continuous-current testing, or with a step-down transformer (10 to 1 ratio) from the 100 volt supply on alternating current when it becomes more convenient to regulate by inserting resistance in the primary of the transformer.

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[*] From a forthcoming book to be published by "The Electrician" Printing and Publishing Co. All rights are reserved.

*Choking Coils.*—In alternate-current work it will be necessary to test certain meters on inductive loads. Meters which are intended for arc lamp or motor circuits should certainly be tested on inductive loads, as they will be expected to register the energy taken by such loads when erected on consumers' premises. The easiest way to obtain inductive loads is by inserting in the circuit a choking coil in series with the non-inductive resistances already referred to. It therefore becomes necessary in alternating-current test rooms to provide such coils, their size depending on the size of meters tested and the amount of choke or lowness of power factor required. As a rule nothing lower than a power factor of 0·5 or 0·6 will be required and these are fairly easily obtained by using ordinary straight coils with iron cores capable of being pulled out of the coil, and provided with some means of fixing the core at definite points to prevent it being sucked back into the coil. Certain forms of arc lamp chokers are very useful for this work.

A choking coil for heavier currents than would be taken by a single arc lamp is shown in Fig. 144. This coil has 245 turns of two copper strips, each $\frac{1}{4}$ in. by $\frac{1}{16}$ in. The core is 13 in. long by $1\frac{3}{4}$ in. wide and $1\frac{1}{2}$ in. deep. The coil is mounted on a board of about twice its length. Riveted to and underneath the core is a strip of brass just over double the length of the core and having a slit along it. This brass strip slides over the top of the pillar at the end of the board and is clamped at any position by means of the milled headed screw which passes through the slit. This makes a convenient coil for obtaining power factors as low as about 0·1 with a current of 30 amperes on a 100 volt 60 period circuit. Two or three coils of similar design with various numbers of turns and sections of wire are very useful. Regulation can be effected either by sliding the choker core or by a carbon rheostat.

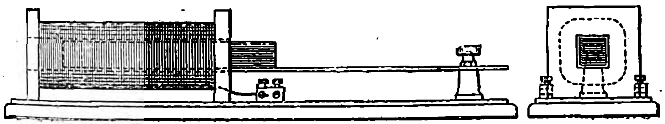

Fig. 144.—Impedance Coil with Adjustable Core.

*Transformers.*—Step-up and step-down transformers are very useful for high-tension and alternating-current testing with heavy currents, and there should certainly be some at the disposal of the department. Large station meters would probably be selected which are suitable for power-factor loads and consequently it is not important that they should be tested on a circuit of power factor = unity. It therefore becomes possible to test them, the main current being obtained from a step-down transformer, which avoids the necessity of providing a large energy-consuming resistance in addition to the advantage of the saving of the energy.

*Secondary Cells.*—Where the continuous-current testing is done entirely on current taken from batteries, special cells for this work will be required. The end cells of a station battery might be used for such work but this would lead to complications as perhaps the testing cells would require charging when the main battery was fully charged. The number and size of cells for supplying the main current depends on the number of meters tested in a batch and on their ampere capacity, but it is as well to have fairly large ones. In estimating the voltage required, it must be borne in mind that the leads, rheostat, and standard instruments will cause a drop in addition to the meters. Assuming meters are tested six in series, and the individual drop on each meter of the smallest size in the type having the largest drop is 1 volt at full load, then it may be reckoned that the mains will cause a further drop of 0·1 volt and the standards and rheostat up to, say, 2 volts, so that a battery of four cells would be required to test the smallest meters six in series at full load. Taking the largest meters tested on the same circuit to be of 75 amperes capacity, having a drop at full load of 0·25 volt, the six meters would only require 1·5 volts, but the connections and leads, assuming the same to be used in both tests, would cause a further drop of 1·5 volts, so that for these the battery would require to be composed of two cells in series.

It is often advantageous to have more than six meters in series, especially if the only means of testing is by running to obtain readings, such as in the case of electrolytic meters. It is, therefore, a convenience to provide a circuit board for connecting up one or more cells to the various testing circuits according to the pressure required to send the current through the meters under test. Such a board was shown diagrammatically in Fig. 127 of the previous chapter.

For supplying the pressure circuits a small battery of cells of, say, 15 ampere-hour capacity would be required, the number of cells depending on the maximum voltage required. A motor generator or continuous-current transformer would be necessary for charging the "current" battery, the "pressure" one being charged off the station 'bus bars or battery.

*Leads.*—For connecting meters in series for testing, short leads are necessary between the meters. It is needless to say that these get an enormous amount of wear, and, unless some special arrangement is adopted, annoyance is continually caused by these becoming too short for use. It will, therefore, be found most economical to provide leads with special ends which will be suitable for most types of meters, as the ends of flexible lead simply soldered soon require to be renewed. It is impossible to get ends suitable for all sizes as well as types, but two sets per table, with ends as in Fig 145, will be found to suit most meters which are fitted with screw terminals.

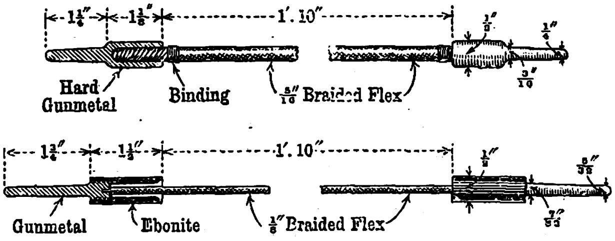

Fig. 145.—Flexible Leads and Ends for connecting Meters in Series for Testing.

For meters provided with sockets it is a good plan to procure a number of spare sockets, and to make a set of leads by soldering "flex" of suitable section into them.

(*To be continued.*)

## S. L. PEARCE'S INAUGURAL ADDRESS TO THE MANCHESTER SECTION OF THE INSTITUTION OF ELECTRICAL ENGINEERS.*

It is gratifying to be able to chronicle a steady increase in the membership of the section, which now numbers 84 members, 212 associate members, 149 associates and 313 students. The success which has attended the formation of the students' section deserves special mention, and this movement will increasingly prove a boon to the younger members of the profession and a source of strength to the section generally. It may not be out of place this evening at the opening meeting of our session if I proffer a few remarks to the younger members present before dealing with the main subjects of this address. Mere text book science will not alone suffice for the student to-day, and when the problems of what has been termed "heavy electrical engineering" are so much to the fore it is of more and more importance that a practical knowledge of the mechanical side should be acquired. There are many branches in the profession open, but you cannot hope to become a specialist in each. A man who runs a supply undertaking is not usually an expert in dynamo or motor design, nor is he expected to be. By all means acquire a general knowledge of the progress that is being made in the various branches of electrical engineering and keep abreast of the times, but do not attempt to specialise in each. It has been stated that "the power of putting ideas on paper is that which differentiates an engineer from an able mechanic." Certainly the preparation of an article or a Paper will force you to think out a question for yourself and enable you to come to definite conclusions, thereby gaining confidence.

I now propose to touch briefly on some few of the recent advances made in electrical work generally, and incidentally to indicate some of the problems that yet await solution. The past year has not produced any revolutionary changes in the sphere of electric lighting, but spurred on by the competition from the gas industry, improvements have been made which tend to the cheaper productions of light. The Nernst lamp has been more extensively adopted for inside lighting, and in many cases has been able to successfully compete for side street lighting with the incandescent gas mantle. The original form of this lamp, known as the "A" type, with vertical glower, up to quite recently proved the most satisfactory, and it is questionable whether it is likely to be superseded by the latest or "D" type, which employs an enlarged spiral burner, supported in a horizontal position, and giving about 75 c.p. with an energy consumption of about 115 watts. The distribution of light from a horizontal burner is hardly as satisfactory, from a street lighting point of view, however suitable this type may prove in more confined situations. Want of uniformity is still a failing with Nernst lamps, and this is most apparent in the life of the burners, and is also noticeable in the rate at which the candle-power falls off. Owing to the burners being largely composed of magnesia salts, which have an affinity for moisture, it must not be overlooked that electrolytic action will be set up in damp atmospheres, and will account for the great percentage of burner failures in wet weather. It will no doubt be possible for the manufacturers to overcome this difficulty.

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* Delivered last Friday. Slightly abridged.

The most striking development in the production of a more efficient incandescent lamp is the tantalum, which may be now taken as having successfully emerged from the experimental stage.[*] The lamps are made in voltages from 50 to 120, burning in series or single parallel. A recent series of tests show that the filament of a tantalum lamp increases in resistance with an increase of voltage, and therefore increases with the current and temperature. This is an important point of difference between this form of lamp and the ordinary carbon filament. Consequently variations in voltage do not have the same effect in the increase of candle-power emitted—speaking roughly, it requires twice the amount of change in voltage applied to the tantalum lamp as the carbon filament lamp to produce the same change in candle-power. Fitted with clear globes, an energy consumption of 1·7 watts to 1·84 per mean horizontal candle-power, and 2·2 watts to 2·47 per mean spherical candle-power was obtained. The distribution of light in a horizontal direction is remarkably uniform, and is in excess of that given by a carbon filament lamp, but in an end on direction is less. The percentage of candle-power emitted end on to that emitted in a horizontal direction in the case of the tantalum lamp is approximately 30. The useful life of these lamps, and the reduction in light emitted, do not differ materially from the ordinary carbon filament type, and the power taken during the life of the lamp is practically constant. Tantalum lamps having a 25 per cent. lower efficiency than those just described, with a reduction of some 35 per cent. in light emitted, have been produced to give a useful life of double the number of hours of burning.

Of the same order may be mentioned the Osmium lamp, with an even lower energy consumption, which, as soon as the initial difficulties in connection with the weakness of the filaments have been overcome, will mark a similar advance in the production of a more efficient incandescent lamp.

Interesting results have attended the experiments made by lamp manufacturers in the States to obtain a new carbon filament.[†] Briefly, the chief characteristics may be said to be due to the proper application of excessively high temperatures to the ordinary carbon filament. This high-temperature treatment is, however, but one beneficial step in the whole process of metallising the filaments. Metallised filaments, having a useful life of about 500 hours with a fall of 20 per cent. in light emitted, are being produced with an energy consumption of about 2·5 watts per candle, as against 3·1, which latter may be taken as the best figure obtainable with an ordinary high-efficiency carbon filament lamp. In the case of all these new forms of lamps an increase in first cost is admissible, having in view the higher efficiency and smaller energy consumption.

The Mercury Vapour lamp has not met with much favour so far in this country, and the progress made in its development is so small that it can hardly be said to have emerged into a practical stage. Attempts have been made to add some red rays, but apparently with little success. A very rapid falling-off in the candle-power is noticeable after a comparatively few hours of burning, which may be partly due to the deposit which is formed on the inner surface of the tube. From the point of view of mere efficiency, the various forms of the Mercury Vapour lamp mark a distinct advancement, their radiation efficiency being five to six times that of the carbon filament lamp.

In the arc-lighting world manufacturers have chiefly given their attention to the improvement of the enclosed "arc" and the development of the "flame" arc. In the case of the former the absorption of light due to the use of a second or outer globe, and the resultant reduction in efficiency, has been responsible for the production of the type known as the single enclosure. Such a step has meant that the enclosed lamp will possess many of the good points of the open arc whilst retaining the special advantages pertaining to the closed type. The practical convenience of having a lamp capable of burning for at least 120 hours without renewing the carbons is obvious, and must be of great commercial value. A further result of the enclosure of the carbons is found in the lengthening of the arc, whereby the lamp can be made to take a much higher voltage across the arc, and no difficulty is now experienced in running enclosed arcs singly on 200-volt circuits.

The improvements that have brought the "flame" arc into its present state have been directed chiefly towards simplifying the feeding devices, and to the manufacture of the electrodes. These lamps have their carbons arranged either parallel or inclined towards each other instead of vertically above one another as usual, the arcs burning under a reflector, being usually controlled by magnetic influence so as to direct the light to the best possible advantage. The early defects of the feeding mechanism in this class of lamp, so as to keep the arc in a fixed position under the reflector, were responsible chiefly for the unsteady and unsatisfactory light that was produced. The impregnation of carbons with calcium, magnesium, or other salts, has received considerable attention of late, and many forms of electrodes of a composite nature have been devised with the object of securing the steadiness of the arc, the lessening of the rate at which they are burnt away, the elimination as far as possible of the noxious vapours that are given off, and a lower first cost. One of the main objections to the "flame" arc is the fact that it does not admit of being enclosed, although efforts are being made to partially secure that end by the employment of magazines which shall contain sufficient carbons to obtain 50 hours of burning. The perfect magazine lamp has been coming for a long time; whether present day manufacturers will meet with any better success than those who have previously attempted is an interesting point. The outlook, however, is distinctly promising.

Mention may be made of the interesting lamp known as the Magnetite,[*] which has been brought forward in America, wherein black oxide of iron is used as one of the electrodes, the other or upper electrode being of copper of such a section that the heat developed is conducted away as fast as it is generated, the copper, never getting very hot, therefore does not burn away. The light is emitted from the magnetite vapour formed, and the rate at which the lower electrode burns away is $\frac{1}{8}$in. per hour. Various salts are added to the magnetite electrodes for the purpose of increasing their life, and it is said to be possible to obtain a life of 500 hours with an 8in. electrode.

The question of the testing and certifying of carbon filament incandescent lamps has been lately receiving the attention of the Municipal Electrical Association, with a view to securing uniformity of practice amongst lamp manufacturers, and a more accurate and reliable grading of lamps. If the recommendation of the report drawn up by the Municipal Electrical Association be, in the main, adopted by the Engineering Standards Committee,[†] there is little doubt that it will lead to a discontinuance of the use of lamps offered at low prices, which are wasteful in energy consumption, and do not give the amount of light specified. It does not appear advisable that municipalities and supply companies should trade in lamps, and the desired end can be attained by enabling all and sundry who trade in lamps to submit them to the local testing authority. Such a plan, if adopted, would have the effect of raising the average efficiency of lamps in use, reduce consumers' accounts, and minimise the unfair and unnecessary advantage which is given to the gas industry by the present use of inefficient incandescent lamps.

The application of the intensified or high-pressure system of gas lighting has found favour in many quarters, and is a competition that has to be seriously faced. We had an example of this only recently in London, when tenders were invited for the lighting of the new thoroughfares of Kingsway and Aldwych. With this exception, however, no town of any size appears to be reverting to gas as the result of definite comparative tests between the two rival systems. On the other hand, lighting by electricity is considerably on the increase. Special mention should be made of the present lighting of Fleet-street, London, by gas, but it is clear that this change is made only as an experiment, and cannot be possibly regarded as a case of the supercession of electricity by gas.[‡] Against this may be set the fact that the Westminster Council, after conducting extended comparative tests between arc lighting and the high-pressure gas systems, have entered into contracts for a considerable period for street lighting with the electrical supply companies. That the improved systems of gas lighting are economical as regards amount of gas consumed, maintenance, and labour must be admitted (a figure of 1.08d. per 1,000 c.p. hours being given as the inclusive cost in one instance). It should be remembered that in the case of incandescent mantles, and more particularly those used on high-pressure lamps, the condition of the mantle will account for great variations in the average candle-power, and this is a point to be taken into consideration when comparing the rival systems on the correct basis, viz., the average total cost per candle-power per annum. Electrical engineers have not much difficulty in showing on this latter basis a superior economy for electric lighting. What the incandescent mantle has done for the gas industry, it appears more than probable the flame arc lamp will finally accomplish for the electrical industry. Available figures from recent tests show that the total cost per candle-power per annum of a system of street lighting, using flame arcs, is some 30 to 50 per cent. more economical than high-pressure gas, according to whether the arcs are long or short hour. The really burning question is what degree of illumination is necessary and adequate for a given area. So often comparisons are made between the costs of lighting per mile of route either electrically or by gas when the relative degree of illumination between the two is out of all proportion. Such comparisons are absolutely useless, very misleading, and give rise to extravagant statements on behalf of the rival illuminants.

One other point touching on this question of street lighting. On analysing some of the published returns for electrical street lighting it will be observed that with a system of open arcs the cost of current may be taken as varying from 50 to 60 per cent. of the total charges, and the cost of the carbons, trimming and general maintenance the remainder. With a system of "single enclosure" lamps it has been found that the cost of current is some 90 per cent. of the total, the maintenance and other charges amounting only to some 10 per cent. It is pretty evident, therefore, that any system giving long hours of burning has a great commercial value, and it is to be hoped that this may be capable of extension to "flame arcs" by the successful development of the magazine lamp.

Turning to the application of electrical power for industrial purposes we find that very considerable progress has been made during the last year. The Yorkshire Electric Power Co., the Lancashire Electric Power

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[*] See *The Electrician*, Vol. LIV., pp. 569 and 589; Vol. LV., pp. 206, 328, 365, 385, 409, 805, 807, 941, 1,012 and 1,044.

[†] *The Electrician*, Vol. LV., pp. 579, 588, 639, 883, 908.

[*] See *The Electrician*, Vol. LIII., pp. 335 and 345, and Vol. LV., p. 160.

[†] See *The Electrician*, Vol. LV., p. 466, and Nov. 17, 1905, p. 170.

[‡] See a number of recent articles, notes and letters in *The Electrician*.

Co., the Clyde Valley Electric Power Co., and the Fife Electric Power Co. have commenced operations, and others will shortly follow. It is noteworthy that of the four new companies the three former are employing three-phase systems operating at 10,000 and 11,000 volts, and the latter a two-phase system at 3,000 volts. Nor have the larger municipalities been behindhand in the development of a power load at cheap rates, assisted by such means as the hiring-out system of motors and the "restricted hours supply" system at very low rates. It may, perhaps, be of some interest to state that in this city at the present time there is in use some 11,000 H.P. in motors, and the power sales for last year show an increase of 75 per cent. over the preceding year. Industrial establishments possessing their own independent steam installations are naturally chary of making changes; but records go to show that as the more economical advantages of electrical driving are appreciated, so will the gradual supplanting of steam plants be accomplished. This is more particularly noticeable in the case of the iron, steel and shipbuilding industries, and for colliery and mining work, all of which show a marked partiality for electrical power, which is evidenced by its extensive adoption at the many centres of the North-East coast, on the Clyde, in South Wales, and in the counties of Lancashire and Yorkshire.

The adoption of electrical transmission of power for textile factories is a problem that more closely concerns us in this part of the country; but on account of the more favourable conditions for operating with steam plants, little progress has been made. This is certainly a matter for some considerable surprise in the light of data obtainable from the States and the Continent, where textile factories have adopted electrical driving extensively. On the other hand it must be admitted that if it be possible for a cotton mill, equipped with steam plant, to operate at a total cost not exceeding £2. 10s. per I.H.P. per annum, it would be difficult from the point of view of economy to show much better figures than these, and some very cogent reasons in favour of electrical driving must be advanced before millowners can be expected to adopt it.

For large industrial installations there is a tendency to adopt three-phase motors where a three-phase supply is available and where a variable speed is not required. A comparison between direct-current and three-phase induction motors shows that as far as efficiency is concerned there is little to choose between the two types; for motors up to 40 H.P. the advantage rests with the three-phase induction motor, and above this output with the direct-current type. The difference in weight is, however, very marked in favour of the former, and the low maintenance costs and general freedom from running troubles are also strong points in favour of its adoption. Hauling gears up to 500 H.P. by induction motors are now becoming common in collieries. Continental practice has done much to perfect winding gears, and there is little doubt that the displacement of older steam plants by motors is gradually being brought about. Electric cranes of high-lifting capacity are being built in increasing numbers, a notable instance of this class of work being the 150 ton revolving-pillar crane at the Dublin Docks.

The past year has evidenced a tendency on the part of manufacturers to produce variable-speed motors without double-wound armatures and without the need for multiple-voltage winding. The development of this class of motor for continuous currents will doubtless popularise the use of motors for individual drive of machine tools, where wide ranges of speed are desired and where complicated gearing is to be avoided.

The question of furnishing energy for large consumers from a public supply or from isolated independent plants is one to which considerable attention has been given. Broadly speaking, it may be stated that unless an exceptional load factor can be shown—viz., something in the neighbourhood of 40 to 50 per cent.—it will be more advantageous for the consumer to obtain energy from supply mains.

For transmission lines the use of bare copper wires has been sanctioned in the case of three or four of the power companies, and incidentally it may be stated in passing that one of these—viz., the "North Wales," avails itself of the use of water power, and will therefore form one of the very few examples of hydro-electric installations in this country. It is also of interest to note that this company, together with the Gloucestershire Power Co., were the first to obtain Parliamentary powers to use overhead bare conductors. We see very few overhead mains in this country, and until recently the Board of Trade would only sanction their use for special purposes at comparatively low pressures. Now, however, they permit bare overhead work for high-pressure transmission lines. Taking a 6000 volt transmission line, the cost of running three-phase mains of any given section overhead would be approximately one-half of an underground main of the same section. For a 12,000 volt transmission line the proportion would be roughly one-third only. It is evident therefore that this factor will have an important bearing on capital costs and the question of cheap supply of power. Long-distance power transmission work with its corollary of extra high voltages has not made much advance in this country up to the present, the highest pressure employed being 11,000 volts. Although hard-drawn copper is still most generally used for bare conductors, the recent rise and maintenance of very high prices for raw copper, due to restricted sources of supply and the financial operation of capitalists, will undoubtedly help to advance the claims of aluminium. For a given conductivity the weight of the latter is only half that of copper, and its tensile strength for a given conductivity is about 75 per cent. of a copper line. Owing to the weight per foot of wire being reduced some 50 per cent. in the case of aluminium, it is possible to use much longer spans. At present prices of copper, the above considerations mean that it would be cheaper to use aluminium.

Although the last two or three years have witnessed a considerable reduction in the cost of production of electrical power on a large scale, electrical engineers should not be unmindful of the fact that there is at the present time an increasing competition for the cheap supply of power for smaller or isolated plants. For plants using up to 200 to 300 B.H.P. suction gas-producers and Diesel engines will prove keen rivals owing to their low fuel consumption. The cost of the latter per B.H.P. hour in the case of a suction-producer has been stated to be only one-half that of Mond gas at, say, 2d. per 1,000 cubic feet. This saving will, however, be discounted in the case of the producers if the plant is subject to a variable load or run for considerable periods much below full load. The difficulty is to obtain reliable and accurate data with respect to this latter point, makers invariably giving the full-load results only.

It will be conceded that where it is necessary and convenient to transmit all the power required from one point in any works, and under conditions that call for a steady load, the suction gas plant may be the more economical. But modern users of electrical power find it more economical and convenient to dispose of their power at certain specified points, so as to eliminate transmission losses and secure independent running for the various parts of their factories. Then the only fair comparison to be made is between a motor-driven factory taking a public supply of energy and a similarly-equipped motor-driven factory taking a supply from its own private gas plant, and it can be shown then that the costs of production do not widely differ. But these are not the only considerations to be taken into account. There are the questions of ground space for the private plant, the expenditure of relatively large sums on same, the ability to run any particular portion of a works on overtime without running the whole generating station, which in the case of a suction plant running at anything under half load would certainly be the reverse of economical.

A steady growth in electric traction work can still be chronicled. The trolley wire system is still by far the most extensively used. Conduits are confined more or less to portions of London and Bournemouth, and the Lorain surface contact system to Wolverhampton. Examples of the Dolter and "G. B." systems of surface contacts are however being installed at Torquay and Lincoln respectively.

Some idea of the extent to which electric tramways and light railways have developed may be gathered from recent published returns, which go to show that the increase in capital invested in these undertakings for the last recorded twelve months over the preceding period is represented by no less a sum than £25,000,000, and the total capital invested in electric traction stood at the end of 1904 at the figure of £107,000,000.

The series-parallel system of control up to recently was the only one adopted successfully, but considerable developments have taken place of late in the introduction of systems embodying the principle of "regenerative control."* It may be taken that the possibility of economising expenditure both upon energy and upon wheels and brakes by the use of the "regenerative principle" has been fairly clearly demonstrated, these savings being proportionate according to the undulations of the routes served. Further the variations in the power taken by each car are not so great as with the series-parallel system, and therefore a better load factor will be obtained at the power station from a system operated "regeneratively." The outstanding matters on which engineers do not appear at present to be agreed are reliability, maintenance and whether such systems are as favourable for "acceleration" or hill-climbing capabilities as the "series-parallel." To these questions, the obtaining of accurate and, as far as possible, independent data from repeated trials under strict commercial conditions will alone supply the answer. For existing tramway undertakings to adopt the regenerative system would entail very considerable capital expenditure, and if, in addition to the modified form of controllers, new motors were also required, the cost would seriously offset the economies to be gained. It may be noted in passing that the principle of regenerative control is more easily capable of application to the induction motor, and most of the three-phase mountain railways on the Continent are so arranged that the energy of the trains on descending should be returned to the line.

The conversion to electric traction of the Metropolitan Underground Railways in London has been one of the outstanding features of this branch of the industry during the last year, and numerous tube lines are in course of construction, all of which work has up to the present been carried out on the composite system, first initiated in this country by the Central London Railway Co., employing three-phase current in the line transmission and direct current on the motors. This system may be good enough for tube and suburban lines, but most engineers are agreed that it will not solve the problem of main line working. The alternative to the composite system hitherto adopted, but of which there is no example in this country—viz., three-phase currents stepped down from the pressure of the transmission lines and supplied to three-phase motors, has given satisfactory results in a good many places on the Continent, notably on the Burgdorf–Thun, Valtellina and Berlin–Zossen lines, under the conditions to which it has been applied, but it would not meet all the essential requirements for the electrification of main line railways.

The impetus to this latter movement was unquestionably given by Finzi's experiments in Milan in 1903, and since that date there has been considerable activity displayed in Germany and the States towards the development of the single-phase commutator motor which in its perfected form is expected to greatly help forward the solution of the problem of main line working. This theory appears also to have appealed to one or two of the British manufacturing firms who are now tackling the problem on similar lines. The question of a standard railway motor is of the utmost importance, and unquestioned advantages would result from a single-phase system as regards chiefly economy, reliability and simplicity of the track construction and rolling stock. As far as the motor is concerned, the essential qualifications may be taken as:—(1) Ability to give a large starting effort; (2) power to vary the speed through wide limits, and (3) they should return energy to the line when coasting or stopping.

Recent developments of the series compensated single-phase motors have made them equal to direct-current motors as far as the first point is concerned, and by the introduction of a transformer between line and motor, with variable ratio of transformation, thus giving a means of regulation between fairly wide limits without serious waste, the second requirement is satisfied. For long lines with no severe gradients and few stops the third point is not of great importance, but for short suburban lines it is of considerable moment, and up to the present this condition is not met by the single-phase motor. Although the work which has been done with one-phase commutator motors has been largely of an experimental nature and on experimental lines, the present year has seen the putting into operation of the first single-phase electric railway in the States,[*] and it is understood that one of the English railway companies has decided on applying the same system to a portion of one of their suburban lines.

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* See *The Electrician*, Vol. LV., p. 548.

When the problem of electrifying the main lines in this country comes to be undertaken, it will be desirable to place the generating stations as close as possible to the natural sources of energy—viz., the coalfields, providing the other conditions governing the selection of suitable sites for power stations are reasonably complied with. Therefore to make the supply commercially possible, high pressures must be adopted for the transmission lines. Employing an alternating-current system does away with the serious conversion losses to direct current. Although the single-phase system has made very considerable strides during the past year, the advocates of the three-phase system are not prepared to lightly give way. Stress is laid on the fact that the three-phase induction motor is a more mechanical piece of work, and therefore the decreased cost of upkeep for the motor would balance the increased repairs due to the use of a double trolley line.

Incidentally may be noted in passing, the recommendations of the London Traffic Commission bearing on the question of electric traction, and its advocacy of the provision of 50 miles of tramways within the County of London, in addition to several miles of subways, and substantial additions to the existing city and suburban railways. It is interesting also to note that the report speaks out with no uncertain voice in favour of electric tramways as against the much belauded motor 'bus, which should bring consolation to many threatened tramway undertakings.

Central station engineers are gradually coming to recognise more and more the value of steam turbine plants. The more extensive adoption of these plants, the larger sizes of units used, on which so much emphasis has of late been laid in the technical press, mark the chief progress of power station developments. Mention may be made of some extremely good steam-consumption tests that have recently been made. With units of 3,000 kw. capacity, 15 lb. to 15½ lb. of steam per kilowatt-hour at full load, and 16·75 at half load have been obtained. It is interesting to note, further, that steam consumption trials conducted on turbines after having been at work for extended periods, give results which show no falling off in efficiency from the results obtained on official tests. This is a point concerning which some doubts have been hitherto expressed. Reciprocating sets are still being built in large sizes, but it is not surprising to note that the general trend is all in favour of the adoption of turbines, especially for large units.

The past year has marked a development in the design and manufacture of turbine-driven continuous-current generators. It is not so very long ago that the difficulty of solving in a satisfactory manner the commutation problem was considered a barrier to their adoption. With high speeds it is impossible to keep down the reactance voltage; with slow speed sets, on the other hand, carbon brushes fulfil all the necessary requirements, and special means for counteracting the armature reaction are not necessary. Two methods are in vogue successfully to-day for compensating the armature reaction on high speed sets: (1) Compensating coils wound in slots in the pole pieces, thus neutralising the armature effect on the field; (2) auxiliary or commutating poles arranged between the ordinary poles. Both systems have given satisfactory results in practical operation, and whilst the latter is the more mechanical arrangement, the former has advantages from an electrical point of view. Another departure from generally accepted practice has been made recently in the use of carbon brushes for turbine-driven generators. Engineers have been generally familiar with the wire brushes and serrated commutators, hitherto considered to give the best results, but it must be allowed that the smooth surface commutator and carbon brushes form a far more mechanical piece of work. Such continuous-current sets provided with carbon brushes are in operation now for the first time in this country on lighting and traction circuits. Towards this improvement the present manufacture of carbon brushes has contributed considerably. The introduction of copper, either mixed with or graded with the carbon, give to the brush those qualities which facilitate commutation.

The gas engine has hitherto found little favour for central station work in this country, and the threatened supersession of steam plants has still to come, and until put forward in the form of the gas turbine is not likely to oust the steam turbine, in view of the very large units being adopted in central stations to-day, and the uncertainty that prevails on the score of satisfactory parallel running with gas plants coupled to alternators. Much, however, has been done recently in the development of gas-engine building, and units of 3,000 H.P. have been constructed. The conditions which militate against the adoption of gas plants for large power stations as compared with turbine plants may be briefly stated as follows: (1) The higher initial capital outlay. Taking a station of 20,000 H.P. to 30,000 H.P., gas plants could not be installed under £18 per kilowatt, exclusive of buildings. A modern steam plant could be put down for two-thirds of this amount, and in fact a figure of £8 has been taken in one notable instance. (2) Increased floor space required. (3) Probable higher rate of depreciation and increased maintenance costs.

Against these may be put in favour of producer gas plants: (1) The saving in actual fuel, which, of course, varies under different conditions, but is not likely to be less than 15 per cent. to 20 per cent. (2) The saving due to the recovery of the sulphate of ammonia. The combination of the latter, however, with high tension plants is not one that commends itself to electrical engineers.

As illustrating the growth of electricity supply stations, it may be of interest to state that the total capital invested has increased from, roughly, £8,000,000 in 1896 to £62,000,000 at the end of last year, represented by 183 companies and 262 municipalities, the total capital being approximately evenly divided between the two classes of undertakings. Whatever the critics may have to say on the subject of municipal trading, it is evident that the electrical industry is at any rate indebted to it. Of this £62,000,000 some 42 per cent. has been spent on the engine and boiler house equipments of the generating stations, and some 35 per cent. on the feeding and distributing systems. An increase in the last decade of nearly 800 per cent. in capital, of 1,000 per cent. in lamp connections, and of 1,500 per cent. in the number of units sold are figures which will speak for themselves.

In the domains of the electro-chemical and electro-metallurgical industries reference should be made principally to the improvements that have been made in the methods of iron and steel production. The earlier attempts to substitute purely electrical methods in the reduction of the iron ores for the more usual process of smelting have not been very successful, and at present the electrical furnace cannot be considered a serious rival to the blast furnace. The trend of events has, however, been towards improvements in the furnaces and methods for producing steel and alloys from pig iron and scrap. It is possible that in the near future the combination of blast furnaces with electric steel refining furnaces will be considered indispensable to all up-to-date steel works. The opinion of the Commission appointed by the Canadian Government, as far as they are capable of application to this country, is worth quoting: "That pig iron can be produced from iron ore, and steel of all grades can be produced in the electric furnace from pig iron, scrap, and ores as easily as by the customary methods, and that the high grade classes of crucible steel and special alloys can be made with marked economy in several forms of electric furnaces." [*]

The manufacture of pig iron in the electric furnace is of little interest to electrical engineers in this country, as with the cheap supply of fuel available here no electric furnace can compete with a modern blast furnace. It is not improbable that the electrical energy required for the electric furnaces will be obtained from gas engines operated by gases from the blast furnaces. Probably only two of the modern electric furnaces are capable of adoption for English steel smelting, but it has been proved that either of these processes can compete successfully with the Sheffield crucible furnace with electrical energy at anything like a reasonable figure.

Aluminium has had an extended use in connection with the "Thermit" process of welding tram-rails, which is being successfully adopted by many of the larger municipalities.

In the telegraph world there is a growing tendency to introduce type-writing telegraphs and machine telegraphs which reproduce the written message in its original form. Electric signalling is being adopted by the principal railways, and during the year an important installation has been put down at Derby on the Midland Railway.[†] The system is purely electrical, and not a combination of electrical and pneumatic devices. Both points and signals are operated by specially constructed motors.

In the field of wireless telegraphy much useful work has been done in popularising the system by the acceptance of messages at post offices for transmitting to vessels at sea and vice versa. Licences are now required for the setting up of stations to avoid interference with other stations which may be near. In certain cases these licences are refused, but permission is given to erect elsewhere.

The common battery system is now practically standard for all large telephone exchanges, and the National Telephone stations are being changed over to it. The chief event of the year is the ratification of the agreement between the Post Office and the National Telephone Co., whereby the former purchases the system of the latter in 1911. By this arrangement municipalities are prohibited from taking out further licences, and the existing municipal systems can be purchased outright. Some interesting figures were produced in the hearing of the evidence before the Telephone Committee.[‡] At the end of March, 1905, the National Telephone Co. had 1,139 exchanges, 320,017 subscribers' stations, and were handling 995,000,000 messages per annum. 683,000 miles of wire were in use, of which 64½ per cent. were underground. 45,000 miles of underground wires were rented from the General Post Office.

Important improvements have been made during the year in the manufacture of domestic and short-distance telephones. Inter-communication systems for office, warehouse, and works use can now be obtained at much lower prices than formerly, and a healthy competition has been the means of bringing the telephone within the reach of the smallest concerns. Continental communication is now possible, and steps are being taken to extend the lines into countries far inland.

From an electrical engineer's point of view, the last Session of Parliament has not been remarkable for the legislation that has been enacted. The question of a cheap power-supply for London in the form of the "Administrative County of London Power Bill" has been the predominating feature. With the details of the Bill many of you are no doubt familiar. The scheduled area of supply covered by the provisions of this Bill was no less than 600 square miles, and was divided into portions, the industrial and non-industrial. In the former, powers were sought to supply tramways, railways, docks, Government offices, &c., and also to individual consumers with the consent of the existing authorised distributor. In the event of that consent being withheld, an appeal to the Board of Trade was to follow. In the non-industrial area, powers to supply in bulk, and to tramways, railways, docks, &c., were asked for, but not individual consumers. The Bill as amended commended itself to a large proportion of the original opponents, viz., the supply companies, which is evidenced by the various agreements which were arrived at between themselves and the promoters of the Bill. Whatever views we may hold as to the fairness or otherwise of allowing a company armed with such powers as this Bill would have given it, coming into competition under conditions favourable to themselves in the same areas with the existing pioneering supply companies and local authorities working under unfavourable conditions, we cannot but regret that this and similar measures should be prevented from becoming law simply by the elapsing of time, and that all the money and labour spent on their promotion should be lost. Evidently there is considerable room for improvement in the method of Parliamentary procedure, and there does not appear any valid reason why the various Bills should not be taken up at the new Session of Parliament at the stage at which they were left in the preceding Session.

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[*] For a description of this line the reader is referred to *The Electrician*, Vol. LIII., p. 826.

[*] See *The Electrician*, Vol. LIV., pp. 180, 876, 919, 961 and 1003, and Vol. LV., p. 407.

[†] See *The Electrician*, Vol. LV., p. 376.

[‡] See *The Electrician*, Vol. LV., pp. 270, 312, 392, 438, 477, 519, an 559.

The "Supply of Electricity" Bill has been introduced for the fourth occasion only to be dropped again. This is certainly a misfortune, as in its present form it is certainly more favourable as regards both powers and restrictions in so far as these apply to local authorities. In particular, the provisions made (1) for the compulsory acquisition or use of land for generating stations, allows of the operation of a generating station without unreasonable risk of being subject to a nuisance clause, and (2) the stand-by clause under which a person is not entitled to demand or to continue to receive a stand-by supply unless agreeing with the undertakers to pay a reasonable return on the capital expenditure incurred, is one which is urgently required. Of equal importance to the Supply of Electricity Bill is some modification of the 1870 Tramways Act, which again was undealt with. It is, therefore, to be regretted that there has been no legislation this year which has in any way helped to improve the conditions of the electrical industry.

The past few months have witnessed considerable activity in the shape of electrical exhibitions in bringing home to the public the advances that have been made in the various applications of electricity. Considering what an important centre Manchester has now become in the electrical industry, it is worth consideration whether in the near future a local exhibition might not be held with advantage to all concerned.

During the last few years British manufacturers have undoubtedly made up a lot of lost ground. But a short time since it appeared that as a country we were not keeping pace with American and continental firms, and that great enterprises were passing into the hands of competitors. Whilst admitting that low prices, brought about by over-production and industrial depression had much to do with the placing of important works abroad, it cannot be said that British manufacturers were in such a strong position then such as they hold to-day. A closer appreciation of the lines on which electrical enterprises are developing, coupled with improvement in designs and methods of manufacture, have placed manufacturers in a position fully equal to their competitors, and able to supply the demands of the country. Whilst the lessons of the past few years' experience have been for the most part turned to good account, British manufacturers have still, it is feared, to learn the meaning of "prompt delivery." It would be interesting if a return could be prepared of the large contracts made during the year and the number of those given that were completed within the specified time. Judging by results, it is apparent that only too often times and dates are given that cannot possibly be complied with, and without any serious attempt to compute the actual time required for their completion. The enforcing of penalties may have weight with the manufacturers, but it is no adequate compensation to the engineer who requires the plant, and from the latter's standpoint reliability for delivery will often weigh as much or more than lower first cost.

The development of electrical storage is desired by all engineers, but all are not agreed that it is on the lines of the ordinary lead couple accumulator that perfection will be found. We should not, however, be unmindful of the great improvements that have been made in recent years towards increasing the life of the battery as a whole by means of automatic "boosters" and improvements in the manufacture and formation of the plates, and a consequent reduction in the cost of upkeep.

The recent experiments of Sir Oliver Lodge, employing high static charges for the purpose of dispelling fog from the atmospheres of our large cities and towns, are worthy of note as containing the possible fundamentals of future developments.

I do not propose to further trespass on your time. Enough has been said to show the value of electrical engineering progress to the community generally, and which has brought in its trail social changes of untold benefit to mankind. Of the electrical engineer may it not be truly said that he has been engaged "in directing the great sources of power in nature for the use and convenience of man." In conclusion, may I express the hope that the session on which we enter this evening may be as successful as those that are past, and that the discussions of the Papers presented may be mutually helpful.

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Mr. T. L. MILLER, in proposing a vote of thanks, alluded to the wide review of the position of the electrical industry given in the address. The subjects touched upon had been elucidated by very valuable and interesting data. It was a record of a period of most encouraging progress. The advice to students was specially good.

Mr. C. D. TAITE seconded in the same strain, and specially hoped that the suggested electrical exhibition for Manchester would take definite shape.

The vote was carried amidst enthusiastic applause.

# DR. W. M. THORNTON'S INAUGURAL ADDRESS TO THE NEWCASTLE SECTION OF THE INSTITUTION OF ELECTRICAL ENGINEERS.*

## § 1. THE SCIENCE AND ART OF ENGINEERING.

In that distant time, a thousand years or so before the invention—by Hero—of the steam turbine, the most interesting study for man was man. What problems there were then of science and of art centred upon him as one engaged in a struggle with the great unknown forces of the material world. Our present knowledge of these would seem to those old-time thinkers superhuman, but the fact remains, though it is apt to be forgotten, that the true interest of it all is still in its relation to man. The wisdom and skill which are able to direct these forces of Nature on a large scale form now our wide profession of engineering, well described by Sir Oliver Lodge as "Half-science, half-art." In spite of the fascination which problems of science or difficulties of art possess in themselves, they must always be for the few. There is still a wider personal interest in the men who work at them, and more in those who are preparing to take them up as a life work.

On the other hand, knowledge of natural phenomena, or science in its broad sense, becomes daily more necessary. Each newly-discovered property of matter is at once pressed into service, and it is the rapidity with which this has been done that gives to electrical engineering the attraction which it has for the lay mind.

In every branch of engineering there are three distinct classes—proprietors, executive staff, and workmen—each of which requires suitable training. The difference between that of the first two and the last is that a knowledge of the physical laws of Nature is essential for the former, and is to be gained best by a special preparatory education. For the latter a knowledge of a few properties of matter is sufficient, to be gained during the practice of the trade. With the training of the artisan I do not propose to deal. His work may be regarded as purely an art, and is handed on through the ages by personal transmission from man to man. There is a transition stage between workman and designer found in the lower orders of draughtsmen. For all practical purposes they may be classed as artisans—they have received the same school training, and their knowledge of first principles is much the same. Every opportunity is now given for talented boys to rise in any class, and the educational systems of Germany and America are good examples of how this may be done well. These countries recognised, one 70, the other 30 years ago, the value of training those whose industry requires either advanced technical knowledge or power of adaptability. The slower movement of our industries relative to theirs has given rise to much anxious thought and to the Mosely Commission. The result has been to emphasise the importance of having a highly skilled staff to carry out new ideas : the work goes on with so much more ease and certainty. There is no doubt that English manufacturers know their work as well as any in the world, but it is a good thing to have a large body of trained subordinates with ideas of their own and eager to have the chance of seeing them carried out. There are as yet few of this class in England compared with Germany and America, and I believe that this has been one cause of weakness.

## § 2. THE EDUCATION OF AN ENGINEER.

It may be well to consider shortly the course of training which experience has shown to produce good results. One can assume that a boy desiring to become an engineer of the better sort has been to a good secondary school, and that he leaves at the age of 17. He should then have an adequate knowledge of his own language and at least another (French or German by preference), the elements of Euclidian and co-ordinate geometry, algebra to the binomial theorem, trigonometry to solution of triangles, mechanics of a sound descriptive kind, and a little chemistry and physics. Those who have not been able with ordinary effort to attain to this moderate standard should be given the choice of another career. Classical scholarship can in the future only be afforded or attained by schoolmasters or men of leisure. There is certainly no greater handicap to a boy entering an engineering career than an education on the classical side of any public or secondary school.

One enters now upon debatable ground. Is it better to go straight from school into the works or to college? A boy fresh from school rapidly absorbs the spirit of the place in which he lives. If he is in the shops and left to himself, it is a fact that he soon takes the workman's view, and may learn to regard foremen and managers as, in a sense, his natural enemies. The effect is, however, more far-reaching. It has the tendency to set his future thinking on a lower mental plane. To have large interests and a wide outlook cannot be too early impressed upon a plastic mind, and the workman's view, judging by his talk, lacks both of these. This can, of course, be corrected by wise home influence, but the necessity for direction is not always seen. After many years of close contact with students of both kinds I have come to think that, on the whole, the gain in works' knowledge and stimulus is more than counterbalanced by the loss of clear thinking and recognition of first principles which prove so valuable later. In addition to this, a boy serving an apprenticeship first rarely has a chance of showing ability within three or four years; his lack of knowledge keeps him back.

All colleges which provide a three or four years' course in engineering insist on a sound knowledge of the elements of mathematics, physics and chemistry. The first year is, therefore, almost entirely occupied with learning or revising these, a few descriptive classes or a little geometrical drawing being added for stimulus. If possible, mathematics should be continued through all three years. The more advanced laws of heat and elasticity and electricity, and the simpler quantitative and more advanced descriptive treatment of technical subjects will form the second year's course. That of the third year is entirely technical, and of such an order that a student should have little difficulty on its completion in judging for himself the significance of any new suggestion or advance in practice or theory. A fourth year may well be occupied in experimental work on new ideas.

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* Delivered on Monday—Abstract.

Technical or "bread" subjects, as the Germans call them, have only within this last year been recognised by Government as having educational value, and the rise of the demand for higher technical education is an interesting study. It is a well-known fact in the history of education that "a new standard or fresh subject of education is impossible without the strong impulse of social or professional interest."* About 40 years ago there was, as an outcome of the democratic ideas at work in England during the earlier part of the century, a general desire for a national system of education. This was the strong social impulse which resulted in the Education Act of 1870. The necessity for higher education was soon after felt, and the rise of the university college movement began; but from that day to this technical subjects have been regarded either as self-supporting or unworthy of support. I suppose any use of public money for that purpose would have savoured of class legislation, but without the strong backing of professional interests—medical, engineering or chemical—university colleges would long ago have degenerated into high schools.

Civic patriotism has played a large part in the development of the larger educational ideals. In Liverpool there are 25 departments in the University, each endowed with £10,000. Manchester, Birmingham, Leeds and Sheffield can all show like results. We are rather isolated here in Newcastle, but we shall no doubt in time feel the wave from the centre of activity further south. Perhaps we are stunned by the shock caused by Mr. Carnegie's gift of £2,000,000 to Scotland. Since 1870 the growth of industry upon Tyneside has been phenomenal. Thousands have made fortunes, millions have been employed. The great coal industry, with its connected shipping interests, rests on a substratum of efficient technical knowledge. Shipbuilding and all branches of engineering are to be found here in highest activity, and it is not too much to say that Tyneside owes an appreciable share of its success to the high standard of training maintained by this college throughout the last 34 years. Notwitstanding this, we have no permanent endowment for any one of our 20 departments.

### § 3. Research a Good Investment.

The most rapid and fruitful return for endowment is in the field of research. It is now generally agreed that the function of a university establishment is both to teach and to extend the boundaries of knowledge. Scientific research falls under two heads. There is, on the one hand, that close study of facts more or less known in order that accurate information may be had for industrial purposes. This is embodied in the National Physical Laboratory, which, being supported by public funds, directs its attention to work of immediate industrial value. On the other hand, there is speculative search into the unknown on lines suggested by unique chains of thought, arising from new observations or strong co-ordinated thinking. Work of this latter kind cannot be undertaken to order. There are times of inventive activity in which ideas come rapidly. Then follows the patient experimental search for truth where so many fall out. Now if it is to come at all, a time of speculative activity almost inevitably follows the completion of a university course, and, it may be, the taking of a degree. It is then that encouragement and, perhaps, pecuniary help are of vital importance to a young student. He should have the opportunity of seeing how to carry out ideas by watching or helping in the research work of his professor, and the advantage is mutual. The enthusiasm of a pupil is the most refreshing thing that can come into the life of a teacher, and the friendship or sympathy of the elder man is always greatly prized by the younger. After all, in the light of the immense unknown, the difference between teacher and taught is very small. It is only the case of one student a little in advance helping another along the same road.

There is in connection with experimental research a disregard by many, though not all, manufacturers of much promising material. We take our young engineers from college and put them for years to routine work which untrained men do as well or better, and are disappointed that they do not show striking results, forgetting that two things are necessary to progress—the man and the opportunity. Medical and engineering students are of much the same calibre, and yet the former are given the opportunity for experiment—under guidance—immediately on graduation. I would suggest that men with a first-class college record should, instead of being treated as beginners, be taken into the confidential departments, design or test room, and set to work on new things, at first under supervision. Of course if there are no new things to work at, the industry is stationary or retrograde. They say no man becomes a good glass blower until he has broken 10 lb. of glass in the process of learning. There should also be some similar allowance made for crude ideas in engineering —say, £10 sterling. Fuses cover a multitude of sins in the test room, and it would take a good deal of work to reach this limit. One result of college training is to produce a large crop of ideas more or less crude out of which finished articles may emerge. In a large industrial centre where there is, as here, close relationship between college and works, I would suggest that where there are not men and instruments available in the works, senior students should be lent occasionally to do a week's work—say, with an oscillograph on wave forms, or on the effects of armrture reaction, or in studying interpolar inductionor commutation in special cases

### § 4 Research and Practice.

One never knows to where an experiment a little off the beaten track will lead. I have recently had a good example of this, on a small scale, which may be o interest to you. Some few years ago I made a few experiments upon bacteria, working mostly with typhoid germs on account of their sensitiveness. During these I found that M. Lortet had discovered what I was looking for, that alternating currents cause them to orientate and place themselves along the lines of flow, but he failed to find any effect with direct currents. As a matter of fact, bacterial of all kinds, living or dead, orientate in the same way under either direct or alternating electrification. On thinking over the cause of this, it was found that the movement depended entirely upon the relative conductivity of the organism and the surrounding liquid. So that the former behaves as a rod of iron in a magnetic field, or one of a dielectric in an electrostatic field, the same laws governing lines of stress or steady flow whether of electricity, magnetism, heat or liquids. In searching for the cause I found that glass orientates in oil, but not in water, and that carbonised silk filaments are very sensitive in either. Some time after I wished to design an apparatus to indicate the state of charge on cables, in order to see whether they were safe to handle. The simple electroscope was first thought of, but rejected as not mechanically strong enough to be placed in a platelayer's hands. It then occurred that one might use the same thing on a small scale, observing the movement in a kind of linen-tester's microscope. On trying this I noticed a small spark pass between two particles of carbon suspended in oil, and the idea at once came, why not look for the sparks? In 10 minutes or so after this the first "voltascope" was made and tried on a 2,000-volt circuit, and a little while later on 20,000 volts. The instrument as it is now made consists of a glass tube containing oil and short fine carbon rods. Contact is made across the mains through a heavily-insulated wire having an ebonite or fibre handle with sharp steel points to get good contact. It works equally well with direct and alternating currents, and in any position. As soon as contact is made the carbon filaments become polarised and form an irregular chain, along which a small current passes, jumping across minute gaps between the particles, and so forming sparks which are instantly extinguished by the oil, their constant appearance and extinction giving the tube the effect of scintillation. It is a far cry from bacteria to an electric life-saving device, but the same line of thought led further to the invention of the high-tension voltmeter shown. So far as I know, this differs from other forms in the use of a *dielectric* needle or quadrant. A short ellipsoid of paraffin or sealing wax is suspended by a fine silk or quartz thread between brass plates, contained in a glass globe about 15 cm. diameter. Theory indicates that the torque on the suspension is proportional to the square of the voltage, and this is found to be experimentally true. One uses the instrument in the same way as a Siemens dynamometer or the Ayrton-Mather voltmeter of the same type. The ellipsoid is brought to a balanced position between stops by rotating the torsion head. The lowest voltage to which it is sensitive is about 500, and I have used it to measure spark-gap voltage up to 100,000. Since specific inductive capacity varies with frequency, a simple correction must be applied for this.

There is a still further extension of the same theme. One can measure the permeability of iron by the torque on a long ellipsoid suspended in a magnetic field, and in the same manner one can determine by this instrument the dielectric constants of all solids, liquids, or gases when a litre of the latter can be obtained. The effect is a function of the relative permittivities of ellipsoid and medium, and a comparative series may be readily formed and checked by reference to air. The fact that the results are comparative, and that the zero position of the moving system is the same for all, enables one to work with considerable accuracy. The ellipsoids must be made very carefully. Messrs. Hilger can be relied on to do this. The microscope might be much more used in electrical engineering than it is at present, if, indeed, it is used at all. We know now that the permeability of iron depends upon the size and distribution of the crystals of carbide of iron in the metal, and that these are changed by the heat treatment this has received. Why should we not estimate permeability by polishing a surface on the metal, observing it through a microscope, and, if necessary, photographing it. After a time, by collecting a set of standards, the quality of any specimen might be assigned in a few minutes by inspection.

## RELATION OF PULL TO DIAMETER OF SOLENOIDS.*

BY CHARLES R. UNDERHILL.

It is well known that when an electric conductor is bent into the form of a circle the magnetising force at the centre of the loop is $H=0{\cdot}2\pi I/r$, (1), where $I$ = current in amperes and $r$ = radius of the loop in centimetres; and since the magnetising force is proportional to the ampere turns, a group of turns, as in Fig. 1, acting together, and having the same general dimensions as a single conductor, as in Fig. 2, produce the same magnetising force at the centre, providing the ampere-turns are the same in both cases. For the group of turns formula (1) would be $H=0{\cdot}2\pi IN/r$, (2), where $N$ = number of turns in the group.

In order to determine the effect due to changing the diameters of solenoids, the writer had two sets of windings mounted on wooden spools, the length L of the windings being 1 in. in all cases. Each set consisted of four windings of different diameters. One of these sets had windings of square cross-section, 1 in. by 1 in., as in Fig. 3, the mean or average diameters, M, being 4, 6, 8 and 10 in., respectively. In the centre of each wooden spool a hole $1\frac{5}{32}$ in. in diameter was bored for the plunger to enter. This set of windings may be called rim windings for convenience.

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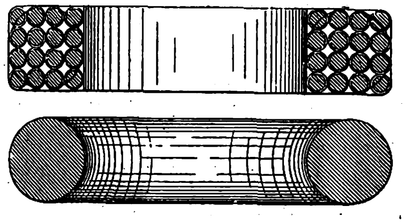
* W. H. Woodward, "Erasmus Concerning Education," p. 85.

* From the *Electrical World* of New York.

The other set consisted of windings with varying outside diameters but with fixed internal diameter, which was $1\frac{1}{4}$ in. all cases (see Fig. 4). The mean diameters were 2·38, 3·63, 4·63, and 5·63 in. respectively. These windings will be referred to as disc windings. Substituting M/2 for $r$ in (2), $H=0{\cdot}4\pi IN/M_1$, (3), where $M_1$ is expressed in centimetres. In English measure $H=3{\cdot}192\,IN/M$, (4).



FIGS. 1 AND 2.—DIAGRAM OF COILS.

The tests were made by the method illustrated in Fig. 5. Here A is a magnetising coil to saturate the core, and B represents the winding to be tested. The core was of Swedish iron, $1\frac{1}{8}$ in. in diameter and 1 sq. in. in cross-section. First the coil A was excited so as to saturate thoroughly the iron core, and then a rim winding was placed over the end of the core in the position of maximum pull and excited from a separate source. Each coil had a rheostat and ammeter in series, the two coils being so connected that attraction would result. Coil A was rigidly fastened to the iron core, and the test coil B attached to the scales. After the core was saturated, a change in the strength of the current in coil A produced an almost inappreciable change in the pull, which was accredited to the change in H; but when the current strength in coil B was changed, the pull varied directly with the strength of the current in coil B. Fig. 6 shows the result of a test of the set of rim windings. This test indicates that the pull due to a solenoid is directly proportional to the ampere-turns in the winding after the core is saturated. It incidentally proves the law expressed by (2).

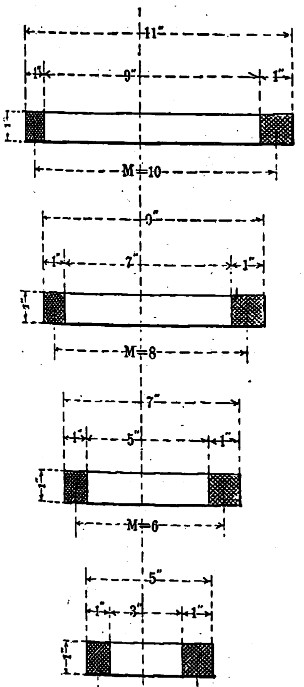


FIG. 3.—DIMENSIONS OF RIM WINDINGS.

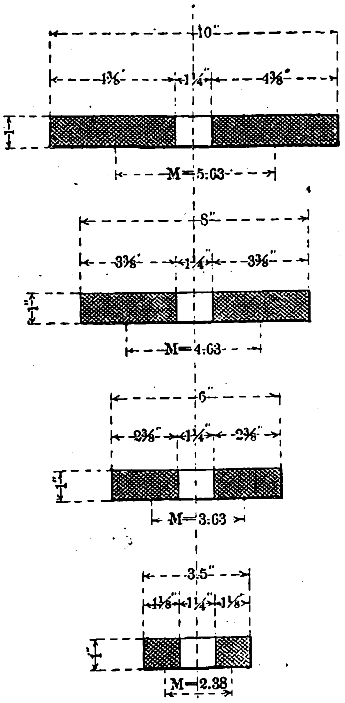


FIG. 4.—DIMENSIONS OF DISC WINDINGS.

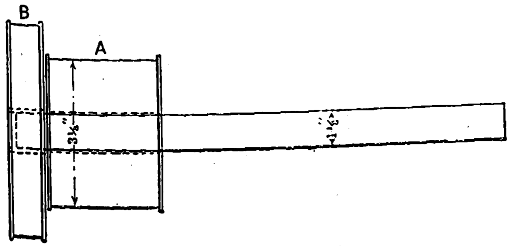


FIG. 5.—DIAGRAM OF TESTING APPARATUS.

When the disc windings were tested under the same conditions as the rim windings, it was found that the pull was not inversely proportional to the mean diameter of the winding, but nearly inversely proportional to the square root of the mean diameter of the winding. Fig. 7 shows the results of the tests of the disc windings. Although the current varied more or less as the test coil heated, or as the line voltage changed, the curves in Figs. 6 and 7 are very accurate, since the turns were known, and hence the ampere-turns varied directly with the strength of the current. The curve from $a$ to $b$ in Fig. 8 is plotted from Fig. 6, the points being taken from the pulls corresponding to the different mean diameters on the ordinate representing 6,000 ampere-turns. Now the mean or average diameter of a disc winding is not the mean diameter representing the mean strength of field, but the latter is equal to the reciprocal of the sum of the reciprocals of the mean diameters of the squares or groups of turns constituting the disc, multiplied by the number of groups. As an example we will refer to Fig. 6 and note the pull for each of the rim windings under test with 1,500 ampere-turns. The pulls are 1·8 lb., 2·3 lb., 3·2 lb. and 4·8 lb. respectively, making a total of 12·1 lb. pull for the four rim windings, with a total of 4 × 1,500 ampere-turns = 6,000 ampere-turns. Now, consider these solenoids telescoped so as to form a disc winding as in Fig. 9. The mean or average diameter of the winding is 7 in., but the mean diameter representing the mean strength of field is

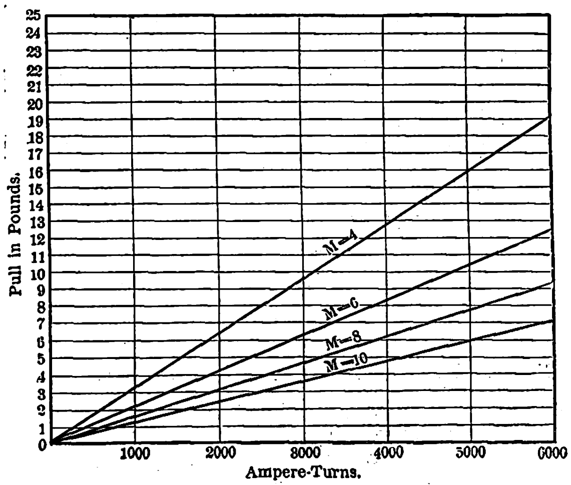


FIG. 6.—TEST OF RIM WINDINGS ON MAGNETISED BAR.

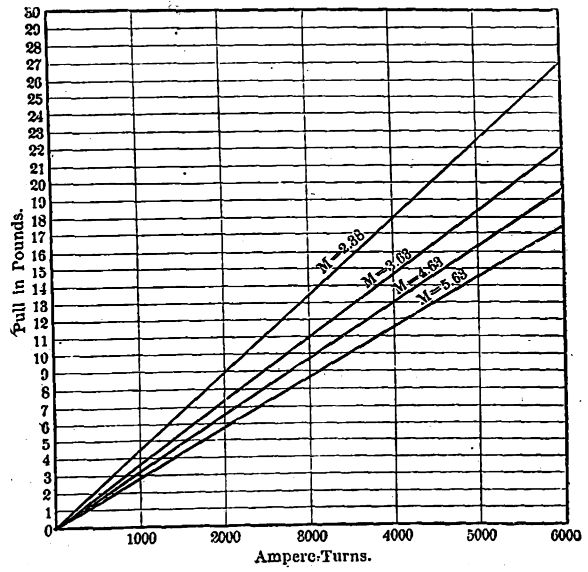


FIG. 7.—TEST OF DISC WINDINGS ON MAGNETISED BAR.

$$M_e=\frac{n(abcd)}{(abc)+(bcd)+(cda)+(dab)}, \quad \dots \quad (5)$$

where $n$ is the number of groups of turns and $a$, $b$, $c$, $d$ the relative mean diameters of the groups. Therefore, in the case under discussion,

$$M_e=\frac{4(4\times 6\times 8\times 10)}{(4\times 6\times 8)+(6\times 8\times 10)+(8\times 10\times 4)+(10\times 4\times 6)}=\frac{7{,}680}{1{,}232}=6{\cdot}23,$$

and hence for a mean diameter of 6·23 in. a pull of 12·1 lb. should be obtained with 6,000 ampere-turns in the entire disc winding, since there are 1,500 ampere-turns in each group of turns, and there are four groups. Referring to Fig. 8 it is seen that this exactly coincides with the curve obtained from separate tests of the rim solenoids. By calculating the diameters representing the mean field strength of the disc windings after this manner, the rest of the curve *a-c* is obtained, which coincides with, and forms a continuation of, the curve representing the tests of the rim windings.

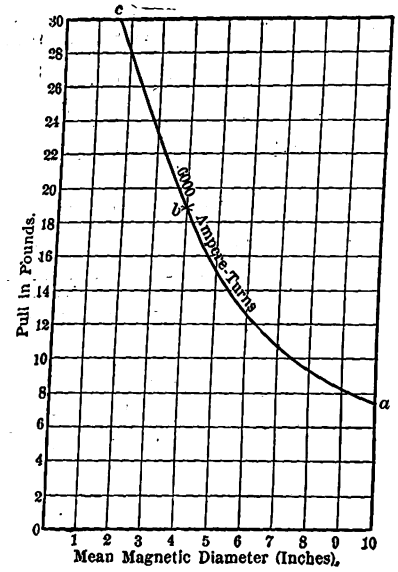


Fig. 8.—Combined Test of Rim and Disc Windings.

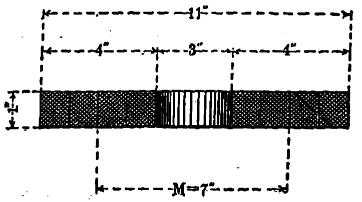


Fig. 9.—Rim Windings Telescoped to form a Disc Winding.

# CORRESPONDENCE.

## STOURBRIDGE ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: At a special meeting of the Council held on Monday, 20th inst., to consider the question of the Council's Provisional Order which expires on December 31st next, the matter was referred back, the Council being unwilling to consider the recommendation of the Electric Committee, who have had the electric question under consideration for several years and have considered ways and means and all possibilities. Ample figures, estimates and various schemes have been prepared by myself as engineer to the Council (the same have been printed and put before the Council), and ample information was given at the public inquiry when we applied for a loan of £4,000 to carry out a bulk supply scheme.

The voting on Monday last was (with the casting vote of the chairman) 14 for an amendment, 13 against, consequently the supporters of the electricity scheme gave way, and the matter must now fall through unless the Board of Trade grants an extension. The voting was singular in this respect, that at a meeting of the Council a month ago, when the matter was under consideration, the voting was 18 to proceed with their own scheme and eight against, such motion to stand if the Power Company with whom the Council were negotiating would not give way on points of an agreement under consideration. The facts of the case seem to show that the Council, having obtained a provisional order on the advice of the Gas committee, endeavoured to keep it in existence as long as possible because they cannot make up their minds whether they should work it themselves or let some company come in and oppose their gas undertaking.

The Council have had three extensions already.—Yours, &c.,

Nov. 22, 1905. J. B. Clarke.

# LEGAL INTELLIGENCE.

## Lambeth Borough Council v. South London Electric Supply Corpn. (Ltd.)

This case came before Mr. Justice Bigham in the High Court on Nov. 17, and was the first of two actions brought by plaintiffs as successors of the Lambeth Vestry. The plaintiffs' claim in the first action was that they were entitled to £738, cost of carting refuse, and in the second to a declaration that defendants were obliged by the terms of an agreement of March, 1897, to maintain a dust destructor, and cremate and dispose of the whole of the dustbin refuse of the Metropolitan Borough of Lambeth. Defendants denied, in the first case, that they were bound by the agreement, as its terms had not been approved by the Board of Trade, and in the second counterclaimed for £47,800 as cost of installing and cost of removing the destructor plant.

Mr. McCALL, K.C., for plaintiffs, said in 1892 Lambeth Vestry obtained a provisional order for the supply of electricity. This order contained a clause 62 providing "That at any time after the commencement of this order the undertakers may, with the consent of the Board of Trade, by deed to be approved by the Board of Trade, transfer their powers, duties, liabilities, and works to any company or person." Another clause (76) provided that nothing should exonerate the undertakers from an indictment for nuisance. In 1896 the Vestry proposed to transfer this undertaking to a Mr. Sax, but the Board of Trade objected to the transfer to a single person, and the South London Electric Supply Corpn. was formed to take over the transfer on March 16, 1897, by an agreement approved by the Board of Trade. By an agreement of even date made between the Vestry and defendant company it was provided that defendants agreed as a consideration of the transfer, to erect and maintain a refuse destructor to be approved by the Vestry, and to cremate or dispose of all the refuse supplied by the Vestry. Defendants began to use the dust destructor, and complaints were made to the Vestry of bad smell, &c. Defendants were fined for nuisance and then took up the position that the Vestry had taken these proceedings, and so relieved them from liability. The plaintiffs had been put to considerable expense in providing for the disposal of the refuse which defendants would no longer accept, and they asked for a declaration that defendants were bound by the terms of the collateral agreement under which the dust destructor was erected. £708. 4s. 3d. was due to the plaintiffs in respect of dust disposal.

Mr. MONTAGUE LUSH, K.C., for defendants, submitted that the getting of the contract was one of the stipulations for the transfer and tainted the deed. If they could show that the deed of transfer purported to contain all the terms of transfer, and defendants could show that another deed contained a term of the transfer, then the transfer was not in compliance with sec. 62 of the order, as there was a term which had not been approved by the Board of Trade, and the Vestry could enter into no such contract. The Vestry were prevented from suing upon the collateral deed, as they said all the terms were in the deed of transfer. A collateral contract embodying terms which had not been approved by the Board of Trade would be bad. The real consideration for transfer was partly the things they undertook to do and partly the benefit the Vestry obtained by defendants taking the dust off their hands, which was put into the collateral deed. It was just the same as if they undertook to pay the Vestry £20,000 to go and get that dust destructor from some one else. The root of plaintiffs' power to enter into the collateral agreement was wanting without the approval of the Board of Trade. This was important, because the Board of Trade insisted that there should be no concealment. The execution of the deed was, therefore, invalid.

Mr. McCALL said the objection was not well founded, and defendants were estopped from raising it. All the Board of Trade said was that they would not consent to the transfer if the clauses were retained in the deed.

Mr. Justice BIGHAM, in giving judgment, said the only question was as to the validity of the second deed of March, 1897, which referred to the construction and maintenance of the dust destructor. At the time of the transfer to the new company the Vestry were anxious to provide for the disposal of their dust, and tried to make an arrangement advantageous to themselves and the company, whereby the new company should destroy and dispose of the dust. It was thought that the terms of transfer of the electric lighting order and the terms on which the dust was to be destroyed could be put in one deed, and that the Board of Trade would approve. But the Board of Trade said that under sec. 62 they were asked to approve the terms of transfer of the electric lighting order, and they would have nothing to do with the approval or disapproval of any contract plaintiffs might enter into for the destruction of the dust, and they declined to have anything to do with the contract about the dust. The terms of transfer of the electric lighting order were put into a deed. They were terms and conditions relating solely to the transfer of that order, and received the approval of the Board of Trade. The Vestry and company were not satisfied, and made a bargain that they would not transfer the order to defendants unless in exchange defendants gave them another contract. The question arose, was that a valid deed? In his opinion it was not. The object of sec. 62 was to give the Board of Trade power of examination into the terms upon which a transfer could be made, and it was necessary to obtain the sanction of the Board of Trade to those terms, and so to enter into a collateral contract containing other terms was a violation of the section itself. There were reasons why the Board of Trade should examine the whole terms. To ask them to sanction some terms, and then to make some other terms which they would not sanction, was to do something which the Legislature intended should not be done. The plaintiffs could not enforce the second contract, nor could he (the learned Judge) help them to enforce it. He thought, when the case was opened, he might discard the provisions in the second deed, which were ultra vires, and accept those that were not, but he could not do that, because he thought the execution of the deed was itself unlawful. Judgment must be for defendants upon the claims in both actions and for plaintiffs upon the counterclaim in the second action.

### Croydon Corporation v. British Electric Traction Co.

In the Chancery Division on Friday, before Mr. Justice Farwell, Mr. Warmington, K.C., applied that certain questions of law in the matter of the arbitration between Croydon Corporation and the British Electric Traction Co. might be decided by his lordship on an early date. The arbitration was to settle the form of a lease, but certain questions of law had arisen and these were to come before his lordship. Under an act of Parliament the Corporation had the right to determine the lease after six months' notice. The lease referred to in this matter expired on May 31, 1906, and it was necessary, therefore, to give notice next week. They had given notice, but it was conceived that, if his lordship's view of the law was in a certain way, they would have to give another notice.

His LORDSHIP directed the case to be put down to-day (Friday).

### Bainbridge and Another v. The Postmaster-General and Crane.

In the Court of Appeal (the Master of the Rolls and Lord Justice Mathew) on Friday judgment was given in this case on the appeal of the Postmaster-General from an order made in Chambers by Mr. Justice Walton allowing the plaintiffs to add the Postmaster-General as a defendant to the action, which was brought to recover damages for personal injuries alleged to have been caused by the negligence of the defendants or their servants in repairing a footway after laying telegraph lines at Wigan. The action was originally brought against Mr. Crane, Post Office sectional engineer of the district, under whose direction the work had been done. Subsequently the plaintiff took out a summons to add the Postmaster-General, personally by name, as a defendant. The District Registrar made the order, adding the Postmaster-General not by name, but in his corporate capacity. The Postmaster-General appealed to Mr. Justice Walton, who held that it was not a matter to be determined on summons, but gave leave to appeal.

In giving judgment the MASTER of the ROLLS, after stating the facts, and referring to the sections of the Telegraph Acts 1863 and 1868 which apply to the case, said the 1868 Act empowered the Postmaster-General to purchase the undertakings of telegraph companies which were to vest in him in his corporate capacity. The plaintiffs contended that the action lay not only against Crane, the author of the wrong, but also against the persons by whose orders he was carrying out the work of laying the telegraph wires, and that the statute constituted the Postmaster-General one of the persons who must be charged with the duties imposed by the legislature. The contention was that the Postmaster-General was responsible for the negligence of his subordinate Crane, and that an action for damages lay against him in his official capacity. But having gone through the cases bearing on the question, he found that the Postmaster-General was not in a similar position to that of a common carrier at common law, and that being so, had the legislature altered the immunity of the Postmaster-General from such responsibilities? Were there any words to be found in the statute which cut down the position of the Postmaster-General with regard to immunity from what it was before he took over the telegraph? When the provisions were analysed they seemed to him to leave the Postmaster-General where he was before. In his official capacity he kept his former immunity. It was not suggested that the Postmaster-General had himself anything to do with the negligence of which the plaintiff complained. The plaintiff was obliged to put his case on the footing that Crane was in the employment of the Postmaster-General. That condition was not fulfilled. Crane was not in the employment of the Postmaster-General, and the suggested nexus between them of master and servant was broken at once. That was sufficient to dispose of the case. The plaintiffs, however, could not show any section providing for any fund out of which damages could be paid by the Postmaster-General in such a case as this. It was clear that the revenue of the country could not be reached by an action brought by a private individual against a public officer in his official capacity. On these grounds he thought Mr. Justice Walton had been wrong in not stopping the action against the Postmaster-General. In point of fact the learned Judge seemed to have done little more than invite the Court of Appeal to consider the question, but in point of form they must reverse his decision and allow the appeal.

Lord Justice MATHEW concurred, and the appeal was allowed. The Postmaster-General did not ask for costs.

### Re L. M. Waterhouse and the Patents Acts (Patent No. 28,632, 1903).

Mr. Justice BUCKLEY, on Wednesday, delivered a considered judgment in this case, the facts of which were reported in our last issue. After referring to the grant and the subject matter of the letters patent in question, his lordship said that in the case of metallic conduits for electric light cables, it was essential that there should be a tight grip or contact between successive parts of the conduit. At the date of the patent there was what was known as the Simplex conduit. The object of the patentee was to tell the public how to obtain the desired metallic circuit without having to use screw tubing. His object was to show how to dispense with screw tubing. At the date of the patent the idea of connecting a plain conduit with screw fittings by a device which would cause the conduit to be gripped by a screw was old. But the patentee said that the particular way in which he made use of well-known devices was new. The patentee's grip was what was called an overhung grip. In Lake's device both direct and overhung grips were used. But it was true that no one of the alleged anticipations used overhung grip alone. In that respect the patentee had taken a retrograde step, and not a step in advance. Moreover, he saw no invention in what the patentee had done. Lake did not fit overhung grip alone, but direct grip also. But there was another anticipation which introduced conduit and coupling of the same size. Bayliss used coning as Mr. Waterhouse did. In his judgment the patentee failed for want of novelty. As he had found that there was want of novelty, it was unnecessary to refer to the other points made by petitioners. In his judgment the petitioners were entitled to an order for revocation and for costs.

### British Pioneer Electric Light & Power Co. of India (Ltd.)

On Tuesday the petition of S. T. Biggs and another for the winding up of this company was in the list for hearing before Mr. Justice Buckley.

Mr. GORE BROWNE, K.C., for petitioners, asked that the petition might stand over in order to answer affidavits, and he also asked for leave to amend the petition, and for an order for discovery of documents.

Mr. YOUNGER K.C., on behalf of the company, opposed any adjournment. The petition was opposed by all the other shareholders. The documents asked for were exhibited.

His LORDSHIP gave liberty to amend, and directed the petition to stand over for a week.

### D. Stewart & Co. (Ltd.) v. Heckmondwike District Council.

Mr. Pollock, K.C., official referee, commenced the trial of this case on Wednesday.

Mr. ACLAND, K.C., said that plaintiffs were engineers and boiler makers, and the action was brought to recover the price of certain water-tube boilers supplied to and for work done for defendant Council in connection with an electricity scheme for the town. The real point was whether the boilers, which were supplied were capable of evaporating 4,000 lb. of dry steam per hour under normal conditions, and with average coal, as specified in the contracts. Defendants said the boilers did not come up to that test, and counterclaimed for damages or set-off. A further point in issue would be as to what was meant in the contract by normal condition and average coal. The Council's engineer claimed the right to say what were normal conditions, but plaintiffs said the amount of draught in the Council's works was abnormally low, and was insufficient to burn the coal properly. Eventually the Council pulled down the boilers and erected other boilers, and the present action was then commenced.

After taking evidence the case was adjourned.

**Lloyd's v. Marconi International Marine Communication Co. (Ltd.)**—This case was in Mr. Justice Kekewich's list yesterday, but was not reached. We understand, however, that the action is likely to be settled.

## PARLIAMENTARY NOTICES.

In the last issue of *The Electrician* we gave brief particulars of some applications for provisional electric lighting orders, and we give below a further list, showing particulars of the notices advertised to be made to Parliament and to the Board of Trade in the 1906 session in regard to proposed new electricity supply schemes, electric railway and tramway undertakings, extension of existing undertakings, &c.

### ELECTRICITY SUPPLY PROVISIONAL ORDERS.

*Barry* (extension of time, transfer of powers, &c.) and *Blaydon* (transfer of powers to County of Durham Electrical Power Distribution Co.) Urban and *Portland Gelligaer* and *Rhigos* Rural Councils.

County of Durham Electrical Power Distribution Co. (power to supply *Crook*, *Willington*, *Brandon* and *Byshottles*, *Brancepeth* and *Ryton*). Electrical Distribution of Yorkshire (*Gomersal*, and *Pontefract*). Foote & Milne (for *Macclesfield* and for *Sunningdale* and District). National & Provincial Electricity Corpn. (*Woodford*, Essex, and *Boston*—repeal of Boston Electric Lighting Order, 1900). Northwood Electric Light & Power Co. (*Pinner*, *Stanmore*, *Harrow Weald* and *Edgware*). Urban Electric Supply Co. (*Godalming* Extension). Wantage Engineering Co. (*Wantage*). Uxbridge & District Electric Supply Co. (extension of area to *Hanwell*, parts of *Eton*, *Beaconsfield* and *Amersham* and *Watford*).

### ELECTRICITY SUPPLY BILLS.

*Shropshire, Worcestershire & Staffordshire Electric Supply Co.*, for further powers; extension of area to Birmingham, Smethwick, Walsall, Wednesbury, West Bromwich and Wolverhampton, Amblecote, Bilston, Brierley Hill, Coseley, Darlaston, Handsworth, Perry Barr, Quarry Bank, Rowley Regis, Rugeley, Sedgeley, Tettenhall, Wednesfield, Wednesfield Heath (Heath Town), Short Heath and Willenhall, and parishes of Busbury and rural districts of Kingswinford and Seisdon, and part of Shifnall in county of Stafford; to define area of supply of company, and, if thought fit, to prescribe separate areas to be designated industrial, non-industrial and rural, &c.; to define purposes and conditions of supply, &c.; to enter into agreements with Midland Electric Corpn. for power distribution, and other companies and authorities to exempt fittings from seizure by way of distress, &c.

*Folkestone Electricity Supply Co.* to enter into agreements for exercise of powers conferred upon Hythe Corporation and Sandgate Council by Hythe Electric Lighting and Sandgate Electric Supply Orders, 1900, transfer of orders, &c.

*Metropolitan Electric Supply Co.*, to extend limits for supply of energy in bulk and other purposes; to extend area for bulk supply to Ruislip-Northwood (Middlesex), Rickmansworth and Chorley Wood (Herts.), Chesham, Beaconsfield, Eton and Slough, Amersham and Wycombe (Buckinghamshire), New Windsor and Windsor (Berks.), Chertsey, Egham and Thorpe (Surrey); to enter into agreements as to supply of energy within or beyond limits of supply to local authorities and companies, to authorise transfer of powers of electricity undertakers, &c.

Power is again sought to incorporate the *Administrative County of London & District Electric Power Co.*, for constructing and erecting electric generating stations and producing, generating, using, transmitting, transforming, distributing and supplying electrical energy and for manufacturing gas for generating energy and generally carrying out the purposes of an electric supply company in the counties of Surrey, Essex and Kent and the Administrative County of London; to acquire lands for generating stations, &c. The areas of supply scheduled are: City of London, Westminster, Battersea, Bermondsey, Bethnal Green, Camberwell, Chelsea, Deptford, Finsbury, Greenwich, Hackney, Islington, Lambeth, Lewisham, Poplar, St. Pancras, Shoreditch, Southwark, Stepney, Wandsworth and Woolwich; Croydon, Richmond, Kingston-upon-Thames, Wimbledon, Barnes, Ham, The Maldens and Coombe, Sutton and Carshalton, parts of Surbiton (Surrey); West Ham and East Ham, Barking, Grays Thurrock, Ilford, Leyton, Romford, Wanstead, Woodford and part of Orsett (Essex); Bromley and Gravesend, Beckenham, Bexley, Chislehurst, Erith, Foot's Cray, Northfleet and Penge, Dartford and part of Bromley (Kent).

The *City of London Electric Lighting Co.* is seeking powers to give a supply of electricity to any company, body or person owning, leasing, working or occupying any railway, tramway, tramroad, canal, navigation or premises situated within or partly within the limits of supply of the company for use within or without or partly within and partly without the said limits; to enter into agreements with companies, authorities, &c., as to supply of electricity, to alter, amend or repeal certain provisions of company's acts and orders.

*Stepney* (London) Council seek authority to empower the Council, either alone or in conjunction with the Council of any other Metropolitan borough duly authorised, to supply electrical energy in bulk to any local authority, company, body or person authorised to supply electrical energy within the Administrative County of London or any part thereof; to enable the Council to purchase electrical energy in bulk from any local authority, &c.; to acquire lands for generating stations; to lay mains within and beyond borough, &c.

Power is sought to incorporate a company to generate and supply electrical energy and to acquire lands in Counties of *Hutingdon, Bedford, Hertford, Middlesex, Essex* and *London*, and to acquire easements along the river Lea, Hertford Union and Regent's Canals; to enter into agreements with railway or canal companies, to authorise agreements with railway or canal companies with respect to laying cables, wires, &c.; to enter into agreements with local authorities, companies, &c., requiring electrical energy outside Administrative County of London; to enter into agreements with authorised undertakers in any area in Administrative County of London, and also for transfer of undertakings of authorised local authorities, companies, &c.; to enter into agreements with railway, canal and tramway companies and others for supply of energy; to exercise power of electrical undertakers in London, &c.

Power is sought by the *Kent Collieries (Ltd.)* to incorporate a company to establish generating stations in Kent and supply electrical energy in Metropolitan area; to enter into agreements with and confer powers upon railway companies, to supply electrical energy to other companies, bodies or persons and to enter into agreements as to laying mains, &c.

*South Wales Electrical Power Distribution Co.* to rearrange capital, &c.

*County of Durham Electric Power Supply Co.*, to authorise supply of electrical energy for all purposes within area of supply to companies, bodies and persons, besides authorised undertakers, to exempt meters, fittings, &c., let on hire from distress or execution, to lay electric lines in, under, over or across the river Wear; to enter into agreements with Newcastle-upon-Tyne Electric Supply Co. and other companies, local authorities, &c.; to acquire or work electrical undertakings by agreement; to exempt County of Durham Electric Power Distribution Co. from restrictions as to association, &c., with local authorities and persons, &c.

### Joint Lighting and Traction Bills.

*Haslingden* Corporation, to construct and convert to electric traction existing tramways, to construct new lines, to purchase tramways, &c.; to attach brackets and wires to houses and buildings, powers to restrict and refuse supply in certain cases; to sell and let on hire electric fittings, motors, &c., and to exempt same from distress or execution; to require consumers to give notice to Corporation before leaving premises supplied with energy; to lay electric apparatus in streets not dedicated to public use; to alter date of filing annual accounts, &c.

*Derbyshire and Nottinghamshire Electric Power Co.*, to enter into agreements with adjoining local authorities, companies, &c.; for supply of electric energy for railways, tramways, canals, &c., within and without area of supply; to acquire from local authorities, companies and others, tramways and light railways; to supply electricity for all purposes within area of supply, to exempt plant and machinery let on hire from sale by owners and mortgagees of premises, to erect overhead cables (with consent), to acquire undertaking of Newark & District Light Railway Co., &c.

*Kingston-upon-Hull* Corporation, to construct electric tramways, to attach brackets to buildings, to supply electrical energy outside city and also to local authorities, companies and persons owning and working light railways, tramroads or tramways within or beyond city; to supply electric fittings, motors and other apparatus, to refuse supply of electricity in certain cases, &c.

Power is sought to incorporate a company to acquire the powers of the Empire Electric Light & Power Co. under *Romford and District* Tramways Act, 1903, to extend time for purchase of lands and completion of tramways; to extend time for laying mains under Romford Electric Lighting Order (1900), &c.

### Electric Traction Provisional Orders.

*Newcastle-upon-Tyne* (additional tramways) and *Rochdale* Corporation (to construct and work electric tramways, &c.), and *Altrincham* District Council (to revive powers to construct and complete tramways, and to make leases and enter into agreements relating to tramways authorised by Altrincham Tramways Order, 1904).

### Traction Bills.

Power is sought to incorporate the *London Outer Circle Railway Co.*, to construct railways in Middlesex and Essex, to acquire lands for generating stations, &c., to enter into agreements with L. & S.W., G.W., G.C., L. & N.W., M.D., Metropolitan, Midland, G.N., G.E. and L.T. & S. Railway Companies, &c.

*Middlesex County Council*, to construct tramways in Edgware-road, to work or lease same to Metropolitan Electric Tramways (Ltd.), to enter into agreements for supply of electrical power with London County Council and other bodies, &c.

*Manchester Corporation*, to construct additional tramways, to enter into working agreements and running powers, extension of time, to amend 1903 Act as to tramways in Cheshire, Sale and Bucklow, &c.

*Oxford Corporation*, to construct tramways within city of Oxford and Counties of Oxford and Berkshire, to reconstruct and adapt existing tramways for electric or other mechanical power, to enter into agreements for working lines, &c.

*North-East London Railway Co.* seek powers to abandon certain authorised road diversions, &c.

*Bury Corporation*, to construct and work tramways within and without borough, to enter into agreements for working or leasing same, &c.

*Baker Street & Waterloo Railway Co.* seek power to construct a short length of railway in Paddington, to abandon portion of authorised railway, to construct subways at Paddington, &c.

*Metropolitan Railway Co.* seek powers for extension of time for construction of works, &c.

*Oldham & Saddleworth District Tramway Co.* seek power to abandon undertaking, &c.

*South Lancashire Tramways Co.*, to extend time for construction of tramways, &c.

*London United Tramways (1901), Ltd.*, to construct new tramways in Middlesex and Surrey, &c.

*North-West London Railway Co.* seek powers to alter railways and works, to construct new railways, &c.

*Metropolitan District Railway Co.*, to construct new railways, subways, &c., to authorise deviation of West London Railway, and to grant running powers over same, to adapt and equip railway for electric traction, &c.

Power is sought to incorporate the *North & South Shields Electric Railway Co.* to revive powers, to extend time for completion of railway works, &c.

Extension of time for completion of works, &c., is sought by the *Watford & Edgware Railway Co*,

Power is again sought to incorporate a company to construct the *Cork Junction Electric Railway*, &c.

*London Southern Tramways Co.* seek authority to work their tramways by mechanical power, &c.

*London County Council* also seek power to construct tramways in the counties of London and Middlesex; to enter into agreements with City of London Corporation as to tramways on Blackfriars Bridge, &c.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT AND FILLED.

Applications are invited for the newly-vacated professorship of electrotechnics at the South African College, Cape Town. Commencing salary £600 per annum. Applications must be sent by Dec. 15 to the Agent-General for Cape Colony, 100, Victoria-street, London, S.W., from whom further particulars can be obtained. See an advertisement.

Vickers, Sons & Maxim, River Don Works, Sheffield, require a thoroughly capable and experienced superintendent for their electrical manufacturing shops. See an advertisement.

At the University of Birmingham a mechanical draughtsman is required, thoroughly conversant with best English practice in the design of dynamos, transformers and accessory apparatus. Salary £250 per annum. Applications to the Secretary by Nov. 27.

Radcliffe Council require an electrical engineer for their electricity undertaking. Salary £150 per annum. Applications by Dec. 2.

Mr. A. Henry, electrical engineer to Radcliffe District Council, has been appointed borough electrical engineer and tramways manager at Nelson.

### EDUCATIONAL NOTICE.

**Birmingham Municipal Technical School.**—The prizes gained by the students were distributed by Prof. W. A. Tilden, F.R.S., on Friday evening last.

The Lord Mayor (Councillor Reynolds) said that during the last three years increased facilities had been provided for carrying on the work of technical education. The success of the school did not depend merely upon numbers, but also upon the efforts of individual students. Many additional classes had been started, notably one in electro-chemistry. A further interesting development was the establishment of summer classes to bridge over the gap between April and September, and it was satisfactory to find that there were 17 such classes engaged on various subjects. There were also the afternoon classes for giving courses of instruction especially suited to engineering apprentices and other employés of engineering firms. These were held from October to June, and he appealed to the employers in the mechanical and electrical engineering trades to make themselves acquainted with the work of the classes and to encourage their employés to attend them.

The Principal (Dr. SUMPNER) said the number of students in the school was nearly 4,000, compared with 3,770 last session; but a better gauge of the work of the school was to be obtained from the attendances rather than from the actual number of students. In October last year the average number of class attendances was 5,400, and this year 5,700. Most departments of the school had altered very little, but the chemical department now contained nearly 700 students, an increase of 36 per cent. over last year, and the physical department, with 1,500 class attendances, had increased 5½ per cent. Apart from the 5,400 class entries there were 734 in the summer classes, but it must be remembered that as the summer lasted but little more than four months compared with six months in Berlin, any comparison between the classes in Birmingham and Berlin was likely to convey a wrong impression. The afternoon classes were very satisfactory, and as the school had been extended it was quite clear the present accommodation was insufficient. He attached great importance to the development of the laboratory work.

After distributing the prizes, Dr. TILDEN delivered an interesting address. There might be a difference of opinion as to the proper business of universities, but there was none as to what ought to be done in the technical school. In the main its purpose was to teach the students to do something theoretically and practically. At the Birmingham Technical School they were creating a large body of expert scientific assistants which was going to be distributed among the industrial firms of the district. He hoped that the district would absorb the whole of them. He was a little tired of being constantly reminded that we were behind other people, but at the same time one nation might easily learn a little from another without any self-abasement. He inquired of a great chemical manufacturer in America last summer what pay was given to youngsters taken into the works who had learned their theoretical and a certain amount of practical work, but who could not be expected to know much about manufacturing operations, and he was told they began at a salary of about $600, or £120 a year. He knew corresponding places in Germany where they got about £150 a year. Of course, the exact pay varied according to the nature of the industry, and the conditions under which the employment was obtained; but still, let them notice the difference between the British employer and the American or German employer. The American or German employer did not expect to get any profit immediately out of the assistance rendered by the young persons. They were really taken in the first instance to learn their business, and the pay which was given to them was a maintenance allowance which enabled them to go on learning the business in which they were afterwards to render, and certainly would render, valuable service. That kind of principle would have to be recognised here. It was not when a man got 30s. a week that he should be expected at once to revolutionise the industry into which he was called. It was not possible, in the first instance, for a young assistant to do more than learn his way about the works and learn the processes. It should be made to his advantage and interest to study them with a view to his improvement, and with a view of sharing with his employers any ideas that might come into his mind. But if he did not take some kind of pecuniary interest in the progress of the business he (Dr. Tilden) did not see how it could be expected that that would come to pass. Was it at all likely that an engineer without mathematics, a student of building construction without a little geometry and mechanical drawing, or a student of metallurgy without any chemistry or physics would ever be able to reach to complete command of the principal subjects in which they were interested if they remained without encouragement in undertaking a complete course of instruction? That question was attended in its surroundings by great difficulties. It was enough to perplex one when one thought of the great people of the past, that Faraday did not know any mathematics at all, not so much as the youngest of the students at that school; that Stephenson and some of the great engineers of the past, he supposed, had no scientific training, and were brought into the works to proceed straight to practical work; and even the great discoverers in science, like Darwin and Wallace, although they had some school education, had nothing of the preparatory education which was now thought desirable. So that it sometimes made one wonder whether, after all, elaborate preparations were not to a certain extent futile. However, he always consoled himself with the reflection that when they got on intimate terms with those great men they found they one and all deplored the deficiencies of their youth, and felt how much more they might have done if they had only had the advantages which were possessed by the students at the Birmingham Technical School.

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**Alleged Electrical Frauds.**—At the Central Criminal Court the trial of Leslie, Webber and Rosenberg and Alice Cheeseman has been proceeding throughout the whole of the week and has not yet been concluded. The case for the prosecution has been closed and part of the defence has been heard. Particulars have appeared in the press of the firms who have been victimised and the amounts, some of which are large. We shall be able to make fuller reference to the case in our next issue.

**Award.**—The arbitrator (Mr. Jas. Swinburne) has given his award on Fulham (London) Borough Council's claim for damages against the National Electric Construction Co. in respect of two fatal accidents at Fulham Public Baths on Dec. 23, 1902. The award is as follows:—

I find that the accident which occasioned the deaths was caused by certain iron pipes forming part of the installation supplied by the contractors under the contract were not electrically connected to earth. If the said pipes had been earthed the accident would not have happened. The omission was a matter of design, and not a matter of materials or workmanship, and was patent to any electrical engineer inspecting the installation. Apart from a reference to the rules of the Phœnix Fire Office, no indication was given on behalf of the Council to the contractors by drawings, specification or otherwise, that they were required to earth the pipes. Having regard to the state of knowledge among electrical engineers at the time of the contract, and of the execution of the works, I have come to the conclusion that the omission to earth the pipes, under all the circumstances of the case, did not indicate a want of reasonable care or skill on the part of the persons responsible for the omission. Assuming that the contractors were responsible for the omission, I find that they were not guilty of want of reasonable care or skill in omitting to earth the said pipes. It was admitted before me that, so far as this arbitration is concerned, the Council did not rely on any defects in the installation other than the omission to earth the pipes. With regard to the rule of the Phœnix Fire Office referred to, I find that in the case of these pipes earthing would not have been desirable so far as the risk of fire is concerned. It would have been desirable so far as risk of accident to bathers is concerned. The buildings and the electrical installation were inspected and passed in April, 1902, by the surveyor of the Fine Art & General Insurance Co., who were the fire office concerned in the risk. I find that the Council have expended the sum of £1,173. 13s. 1d. in respect of the matters in dispute in this arbitration, and that if they were entitled to recover against the contractors in this arbitration by way either of indemnity or of damages, that is the sum which they are entitled so to recover. If the Court decides that the Council are entitled to recover, then I award that the Council are entitled to receive from the contractors the said sum of £1,173. 13s. 1d., and I direct that the contractors pay to the Council their costs of the reference, and also the costs of this, my award. If the Court decide the question in the negative then I find that the Council are not entitled to recover anything against the contractors, and I direct that the Council pay the contractors their costs of the reference, and also the costs of this, my award.

**Barking.**—The East Ham section of Barking light railways was inaugurated last week.

An arrangement has been entered into between Barking District Council and West Ham Corporation, under which Mr. A. H. Seabrook's services will for some time be divided between the two authorities.

**Bath.**—An extension of the electric tramways to the suburb of Salford was opened on Tuesday.

**Belfast.**—The Corporation have agreed to pay the Harbour Commissioners 4 per cent. on the outlay in constructing the Queen's-road tramways, the Commissioners to maintain the carriage way and the Council to maintain the overhead system, a lease for 15 years being granted to the Corporation.

In connection with the progress of the tramway contracts, and especially that for the engines, the borough electrical engineer (Mr. Victor A. H. M'Cowen) recently reported

That it would be necessary to run the three engines for a lengthened period on full load before he considered they should rely on them for running the tramway system. He had asked the engine builders to let him know when they were ready for a 12-hour non-condensing run, but he had not yet received that information. He had, however, received a letter from the contractors (Messrs. J. G. White & Co.), enclosing copy of a letter from the engine builders, stating that it would not be advisable to run those engines at full load non-condensing for lengthy periods, owing to the excessive strains which would be placed on some parts of the engines. That he (Mr. M'Cowen) considered most unsatisfactory, as it was absolutely essential for the safe operation of the system that the engines gave their full load under either condensing or non-condensing conditions without risk of breakdown due to excessive strains, as he would find it necessary to run them either condensing or non-condensing for long periods. He might mention that the engines employed in the electric lighting section fulfilled those conditions, and he should require the engines for the traction system to be at least equally reliable. Their contractors (Messrs. White) had given them steam consumption guarantees under both conditions, and he could not accept those engines as satisfactory on the terms named in the letters referred to. He considered the committee would be incurring a grave risk in doing so, as in the event of a derangement of the condensing and pumping plant the continuity of supply would be altogether dependent on the engine working satisfactorily when running non-condensing.

Messrs. J. G. White & Co., in their communication, expressed the opinion that the contention of the engine builders was a perfectly legitimate one, and that the point made by them was one that would be made by any engine builder.

The engine builders, Messrs. Fairbairn, Lawson, Combe, Barbour, intimated that they had had one engine working under full load and 10 per cent. overload when running non-condensing and that the remaining two engines would, as far as they could see, be fully completed and all three ready for taking the load shortly. They pointed out that the condensing plant would not be ready for a considerable time, and they would strongly object to running the engines non-condensing under full load—that was, when generating 1,000 kw. The engines were capable of doing it if called on, but they thought it would be highly inadvisable to run them in that way for any lengthy period. They would be quite capable of driving a fair load—say, about three-quarter load—without opening the bye-pass to the m.p. cylinder, and they thought Messrs. J. G. White & Co. should advise the Corporation to load them to that extent only until such time as the condensing apparatus was complete. In the specification there was no mention of running the engines full load non-condensing for any lengthy period, and it was naturally understood that that method of running was only in cases of emergency.

At the meeting of the Tramways and Electricity committee on Monday the general manager (Mr. A. Nance) reported that, in his view,

The result of the trial of the three tramway engines created a serious state of affairs. He should require two engines working under full load during a day of 17 hours to work the whole service of 174 cars, and there must be a third stand-by engine, also capable of working under full load in case one of the others had to be stopped. He could not start the full electric service until Mr. M'Cowen was satisfied beyond doubt that all three engines were capable of working under full load for a lengthy period. The engines could not work under full load at present. The contractors suggested that the engines should be worked under three-quarter load while being run non-condensing. That was out of the question for a full service of the tramways. Under the circumstances, the earliest date that could be fixed for the establishment of the complete electric service was Feb. 1. The only thing to be done was to work the southern lines with one engine under three-quarter load, having the second engine as a stand-by, and leaving the third engine in the hands of the builders, in the hope that they can do whatever is necessary to the engines, one by one, until they are capable of running under full load non-condensing for a lengthened time. He did not hesitate to say that they should never be out of danger of breakdown in the winter unless that result was secured. He proposed to commence the limited service on Nov. 30.

Mr. Fisher (representing Messrs. J. G. White & Co.) and Mr. Nichols (representing Messrs. Combe-Barbour) attended the meeting and gave explanations on points raised in Mr. M'Cowen's report.

The Board of Trade inspection of part of the system will take place on 29th inst.

**Berlin.**—The Municipal Council have decided to construct an underground electric railway from the north to the south of the city.

**Chelmsford.**—After a very severe fight with the local gas company the Chelmsford Electric Light Co. has secured the street lighting contract for a number of years. 300 ½-ampere A type Nernst lamps will be used, which are being supplied by the A.E.G. English Mfg. Co., who hold the Nernst lamp patents for Great Britain, all British Colonies, Asia, Africa and South and Central America.

**Chesterfield.**—The borough electrical engineer (Mr. R. L. Acland) has drawn up for distribution among electricity consumers a hanging card containing a number of practical hints on the purchase and treatment of incandescent lamps. The cards, which Mr. Acland has found very useful in educating his own customers, can be obtained in quantities from Broomhead Bros, Packers-row, Chesterfield.

**Chile.**—Permission has been granted to the Valparaiso Electric Lighting and Tramways Co. for the public lighting by electricity of the upper and lower parts of the city for a period of 10 years.

The General Industrial Electricity Co. has been granted powers to supply current for lighting and power to the town of Quillota and suburbs.

A concession for the construction and working of an electric railway between Santiago de Chile and the Baños do Colina has been granted to Don F. Petite.

**Cuba.**—The Cuban Electric Co. (through Mr. G. F. Greenwood) has applied to the Cuban Government for permission to construct and work electric tramways in Regla and Guana Bacoa.

**Darlington.**—At the December meeting of the Council the chairman of the Electric Light and Tramways committee will present a report which it is considered will prove of considerable interest to all concerned in tramway management.

The report covers a period of six months. Darlington tramways consist of 5 miles of single track, which has cost the borough £66,148, in addition to the cost of the old tramways and the additional plant necessitated at the electricity works. For the past half-year the traffic expenses work out at 2·199d. per car mile, general expenses 0·525d., repairs and maintenance 0·475d., power (214,918 units at 1¼d.) 1·411d., equal to 4·61d. per car-mile run, or £3,660. 12s. 3d. Gross receipts have been £5,663. 9s. 6d., or 7·137d. per car-mile. The number of passengers carried is 1,699,105. The gross profit was £2,002. 17s. 3d. and interest and redemption £2,138. 14s. 6d., equal to 2·695d. per car-mile, which shows a net loss of £135. 17s. 3d. or 0·171d. per car-mile. The estimate of the receipts and expenditure for the succeeding winter half-year brings the total net loss on the year's working to £1,400, without allowance for depreciation, the Finance committee having declined to set anything aside under this head for three years, against, we understand, the opinion of the present chairman of the Tramways committee, who contended for an immediate appropriation on this account. It will be seen that if depreciation at from 5 to 7½ per cent., as in other towns, is added, there will prove to be a considerable loss on the actual working of the undertaking.

It would appear that the ½d. fare experiment made at Darlington, is in the main, responsible for the present loss, and it is interesting to note that the Tramways committee were almost unanimously against the adoption of ½d. fares, but their decision was overruled by the casting vote of the then Mayor. Working expenses equal 66⅓ per cent. of the average receipts, and it is stated that the ½d. fares have led to an average reduction of 21½ per cent. of the receipts from passenger traffic. It is likely that the subject of reverting to 1d. fares will be considered at the next meeting of the Council.

The consumption of electric current for lighting and power is rapidly increasing in Darlington, where arrangements are being made for letting out electric motors on hire. 68 of these motors, representing 324 H.P., have been fixed, and about 80 H.P. are on order.

**Dewsbury-Birkenshaw Tramways.**—The electric tramway service along Bradford-road from Dewsbury, through Batley to Birkenshaw, was inaugurated on Saturday.

**Dundee.**—The city electrical engineer (Mr. H. Richardson) reported to the Electrical committee on Monday that the business of the electricity department had grown to such an extent that the question of providing extra generating plant and laying additional feeder cables must be settled immediately.

Mr. RICHARDSON pointed out that the Lochee district had never yet been supplied with electricity, although it was required there. The load in the other districts was such as to give the present station and cables as much work as they could do. In fact, some of the cables were overloaded to an extent which made it impossible to keep up the pressure through the coming winter. To extend both cables and machinery on the same low pressure system in conformity with the present plant and system would cost about £35,000. The plant would enable the department to meet the extra demand for the next two or three years, but the cables were far too expensive for the supply of power to those outlying districts. That was owing to the low-pressure system being employed. An alternative method was to put down a new power station on the high-pressure system and distribute the energy to sub-stations in outlying districts. This would give the department a more elastic system of electricity supply, and would also give an unequalled facility for the supply of cheap power for the development of all industries. The cost of beginning such a station with, say, two sub-stations, would not be less than £75,000 exclusive of land. It was therefore important that the matter should be faced and settled immediately, because the business of the department would not admit of delay. Mr. Richardson asked that he be authorised to prepare specifications and to invite tenders for: (1) the installation of a new system and new power station; or (2) the extension of plant in the present generating station.

Owing to the great importance of the matter, the committee resolved to defer consideration for a month in order that the engineer might supply fuller particulars of the alternative scheme, and that they might have time to consider the question in all its bearings.

**Easthampstead.**—The Council will oppose the application of the Camberley Electric Supply Co. for an electric lighting order.

**Electricity Supply in South London Suburbs.**—The S. Metropolitan Electric Light & Power Co is issuing a circular to householders in the company's area of supply, and on the back of the pamphlet is a map of the various districts in which the company has power to supply electricity. The area extends from the river Thames on the north to Anerley and Croydon on the south, and from Woolwich on the east to Lambeth and Camberwell on the west. In addition the company has power to supply in bulk at the boundary line to undertakers authorised to supply electric energy for (1) tramways partly within and partly without the company's area of supply and (2) for other purposes. The various conditions of supply of electricity for light, power, cooking, heating, &c., are clearly set out in the pamphlet.

**Fulham.**—Mr. Carson Roberts, the L.G. Board district auditor, has issued his report on the audit of Council's accounts for the year ended March last.

Referring to the electricity undertaking, he states that he mentioned in his last report that there did not appear to be legal authority for dealing with the income and expenditure of the dust destructor and brick-making plant in the account kept under the electric lighting order; that the provision of arc lamps for public lighting was a matter to be dealt with in the general-rate account, and not in the electricity accounts, with an annual charge to the rates for their use. No change had, however, been made in regard to either of these matters, but arrangements have been made for the necessary alterations in the accounts. Mr. Roberts also reported that before a true profit and loss account for the electricity undertaking could be produced it was necessary to take account of some other matters—*e.g.*, that the electricity revenue be charged with an appropriate share of the central establishment expenditure and with the actual cost incurred by its overdraft on cash account. Discounts were at present allowed on accounts for current paid within 14 days of demand, and that necessitated provision in the accounts for recording the dates of demand, and made it more difficult to check the correctness of the collection accounts. If it could be arranged that the allowance of discounts should cease after a fixed date in each quarter matters would be greatly simplified. It had been represented in the accounts that reserves for renewals to the amount of £7,400 had been set aside out of rate contributions in aid of the undertaking. Of this, £3,600 had, in fact, been spent upon paving works and was treated in the accounts as having been restored on loan to the general rate fund to be repaid with compound interest in 1909, 1910, 1911. The inclusion of that £3,600 in the accounts as an electricity reserve was not a matter which could be recognised in the certified accounts for several reasons—viz.: (1) No such reserve of £3,600 existed in fact, as the money had been spent upon general rate purposes, and the arrangement was in effect simply a reduction of the rate contributions in aid of the undertaking to that extent; (2) no authority had been obtained to charge the cost of those particular paving works otherwise than on the funds of the year in which they were carried out (*i.e.*, there was no sanction to borrow); (3) real electricity reserves could not lawfully be invested in the Council's own funds; (4) the proposed contributions for 1909, 1910 and 1911 would in fact be new contributions in aid of the electricity revenues, and not payment of paving debt, and, as well as being the correct method, it would be much simpler to treat them as such. The report has been referred to a sub-committee.

The L.G.B. has, in order to obviate disallowances, sanctioned the following payments, with an intimation that they do not consider it was contemplated that recurring expenditure of the kind could be again passed: Subscription to municipal electrical association, £2. 2s.; expenses of delegates to conference of electrical engineers at Sheffield, £13. 18s. 6d.

**Heywood.**—The electric tramway service was inaugurated on Friday last.

**Hospital Collecting Boxes in Tramcars.**—Some time ago Mr. T. B. Goodyer, general manager of the Croydon Corporation tramways, suggested the placing of hospital collection boxes in the Croydon tramcars as a means of obtaining funds for the local hospital. Two small collection boxes have since been placed inside each car, and the result has been encouraging. At the annual meeting of the governors of the hospital last week Mr. Goodyer was elected an honorary life governor of the hospital as an appreciation of his good work for the institution.

**Inquest.**—An inquest was held on 15th inst. into the circumstances attending the death of a young drawer named Jones, who was engaged drawing coal to the pit eye in the Ince Yard Mine of the Ince Hall Collieries (branch pit), and was discovered lying dead on the morning of the 14th inst., apparently electrocuted.

The coroner (Mr. Brighouse) intimated that the whole question of the use of electricity in mines might come under consideration. According to the police report, deceased, who was 20 years of age, went down the pit about 8 p.m. of the 13th, and commenced work as a drawer, taking full tubs of coal from the Yard Mine to the pit shaft down a road along which an electric cable ran 12 in. from the rails on which were the tubs. All went well until about 3 a.m. next morning, when deceased, with a man named Wilks were taking tubs to the shaft. Wilks was in advance of Jones, and looking round noticed that deceased's tub was stopped. He went to see what had happened, and found the rails had slipped towards the electric cable. Deceased's tub, which was iron-plated, was on its side, and the top corners of the tub were against the electric cable. Jones was lying behind the tub apparently electrocuted. The current had passed to earth through him. Another workman joined Wilks, and they put on rubber gloves and managed to release Jones. Wilks, when earlier trying to give assistance, had been thrown to the other side of the road. Artificial aid to respiration was applied to Jones, but without effect, and he was pronounced by Dr. Fletcher to be dead.

Mr. Henry Knight, manager of the colliery, said the electric cables were laid from the surface down the pit shaft and along certain roads, so that the electricity might drive two coal-cutting machines. The dynamo was on the surface, and was driven by engines there. The positive and negative cables ran up to a certain point, along which no one travelled except the officials, while in the first portion, where everyone travelled, the cable was concentric. Those cables were protected.

The Coroner asked if witness thought the rails slipped in the first instance, and witness replied that there was every evidence of this, looking at the ground. The tub got off the rail, and then deceased went to the lower side and tried to get his tub on. In doing that deceased had either got his arm or leg over the cable, most probably his leg. Lifting the tub he had brought the cable towards the tub, and got it hooked in the corner iron of the tub. Then he brought it with the tub until when he came to where the cable was suspended, where he got fast and pushed along until he pushed the corner iron through the insulation into the cable and received a shock which killed him. That was the first accident they had had at the pit. The cables were bought under the advice of electrical engineers in Wigan. The concentric cable so far as it went was armoured with wire. In his opinion such a cable was safer in some mines than others, but he agreed that it would take greater force to do damage to it than would be required to damage the cable that was cut in this case. During the three years they had had electric coal cutters at work they had used the same kind of cable for the interior of the mine and not concentric cable.

The Coroner: I suppose a fall of roof or stone on to this cable might cut it?—Yes.

So that when the man is clearing the fallen stone away, if there is a part of the conductor bared owing to the fall, and he touches it with his shovel, he gets the same shock as the man whose death we are inquiring into?—I think he would get a slight shock, but in this case he is holding an iron bar. Holding a shovel in his hand with a wooden shaft he would only get a slight shock if the shovel touched a bare part of the cable. The timber would be a non-conductor to a certain extent, I think.

Mr. Osman said that the man got the whole of the current through his body owing to the cutting of the cable. In the ordinary way the shock would not kill an ordinary man, as they were working at very low pressure. The man must have been very sensitive or probably suffered from some affection of the heart. Only one man in a hundred would suffer from the shock. The pressure of the current was only about 500 volts. Between 250 and 650 volts was practically a safe current to work with. He had himself had shocks from current of that voltage a good many times, and he knew of hundreds of men who had also withstood similar shocks.

The Coroner said he would like to have an opportunity of reading the special rules and regulations applying to the use of electricity in mines. Here was a new power they were introducing into coal mines, a new power that was no doubt a very faithful and a very good servant, but still it was surrounded with danger. It would not be right to hurry the inquiry. They must consider the matter carefully and have it threshed out. He therefore adjourned the inquiry until the 27th inst.

**Jungfrau Railway.**—A violent storm has destroyed two of the stations on the famous Jungfrau electric railway—those at Scheidegg and Eiger. Considerable damage has also been done to the railway.

**Leith.**—The final sections of the Corporation electric tramways were officially inspected on Tuesday and the lines were opened for traffic. The whole of the tramway system is now working.

The National Telephone Co.'s new central battery telephone exchange has just been opened.

**Light Railway.**—Mansfield & District Light Railway Co. seek powers to extend authorised railways in county of Nottingham and to abandon portions of authorised railway; further capital powers, &c.

**Lincoln.**—The official inspection of the permanent way of the Corporation electric tramways took place on Wednesday. The inspection of the electrical equipment (which is on the G.B. surface-contact system) took place yesterday.

**Liverpool.**—Mr. R. Dart has been re-elected chairman of the Electric Power and Lighting committee, and Mr. Max Muspratt has been elected deputy-chairman.

**Llanelly.**—On Tuesday the Council were recommended to accept Mr. J. C. Howell's terms for reporting upon electricity supply, managing the projected station, &c.

The terms offered by Mr. Howell were that in lieu of the engineers' fees mentioned in his report as portion of the capital outlay of £6,000, the council should secure his services for five years at £200 per annum, and for that he would undertake the whole of the professional work necessary for carrying out the work. He would also agree to find all the superintendence and the staff required in running the station up to an output of 50,000 units per annum, and for any greater output he would require for the same services ½d. per unit for every unit above 50,000.

Consideration of the question was deferred.

**London County Council.**—At Tuesday's meeting a loan for electric lighting of £5,860 was made to Stoke Newington.

*Electric Lighting Loans.*—Discussion arose upon the recommendation of the Finance committee to grant a loan of £25,000 to Fulham Council for electricity supply purposes which the Council passed a fortnight ago on the annuity system.

Sir R. M. Beachcroft asked if it would not be better to grant the loan on the instalment system, and pointed out that under the annuity system ratepayers 30 years hence would be charged the same in regard to the loan as the ratepayers now, whereas the works for which the loan was granted would all be worn out.

Mr. E. Collins asked what security they had for the money they were constantly advancing. They were told that the municipal authorities were making a profit on their electric lighting undertakings, but consumers were being charged 4d. to 7d. per unit, while promoters were coming forward offering to supply electricity at ½d. per unit.

Mr. J. Burns, M.P., said that 13 out of 16 London municipalities were making a profit on their electricity undertakings, and were charging less for current than companies who were supplying in non-competitive areas.

Mr. S. Buxton said the point was that while the loan was spread over 42 years, the life of the materials purchased by the loan could not be set down at most at more than 25 years.

Lord Welby agreed that the instalment system was the better one, but the annuity system had not been abused so far. The question of 42 years for the repayment of loans for electrical undertakings was a serious one, and was engaging the attention of the Finance committee.

The recommendation was approved.

*Tramways.*—It was agreed that the Highways committee should be authorised to expend a sum not exceeding £2,100 for the provision of machine tools for use at Greenwich electricity generating station.

The Highways committee recommended that the manufacture of car ploughs required in connection with the order placed with the British Westinghouse Co. for electric car equipments be executed by the Highways Department as allowed by the contract at a cost of £1,800.—Agreed.

**Maidstone.**—Electricity consumers are now afforded the opportunity of renewing their incandescent electric lamps at a charge of 8½d. each, no profit accruing to the Council from the sale. Inspectors for the supervision of incandescent lamps will be provided free on consumers' request.

Last week the Council referred back a report by the Light Railways committee recommending that application be made for an order authorising the extension of the tramways.

**Motor 'Buses as Tramway Feeders.**—Leeds Tramway committee have decided to run a motor omnibus service form Headingley to Adel and the golf course.

**Municipal Telephony.**—On Tuesday intercommunication was established between the municipal and the National telephone systems at Swansea.

**Newcastle-on-Tyne.**—The strike of the Corporation tramway employés, which commenced on Friday night, was ended on Sunday, the men returning to work on the understanding that matters be discussed by representatives of both sides.

**Oldham.**—Ald. Bolton has been re-elected chairman of the Electricity committee. The equivalent of 74,875 8 c.p. lamps is connected to the mains as well as 209 motors.

**Olympia Motor Exhibition.**—There are very few electrically-driven cars exhibited at Olympia this year, and the accessories, such as spark coils, ignition cells, magnetos, sparking plugs, &c., do not present any features of particular novelty. Messrs. Henry F. Joel & Co., at Stand No. 10, show an "electric park phæton." This carriage will seat two at the back, with an additional seat in front, and will run 50 miles with one charge, carrying two, at speeds from 4 to 20 miles an hour. It is designed on the latest French model, and has a weather hood and leather wings. It is made on a steel chassis and upholstered in leather. The wheels are all same size, with artillery hubs and pneumatic tyres. The motor is of 4 H.P. to 6 H.P. with an efficiency of 87 per cent., weighs only 200 lb. This is suspended on a tubular underframe independently of the carriage body, and this underframe, with the motor and gears, can be easily detached and lowered on the ground for inspection, cleaning, &c. The motor drives the back wheels by means of a chain and balance gear. The underframe connects the front and back wheels by means of a spring support on the front axle, and adjustable screw connectors on the back axle, which allows the chain to be tightened as desired. Every part, motor, gears, &c., can be easily seen for oiling through traps in the footboard. The battery has 42 cells, weighs 7 cwt., and is divided into seven portable trays, which are easily handled for inspection. The system of control is such that the carriage can be run backwards or forwards from 4 to 20 miles an hour, as desired, and on the slow speeds in traffic without moving the controller handle. The Electromobile Co., at Stand No. 67, has its usual fine display of double and single landaulettes, broughams, &c., but the electrical details of these are almost identical with those of last year. In the annexe, at Stand No. 129, the Kriéger Electric Carriage Co show three of their vehicles. These have already been described in our columns, and it will be remembered that their distinctive feature is a front-wheel drive, which, it is claimed, eliminates side slip.

**Platinum.**—The "Brazilian Review" recently contained an article in which an endeavour was made to demonstrate the existence of platinum in Brazil, although this valuable metal has not yet been discovered in sufficient quantity in that country to make its extraction remunerative. It is stated that the existence of platinum has been recognised in the Lages stream in the Serro district, in alluvial deposits at Itabira do Campa, in the Ouro Preto district, and in the river Abaete, all in the State of Minas Geraes. At the same time it is pointed out that confusion has frequently occurred between platinum and palladium gold.

**Shoreditch (London).**—The town clerk (Dr. H. Mansfield Robinson) has written to the L.C.C. asking for the insertion of protective clauses in the bill promoted by that body.

The Highways committee consent to the L.C.C. proposal to construct a single track tramway from Kingsland-road via Harwar-street to Hackney-road.

**Simplon Tunnel Railway.**—From Berne it is announced that a contract is about to be given for the construction of an electric railway through the Simplon Tunnel, and further that the firm of contractors for the work undertake under heavy penalties to effect completion by May 1, in time for use for the Milan Exhibition, which opens on the 19th of that month.

**Southport.**—It is reported that the recent electrical exhibition was a success, over 10,000 visitors having passed the turnstiles in the course of the week, while 9,600 tickets of admission were paid for. All the exhibitors report having done excellent business. The cookery lectures proved of great interest.

**Stockton-on-Tees.**—The Board of Trade having signified their intention of revoking the electric lighting order, the Rural Council have applied for an extension of one year.

**Stourbridge.**—The question of electricity supply was again discussed by the Council on Tuesday. The Electric Power committee recommended the Council to accept and seal an agreement with a company for a supply of electricity in bulk, but an amendment was carried by 14 votes to 13 referring the report back to the committee with an instruction that "the Council was unwilling to consider a scheme prepared without any estimates which would enable the Council to judge of the responsibilities of the ratepayers" [Some further information with regard to this matter is given in our Editorial Notes and Correspondence Columns.]

**Sunderland.**—The District Council have decided to oppose the application of the United Kingdom Tramway Light Railway and Electrical Synd. for an extension of the term of their provisional order.

**Torquay.**—The National Electric Construction Co. have offered to purchase the electricity supply works of the Corporation, and the offer is being considered.

**Tunstall.**—Considerable progress has been made with the laying of the electric lighting mains in this district, and a supply of current will be given Burslem Council in a few days.

**Willington.**—The Council have refused assent to the application of the County of Durham Electric Power Distribution Co. for a provisional electric lighting order.

**Woodford.**—Owing to the adverse result of the poll of the ratepayers the Council have decided not to apply for a provisional electric lighting order.

**Woolwich (London).**—The borough electrical engineer (Mr. John B. Mitchell) recently tendered his resignation (but under protest) to the General Purposes committee, and after discussion this was accepted.

Mr. Mitchell was appointed in 1899 electrical engineer to the late Plumstead Vestry, and was transferred to Woolwich Borough Council on its formation in 1899.

At the Council meeting on Thursday last, Councillor Widger protested against the action of the Electricity committee. He alleged that every little complaint that there had been in reference to the department had been laid to the blame of the electrical engineer, and spoke of councillors believing the tittle-tattle of disloyal members of Mr. Mitchell's staff. He recounted the interviews which had taken place in the Mayor's parlour between at one time three and at another two councillors and the engineer. He then submitted a sketch of Mr. Mitchell's career since his appointment. He accused the Electricity committee of rushing the work they had in hand, with the result that the electricity department had not been able to keep up with the demands made upon them. It got behind with its work and the chief got the blame, as usual. Now the committee had practically ruined him.

Ald. Macnamara defended the action of the committee, and alleged that the engineer was behind with his accounts. Three temporary clerks had been appointed to put them straight, and not even Councillor Widger knew how they stood.

Councillor Syer said the reason some members of the committee had voted as they did was that they were ordered to do so.

Councillor L. J. Jones said that all he, Councillor Grinling and Councillor Sheppard had done had been in Mr. Mitchell's interests. They had spoken to him in a friendly way, and Mr. Mitchell had at first understood the interviews to be friendly. They had given him time to consider his position and offer any alternative. They had even postponed the recommendation in committee in order that he might apply for another situation, and he had been prepared to accept one at £200 a year less than he had been getting from the Council. The electrical department was a failure, but they were determined to make it a success. They had acted as they had because they wanted to make it a success, and a success it was going to be.

Councillor Grinling spoke as a personal friend of Mr. Mitchell, and said that it was because he was a friend that he was asked to be present at the interviews. At the same time he had to admit that the engineer was not a strong enough man to cope with the electrical undertaking.

On a division the acceptance of the resignation was carried by 22 votes to 6.

At the same meeting of the Council it was decided to take up a loan of £5,111 for electricity supply and street lighting.

**Dinner.**—The annual dinner of the cricket club of the staff of Drake & Gorham (Ltd.) was held on the 16th inst. The chair was taken by Mr. Bernard Drake, who was supported by Mr. J. C. Forster. The secretary of the club reported a very good season (13 wins out of 21 matches played). The club's finances were also very satisfactory.

The Chairman, in replying to the toast "Success to Drake & Gorham (Ltd.)," said that, in spite of keen competition, the company had been able to hold its own. The past year had shown improved results on the previous one, and he hoped the current year would be better still. He thought many people who would have adopted the electric light had delayed doing so, and bought a motor car instead. Referring to the political question of the time, Mr. Drake recommended the staff to look into the question of supporting the reform of tariffs in the event of a general election, as, although he was not a politician, it appeared to him to be senseless to tax such things as tobacco and tea, which we could not produce in England, and yet allow foreign goods which we could produce to come into the country free of duty. He considered it was conceit for British manufacturers to think they could compete with foreign-made goods, however many advantages were given to the foreigner. He saw no objection to the price of food being higher, so long as the people had correspondingly more money to pay for it.

## TRADE NOTES AND NOTICES.

### TENDERS INVITED.

The Directors of the *North-Eastern Railway Co.* invite tenders for stores during six or 12 months from Jan. 1, 1906, including telegraph apparatus, telegraph wire and line stores. Forms of tender from the telegraph superintendent (Mr. C. H. Ellison), York. Tenders to the secretary (Mr. R. F. Donell), York, by 9 am. Dec. 2. See also an advertisement.

*Glasgow* Corporation invite tenders for supply of (1) 1,000 kw. motor generators and (2) high and low-tension sub-station switch gear. Offerers must be able to show plant similar to that for which they tender. Copies of specification and forms of tender from the the chief engineer (Mr. W. W. Lackie), 75, Water-street, Glasgow. Tenders to the town clerk (Mr. John Bowers), City-chambers, Glasgow, on or before Dec. 4. See also an advertisement.

*Glasgow* Corporation also want tenders by 10 a.m. 27th inst. for electric lighting, heating and ventilating of Pollokshields district library.

*St. Pancras* (*London*) Council invite tenders for supply of lead-covered and armoured cables. Specifications, &c., from the chief clerk (Mr. A. E. Pycraft), Electricity Department Offices, 57, Pratt-st., London, N.W. Tenders to the town clerk (Mr. C. H. F. Barrett), by noon, Nov. 30. See also an advertisement.

*Ilford* District Council invite tenders for supply of 0·5 in. triple concentric armoured cable. Specifications from the chief electrical engineer (Mr. A. H. Shaw, M.I.E.E.), Electricity Works, Ley-street, Ilford, after 27th inst. Tenders (addressed to the Chairman), to the clerk (Mr. John W. Benton), Town Hall, Ilford, on or before 4 p m. Dec. 12. See also an advertisement.

The Guardians of *Poplar* (London) Union invite tenders for supply and erection at the Children's Home and Schools (now in course of erection at Hutton, Essex) of steam engines, dynamos, pipe-work, &c.; main switchboard, wiring, motors, &c.; fire alarms, telephones and electric bells. Tenders to the clerk, Mr. G. Herbert Lough, Guardians Offices, 45, Upper North street, Poplar, before 6 p.m. Dec. 13.

*Dublin United Tramways Co.* (*Ltd.*) invite tenders for supply of general stores, including car fittings, iron and steel castings, oil, electrical supplies, timber, &c., for the year ended Dec. 31, 1906. Forms of tender (after Nov. 22) from the Secretary's office, 9, Upper Sackville street. Tenders to Chairman by Nov. 27.

*Salford* Corporation invite tenders for wiring the Higher Grade Council School for Girls, Victor-street, Salford. Tenders to the Director of Education, Chapel-street, Salford, by Nov. 30.

*Clyde* Navigation Trustees want tenders by noon Dec. 18 for one 20-ton hand or electric overhead travelling crane, six electric quay capstans, two [electric double-geared pier-head capstans and two electric tipping turntables.

The Mayor and Aldermen of the City of *Launceston* (*Tasmania*) invite tenders for supply of 500 or more electric meters and of maximum demand indicators. Specifications, &c., from the city electrical engineer (Mr. Wm. Corin), Launceston, Tasmania, or from Messrs. John Terry & Co., 7, Great Winchester-street, London, E.C. Tenders to the own clerk (Mr. C. W. Rocher), Town Hall, Launceston, by noon Jan. 15.

Tenders will be opened at noon Jan. 16, by the Director-General of Public Works, *Madrid*, for a concession for the construction and working of an electric tramway between Zumárraga and Aziotia (Guipúzcoa). An application has already been lodged for this concession by Don D. Sorseta, who will have preferential rights over other tenderers at the same amount. "The Madrid Gazette" for Nov. 13 contains additional particulars.

## TENDERS RECEIVED AND ACCEPTED.

The following tenders were received by London County Council for 34 single-deck steel cars for the Aldwych to the "Angel," Islington, tramway route:—

*34 Single-deck Car-bodies.*

| | | | |
|---|---|---|---|
| Hurst, Nelson & Co. | £19,550 | United Electric Car Co. | £14,790 |
| Met. Amalgamated Ry. Carriage & Wagon Co. | 16,252 | Brush Co. | 14,773 |

*34 Car Trucks.*

| | | | |
|---|---|---|---|
| Peckham Mfg. Co. (U.S.A.) | £4,930 | Mountain & Gibson | £4,046 |
| Met. Amalgamated Co. | 4,862 | Hurt, Nelson & Co. | 3,978 |
| United Electric Car Co. | 4,420 | Brush Co. | 3,774 |

*Electrical Equipment and Assembly of 34 Single-deck Cars.*

| | | | |
|---|---|---|---|
| British Thomson-Houston Co. | £11,084 | Witting, Eborall & Co. | £10,693 |
| | | British Westinghouse Co. | 9,996 |

Alternative tenders:—

*34 Single-deck Cars complete.*

| | |
|---|---|
| Hurst, Nelson & Co. | £33,694 |
| British Westinghouse Co. | 34,170 |
| Brush Co. | 30,243 |
| Dick, Kerr & Co. | £29,325 and 29,818 |
| British Thomson-Houston Co. | £28,947, £29,380. 10s. and 29,636 |

As the amounts of the lowest tenders appeared somewhat large, the Highways committee communicated with the Brush Co. and the British Westinghouse Co. (the lowest tenderers for each of the three separate items) to ascertain whether they would not be prepared to make some reduction in the amount of their tenders. The Brush Co. agreed to reduce its tenders for car bodies to **£14,280**, but not the amount for the trucks. The British Westinghouse Co. could make no reduction in the tender for electrical equipments, but was willing to supply both trucks and equipments, and to erect the cars for an inclusive sum of **£13,481**. The committee recommended that the Brush Co.'s revised tender for car bodies and the British Westinghouse Co.'s combined tender for trucks and equipments be accepted, and this was agreed to.

On Tuesday London County Council considered the following tenders for the supply and erection of 12 steel coal trucks for Greenwich electricity generating station:—

| | | | |
|---|---|---|---|
| Kerr, Stuart & Co. (*accepted*) | **£990** | Hurst, Nelson & Co. | £1,290 |
| Brush Co. | 1,596 | Mountain & Gibson | 1,254 |
| Flavell & Churchill | 1,317 | S. J. Claye (Ltd.) | 1,098 |
| T. Davies (Ltd.) | 1,294 | | |

Shoreditch (London) Council have received the following tenders in connection with the extension of plant at Whiston-street:—

*Three Water-tube Boilers, Superheater, &c.*

| | | | |
|---|---|---|---|
| Stirling Boiler Co. (*provisionally accepted*) | **£6,605** | J. Fraser & Son | £9,873 |
| | | Babcock & Wilcox | 7,150 |

*Steam and Water Pipes, Valves, &c.*

| | | | |
|---|---|---|---|
| Stirling Boiler Co. (*provisionally accepted*) | **£1,175** | John Spencer (Ltd.) | £1,408 |
| Bennett, Sons & Shears | 2,050 | Babcock & Wilcox | 1,395 |
| J. Wilson & Co. | 1,472 | Aiton & Co. | 1,375 |
| | | E. Le Bas & Co | 1,176 |

*Wrought Steel Flue.*

| | | | |
|---|---|---|---|
| J. Fraser & Son (*provisionally accepted*) | **£531** | Pierson & Co. | £810 |
| Westwood & Wrights | 875 | Mechan & Co. | 796 |
| Stirling Boiler Co. | 872 | Fraser & Fraser | 786 |
| | | Babcock & Wilcox | 750 |

Marylebone (London) Electric Supply committee have received the following tenders for cables:—

| | | | |
|---|---|---|---|
| St. Helens Cable Co. (*accp.*) | **£6,405** | Callender's Co. | £7,502 |
| W. T. Glover & Co. | 7,581 | W. T. Henley's Co. | 7,333 |
| Siemens Bros. & Co. | 7,516 | British Ins. & Helsby Cables | 7,333 |

The committee has provisionally accepted the tender of Elliott Bros. for supply and erection of a switchboard at £2,818. 5s.; that of Chadburn's (Ship) Telegraph Co. for supplying and fitting telegraph instruments in connection with the switchboard at £215; and that of C. A. Parsons & Co. for spare armature for each of the two sides of dynamo installed at generating station at £1,754.

The following contracts have recently been obtained by Messrs. Willans & Robinson, Victoria Works, Rugby:—

Vickers, Sons & Maxim, a 1,000 kw. turbine, complete with condenser, &c., for their Sheffield works; steam turbines for the South Metropolitan Electric Light & Power Co.'s Greenwich works, comprising a Willans-Dick Kerr turbine set with condensing plant complete.

Southwark (London) Borough Council have accepted the tender of Johnson & Phillips for 220 yds. 0·05 cable at £28. 19s., 0·1 cable at £47. 17s. and 0·3 cable at £58. 15s. Tenders were also submitted by W. T. Henley's Co., British Insulated & Helsby Cables, Siemens Bros. & Co., W. T. Glover & Co., Anchor Cable Co. and Callender's Co..

Brighton Council are recommended to accept the tender of the British Westinghouse Co. for a motor-generator at £1,462. 10s., and that of the British Thomson-Houston Co. for a switchboard at £670 in connection with the supply of electricity to Aldrington.

Watford Council have accepted the tender of W. T. Henley's Co. for the supply of cables and those of the British Thomson-Houston Co. and of the Tudor Accumulator Co. for the equipment of the Cassiobridge sub-station at £2,229.

Battersea Lighting committee has accepted the tender of the Electric Construction Co. at £358. 10s. to provide and fix an 18 H.P. electric motor for driving the shafting and gear of the chain-grate stokers to the boilers at the generating station.

Stoke Newington (London) Council have accepted the tender of Pinching & Walton for supplying and laying cable pipes in the transformer station, Edward's-lane, at £82. 6s. 2d.

Stourbridge Guardians have accepted the tender of Cross & Cross for the supply and erection of telephones, electric bells and tell-tales at £337. 12s.

Battersea (London) Lighting committee has accepted the offer of Chitty Bros, to purchase scrap carbons at 35s. per ton.

**Arc Lamp Contracts.**—Messrs. Foster & Co., Worple-road, Wimbledon, S.W., inventors of the well-known Foster hot-wire arc lamps, have been favoured with an order from Belgium for 300 arc lamps, and are working night and day shifts to complete orders, both for this country and abroad. The orders now in hand are for Canada, Germany, South Africa, India and Australia.

## BUSINESS NOTICES.

Owing to increasing demands for their specialities in deck machinery, Messrs. Clarke, Chapman & Co., Victoria Works, Gateshead-on-Tyne, are devoting the company's extensive shops, at present engaged in general work (such as cranes, capstans, hauling engines, &c., as well as winch and windlass work), to winches and windlasses alone, and are building large shops for the manufacture of their general engineering specialities. This will enable them to meet all demands for this class of machinery, and ensure prompt delivery. The company anticipate that when these arrangements are completed about the end of this year they will be in a position to build from 60 to 70 winches a week and about 60 windlasses per month. Large additions are being made to the plant in order that the equipment shall be complete when the building extensions have been made. The company will in this way be in a position to keep on hand a stock of finished winches for immediate despatch, and windlasses always in an advanced state of manufacture, as well as increasing the general facilities of the works.

D. H. Bonnella & Son ask us to announce that Mr. A. E. Armstrong no longer represents them, and that Mr. H. E. Benwell has been appointed as their representative.

The various departments of R. W. Vicarey, Ltd., have been redistributed. The London department (St. Antholin's House, 15, Queen-street, Cheapside, E.C.) is for consultation, the Shropshire department takes the analysing and the Stafford branch is being retained for the convenience of Midland clients.

## BANKRUPTCIES, LIQUIDATIONS, &c.

In the failure of Harry Jones and Gwilt Lloyd Cathrall, electrical engineers, &c., 19, Chester-street, Wrexham, the first meeting of creditors will take place on 29th inst. at Crypt-chambers, Eastgate-row, Chester, and the public examination on Dec. 12 at the Town Hall, Wrexham.

A meeting will be held on Dec. 18, at 35, New Broad-street London, E.C., to receive an account of the winding up on the New Zealand Electric Light & Traction Co. (Ltd.).

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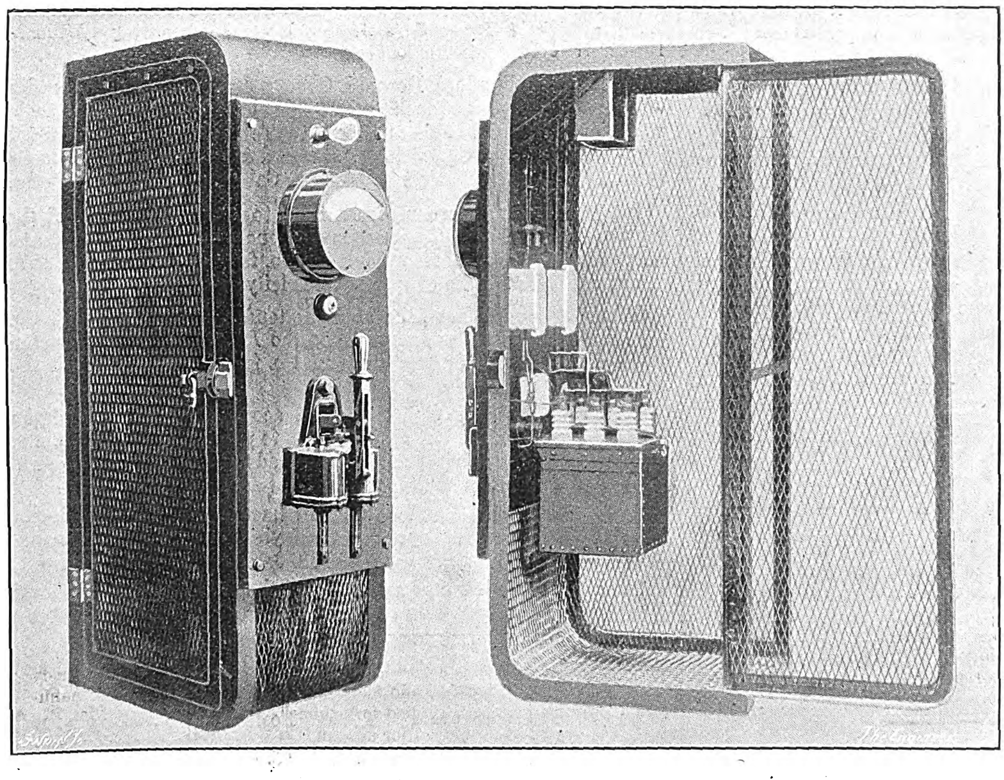
**Plant, &c., for Sale.**—Mr. R. Archer, Horsforth, Leeds, advertises for sale Evershed testing sets.

The Director of the Salvation Army Printing Works, St. Albans, advertises for sale a Kummer dynamo.

**Premises to Let.**—Mr. Fred. Cousins, Wedmore-street, Upper Holloway, London, N., advertises some manufacturing premises to let.

**Reyrolle's Motor Panels for Colliery Work.**—The accompanying illustrations show a new form of H.T. enclosed panel, made by A. Reyrolle & Co., Ltd., of Hebburn-on-Tyne, for use in collieries and works. It consists of a slate base mounted upon an enclosed iron framework. Doors are provided at the sides of this frame, and the parts inside are only accessible to those possessing the key. The panels, which are made of various capacities, contain three-phase oil break switches, either hand operated only or provided with an overload automatic release in addition to the hand operating device. A pilot lamp is mounted at the top of the board over the ammeter, to indicate the potential on the panel and to show when the connections are alive. The potential transformers are protected by dust fuses enclosed in the porcelain boxes, seen in one of the illustrations, directly over the switch.



Reyrolle's Motor Panel for Colliery Work.

**Catalogues.**—The General Electric Co., 71, Queen Victoria-street, London, E.C., are issuing an unusually interesting catalogue, containing technical and commercial information regarding the company's direct-coupled steam, gas and oil generating sets, steam turbine generator sets, electric lifts and cranes, boilers, &c. Special attention may be drawn to the horizontal turbo-generator sets, the standard sizes of which range from 150 kw. to 1,500 kw. in the case of alternating current and from 35 kw. to 1,000 kw. in respect to continuous current. Another interesting item is the oil-engine dynamo sets, which are gaining in favour for lighting country houses, private yachts, &c. These sets are made in half a dozen different sizes, ranging from 2·2 kw. to 11 kw. output. The electric cranes and lifts include patterns for practically all purposes. Pelton water wheels and water turbines of the double vortex pattern are also described and illustrated, and much useful advice is given as to how to measure the water power that is available. Dowson gas-producer plant, suction gas producers and fuel economisers are amongst the other plant dealt with.

Callender's Cable and Construction Co. have sent us an admirable catalogue of electrical distribution appliances, prepared in book form and bound up in cloth covers. It is divided into seven sections, the first relating to details of feeder pillars, joint boxes, &c. Section 2 deals with tramway and light railway pillars and accessories; section 3 (sub-section A) with feeder pillars for two and three-wire lighting systems, (sub-section B) Callender-Ward network manholes, (sub-section C) standard mushroom network boxes, (sub-section D) standard link and block connecting network boxes, (sub-section E) standard straight-jointer boxes non-disconnecting, (sub-section F) standard service boxes, (sub-section G) standard dividing boxes, (sub-section H) standard house-fuse boxes; section 4, standard H.T. junction boxes; section 5, standard frames and covers; section 6, standard junction boxes and cable accessories for use in mines; section 7, switchboards and miscellaneous.

Dealing with the question of coal-conveying plant at the Acton-lane works of the Metropolitan Electric Supply Co., an interesting pamphlet is being distributed by Messrs. Ed. Bennis & Co., Little Hulton, Bolton, who are also circulating a pamphlet describing the coal and ash-handling plant supplied by the company to the Grimethorpe, Frickley and Carlton Main Collieries, Barnsley. Both pamphlets are well illustrated, and are of particular interest to those desirous of effecting boiler-house economies. Messrs. Bennis will be pleased to send copies to engineers and others.

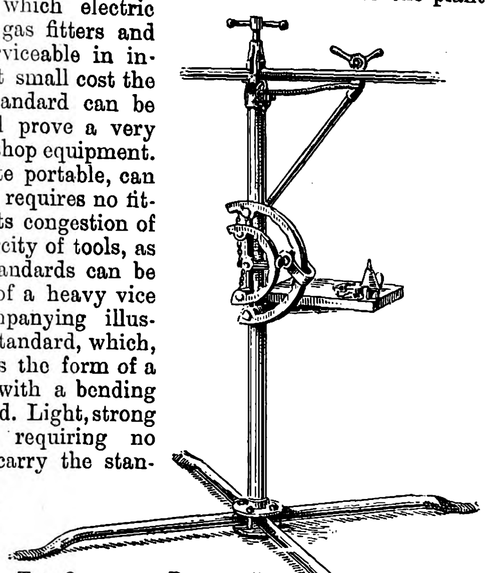
Catalogue No. 50 has been issued by Ferranti Limited, Hollinwood, Lancs., and deals with single-pole single-throw quick-break knife switches, from 25 to 2,500 amperes capacity. Some excellent examples of these switches are illustrated.

**"Britannia" Electric Lamps.**—We learn that the Britannia Electric Lamp Works (Ltd.), of Seven Sisters-road, South Tottenham, London, N., are now manufacturing their incandescent lamps on an entirely new system. The filament is superheated to an extent that it is claimed ensures absolute carbonisation of every atom of the filament, increases its hardness and elasticity, and in consequence the candle power, with the advantages of a decreased consumption of current and an extension of the life of the lamp. The company's factory has been, we are informed, equipped with the latest machinery and plant, and the new system of manufacture ensures the practical elimination of breakage and waste.

**Arc Lamp Lowering Gear.**—The London Electric Firm, George-street, Croydon, inform us that their "one working part" arc lamp lowering gear (described in *The Electrician* of Nov. 3 last) is meeting with considerable favour and, although it has only been on the market a short time, has been supplied to two Government departments, 16 corporations and supply companies, to several railways, and to a number of contractors. One of the latter orders was for 50 complete sets of the gear.

**"Practical Advertising."**—This is the title of the annual Press Directory and Advertiser's Guide issued by Mather & Crowther, New Bridge-street, London, E.C. The object of this publication is to place before advertisers particulars of the facilities which Messrs. Mather & Crowther possess for dealing with advertising matters of every kind on a large scale. There are a large number of specimen advertisements included in the book, which show considerable skill in the preparation of these announcements.

**New Pipe Standard.**—The Oldbury Steel Conduits, Ltd., of Birchfield-lane, Oldbury, have made a useful addition to the plant they supply, and which electric wiring contractors, gas fitters and others will find serviceable in installation work. At small cost the "Paragon" pipe standard can be purchased, and will prove a very useful item of workshop equipment. The standard is quite portable, can be taken to the job, requires no fitting up, and prevents congestion of work owing to scarcity of tools, as several of these standards can be employed in place of a heavy vice bench. The accompanying illustration shows the standard, which, it will be seen, takes the form of a portable pipe vice with a bending attachment combined. Light, strong and durable, and requiring no fixing, a lad can carry the standard, and it is ready for use whenever and wherever required. The bracket and back grip on the "Paragon" standard gives absolute rigidity to the pipe, thereby preserving the jaws, which are cast steel, case hardened, and can be renewed in a minute when necessary at trifling cost. The combination of a pipe-bending wheel with the standard is claimed to be unique. As shown, there is also a tool tray attached to the standard, and by unscrewing two of the steadying arms of the base it can be taken through a space sufficiently wide for a man to pass.


The Oldbury "Paragon" Pipe Standard.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Nov. 15 to 21, with the ports of destination:—

*Africa.*—Delagoa Bay, £713 (including £627 telegraph material); Durban, £1,953 (including £465 telegraph material); East London, £150 (telegraph material); Port Elizabeth, £36. *Argentina*—Buenos Ayres, £4,510 (including £27 telegraph material); Rosario, £705 (telegraph material). *Australasia*—Adelaide, £25; Fremantle, £482; Launceston, £47; Lyttelton, £16; Melbourne, £452 (including £350 telegraph material); Otago, £38; Perth, £862; Rockhampton, £157; Sydney, £460. *Belgium*—Brussels, £45; Ostend, £88. *Burma*—Rangoon, £26. *Canada*—Montreal, £50. *Ceylon*—Colombo, £18 (telegraph material). *Channel Islands*, £60. *China*—Shanghai, £591. *Denmark*—Copenhagen, £240 (telegraph material). *France*—Bordeaux, £20; Paris, £25. *Germany*—Bremen, £20. *Gibraltar*, £101 (including £90 telegraph material). *Holland*—Amsterdam, £607 (including £24 telegraph material); Flushing, £20; Rotterdam, £35. *Hong Kong*, £1,543 (including £1,302 telegraph cable). *India*—Bombay, £817; Calcutta, £2,912 (including £21 telegraph material). *Japan*—Kobe, £2,789; Nagasaki, £84; Yokohama, £945. *Java*—Batavia, £55. *North Atlantic*, £660 (telegraph material). *Russia*—Kure, £304; Riga, £12. *Siam*—Bangkok, £29. *Spain*—Bilbao, £305. *Straits Settlements*—Penang, £20; Singapore, £229. *Surinam*, £70. *Sweden*—Stockholm, £48 (including £22 telegraph material). *United States*—New Plymouth, £627. *Uruguay*—Monte Video, £27 (telegraph material). Total, £24,028, against £16,295 in the corresponding week last year (Nov. 16 to 22).

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

Note.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specification. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

October 14, 1905.

20,805 Entwistle & Entwistle. Trolley poles of electric vehicles.

20,814 Kean, Spiers & Kelvin & James White. Mariner's compass.

October 16, 1905.

20,893 Brooke. Holders for incandescent lamps and other electric fittings.

20,898 Rüber. Electrolytic apparatus. (Date applied for, Oct. 15, 1904.)*†

20,933 Nussbaum. Microphones.

20,950 and 20,951 Otis Elevator Co. (Otis Elevator Co., U.S.) Electric elevator control systems.*

20,960 Quertier. Non-reversing two-way running trolley pole.*

20,972 Mills. (Maschinen & Dampfkesselfabrik Guilleaume Werke G.m.b.H., Germany.) Automatic smoke-consuming apparatus.

20,974 Quertier. Apparatus for clearing the rails of tramways.*

20,990 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.

October 17, 1905.

20,995 Cowper-Coles. Vessels for fused salts during electrolysis.

21,020 Heinze. Rotary-current interrupters.*

21,034 Arnold & La Cour. Single-phase alternating-current motor with commutating poles. (Date applied for, Oct. 17, 1904.)*†

21,038 McNulta. Electrical transmission of power on motor vehicles and boats. (Date applied for, Dec. 10, 1904.)*†

21,064 B.T.-H. Co., Meyer & Mossay. Alternating-current motors.

21,068 Siemens Bros. & Co. & Lydall. Apparatus for controlling electric trains.*

21,070 E.-A.-G. vorm. W. Lahmeyer & Co. Polyphase alternate-current commutator machines. Date applied for, Oct. 17, 1904.)*†

21,071 Knight & Nagel. Improvements in and relating to conduits or casings for electric conductors.

October 18, 1905.

21,108 Marr & Chalmers. Non-slipping device for steam and electric traction engines.

21,145 Von Ammon. Conveying electric currents.

21,162 Bumiller. Telephone receivers and the like.*

21,165 Bateman. Tramway rails.

21,173 Nicholson. Electrically igniting the charges in internal-combustion engines.*

21,181 Varley. Electrical measuring instruments.*

21,198 Mawdsley & Burleigh. Pole-pieces of dynamo-electric machines.

October 19, 1905.

21,202 Veritys Limited & Thorpe. Electric light fittings*

21,204 Tierney & Malone. Moving electrically points on electric tramways and railways.

21,223 Brown, Brown & Whelan. Electric stop motions.

21,224 Simplex Steel Conduit Co., Huggins & Waterhouse. Conduits for electric cables.

21,243 Marter. Composition for insulation purposes.

21,248 Pellorce. Electric machine for use in automobiles.

21,258 Richardson. Dynamo-metric governors.

21,259 Chilton & Brush Electrical Engineering Co. Throttle valves for governing steam turbines, &c.

21,260 Snow. Switch stands. (Date applied for, Dec. 15, 1904.)*†

21,261 Ruddick & Fry. Arc-lamp suspender.

21,263 Lentz. Steam and gas turbines.*

21,264 Dakhyl, Galanti & Dakhyl. Construction of secondary batteries.

21,268 De Saint-Romain. Magneto-electric apparatus for igniting charge in internal-combustion motors. (Date applied for, April 27, 1905.)*†

21,279 Fippard. Batteries.

21,289 Moffat, Bott, Manley & Electric Safety Appliances Co. Indicating and obviating leakage from conductors of electricity.

October 21, 1905.

21,386 Venner. Vapour electric lamps.

21,391 Swinburne. Electro-deposition of zinc.

21,398 Bowring. Lifeguards for tramcars.

21,437 Kother. Electrodes for the manufacture of bleaching liquor*

21,439 B.T.-H. Co. & Wedmore. Switches.

October 23, 1905.

21,466 Moul. Carbon holder for arc lamps.

21,470 Skwirsky. Thermo cutout.

21,474 Edmonds, Edmonds & Edmonds. Electric ignition for gas and oil engines.

21,478 Downes. Electrical terminals and connections.

21,485 Electric & Ordnance Accessories Co. & Hall. Electrical switches.

21,519 Cox. Supports for incandescent lamps.

21,523 Thompson & Bowden. Prepayment electricity meter.

21,533 and 21,534 Jungner. Manufacture of electrodes by continuously operating machines, and electrodes and accumulators thus manufactured. (Date applied for, June 10, 1905.)*†

21,535 Berglund. Insulation for accumulators with alkaline electrolyte. (Date applied for, March 15, 1905.)*†

21,565 Andrews. Telephonic apparatus.

October 24, 1905.

21,581 Collie. Trolley poles.

21,583 Bolton. Automatic starting resistance for motors.

21,615 Battersby. Accumulators.

21,617 Lambert. Automatic life guards for tramway cars.

21,641 and 21,642 Kritzler. Ignition devices for internal-combustion engines.*

21,643 Kritzler. Insulating the sparking plugs of internal-combustion engines.*

21,652 Lake. (International Holding Co., U.S.) Electric motors.

21,658 Védrine & de Quélen. Electric motors, dynamos, electromagnets, &c. (Date applied for, Oct. 25, 1904.)*†

21,659 Védrine & de Quélen. Electric road motor vehicles. (Date applied for, Oct. 26, 1904.)*†

21,661 Lebiedzinski. Sound boxes for phonographs, telephones and the like.*

21,672 Allgemeine Elektricitäts-Gesellschaft. Electricity meters. (Date applied for, Oct. 28, 1904.)*†

21,673 Peckham. Trucks for tramway, railway or like vehicles.*

21,674 Warwick Machinery Co. (G.E. Co., U.S.) Turbines.

21,675 B.T.-H. Co. (G.E. Co., U.S.) Systems of electric motor control.

21,681 Hatfield & Lewis. Electric shunts.

## SPECIFICATIONS PUBLISHED.

These may be obtained at the Sales Department of the Patent Office, Quality-court, Chancery-lane, London, W.C., at a uniform price of 8d.

### PUBLISHED NOVEMBER 2, 1905.

### 1904 Specifications.

17,220 Union Electricitäts Ges. Starting and controlling alternating-current commutator motors. (Date applied for, Aug. 8, 1903.)
21,562 Koopman. (Townsend.) Electrolytic production of white lead.
21,684 Union Electricitäts Ges. Alternating-current repulsion motors. (Date applied for, Oct. 9, 1903.)
21,889 Lindström. Alternating-current generators. (Date applied for, Oct. 16, 1903.)
22,401 Jewell. Automatic signalling apparatus for electric tramways.
22,832 Tangye Tool & Electric Co. & Bate. Automatically-operating electric motor starters.
23,765 Rudenick. Insulating material for electrotechnical purposes.
24,915 Highfield. Insulating coils of high-tension electrical machinery.
25,041 Kneen. Trolley heads.
25,801 Electric & Ordnance Accessories Co., Hall & Garner. Reversing controllers.
25,817 James. Electrical incubator alarm.
26,172 B.T.-H. Co. (G.E. Co., U.S.) Electric switches and the like.
26,194 Torda. Dynamo-electric generators and motors.
26,475 McNeil. Electric fire alarms and thermo-indicators.
26,786 Hardingham. (Felten & Guilleaume Carlswerk Act.-Ges.) Rendering insulation fireproof.
26,759 Dear. Holders and contacts for electric incandescent lamps.
26,906 Dick & Reason Mfg. Co. Electric demand indicators.
27,100 Mavor & Coulson & Mavor. Electric motor apparatus.
27,479 Andrew & Johns. Inverted arc lamps.
28,678 Reed & Craven Bros. Electric cranes and other lifting machinery.

### 1905 Specifications.

402 B.T.-H. Co. (G.E. Co., U.S.) Fusible cut-outs.
883 Jones. Electric ignition for gas and oil engines.
2,491 B.T.-H. Co. (G.E. Co., U.S.) Thermal electric cut-outs.
2,894 Hirst & Bevis. Electric lampholder with locking device.
3,177 Geipel & Lange. Control of electric motors.
4,131 Whalley. Telephone cables.
4,166 Bines. Telephone apparatus.
4,167 Bines. Induction coils.
4,167a Bines. Telephone systems. (Date applied for, Feb. 28, 1905.)
7,617 Frecheite. Switches.
11,442 Hartmann & Braun Akt.-Ges. Bobbins for electrical measuring instruments. (Date applied for, June 16, 1904.)†
11,770 Agaggio. Electrical bells on high-tension circuits.
13,682 Siemens Bros. & Co. (Siemens & Halske Act.-Ges.) Electrical condensers.
14,209 Siemens Bros. & Co. (Siemens Schuckertwerke G.m.b.H.) Supplying electrical energy to a network by an auxiliary-current generator and auxiliary line wire.

# COMPANIES' MEETINGS AND REPORTS.

◆

## West India & Panama Telegraph Co. (Ltd.)

The fifty-seventh ordinary general meeting was held on Wednesday Mr. W. B. Kingsford presiding.

The MANAGER and SECRETARY (Mr. R. T. Brown) read the notice convening the meeting, and the auditors' report.

The CHAIRMAN: You will have seen that, as compared with the corresponding period of last year, our receipts show a decrease of £1,808. Of this decrease message receipts are responsible for nearly £1,000, and subsidies for £750. As regards traffic, I am sorry I cannot report any increase in the volume of traffic handled by us; on the contrary, there was a falling off of over 29,000 words during the half-year under report. I am glad to say, however, that our traffic returns for the half-month which ended on the 15th inst. show an increase sufficiently large to counterbalance the decline for the current half-year mentioned in the report. This is attributable chiefly to the interruption of a cable belonging to the French company, their messages having been handed to us for transmission over our cables. The decrease of £750 in the subsidies is accounted for by the reduction of the British Guiana subsidy from £4,500 to £3,000 per annum, which came into force on April 1 last, and by certain deductions on account of interruptions. I may mention that £3,000 was the original amount of the British Guiana subsidy. Subsequently it was increased to £4,500, and when we laid a new cable between British Guiana and Trinidad this increased subsidy was granted to us for a fixed period of 10 years. That period expired on Dec. 31, 1901, but the increased subsidy continued to be paid to us until the end of last March, from which date we were notified that the present reduction would be made. There has been a total decrease in the expenses of £208, due to several small items. In the cost of maintaining the cables, there is a reduction of £176. We have not yet succeeded in completing the repair of the Colon cable. The "Henry Holmes" repaired one break close to Colon, and was just going to begin operations on another break in that cable, but they, unfortunately, had to be suspended owing to her services being required elsewhere. In connection with this, I regret to report that, during the current half-year, we have experienced some of those unlucky and unpreventable occurrences from which we so often suffer. In September last a Norwegian steamer was driven ashore at Santiago de Cuba, and her keel severed one of our cables there, and accordingly it was thought desirable to withdraw our repairing steamer from her work on the Colon cable in order to repair this break, which, being close to shore, could be done expeditiously. The ship will resume operations on the Colon cable as soon as it is possible to do so. In October our cable hut at Holland Bay, Jamaica, was destroyed by floods, and the cables connected up in the hut were all washed out. Thanks, however, to the energy of our clerk-in-charge at that station, who succeeded in disentangling the cables from the débris, and in joining them up on the beach, there was little or no interruption of communication. The ship's crew has now built a new cable hut, and put the cables again into thoroughly good order, and made everything secure. Unfortunate occurrences such as these, which, in one form or another, happen, as you know, very frequently, and are of course absolutely beyond the Company's control, are some of the many adverse conditions which render the maintenance of our cables—our 26 cables—in West Indian waters a very anxious task, and also one of costliness and difficulty. Everybody connected with the West Indies expected, and, I think, not unreasonably expected, that, with the abolition of the continental sugar bounties, the sugar industry of the West Indies would considerably improve. It appears, however, and a most disappointing thing it is, that the present price of sugar is actually below the cost of production, and, therefore, until prices substantially improve, it is clear that the position of sugar producers generally must be far from satisfactory. As a matter of course, this state of things has had an injurious effect on our own business, and probably accounts to some extent for the falling off to which I have already referred. I have laid before you this morning an unusually brief statement. I wish I could have made it fuller and more interesting, but the half-year under report was an uneventful one, and thus no other point occurs to me with which I could profitably occupy your time. I now move the adoption of the report and accounts.

Mr. HENRY HOLMES seconded the resolution.

Mr. THORP inquired whether it was proposed to restore their cable communication with Martinique?

Mr. R. T. BROWN said the Chairman would perhaps allow him to answer the question. Seeing that St. Pierre no longer existed, and that, consequently, there was hardly any business at Martinique, it was not worth while renewing the cables which were partly destroyed by the eruption of Mont Pelé and running them into that island. What they did contemplate doing at the earliest convenient opportunity was to join up the Dominica–Martinique and Martinique–St. Lucia cables into one section. They would then still be able to maintain communication with Martinique, not by their own line, but by the French company's line at Guadeloupe.

The resolution was then carried unanimously.

A vote of thanks to the chairman and directors terminated the proceedings.

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**CAPE ELECTRIC TRAMWAYS (LTD.)**—For the year ended June 30 the profit, after providing for interest and redemption of debentures, was £33,550. 3s. 2d., added to £792. 16s. 6d. from last year, making £34,342. 19s. 8d. Out of this sum 5 per cent. has been paid in two interim dividends. The reserve has been credited with £8,000. During the year the tramways in Cape Town carried 15,020,503 passengers, earning £180,905. 15s. 7d., against 15,902,998 passengers and £195,015. 11s. 7d. in 1903-1904. In Port Elizabeth 4,227,576 passengers were carried, earning £46,708. 10s. 9d., against 4,509,786 passengers and £50,157. 2s. 6d. In regard to the decrease in gross revenue of £17,558. 7s. 9d., this is attributed to the unsatisfactory conditions which have weighed upon and still depress the entire business situation in Cape Town, Port Elizabeth and the Cape Colony generally, and as to which no improvement seems apparent. In Oct., 1904, Mr. Wm. B. Rommel was appointed managing director. Mr. J. E. Lloyd, general manager in Cape Town, resigned his position at the end of last year, and Mr. Alfred S. Giles, late manager of Blackburn Corporation Tramways was appointed to succeed him. Mr. Giles took up his duties in January last. The Camps Bay tramway, leased from Cape Town Consolidated Tramways and Land Co., has again proved a disappointment, and the year's working shows a loss of £13,225. 9s. 9d., but against this must be set the considerable revenue derived by the Cape Town system through the operation of the Camps Bay tramways. During the past session of the Cape Parliament a bill was passed authorising the expropriation of the Sea Point railway, the property of this company, which was acquired in 1900. The amount to be paid as compensation for expropriation is to be settled by arbitration.

**DRAKE & GORHAM (LTD.)**—At the meeting on Thursday last week the chairman (Mr. B. M. Drake), in moving the adoption of the report (given in our issue of 10th inst.) said the net profit for the year was £10,821. Although those figures would have justified a larger dividend than the 6 per cent. recommended, the directors thought it wiser not to pay more at present, notwithstanding the fact that the company was now doing more business than ever. They wished to place £3,000 to reserve and to carry forward £2,044. The directors had decided that certain members of the staff, holding responsible positions, should become members of the firm. The motion was seconded by Mr. J. H. Gorham and carried unananimously. At an extraordinary meeting afterwards a resolution was approved that the directors be paid all out-of-pocket expenses in connection with board meetings.

**ELECTRIC TRACTION CO. OF HONGKONG (LTD.)**—At the meeting on Thursday last the directors' report and accounts were adopted.

**LANCASTER & DISTRICT TRAMWAYS CO.**—At the meeting on Saturday the chairman (Mr. A. Bell) said Messrs. Kershaw, a Birmingham firm, had offered to buy the company's undertaking for £45,000, but the proposal could not at present be accepted, owing to the Corporation's refusal to waive their right to acquire the system. Negotiations are still proceeding. He hoped that before long the line between Morecambe and Lancaster would be converted to electric traction.

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. | | |
|---|---|---|---|---|---|---|
| | | | | No. of weeks. | Amount. | Inc. or Dec. (a) |
| | | £ | £ | | £ | £ |
| Aberdeen Corporation | Nov. 18 | 1,166 | + 12 | 25 | 86,513 | − 1,537 |
| Airdrie | " 10 | 210 | + 5 | 45 | 9,261 | + 130 |
| Anglo-Argentine | " 18 | 14,571 | + 1,105 | 45 | 614,963 | + 39,134 |
| Ayr Corporation | " 18 | 176 | − 5 | 27 | 9,641 | − 141 |
| Barcelona Trams Co. | ... | ... | ... | ... | ... | ... |
| Barcelona, Ensanche, Gracia | ... | ... | ... | ... | ... | ... |
| Barnsley | " 10 | 151 | − 8 | 45 | 7,260 | − 326 |
| *Barrow | " 10 | 209 | + 6 | 45 | 10,952 | + 2,152 |
| Bath Electric Trams, Ltd. | " 15 | 632 | + 37 | 46 | 31,658 | + 1,957 |
| Birkenhead | " 19 | 898 | − 49 | 7 | 6,694 | − 262 |
| Birmingham Corporation | " 18 | 890 | + 70 | 33 | 11,984 | + 1,452 |
| *Birmingham & Mid. | " 10 | 1,344 | − 189 | 45 | 71,694 | + 91 |
| Blackpool Corporation | " 16 | 304 | − 49 | 20 | 43,571 | + 1,788 |
| Blackpool and Fleetwood | " 18 | 168 | − 26 | 20 | 19,196 | − 1,058 |
| Bolton Corporation | " 19 | 1,790 | + 107 | 34 | 65,846 | + 2,475 |
| Bournemouth Corporation | " 15 | 1,203 | + 336 | †32 | 47,724 | + 9,021 |
| Bradford Corporation | " 18 | 3,932 | + 216 | 33 | 147,503 | − 6,968 |
| Brighton Corporation | " 19 | 722 | − 72 | 34 | 86,044 | + 382 |
| Bristol Trams & Carriage | " 17 | 4,579 | − 52 | 15 | 74,599 | + 859 |
| Buenos Ayres & Belgrano | " 19 | 3,518 | − 142 | 46 | 159,669 | + 7,723 |
| Buenos Ayres Elec. Trams | Oct. 21 | 1,270 | ... | 42 | 48,820 | ... |
| Burnley Corporation | Nov. 18 | 988 | − 17 | 33 | 47,158 | + 2,083 |
| Burton Corporation | " 19 | 262 | − 7 | §33 | 10,678 | − 1,338 |
| Bury Corporation | " 12 | 677 | ... | §32 | 28,982 | ... |
| Calcutta Tramways Co. | " 18 | R16,074 | + R8,282 | 20 | R555,623 | + 110,673 |
| Camborne-Redruth | " 18 | 102 | + 1 | 3 | 306 | − 38 |
| Cardiff Corporation | " 11 | 1,904 | − 97 | 33 | 69,425 | + 132 |
| | " 18 | 1,729 | − 2 | | | |
| Carlisle Tramways Co. | " 18 | 149 | − 27 | 46 | 8,502 | − 603 |
| Central London Railway | " 18 | 7,215 | + 158 | 20 | 123,978 | − 910 |
| Chatham & Dist. Lt. Rys. | " 16 | 569 | + 73 | 46 | 80,444 | + 3,221 |
| *City of Birm'gh'm Tram Co | " 10 | 5,076 | − 489 | 45 | 242,121 | + 420 |
| City & South London Rly. | " 19 | 3,095 | + 132 | 20 | 50,545 | + 281 |
| Colchester Corporation | " 16 | 146 | − 28 | 16 | 8,322 | − 1,488 |
| Cork Electric Trams Co. | " 16 | 401 | − 28 | 46 | 22,376 | + 630 |
| Devonport & Dist. Trams | " 10 | 481 | − 44 | 45 | 20,887 | − 3,177 |
| Dover Corporation | " 18 | 176 | + 18 | 33 | 7,802 | − 88 |
| Dublin & Lucan Railway | " 17 | 97 | + 1 | 20 | 2,627 | − 20 |
| Dublin Southern District | " 17 | 796 | − 46 | 20 | 103,202 | − 1,122 |
| Dublin United | " 17 | 3,778 | + 72 | | | |
| Dudley—Stourbridge | " 10 | 771 | − 4 | 45 | 40,635 | + 1,359 |
| Dundee Corporation | " 15 | 895 | + 78 | §26 | 24,193 | + 1,276 |
| East Ham Council | " 18 | 741 | + 159 | 33 | 27,837 | + 3,012 |
| Gateshead & Dist. Trams | " 10 | 922 | − 2 | 45 | 41,547 | + 795 |
| Glasgow Corporation | " 18 | 14,548 | + 76 | 25 | 877,183 | + 17,852 |
| Glossop | ... | ... | ... | ... | ... | ... |
| Gloucester Corporation | " 15 | 239 | + 17 | 33 | 10,244 | ... |
| Gravesend—Northfleet | " 10 | 206 | − 1 | 45 | 10,520 | − 942 |
| Gt. Northern & City Rly. | " 18 | 1,783 | + 318 | 20 | 80,531 | + 7,098 |
| Greenock & Port Glasgow | " 10 | 654 | + 74 | 45 | 29,190 | + 3,134 |
| Halifax Corporation | ... | ... | ... | ... | ... | ... |
| Hartlepool Tramways | " 10 | 244 | − 4 | 45 | 12,058 | − 1,204 |
| Hastings Elec. Trams Co. | " 16 | 816 | ... | 15 | 8,665 | ... |
| Huddersfield | " 18 | 1,811 | + 129 | 33 | 45,604 | + 1,529 |
| Hull Corporation | " 18 | 2,101 | + 61 | 33 | 74,024 | + 565 |
| Ilford Dist. Coun. | " 18 | 358 | + 52 | 33 | 16,263 | + 324 |
| Ipswich Corporation | " 18 | 324 | − 4 | 33 | 15,147 | − 1,856 |
| Isle of Thanet Co. | " 18 | 251 | − 20 | 7 | 2,155 | − 464 |
| Kidderminster & District | " 10 | 93 | − 11 | 45 | 5,642 | − 321 |
| Kilmarnock Corporation | ... | ... | ... | ... | ... | ... |
| Kirkcaldy Corporation | " 16 | 198 | − 14 | 11 | 2,250 | − 78 |
| Lanarkshire Trams Co. | " 16 | 794 | + 137 | 46 | 34,447 | + 4,232 |
| Leamington | " 10 | 119 | + 26 | 17 | 3,387 | + 1,244 |
| Leeds Corporation | " 18 | 5,852 | + 261 | 33 | 202,657 | + 4,090 |
| Leicester Corporation | " 18 | 1,967 | + 121 | 46 | 95,616 | + 28,942 |
| Liverpool Corporation | " 11 | 10,848 | + 6 | 45 | 476,599 | + 8,834 |
| Liverpool Overhead Rly. | " 19 | 1,326 | − 113 | 20 | 31,989 | − 1,442 |
| *London County Council | " 11 | 18,671 | + 834 | 32 | 483,288 | + 67,421 |
| Lowestoft | " 18 | 141 | − 1 | 7 | 1,123 | − 81 |
| Maidstone Corporation | " 16 | 85 | − 23 | 33 | 4,400 | ... |
| Manchester Corporation | " 18 | 12,025 | + 346 | 33 | 430,468 | + 17,016 |
| Mersey Railway | " 18 | 1,655 | + 82 | 20 | 31,361 | + 1,917 |
| Merthyr | " 10 | 182 | − 18 | 45 | 8,577 | − 471 |
| *Metropolitan Elec. Trams | " 10 | 2,517 | + 775 | 45 | 120,577 | + 51,916 |
| Middleton | " 10 | 287 | + 13 | 45 | 15,393 | + 627 |
| Musselburgh | " 9 | 132 | ... | 47 | 10,651 | ... |
| Nelson Corporation | " 18 | 119 | + 10 | 34 | 4,520 | + 416 |
| Newcastle-on-Tyne Corp. | " 18 | 2,973 | − 619 | 33 | 126,948 | + 2,983 |
| Newport (Mon.) | " 18 | 498 | − 1 | 7 | 3,749 | + 269 |
| Northampton Corporation | " 17 | 854 | + 13 | 32 | 13,976 | + 4,789 |
| Oldham, Ashton & Hyde | " 10 | 550 | + 28 | 45 | 25,210 | + 581 |
| Oldham Corporation | " 19 | 1,542 | + 229 | 34 | 56,228 | + 14,787 |
| Perth (W. A.) Elec. Trams. | " 17 | 1,896 | + 8 | 46 | 63,063 | + 3,667 |
| Peterborough | " 10 | 102 | − 15 | 45 | 6,197 | − 655 |
| Pontypridd Dist. Council | " 18 | 139 | ... | 33 | 5,477 | ... |
| Portsmouth Corporation | " 18 | 1,390 | − 72 | 33 | 70,099 | + 928 |
| Potteries | " 10 | 1,773 | − 46 | 45 | 76,871 | + 526 |
| Preston Corporation | " 15 | 588 | ... | 7 | 4,212 | ... |
| Reading Corporation | " 16 | 580 | + 13 | 7 | 4,040 | − 252 |
| Rotherham Corporation | " 16 | 438 | + 19 | 33 | 15,200 | − 666 |
| Rothesay | " 10 | 45 | + 11 | 45 | 9,384 | + 2,664 |
| Salford Corporation | " 20 | 3,831 | + 103 | 34 | 148,892 | + 7,077 |
| Sheerness | " 8 | 52 | − 8 | 45 | 3,200 | + 290 |
| Sheffield Corporation | " 19 | 4,632 | + 229 | 34 | 168,142 | + 7,575 |
| Southampton Corporation | " 15 | 852 | − 86 | †7 | 5,775 | − 486 |
| Southend Corporation | " 15 | 230 | + 9 | 33 | 13,817 | + 656 |
| Southport Tramways | " 10 | 236 | + 1 | 45 | 14,295 | − 511 |
| S. Staffordshire Trams. | " 10 | 734 | + 44 | 45 | 33,237 | + 1,222 |
| Stockport Corporation | " 17 | 737 | + 277 | 33 | 25,434 | + 5,735 |
| Swansea Trams | " 10 | 779 | + 318 | 45 | 32,563 | + 8,106 |
| Swindon Corporation | " 15 | 175 | ... | 33 | 6,676 | ... |
| Taunton | " 10 | 20 | − 18 | 45 | 1,890 | − 247 |
| Tynemouth and District | " 10 | 166 | − 27 | 45 | 11,883 | − 1,588 |
| Tyneside Trams Co. | " 15 | 351 | + 7 | 46 | 19,118 | + 1,048 |
| Wallasey District Council | " 18 | 674 | + 28 | 33 | 26,559 | + 711 |
| Walsall | " 18 | 491 | + 41 | 45 | 22,614 | + 820 |
| Warrington Corporation | ... | ... | ... | ... | ... | ... |
| West Ham Corporation | " 16 | 1,814 | + 806 | 33 | 59,556 | + 25,036 |
| Weston-super-Mare | " 8 | 81 | − 9 | 45 | 6,676 | + 607 |
| Wolverhampton Corpn. | " 15 | 759 | ... | 7 | 5,316 | ... |
| Wolverhampton District | " 10 | 864 | − 11 | 45 | 17,871 | + 197 |
| *Worcester | " 10 | 241 | − 38 | 45 | 13,816 | + 434 |
| Wrexham | " 10 | 88 | + 4 | 45 | 4,571 | − 381 |
| Yorkshire W.R. Trams | " 19 | 612 | + 201 | 46 | 82,936 | ... |
| Yorkshire Woollen District | " 10 | 791 | + 210 | 45 | 29,775 | + 3,553 |

(a) These comparisons are with the corresponding period last year. † Minus 8 days. § Plus 2 days. * Partly electrical.

## CITY NOTES.

**MEMORANDA** (Nov. 23).—Bank rate 4 per cent. (since Sept. 28, 1905) Price of silver $29\frac{13}{16}$d. per oz. Consols $88\frac{1}{16}$—$88\frac{3}{16}$ for money, $89\frac{1}{8}$—$89\frac{3}{4}$ for account; $2\frac{1}{2}$ per cent. annuities 88—$88\frac{1}{4}$. Consols Pay Day, Dec. 1; Stocks and Shares Continuation Day, Nov. 28; Ticket Day, Nov. 29; Pay Day, Nov. 30; Mining Share Carry-over Day, Nov. 27.

**KENT ELECTRIC POWER CO.**—34,250 $4\frac{1}{2}$ per cent. irredeemable debenture stock of this company has been offered for sale during the week at $92\frac{1}{2}$ per cent.

**NATIONAL TELEPHONE CO. (LTD.)**—The directors have decided to offer at par to the holders of the preferred and deferred stock the remaining 90,000 unissued £5 ordinary shares in equal shares.

**RENO ELECTRIC STAIRWAYS & CONVEYORS (LTD.)**—After paying debenture interest the accounts of this company show a debit of £2,400.

**SOUTH LANCASHIRE ELECTRIC TRAMWAYS.**—The Hon. Arthur Stanley, M.P., and other debenture-holders of the South Lancashire Electric Traction & Power Co. have completed the purchase of the company's electric tramway system at £150,000. Mr. Stanley proposes to form a new company to take over the undertaking.

**STOCK EXCHANGE NOTICES.**—The Stock Exchange committee have granted quotations to 10,000 £5, fully paid, 6 per cent. cumulative preference shares of the *Adelaide Electric Supply Co. (Ltd.)*; a further issue of £35,900 £100 5 per cent. debentures of the *Amazon Telegraph Co. (Ltd.)*, and £50,000 5 per cent. first mortgage debenture stock of the *Anglo-Portuguese Telephone Co. (Ltd.)*.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Nov. 22. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Nov. 22. | |
|---|---|---|---|---|---|---|---|
| | | | | | | Highest. | Lowest. |
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | £ s. d. | | | |
| 5 | 8/0 | Anglo-Argentine Ord. Shares | $8\frac{5}{8}$—$8\frac{7}{8}$ | 4 10 5 | Ap, Oct | $8\frac{11}{16}$ | .. |
| 5 | 2/9 | Do. $5\frac{1}{2}$% Cum. Pref. | $5\frac{7}{8}$—$6\frac{1}{8}$ | 4 9 8 | — | $6\frac{1}{16}$ | $6\frac{1}{32}$ |
| St. | 6% | Do. Permanent 6% Deb. Stock | 142 —145 | 4 2 8 | — | $144\frac{1}{2}$ | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 105 —107 | 4 13 5 | — | $106\frac{1}{2}$ | .. |
| 10 | 12/0 | Barcelona Tramways Ord. | $13\frac{3}{4}$—$14\frac{1}{4}$ | 4 4 0 | — | .. | .. |
| 10 | 5/0 | Do. 5% Cum. Pref. | $9\frac{1}{2}$—10 | 5 0 0 | — | .. | .. |
| St. | $4\frac{1}{2}$% | Do. $4\frac{1}{2}$% Deb. Stock (red.) | 97 —102 | 4 8 8 | — | .. | .. |
| 100 | 5% | Do. 5 per Cent. Debs. | 93 —101 | 4 19 0 | — | .. | .. |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1 —$1\frac{1}{2}$ | .. | .. | $1\frac{3}{16}$ | $1\frac{5}{32}$ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 4 —$4\frac{1}{2}$ | 5 18 3 | — | $4\frac{3}{16}$ | $4\frac{1}{16}$ |
| St. | $4\frac{1}{2}$% | Do. $4\frac{1}{2}$ per Cent. Db. Prov. Cts. | 95 —98 | 4 12 0 | — | .. | .. |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 124 —127 | 4 14 6 | — | 125 | .. |
| St. | 5% | Do. Pref. Ord. Stock | 113 —116 | 4 7 9 | — | .. | .. |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock. | 103 —109 | 4 11 8 | — | .. | .. |
| 4 | $4\frac{1}{2}$% | Do. $4\frac{1}{2}$ per Cent. 1st Mort. Dbs. | 103%—105% | 4 5 9 | — | .. | — |
| 100 | $4\frac{1}{2}$% | Do. Vancouver Power Debs. | 102 —105 | 4 5 9 | — | .. | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | $3\frac{1}{4}$—$3\frac{3}{4}$ | 5 6 8 | — | $3\frac{11}{16}$ | $3\frac{5}{8}$ |
| 5 | 3/0 | Do. 6 per Cent. "A" Cm. Pref | $5\frac{11}{16}$—$5\frac{15}{16}$ | 5 2 0 | — | $5\frac{13}{16}$ | .. |
| 5 | 3/0 | Do. "B" | 6 —$6\frac{1}{2}$ | 5 9 1 | — | $6\frac{1}{16}$ | $6\frac{5}{32}$ |
| St. | 5% | Do. 5 per Cent. Debs. | 107 —109 | 4 11 8 | — | 107 | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102 —105 | 4 16 8 | — | .. | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 98 —100 | 5 0 0 | .. | .. | .. |
| 100 | $5\frac{1}{2}$% | Buenos Ayres Grand National $5\frac{1}{2}$% Pref. Debs. | 101 —105 | 5 4 9 | .. | .. | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 101 —108 | 5 11 1 | .. | .. | .. |
| 5 | 8/6 | Calcutta Tramways (Nos. 1 to 105) | $9\frac{1}{4}$—$9\frac{3}{4}$ | 4 7 2 | — | $9\frac{9}{16}$ | $9\frac{1}{2}$ |
| 5 | 0/3 | Do. Nos. 105,001 to 137,610 | $8\frac{1}{2}$—9 | .. | .. | $8\frac{5}{8}$ | .. |
| 100 | $4\frac{1}{2}$% | Do. $4\frac{1}{2}$% 1st Deb. Stock (red.) | 107 —109 | 4 2 7 | — | .. | .. |
| 1 | 0/6 | Cape Electric Tram Shares | $\frac{7}{8}$—$1\frac{1}{8}$ | 4 8 10 | — | 1 | .. |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 101 —103 | 4 17 2 | — | 102 | .. |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 97 —99% | .. | .. | $98\frac{1}{2}$ | $98\frac{1}{4}$ |
| 1 | .. | Lisbon Elec. Trams Ord. | $1\frac{5}{16}$—$1\frac{3}{8}$ | .. | .. | .. | .. |
| 1 | $0/7\frac{1}{2}$ | Do. 6% Cum. Pref. | $1\frac{1}{8}$—$1\frac{1}{4}$ | 4 13 0 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 101 —104 | 4 16 3 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 103 —105 | 4 15 3 | Ja, Jul | $103\frac{1}{2}$ | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101 —104 | 4 16 2 | — | .. | .. |
| 100 | $4\frac{1}{2}$% | Do. Sterling $4\frac{1}{2}$% Debs. (1922) | 102 —104 | 4 6 7 | — | — | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 104 —107 | 4 13 5 | .. | 106 | $105\frac{1}{2}$ |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 144 —147 | 5 8 9 | .. | .. | .. |
| .. | .. | Do. 5% 1st Mt. $500 Dbs. | 99 —101 | .. | .. | $100\frac{1}{4}$ | .. |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | — | Adelaide Elec. S'ply Co. 6% Cu. Pr. | 5 —$5\frac{1}{2}$ | — | .. | .. | .. |
| 5 | 3/3 | †Calcutta Elec. (1-50,000) | 9 —$9\frac{1}{2}$ | 4 4 2 | — | $9\frac{3}{8}$ | .. |
| 5 | 2/3 | † Do. (60,001-80,000) | 9 - $9\frac{1}{2}$ | 4 14 9 | .. | $9\frac{1}{8}$ | 9 |
| 100 | 5% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50 —52 | 4 16 1 | .. | $50\frac{1}{2}$ | .. |
| .. | .. | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 6% Bds. | 96 —98 | .. | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | $2\frac{1}{2}$—3 | .. | .. | .. | — |
| St. | 5% | Do. 5% Debs. | 85 —90 | 5 11 1 | — | .. | — |
| 10 | .. | Havana Electricity Co. Shares | 9 —10 | — | — | .. | .. |
| 100 | 15/6 | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 94 —96 | 5 4 2 | .. | $95\frac{1}{2}$ | .. |
| St. | .. | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. 50% pd. | 60 —62 | .. | .. | $61\frac{1}{4}$ | .. |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | $1\frac{5}{8}$—$1\frac{11}{16}$ | 5 18 0 | — | .. | — |
| 1 | 1/0 | Rand Electric | $1\frac{1}{4}$—$1\frac{3}{8}$ | .. | — | .. | — |
| 1 | .. | River Plate Electricity Co. Ord. | $\frac{5}{8}$—$\frac{3}{4}$ | .. | .. | .. | .. |
| 1 | $1/2\frac{2}{5}$ | Do. 6% Non. Cum. Pref | $1\frac{5}{8}$—$1\frac{11}{16}$ | .. | .. | .. | .. |
| St. | 5% | Do. 5% Deb. Stock | 103 —105 | 4 15 0 | .. | .. | .. |
| 5 | 8/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | $5\frac{1}{4}$—$5\frac{3}{4}$ | 5 4 4 | .. | .. | .. |
| 5 | 3·23d | Do. (12,001-20,000) | 5 —$5\frac{1}{2}$ | 3 8 0 | .. | .. | .. |
| 100 | $4\frac{1}{2}$% | * Royal Elec., Montreal $4\frac{1}{2}$% 1st Mort. Deb | 100 —103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 10/9 | Shawinigan Water and Power 5% Bds., Scrip | 99 —101 | 4 19 0 | .. | $100\frac{1}{8}$ | $99\frac{3}{8}$ |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Share. | Last Dividend | Name. | Price Wed., Nov. 22. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Nov. 22. | |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | £ s. d. | | Highest. | Lowest. |
| 1 | .. | Bath Elec. Trams Pref. Ord. | 15/16—1 | .. | .. | 31/32 | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16—1 1/16 | 4 14 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) .. | 103 —106 | 4 5 9 | .. | 102½ | .. |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 104 —106 | 4 5 9 | .. | 105 | 104¾ |
| 10 | 9% | Bristol Tramways and Carriage Ord. ... | 17 —17½ | 5 2 11 | Feb, Aug | .. | — |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10 —10¼ | 3 18 0 | .. | .. | — |
| St. | 4% | Do. 4 per Cent. Debs. | 105 —107 | 3 14 10 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 9¾—10¼ | 5 17 0 | .. | 10⅛ | 9⅞ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 11 —11½ | 5 4 4 | Feb, Aug | 11 5/16 | 11 3/16 |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 121 —123 | 4 1 0 | .. | 122¼ | 121½ |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock.... | 98 —100 | 4 10 0 | .. | 99½ | 98⅞ |
| St. | 4% | Central London Ordinary Stock | 92 —94 | 4 5 1 | June, Dec | 94 | 93½ |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 106 —108 | 3 17 8 | .. | 102½ | .. |
| St. | 4% | Do. Deferred Stock | 85 —88 | 4 11 0 | .. | 87½ | 86 |
| 100 | 4% | Do. 4 per Cent. Debs.. | 110 —112 | 3 11 5 | .. | .. | .. |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 4⅞—5⅛ | 4 17 6 | .. | .. | — |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 100 —103 | 3 17 8 | .. | .. | .. |
| St. | 2% | City and South London Rly. Con. Ord. | 44 —46 | 4 2 6 | Feb, Aug | 45¾ | 44¾ |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) ... | 119 —122 | 4 2 0 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 117 —120 | 4 3 4 | .. | .. | .. |
| St. | 5% | Do. (1901) | 114 —117 | 4 5 6 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 105 —108 | 3 14 1 | May, Nov | .. | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13½—14½ | 4 2 8 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½—15½ | 3 17 8 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5¼—5¾ | 6 19 2 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8 —9 | 4 8 11 | .. | 8¾ | — |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 101 —103 | 4 7 6 | .. | 102¼ | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 17 —18 | 5 0 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 13¾—14¼ | 4 4 2 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 108 —110 | 4 1 10 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼—2¾ | 9 8 6 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 83 —88 | 4 10 11 | — | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8⅛—8⅜ | 3 18 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾—10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99 —102 | 3 19 3 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9¾—10¼ | 4 17 6 | — | 10⅛ | 10 |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 100 —103 | 3 17 8 | — | 101½ | 100½ |
| St. | .. | Mersey Con. Ord. Stock | 7 —9 | — | — | 7⅛ | 7 |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8 —11 | — | — | — | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32—9/32 | .. | — | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1 —1 1/16 | 4 14 1 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106 —108 | 4 3 8 | — | 107½ | 106 |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½—1½ | .. | May — .. | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾—9¼ | 5 5 8 | .. | .. | — |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9½—10 | 5 0 0 | Feb, Aug | .. | .. |
| St. | 4½% | † Do. 4½ per Cent. Deb. Stock | 101 —104 | 4 6 4 | — | .. | .. |
| 1 | — | South Lancs. Elec. Trac. & Power Ord. | .. | — | — | .. | .. |
| 1 | — | Do. 6% Pref. (£1 paid) | — | — | April, Oct | .. | — |
| St. | — | Do. 4½% Deb. Stock (100% paid) .... | .. | .. | Jan, July | — | — |
| 100 | .. | Sunderland Dist. Elec. Trams. 5% 1st Mort. Debs. | 95 —99 | .. | .. | .. | .. |
| .. | 5% | Underground Elec. Rys. Co. of London | 99½—100½ | 4 19 6 | .. | 99¾ | .. |
| St. | 3% | Waterloo and City Ord. | 94 —97 | 3 2 0 | June, Dec | 95 | 94½ |
| St. | 12/11 | Yorkshire W. R. Elec. Trams Co. 4% 1st Debs. | 96 —98 | 4 1 6 | .. | 96¾ | 95 |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | * African Direct Tel. 4% Mrt. Deb. (red.) | 99 —102 | 3 18 5 | Jan, July | .. | .. |
| 10 | — | Amazon Telegraph | 4 —4½ | .. | Jn, Dec .. | 4 1/16 | 4 1/32 |
| 100 | .. | Do. 5% Debs. (red.) | 85 —90 | 5 11 0 | .. | .. | .. |
| St. | 15/0 | Anglo-American | 62 —64 | 4 14 0 | F,My,Ag,N | 63 | .. |
| St. | 30/0 | Do. Preferred | 109½—110½ | 5 4 1 | F,My,Ag,N | 110 | 109½ |
| St. | 2/0 | Do. Deferred | 17⅝—17⅞ | .. | F,My,Ag,N | 18 1/16 | 17⅞ |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 96 —98 | 4 1 8 | Jn,Ap,Jy,O | 97⅛ | 96½ |
| 10 | 5/0 | Cuba Submarine Ord. | 8¾—9¼ | 5 8 8 | Feb, Aug | 9 1/16 | .. |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17 —18 | 5 11 2 | Feb, Aug | .. | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜—3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 9¼—9¾ | 5 2 6 | April, Oct | .. | .. |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 100%—103% | 4 7 5 | Jan, July | 102½ | .. |
| 20 | 8/0 | Direct United States Cable | 13¼—13¾ | 4 18 2 | Ja,Ap,Jy,O | 13⅜ | 13⅛ |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 100 —102 | 4 8 3 | Jn, Dec .. | .. | .. |
| St. | 25/0 | Eastern Ordinary | 144 —147 | 4 15 8 | Ja,Ap,Jy,O | 146 | 144 |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 89 —91 | 3 16 11 | Ja Ap,Jy,O | 90½ | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 106 —108 | 3 14 1 | May, Nov | 107 | .. |
| 10 | 2/6 | Eastern Extension | 14½—15 | 4 18 4 | Ja,Ap,Jy,O | 14⅞ | 14½ |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 106 —108 | 3 14 1 | Feb, Aug | 107½ | 107¼ |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 99 —101 | 3 19 2 | Feb, Aug | .. | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debr. (red.) | 99½%—101½% | 3 18 9 | May, Nov | .. | .. |
| 10 | 5/0 | G. N. (of Copenhagen) | 35 —36 | 6 17 6 | Jan, July | .. | .. |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 100 —102 | 4 8 3 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57 —59 | 5 10 0 | May, Nov | 58¼ | 57½ |
| 100 | $1 | Mackay Companies Common | 51 3/16 | 3 13 1 | Jan, July | .. | .. |
| 100 | 4% | Do. Preference | 74 3/16 | 5 7 9 | Ja,Ap,Jy,O | .. | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. .... | 1 5/16—1 7/16 | .. | .. | 1⅜ | — |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 100 —103 | 3 17 8 | June, Dec | .. | .. |
| 10 | 5/0 | West African Telegraph Shares | 10 —10½ | 4 15 3 | .. | .. | .. |
| 2½ | — | West Coast of America | 9/16—11/16 | .. | — | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100 —102 | 3 18 5 | Jan, July | .. | .. |
| 10 | — | West India and Panama | ½—¾ | .. | May, Nov | 9/16 | .. |
| 10 | 5/0 | Do. 6% 1st Pref. | 8½—9 | 6 13 4 | May, Nov | 8⅞ | 8½ |
| 10 | — | Do. 6 per Cent. 2nd Pref. | 6½—7½ | .. | May, Nov | .. | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 101 —104 | 4 16 2 | Jan, July | .. | .. |
| 10 | 5/0 | Western Telegraph ……xd & bonus | 14 —14½ | 4 16 7 | Mr,Jn,O,D | 14⅜ | 14⅛ |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 102 —104 | 4 16 0 | June, Dec | .. | — |
| St. | 4% | Do. 4% Deb. Stock (red.) | 103 —105 | 3 16 0 | .. | .. | .. |
| | | **TELEPHONES.** | | | | | |
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 101 —103 | .. | .. | .. | — |
| 5 | 5/0 | Chili Telephone (fully paid) | 7½—7¾ | 5 3 8 | August .. | 7⅝ | .. |
| 1 | 0/9¾ | Monte Video Telephone Ord. | 1 3/16—1 5/16 | 3 14 5 | — | .. | .. |
| 1 | 1/0 | Do. 6% Pref. | ⅞—1 | 5 0 0 | .. | .. | .. |
| St. | 6% | National Co. Pref. Stock | 111 —112 | 5 7 1 | — | 112¾ | 111⅞ |
| St. | 5% | Do. Def. Stock | 107 —109 | 4 11 8 | — | 109 | 107⅛ |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13 —15 | 4 0 0 | Feb, Aug | 14 | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 12 —13 | 4 12 4 | Feb, Aug | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅜—5⅞ | 4 5 2 | Feb, Aug | 5⅝ | 5¾ |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) ... | 97½—99½ | 3 10 4 | June, Dec | 98½ | 98¼ |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 104 —106 | 3 15 6 | — | 105½ | 104 |
| 1 | 0/7½ | Oriental | 1¼—1⅜ | 3 12 9 | April, Oct | .. | .. |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1 1/16—1 3/16 | 4 11 6 | — | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 102 —105 | 4 5 9 | .. | .. | .. |
| 5 | 5/0 | United River Plate | 7 —7½ | 5 6 8 | July | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅜—5⅝ | 4 8 10 | June, Dec | 5 9/32 | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) .. | 110 —112 | 4 10 8 | June, Dec | .. | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 4¾—5¼ | 5 14 4 | .. | .. | .. |
| 10 | 2/0 | Globe Telegraph and Trust | 10½—10¾ | 5 0 8 | Ja,Ap,Jy,O | 10 11/16 | 10½ |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14⅛—14⅜ | 4 8 0 | Ja,Ap,Jy,O | 14 5/16 | 14⅛ |
| 10 | 6% | Submarine Cables Trust (Cert.) | 125 —128 | 4 13 9 | April, Oct | .. | — |

| Share. | Last Dividend | Name | Price Wed., Nov. 22. | Rate per Cent. Yielded. | Dividend Due. | Business Week to Nov. 22. | |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | £ s. d. | | Highest. | Lowest. |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12¼—12¾ | 5 9 10 | .. | 12 11/16 | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10½—10⅞ | 4 4 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 12¼—12¾ | 4 18 0 | .. | .. | — |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) ... | 107 —109 | 4 2 6 | .. | — | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5½—5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 102 —105 | 4 5 9 | — | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 8¼—8¾ | 5 2 6 | — | 8½ | .. |
| 5 | 8/6 | Do. 7 per Cent. Pref. | 9 —9½ | 3 14 5 | Mar, Sept | — | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 105 —108 | 3 14 1 | — | .. | .. |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 6¾—7¼ | 4 9 8 | Feb, Aug | 6⅞ | .. |
| 5 | 2/8 | Do. 4½ per Cent. Pref. | 5½—5¾ | 3 18 3 | Feb, Aug | 5½ | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 103 —105 | 3 16 2 | — | .. | .. |
| 5 | 2/8 | Do. City Undertaking 4½% Cm. Pref. | 4¾—5 | 4 10 0 | — | .. | .. |
| 5 | 2/8 | Do. Do. (1903) | 4¾—5 | 4 10 0 | — | .. | .. |
| 5 | 2/3 | Chelsea Electric Supply Ord. | 5¾—6¼ | 4 16 0 | March .. | 6⅛ | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) ... | 110 —112 | 4 0 4 | Jn, Dec .. | 110½ | 110 |
| 10 | 5/0 | City of London Electric Lighting Ord. | 13¾—14¼ | 4 18 0 | Feb, Aug | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 14—14½ | 4 4 2 | Jan, July | .. | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 124 —128 | 3 18 1 | Jn, Dec .. | 124⅞ | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 104 —106 | 4 4 10 | .. | .. | .. |
| 5 | .. | County of Durham Elec. P.D. Ord. £2 pd. | 2 3/16—2 7/32 | .. | April, Oct | 2 3/16 | .. |
| 5 | 1¾d. | Do. Do. 5% non cum. pref. | 5⅛—5½ | .. | April, Oct | .. | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. .. | 9½—10 | 4 0 0 | — | 9⅞ | 9¾ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅝—12⅞ | 4 13 2 | Mar, Sept | 12 13/16 | 12⅝ |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 111 —114 | 3 18 11 | .. | .. | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs.. | 102 —104 | 4 6 7 | .. | 103½ | 103 |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5 —5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101 —104 | 4 6 6 | .. | .. | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8¼—8¾ | 4 17 2 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100 —103 | 4 7 5 | .. | .. | .. |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 11¼—11¾ | 5 0 0 | .. | 11½ | 11¼ |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½—7 | 4 5 9 | Jan, July | — | — |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) .. | 98 —101 | 3 19 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101 —103 | 3 17 8 | .. | .. | .. |
| 8 | 1/9¾ | London Electric Supply Ord. | 1¾—2¼ | 4 0 0 | .. | .. | .. |
| 5 | 8/0 | Do. 6 per Cent. Pref. | 4¾—5¼ | 5 14 4 | .. | 5 | 4⅞ |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 99 —102 | 3 18 5 | Mr,Jn,S,D | 101½ | 101 |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 10 —10½ | 5 4 9 | April, Oct | .. | .. |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5⅝—5⅞ | 3 16 8 | Jan. July | 5¾ | 5⅝ |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 109 —113 | 3 19 7 | Jn, Dec .. | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 97 —99 | 3 10 8 | — | .. | .. |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 101 —103% | 4 7 5 | — | .. | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 12½—12¾ | 5 19 1 | Feb, Aug | .. | .. |
| 100 | .. | Do. 4½% Deb. | 104½—106½ | .. | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8⅛—8¼ | 4 18 2 | Feb, Aug | 8 3/16 | 8⅛ |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. .. | 6¼—6½ | 3 18 6 | Feb, Aug | 6⅜ | 6¼ |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99 —100 | 4 0 0 | Jan, July | .. | .. |
| 1 | 8% | Northern Counties Elec. Sup. 17/- paid | 1⅜—1⅝ | 3 1 1 | Mar, Aug | .. | .. |
| 100 | .. | Do. 4½% Deb. | 100½—101½ | .. | Jan, July | .. | .. |
| 10 | 6/0 | Notting Hill Electric Ord. | 14½—15½ | 3 17 6 | March .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98 —100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅝—6⅞ | 5 1 6 | March .. | 6 11/16 | 6⅝ |
| St. | 4% | Do. 4% Deb. Stock | 100 —102 | 3 18 5 | — | .. | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 13 —14 | 5 3 7 | Feb, Aug | 13⅜ | 13⅛ |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 8¾—9¼ | 3 16 0 | Feb, Aug | 8⅞ | 8¾ |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) ... | 98 —100 | 3 10 0 | — | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord... | 2 —2½ | 8 0 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76 —80 | 5 0 0 | — | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord ... | 3½—4 | 5 0 0 | .. | .. | .. |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | 1⅜—1⅝ | .. | .. | .. | — |
| 1 | 0/8¾ | Do. 7% Cum. Pref. | 1 5/16—1 7/16 | 4 17 2 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105 —108 | 4 3 8 | — | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4½—4¾ | 5 5 8 | — | 4 11/16 | 4⅝ |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5 —5¼ | 4 15 3 | — | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. | 104 —106 | 4 4 10 | .. | 105⅜ | 105 |
| 5 | 6/6 | Westminster Electric Supply Ord. | 12 —12½ | 5 12 0 | Mar, Sept | 12⅜ | 12¼ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 6 —6½ | 3 16 11 | .. | 6⅜ | 6¼ |
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝—⅞ | 5 6 6 | — | .. | .. |
| 1 | 6d. | Aron Elec. Meter 6% Cum. Pref. | ½—⅝ | .. | .. | .. | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 1¾—2 | 5 0 0 | .. | .. | .. |
| 1 | 7½d. | Do. Pref | 1 7/16—1 9/16 | 3 16 10 | .. | .. | .. |
| 5 | 4/0 | British Insulated & Helsby Cables Ord. | 6¾—7¼ | 5 10 3 | July, Feb | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref | 6¼—6½ | 4 16 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103 —106 | 4 4 11 | .. | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98 —100 | 4 10 0 | .. | 98⅞ | .. |
| 5 | .. | British Westinghouse 6% Pref. | 2 —2⅜ | .. | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock ... | 85 —89 | 4 9 11 | .. | .. | .. |
| 2 | .. | Brush Electrical Engineering | ¼—⅜ | .. | March .. | 1 5/16 | .. |
| 2 | 2/4½ | Do. 6 per Cent. Pref. Non-Cum. | 1½—1¾ | 6 17 2 | Mar, Sept | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 93 —97 | 4 12 10 | Mar, Sept | .. | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 77 —80 | 5 12 6 | Jan, July | .. | .. |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11 —12 | 5 0 0 | Jan, July | 11⅝ | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝—5⅞ | 4 5 2 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 109 —111 | 4 1 1 | Nov, May | .. | .. |
| 1 | 4½d. | † Castner-Kellner Alkali Co. | 1 —1½ | 4 0 0 | .. | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 97 —102 | 4 8 8 | — | .. | .. |
| 1 | 9⅜d. | Chadburn's (Ship) Telegraph Ord. | 1 3/16—1 5/16 | 4 10 6 | .. | .. | .. |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1 1/16—1 3/16 | 5 2 7 | .. | 1⅛ | .. |
| 3 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) ... | 1¾—2 | 3 16 6 | Jan, July | .. | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 94 —99 | 5 1 0 | Jan, July | .. | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8½—9 | 5 11 1 | Sept | 8⅝ | .. |
| 5 | 3/0 | Do. 6% Cum. Pref. | 5¾—6¼ | 4 18 0 | Sept | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106—108 | 4 4 1 | .. | 108 | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅛—1⅜ | .. | Feb, Aug | .. | .. |
| 5 | 2/6 | Do. (£5 paid) | 2 —2⅜ | .. | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 85 —90 | 4 8 11 | June, Dec | .. | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92 —97 | 5 3 1 | .. | .. | .. |
| 5 | 4/6 | Edmundson's Elec. Corp. Ord. | 5¼—5¾ | 6 1 9 | H'lf-yearly | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5⅞—6⅛ | 4 18 0 | .. | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 108 —110 | 4 1 6 | .. | .. | .. |
| 2 | 1/7½ | Electric Construction Co. | ⅝—⅞ | 8 0 0 | July | .. | .. |
| 2 | 2/9¾ | Do. 7 per Cent. Cum. Pref | 1⅞—2⅛ | 5 18 8 | July | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 92 —95 | 4 4 2 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref... | 9½—10 | 5 0 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96 —100 | 4 0 0 | .. | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 12½—12¾ | 5 11 1 | Feb, Aug | 12⅝ | 12½ |
| 5 | 2/8 | Do. 4½ per Cent. Pref. | 5⅝—5⅞ | 4 3 9 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | 109 —111 | 4 1 1 | Feb, Aug | 110½ | .. |
| 10 | 5/0 | India Rubber, Gutta Percha, &c., Wrks. | 16 —17 | 2 18 9 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99 —102 | 3 18 5 | Mar, Sept | .. | .. |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¼—11¾ | 4 5 1 | Mar, Sept | 11½ | 11⅜ |
| 15 | 12/0 | Telegraph Construction & Mainten'ce. | 32 —34 | 5 5 10 | Mar, July | .. | .. |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 .. | 102 —104 | 3 16 11 | Jan, July | .. | .. |
| 5 | — | Willans and Robinson Ord. | 1½—2 | — | Apr, Oct | 1⅝ | 1⅝ |
| 5 | — | Do. 6 per Cent. Cum. Pref. | 2½—3½ | — | Apr. Oct | .. | .. |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. .... | 85 —90 | 4 8 11 | May Nov | .. | .. |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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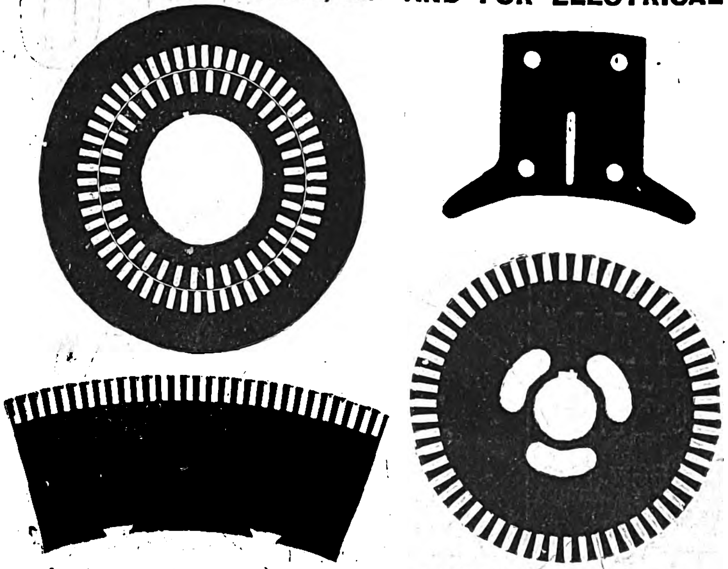

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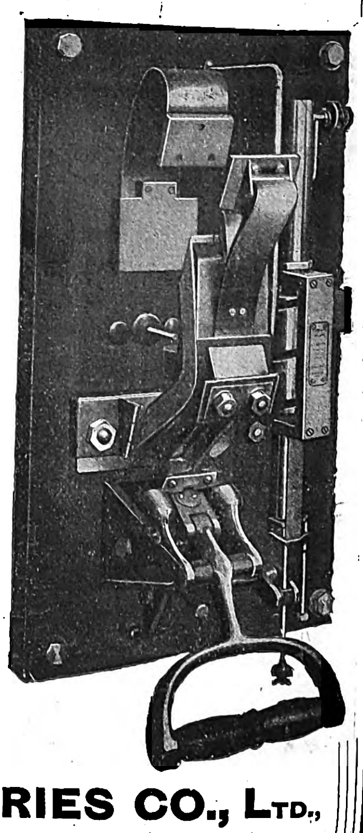

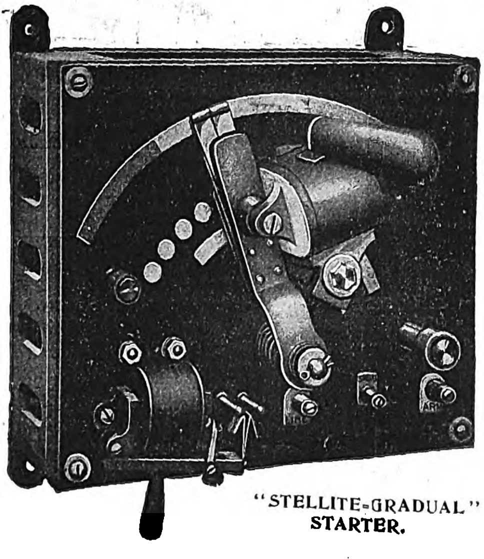

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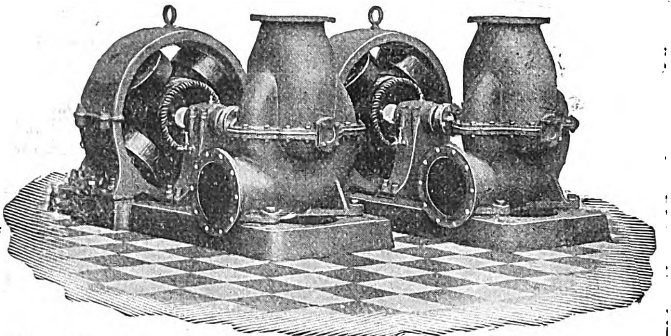

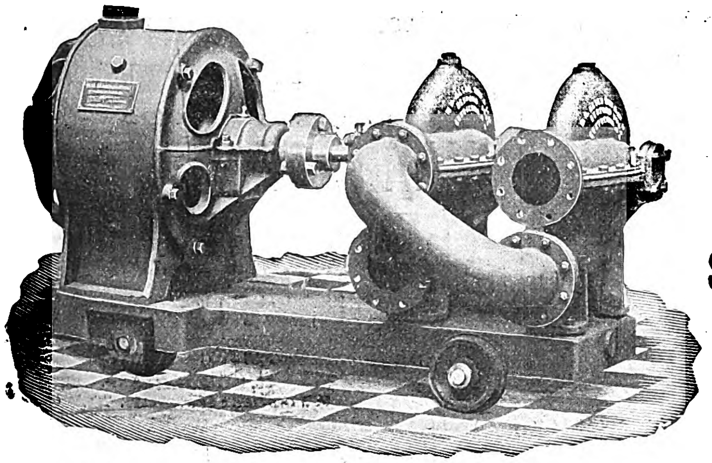

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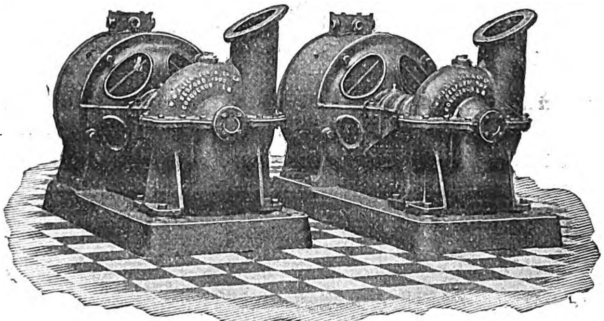

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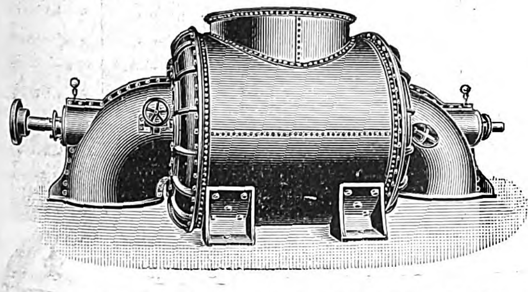

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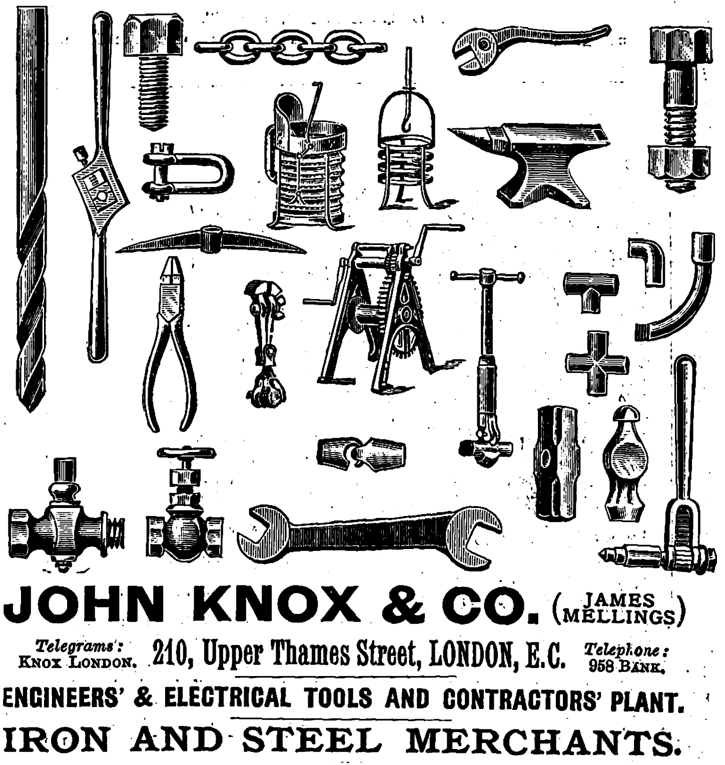

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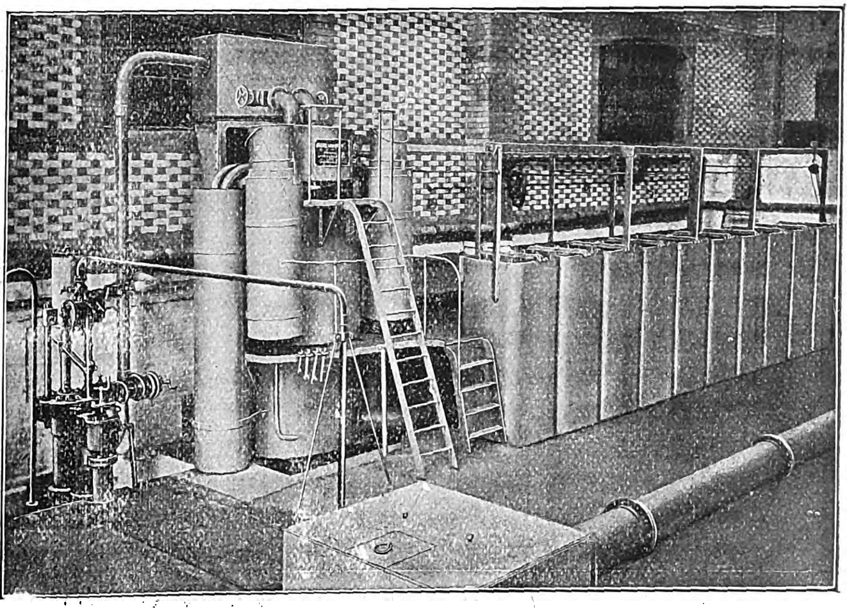

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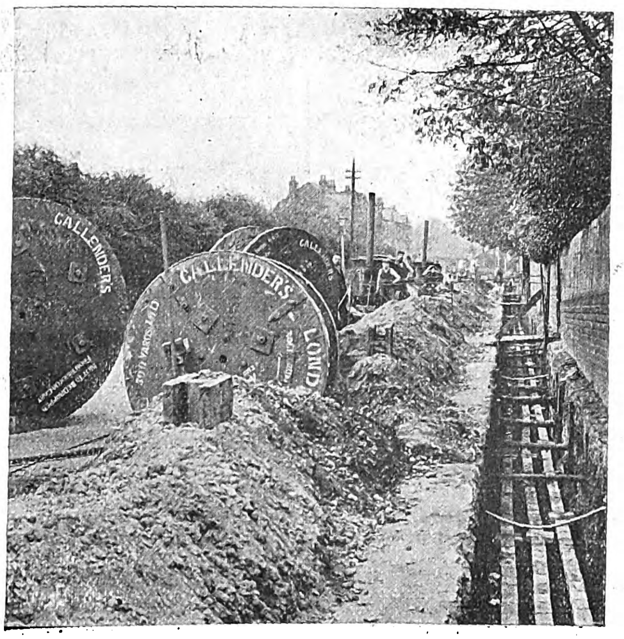

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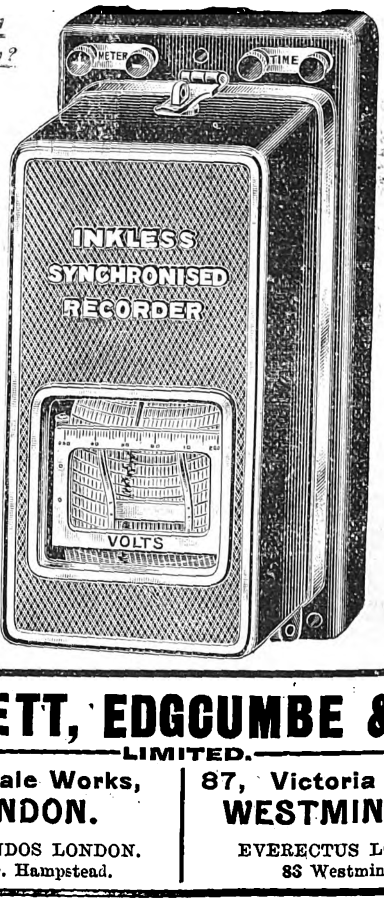

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THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF
ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.
ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,437. [No. 7. Vol. LVI.] FRIDAY, DECEMBER 1, 1905. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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## NOTES.

IN an article last week some mention was made of the Parliamentary notices, chiefly in relation to the proposed Bills dealing with electric power supply in London. Taking up the thread of our narrative in connection with the notices generally this week, the question of power supply in London again so completely predominates that the remaining notices almost sink into insignificance. Including the schemes referred to last week, there are now, it appears, about a dozen affecting the question of electric power supply in London, and one or two of them are remarkable,—in different ways, however. For instance, it is a welcome sign to see a number of companies and borough councils in the north-west and west of London combining to obtain sanction to give each other a supply in bulk for various purposes. The most startling proposal of all, however, is the scheme of the London County Council, which has scheduled an area greatly exceeding that of the Administrative County of London and District Electric Power Co. The result of the passing of the London County Council Bill would be competition with the North Metropolitan Electric Power Co. and the Metropolitan Electric Supply Co. under the terms of the latter company's Power Act of 1905. Districts as far outside the London County boundaries as Willesden, Wood Green, Brentford, Orsett (Essex), Dartford, Foots Cray and Richmond, in the various directions, mark the limits of the area outlined in the County Council notice. We feel it is so impossible to take the scheme seriously that we will leave the matter here; it condemns itself.

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IN addition to the combination of West-end Companies and Borough Councils for the purposes of mutual supply, fifteen of the London Companies have also joined hands with the same object in view. The Hackney Borough Council will promote a Bill to enable a number of municipal authorities in the east and north-east of London to combine for the purposes of electric supply, the St. Pancras Borough Council seeks to acquire additional lands for generating or sub-stations, and to exempt it from liability for nuisance, and the South Metropolitan Electric Lighting and Power Co. desires to enter into agreements with authorised distributors in London, Kent or Surrey. All these proposals directly bear on some remarks made in our leading article on November 17th, a week before the notices appeared—viz., that in applying independently for powers to link up their generating stations, the existing authorities would, in a way, be making a protest against the dilatory methods which have been adopted in connection with the Electricity Supply Bill, which dealt with this and other matters tending to remove the restrictions imposed by the Electric Lighting Acts. At the time our remarks were written we had no idea that such an extensive combination of supply authorities as that referred to above was contemplated, but that a very real grievance exists in this matter there are sufficient indications both in and out of London. Thus, the two companies supplying electricity in Newcastle are asking for similar powers for mutual supply.

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ONE of the most interesting proposals coming from the provinces is that of the Lancashire Electric Power Co., which seeks to extend the scope of its original Act of 1900 so as to include public lighting authorities who would not come within the definition of authorised distributors under the Company's 1900 Act, as well as "any company, body or person" requiring a power supply for use within or beyond the area of the Company. Another company seeks powers to supply electricity and power gas in parts of Cumberland, whilst the Kent Collieries Bill, somewhat indefinite in its notice, would appear to contemplate the distribution of electrical energy to railway companies, and incidentally in the Metropolitan area. It is also sought to incorporate a number of new tramway companies in the provinces. Fuller particulars of all the Bills are given on another page.

Tube railway schemes in London are not numerous, despite the report of the Royal Commission on London Traffic, and we note that the scheme relating to the completion of the Central London Railway loop from Shepherd's Bush to the Bank along the Kensington–Piccadilly–Fleet-street route, which was first brought forward in 1902 and has been introduced each year since, has apparently been dropped. The Hammersmith, City & North-East London Railway Bill, rejected by the Standing Orders Committee last year, is revived, and appears to be the only suggestion for a tube railway along this route, whilst a London Outer Circle line is proposed, the notice for which contemplates agreements with all the companies having termini in London. An extension to Victoria of the North-West London Railway (a line from Cricklewood to the Marble Arch, authorised many years ago but not yet constructed), exhausts the list of tube railway bills. Of the tramway bills, we need hardly mention that the London County Council has again given notice of its intention to promote tramways along the Thames Embankment and over Westminster and Blackfriars Bridges, this time with the support of the City Corporation. A number of municipal "omnibus" bills have reference to electricity supply, and the London County Council once more seeks powers for the London Borough Councils to undertake house-wiring. It will also be noticed that the Metropolitan Pneumatic Dispatch Bill is re-introduced.

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THERE are few people who do not derive infinite pleasure from listening to or reading an address by Mr. JAMES SWINBURNE, and his address to the Manchester students of the Institution of Electrical Engineers, although of a different type from that delivered to the London students, contains some noteworthy passages. It is not often that Mr. SWINBURNE airs his views on municipal trading, nor is it often that the subject will appeal to students. But the economics—or lack of economics—of municipal trading were put in a nutshell in this discourse, and the reference to the famous "Bermondsey" clause was peculiarly happy.

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AN interesting case recently came before the Faversham County Court. Faversham consumers of under 250 units per quarter are supplied at the rate of 5d. per unit, but if they reach 250 units they have to pay only 4½d. per unit. Now a certain consumer had succeeded in using 240 units, and his bill, therefore, came to £5; but it will be noted that if the consumer had used just 10 more units his bill would have amounted to 6s. 3d. less than it did for the 240 units, and he therefore tendered the smaller sum. In such circumstances, we regret that the judge was obliged to decide in favour of the electricity supply authority; even he was obliged to explain that he was only there to administer the law and had nothing to do with common sense.

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DR. H. LEWIS JONES' admirable lecture delivered before the Hunterian Society, and reprinted in another column, well repays careful reading. It shows concisely and conclusively what are the useful therapeutic applications of electricity, and with equal clearness outlines their limitations. High-frequency treatment, Dr. LEWIS JONES maintains, "has already shrunk into its proper small dimensions," and the light bath "is destined to become a more or less ornamental accessory in Turkish bath establishments." Statements of this kind, although more or less disappointing, are yet welcome from an authoritative source, for they make it possible for a line of demarcation to be drawn between the useful and the useless. Regarding the applications of electricity from which benefit is known to accrue, Dr. LEWIS JONES had a good deal of technical information to impart, and his description of the treatment of lupus and rodent ulcer by means of electrolysis is exceedingly interesting. We congratulate him on his ability as an electrician, in addition to his skill as a medical man, for which he is justly famous.

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**Electrical Exhibition, Olympia, 1905.**—The following announcement has been sent to us for publication :—

> The financial affairs of the recent exhibition are now so far advanced as to enable me to inform you that the exhibitors will receive a rebate of 25 per cent upon the sums paid by them for space, and a very considerable sum will be available for benevolence. The fact that the exhibition was an unqualified success from every point of view is satisfactory, not only to the Executive committee, but to the exhibitors and trade generally.—W. DAVENPORT, Secretary.

**Opening of Lincoln Electric Tramways.**—This system of electric tramways was opened to the public on Thursday last week, the Board of Trade inspection having taken place on the previous day. Special interest attaches to the event owing to the fact that Lincoln is the first place to adopt the Griffiths-Bedell surface-contact system. Up to the present the length of double track is only about 1½ miles, but in the event of this proving satisfactory it is certain that considerable extensions will be put in hand.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Tarifa—Tangier | Jan. 18, 1904 |
| Jamaica—Colon | Jan. 10, 1905 |
| Cadiz—Teneriffe | July 20, 1905 |
| Tangier—Cadiz | Oct. 30, 1905 |

**The Gale.**—During the severe gale which raged on Sunday night the wireless telegraph pole on the Shakespeare Cliff at Dover was carried away by the wind. At Sandgate the beach was washed up on to the roadway to such an extent as to stop the tramway service. The new municipal electricity works at Brussels, which were approaching completion, were wrecked. Eleven steel columns supporting the iron roof were blown out of the perpendicular, and the roof itself, measuring 282 ft. by 80 ft., was carried a distance of about 16 yds. Some of the machinery was damaged and the loss is estimated at £12,000.

**Supply Interruption at Battersea.**—On Saturday evening last an interruption to the electric supply in Battersea took place, but it did not last for a considerable period. There have been one or two similar accidents at Battersea recently, one of which we recorded in our issue for October 20th. On that occasion the armature of a 750 kw. turbo-generator failed when it was carrying three-quarters of the total load. Mr. W. A. Kemm, the borough electrical engineer at Battersea, informs us that he is still awaiting the report of the makers of the machine as to the causes of these mishaps and what steps can be taken to prevent a recurrence of the trouble.

**The British Association in South Africa.**—In a well-received Paper with the above title, read by Sir William Preece, K.C.B., F.R.S., before the Society of Arts last Wednesday evening, the author recorded the impressions which he gained while in South Africa with the British Association. A great variety of subjects were touched upon, including the geographical and climatic conditions of South Africa, its people, its government, its educational system, its missions, its industries, the labour question, the railway system, the great natural resources of the country, and so forth. The trip of the Association had been termed a "picnic," but he hoped that the visit had been beneficial and stimulative to their Colonial hosts. South Africa, Sir William concluded, was a country with a great future before it.

**Speed in Telegraph Cables.**—Mr. F. D. Black has written us to suggest that the working speed in underground telegraph cables, such as those from London to the North of England and Scotland, may be increased by the substitution of magneto-electric currents for the present continuous currents. By the adoption of such a method, he thinks that an increase in the speed of transmission of at least 30 per cent. over the present rate of speed can be attained. Our correspondent's idea is not new. Messrs. Crehore & Squier have made a large number of trials with sine-wave transmission on cables and land lines, but these experiments have not led, we believe, to an extensive adoption of the system. In the discussion of a Paper by these authors before the International Electrical Congress in Paris in 1900, Mr. Gavey is reported to have said that the results obtained by Messrs. Crehore & Squier in their "synchronograph" transmitter were no great advance on the best Wheatstone practice in this country.

**Note on the Aurora of November 15, 1905.**—Dr. T. C. Porter has sent us the following interesting note on the aurora he observed at Eton, Bucks., on November 15th last:—

First observations from 5:50 p.m. to 6:12 p.m., maximum altitude of streamers 70 deg.; colours—cream, salmon pink; there was also a deep crimson glow in two detached masses about 10 deg. above the horizon. At 7:30 p.m. flashes of white light were seen low on the N.N.W. horizon, but no glow or streamers till 8:40 p.m., when the display was again brilliant, but without the deepest crimson glow. Part of an arch of white light appeared low down in the N.N.W. One very fine streamer with a sharply-defined W. edge moved with an apparent angular velocity of about 1 deg. in two minutes past *eta Draconis* from E. to W., which indicates that the electric discharges were from N. to S. By 9:15 this second display had faded. It is of interest to know that, apart from the well-known 11-year period of maxima in auroral displays, there is a longer period of about 60 years. 1728, 1780, 1842 were all years of exceptional displays. We may, therefore, expect 1905-1906 to form the new term of the series.

It is, perhaps, worth placing on record that the Slough fire brigade were called out, and the engine got ready. It did not, however, actually start on its journey, for the mistake was fortunately discovered in time.

**Birmingham Local Section of the Institution.**—The opening meeting of the Birmingham Local Section of the Institution of Electrical Engineers was held at the University on November 23rd.

Dr. SUMPNER, having taken the chair, congratulated the members on the success of the previous session's work, and pointed out that not only had all the Papers been published in full in the Institution *Journal*, but that two of them had been awarded premiums. The most important event of the session was, however, the coming of Prof. Kapp, who was present with them for the first time, and whom they would cordially welcome. Among his many great services rendered to the electrical engineering industry perhaps none was greater than that rendered when, in 1885, he pointed out simultaneously with Dr. Hopkinson the true theory of the magnetic circuit, and made it clear to dynamo designers. Dr. Sumpner then vacated the chair in favour of Prof. Threlfall after thanking the members for their support during his term of office.

Prof. Threlfall then delivered his address "On Some Problems in Electro and Electro-thermal Chemistry," the publication of which we commence in another column of this issue. On its conclusion a cordial vote of thanks was passed on the proposal of Mr. R. A. Chattock, seconded by Prof. Gisbert Kapp.

**Electric Traction in the Simplon Tunnel.**—Messrs. Bruce Peebles & Co. inform us that the Swiss Government has finally decided to open at once the Simplon tunnel with electric traction. The line which runs through the tunnel is the longest tunnel line in existence, being about 20 km. in length, and is the last link of an international railway line connecting Switzerland with Italy. The system to be applied is that propagated by Messrs. Ganz & Co., for whom Messrs. Bruce Peebles & Co. hold the British patent, viz., the high tension three-phase system at 15 periods and 3,000 volts in the trolley wires. Credit for the initiative to apply electric traction in the Simplon tunnel must be given to the Italian Government, who, for this purpose, invited the Swiss Government to inspect the Valtellina line. The Swiss Government Commissioners made a careful study of the installations of the Valtellina line, and were so favourably impressed that they decided for the application of that system on the Simplon line. Five electric locomotives supplied by Ganz and Co. for the Valtellina line are being loaned by the Italian Government for work in the Simplon tunnel, which will be opened for public traffic on May 1, 1906.

**Obituary.**—We greatly regret to announce the death of Capt. W. R. Cato, which took place at his residence at Upper Norwood, London, on Sunday last. Capt. Cato was born in 1834, and first went to sea in 1848. In 1855 we find him engaged in the Government transport service, carrying troops to Balaclava and elsewhere in the Crimea. In 1865 he entered the National Steamship Co.'s service, and was chief officer on board that company's s.s. "Denmark" in 1869, when in a cyclone that vessel lost her captain, her boats and everything movable on deck. This made Cato the senior officer and he took command of the ship, and, despite difficulties, safely brought the vessel to port, receiving the thanks of the directors of the company, and his command of the vessel was confirmed. At the end of the year 1869 he left the National line and entered the service of the Telegraph Construction & Maintenance Co. as second officer of the "Great Eastern" when that vessel laid the first Aden-Bombay cable. He was chief officer of the "Great Eastern" during the laying of the 1874 Atlantic cable, this being her last voyage in the service of the T. C. & M. Co. Capt. Cato also commanded the "Edinburgh," "Hibernia," "Calabria," "Scotia" and "Anglia," all cable steamers belonging to that company. His last voyage was in 1901, when the cables were laid between Sierra Leone, Ascension and Durban and Mauritius. On his return home he was appointed marine superintendent of the T. C. & M. Co.'s fleet. The company have always regarded Capt. Cato's seamanship and navigation as of the highest order. In 1888 Capt. Cato was gazetted an honorary lieutenant in the Royal Navy Reserve, and for many years he was an active member of the Shipwrecked Mariners' Society. A kind-hearted, genial and cheery man, he was an admirable example of the British sailor. His death will be deplored by many friends, not only in this country, but in many other parts of the world where he was well known.

We regret to announce the death at his residence, Samares, Jersey, on Nov. 20, of Mr. Frederick le Breton Bedwell, who for many years acted as hydrographer to the Telegraph Construction and Maintenance Co. Mr. Bedwell joined the Navy in 1853, and saw active service in the Crimean War, and in India and China. He was engaged from 1859 to 1862 in surveying the coasts of China, Tartary and Japan, and in 1868 joined the Telegraph Construction and Maintenance Co. on the introduction of Admiral Sherard Osborn. On his retirement, in 1899, he went to live in his native Jersey, where he was visited by numerous friends in the world's telegraph services, who will deplore his loss.

**The Paving of Roadways.**—Mr. Walter L. Green read a most interesting Paper on the above subject before the Tramways and Light Railways Association on Thursday, November 23rd, Mr. James Devonshire presiding.

After giving a brief historical sketch on the art of roadmaking, the lecturer described various methods employed for providing a good road surface. He dealt with ordinary macadam, tar macadam, stone and composite paving, wood paving and asphalt. An excellent method of armouring macadam roads, which had been in use on the Continent for many years, was now being introduced into this country. It was first employed by Baurath Gravenhorst, of Stade (Germany), who showed that the destruction of road metal spread in the usual manner is chiefly caused by the stones, which vary so greatly in shape, size and strength and crush each other under the pressure of the traffic. To avoid this, he selected stones of approximately equal size and cubical shape, and placed them singly side by side on the carefully levelled and rolled surface of the old road. The result was a mosaic-like covering, which proved to be of extraordinary durability. The next step was to increase the size of the stones, and make them specially for the purpose, the two sizes now in general use being 3½ in. by 4 in. and 4 in. to 4½ in. depth. It was important that the depth of the stones should not vary much, but otherwise no great regularity was required, even stones with triangular heads being used. After removing as little as possible from the surface of the road, it is levelled and rolled, and the stones placed in position, sand being used sparingly and only for the purpose of bringing up the shallow stones to the level of those of full depth. Sand was then spread over the surface and allowed to remain for some days, so as to work into the joints. Many of these roads in Wiesbaden had been down six years, and showed practically no signs of wear, whilst in other parts of Germany there were roads with a 12 years' record. Owing to the small heads of the setts and the numerous irregular joints, the new paving afforded excellent foothold, and was used on steep inclines with success. Granite and similar stone was far preferable to basalt for small sett paving.

The roughness of the heads of the small setts wore off under the traffic, leaving an even surface, over which the wheels passed as easily as over asphalt, without becoming slippery in damp weather. The small setts placed in sand had been found as stable and durable as when set in cement, and it was only in towns and for hygienic reasons that they were laid in a dry mixture of three parts of sand to one of cement, and afterwards watered; or the joints might be filled with pitch. Wood paving was gone into at length, the order of merit of various woods for road making purposes being karri, jarrah and red gum, deal and creosoted deal constituting a fourth class. Soft wood deadened the noises from street traffic much more than hard wood, but in point of durability, economy, hygiene, ease of cleaning and traction resistance hard wood was easily first.

In the discussion which followed the Paper,

Mr. Trier said that roads paved with small setts, referred to by the lecturer, had been laid in Hanover as long as 18 years ago, and at the present time they were to be found all over Germany, giving excellent results. The absence of noise was most noticeable. Such paving was very suitable for the space between the rails of tramways, but large setts were better for the margin. The small setts required to be well bound from the side. Mr. Percy Morris thought jarrah better than karri for paving purposes. Granite setts were cheapest in the long run. Tramway engineers would get much better results if they allowed more time for the paving. Mr. A. H. Pott asked a number of questions regarding the best material and the life of hard wood for the margin of tramway tracks. Mr. W. Green, in reply to the discussion, agreed with Mr. Morris that shortness of time was often responsible for unsatisfactory results, especially if concrete were concerned. The paving on the Thames Embankment referred to by the chairman, was tar macadam, and the difficulties experienced were no doubt largely due to the subsoil of the Thames Embankment.

**The Measurement of High-Frequency Currents and Electric Waves.**—Prof. J. A. Fleming, F.R.S., delivered the first of four Cantor lectures on the above subject before an appreciative audience at the Society of Arts last Monday evening. In commencing, the lecturer explained what was meant by the "capacity" of a body, and he drew particular attention to the fact that the capacity was not alone a function of the form of the body itself, but also depended on the surrounding objects. Although it was possible to calculate the capacity of certain simple forms of bodies, the only accurate method of determining the capacity of complicated bodies or bodies surrounded by other objects was by direct experiment. A diagram of connections of the arrangement used by Prof. Fleming for carrying out such measurements was then thrown on the screen and explained, after which the lecturer proceeded to measure the capacity of a number of objects, including condensers in air and in oil, the human body, &c. It was mentioned *en passant* that the capacity of the earth was 800 mfd., and that of a single wire 100 ft. long and 0·1 in. in diameter $\frac{1}{5000}$ mfd. Mention was then made of the fact that high-frequency currents flow on the surface of the conductor. The resistance offered to high-frequency currents in a metallic wire was very high. A convenient formula for calculating this high-frequency resistance ($R'$) was the following: $R' = R\pi d\sqrt{n}/80$, in which $R$ = ordinary ohmic resistance, $d$ = thickness of wire, and $n$ = frequency of oscillations. This phenomenon was very neatly verified by showing that a high-frequency current would jump across an air-gap rather than flow through a small loop of copper wire of small resistance connecting the two spark knobs. The method used by the lecturer for measuring inductances was then explained with the aid of a diagram thrown on the screen. It is based on the Wheatstone-bridge principle. Self and mutual induction were next dealt with, and the lecturer's device of counting sparks was explained and shown in operation. Its principal parts are a small motor and a pendulum arrangement, which is released by pressing a button and automatically stopped after one full swing has been completed. A suitable pulley is fixed to the motor's shaft, and a paper ribbon passes loosely between this pulley and a small jockey pulley. When the button is pressed, the pendulum begins to swing, the spark is caused to pass, the jockey pulley presses the paper ribbon on the motor pulley, and the paper tape is rapidly drawn between the two needle points of the spark discharge. Each spark pierces the paper and leaves a record in the form of a fine hole. Of course, each spark itself consists of a train of oscillations which gradually die away, but no trace is left of these oscillations. Prof. Slaby's method of measuring spark resistance was then described, as also the lecturer's modification of it. The modification consists in using a resistance of dilute sulphuric acid instead of carbon, as the latter material is not altogether satisfactory on account of local heating effects. It was found that the spark resistance increased with the spark length, but at a somewhat irregular rate. The resistance (beyond a certain small air-gap) was smaller for zinc or brass spark knobs than for iron knobs. This must be put down to the lower melting point of zinc, which volatilises more readily than iron and thus forms a conducting bridge of metallic vapour at a lower temperature. In order to get the equivalent of a long spark, combined with a low spark resistance, a number of spark knobs, separated by a small air-gap from one another, could be arranged side by side. In contradistinction to the results obtained by Prof. Slaby and himself (Prof. Fleming), M. G. Rempp had found during similar experiments that the spark resistance touched a minimum for a certain length of spark and was larger for all other spark lengths. This result could be explained, however, by the difference in the conditions in both cases; the sparks, in fact, belonged to different classes. The lecture was illustrated by a great number of interesting experiments and a series of lantern slides, while a collection of wall diagrams also helped to render the lecture as instructive as possible. The synopsis of the second lecture on Monday next is as follows:—

Damping of electrical oscillations—Maximum and mean square values—The damping factor and logarithmic decrement—The resistance decrement and radiation decrement—Damping due to dielectric hysteresis and magnetisation—Methods of determining maximum and mean square voltage—Spark voltage in air at various pressures—Electrometer measurements—Calculation of maximum currents during discharge—Methods of determining logarithmic decrements employed by Rutherford, Bjerknes, Drude and others—Analysis of the discharge of a Leyden jar or condenser.

## ARRANGEMENTS FOR THE WEEK.

**(To-day) FRIDAY, December 1st.**

Northampton Institute Engineering Society.

*7:30 p.m.* Meeting at the Northampton Institute, Clerkenwell, London. Paper to be read: "Water Turbines as Applied to the Generation of Electricity," by W. Chappell.

Institution of Civil Engineers: Students' Section.

*8 p.m.* Meeting at 25, Great George-street, Westminster, S.W., when the following Paper will be read: "An Installation for the Bacterial Treatment of Sewage at Neath," by W. L. Jenkins.

**SATURDAY, December 2nd.**

Glasgow Technical College Scientific Society.

*7:30 p.m.* Meeting at the Glasgow and West of Scotland Technical College, George-street, Glasgow. Paper to be read: "Metallography," by James Muir.

**MONDAY, December 4th.**

Society of Arts.

*8 p.m.* Cantor Lecture II. on "The Measurement of High-Frequency Currents and Electric Waves," by Dr. J. A. Fleming, F.R.S.

Society of Chemical Industry: London Section.

*8 p.m.* Meeting in the rooms of the Chemical Society, Burlington House, London. Among the Papers down for reading is the following: "Notes on Gutta-percha and Balata," by W. A. Caspari.

**TUESDAY, December 5th.**

University of Liverpool Engineering Society.

*5:30 p.m.* Meeting in the University. Paper to be read: "The Generation of Electrical Energy by Water Power," by H. W. Wilson.

Institution of Civil Engineers.

*8 p.m.* Ordinary Meeting, when the following Paper will be read: "The Steam Turbine," by the Hon. C. A. Parsons, F.R.S., and G. G. Stoney.

**THURSDAY, December 7th.**

Institution of Electrical Engineers.

*8 p.m.* Ordinary General Meeting. Paper to be read: "The Charing Cross Company's City of London Works," by W. H. Patchell.

Rontgen Society.

*8:15 p.m.* Ordinary Meeting at 20, Hanover-square, London, W. Paper to be read: "The Spontaneous Action of Radium and other Bodies on Gelatine Media," by J. Butler Burke.

**FRIDAY, December 8th.**

Institution of Electrical Engineers.

*7 p.m. for 7:30 p.m.* Annual Dinner at the Hotel Cecil (Grand Hall).

Manchester Students' Section: Institution of Electrical Engineers.

*7:30 p.m.* Meeting in the Manchester Municipal School of Technology. Paper to be read: "The Electrification of existing Steam Railways," by W. H. M. Parr.

## THE LEITH CORPORATION TRAMWAYS.

The Corporation of Leith last year purchased from the Edinburgh Street Tramways Co. the horse tramways in the burgh. These tramways constituted that portion of the Edinburgh Street Company's property in the burgh of Leith. The greater part of this company's lines were originally in Edinburgh, but in 1892 the Corporation of Edinburgh purchased the lines in the city, and converted them for cable traction in 1896. Since that time there has been a break in traffic in Pilrig-street, the boundary between Edinburgh and Leith, and passengers have had to change from the cable into the horse cars.

After the Leith Corporation had purchased the horse tramways in Leith they approached the Edinburgh Corporation with a proposal to equip electrically the cable line from the boundary up to Princes-street, in order to obviate the break in traffic at the boundary and so get the advantage of through running. This would have been a very great advantage to both the Edinburgh and the Leith concerns, as it would render the half mile on each side of the boundary productive, which is not the case when passengers have to change cars. The Edinburgh Corporation, however, would not entertain the idea, and the break in traffic therefore remains. In these circumstances the Leith Corporation resolved to reconstruct the lines within their own burgh and to make an extension for overhead electric traction, and appointed Mr. James More, jun., engineer for the scheme.

The total length of line purchased from the company was about 5 miles of route, and with the extension the total route miles are 6½, which is all double line, excepting at certain curves and one short length in a narrow street where double track was not feasible. The track is generally laid along the middle of the roadway. There are, however, two routes where the double track is laid with the nearest rail 5 ft. from the kerb. These are the routes along the road from Commercial-street to Newhaven, where the north side of the road adjoins the railway or sea wall of the Forth, and also on the road adjoining the Leith links or public common.

The rails are 7 in. deep and of a special section. Their weight is 106·7 lb. per yard, and the composition and physical tests of the steel are according to the British standard specification. The standard length is 45 ft. Dicker fishplates have been employed, the outside one being checked into and coming up flush with the rail head. They are 24 in. long, and are fastened by six steel bolts of 1 in. diameter, with lock nuts. Tie-bars are fixed in the webs of the rails at average centres of 6 ft. They are of the ordinary flat bar type and have two bolt ends with two nuts and washers at each end. The excavation was got out 14 in. deep to allow for the depth of the rail, 1 in. of packing and 6 in. of concrete.

The concrete is composed of macadam to pass through a 2 in. ring with the fine shivers left in, sharp pit sand and portland cement, in the proportion by measure of macadam shivers and sand five parts and cement one part. Crushed granite and portland cement in the proportion of three parts of crushed granite to one of cement by measure is used for packing. This was done before the concrete was quite set and only damped slightly. After it had been beaten in tightly under the rails it was watered from a can with a rose.

The paving is in some routes granite and in some whinstone. The setts are 6 in. by 4 in. They are bedded on cement bedding of sharp pit sand and cement, three to one proportion. This bedding was only damped immediately before laying the setts and these were racked and rammed immediately. The joints of the paving were racked with clean broken whinstone passed through a ½ in. riddle and stopped in a ¼ in. The grouting is of pitch properly tempered with oil. The points and crossings are of manganese steel. All the special junctions were put together at Messrs. Hadfield's works with most satisfactory results. The junction at the foot of Leith Walk is a particularly difficult and rigid piece of work which was put together in a remarkably short time, and is fitted exactly in every way. Rail drains, supplied by Messrs. Hadfield, are put in wherever necessary. Under each pair of fishplates two 4/0 S.W.G. Forest City flexible bonds are fixed. The two rails of

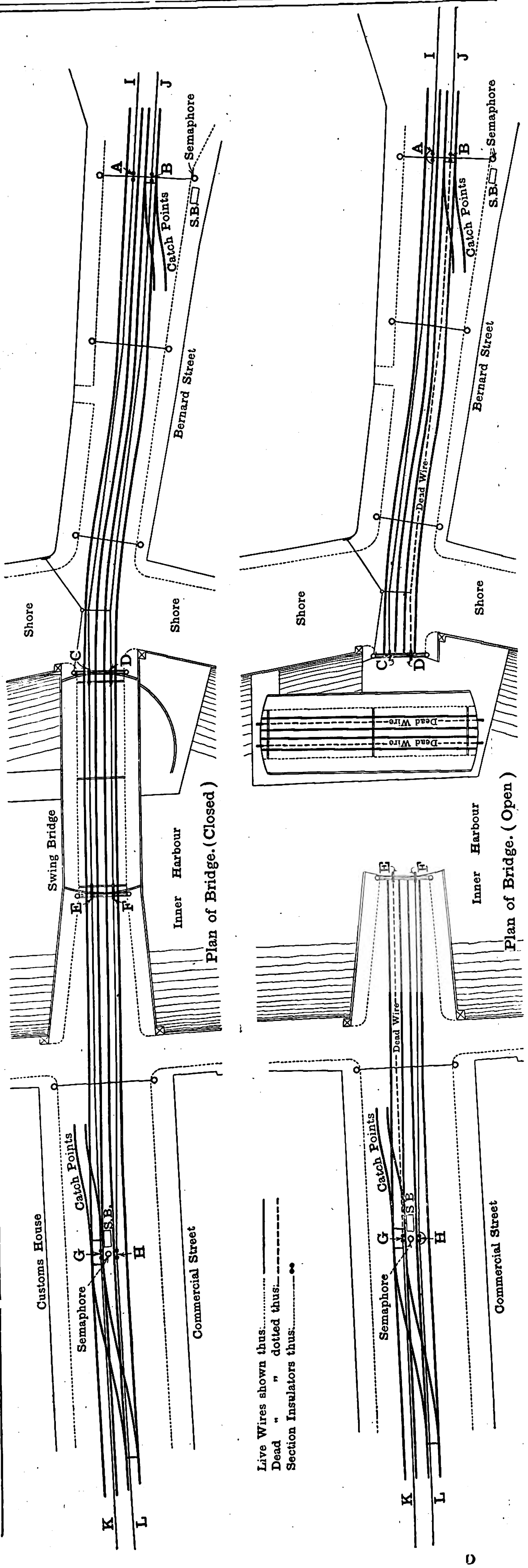

FIG. 1.—DIAGRAM PLAN OF BERNARD-STREET SWING BRIDGE.

each track and the two tracks are bonded by stranded bonds of the Forest City make at 120 ft. centres.

The poles used for the overhead equipment are of the Mannesmann Co.'s solid drawn, seamless, one piece, stepped type. There are three different sizes, the length of the steps being the same in all—viz., lower step 17 ft., middle step 7 ft., upper step 7 ft. The steps are of equal diameter throughout their length. It will be seen that the lengths of the steps are not in accordance with those specified by the Engineering Standards Committee, although the diameters are. The thicknesses are as follows:—

| | Lower step. | Middle step. | Upper step. |
|---|---|---|---|
| No. 1 size.......... | $\frac{5}{16}$ in. .... | $\frac{5}{16}$ in. .... | $\frac{5}{16}$ in. |
| „ 2 „ .......... | $\frac{13}{32}$ in. .... | $\frac{13}{32}$ in. .... | $\frac{13}{32}$ in. |
| „ 3 „ .......... | $\frac{7}{16}$ in. .... | $\frac{7}{16}$ in. .... | $\frac{7}{16}$ in. |

The usual tests were applied to a proportion of these poles at the works and they gave most satisfactory results. The thickness is good as regards uniformity. They are particularly straight, and the finish and "skin" is exceptionally good compared with the usual pole or tube for this work. Three different types of pole are in use—viz., centre, side bracket and span—to suit local circumstances. The scroll work is of wrought iron, and in the side bracket and span poles the clamps are of cast malleable iron. In the centre poles the top clamps are of mild steel forged. At the feeder poles a vertical slot $6\frac{5}{8}$ in. by $1\frac{5}{8}$ in. is cut to admit of the fixing of a cast-iron inlet bend to carry in the line cables.

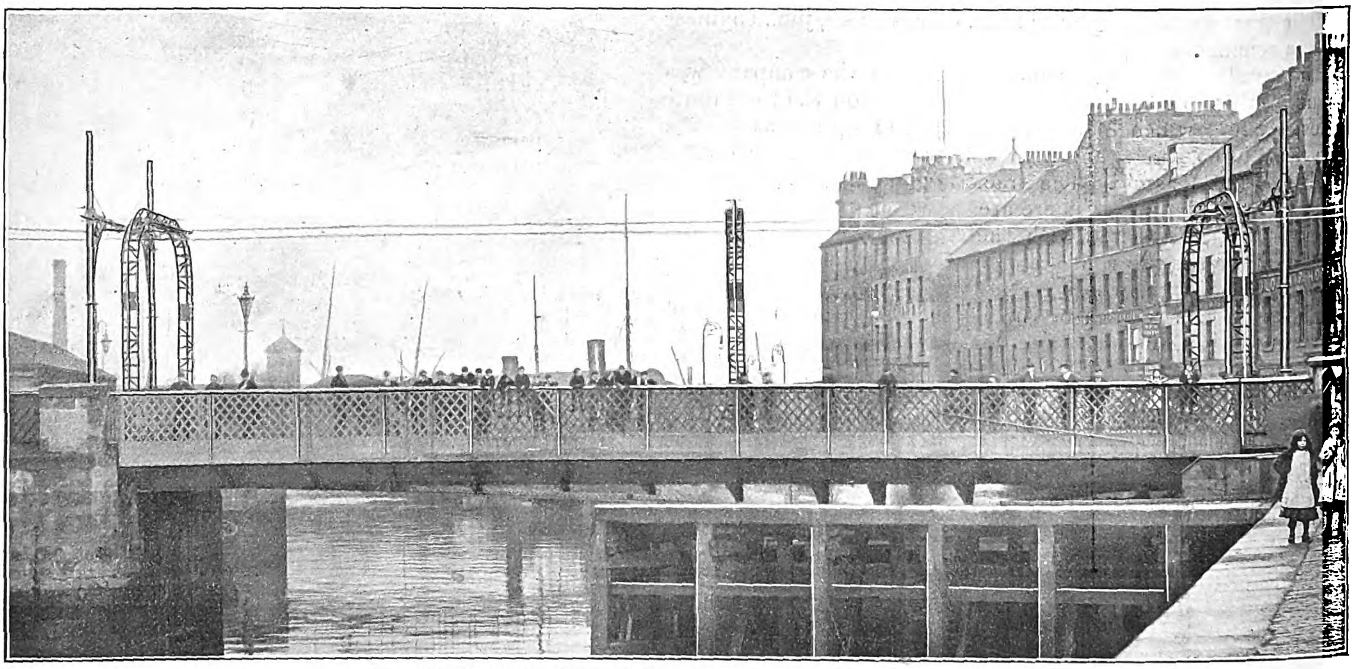

Fig. 2.—General View of Bernard Street Swing Bridge.

The position of the trolley wire in relation to that of the track varies laterally. Where centre poles are used each of the wires is 2 ft. 6 in. inside of the middle line of each track. Where side bracket and span poles carry the wires their position varies from the middle of the track to a maximum of 6 ft. outside. The height of the trolley wire from the rails is normally 21 ft. 6 in. at the ears, but it varies from this, of course, at the bridges, &c. Flexible bowstring suspension is used throughout with a strand of 7/12 S.W.G. galvanised steel wire. The trolley wire is of the grooved section 4/0 S.W.G sectional area. It is to the usual specification as to tensile strength and conductivity, and was supplied by the British Insulated & Helsby Cable Co. Mechanical ears, with a main and clamping member to clip and hold the trolley wire by the groove, are employed, the clamping being done by snap-head slotted screw studs of steel. The ears used on the straight line are 18 in. long with six studs, on easy angles or curves 24 in. ears are used with eight studs, and on all curves of less than 200 ft. radius 36 in. ears are used with 12 studs. The section insulators are of Hewer's patent type with a lignum vitæ insulating strip. All overhead fittings, ears, hangers, pull-offs, frogs, crossings, section insulators, point controllers, &c., were supplied by Messrs. S. Dixon & Son. John Manville insulating material is used excepting in the section insulators, which is Aetna and $\frac{3}{4}$ in. suspension bolts are used in all hangers. The guard wire is the usual stranded 7/16 S.W.G. galvanised steel wire, and is earthed at every fourth pole.

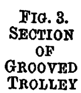

Fig. 3. Section of Grooved Trolley Wire.

Eight sets of Turner's patent point controllers* are in use and are giving very satisfactory results. Six are in use for the purpose only of moving the tongues of the movable points, while two others are used for operating signal arms and catch points on each side of Bernard-street swing bridge. They are also applied to signals to block three single-line curves so that the motormen may know when a car coming in the opposite direction has entered the single line at the other end.

The feeders are paper insulated, lead covered, armoured cables laid in wooden troughs and run in with pitch. There are, of course, positive and negative or return cables, and they vary in sectional area from 1 sq. in. to 0·15 sq. in. The largest return cable is 1 sq. in. in area, and the positive feeder has an area of 0·5 sq. in. There is, of course, the usual three-core cable for telephone and pilot wires.

Power is supplied to the tramways from the Corporation electric light station, which is very conveniently situated. The price per unit has been fixed at $1\frac{1}{4}$d. from the tramway 500-volt circuit.

In order to cross the inner harbour, the tramways traverse a swing bridge, the total length of the swinging portion of the bridge from heel to toe being about 98 ft., with a clear span of 40 ft. Three light lattice work arches or trestles have been erected to carry the trolley wire, which is 2/0 S.W.G., and of grooved section. Before being swung the bridge has a vertical tilting motion. The heel end at C and D drops about $4\frac{1}{2}$ in., and the toe end E F rises a proportionate distance. This tilting action allows the bridge to come down on to the turntable, and it is then ready for swinging. There are no gates to close against the traffic when the bridge is open, but catch points and signals are used, which are automatically worked by the tilting of the bridge before it is swung. Referring to Fig. 1, which shows the positions of poles, semaphores, catch points, &c., when the bridge is closed the approaching length of trolley wire in Commercial-street is fed from the section box A in Bernard-street through two vertical knife switches E and C on the bridge. The approaching trolley wire BD in Bernard-street is fed from the section box H in Commercial-street through two vertical knife switches, F and D, on the bridge. The tilting action of the bridge before swinging opens the switches EF and CD on the bridge trolley wire, thus cutting out the current from the approaching lines on both sides, BD in Bernard-street and GE in Commercial-street. By the same tilting motion of the bridge two of Turner's patent point controllers are brought into operation; and these actuate the semaphore arms and catch points at points G in Commercial-street and B in Bernard-street. The whole bridge equipment, safety signals, catch points, &c., were installed by Messrs. S. Dixon & Son, under the personal superintendence of Mr. W. H. Turner, their chief engineer, and the patentee of the automatic point controller. A car shed has been erected and will house about 48 cars, while the repairing shop accommodates seven cars. There are 10 sidings in the former, all with repairing pits under practically their full length. Rails are laid in the bottoms of these repairing pits on which may be run small bogies or trucks. These have a lifting jack for the purpose of carrying any part of the motor equipment from under the car. The trucks can then be run on to a traverser truck in the pit at the end of the car shed, along the gable, into the repairing shop or vice versa. This saves a considerable amount of handling, and the traverser pit does not encroach on the storage capacity of the car shed. The trolley wiring of the car shed and repairing shop is all suspended on span wires and no troughing is used.

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* *The Electrician*, Vol. LIII., p. 382.

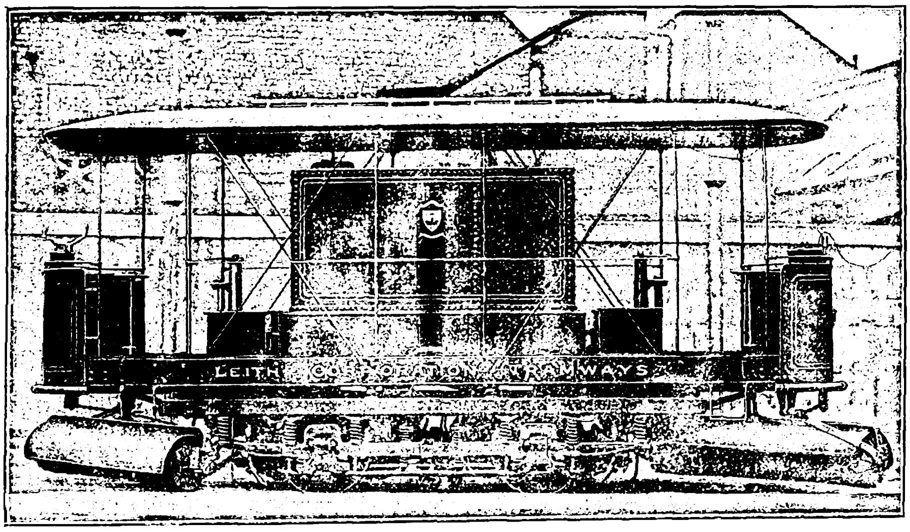


Fig. 4.—Sweeping and Sprinkling Car.

There are 30 ordinary double-deck cars and six covered top double-deck cars. The contract for them was equally divided between the British Thomson-Houston Co. and the Brush Electrical Engineering Co., each supplying 15 ordinary double-deck cars and three covered top cars. The bodies and trucks of the B.T.-H. cars were made at Preston at the United Electric Car works. Their overall length is 27 ft. 6 in., the overall width 6 ft. 9 in., and the height from rail to trolley plank 9 ft. 7 in. on the double deck cars and 15 ft. 8 in. on the covered top cars. Both have four side windows. The seating capacity of the double-deck cars is 22 inside and 36 outside, a total of 58, and of the covered top cars 22 inside and 34 outside, a total of 56. The wheel base is 6 ft. in length. All cars are fitted with Brill 21 E. type trucks with wrought iron centre wheels and steel tyres 31¾ in. diameter, made by Messrs. John Baker & Co. Ordinary rachet spindle hand brakes are fitted with a block to each wheel and also Tidswell life guards.

The electrical equipment consists of two motors of the G.E. 54 type with four turn armatures, two controllers of the G.E. 8·18 type with rheostatic brake of five notches and the necessary resistances, circuit breaker, fuse, lightning arrester and trolley earth indicator, &c. On the ordinary double-deck cars there are 18 16 c.p. incandescent lamps and on the covered top cars 22 lights. The covered top cars have sash side windows and sliding panels on the roof similar to those on the Liverpool cars.

The bodies, trucks and equipment of the Brush cars were made at the Brush Company's works. Their overall length is 28 ft., the width 6 ft. 9 in., and the height to trolley plank on the ordinary double-deck car 9 ft. 10⅝ in., and of the covered top car 15 ft. 8 in. from the rail. Each double-deck car is capable of seating 22 inside and 34 outside, a total of 56, and each covered top car carries 22 inside and 32 outside, a total of 54. The wheel base is 6 ft. in length, and the trucks are the Brush A.A. type. The wheels are by Messrs. John Baker & Co., with wrought-iron centres and steel tyres 31¾ in. diameter. Ratchet spindle hand brakes are fitted, with a block on each wheel, and Hudson & Bowring life guards. The motors are of the Brush 1,002 B type. Rheostatic braking controllers are fitted, with five brake notches and the necessary resistances, circuit breaker, fuse, lightning arrester (Garton), and trolley earth indicator. The ordinary double-deck cars have 18 16 c.p. lights, and the covered top cars have 22. Fig. 4 shows the sprinkler and sweeper car, whose tank has a capacity of 1,000 gallons of water. It has two G.E. 58 motors with six-turn armatures, two B.T.-H. B. 18 controllers, and the other B.T.-H. equipment. It is fitted with two revolving brooms, snow plough and sprinkler. The body and truck were made by the United Electric Car Works, Preston, and the electrical equipment by the British Thomson-Houston Co.

The permanent way, overhead equipment and the car shed were all constructed by the Corporation: the permanent way under the superintendence of Mr. J. R. Findlay, burgh surveyor: the car shed under Mr. George Simpson, burgh architect; and the overhead equipment under Mr. A. Peden Rutherford, burgh electrical engineer. Mr. Rutherford also carried out all the extensions for the tramways in the electric light station, including boilers, engines, switchboard, &c.

## ELECTRICITY AND SEWAGE DISPOSAL.

(*Concluded from page 214.*)

Where tappings are taken from the main overhead line, or where sharp curves are encountered, steel poles and shackle insulators are employed, but for the rest of the way wooden poles, thoroughly soaked in creosote, and ordinary petticoat insulators are used. The shackle insulators are 7 in. in diameter and 5 in. in depth, and each has two ridges; the petticoat insulators are 5 in. wide and 5 in. high, and each has three sheds of a depth of 2¼ in.; the poles are 32 ft. 6 in. high, 10 in. in width at the bottom, and 6½ in. at the top.

Naturally the overhead line is not of the same section throughout, many of the tappings being much smaller, as is also the line itself towards its end. This grading has been effected so skilfully that a drop in pressure of only 7½ per cent. over the whole line is obtained at maximum load. In all cases where the overhead line enters or leaves a building, lightning arresters of the standard B.T.-H. type have been installed.

From the generating station the line proceeds to the Drainage Board's Saltley farm. Here the line is tapped and led into a sub-station, which is a portion of the old farm buildings converted for the purpose. This sub-station contains three B.T.-H. transformers, each of 5 kw. capacity and the necessary controlling switchgear. These transformers are used for supplying power to three 2½ h.p. B.T.-H. motors driving sewage screens, and one 8 h.p. B.T.-H. motor driving farm machinery through a countershaft, and for lighting the offices and the house of the superintendent of works. The 2½ h.p. motors for driving the screens are 200-volt 50-cycle machines, running at 1,420 revs. per min., and are connected to the screens through spur reduction gearing. From Saltley the H.T. line proceeds towards Minworth to the Troutpool pumping station. Each pumping station is divided into two rooms, one containing the pump, motor, starting gear and H.T. switch gear, and the other the transformers. The Troutpool pumping station contains one 6 in. Gwynne centrifugal pump, designed to raise 696 gallons per minute against a head of 16 ft. It is directly connected to a B.T.-H. 8 B.H.P. 712 revs. per min. three-phase motor. The starting gear for this motor is supported on brackets from the floor immediately adjacent to the motor, and the same plan is followed in all the other pumping stations.

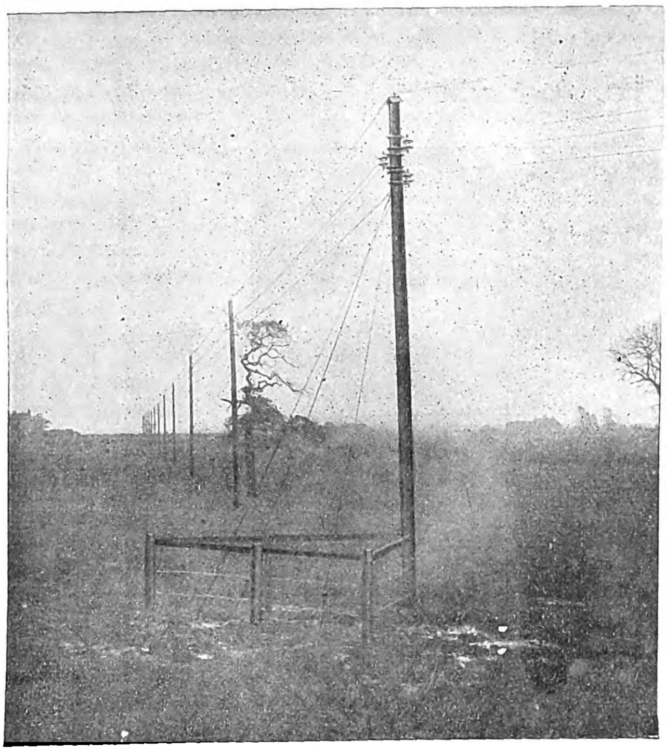


Fig. 6.—View of Overhead Line.

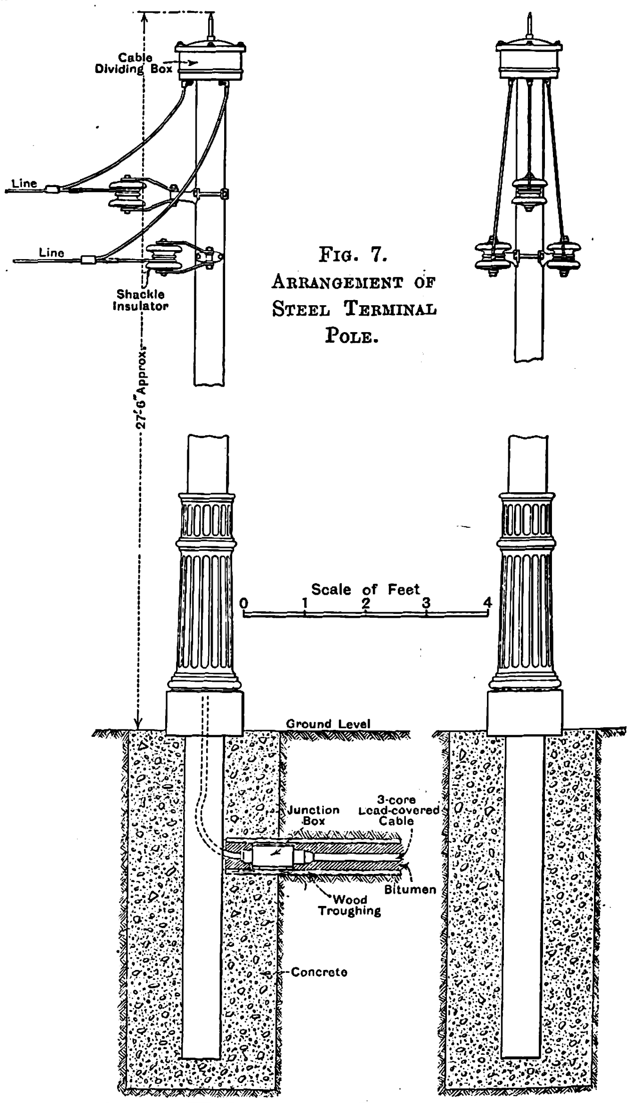


Fig. 7. Arrangement of Steel Terminal Pole.

Cable Dividing Box
Line
Line
Shackle Insulator
27'-6" Approx.
Scale of Feet
0
1
2
3
4
Ground Level
Junction Box
3-core Lead-covered Cable
Bitumen
Wood Troughing
Concrete

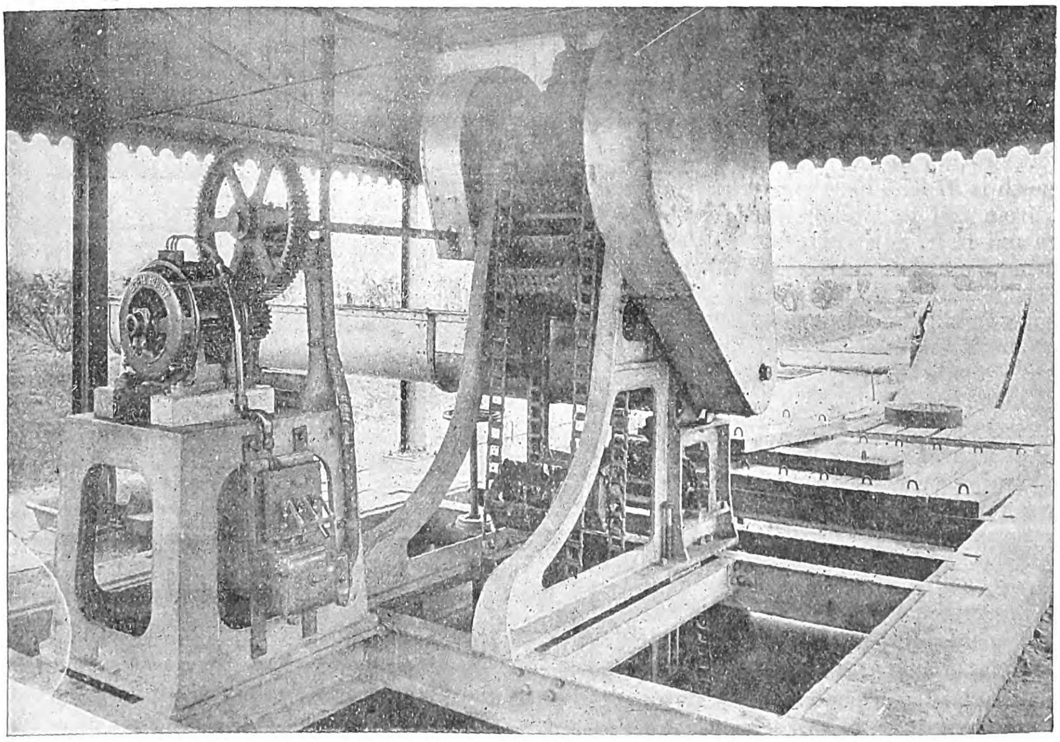
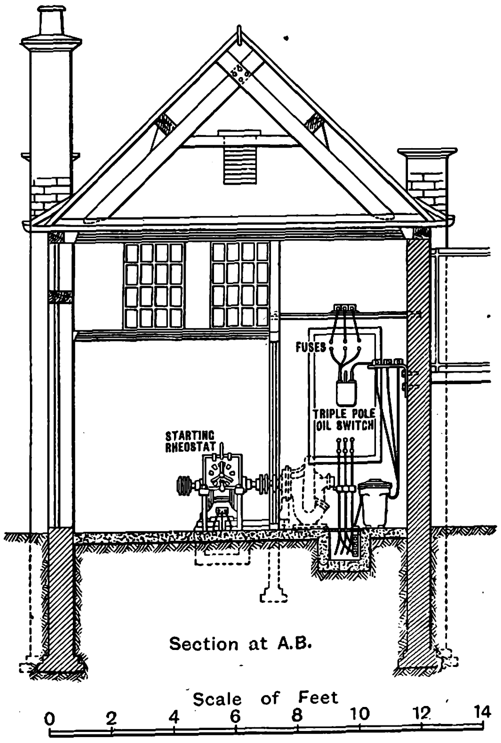


Fig. 8.—Electrically-driven Sewage Elevator.

The switch panel (which in every case includes a B.T.-H. high-tension oil switch for isolating the station from the line) is built into the wall so that the back of the panel is accessible from the transformer chamber only. All parts carrying high-tension current are on the back of the panel, and it is, therefore, impossible for accidental contact to be made with the high-tension gear from the front of the panel. The transformer chamber at Troutpool contains two 4 kw. single-phase transformers having a ratio of 2,200 to 200, and is divided from the pump room by a brick partition, the door between being kept locked, and access to it obtained only by the authorised staff of the Board; thus the risk of accident, due to ignorance or carelessness, is reduced to a minimum. Similar precautions are taken at all the other stations.

In all the pumping stations the cables connecting the transformers to the switchboard are run in special trenches, covered by chequer plates, and readily accessible. The back of the switch panel projects into the transformer chamber in such a manner that the switch panel itself really forms a portion of the dividing wall between the pump room and the transformer chamber. This ensures the most efficient and shortest length of cable connections possible between the transformers and the controlling gear. All the pumping and sub-stations are arranged in a similar manner, the only difference being in the number of circuits controlled from the sub-station to meet the requirements of the particular area supplied from it.



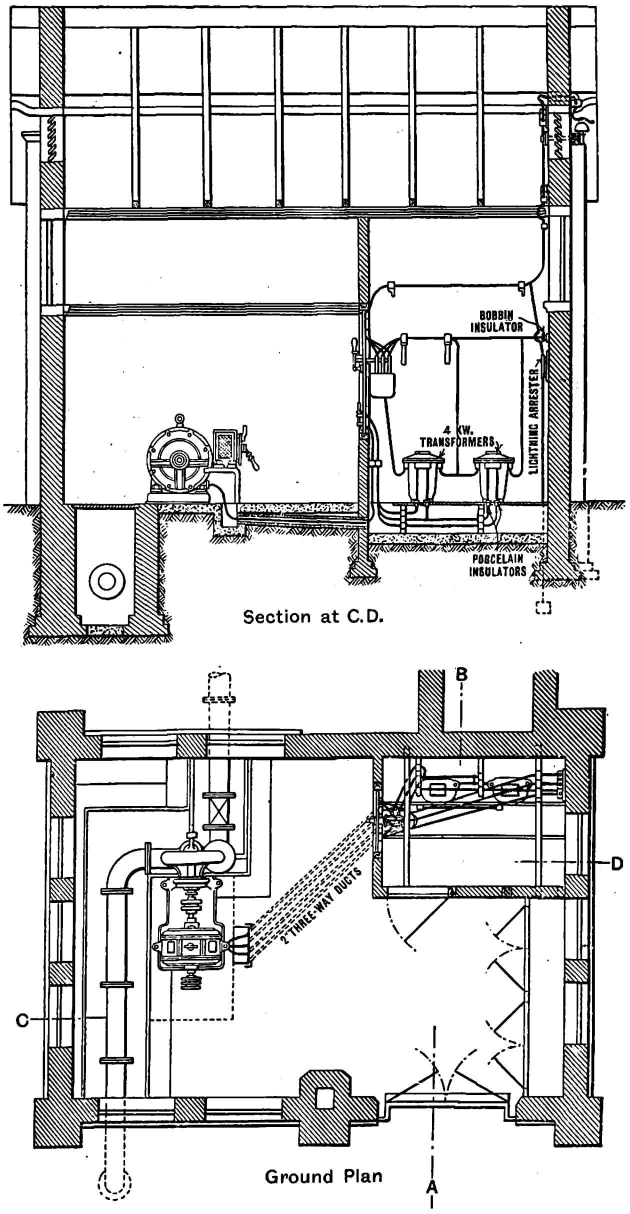


Fig. 9.—Bromford Pumping Station, showing General Arrangement of Plant.

From Troutpool the line proceeds to a pumping station at Bromford, which, like the Troutpool pumping station, is equipped with a Gwynne 6 in. centrifugal pump designed to raise 696 gallons per minute against a head of 16 ft., and direct-connected to a B.T.-H. motor of 8 B.H.P. capacity. The transformer equipment in this station is similar to that at Troutpool. At Ashold is another pumping station. This station contains one 7 in. pump designed to raise 896 gallons per minute against a head of 32 ft. It is directly connected to a B.T.-H. motor of 22 B.H.P. capacity, working at 575 revs. per min.

The transformer chamber at the Ashold sub-station, which is designed in a manner similar to those already described, contains three single-phase transformers of 10 kw. capacity each, and a switchboard built in the wall for controlling the high-tension current from the line to the transformer and thence to the motor. In the case of this sub-station, however, the high-tension line is brought into the station underground, whereas in the case of the others the high-tension line is tapped immediately opposite the sub-station, an offset being taken, and the line led into the sub-station from shackle insulators, to which are connected three highly insulated cables, which are led through the wall of the sub-station through a special type of porcelain duct. There are two low-tension circuits at Ashold, one for the pump motor and one for the 3½ H.P. motor driving an elevator similar to that at Tyburn.

From this station the high-tension line proceeds directly to Tyburn, where the largest pumping and sub-station is situated. This station is also connected to the high-tension line by underground cable. The transformer chamber contains three 15 kw. and three 7½ kw. single-phase transformers, each being arranged for a ratio of 2,200 to 200 volts. The 15 kw. transformers are for the power circuits, and the 7½ kw. transformers for the lighting circuits. They are all of the B.T.-H. standard "oil-cooled" type. At Tyburn the three power circuits are as follows:—Circuit No. 1 controls one B.T.-H. motor of 8 H.P. running at 960 revs. per min., and one 11 H.P. motor running at 965 revs. per min. These motors are used for the operation of general farm machinery and for driving machinery in the mechanics' and joiners' shops where the mechanical repairs required to the existing plant on the Board's estate are carried out, and any special tools required on the estate are made. Circuit No. 2 controls the pumping station proper, which, as in the case of the other stations, is immediately adjacent to the transformer chamber and contained in the same building. This station contains a Gwynne 8 in. centrifugal pump designed to raise 963 gallons per minute against a head of 30 ft. It is directly connected to a B.T.-H. three-phase induction motor of 22 H.P. running at 575 revs. per min. Circuit No. 3 controls one 3½ H.P. motor running at 1,420 revs. per min., and driving a sewage elevator. The cable supplying this motor is partly underground and partly overhead. The secondaries of the lighting transformers are connected to a special switchboard from which the circuits for the offices, engineer's residence, and the home farm buildings are controlled. The cables for supplying these circuits are laid underground from the sub-station to the various buildings.

The high-tension line continues from Tyburn to Plant's Brook, which has the heaviest duty of any of the pumping stations on the estate. This station is a pumping station only, and contains one Gwynne 10 in. centrifugal pump designed to raise 1,900 gallons per minute against a head of 17 ft.; it is direct connected to a 28 H.P. three-phase B.T.-H. induction motor, running at 475 revs. per min. The transformer chamber contains three 10 kw. single-phase transformers having a ratio of 2,200 to 200 and the usual controlling switchboard.

Near this station the high-tension line is led into a conduit laid for the purpose under the Midland Railway in 1900, and thence to Minworth Greaves, where at present it terminates. The sub-station at Minworth Greaves is used for supplying power to operate two sewage distributors, which were previously operated mechanically, and are used for distributing sewage over circular bacteria beds. This sub-station contains three transformers having a ratio as before of 2,200 to 200 volts, and the necessary switchboard.

Provision has been made under a new contract to extend the high-tension line from this point ½ mile further towards Curdworth, where the Drainage Board are carrying out very extensive works in the building of bacteria beds, and where it is intended to light the beds with arc lamps and to operate electrically the gravel-washing machinery, consisting of a pump, stone-crusher and winch.

It is also intended to extend the use of the electric power thus obtained by installing silt pumps 400 yds. from the Minworth Greaves terminus. These pumps will be supplied with current at a pressure of 200 volts from the same sub-station as the gravel washer.

In concluding this article, we have to express our thanks to Mr. J. D. Watson, engineer to the Drainage Board; to the British Thomson-Houston Co. who have carried out the entire contract; and to Mr. J. Cosans, their resident engineer, who has been responsible for the erection of the plant and transmission line and so courteously conducted us over the works and gave us a large amount of information.

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## APPLICATIONS OF ELECTRICITY IN THE ROYAL GUN FACTORY, WOOLWICH ARSENAL.*

BY COL. H. C. L. HOLDEN, R.A., F.R.S.

(*Continued from page 218.*)

*North-east Shop.*—This is the most recent shop built in the Royal Gun Factory, and was designed with a view to electric driving. The work done in this shop is in connection with the smaller kinds of guns, and their mechanisms. It is a lofty building measuring 200 ft. by 120 ft., with the now common saw-tooth roof, and divided into four bays running east and west. There is a gallery running all round it for fitters and bench work, offices, &c., and the large amount of glass makes it very light. Each bay is served by two 8-ton electric cranes. Altogether on the ground floor there are 83 machine-tools, of which 21 are separately motor-driven, the other 62 being grouped and driven from one of the four main shafts which serve the same number of bays. The method of driving these main shafts 200 ft. long is by means of a 30 H.P. motor (Fig. 7) suspended from the girders and situated in the centre of the shaft, to each half of which it is coupled direct; the speed of the shaft is 250 revs. per min.

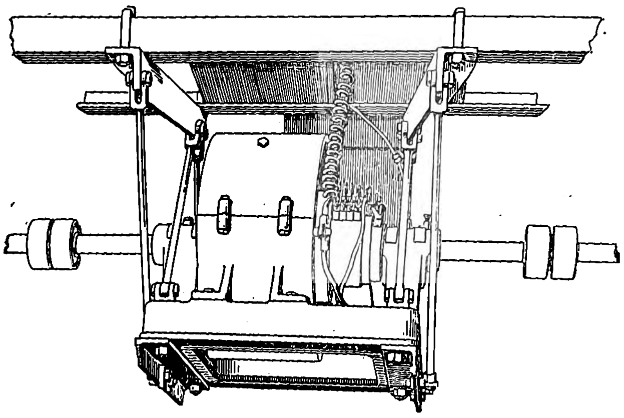

FIG. 7.

*Grindery.*—As in most modern workshops, it is the custom to grind the workmen's tools for them, and not to allow them to do this for themselves in the old-fashioned haphazard way on a grindstone. In the grindery devoted to this work some 12 Gisholt tool-grinders are continually in use, and the problem to be solved was to drive them in the most economical and efficient manner. The grinders were arranged half on either side of the shop, and driven by belting (Fig. 8) from a shaft running at very nearly the same speed as the wheels, and coupled direct through a flexible coupling to a 6 H.P. shunt motor standing on a bracket fixed to the wall. The speed of the shaft is 1,400 revs. per min. Besides the tool-grinders there are also two small cutter-grinders, and in order to drive these latter, which are placed across the shop, it was necessary to have a shaft running at right angles to the other two. As the power required was small, this motion was transmitted by a friction disc and wheel, the wheel being advanced so as to be in contact with a disc when it is required to rotate the shaft, which consists of a thin steel tube, and runs at 2,500 revs. per min. Some doubt was expressed as to the life of these high-speed shafts and bearings when they were first erected, but as they have been working for the last three years with practically no wear; it is evident there is no need for apprehension that they will not last. The economy in transmission here is considerable, owing to there being none of the usual countershafting; it is not uncommon to see machines of this sort driven from a high-speed motor, which from a small belt pulley on its own shaft, drives a large one on a countershaft, which again drives by means of another large pulley the small pulley of the grinder. The best wheels for use on these

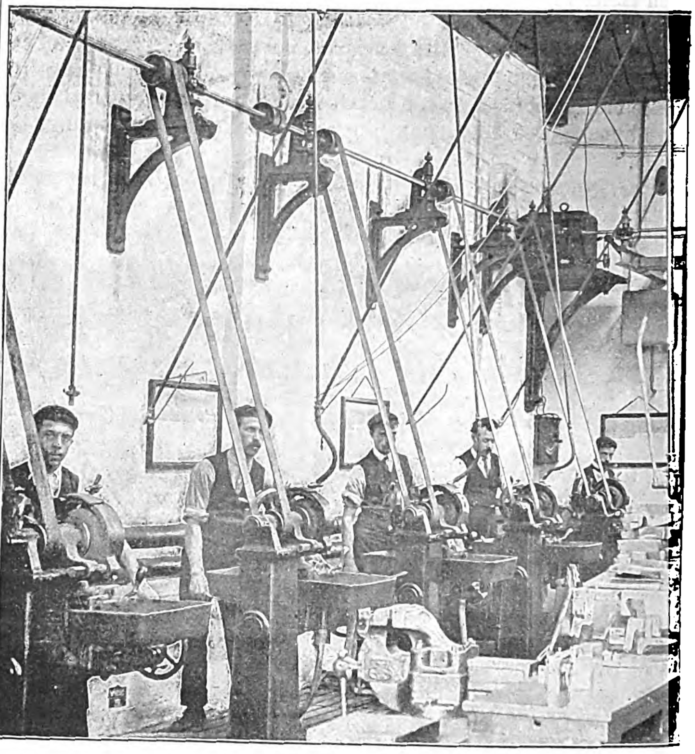

FIG. 8.

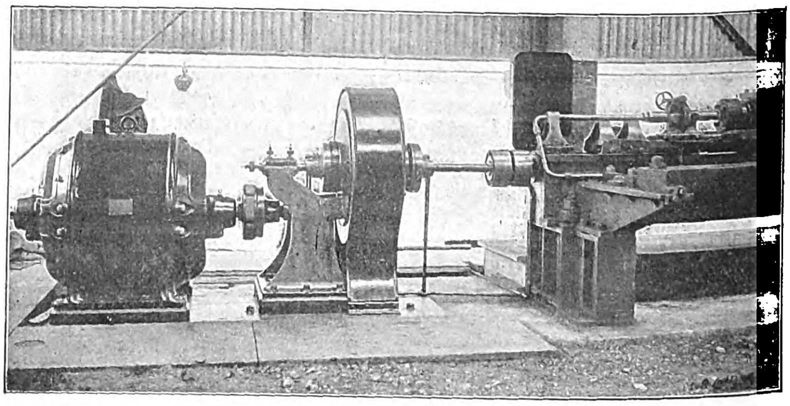

FIG. 9.

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* Paper read before the Institution of Electrical Engineers, Nov. 23rd.

grinders for high-speed tool steel have been found to be carborundum ones. Carborundum, as we know, is itself electrically produced at Niagara Falls.

*Rifling Machine.*—The method of driving of a large rifling machine for 12 in. guns is shown in Fig. 9. The term "rifling," of course, is applied to the operation of cutting the grooves which run spirally along the bore of a gun. In order to do this, a bar carrying one or more tools to cut the grooves, is drawn through the gun, and turned as it is moving to give the required twist. The saddles which guide the bar are carried on a bed within which is the screw for actuating the bar; as this screw revolves in one direction or the other, so the bar is moved in or out of the gun—cutting is always done by pulling the bar through, not pushing it, and indeed I may remark that in boring operations it is always better to have the cutter bar in tension than in compression; the end of this screw is coupled to a shaft passing right through the gear-box and supported in the bearing shown on the left of it in the picture. This shaft carries two magnetic clutches (Fig. 9), one on either side of the gear-box. The motor of 30 H.P. drives a pinion which is always in gear with the teeth of the large internally geared wheel and also with a small spur wheel, running on the same centre as the former, but of course in the opposite direction. A clutch on the left connects the screw shaft to this latter wheel, whereas the clutch on the right attaches it to the internally-geared wheel. It will be obvious that the direction of rotation of the screw shaft will be different, according as one clutch is in action or the other, and owing to the different ratio of the gears a quick return motion when not cutting is obtained. The motor and the gears run continuously in one direction, and therefore there is only the momentum of the screw shaft and inertia of the screw and saddles with the rifling bar to overcome on reversal of its motion. The action of reversing is entirely automatic, and worked by the movement of the rifling bar saddle. This drive works very smoothly and well—it enables the rifling of a 12 in. gun to be carried out in 40 hours, six grooves being cut simultaneously, whereas only a few years ago the same operation, with one tool only cutting, took more than three weeks, working day and night; no less than 26 cuts have to be taken to finish each set of grooves, and I am able to show specimens of the shavings taken.

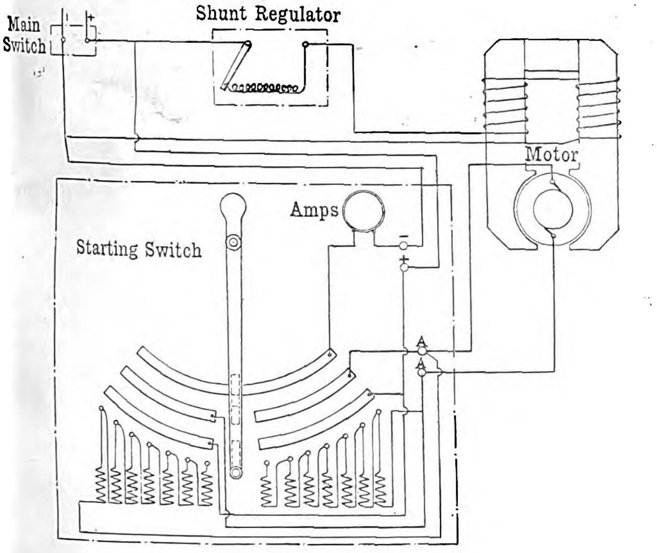

FIG. 10.

In contrast to this machine, I have an illustration of another driven by the older method of crossed belts, which go through the usual shrieking performance whenever the drive is reversed. Within the last few weeks, however, this latter machine has been dismantled in order to lengthen it, and fit it with a driving gear similar to the one already described.

For lapping the bores of guns, an operation which has to be done in order to get the extreme uniformity of diameter that is necessary in the bore, both during manufacture and sometimes after the gun has been in use, there are three machines in the factory for dealing with various sizes of guns. Two of these were designed to be driven by separate motors, and the third was converted to an electric drive.

I may remind you that the operation of lapping is performed by means of an expansible lead-covered block or head charged with abrasive material, such as emery or corundum, which is attached to the end of a rapidly revolving shaft, and is capable, whilst revolving, of being moved from one portion of the bore to the other. A short and rapid to-and-fro motion should preferably be given to this head, so as to prevent the cutting of rings in the bore. The largest of the three machines is devoted to the larger guns, such as the 9·2 in. and the 12 in., and the motor is mounted above the saddle which carries the lapping shaft, and drives the latter by means of a short link belt. The large pulley is attached to the shaft by a feather sliding in a feather-way cut the whole length of it, and in this manner rotates the lapping head. The saddle is traversed backwards and forwards along the bed by a screw extending the whole length of the bed and similar to the leading screw of a lathe. This screw, however, is stationary, and the traversing motion of the saddle is produced by means of a revolving nut, which is driven also by a linked belt and through reducing gear from a pulley carried on the other end of the motor shaft. The quick to-and-fro motion is given to the bar by the sleeve, which is clamped on to the bar between the two cheeks of the saddle and has cam grooves around it in which guide blocks fixed to the saddle are made to engage when required.

The liquid reverser, worked either automatically or by hand, is in front of the starting switch. The tightening of the belt is accomplished by sliding the motor across the saddle, and can be done by the hand-wheel when the machine is running.

The next size of machine is somewhat similar in design, but the motor is underneath the bed, and drives by gear entirely; the motor is not easily accessible, and is more liable to damage from emery and oil, and is mentioned more as an example of how not to do it. I must add, however, that it works very well. A diagram of the switch connections is shown in Fig. 10.

The smallest machine, situated in the north-east shop, is really a converted lathe, and is devoted to the smaller size of guns up to 4·7 in. I mention this as a practical example of the advantages possessed by magnetic clutches over the old system of reversing by a shifting belt. The machine, originally, had two shifting belts with loose pulleys and a fast pulley between them, on to which the belts were shifted in turn for reversing the direction of motion of the screw actuating the saddle. The central pulley was done away with, and magnetic clutches were applied to the other two; either one of these can be energised by a rocking switch actuated by hand or automatically. The result of this change was to enable the saddle screw to be run much quicker than before, the reducing-gear between the pulleys and the screw being removed, and the latter driven direct, while the motion is reversed silently, instead of with a screeching of belts and clashing of gear. Altogether, four magnetic clutches are used with this machine, two on the main shaft, one to drive the headstock which rotates the gun, and another to drive the open and crossed belts, and then there are the two already described. This may seem a somewhat extravagant number to employ on one machine, but it is justified because the machine is not one that is in constant use, and the power absorbed by running three belts idle is very considerable, and quite a large figure when compared even with the total capital cost of the clutches, instead of the interest thereon and depreciation.

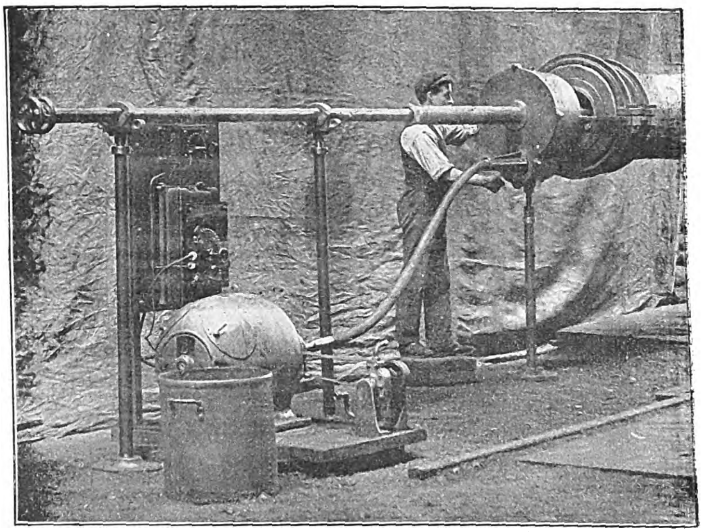

FIG. 11.

An illustration is also given of a portable electric lapping machine (Fig. 11) for use on board a ship or elsewhere. The machine itself, which embodies most of the features of the large machine, is here attached to the muzzle of the gun, and rotation is imparted from the motor to the machine by a flexible shaft (Fig. 12). The forward and backward feed of the lapping head is obtained by means of a friction clutch, controlled by a small lever, which regulates the movement of the nut through which the screw-feed bar passes. If the nut is held still, the bar advances at the highest speed; if the nut is allowed to revolve at the same speed as the bar, no forward or backward movement takes place; and if the nut is driven faster than the bar the motion of the latter is a backward one. In the first case the friction clutch is out and the nut held; in the second case the nut is free to revolve; and in the third case, the friction clutch being in, the nut is revolved at a higher speed than the bar, and so the bar is withdrawn. The power required for a lapping machine is always out of all proportion to the weight of metal removed, and in this case a motor of 6·5 H.P. is necessary.

We now pass to the electrically-driven planing machines, and I may here say that, so far as planing machines generally are concerned, I am in favour of cutting in both directions with two separate tools whenever and wherever it is possible, the economy in power, time, and labour being greater than having a quick return stroke, for it is obvious that however rapid the return stroke may be, time is lost, and no useful work is done. This will explain why the gear is so designed that the speed of the table in either direction is the same. In the case of planing machines, as in the case of the boring machines, I hold a strong brief for the screw drive as against the rack and pinion drive. The former undoubtedly does the better work. The planing machines are driven by a shunt-wound variable-speed motor, which runs continuously in one direction, and drives, by means of a bevel pinion, two bevel wheels revolving in opposite directions (Fig. 13); these two bevel wheels are concentric with the shaft which drives the screw of the planing machine, and are each furnished with a magnetic clutch, by which they can be attached to the shaft; the clutches are alternately energised by a rocking switch, actuated by adjustable tappets on the bed of the planer. The reversing action of these machines is very quick and silent. No check or change of speed is discernible in the motor, though, of course, the ammeter shows a momentary rise of about 25 per cent. on the reverse.

The special shaping machines used for interrupting the screw threads in the breach openings of guns seem very well adapted to driving in pairs, and this arrangement has therefore been adopted. The motor drives a counter-shaft placed above it, and the two machines are driven each by its own magnetic clutch, from this countershaft, by belting.

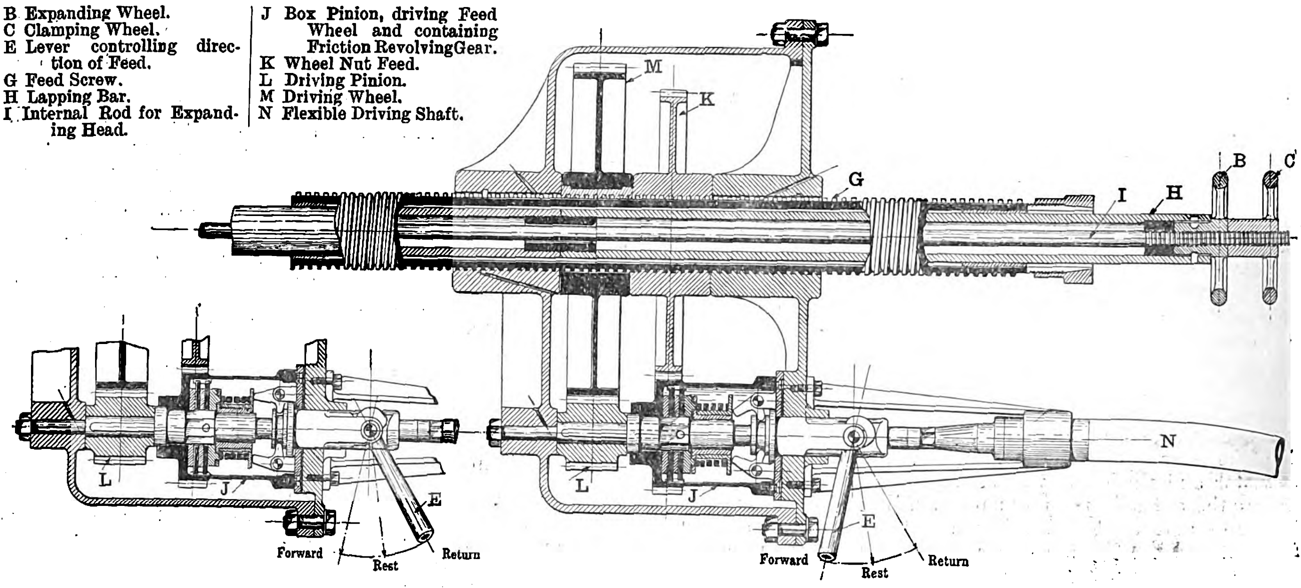
B Expanding Wheel.
C Clamping Wheel.
E Lever controlling direction of Feed.
G Feed Screw.
H Lapping Bar.
I Internal Rod for Expanding Head.
J Box Pinion, driving Feed Wheel and containing Friction Revolving Gear.
K Wheel Nut Feed.
L Driving Pinion.
M Driving Wheel.
N Flexible Driving Shaft.

FIG. 12.

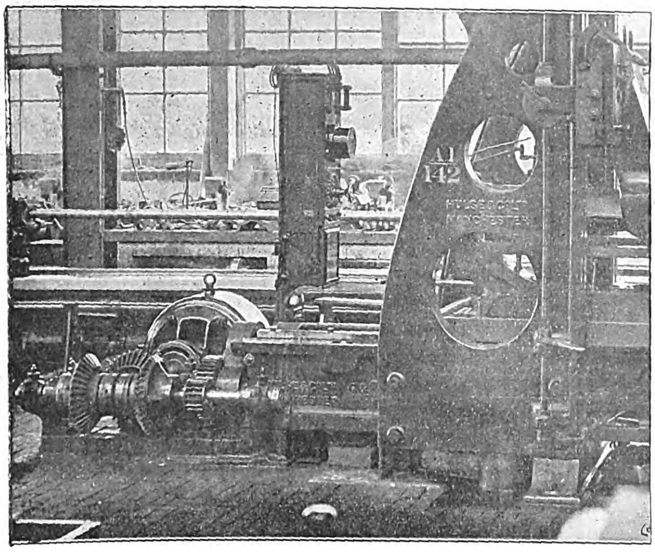

FIG. 13.

Mention may also be made of a heavy vertical milling machine, which was not originally designed for electric driving, but had to be converted. Though I am not in favour of very short belt drives when there is a difference of diameter between the driven and the driver, yet, in this case it was almost the only arrangement possible, and, in point of fact, it has been very successful, the motor being supported on a T-shaped bracket attached to the upright of the machine, and to the portion of the frame carrying the driving shaft.

Earlier in the Paper I described a separate-feed arrangement for a large boring machine, and I now propose to illustrate a smaller one for high-speed solid boring fitted with a somewhat similar arrangement. The machine itself has a mandrel, which is driven by a motor through a single-reduction gear, for the reason that, although it would have been preferable to drive it direct from the motor shaft, this was not practicable, owing to the comparatively low speed required; the thrust of the boring tool (which is very considerable) is taken by a ball bearing of large diameter forming the back of the face-plate (Fig. 14), a device which has been very effective.

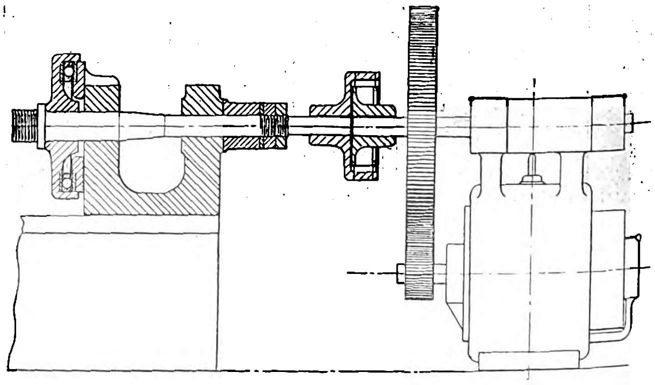

FIG. 14.

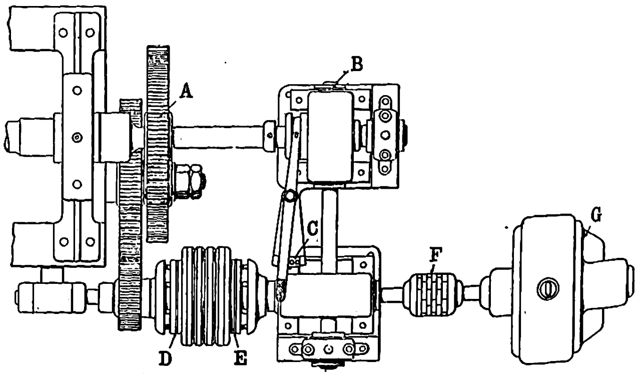

FIG. 15.

The feed gear is shown in Fig. 15. This, as in the other example, fulfils two functions—viz., that of the actual feed of the tool into the work, and also the quick withdrawal and advance of the same. In this instance two clutches are used, in conjunction with a claw clutch; and besides the safety arrangement provided to prevent the feed gear running after the headstock is stopped, or being started before the other is in motion, there is also a switch worked by the lever actuating the claw clutch, which prevents the two clutches being operated simultaneously, or even the wrong one being operated. When the feed is in operation the motor is clutched to the first worm shaft and turns the first worm wheel, which in turn drives the worm of the second worm wheel, and the claw clutch being engaged, the screw is driven, and the saddle carrying the boring bar advanced. If now it is desired to withdraw the bar rapidly, the claw clutch is withdrawn, and the motion of the lever effecting this allows the second magnetic clutch to be rendered active, and this clutches the pinion to the motor shaft, and drives the spur wheel through the intermediate wheels. The speed of the carriage when feeding varies from 33 in. to 115 in. per hour, whilst the quick return is from 7 in. to 24 in. per minute, or nearly 13 times faster.

In the south boring mill it used to be the custom, as elsewhere, to have each large boring machine supplied with cutting lubricant by a small and separate plunger pump, but a short time since, it occurred to me that it would be preferable to have a constant and general supply from one source, and to do away with the small separate pumps. A high lift centrifugal pump, driven direct from a motor, appeared to be the most suitable pump for the purpose, and the pressure required being only 30 lb. per square inch, an old boiler was utilised as an accumulator and air vessel to maintain the pressure. The motor is coupled to the pump (Fig. 16) through a magnetic clutch and flexible coupling, and runs at 1,200 revs. per min., the clutch being used to connect or disconnect the two when the pressure falls below or rises above the amount that the automatic switch is set for. It is somewhat remarkable to see the extremely quick, and yet, as it must be, gradual, action of the clutch in starting the pump, which is of course started from rest with a full head—there being no appreciable delay or shock in so doing. This installation has proved so successful that a second set is being obtained, to enable the whole shop to be supplied. The motor of the second set will be so arranged that it will only be started when the first set cannot meet the requirements. The pump takes 14 E.H.P. and lifts 300 gallons per minute.

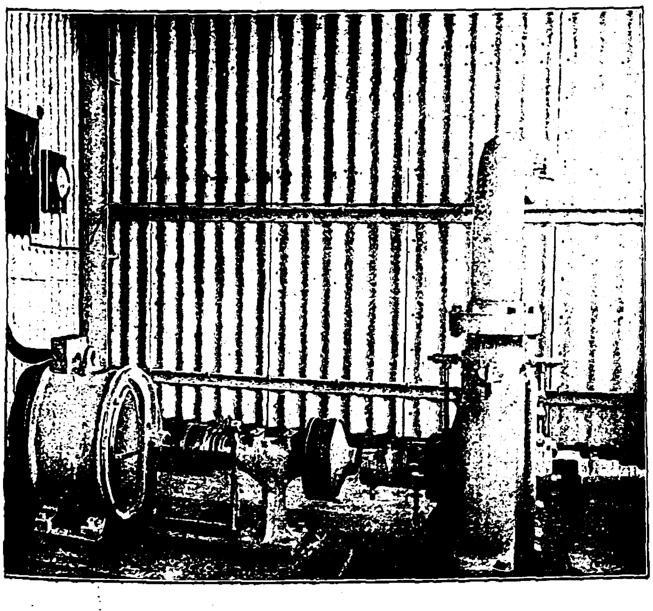

FIG. 16.

(*To be concluded.*)

## EFFICIENCIES.*

BY JAMES SWINBURNE.

The title of this Address is put in the plural to prevent any misunderstanding as to its nature. Efficiency is, I believe, a catchword in party politics, and is, therefore, largely employed in connection with people who have no real output at all. This Address on the contrary is concerned with real questions. The term "efficiency" is used by serious people to denote the rate of the useful part of the energy or power obtained, to the energy or power put in. There is another aspect of the question, and the term "efficiency" may be stretched to cover questions of money. For instance, if in a bargain you get 15s. worth of goods for £1 the purchase may be said to have an efficiency of 75 per cent. But in cases of this sort it is not quite usual for a bargain to have an efficiency of more than 100 per cent. from each point of view. This is because in the case of a well conducted bargain, each of the parties, to use a legal word, gives what he prefers to part with for what he wants more; so that both are satisfied. But the seller may take another view; he may have bought an article for 15s. and sold it for £1. In that case he apparently makes 5s., and it might be called 33 per cent. of the cost price, or 25 per cent. on the selling price. The term "efficiency" is not applied to such cases, because "efficiency" is employed in cases where there is a partial loss, to show how much has not been lost. Cases of profit would be cases of efficiencies of over 100 per cent. A trader who looked upon buying at 15s. and selling at £1 as making a profit of 33 per cent. would really be deceiving himself, because in such cases it is not really a question of how much is made over and above the apparent purchase price, but of what profit is made per annum on his trade capital. Into this question all sorts of considerations enter, that do not appear in the statement of simply buying and selling. If he is merely a trader who buys and sells he has to pay rent, incurs bad debts, loses stock through depreciation and other causes, and has to give his time to the work. He also may have to spend a good deal on advertising.

Another simple case is that of manufacturing. If an engine builder, for example, spends £1,000 on wages paid to men who have made an engine, and £1,000 for material, and sells an engine for £3,000, it is commonly said that he has no business with the odd £1,000; either he is said to have overcharged his customer £1,000, or he has robbed the workmen of £1,000, as it was their work that made the engine. Both these notions arise from ignorance; and this ignorance, like all other kinds of ignorance, does a great deal of harm. The argument that all the money paid to manufacturers should go to workmen who actually make the goods is always employed by the agitators who live by stirring up the passions, and flattering the weaknesses of their victims. It may seem strange to bring forward such questions in an address to electrical engineers; but I want to urge the importance of looking at things from a money point of view, because all engineering is a question of money; and I want to bring some money questions as well as energy and power questions before you to-night.

In making any bargains with Nature, we always lose in a sense; and we are so accustomed to it that we take it quite contentedly, and merely try to lose as little as possible in the transaction. As I said before, the relation of what we do not lose to the whole is termed the "efficiency." In dealing with our fellow men we always hope to make a profit, and we sometimes do. In such a case it might be correct to talk of an efficiency of over a 100 per cent, but it would be unusual. It might be still more unusual to say a bankruptcy which resulted in a payment of 6s. 8d. in the £ was a transaction with an efficiency of $33\frac{1}{3}$ per cent. But there would be enough justification for such a proceeding to enable me to discuss some aspects, even of electrical commerce, under the head of "efficiency."

Heat includes what is called sensible heat, or heat that makes things hot; latent heat, such as the heat that disappears when ice is melted or water vaporised at constant temperature, and chemical energy. I must tell you that it is not orthodox to call chemical energy heat; and you will not find any such treatment of the subject in books on thermodynamics. At present I believe I am alone in classing chemical energy or defining heat so as to include chemical energy; but the treatment of chemical energy in chemical thermodynamics is quite consistent with my definition, so I may use it provided I give you due warning of any heterodoxy. I think that it is not realised that chemical energy is necessarily low-grade energy, only partially convertible into work. This involves the idea of chemical temperature which may be important in chemistry in discussing the way any given possible reaction will go; but we are not concerned with that here. It will be said that the coal is cold when it is put into the furnace, as cold as the air in fact; so that if this idea is right none of the chemical energy is available. But I must give some idea of what I mean by chemical temperature. If carbon and oxygen are heated to a high enough temperature you get a state in which on the least fall of temperature the carbon and oxygen combine and give out sensible heat at that temperature, under the other circumstances that obtain. The least increase of temperature, however, causes the carbon and oxygen to separate again, absorbing sensible heat. At this temperature, therefore, under the pressure and quantitative relations of the carbon, oxygen, and carbon monoxide, sensible heat and chemical energy are interchangeable. This temperature may be called the chemical temperature of the energy of carbon and oxygen. I need not trouble you with discussions as to whether the energy is really in the carbon or the oxygen or the ether, or as to the effect of pressure and proportions of carbon oxygen and monoxide on the reaction. I merely want to give you a broad idea of carbon as having or controlling chemical energy, or heat with a corresponding "chemical temperature" of the order of 3,000°C. or more. If the burning coal, containing of course other constituents, such as hydrocarbons with other chemical temperatures could hand over their heat at 3,000°C., nearly all of it would be available. As the heat is finally rejected at condenser temperature of 100 deg. or so, 3,000 - 100/3,000, or about 97 per cent. of it would be available. But the boiler takes it up at under 500°C. absolute, so that five-sixths is degraded or rendered unavailable right off.

It might be supposed that there is enormous room for improvement in the steam engine. An efficiency diagram looks as if all the loss is due to the engine which gets 68 per cent. and only gives out 7 per cent., but we must not be hard upon the engine. It is turning out work, or high grade energy, and it is receiving heat, or low grade energy. This engine is probably taking in steam at about 450°C. absolute, and rejecting it at about 375°C.A., so it could if perfect only turn out $68 \times 75 \div 450 = 11{\cdot}3$; so it is not really doing so badly. The real loss is between the fuel and the boiler, and it is not loss of energy, but loss of availability. Though the chemical is low grade energy, it has such a high chemical temperature that 97 per cent. is theoretically available; but we cannot run a boiler and engine between 3,000°C. and 4,000°C. Engineers are always trying to improve the results by using higher and higher temperatures; but as you cannot use the pressures that would then correspond with saturated steam you can only superheat. This does not mean that most of the heat is taken in at the high temperature, and the resulting gain is chiefly due to such things as reduction of cylinder condensation. There are great practical difficulties in reducing the lower temperature. The condenser reduces it to about 100°C. or 373°C.A.; but even then the steam is not completely expanded, and blows into the condenser under pressure. The efficiency has been raised more recently by reducing the lower temperature limit by means of sulphur dioxide. I do not know who was first to propose this. Rayleigh suggested it as early as 1876. It is being put in practice now in Germany.

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* Abstract of an address delivered last Friday to the students of the Manchester Local Section of the Institution of Electrical Engineers.

At this stage I would like to say that this is given as an address in my own name because I was asked to give an address. If it had been a Paper, Mr. Walter Claypoole, lecturer on electric lighting and power distribution at Croydon Central Polytechnic, would have been joint author nominally, as well as in reality. I am indebted to him for all the hard work.

The right hand part of the accompanying diagram illustrates the yearly losses in the Metropolitan system, supplying several London areas from Willesden. I am indebted to Mr. Highfield for the figures. It will be seen that the transformers are very efficient, and when they can be cut out at light loads so that the transformers in use are always well loaded, the efficiency can be made very high. The diagram is also a little deceptive because it takes no notice of the time at which the energy is wasted. Energy wasted at the time of station full load is serious, because if it were not wasted it might be sold, or else the station might be a little smaller in proportion. But most of the waste in transformers is at light loads, and it costs very little extra to generate extra power at times of light load; for it costs nothing extra in capital, superintendence or labour, and it does not cost much in coal, for the boilers have to be kept hot, and some engines have to be kept running in any case. These points have to be borne in mind in considering the meaning of such diagrams. It will be seen that there is a loss of 6 per cent. in "station losses," only 2 per cent. feeder losses to sub-stations and 13 per cent. conversion losses and lighting of the sub-stations.

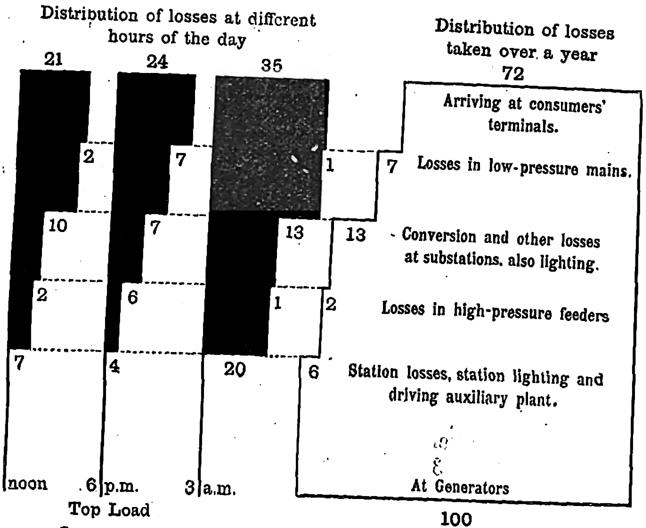

Diagram Illustrating Losses on the Metropolitan Electric Supply Company's System.

These are for the year. They alter from time to time, so the wastes are shown black to the left for three representative times. Thus the station losses are 7 per cent. at noon, 4 per cent. at top load, and 20 per cent. at three in the morning, and so on. This is because the losses do not vary in proportion to the loads. Through the various sources of waste energy, the final result is that there is 21 per cent. loss at noon, or 79 per cent efficiency and 74 per cent. efficiency at 6 p.m., and up to 65 per cent. at 3 a.m., which is astonishingly good when the system is considered.

If a station is run by a town the accounts must be kept by an absurd system. Towns are generally concerned with such things as sewage systems, in which there is no profit and loss account. The town may not treat its sewage system as a permanent asset at all. It has to borrow money to put down its sewage system, say £100,000 at 3 per cent. Then it has to pay £3,000 a year interest. But that is not all—it has to pay back the whole of the £100,000 in a certain number of years. To do this it has to provide out of the rates a sinking fund, such that in the prescribed term of years the whole of the debt is paid off. The town then has a sewage system to the good, which has been paid for over many years out of the rates. The town therefore does not save money like the private individual and then buy what it can afford. I do not think it would be allowed to do such a rational thing; it has to borrow money for everything and pay it back over a term of years, The length of the term has no reference whatever to the nature of the work done, as the work is not in any way security for the loan; the local rates are the security. There is an epidemic of outcry just now about municipal indebtedness, but it is apt to give a totally wrong impression to the average reader, as he does not realise that municipalities must be in debt owing to the way these things are arranged. For a private individual always to be in debt would be bad; for a town it is another matter; the only question is how much the town ought to be in debt. The nation itself does business in the same sort of way; it has no ready money, and when anything has to be done it borrows. But local authorities are now taking up such businesses as electric supply and tramways, which have profit and loss sides; but they are obliged to work the businesses on the same lines as town improvements, which is absurd. A municipal electric light scheme is thus worked under absurd difficulties. It is like a public company that has a negative capital—that is to say, all its money is borrowed. The shareholders are the ratepayers. They hold shares depending on the rate assessments. The dividends are generally negative. All the shareholders are so by compulsion if they live in the place. The only thing they can do if they do not want to be shareholders in such undertakings is to move off to another town; but then they become shareholders in another set of ventures. I believe the only way to avoid being shareholders in these compulsory undertakings is to live in a barge on a canal. Be this as it may, the undertaking, though a profit and loss concern, must keep its accounts on the same principle as if it were a sewage system. To begin with, the town may only borrow enough money to put down the plant. This has to be paid off, as already explained, by the sinking fund, which returns all the borrowed money, in, say, 20 years. The plant may last 10 years, or it may last 50; that has nothing to do with the case. If the plant lasted 20 and then went into powder, like Holmes' "one-hoss shay," the sinking fund would correspond with correct depreciation. If it lasts less something more should be allowed, and less should be written off for the parts that will last longer. This right depreciation to be allowed in municipal works is a burning question between the advocates of municipal trading and its opponents. Again, a private concern would start business with enough capital to put down the station, and to run it at a loss for a year or two until it turned the corner. The municipality may not do anything as sensible as that; it may only borrow money enough to put down the station, and the first few years' losses must be paid for out of the rates for these years. This sometimes excites the ratepayers. Almost any business has to be run at a loss at first, and enough capital is provided to meet the deficit, and when the business pays it ought to pay on the whole capital. No one would think of starting, say a works, with no working capital at all, and distributing a negative dividend during the next few years to pay the losses. This is one of the many absurd conditions under which municipal work has to suffer. In one case a lovingly solicitous gas company felt that it was hard that a municipality should lose during the first years, so it got a clause inserted to the effect that if there were a loss the price should be raised and raised until there was either no loss or no customers; it did not matter which, though in its heart of hearts the gas company preferred the latter. This clause was solemnly inserted in one or two acts by the collective wisdom of the country. It may interest you to realise that the large commercial interests of this country are controlled by a set of people who think that if a manufacture does not pay the simple expedient of raising the price will put things right.

Referring to the comparative costs of different artificial illuminants, if electrical energy costs 4d. a Board of Trade unit, an ordinary glow lamp will give nearly 800 candle hours for 1s. A flame arc with energy at 3d. gives you 14,000 candle hours. It must be remembered that the 1s. is all spent on energy, nothing is allowed for renewal of lamps, interest on fittings, meter rents, interest on arc lamp, cost of carbons or labour. For a 1s., with energy at 5d., you get about the same light as with a flat-flame gas burner and gas at 4s. The ordinary oil lamp, with paraffin at 8d. a gallon, beats them both hollow, and it is out of the running with acetylene. The great fight between electricity and gas has been fought with flat-flame burners and carbon lamps, and there has been much discussion. I have been accused of a strong partiality for electric light; but I feel impartial; I really do not know which is the worst. The gas mantle makes an enormous difference, and brings gas, say, at 3s. ahead of everything but the mercury and flame arcs at, say, 4½d. a unit. The flame arc is essentially for large lights, while the mantle lights can be made quite small. The comparison is, I repeat, only for the same money paid for gas or energy. To make a real comparison many other factors are to be taken into account. There is the interest on the mercury lamp for one thing; then its colour is not good; and if you add carbon lamps the efficiency goes down. On the other side, however, you have to estimate the cost of mantles, the trouble and worry of breakages, and of the jets getting stopped up, and so on. Even then it must be clear that the mantle has a large margin of economy for the house lamps, such as the Nernst, the metal and the carbon incandescents. For outdoor use, and for large buildings, the flame arc seems to have plenty of margin over the mantle, though large mantle lamps are even better than some of the smaller ones.

In addition to the cost of lamps, mantles, &c., we must remember that if an illuminant spoils the decorations the extra cost of redecorating should be charged against it. Gas blackens the ceilings and destroys paint, and so on; and the extra cost of decoration may be as heavy as the whole cost of electric light, in which case it does not pay to employ gas at any price. This argument annoys the gas industry, so it is sound and good.

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In the unavoidable absence of Mr. Swinburne, his address was read by Mr. D. L. Sands, the hon. secretary. Mr. S. L. Pearce, chairman of the section, occupied the chair. At the conclusion of the address, Mr. A. E. Jepson proposed and Mr. A. Wood seconded a hearty vote of thanks to Mr. Swinburne. Votes of thanks were also accorded to principal J. H. Reynolds, of the School of Technology (where the meeting was held), to Mr. D. L. Sands, and to the chairman. In his reply, Mr. Pearce expressed great satisfaction at the number of students present, and hoped that the address they had heard that evening would form a companion to that delivered by Mr. Swinburne to the London students. He thought that the address indicated that all the Manchester students were intending to become central station engineers; at any rate, Mr. Swinburne had enlightened the students present on many of the sidelights of central station experience. Mr. Pearce also referred to the progressive state of the students' section; the syllabus for the session 1905-1906, he said, reflected great credit on those whose duty it was to make the arrangements.

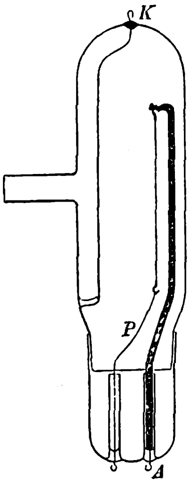
## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

*Electron Theory of the Coherer.*—In a lengthy Paper on contact resistances, A. Blanc reviews the theories hitherto advanced to account for the action of the coherer. Lodge's welding theory is best supported by experiments, but these have usually been made with currents much stronger than the coherer is capable of indicating, and the welding produced by these feeble currents, if it takes place, must remain imperceptible. Branly's assumption of a "modification of the dielectric" is discountenanced by the fact that the dielectric seems to be of no account. The prevalence of the ionisation idea might lead one to suggest that the gaseous or liquid medium might be ionised, but here again the author's own experiments, made with Röntgen, radium and ultra-violet rays, fail to show the slightest effect upon the resistance of a contact, either before or after coherence. The heat rays from an Auer burner affect the resistance in an irregular and uncertain manner, but this effect is simply the well-known action of heat. The only agency which had a decided and well-determined effect upon contact resistance was found to be pressure. Meyer has studied this action, with heavy pressures. But these are not practically as interesting as lighter pressures. The author produced these between a steel plane and a hemisphere, the latter being attached to a lever bearing at its end an armature attracted by an electromagnet, counterbalanced by a spring. Very light pressures could thus be applied without shock. On increasing the pressure, the resistance diminishes very rapidly at first, and then more and more slowly. On releasing the pressure, the resistance never becomes as high as before, the pressure having increased the adherence. The marked influence of pressure suggests to the author a theory in which diffusion plays the main part. Besides gaseous and liquid diffusion, there is also a diffusion of solids in mutual contact, as shown by Barus, Spring and others. A pressure induces this diffusion, and its result is to assimilate the surface layers of the metal to the interior of the metal. In coherence, the pressure is produced by the electric field which induces changes of opposite kinds on the surfaces of two grains facing each other. Now, the interior of a metal contains more free electrons than do the surface layers. The effect of diffusion is, therefore, to give the latter a higher conductivity. The positive ions of the metal would also take part in the diffusion, and the elevation of temperature may aid the transference of ions from one metallic grain to another.

[A. Blanc, *Journal de Physique*, November, 1905.]

*Conducting Quartz Fibres.*—To make quartz fibres conducting, and so avoid the necessity of charging an electrometer needle by contact, Himstedt silvers the fibre, while Dolezalek moistens it with a hygroscopic solution. In the first case, the elasticity of the fibre is interfered with, and in the latter case, the apparatus cannot be properly dried. A. Bestelmeyer has, however, devised a third method, which is free from both objections. He platinises the fibre by cathode disintegration. He used a vacuum tube as shown in the diagram, where K is a platinum wire serving as a cathode, A is an aluminium wire acting as an anode, and holding the quartz fibre, while P is a platinum wire which keeps the fibre stretched and also serves as a third electrode for the purpose of testing whether the fibre has become conducting. The author uses a vacuum of 0·1 mm. Hg., a voltage of 1,280, and a current of 1 to 3 milliamperes. The fibre becomes conducting in about 10 minutes, except the ends which are embedded in sealing wax. It is best to silver the sealing wax by chemical means. The fibres so platinised show no elastic after-effect, and their conductivity appears to be permanent.



[A. Bestelmeyer, *Zeitschrift für Instrumentenkunde*, November, 1905.]

*Resistance of Selenium.*—To measure the resistance of selenium it is usually fused between two metallic plates. By rapid cooling a vitreous form is obtained, which is insulating. By annealing it is transformed into metallic selenium which is conducting. Selenium combines with most metals, and it thus usually contains selenides when fuses in contact with them. That this is the case has been proved by M. Coste, who fused selenium on gold leaf and then drove it off by heat, when it left a residue of pure gold. The resistance usually attributed to selenium is untrustworthy for that reason. Carbon electrodes are not open to this objection, and the author has, therefore, operated with these. When the vitreous selenium is transformed into the metallic variety, it shows under the microscope a number of fissures and pointed geodes. The number of fissures varies greatly with the mode of transformation and the rate of cooling. Hence the different results obtained by various observers. In spite of the fissures, the metallic variety is denser than the vitreous. The contraction commences on the surface, and leaves the fissures as it proceeds inwards. When light impinges on the selenium, some fissures are bridged, and the resistance thus decreases. The author found a resistance of 86,000 ohms in a stick 9 cm. long and of ½ sq. mm. sectional area.

[M. Coste, *Comptes Rendus*, November 6, 1905.]

*Radiation from Metals and Crystals.*—F. Sanford has pursued his researches on the ultra-violet radiation from metals when joined to the cathode of the secondary of an induction coil or placed in the field of an air condenser, the plates of which are joined to the terminals of an induction coil. The wave-length of the radiation was measured by means of a Rowland grating, this and the photographic plate being enclosed in a dark box placed between the glass plates upon which the tinfoil condenser sheets were pasted. The rays passed through a slit in a vulcanite screen and through the grating and fell upon the sensitive plate. The wave-length was determined in the case of 15 metals, and was found to range from 329 $\mu\mu$ in the case of tinfoil to 380 $\mu\mu$ in the cases of zinc, manganese, lead and platinum. A number of crystals of various salts were tried as radiators by sticking a crystal with glue on a piece of cardboard which was placed upright in a dark box in front of the ebonite slit. Silver nitrate and potassic ferrocyanide showed a wave-length of 334 $\mu\mu$, and potassic bromide 370. In the case of radiation from crystals, even more than from metals, it was found that sharp points or edges were the principal sources of the radiation. Photographs of crystals made by means of their own radiations and by the use of a quartz lens showed only a number of point or line sources of the radiation.

[F. Sanford, *Physical Review*, November, 1905.]

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Synchronous and Other Multiple Telegraphs: Some Methods of Obtaining Independent Telegraph Circuits on a Single Wire both With and Without Synchronism." By A. C. Crehore. (New York: McGraw Publishing Co.) 8s. 6d.

"The Alternating Current Circuit and Motor." By W. Perren Maycock. Second Edition. (London: Whittaker & Co.) 4s. 6d.

"London University Guide, 1906." (London and Cambridge: University Correspondence College.)

"The Application of Electric Motors to Machine Driving." By Andrew Stewart. 3rd edition. (London: S. Rentell & Co.) 2s.

Science Abstracts. November. Section A—Physics: Section B—Electrical Engineering. (London: E. & F. N. Spon, Ltd.) 1s. 6d. each.

"Telegraphy." By T. E. Herbert (London: Whittaker & Co.) 6s. 6d.

"Engineering Mathematics Simply Explained." By H. H. Harrison. (London: Percival Marshall & Co.) 1s. 6d. net.

"Die Dampfturbine." By W. H. Eyermann. (Berlin: R. Oldenbourg.) 9m.

"Über die Entwicklungsmöglichkeiten des Induktionsmotors für Einphasen-Wechselstrom." By Dr. R. von Koch. (Berlin: Julius Springer.) M. 2.60.

"Elektrische und Magnetische Messungen und Messinstrumente." By H. S. Hallo and H. W. Land. Translation from the Dutch "Magnetische en Elektrische Metingen," by G. J. van Swaay. (Berlin: Julius Springer.) 15m.

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## TRANSMISSION OF POWER FROM VICTORIA FALLS TO THE RAND.

The total power used in the Rand mines in South Africa is, on a rough estimate, 100,000 H.P. At present it is chiefly generated at the mines themselves, each mine having its own steam plant or electrical generating station, but some groups of mines are supplied with current by the Rand Central Electric Co. Now there can be no doubt that if the conditions are otherwise favourable, there should be a good opening here for a power company, and two schemes have already been put forward. One of these has already been dealt with in our columns in a Paper read by Mr. ROBERT HAMMOND before the British Association last summer. We believe that Mr. HAMMOND had previously spent some time on the Rand with a view to forming a power company on the lines of the present undertaking on the Tyne and the more ambitious project for London submitted to Parliament last year. He estimated that some 20,000 H.P. of motors were already in use in the mines, and with coal at 10s. 6d. per ton, and a station load factor of 70 per cent., such an undertaking could be run on a profitable basis, selling electrical energy to consumers at 0·7d. per unit. While there can be little doubt that it would be profitable for nearly all the mines to take power at this rate, considerable doubt exists as to whether these low costs of generation could be attained; those who spoke on the Paper suggested that the load factor assumed was too high, and in any case many of the items in the capital and running cost require confirmation before they can be accepted as applicable to South African conditions. We have not yet heard that the necessary financial support has been obtained for Mr. HAMMOND'S scheme; it should doubtless be forthcoming if he can substantiate his estimates, and if there is no competing project offering power at a lower rate.

The second scheme which is under consideration is a proposal to utilise the power of the Victoria Falls, the distance from which to the Rand is about 550 miles in a straight line, or about 750 along the new railway opened last year. If this scheme is carried out, it will certainly be one of the greatest records that electrical engineers can place to their credit. There is, moreover, no reason, from a purely engineering standpoint, why many thousands of horse-power should not be transmitted electrically over this distance, although we believe that up to the present 200 miles has not been greatly exceeded. Just as in the case of Mr. HAMMOND'S scheme, commercial considerations are the real limiting ones. The cost of the transmission line must necessarily be large, and, even with the highest pressure that can be used, the line losses will be considerable. All these points are being thoroughly gone into, however, by the engineers who have been consulted by the African Concessions Syndicate, which is affiliated to the British South Africa Co., and in an interview with a representative of *South Africa*, Mr. H. WILSON FOX, manager of the Company, sketched out what progress had been made with the preliminary investigations and inquiries. The article enters to some extent upon technical matters and we are in a position to amplify in some particulars the information given. Prof. AYRTON'S recent advocacy of the high-tension, continuous-current system was apparently based on a fore-knowledge of what had been proposed by the engineers responsible for the preliminary work of this Victoria Falls power transmission scheme. The syndicate has taken the advice of Dr. E. TISSOT, M. BLONDEL, and Prof. GISBERT KAPP on a project by M. THURY, and Mr. R. D. MERSHON, who is identified with many of the long-distance power transmission schemes in California, has also been consulted. It appears that the three first-named gentlemen are all of opinion that M. THURY'S continuous-current system would be the most suitable for the transmission from the Falls to the Rand, while Mr. MERSHON, though favouring a three-phase system in the first instance, was considerably impressed by the views of the other experts and, having made an examination of M. THURY'S recent high-pressure works, has reconsidered his views on the question. The proposal is to transmit 20,000 H.P. in the first instance from the Falls to the Rand, and to erect a sub-station where the power received would be converted to three-phase alternating current for distribution. The Thury system would thus be employed for a purely point-to-point transmission system, which is the application in which it has been most successfully applied, and the difficulties of distribution on the high-tension continuous-current system would be avoided. A pressure of 140,000 volts between conductors is proposed; to produce this a number of dynamos are connected in series, and the centre-point of this generating system is earthed, so that the pressure of each conductor above earth would be 70,000 volts. The commutator difficulty has been overcome in M. THURY'S recent machines to the extent that 3,560-volt machines are being employed on the Moutiers-Lyons power-transmission scheme, which is now under construction. Four of these machines are driven by each turbine in the case of the Moutiers-Lyons scheme, and there the line pressure is 57,000 volts (28,500 volts between each line and earth). A difficulty will be the insulation of each machine from its turbine in the case of the higher pressure proposed for the Victoria Falls scheme, and doubtless M. THURY has been conducting experiments with his insulating coupling which have led him to expect that he can improve it sufficiently to stand more than double the voltages used hitherto. The pole line would follow the usual Californian practice—an aluminium cable supported on lattice-work towers—and the type of insulators which have been employed on the 60,000 volt three-phase alternating schemes in America could possibly be made to bear the higher continuous-current pressures without a prohibitive increase in dimensions or a radical alteration in design. When we add to the names of the electrical engineers we have mentioned, that of Sir Douglas Fox & Partners, who have already made the necessary surveys for the hydraulic works, it will be evident to our readers that the scheme is being considered seriously on its merits. It is, of course, premature to express an opinion as to the success of the project until detailed estimates and specifications are available, but whether the power used in the Rand mines will ultimately be generated at the Victoria Falls or in a large central power station in the Rand itself, we may regard it as certain that electrical power distribution on a large scale must replace the existing methods in the near future. At present from £25 to £40 and over is the cost per horse-power year to the power user in the Rand, and there is no doubt that a considerable reduction of this price should be possible.

## THE BELFAST CITY TRAMWAYS.

The tramway undertaking in Belfast became the property of the Corporation on January 1, 1905. The amount paid by the Corporation to the Belfast Street Tramways Company for their undertaking, including 35 route-miles of tramway, was settled by arbitration, and the amount awarded by the arbitrator, Mr. L. L. Macassey, LL.D., including the value of three years' unexpired lease, compensation to officers, and £60,000 debentures (to be paid off by the Corporation) was £364,448, and when the amounts of the various contracts, given below, are added to this it will be seen that the total cost of the undertaking (which includes nearly 40 miles of double-track route) has amounted to nearly a million pounds. Purchasing powers had been obtained in the Belfast Corporation Tramways Act, 1904, and on the passing of the act the Corporation at once made arrangements for the early electrification of the system. The necessary plans, specifications, &c., for the work were prepared by their own officers.

Mr. H. A. Cutler, the City Surveyor, was responsible for the permanent way and the extensions to the generating station buildings; Mr. Victor A. H. M'Cowen, the City Electrical Engineer, prepared the scheme for the electrical operation of the system, including specification for the additional generating plant required, the overhead trolley equipment, and the underground distributing cables; and, lastly, to Mr. Andrew Nance, who had for many years managed the Horse Tramway system under the old company, and had been appointed Manager for the Corporation, was allotted the task of providing for new cars, conversion of old cars, &c. On the recommendation of the above officers, their specifications were subsequently submitted for expert opinion to Messrs. Lacey & Sillar, who agreed throughout with the proposed scheme.

The contract for the whole of the work, with the exception of the buildings, was placed with Messrs. J. G. White & Co., on December 1, 1904, for a sum of £543,404.

The sub-contractors were:—

| | |
|---|---|
| *Rails* ........................ | North Eastern Steel Co. |
| *Special Track Work* ........ | The Lorain Steel Co. |
| *Feeder Cables* .............. | Callender's Cable & Construction Co. |
| *Engines* ...................... | Fairbairn, Lawson, Combe & Barbour. |
| *Electric Generators and Switch Gear* .................... | British Westinghouse Electric & Mfg. Co. |
| *Boiler House and Coal Conveying Plant* ............... | Babcock & Wilcox. |
| *Car Bodies* ................. | Brush Electrical Engineering Co. |
| *Electrical Equipment and Cars* | British Westinghouse Electric & Mfg. Co. |

In the supervision of the electrical equipment of the system, Mr. M'Cowen was ably assisted by his deputy, Mr. Bloxam, and his tramways distributing assistant, Mr. Croft, and we have to thank Mr. M'Cowen for supplying us with the information contained in this article, as well as a complete set of drawings.

The tramways are now practically completed, and some routes were opened to the public yesterday after an official inauguration on Wednesday. It is hoped that the remaining routes will be opened next week.

### Generating Station.

The generating station forms an extension of the electricity supply works which were erected in 1898 to replace the original gas-driven station, and fully described in *The Electrician* at that time. The site is close to the river Logan in the south-west of the city and about a mile from the centre. It has been recommended by Mr. M'Cowen as a suitable point for distributing energy for the city's requirements both for lighting and traction purposes, and all the plant installed has been arranged for both lighting and traction supply. The generators are provided with compound windings for tramway supply at 550 volts, and when run as shunt machines for lighting they supply a pressure of from 440 to 500 volts for the outers of the three-wire system.

The plant in the original works consisted of a 200 kw. Belliss-Parker two-pole undertype set and two 2 × 50 kw. Belliss-Parker "double enders" for balancing. Additional sets were gradually added to bring up the total capacity of the station to 3,400 kw. All the engines were of Messrs. Belliss & Morcom's make, and the additional dynamos were supplied by Messrs. Parker, Mather & Platt and Johnson & Phillips. Before the extensions which have now been completed, the boiler-house plant consisted of six Lancashire and six B. & W. water-tube boilers, together with economisers and steam and electrically-driven feed pumps. The condensing plant was of the Wheeler combined type with steam-driven horizontal air and circulating pumps placed below the condenser, and cooling water was obtained from Wheeler & Klein cooling towers.

Owing to the large developments in the lighting and power demand, it has been found necessary to extend the building and instal further plant. Provision, however, is made for running three of the large lighting generators on the tramway system if required.

*Power Station Buildings.*—The contract for the new buildings was let to Messrs. M'Laughlin & Harvey of Belfast, whose tender amounted to £19,690.

The building was designed by Mr. Cutler in such a way as to make it possible to install the plant during the erection of the building. The work was commenced in April last, and, owing to the soft nature of the ground, some 1,750 piles had to be driven through 30 ft. of river mud down to the rock. The foundations on top of the piles are formed with cement concrete in which is embedded a steel grill work made of old tram rails. The frame work of the building is made of steel, and the roof and floors were erected before the brickwork was commenced, which enabled the coal bunkers, boilers and engines to be installed during the time the building was being erected. This arrangement afforded the only possible way of having power available for running the cars in such a short time as was allotted for the completion of the work. As a result of the preparation made in designing the structure, the engines are now running and current is being generated, although the building is not completed.

The new building is designed to harmonise with the existing electric light station. It has a frontage of 180 ft. to East Bridge-street, and 138 ft. to the Lagan Bank-road. It is faced with red brick with stone dressings. The floors in the basement of the building are formed of concrete rendered with cement, and the stoking floor and switch gallery floors are formed with concrete on steel joists. The stoking-floor is finished with Staffordshire blue paving-bricks, the switch-gallery floors with vitrious glass mosaic, and the floor of the engine-room with encaustic tiling. The skylights for lighting the engine-room and boiler-houses are glazed with Helliwell's patent glazing, and the walls of the engine-house and switch-galleries are faced with glazed tiles. The great care and energy which have been displayed by Messrs. M'Laughlin & Harvey in carrying out their contract have been no small factors in the expeditious completion of the work, and they have been highly commended for the facilities they have afforded other contractors working in the building. In designing and supervising the construction of the power-house and pump-house Mr. Cutler was ably assisted by his Chief Architectural assistant, Mr. J. C. M. Browne, and by Messrs. J. Trotter and F. Byers, who acted as Clerks of Works.

*Coal Handling Plant.*—Fig. 1 shows the general arrangement of the coal-conveying scheme. The coal is brought alongside

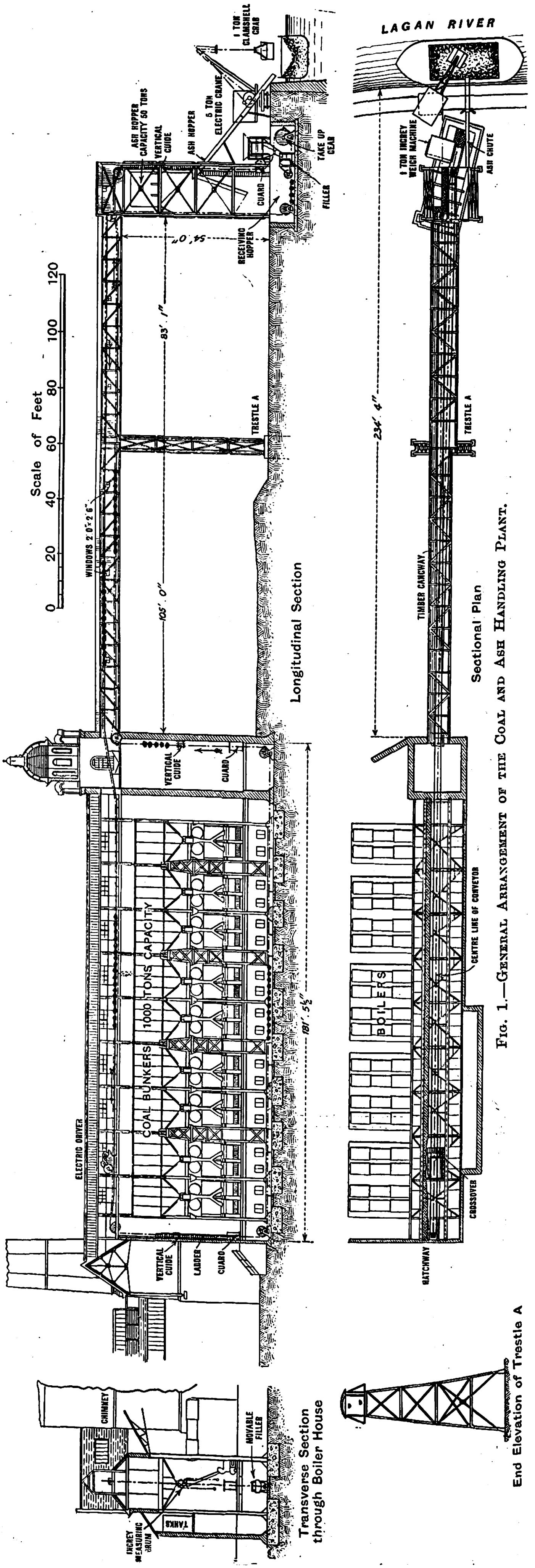
LAGAN RIVER
Scale of Feet
0 20 40 60 80 100 120
1 TON CLAMSHELL GRAB
5 TON ELECTRIC CRANE
ASH HOPPER
ASH HOPPER CAPACITY 50 TONS
VERTICAL GUIDE
GUARD
TAKE UP GEAR
FILLER
RECEIVING HOPPER
40' 6"
83' 1"
105' 0"
181' 5½"
234' 4"
TRESTLE A
WINDOWS 2'0"×2'6"
COAL BUNKERS 1000 TONS CAPACITY
ELECTRIC DRIVER
LADDER
Longitudinal Section
1 TON INCREY WEIGH MACHINE
ASH CHUTE
TIMBER CANEWAY
CENTRE LINE OF CONVEYOR
BOILERS
CROSSOVER
HATCHWAY
Sectional Plan
CHIMNEY
MOVABLE FILLER
TANKS
INCREY MEASURING DRUM
Transverse Section through Boiler House
End Elevation of Trestle A

Fig. 1.—General Arrangement of the Coal and Ash Handling Plant.

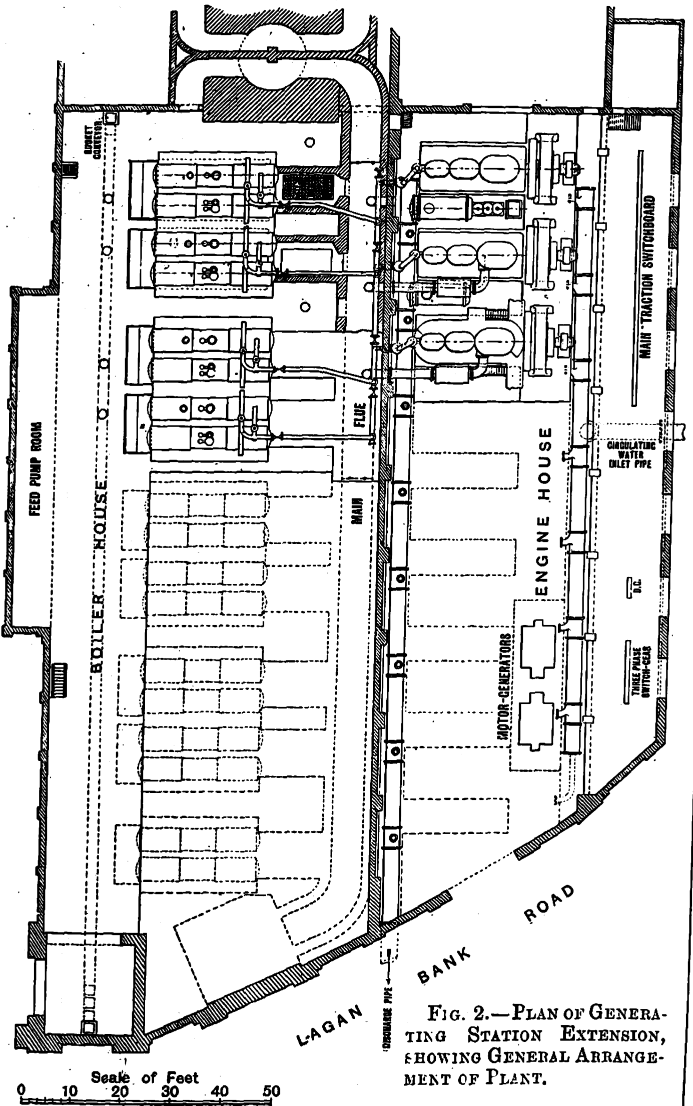
FEED PUMP ROOM
BUCKET CONVEYOR
BOILER HOUSE
FLUE
MAIN
ENGINE HOUSE
MOTOR-GENERATORS
MAIN TRACTION SWITCHBOARD
CIRCULATING WATER INLET PIPE
D.C.
THREE PHASE SWITCH-GEAR
DISCHARGE PIPE
LAGAN BANK ROAD
Scale of Feet
0 10 20 30 40 50

Fig. 2.—Plan of Generating Station Extension, showing General Arrangement of Plant.

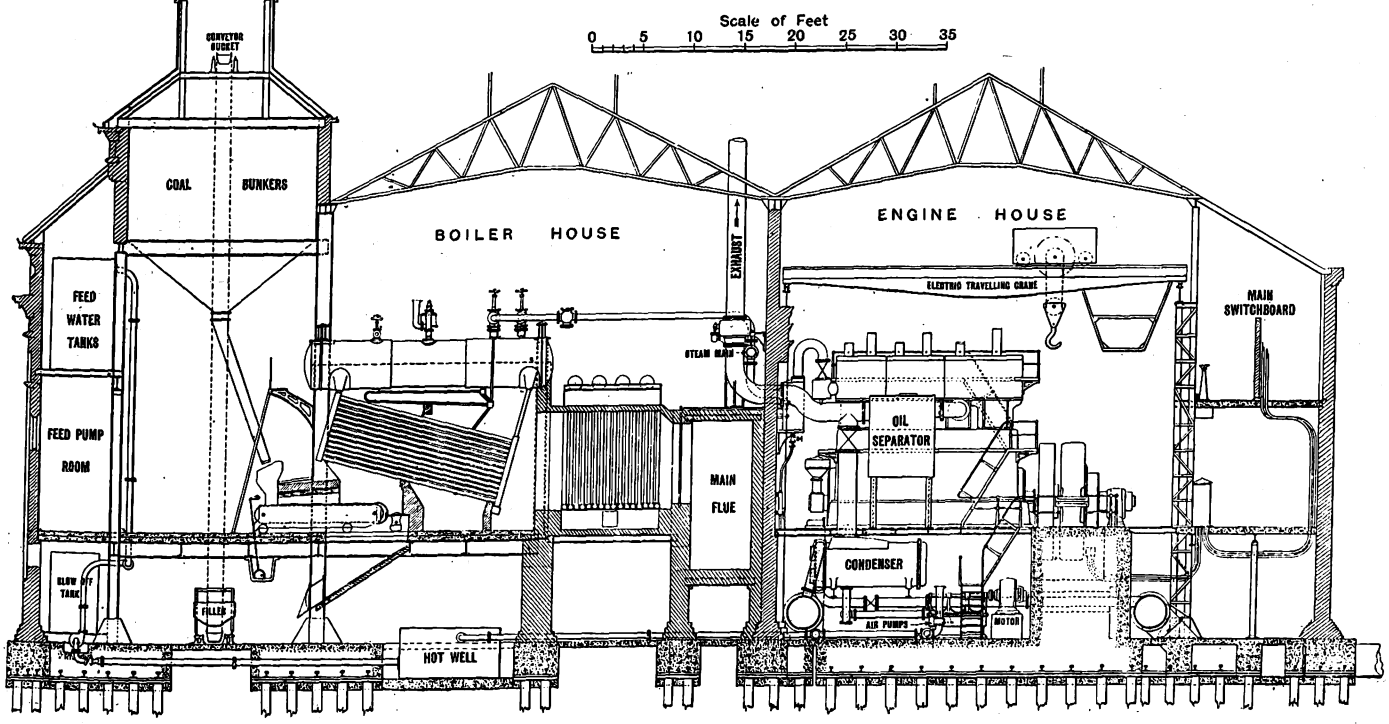
Scale of Feet
0 5 10 15 20 25 30 35
CONVEYOR BUCKET
COAL BUNKERS
FEED WATER TANKS
FEED PUMP ROOM
BLOW OFF TANK
FILLER
HOT WELL
BOILER HOUSE
EXHAUST
STEAM MAIN
MAIN FLUE
ENGINE HOUSE
ELECTRIC TRAVELLING CRANE
MAIN SWITCHBOARD
OIL SEPARATOR
CONDENSER
AIR PUMPS
MOTOR

Fig. 3.—Cross-section of Generating Station Extension.

the quay in barges, and there discharged by means of a grab operated by an electric locomotive crane, which deposits it into the hopper of an "Ingrey" automatic weighing and recording machine, which discharges it into a receiving hopper underneath. From this hopper the coal passes by means of a shoot with regulating valves into an automatic filler, which fills the buckets of the conveyor without spilling. The coal is then elevated vertically by the conveyor to a suitable height to cross the public road through a covered way into the building, above the level of the overhead bunkers. Each bunker is provided with a pair of suitable dumping cams, so that the coal can be deposited where required. The overhead bunkers are of steel construction throughout, and are situated over the boiler stoking floor, and have a capacity of 1,000 tons. The conveyor runs above the bunkers the whole length of the boiler house, and descending at the end wall passes through the basement, where it is again employed for removing the ashes from below the boilers. It then re-ascends at the other end of the boiler house, and recrosses the road through the covered way, and deposits the ashes in the ash hopper on the river side. From this hopper the ashes can be discharged at suitable times, by means of a shoot with regulating valves, into either carts or barges underneath. It will thus be seen that the conveyor can be employed for both the delivery of the coal and the removing of ashes at the same time.

The conveyor is of the endless-chain pattern with buckets of the gravity type, and is capable of handling from 40 to 50 tons of coal per hour with a speed of the conveyor chain of 40 ft. to 50 ft. per minute. The conveyor chain is driven by a special driver with pawls which engage the link studs in each part of the chain on both sides of the buckets. This driver is coupled through suitable spur and pinion gear to a 9 H.P. motor of the enclosed type. A moveable filler is also provided in the basement for facilitating the trimming of the coal from one bunker to another, and in connection with the removal of the ashes. The "Ingrey" patent automatic weighing and recording machine registers in tons and decimals each charge of coal as it is delivered by the grab, and the total quantity of coal delivered at any time can be ascertained by reading the index. The accuracy is guaranteed to within a half of 1 per cent.

*Boilers.*—The lay-out of the boiler house extension is seen in Figs. 2 and 3. The arrangement is a single row of boilers placed in batteries of two; each boiler is provided with its own 128-tube economiser immediately at the back, and this opens directly into the main flue. By this means the economisers receive the full heat value of the waste gases before cooling due to radiation or leakage can take place. Four Babcock & Wilcox water-tube boilers with chain grates are erected under this extension; each boiler is composed of 20 sections of 13 tubes, 4 in. diameter and 18 ft. long connected at the ends by staggered headers to the steam and water drums which are each 25 ft. long, and 54 in. diameter. Each boiler has a heating surface of 5,764 sq. ft., and a grate area of 100 sq. ft., and is capable of evaporating from 20,000 lb. to 25,000 lb. of water per hour from and at 212°F. As seen in the sectional view., each boiler is fitted with a superheater. This has 900 sq. ft. of heating surface, and is capable of imparting a superheat of 150°F. The chain grates are driven by a line shaft placed beneath the stoking floor, and connected by clutch gear to duplicate electric motors geared by means of worm reduction gear.

The scraper gear of each economiser is likewise driven through a worm gearing by means of an electric motor, and very complete provision is made for removing soot from both the boilers, economisers, and flue, and depositing it in the basement, where it can be removed by means of the conveying plant.

*Pipe Work, Feed Pumps, &c.*—The arrangement of steam pipe work is extremely simple, as can be seen in Figs. 2 and 3. Each boiler, economiser, and steam dynamo, forming a unit, are connected by means of an 8 in. steam pipe, and the 10 in. main steam pipe in the boiler house simply acts as an equaliser between the various units. Each unit, therefore, can be separated from its neighbour by means of a valve on the main steam pipe placed between the unit branches and run independently. The pipes are arranged to obviate the necessity of steam traps on the pipe range; each section of pipe work drains to its own engine separator, which, of course is protected by a trap. The steam pipes are of weldless mild steel having a tensile strength of 24 lb. to 27 lb. per square inch with an elongation of 20 per cent. in a length of 6 in. No cast iron or copper is employed. All pipes up to 6 in. diameter have wrought-steel flanges screwed on, and the pipe is afterwards carefully expanded into the flanges; for pipes above 6 in. diameter the flanges are rivetted on. The branch connections are formed by means of mild-steel nozzles rivetted to the pipe. The valves on the boiler are arranged so that either "raw" or "superheated" steam can be taken.

A duplicate system of feed is provided throughout. The feed water is taken from two of the Belfast Water Commissioners' mains, and the supply pipes are connected to the overhead storage tanks and the hot-feed tank through ball equilibrium-float valves. Duplicate suctions are connected from these tanks to the pumps, and duplicate deliveries are run between the pumps and the boilers. One of the deliveries is connected through a 6 in. Railton & Campbell pressure feed-water filter, a 6 in. Kennedy water meter and an auxiliary heater (which takes the exhaust from the steam pumps) to the economiser, and thence to the boilers. The other delivery, which is only used in case of emergency, is connected directly from the feed pumps to the boilers.

The feed pumps consist of the following: One Hall compound vertical steam pump capable of delivering to the boilers 8,000 gallons of water per hour with and against 170 lb. to 200 lb. pressure per square inch, at a speed of 12 double strokes per minute; and two Hayward-Tyler "Sinclair's" electrically-driven variable-stroke pumps, each capable of delivering to the boilers 8,000 gallons of water per hour against the boiler pressure. The variable-stroke feed pump has two properties that render it particularly suitable for electric drive —viz., that it can always be started at "no stroke," and that no variation in speed is required. In order to enable the attendant to regulate the pump to the requirements of the boilers an automatic indicator is fitted to the end of the shaft, which shows either the stroke in inches or the equivalent discharge in gallons per hour. The following are the guaranteed figures for the feed pumps: Steam pump, 110 lb. of water per pound of steam; electric pumps, 3,600 lb. of water pumped per Board of Trade unit.

The boilers and all steam and feed pipes are covered with non-conducting material to a thickness of 2½ in., the pipes in the engine room being further finished with a covering of planished steel. The boiler house is provided with an "Ados" flue gas recorder and a steam-pressure recorder.

*Engine-House Plant.*—The generating plant erected under this extension consists of three 1,000 kw. continuous-current steam dynamos. The engines are of the vertical inverted three-crank triple-expansion enclosed pattern, with forced lubrication. They were built by Messrs. Fairbairn, Lawson, Combe & Barbour, and are designed on the principle of the Belliss engine. Their rated output is at 180 revs. per min., with steam pressure of 170 lb. per square inch and 150°F. of superheat. The cylinder dimensions are 22 in., 33 in. and 50 in. by 24 in. stroke. The steam consumption at full load, condensing under the above conditions of steam pressure and temperature, and with 25 in. of vacuum, is guaranteed at 16¾ lb. per kilowatt-hour, subject to additions or deductions of £250 per engine for every pound of steam per kilowatt-hour below or above that figure.

The generators are of Westinghouse make. They have 16 poles, and are wound for a constant voltage of 550 when connected as compound for traction purposes, and 450 to 500 when connected as shunt for lighting purposes. These sets are capable of standing 25 per cent. overload for short periods and 50 per cent. overload momentarily. The specified maximum temperature rise after 12 hours' run at full load is 70°F.

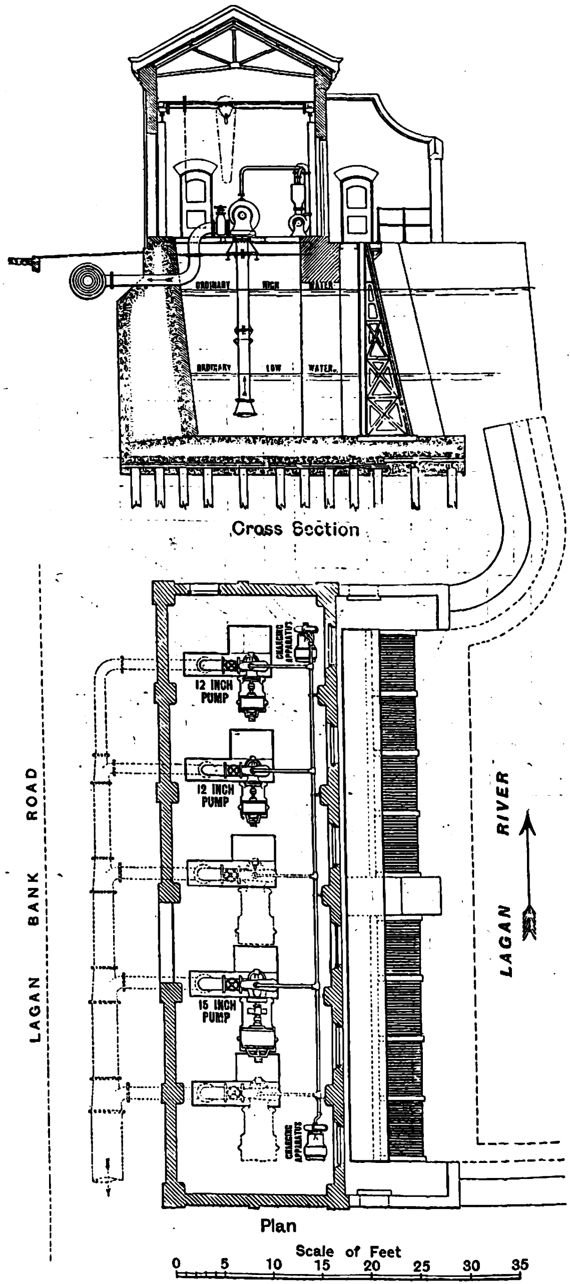

Fig 4.—Cross-section and Plan of Pump-house in River Bank, for Condensing Circulating Water.

*Condensing Plant.*—The circulating water for the condensing plant will now be obtained from the river instead of use being made of cooling towers as hitherto. Three Gwynne electrically-driven centrifugal pumps are arranged in a pump house on the river bank (Fig. 4), two 12 in. and one 15 in., and provision is made for the erection of two more when required. The 12 in. pumps are each directly coupled to a 30 B.H.P. motor, and will deliver 150,000 gallons of water per hour. The 15 in. is coupled to a 50 B.H.P. motor and will deliver 300,000 gallons of water per hour. As the river is a tidal one, the height of lift varies to the extent of 9 ft., but the maximum lift is not greater than 15 ft. A 36 in. steel pipe is laid between the pump house and the generating station, and connections are provided for the ultimate requirements of about 12,000 H.P. The contract for building the pump house was let to Messrs. Courtney & Co. of Belfast, whose tender amounted to £6,281. A coffer dam along the river front and two sides had to be constructed before the work was commenced. The pump house is 68 ft. long and 16 ft. 6 in. wide, and is built of red brick with stone dressings. The pump wells are built in concrete faced with blue brick and the openings to the river are protected with movable screens to prevent foreign matter entering the wells. The pumps are carried over the pump wells on steel joists and the floor is constructed of concrete and paved with tiles. The discharge pipe, which is of similar size and material, is brought back to the river higher up, and is placed well below low-water level. Two sets of Gwynne-Sargent motor-driven charging apparatus are also provided in the pump house for priming the pumps.

Each main engine is provided in the basement with a separate Mirrlees-Watson engine condenser, having 2,350 sq. ft. of cooling surface, and an electrically direct-driven three-throw Edwards' air pump. The discharge from the air pump gravitates into a large cast-iron tank in the boiler-house basement, and is lifted from thence to the hot well over the feed pump house by means of electrically-driven centrifugal pumps.

An exhaust steam grease separator is placed between the engine and the condenser, and each engine is also provided with an atmospheric exhaust controlled by an automatic valve which opens in the event of the vacuum failing, so that the sets can run non-condensing.

*Three-phase Plant.*—Energy is transmitted at 6,000 volts three-phase to a sub-station at the Fortwilliam Depot for operating the portion of the system in that district, and for the supply to the Cavehill and Whitewell Tramway Co. for their line. Two 250 kw. three-phase synchronous motor generators are at present erected in the power station. These machines are supplied with continuous current from either the traction or the lighting switchboards at a pressure of 500 to 550 volts, and they generate three-phase current direct at 6,000 volts, 50 cycles, when running at 500 revs. per min. The alternating-current three-phase generators are of the Westinghouse revolving field type (12-polar) and the direct-current motors are 6-pole and are coupled to the generators on a compound bedplate. An exciter is provided on one end of the shaft for supplying the alternator field current.

Three 125 kw. three-phase synchronous motor generators are erected in the sub-station (Fig. 5). These are similar to the 250 kw. sets, with the exception that each is provided with a small three-phase induction starting motor mounted on the opposite end of the shaft to the exciter.

The efficiencies guaranteed for these machines are as follows, the efficiency being taken as the ratio of the direct-current input to the alternating-current output:—

| Load. | | 250 kw. set. | | 125 kw. set. |
|---|---|---|---|---|
| 1 | ...... | 87 per cent. | ...... | 83½ per cent. |
| ¾ | ...... | 86 ,, | ...... | 82 ,, |
| ½ | ...... | 82 ,, | ...... | 78 ,, |

The three-phase switch gear is of the Westinghouse standard pattern. All metal conductors are entirely enclosed in masonry cubicles, so that in the case of fire originating in one of these cubicles it is entirely confined to it. The oil switches are of the remote control type, with a separate double break switch in each phase. Each switch is entirely enclosed in a masonry structure thus separating it from adjacent phases The switches are automatically opened by means of a trip coil, energised by means of series transformers placed in the main circuit.

Duplicate three-phase 'bus bars are provided to which the various generators and feeders are connected through selector switches, so that either 'bus bar can be made dead for cleaning or other purposes. Provision is also made for starting the motor generators from the direct-current side.

The sub-station is situated about 3 miles from the generating station, and is connected by means of a duplicate E.H.T. three-core trunk main, the section of each core being 0·075 sq. in. These are lead covered and armoured and laid in earthenware troughs filled in solid with bitumen.

*Switch Gear.*—The main traction switchboard and the three-phase operating switchboard are erected on a gallery which runs the full length of the engine room at a height of 12 ft. above the main floor level. The main traction switchboard consists of three 500 kw. generator panels, three 1,000 kw. generator panels, one totalising panel, one Board of Trade panel, eight feeder panels each for two feeders, and one auxiliary power and lighting panel. The panels are of white Sicilian marble 2 in. thick, the overall height being 92 in., the total length of the traction board being 50 ft. Each generator panel is provided with a Bertram Thomas magnetic blow-out circuit-breaker, a Weston illuminated dial ammeter, three generator switches and a Thomson integrating wattmeter. The totalising panel has mounted on it one 10,000 ampere Thomson integrating wattmeter, one 10,000 ampere Weston illuminated ammeter, four Weston illuminated ammeters for rail returns and two extra large Weston illuminated voltmeters on swing brackets for indicating the 'bus bar and machine voltage.

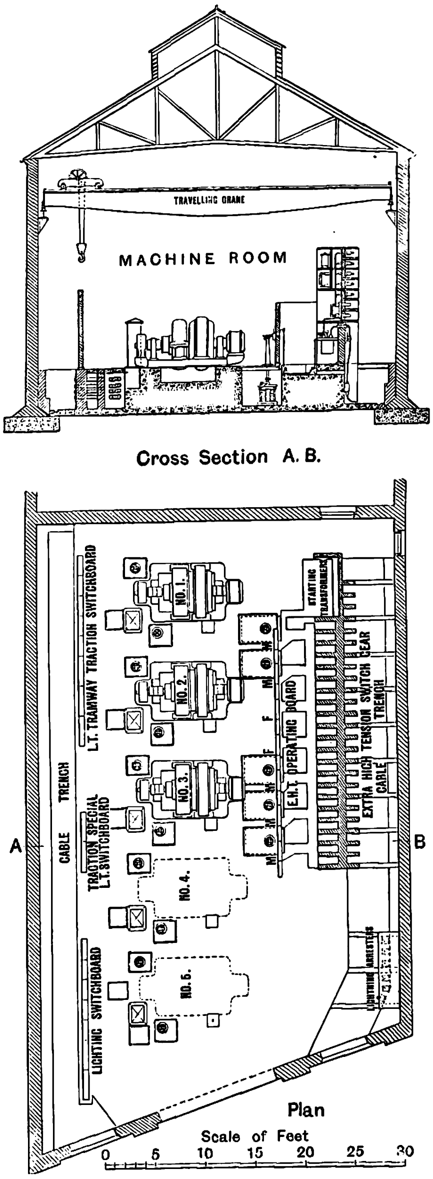

Fig. 5.—Plan and Cross-section of Fort William Sub-station.

The Board of Trade panel is equipped with Elliott recording instruments, including an ammeter reading up to 10,000 amperes, a voltmeter up to 750 volts, two voltmeters recording from 0 to 10 volts for rail drop, one 0 to 10 ampere ammeter, and there is one Weston ammeter with double scale 0 to 0·05 and 0 to 5 amperes. The necessary multiple contact switches for taking the line leakage tests on the various routes are also provided on this panel, as well as the multiple contact switches for getting the rail drop between any of the four earthed points of the track and any of the route termini.

Each feeder panel has mounted on it two Bertram Thomas magnetic blow-out circuit-breakers, two Weston illuminated ammeters, two single-pole quick-break switches, two Thomson integrating wattmeters and two Wurtz lightning arresters and kicking coils. As each route is supplied by a separate feeder, the energy used from day to day on any route can be ascertained, and valuable information obtained regarding the operation under different conditions.

A main three-pole throw-over switch in the circuit of each generator is mounted on a pedestal on the floor below the switch gallery, for connecting generators to the traction switchboard as compound machines, and to the lighting switchboard as shunt machines. The shunt resistances are mounted below the Gallery floor, and are operated by means of hand wheels erected in convenient positions in front of the switchboard.

### OVERHEAD EQUIPMENT.

The overhead equipment was carried out by Messrs. J. G. White & Co., and the greater portion is of span-wire construction, with the exception of 2½ miles of side bracket, in outlying districts, and 2¾ miles of centre-pole construction in the wide main thoroughfares in the centre of the City.

The poles are of lap-welded mild steel of the sectional type to the British Standards specification, and their fittings are of pressed steel, all straps, bolts, and nuts being galvanised. The poles are planted at the usual distance of 40 yds. apart, and the holes have been filled in with 5 to 1 Portland cement concrete to a radial depth of not less than 8 in. around the pole. Hard-drawn copper trolley wire of circular section and 0·4 in. diameter, is employed; its specified breaking stress is 24 tons per square inch. The trolley wire, which is double throughout, is fixed at a height of 22 ft. above the track, and flexible suspension has been adopted in all cases. It is arranged for centre running on all span work, and no greater deviation than 6 ft. from the centre of the track has been allowed in any case. On curves the wire in no case assumes an angle of less than 160 deg. 18 in. ears are employed on the straight, and 30 in. and 33 in. ears on curves.

The section insulators are of the straight under-running air-gap pattern, and are capable of standing a stress of 4,000 lb. Span wires of 7/12's S.W.G. galvanised steel have been employed, with a breaking stress of not less than 4,000 lb. Duplicate insulation is used throughout. The insulator bolts are ¾ in. in diameter, and both insulators and "Brooklyn strains" are capable of withstanding a stress of 6,000 lb.

The guard wires are of 7/16's S.W.G. galvanised steel, with a breaking stress of 2,500 lb. Guard wiring, however, has been reduced to a minimum, owing to the Corporation, on the advice of Mr. M'Cowen, having required the telephone company to put all their telephone wires on tramway routes underground. This, it is expected, will considerably minimise trouble with the overhead equipment.

Section feeder pillars are placed half a mile apart on all routes, and at shorter distances in the centre of the city to suit local conditions. The section and feeder pillars are arranged for double insulation, and are provided with the following switch gear: Two 400-ampere quick-break switches, four 200 ampere quick-break switches, a 'bus bar of 1 sq. in. section, a lightning arrester and kicking coil, a terminal board for telephone and test-wire terminals, and a telephone plug box. The current density for all switches and connections is 500 amperes per square inch. A small separate door is provided for getting to the telephone plug boxes, and owing to trouble from damp experienced with telephone instruments placed in pillars, the usual method has been departed from, and plug boxes only are provided in the pillars. The instruments themselves are provided with an induction coil in the handle, and an instrument is taken on each car. This can be plugged on to any pillar, and communication is thus made with the power house or car sheds as desired.

The centre poles are lighted by means of two incandescent lamps fixed on each pole at a height of about 12 ft. from the ground; these are simply for the purpose of indicating the position of the poles at night, and not for street lighting. They are supplied from the lighting mains. Provision was made for erecting arc lamps on the centre poles for street lighting, but this matter has been deferred for the present.

The overhead equipment in the six car sheds and the approaches to them has been carried out by Mr. M'Cowen's own staff. Mechanical ears have been employed on this work, and Mr. M'Cowen informs us that it has resulted in a considerable saving in cost and gives excellent running. In some of the larger sheds one trolley wire is arranged to serve two lines of track; this method has been adopted with a view to reducing complications in the overhead special work, and as in one case as many at 17 tracks are taken off the two approach tracks, and in another 20 tracks are taken off a single track, the possible complications of overhead equipment can be imagined. The overhead wiring of each shed is separated from the street wiring by section insulators, and the supply of energy to each shed is controlled by a circuit breaker and wattmeter, so that the energy used in the sheds can be carefully watched and the outside lines protected from interruptions due to faults in the car sheds. The approaches to each shed are brilliantly lighted by means of arc lamps supplied from the lighting mains where these are available, and in the other case from the tramway supply.

### UNDERGROUND FEEDERS.

The feeder cables are of Callender's well-known bitumen insulated type, laid in earthenware troughs run in solid with bitumen, the troughs being covered with hard burnt tiles. Two cables only are laid in each trough, the arrangement throughout being that the feeder together with the telephone and test wire for the same route are placed in the same trough. There are 16 line feeders and four rail return feeders.

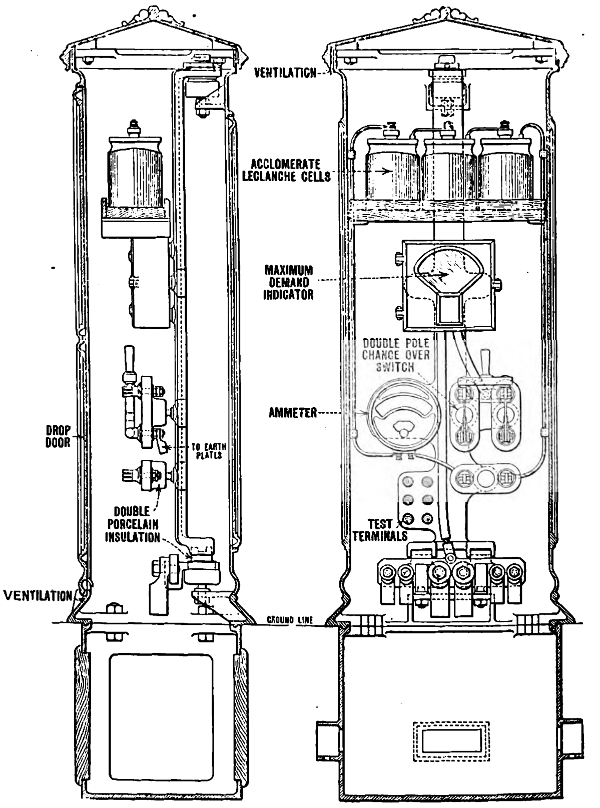

FIG. 6.—BOARD OF TRADE EARTH RETURN TEST PILLAR. Scale 1 : 20.

A line feeder is provided for each route, and two line feeders to the central district of the city. The rail return feeders are taken to four of the principal junctions, and are connected to the rails at these points through special switch pillars (Fig. 6) provided with a maximum demand indicator to register the earth plate current, and an ammeter, together with the necessary switch gear and battery for testing the condition of the earth plates which are placed at these four points. The rails are not earthed at the generating station, and neither positive nor negative boosters are at present employed in connection with the distributing system.

The length of the feeders varies from 1,500 yds. to 7,500 yds., and the section varies from 1 sq. in. to 0·15 sq. in. of copper. The section of the rail return feeders varies from 2½ sq. in. to 1½ sq. in., depending on the load in the various districts. All cables were subjected to the specified pressure test of 2,500 volts. and short lengths after being submitted to the usual bending tests failed to break down with 30,000 volts. These tests were carried out in the presence of Mr. M'Cowen at Messrs. Callender's works.

Sykes' conduits have also been laid to various junctions throughout the system, with a view to increasing the feeder capacity at a future date, as spare ways should the development of the undertaking require it.

### PERMANENT WAY.

The reconstruction of the permanent way was commenced last February under the superintendence of Mr. E. S. Pinkerton, who acted as resident engineer, and Mr. F. Lewis, who acted as clerk of works. All the routes were laid as double line to a gauge of 4 ft. 9 in., and the work now completed consists of about 80 miles measured as single track. Sixteen single-track miles of the tramways were laid only five years ago, and as this portion of the work was in fair condition the renewal of the special work, bonding and general repairs, was the only work necessary in connection with them.

British standard sections were adopted for the rails and fish plates used in the new track. No. 4 section, weighing 105 lb. to the lineal yard, was used on the straight and flat curves, and No. 4C section, weighing 111 lb. per yard, on curves of 66 ft. radius and under. The rails were manufactured to the British standard specification by the North-Eastern Steel Co.

The rails are anchored at the joints with Cooper anchors, consisting of 2 ft. lengths of rail inverted and riveted to the under flange of the rails with 12 rivets at each joint. Attached to the rail between the joints are intermediate anchors spaced about 11 ft. apart, consisting of sections of steel joists 8 in. long riveted transversely to the under flange with four rivets to each anchor. The tie-bars which are of mild steel 2 in. by ¼ in. are Bayliss's patent with lock nuts at both ends. The joint bonding has been executed with 0000 B and S gauge copper bonds of the protected type. Two bonds are fitted to each joint under the fish-plates. Solid crown cross bonds have been put it at 40 yd. intervals in the tracks and 80 yd. intervals between the tracks.

The whole of the special work was manufactured and supplied by the Lorain Steel Co.; it was manufactured and fitted together at the company's works in America and delivered in Belfast ready for laying. At junctions the points are made to a radius of 150 ft. and are armoured with manganese-steel insert pieces. The crossings are of the iron-bound type with steel-armoured centres. We are informed that the care with which the work had been designed and manufactured enabled it to be put together on the site without the slightest trouble. Owing to the close spacing of the rail anchors it was possible for some modifications of the usual method of track-laying to be made, and to do away with the necessity for removing temporary rail packings after the concrete had been put in. The method adopted was as follows:—

When the necessary excavation had been completed the rails were put in position, the fish-plates, anchors, tie-bars and bonds fitted, and the rails packed temporarily in the usual way, leaving sufficient space underneath for the proper thickness of the concrete bed; then, when the plate-laying had been completed, plastic concrete packing was put under the anchors and left for about 24 hours to set. The concrete bed was then put in in the usual way and packed tight under the rails while in a plastic state, the temporary packing being drawn in front of the concrete gang, leaving the track supported on the permanent anchor packing instead of relying upon the temporary packings which usually have to be withdrawn after the concreting has been completed.

The concrete bed under the rails consists of broken stone, gravel and cement mixed in the proportions of six of the aggregate to one of cement. Its normal thickness was 7 in., and the upper surface was finished 1 in. above the rail bed. Where the foundation was considered unreliable the thickness of the concrete was increased, in some places to as much as 12 in. The paving has been executed with granite setts 5 in. to 5½ in. deep and 3 in. to 4 in. wide. The setts were laid on a dry compo bed, mixed in the proportions of four of sand to one of cement, which was thoroughly wetted after the paving had been laid, and the joints were then grouted up with three to one compo. and back washed after the setts had been rammed. In the bulk of the work the rails were not parged, as the grouting was found to fill properly the space between the setts and the web of the rail, and to make a more satisfactory job. In some places, where it was necessary to turn the traffic on to the road immediately after completion, such as at road crossings, the rails were parged, the setts bedded on sand, the joints racked up with chippings, and grouted with pitch and creosote oil.

The work in connection with the permanent way was started in February, and has been completed in a record-breaking time, which speaks well for the organisation and energy of the staff of the contractors. In carrying out the work numerous alterations had to be made to sewers, gas, water and other mains, and in two places roads had to be lowered to provide the proper headway under bridges.

### CAR DEPOTS AND CARS.

When the Corporation took over the tramways there were five existing car depots, and four of these depots have been reconstructed. An entirely new car depot has also been built, which provides accommodation for about 30 cars. One of the reconstructed car sheds will serve as a central depot, and a large portion of it will be laid out eventually as car building and repairing shops. The special track work at this depot was particularly complicated, as owing to the narrowness of the street 20 lines had to be passed into the depot off the single street line. This work was carried out by Hadfield's Steel Foundry Co.

The floor work is much the same at the various depots. The lower floor, or pit, is 4 ft. 6 in. below the rail level. When completed, the sheds will be able to house a total of about 380 cars. The 170 cars are of the double-deck, single-truck Brush type, with a carrying capacity of 54 passengers. Their overall length is 28 ft., width 6 ft. 10 in., and the extreme overall height is 13 ft. 2 in. Hudson & Bowring's patent life-guards are fitted to each car, and Acme linen screen type direction indicators are used, lit up with three glow lamps. The total weight of each car is about 8 tons.

Besides these 170 new Brush cars, there are 50 horse cars undergoing conversion for use on the new system; the appearance of these cars when reconstructed will not differ materially from the new ones, save in the upper deck, where they are a few feet shorter than the Brush cars. They will carry 48 passengers instead of 54. The electrical equipment of the converted cars is similar to that of the new cars, and both have been supplied by the British Westinghouse Co. The car reconstruction work has all been done in Belfast, under the superintendence of Mr. A. A. Blackburn, the car works superintendent. It is expected that a further number of horse cars will be converted for electric traction.

## DESTRUCTORS AND THEIR BYE-PRODUCTS.*

BY F. L. WATSON.

With regard to the construction of destructors themselves, the various designs differ principally in the methods of feeding, the methods of taking off the gases of combustion and the methods of applying forced draught to the furnaces. The simplest and most primitive method of feeding is the "front feed." In this system the furnace has only one door, into which the refuse is thrown by the shovel, and from which the clinker is withdrawn when necessary. This system is very suitable and convenient for small plants, where the cost of labour is of no great importance, and it has had a very considerable vogue, even for large plants, in cases where high steam raising results have been considered more important than cost of labour or other considerations. This system lends itself readily to the "spoon-feeding" of a furnace, which, in the case of coal fired boilers as well as of destructors, is productive of a maximum rate of evaporation, but not necessarily of final economy. The "front-feed" system has the disadvantage that the unburnt refuse and the clinker have to be dealt with on the same floor, and there is always a risk of getting the two articles mixed up.

The "back-feed" system has been applied in many successful installations and has been adopted by various makers. It appears to me to possess every advantage which may be claimed for the "front-feed" system, and some additional advantages. In the "back-feed" system the refuse is stored in a convenient bin, which may, if desired, be enclosed to form a hopper, at the back of the cells away from the heat of the furnaces, and at a level which may be most conveniently arranged for easy charging. The refuse is thrown into the furnace by the back door, and the clinker is withdrawn from the front. The grate and drying hearth may be conveniently sloped so as to facilitate both the charging and clinkering operations. It will also be apparent that the height of cill convenient for throwing refuse in is not the same as the height most convenient for drawing clinker out. With "front-feed" cells a compromise has to be arrived at, but with "back-feed" cells the cills of charging doors and clinkering doors may each be fixed at the most convenient height above the respective floors.

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* Abstract of a Paper read before the Leeds Local Section of the Institution of Electrical Engineers, November 23rd.

The "top-feed" system is also one which has enjoyed and still enjoys a very large measure of popularity, and has been adopted with more or less success by, I think, all the different makers of destructors. In the most usual form of "top-feed" destructors a floor is provided on the top of the furnaces on which the refuse is tipped, and feed holes of various forms are arranged so that the refuse can be pushed or shovelled by hand into the furnace. "Top-feed" furnaces are frequently arranged "back-to-back," or in double rows, thus economising space and keeping the whole plant more compact. The charging holes are sometimes closed by lids, and sometimes, by packing the refuse into the feed hole, whose form is arranged to permit of this being done.

It will be observed that on all these methods of feeding, a provision is made for the storage of a certain quantity of refuse, and this is always necessary because a destructor must work with strict regularity if it is to be successful, and the collection and cartage of refuse is usually arranged to be done in the shortest number of hours per day, and cannot very well be changed about to suit the requirements of the destructor.

It would solve a great many difficulties if ordinary town refuse could be stored in a large hopper tapering towards the bottom, and having a door out of which it could flow when required, exactly as is done in the case of the storage of coal for gasworks and boiler purposes. Unfortunately, even with the best of arrangements, a piece of matting or oilcloth, or a large can coming through with the refuse is sufficient to cause a block and stop the whole business, and we must therefore reckon with the ascertained fact that refuse will not flow as a dry material will. It is, undoubtedly, a great advantage to get rid of handcharging altogether, and this has been done with some success in several plants. I have a diagram of one method which has been adopted at Westminster and at Blackpool, and with some modification at Bromley. In this arrangement the refuse carts tip their load bodily into the furnace on arrival at the destructor. A door is provided large enough to permit this, and is sealed by dipping into water all round its edges when closed. When the door is opened a movable hopper fits into the opening so that the refuse does not fall into the water trough. The arrangement works very well and is remarkably clean and wholesome for the workmen. The one difficulty it presents is that of storage, and in the instances mentioned this difficulty is got over by providing sufficient spare carts to stand full at the destructor until required.

For larger plants another system of storing has been devised, which is being installed on a small scale for the Leeds Corporation, and is also under construction in St. Petersburg, and will shortly be employed at Newcastle. In this arrangement the place of the spare carts is taken by a series of storage tubs having self-opening bottom doors which are held closed by means of lifting chains. Into these tubs the carts tip their loads on arrival at the destructor. The tubs are lifted by an overhead travelling crane, and stacked full until required. Each tub holds a full charge for a furnace, and in charging, the tub is lifted by the crane and placed on the top of a movable hopper, which is caused to descend by the weight of the tub. The water-sealed door is connected to the hopper by an arrangement of rods and levers, and is thus automatically opened by the descent of the tub, and in the same way automatically closed when the tub, after being emptied, is lifted clear by the crane. It is too early yet to say much of the results which will attend this method of charging destructors, but it has been considered to promise sufficiently well to justify its construction under guarantees. It will, in large plants, effect a considerable saving in labour, and this will be sufficient to justify the capital expense of the additional machinery involved; it is not, however, suitable for small plants. For capacities up to 60 or 80 tons per day I do not think anything will be found superior to the ordinary "back-feed," or the ordinary "top feed," or the Bromley "cart-feed" system, either of which may be adopted according to circumstances.

As regards the taking-off of the gases of combustion, there are, speaking broadly, three methods in use.

The first and most primitive is the drawing off of the gases at the back of the furnaces. This answers quite well with "front-feed" cells, but if adopted with cells which are fed from the back it results in unburnt gases and smoke passing away to the flue.

The next method to be considered is that by which the gases from one cell, or "division," of the destructor (for in this system the destructor can hardly be said to have any cells) are carried into the next division, and so on to the end of the battery. The last section of the battery has thus to carry through the whole of the gases from the plant, which makes it pretty warm for the stoker at that end. Furthermore, there does not appear to me to be quite the same certainty of perfect combustion in the last section as there is with cellular systems, and it is not possible to repair any one section without stopping the whole plant. For these reasons I should not advocate this system except for small plants, and if adopted for large plants I should consider it necessary to divide them up into small batteries.

The next system is that in which the outlet flues are situated towards the front of the furnaces, and are connected by cross flues with a common combustion chamber, in which all the gases mix before passing to the boilers. This system, which was originally invented by Mr. William Horsfall, of Leeds, has been adopted very largely, and is now used by several of the best known makers. The system ensures a perfect mixture of gases at all times, and enables each cell to be repaired independently. The course of the gases from the grate to the boilers is a trifle longer with this arrangement than with that in which they pass from one section to the next and so on, but this is, in my opinion, more than counterbalanced by the other advantages of the system.

To come now to the different methods of applying forced draught. Steam jet blowers are frequently accused of being very wasteful in steam, but as they have been tested down to 10 per cent. of the steam raised, I do not think that fan draught can show a much more economical result than that. For refuse containing large quantities of carbon, the injection of steam with the air has an advantage in the production of water-gas in the lower part of the fire, and the carrying of the combustion to a point further on in the furnace, and the production of a longer flame; it also assists in preserving the grate bars. Fan draught, on the other hand, seems specially suitable for refuse which is chiefly of a vegetable character, and when suitable fans or blowers are used, it is possible to get a very much higher blast pressure than is practicable with steam jets. If a system of feeding be adopted which will enable very large quantities of refuse to be charged into the cell practically instantaneously there is going to be a great advantage from an increased rate of combustion; and in such plants I have no doubt that fans will be the most successful. For smaller plants I consider that steam jets, if well designed and properly made, will hold the field for a long time to come.

There is a considerable advantage from heating the blast for destructors, and this has been done in various ways. In some cases an air heater consisting of a stack of pipes fixed in the flue at the back of the boilers, is used, through which the air for combustion is drawn by the blower or fan. The rise of temperature obtained by this means, though undoubtedly valuable, cannot be very great unless there is a big waste of heat from the boilers.

Another system is to deliver the air through cast iron side boxes, fixed in the furnace sides, which boxes are kept hot by their contact with the clinker and burning refuse, and at the same time these boxes give a protection to the brickwork of the cell against destruction by clinker. An ashpit temperature of 400°F. to 600°F. can thus be obtained, which must very materially assist combustion.

In furnace details great improvements have been made, and it should particularly be mentioned that all doors should fit tightly on planed faces to prevent the escape of gases or the inrush of cold air, and modern high temperature destructors require to be very strongly stayed. The furnace linings must also be constructed of the best firebricks, or their life will be short. It must be remembered that in a good destructor, properly worked with forced draught, the connecting flues and combustion chamber, as well as the inside of the furnaces will be maintained at a constant bright red or nearly white heat, and it should be the aim of a destructor foreman to see that the heat is never permitted to drop while the plant is at work.

It is very largely a question of perfectly regular stoking, and of the proper adjustment of the chimney pull and the forced draught. Too strong a chimney pull will at once reduce the temperature, and the aim should be to work with the least possible draw over the fire, practically a plenum in the furnace itself. It will also reduce to a minimum the amount of dust carried out of the furnace, which is most marked when a very strong chimney draught is used. As close as possible to the furnace combustion chamber should be fixed the boiler or boilers which are to utilise the available heat. For every 10,000 inhabitants there is roughly 10 tons of refuse per 24 hours, and this is capable of producing over 50 H.P. if properly utilised. Therefore the boilers are a most important item, and they should be properly proportioned to the plant. They may be of any of the well-known types, but the "water-tube" boiler is generally the most convenient, and I think the most efficient.

After the boiler, in all but the smallest of plants, a dustcatcher should be fixed. The most widely-known form of dustcatcher is on the centrifugal principle, the heavier particles of dust being separated from the gases by centrifugal force while the gases are passing rapidly round the interior of a circular annular chamber. The dust is collected in external pockets attached to the chamber. It has been found that such a dustcatcher is capable of arresting over 98 per cent. of the total dust contained in flue gases. The material collected in the dustcatcher is extremely fine, sharp and clean, and is used for various purposes, one of the most important being as a base for disinfecting powder. From the dustcatcher the gases pass to the chimney, and this need not in most cases be of any great height. The old-fashioned high chimneys were only necessary for old-fashioned low-temperature destructors. With a modern destructor, unless the situation is very exceptional, a chimney from 60 ft. to 90 ft. in height is all that is necessary.

One could almost fill another Paper with descriptions of the various machinery for the manufacture of mortar, crushing and screening of clinker, the convenient removal of clinker from the front of the furnaces, and the manufacture of clinker bricks and of concrete flags, &c. All these machines have been made the subject of deep study, and may be obtained specially adapted to destructor work.

With regard to the buildings surrounding the plant, these should, as far financial considerations will permit, be ample in size, lofty, well ventilated, and lighted from the top, and the openings for wheeling out clinker, &c., should be provided with doors, in order to prevent the draughts which are frequently troublesome in destructor houses, causing dust to blow about and get into people's eyes and throats.

Generally, it may be said that when all proper precautions have been taken in the construction and working of the plant a destructor is a source of no nuisance whatever, and the only inconvenience of which the neighbours could possibly complain is that due to the carting of the refuse through the streets. Even that can be reduced to a minimum by the use of proper carts and by proper attention to cleanliness. In numerous instances dwelling houses have been built in large numbers close to an existing destructor after the latter has been at work, and I remember one instance in which the owners of some property near a proposed destructor, after attending at the Local Government Board enquiry and raising all the opposition of which they were capable, proceeded as soon as the plant had been erected to acquire more land and construct more houses much closer to the plant than those which they originally possessed.

As examples of good practical results in the way of steam raising and electrical production, I insert here particulars of the official 12 hours' test of the Batley destructor in May of this year, and an abstract of the report presented to the Corporation of Bradford by Mr. W. M. Binny on a trial carried out by him at the Sunbridge-road destructor in that city. It will be observed that the latter trial was run over seven days and nights continuously. The steam-raising results agree reasonably with those which have been got in other instances, bearing in mind that the refuse of different towns is by no means equal in calorific value. The total electrical output for the week being 50,638 units, and the refuse burnt being nearly 833 tons, the output per ton was 60 units, which is pretty good for a continuous result, seeing that all steam used by jets and feed pumps, and blown off through the safety valve, was also raised by the destructor itself. At Batley a superheater is installed, so that the steam is delivered to the engine over 50 yds. away at a considerable superheat.

### TEST REPORT ON BATLEY DESTRUCTOR.

| | |
|---|---|
| Date of test .................... | May 18, 1905. |
| Duration of test ................ | 12 hours. |
| Number and type of cells ........ | Three cells, "back-feed" type. |
| Total grate surface ............. | 90 super. feet. |
| System of forced draught ........ | Horsfall patent steam-jet hot blast. |
| Nature of refuse ................ | Trade, household and night soil. |
| Number, size and type of boilers .. | One Lancashire boiler, 8 ft. by 30 ft. |
| Economiser—No. of tubes ........ | "Green's," 72 tubes. |
| Total quantity of refuse burned .. | 16 tons 10 cwt. |
| Total quantity of refuse burned per square foot of grate per hour.... | 1 cwt. 0 qr. 5lb. |
| Tons per man per shift .......... | 5½. |
| Total water evaporated .......... | 4,880 gallons. |
| Total water per hour ............ | 406·6 gallons. |
| Total water per lb. of refuse from and at 212°F. or 100°C. ........ | 1·60 lb. |
| Percentage of clinker and ash to refuse burned ................ | 33 per cent. |
| Mean steam pressure ............ | 175·4 lb. |
| Mean feed temperature .......... | 56·7°F. |
| Mean main flue temperature...... | 2,000°F. |
| Mean temperature behind boilers.. | 675°F. |
| Horse-power developed at 20 lb. steam per I.H.P. per hour ...... | 203·3. |
| Purpose for which steam is utilised | Generating electric current, central station adjoining. |

No. 1 Test.—*Of the whole of the Destructor and Electricity Plant together.*

| | |
|---|---|
| Date of test .................... | From noon, March 15, 1905, to noon, March 22nd, inclusive. |
| Duration of test ................ | 168 hours. |
| Number and type of cells ........ | 12 cells single-row top-fed. |
| Total grate surface ............. | 360 sq. ft. |
| System of forced draught ........ | Hot blast, with steam jet blowers. |
| Average air pressure under grates .. | 1 in. water. |
| Average steam pressure on blowers. | 54 lb. per square inch. |
| Nature of refuse ................ | Ash-pit, market and paper. |
| Total quantity of refuse burned .. | 832 tons 16 cwt. 3 qr. |
| Total quantity of refuse burned per cell per 24 hours .............. | 9 tons 18 cwt. 1 qr. |
| Tons per man per shift .......... | 6·6 tons. |
| Total of clinker and ash from refuse burned during test ............ | 421 tons. |

(Note.—Ashes were weighed wet as cooled.)

| | |
|---|---|
| Number of firemen and chargers .. | 18. |
| Wages per day .................. | 4s. 10d. |
| Number of boilers and type ...... | Two marine type, Babcock & Wilcox water tube. |
| Size of boilers .................. | 2,393 sq. ft heating surface in each. |
| Mean steam pressure on boilers.... | 146·5 lb. per square inch. |
| Total steam generated in boilers .. | 2,191,000 lb. |
| Total steam gnrtd. in boilers pr. hr. | 13,042 lb. |
| Total steam generated per sq. ft. heating surface per hour........ | 2·72 lb. |
| Total steam generated per lb. of refuse from and at 212°F. ......... | 1·25 lb. |
| Mean feed temperature .......... | 195·6°F. |
| Mean main flue temperature ...... | 1,880°F. |
| Mean temp. of flues leaving boilers. | 496°F. |
| Economiser .................... | 160 tubes. |

No. 2. Test.—*Steam used by jets for forced draught (including feed pump, economiser, engine and leakage). The electric light engine was stopped and disconnected.*

| | |
|---|---|
| Date of test .................... | March 22, 1905. |
| Duration of test ................ | 6 hours. |
| Total evaporation by boilers in 6 hrs. | 13,698 lb. |
| Number of boilers in use ........ | One. |

(Note.—No. 2 boiler was shut off entirely.)

| | |
|---|---|
| Water evaporated per hour ...... | 2,283 lb. |

No. 3 Test.—*Steam used for feed pumps, economiser engine and leakage. The steam jets and electric light engine shut off and disconnected.*

| | |
|---|---|
| Date of test .................... | March 22, 1905. |
| Duration of test ................ | 2¼ hours. |
| Total evaporation of steam by boiler for 2¼ hours .................. | 2,258 lb. |
| Water evaporated per hour ...... | 1,003·6 lb. |

During Test No. 2 the destructor cells were kept working at the same capacity as during No. 1 Test, thereby deducting steam used per hour in Test No. 3, when the steam jets were shut off, from steam used per hour in Test No. 2. The difference, namely, 1,280 lb. of steam per hour is the amount approximately required to work the jets for forced draught when the cells are working at their guaranteed capacity.

No. 4 Test.—*Electrical output of the steam engine and dynamo.*

| | |
|---|---|
| Date of test .................... | from noon, March 15, 1905, to noon March 22, 1905, inclusive. |
| Duration of test ................ | 168 hours. |
| Readings of dynamometer at beginning of test ............... | 54,840. |
| Ditto at end of test .............. | 105,478. |
| Difference ...................... | 50,638. |
| Mean voltage .................. | 516·7. |
| Mean steam pressure in steam chest | 130 lb. per square inch. |

The above output might be increased if it could be arranged for the engine and dynamo to utilise the steam that blows off at the relief valve.

### Summary of Tests.

From the above tests it is possible to ascertain if the conditions were carried out by the contractors. With regard to the first condition, the tests show that the average consumption of refuse was slightly less than the guaranteed consumption, but this may be attributed to poor results obtained on the first day of the test, when the stokers were probably inexperienced in getting the best results possible, and if the test had been continued for another 24 hours, so as to eliminate the first 24 hours, the results would have been quite up to, or over the guarantee; and this is borne out by the steady improvement during the progress of the test.

With regard to the second condition, the test shows that the boilers can generate 25 per cent. more steam than they guaranteed for.

With regard to the third condition, the test shows that the boilers were able to raise and provide steam at the rate of 13,042 lb. per hour instead of the guaranteed rate of 11,200 lb. per hour. The average steam pressure was 146·5 lb. per square inch, while the guarantee was for 145.

With regard to the fourth condition, the test shows that the steam required for the purpose of creating the necessary draught amounted approximately to 1,279·4 lb. weight per hour, while the guarantee was for 1,200 lb. weight per hour.

This result can only be taken approximately, as it was very difficult with the plant arranged as it is to make this test, on account of allowances having to be made for steam used by feed pumps, economiser engine and leakages of steam, and I do not attach much importance to the excess amount, as so very much more steam was generated than was possible to be used in the electric light engine, and a great deal of surplus steam was continually blowing off to waste through the special escape valve I had provided for it.

These reports lead me to a matter of great importance to electrical engineers—the allocation of costs and returns as between the destructor and the electricity works, and the management of the joint undertaking. If the cleansing department runs the destructor and sells steam to the electricity department, it will be run for sanitary purposes, and may not give its maximum results when the electricity department wants them ; if by the electricity department, it may be run for steam regardless of sanitary considerations. Again, if the sanitary department is to be paid for steam, how is the quantity to be ascertained ? I know of no satisfactory method, since the quantity used in the destructor itself is generally more or less uncertain. The value of the steam per ton is easily ascertained from the cost of raising the same quantity by means of coal. The ideal method would appear to be to drive an independent generating set from the destructor, and to work this set as nearly as possible at a constant load, crediting the destructor with the actual output. If the generating set can also be retained in the control of the cleansing department, and the current delivered by meter to the electricity department, it is better still.

## SOME NEW LINES OF WORK IN ELECTRO-THERAPEUTICS.*

BY H. LEWIS JONES, M.D. CANTAB., F.R.C P., LOND.,
Medical Officer in Charge of the Electrical Department at St. Bartholomew's Hospital.

Papers on electro-therapeutic subjects are not often read at the meetings of the general medical societies, and therefore your invitation to deliver this first Hunterian lecture on an electro-therapeutic subject is much appreciated by me as a mark of honour not so much to myself as to the subject with which I have had the happiness of being identified for nearly 15 years. During those years great changes have taken place in the applications of electricity to medical work. The widespread distribution of electricity for electric lighting purposes has rendered possible the utilisation of electricity on a scale which would have been impossible in former times. These modern facilities for obtaining supplies of current would not of themselves have altered the aspect of electro-therapeutics had there not always been a few medical men who were attracted to the study of the science of electricity for its own sake and by a recognition of its therapeutic possibilities. As a matter of fact, the medical profession has never been slow in seeking to apply new scientific discoveries to medical uses. In electricity the frictional machine, the voltaic pile, the induction coil, and every other discovery of note have been tried in therapeutics immediately upon their discovery.

Although there have always been a few patient workers in the field of medical electricity, it is nevertheless the case that among the rank and file of the profession the interest excited by electrical methods of treatment has been slight. To those who judged merely by results the field seemed to be a barren one, and so long as electricity was used in medicine mainly for the relief of states of debility, for the treatment of chronic paralytic affections and for old rheumatic cases, one could understand this attitude. The results of electrical treatments in those morbid conditions were of the same order of merit as those afforded by change of air, by sea-bathing, or by shampooing and gymnastic exercises, and as they entail more trouble for their administration they failed to attract the busy practitioner. Electro-therapeutics could not thrive so long as it served mainly as a useful adjunct or accessory to other modes of treatment, but it has now made many forward strides and is becoming able to take a leading part in the treatment of many morbid states.

If any method of treatment is to command the general attention of the medical profession it must be able to render services which are superior to any which can be had from already tried and older methods, and, further, it should apply to conditions of disease in which relief is urgently needed. For example, let us take the treatment of urethral stricture by electrolysis. There is no doubt at all that these strictures can be treated with success by the electrical method, but its use has failed to become firmly established in general practice because the other modes of treating strictures give results which are equally good. On the other hand, if we consider the cystoscope, which is another electrical appliance for use in diseases of the urinary tract and, therefore, presumably appeals to the same class of practitioner as that which has rejected the electric treatment of stricture, we find that the cystoscope has been universally adopted in the surgery of the urinary organs for the simple reason that it renders services which cannot be obtained in any other way. The general adoption of the cystoscope by surgeons during the last 12 years is well shown by my own experience with the instrument. Formerly I was often called upon to attend at consultations with my battery and cystoscope in order that the bladder might be examined by their means, but for many years past I have received no such request, because the surgeons now possess their own instruments and have mastered all the technical knowledge necessary to enable them to manipulate their cystoscopes for themselves without the intervention of an electro-therapeutic specialist.

The eagerness with which Röntgen rays were taken up by the medical profession as soon as they were discovered may be adduced as a further proof that electrical methods will never suffer from neglect if they are capable of giving first-class results.

The history of medical electricity has been a history of gradual progress by the method of trial and error—empirical for the most part, though based upon physics and physiology—and while there has been much chaff there has also been a harvest of grain. If we review for a moment the benefits which medical science has gained from electricity, confining our attention to those things only in which the advantages of electricity are incontestable, we shall see that the list is a goodly one. The names of Duchenne and of Remak may be made our starting point, their work having been the inauguration of modern methods of application of battery currents (galvanism and faradism) between the years 1850 and 1860.

The evolution of a systematic method of procedure for the examination of nerves and muscles by Erb during the succeeding ten years forms the next landmark. Owing to the exactness of its diagnostic results this section of electrical work has been one of the most precious gifts of electricity to medicine. The principles of electrical testing in paralytic disorders are universally accepted, but the anatomical knowledge which is needed to form the basis upon which the diagnosis of nervous disorders is built has been something of an obstacle to the general adoption of electrical testing by the profession at large.

The invention of the incandescent lamp of Edison and Swan has given medicine some instruments which are quite indispensable. Even before the carbon filament was invented the importance of the electric lamp for purposes of medical diagnosis had been realised. Nitsche used tiny loops of platinum wire in his early cystoscopes and although he experienced endless vexations through the fusion of the wire filaments, so that it is said that his lamps required almost daily renewal at great expense, yet he was so convinced of the value of the electric exploring lamp in the field of bladder surgery as to persevere in the face of all difficulties until the invention of the carbon filament provided him with a satisfactory solution of the problem. Numerous lamp instruments are now used by surgeons, but it is only necessary to specify two of them—the cystoscope and the Antrum lamp—to show that here, too, electricity has rendered good service.

Electrolysis as a means of destroying certain classes of nævi and for removing hairs and small moles may also be given a place in the list of first-class matter contributed to medical practice by electricity. Although the conditions relieved are not dangerous to life, yet the method fulfils the requirements we have laid down as essentials, because it gives results which are not attainable by any of the older procedures, and I am sure that there are large numbers of people who either are, or ought to be, very grateful for the results which electrolytic methods have given to them in the direction of cosmetic surgery.

The short list of matters which I have just given you may serve to represent the position of electricity in medicine down to the time (1895) of the discovery of Röntgen rays. Although I have purposely omitted all reference to what we may call second-class matter, it by no means follows that there was no good thing among all the other applications of electricity to medical treatment, but for my present purposes I am confining my attention solely to those advantages of electrical methods in practice which admit of no question.

The discovery of Röntgen rays at once increased the claims of electricity to proper recognition. The demands for X-ray apparatus have kept the instrument makers busy from that time to this, and the developments of the therapeutic uses of X rays, as well as the diagnostic uses, have had the effect of overshadowing the rest of the applications of medical electricity, so that they have been in danger of being forgotten by the general mass of the profession. The list of real gains in X-ray therapeutics is large and highly important. If I pass by the question of malignant disease, in which, nevertheless, X-rays may be of considerable value in prolonging life, we yet find a goodly list: rodent ulcer, lupus, psoriasis, chronic eczema, ringworm, sycosis, acne, pruritus and leukæmia—all these may be confidently claimed as conditions in which X-rays give results of great value.

Time does not permit me to make more than a casual reference to the Finsen treatment of lupus. This may be claimed as a distinct gain, and may be credited to electricity, though as a practical method it labours under the disadvantage of extreme cost and extreme slowness of operation.

As the field of electro-therapeutics goes on growing, and as it continues to embrace the treatment of the more serious diseases which afflict humanity, we shall, I think, see less and less of the unqualified electrician. That individual derives his gains very largely from pandering to slight ailments and trivialities. Moreover, he has to trust very largely to his machines in fault of knowledge of physiology and medicine. When the relief sought for is of the nature of tonic or invigorating effects or the easing of a little rheumatism, or the strengthening of some impotent part, or the restoration of youth to the old, then the prescribing druggist or the man with the electrical machine is considered sufficient for the dealing with matters of such small relative importance. When, on the other hand, the patient is really anxious about himself and suffers from some disorder of a precise nature and really feels in need of skilled medical advice he takes good care to look for the best physcian or surgeon that he can find, unless, indeed, he happens to be a person with considerably less than the average amount of common sense.* I do not think that the unqualified electrician is often asked to investigate and report on a case of nerve injury. Anatomical and medical knowledge is needed for electrical testing and diagnosis and the unqualified man does not possess it. X-ray photography is rapidly becoming too difficult for him and X-ray treatment too dangerous. High frequency has already shrunk into its proper small dimensions. The light bath—red, white and blue—is destined to become a more or less ornamental accessory in Turkish bath establishments instead of being relied on as a panacea for all kinds of painful and other affections.

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* Delivered before the Hunterian Society on October 11th. Reprinted from the *Lancet*.

With this somewhat long preamble, which I trust you have not found tedious, I now come to the more immediate subject of my lecture—namely, the consideration of certain new lines of electro-therapeutic work. In spite of all the striking advances which have been made in the field of X-ray therapeutics, I am by no means of the opinion that the older field of work with the so-called galvanic and faradic currents is exhausted. For example, the subject of electrolysis has lately come into prominence afresh, not for the destructive actions which it exercises in its application to nævus, moles, &c., but as a means of introducing drugs into the system, and also, perhaps, for the withdrawal of injurious chemical bodies from the system. This use of electrolysis is not entirely novel; something may be found upon the subject in most of the older text-books of medical electricity, but of late a better comprehension of the physical laws of electrolysis is leading to new medical applications which promise to be useful. Although doubtless you are familiar with the general principles which underlie electrolysis, it may, perhaps, simplify my task if I recapitulate them briefly from the medical point of view. When a battery or other source of direct current is connected to a patient by means of the usual moistened pads a current flows through the circuit, because the wires, the moist pads, and the body are conductors. The mechanism, however, of the conduction in the non-metallic parts of the circuit is not the same as that which holds good for the wires. Conduction in watery solutions of salts (and the tissues of the body may be regarded as coming into this category) takes place only by the conveyance or transport of charged particles or "ions" through the liquid from one metallic terminal to the other, and without this movement of material particles there is no conduction in liquid solutions. The moving particles or ions are the result of the dissociation of the molecules of the salt by the process of solution, so that a solution of sodium chloride in water contains abundance of dissociated ions of chlorine carrying negative charges and of sodium carrying positive. When a current is applied there is a double movement among those ions—a procession of the chlorine ions to the positive pole and of the sodium ions to the negative, every ion carrying its appropriate positive or negative charge, so that the measurement of the current by a galvanometer in the circuit gives an accurate indicate of the number or amount of the chlorine ions brought to the positive pole and of the sodium ions brought to the negative.

An ingenious illustration of the state of things in a watery solution of salts to which an electric current is applied has been drawn from a ball room, and though the simile is by no mean a perfect one I think it may interest you. The inventor of the simile says, imagine a ball room filled with people of both sexes, evenly distributed, some waltzing together in couples, others moving about irregularly, talking together and passing on and breaking up into changing groups and pairs. This represents the solution of the salt in its normal state, the waltzers being the undissociated molecules of the salt, the other individuals being those molecules which are dissociated into ions. All are in movement, but the net result of all the movement leaves unchanged the general distribution of individuals throughout the extent of the room. Then, to represent the turning on of the current, let a sumptuous drinking bar suddenly appear at one end of the room and a gorgeous mirror at the other. The unattached individuals will at once commence a movement towards these poles of attraction—the men to the bar, the women to the mirror. Gradually, too, the waltzers or undissociated molecules will separate into their components, and these will also commence their respective movements to the one pole and from the other, until after a certain lapse of time there will be a concentration of men round the drinking bar and of the women round the mirror, and the number of the waltzers or dissociated molecules will have decreased. In the case of pads moistened with salt solution and conveying current from one part of the body to another the movements of ions are as follows. At the positive pole sodium moves inwards, penetrating the surface in contact with the positive pad on its march to the negative pole, and chlorine moves outwards, reaching the metal backing of the pad, and there is either liberated as free chlorine or else enters into combination with the metal to form a chloride. The phenomena at the negative pad are the complements of those at the positive—chlorine ions entering the skin and tissues, sodium ions moving to the metal backing of the pad and there appearing as metallic sodium, though rapidly suffering immediate decomposition from reaction with the water which exists there. If the body to be introduced through the skin be a kathion or positively-charged ion it will migrate from the anode, and the substances which enter from the anode are the ions of the metals, of the alkalies and of the alkaloids; while among those which may be usefully introduced from the kathode are salicylic acid and other acid radicles. In order to introduce ions of zinc into a given area the proper procedure is to apply a pad of lint or of cotton wool moistened with a solution of a zinc salt and to bring to the outer surface of the pad a rod or plate of metallic zinc connected to the positive pole of a battery. The current which flows is carried by the zinc ions of the solution, which migrate inwards through the skin, and, their place being supplied by fresh zinc ions set free from the zinc electrode, there is no fear of exhaustion of the supply, or of the contamination of the pad by ions of other metals, as would be the case if the metal used for the electrode were not zinc but copper or any other soluble metal. When the substance to be introduced is one like quinine or salicyclic acid the supply of its ions must be maintained by the provision of an ample quantity of its solution in the fluid of the moistened pad and the metal of the electrode must be of platinum in order that extraneous ions may not complicate the process. Carbon discs or plates, if thoroughly pure, may be used instead of platinum, as carbon liberates no ions under the conditions of the experiment.

Having so far considered the essential rules for the introduction of ions into the living body the next and obvious question is as to the advantages to be gained by the procedure. As this is far more complicated than the administration of drugs by the mouth or by hypodermic injection it must have some corresponding advantages if it is to be adopted into medical practice. For purposes of local medication there might be a field of employment for electrolytic medication, although for general medication its use might be of no practical advantage. But even for local medication the method must be able to compare advantageously with the methods of subcutaneous injection, of fomention, or of inunction. In theoretical support of the electrolytic method it may be pointed out that whereas a hypodermic injection passes into the interstices and lymph spaces and may never reach the actual cells, the ions introduced electrically must enter into the composition of every cell through which the current penetrates, at least in those portions which are in close proximity to the active electrode, and, by reason of that penetration, they may be enabled to act more effectually and for a longer time before they are carried off into the general circulation by the lymph stream. The amount of penetration which follows fomentation or inunction is rarely of great use in medication.

The better way of settling this question of the merits of electrolytic medication is to try experiments and to observe the results, and I shall therefore proceed at once to give you details of some experiments which I have made upon the local treatment of rodent ulcer and lupus by the introduction of the ions of zinc. My attention was called to this mode of treatment by a Paper by Dr. Stephane Leduc, Professor of Medical Physics in the University of Nantes, which appeared in the latter part of 1904 under the title of "The Ions in Medicine," and gave a masterly sketch of the whole subject of electrolytic phenomena in medical practice. In that Paper Prof. Leduc referred again to a subject on which he had previously written —namely, on the healing of a rodent ulcer after an application of zinc electrolysis. I was much struck by the originality of this Paper, and reproduced it in the form of an extended abstract for the benefit of English readers in the February number of "Medical Electrology and Radiology." I also commenced treating some cases of rodent ulcer, choosing to begin with simple, uncomplicated small rodent ulcers which had not had any other kind of treatment. The first of these received an application in December of last year, and I was agreeably surprised to see it heal completely within two or three weeks from the time of the introduction of the ions of zinc. Moreover, the disease has not returned, for I saw the patient quite recently and found the condition excellent, without any sign of relapse, although more than nine months have passed since the application of the zinc. Since treating this patient I have been able to try the same method upon six or seven other cases of small rodent ulcer, and in every one of them I have been able to observe that the treatment exercises a markedly beneficial effect. I have not been able to secure so complete and rapid a healing in all of these cases as that which occurred in the first one, but the results have been uniformly good, nevertheless, and I would like to recount them in order that you may draw your own conclusions.

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* A word in season may be spoken here as to the unfortunate tendency of some medical men to send their cases to unqualified electricians. If those medical men could hear the kind of conversation with which their patients are regaled while under such treatment it would, I think, "give them furiously to think," if I may quote a French idiom. It commonly consists of systematic disparagement of medical men who are said to be "behind the times"; "only capable of prescribing useless drugs"; "ignorant of modern therapeutics," and so on. This kind of wholesale detraction goes on to a considerable extent, even the sender of the case coming in for innuendo and disparagement.

*Case 1.*—One application, in January, 1905, was followed by healing in two or three weeks. The ulcer was seen in August and was found quite soundly healed without relapse.

*Case 2.*—One application on March 1st. The patient was about to leave for the south of France, and I was asked to do what I could in one application. The patient was an elderly lady and needed gentle handling, and the strength of current was kept rather low. In May I wrote to inquire and received a letter from her medical man as follows: "The result has been most satisfactory. I found there was only a slight hardness left." Another letter received this week says: "The patient is still quite well. It is indeed most interesting to me."

*Case 3.*—One application on July 3rd. The patient has not been seen since. A letter was received to day from the medical attendant in answer to an inquiry which says: "If you had asked me some time ago I should have said that the rodent ulcer was quite well. But on Sunday he showed me a pin-point little abrasion on the upper part of the scar. I shall see him again in a few days and if there is any ulcer shall send him up to you."

*Case 4.*—Two applications on May 11th and June 29th. The ulcer was seen on October 6th and found to be healed over, but with a few suspicious points at the margins. There was great improvement on the orginal condition. The application was repeated.

*Case 5.*—Three applications on July 18th, August 30th and September 13th. The ulcer was quite healed on September 27th and shows no sign of recurrence so far.

*Case 6.*—Three applications on June 22nd, July 27th and September 4th. An irregular ulcer of the upper lip complicated by the presence of a moustache. Seen lately and found healed in great part, but still showing unhealed portions here and there.

*Case 7.*—Four applications on January 24th, February 14th, June 20th and August 1st. The ulcer was situated at the side of the nose near the left eye. The condition was like that in the last case. The patient had X-rays previously, and was treated with great caution through uncertainty as to what the skin would tolerate. The patient is improving. The ulcer is healing irregularly, but is not well.

These results seem to me to be worthy of your attention, and I have great pleasure in making my first report of them to this society. I consider them to be of considerable promise for the future. I attribute the special success of the first two cases to the condition of the ulcer at the time of the application. This is an important factor for the following reasons: To obtain a successful effect requires an evenly distributed action of the zinc over the whole area of the ulcer, and in many instances this is rendered difficult by the state of its surface which may be partly crusted over, conducting badly, and partly moist and raw, conducting well. Then, too, there is the advancing pearly edge of the disease still covered by a protecting layer of epidermis. In these ordinary circumstances the distribution of current, and therefore of the zinc ions, is an unequal one and some portions of the ulcer receive a better quantity of the zinc ions than other parts.

There are still several small details of practice to be worked out in this electrolytic employment of zinc ions and it takes a good deal of time to get these small matters just right. At present I use a solution of zinc chloride of the strength of 5 grains to the ounce, which is very nearly a 1 per cent. solution. I have also used zinc sulphate at the same strength and this seems to answer equally well. In either case owing to the dilution there is no question of caustic effects. I mention this because chloride of zinc has long been used in concentrated solutions for the destruction of unhealthy tissues, but its action as used electrolytically is not a caustic action and the treatment produces no additional scarring; indeed, the healed part may show hardly any evidence of the former existence of the rodent ulcer. The magnitude of current to employ depends upon the surface under treatment. Leduc has suggested a strength of 2 milliamperes per square centimetre, applied for about 15 or 20 minutes. In my experiments I have used rather stronger currents for proportionately shorter time. The treatment causes some slight pain or discomfort if the current has too great a density, but in general the little operation is well borne. If that is not the case I introduce a little cocaine first, using a separate pad for the purpose.

I have brought some of my electrodes for inspection. As you will see, they are of simple patterns and can easily be made. The metal is covered by lint or cotton, tied on in some cases, and in others the lint is applied to fit the part under treatment and the metal held upon its surface. The zinc ions seem to remain in the cells of the affected part for some time, or at least the effect set up by the application seems to continue for a considerable time afterwards. For instance, in one of my patients, where it was evident on September 6th that the pearly edge of the rodent ulcer treated on August 30th had not disappeared, it was decided to allow another week to pass before repeating the application, and a week later this edge had become very much less definite, although nothing further in the way of zinc electrolysis had been done to it, and a fresh application on September 13th brought the case to a satisfactory conclusion. The appearance of the rodent ulcer at the end of the application is peculiar. When the zinc ions have penetrated thoroughly it has a milk-white look, rather disquieting in aspect until one is familiar with it; but this dead-white colour does not mean that there is going to be any necrosis of tissue and seems merely to be the proper appearance of a tissue impregnated with zinc ions. The white colour slowly fades away and leaves the surface rather sore for a week or more. During this period a little simple ointment may be applied, but there must be no question of repeating the electrolysis for at least a fortnight or three weeks. At any rate, that is my present opinion. The depth to which the zinc ions can penetrate in a given time is also a matter requiring investigation. The rate of movement of ions in an electrolytic conductor has been determined and in the case under consideration is probably less than a centimetre in an hour, the actual figure being influenced by the magnitude of the applied E.M.F. The amount of zinc set in movement in an ordinary application of 10 milliamperes for 10 minutes is about 4 milligrammes. The effect of the applications is, therefore, strictly local

I am not in a position to say anything to-day about the influence of zinc electrolysis upon lupus, although I have tried, and am trying, the method in several cases of the disease. The cases which I chose at the outset for purposes of experiment have not yet proved successful, partly because of their irregular attendances and partly through my own absence from the department during the greater part of July and August, but the partial results so far obtained are not altogether discouraging, and I still hope that an electrolytic method of treating this disease either by zinc (or perhaps by copper) may be obtained. Leduc, in his highly suggestive Paper on the "Ions in Medicine," does not by any means limit his remarks to the use of zinc and the treatment of rodent ulcer. He suggests strongly that zinc ions should be tried for all kinds of indolent ulcerations and discharging sinuses by reason of the great antiseptic effect which it exercises. He also deals with the electrolytic introduction of the ions of other metals, of quinine, of salicylic acid, of iodine, and many other drugs, and the impression conveyed by his Paper is that, if it can only be established by further experiment that electrolysis provides an effectual mode of percutaneous local medication, its applications in medical practice may become numerous. There is evidently a great deal of work to be done in the development of his ideas. It is historically interesting to recall the fact that Benjamin Ward Richardson made many experiments in the production of local anæsthesia by the introduction of aconite in 1859, but his work met with so much opposition and incredulity that he was forced to give it up. More recently, the discovery of cocaine has enabled the production of local anæsthesia by electrolysis to be carried out with greater success, and I have used this procedure frequently before removing moles and small papillomata by needling.

Edison, in 1890, suggested electrolysis for the introduction of lithium into gouty tissues and since his time several medical experimenters have noted the good effect of this form of treatment. Quite recently Bordier* repeated these experiments, also using as electrode a bath containing a solution of lithium, and made a series of applications to a patient with large gouty deposits in the hands. He was not only able to demonstrate the presence of lithium in the patient's urine, as had been done before by others, but, and this is even more striking, he detected the presence of uric acid in the liquid of the arm baths, thus proving both the introduction of the kathion lithium and the extraction of the anion uric acid at one operation. There was also a marked change for the better in the condition of the patient's gouty deposits as a result of the experiments. It takes time to follow up and to work out the various lines of research suggested by these new notions of electrolytic medication. The possibilities, as I have endeavoured to show, are highly attractive, but much patient work is still necessary before we can claim anything like final results, and I am sure that there is room for many workers in this new line of electro-therapeutic work.

In conclusion, I wish once more to emphasise the fact that the ideas involved in this account of electrolytic medication are the ideas of Prof. Leduc of Nantes, and that my own position in the development of this line of work is simply that of a follower and disciple of a much esteemed friend.

**The King of Portugal and Science.**—During a visit to Paris on Friday last the King of Portugal paid a call at the Museum of Natural History. There he listended to five lectures, each of five minutes, delivered by five of France's foremost scientists. M. Becquerel discoursed on uranium, Mme. Curie on radium, M. Lippmann on colour photography, M. Lacroix on the eruption of Mont Pelée and M. Moissan on the electric furnace. The last named made an artificial diamond and presented it to the King.

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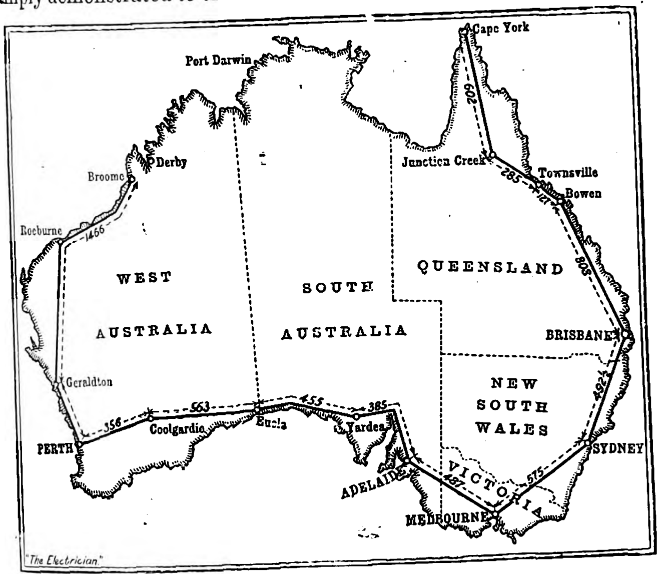
* "Archives d'Électricité Médicale," 1900, p. 529.

## LONG-DISTANCE TELEGRAPHY IN AUSTRALIA.

Mr. T. Howard, assistant electrical engineer, G.P.O., Melbourne, has sent us the following account of some interesting long-distance telegraph records made on Sunday morning, September 24th. Mr. Jenvey, electrical engineer for Victoria, who was on an official visit to Western Australia had made the suggestion during the preceding week that a trial should be made on the following Sunday, and the admirable co-operation of the electrical engineers in the other States of the Federation resulted in Broome, a station on the north coast of Western Australia, being placed in easy and perfectly plain communication with Cape York, an office on the extreme northern point of Queensland, over a distance by the route of the line of 6,601¼ miles.

The experiments were commenced at 11 a.m. Melbourne, Sydney, Brisbane, time, which under the prevailing zone system was 9 a.m. at Perth. Adelaide, Melbourne, Sydney, Brisbane and Townsville were in attendance and ready at the former hour and greeted each other. Cape York was then joined to the circuit, the signals to and from him being clear and firm. Owing to an unexpected delay at Eucla, which is a main repeating station situated on the Great Australian Bight, Perth was not in a position to communicate with Melbourne and the other capitals until 12 noon, but when he did appear there was no difficulty in speaking through to Cape York freely and well. Broome, a duplex station, 1,466 miles distant from Perth, was then connected to the circuit and he and Cape York passed the time of day and carried on a conversation for 15 minutes, at a key speed of 20 words per minute, without the least sign of lag in the signals. Broome stated that the temperature was 100 deg. in the shade there, while Cape York set it down at 80 at his end.

The signals passed from one terminal station to the other splendidly, annihilating distance in a most pronounced manner, and amply demonstrated to the satisfaction of all concerned that through telegraph working from one end of Australia to the other was a practicable feat. With the arrival of this successful issue the terminal stations were taken off, the intermediate circuits were dismantled, and the experiments came to an end.



By referring to the attached skeleton map of Australia the course of the circuit can be readily traced. There were 13 repeating stations, numbered in the column 1 to 13, and the various sections of line were made up as follows, viz.:—

*Long-distance Telegraphy.*

| No. | From | To | Telegraph system. | Class of line wire in use. | Distance in miles. |
|---|---|---|---|---|---|
| 0 | Broome | .. | .. | .. | .. |
| 1 | Repeater at | Roeburne | .. | .. | .. |
| 2 | Do. | Geraldton | .. | .. | .. |
| 3 | .. | Perth | Duplex | 400 lb. iron | 1,466 |
| 4 | Perth | Coolgardie | Quad | 200 lb. copper | 356 |
| 5 | Coolgardie | Eucla | Do. | Do. | 563 |
| 6 | Eucla | Yardea | Do. | 300 lb. copper | 455 |
| 7 | Yardea | Adelaide | Do. | Do. | 385 |
| 8 | Adelaide | Melbourne | Do. | Do. | 487 |
| 9 | Melbourne | Sydney | Do. | 800 lb. iron | 575 |
| 10 | Sydney | Brisbane | Do. | 400 lb. copper | 173¾ |
|  | .. | .. | Do. | 300 lb. copper | 318 |
|  | .. | .. | Do. | Sub. cable | ¼ |
|  | .. | .. | Do. | Aerial cable | ¼ |
| 11 | Brisbane | Bowen | Duplex | 200 lb. copper | 430 |
|  | .. | .. | Do. | 400 lb. iron | 378 |
| 12 | Bowen | Townsville | Do. | Do. | 127 |
| 13 | Townsville | Junction Ck. | Do. | Do. | 285 |
| 14 | Junction Ck. | Cape York | Do. | Do. | 602 |

Grand total—6,601¼ miles.

Some 10 years ago when Mr. Jenvey was again in West Australia—viz., on Sunday, May 26, 1895, a similar trial was made, and on that occasion Derby, a station 124 miles north of Broome, was linked to the circuit. At that period the various State Postal Departments of Australia were working under different and separate administrations, some using the Universal and others the Australian Telegraph Code, which fact reduced the key speed to 10 words per minute for that trial. All Australian Departments are now subservient to the control of one Central Federal Office, and the Universal Code has become general since 1897. For some reason not assigned, Derby was not available for the recent test. There is no direct line connecting Derby to Port Darwin, or the latter to Cape York, so that it was not possible to encircle the whole of the continent by one speaking circuit.

The composite nature of the line and the character of the ground traversed must be considered in estimating the value of this achievement. Some sections pass over desert, forest and mountainous country and through water, and are exposed to the destructive effects of high winds, storms and rain, also damage from passing traffic. In order that a test of the description under review may be successfully carried out it is necessary that: (1) The sections of the line must be in good working condition; (2) the repeaters should be well adjusted and carefully watched; (3) batteries must be well up to their maximum strength; (4) there should be good local management and supervision of the circuits. The following were the technical officers principally concerned in the test, viz.: Messrs. Jenvey and Diercks, at Perth; Mr. Unbehaum, at Adelaide; Messrs. Howard and Fitzgerald, at Melbourne; Mr. Nelson, at Sydney; Mr. Hesketh, at Brisbane; and Mr. Murphy, at Townsville.

## ON SOME PROBLEMS OF ELECTRO AND ELECTRO-THERMAL CHEMISTRY.*

BY R. THRELFALL, F.R.S.

The position of a chemical manufacturer when called upon for a presidential address is not a particularly happy one. Reticence is a tradition of the chemical industry, and the introduction of processes based on electro-chemical operations has, if anything, increased the habit of, as well as the necessity for, uncommunicativeness. It is hoped that this remark may serve as my excuse for adopting a distant standpoint in the brief survey I propose to make of some electro-chemical matters.

The general condition of the industry is the topic which naturally presents itself as of greatest interest. In the early nineties of the last century there is no doubt that very extravagant ideas were current as to the part which electricity was to play in the chemical industries. The Patent Office records support this view. The number of patents appearing in the Patent Index for each year under the heading "Electrolysis" from 1891 to 1904 is as follows:—1891, 55; 1892, 66; 1893, 90; 1894, 99; 1895, 87; 1896, 82; 1897, 74; 1898, 61; 1899, 71; 1900, 79; 1901, 67; 1902, 63; 1904, 71. The early anticipations have not been altogether realised, and it is now pretty clearly seen that there are many processes in which the intervention of electricity is not commercially advantageous even though it may be technically practicable.

### FIXATION OF NITROGEN.

Possibly an illustration may be the direct fixation of the nitrogen of the air in the form of oxides by some form of electric discharge. The chief difficulty here is that Nature has long ago fixed a great deal of nitrogen in the nitre beds of Chile, and at present it is cheaper to dig up the fixed nitrogen and to carry it to where it is required than it is to fix it electrically at some point nearer to the centre of consumption. The electric process, however, is no doubt susceptible of improvement, and apparently occupies the minds of a good many inventors. The shortest cut to a successful result will probably be found in a thorough study of the theory of the reaction. A beginning has already been made by von Lepel Ber, 1903–1905, and Dr. Otto Scheur (*Zeitschrift für Elektrochemie*, September 1, 1905), though no doubt a great amount of unpublished experimental work has been already accumulated by various patentees. The yield of oxides (for all the oxides of nitrogen appear to be formed) depends on the nature of the spark or electric flame, on the shape of the containing vessel, and velocity of the air stream among other factors, and it may well be years before the conditions for best working are clearly set forth.

In their French patent No. 335,692, Eyde and Birksland claim to be able to make as much as 650 kilos of oxydised nitrogen (calculated as nitric acid) for one kilowatt year. On the basis of power at Niagara price (nominally $20 per E.H.P. year) I find that 1 lb. of (mostly potential) nitric acid would cost about 0·9d., while if $10 power be considered the standard, the cost for power would be naturally 0·45d. With Chile saltpetre at 10s. 6d. per cwt. at Liverpool, the value or the nitric acid content could be put at about 1·17d. per pound $HNO_3$. The air oxidation workers would, however, require to neutralise their product for manureal purposes presumably with limestone, the cost of which is inappreciable in a rough calculation, though the labour and packing of the nitrate and nitrite mixture probably is not. There is no information available as to the other items of manufacturing cost, but it looks as if there was a possibility of an industry in this direction with a $10 power in an agricultural country. If I were working at this problem, I think I should try the effect of a discharge in an atmosphere carrying a lime-water fog in suspension and in rapid motion.

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* Inaugural Address to the Birmingham Section of the Institution of Electrical Engineers. Delivered November 22, 1905.

Some years ago (*Phil. Mag.*, 1893, p. 27) I noticed that mercury and nitrogen can be made to combine by an electric discharge at about 0·8 mm. pressure, and not too high a temperature—say, under 200°C. It might be worth while to examine whether mercury vapour air and steam at, say, 160°C., where the vapour tension of mercury is 5·9 mm., could be made to yield ammonia, if not oxide of nitrogen: the mercury could possibly be recovered; if it could not its use would be impracticable. Meanwhile, the researches of Caro and Frank seem to have reached a practical stage in the commercial production of cyanamide with the electric furnace. So far as I understand the matter, calcium carbide was originally treated at about 2,000°C. with nitrogen—giving calcium cyanamide. At a later date the cyanamide was to be produced in the same furnace as the carbide, though, so far as I know, details have not been published. According to Dr. Frank (*Zeitschrift für Elektrochemie*, Vol. IX., p. 858, 1903) calcium cyanamide can be used direct as an artificial manure.

It was originally proposed to use cyanamide as the basis of a process for making potassium or sodium cyanide, but so far as is known to me, this idea has been given up, cyanide of the very high quality now required by consumers being more easily produced in other ways.

The whole subject of the fixation of nitrogen is of the greatest interest to mankind—of greater interest than any other chemical problem; but whether the fixation can be best done by electricity or in other ways—by bacteria, for instance—is a question which time alone can decide.

The world's consumption of ammonia and nitrate in 1903 amounted, according to Dr. Frank, to between eighteen and nineteen million pounds sterling: not a very large sum having regard to the greatness of the agricultural industry. I look forward to the time when, through the labours of chemists, the price of fixed nitrogen shall have dropped to something like one-tenth of its present value, and the consumption be limited mainly by the cost of distribution.

### NONCONDUCTING CARBON.

Though of far less intrinsic importance than the fixation of atmospheric nitrogen, the artificial production of diamonds presents many problems of great interest. As is well known, Moissan succeeded in producing minute diamonds by saturating iron and other metals with carbon at electric furnace temperatures, and then suddenly cooling the molten mass by dropping the crucible and its contents into water, mercury, or melted lead. These experiments have been followed up by Mayorana and others, ending with Sir William Crookes, who produces some evidence of the formation of microscopic diamonds by the explosion of cordite in a closed vessel.

By far the most important investigation hitherto published on this subject is that of Dr. A. Ludwig in the *Zeitschrift für Elecktrochemie*, Vol. VIII, p. 273 (May 8, 1902), and in several patents—*e.g.*, British 16,908 and 17,119 of 1900, and 5,482 of 1902. Dr. Ludwig has made a brave but unsuccessful attempt to produce diamonds, or rather cubic carbon, on the large scale.

The apparatus consists of compression vessels and compression pumps enabling carbon to be kept under high pressure. The carbon was heated electrically in compressed hydrogen, and it was found necessary to cool the product of the operation very suddenly: this was accomplished by injecting water at enormous pressure, so that the carbon under investigation was struck by jets of water moving at immense velocities. The result of a successful experiment was to produce a sort of carbon glass, for obviously the rapid cooling does not afford time for the formation of crystals of appreciable size, and the glass tended to resemble black diamond rather than clear cubic crystals. Dr. Ludwig does not state how much of this material was obtained, so that it is not possible to form an opinion as to whether the process has any commercial interest. There can, however, be no question as to the interest and importance of some of the facts disclosed, and as this work does not seem to have received the notice to which it is entitled in this country, I propose to give a summary of some of the experiments.

First in regard to the heating. At a hydrogen pressure of 1,500 atmospheres it was found impossible to form an arc between carbon terminals, even at 70 volts p.d.; while with metal electrodes the formation of an arc required practically no pressure at all, so that heat could not be developed conveniently in this way. According to the old experiments of Dulong and Petit, the cooling effect of different gases depends on the pressure in such a way that the effect is proportional to the pressure raised to the 0·45 power for air and the 0·38 power for hydrogen. These experiments of Dulong and Petit were only made at comparatively low temperatures, and may have been superseded for all I know, but it is probably safe to assume that the cooling effect of a gas (particularly hydrogen) does not increase very rapidly with the pressure, so that to produce a state of high pressure by means of hydrogen does not seem an unreasonable proposal, nor does it seem likely that we are to ascribe the non-formation of an arc in hydrogen to excessive cooling.

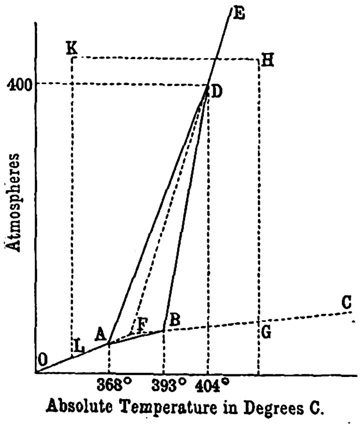
By placing two carbon rods in contact and in series with a source of current at the hydrogen pressure mentioned (1,500 atmospheres = 9·84 tons per square inch) Ludwig encountered a very instructive phenomenon. The current flowed for a few seconds and then stopped; after a few seconds more it rose again—again to fall to zero. The alternations, if I understand the description aright, continue indefinitely so long as the rods are kept in contact. The points of contact are found to have been converted into graphite at the close of the experiment. This is, so far as I know, a unique experience, and most probably we may accept Ludwig's explanation as correct—viz., that the first result is to transform the heated carbon into a solid or liquid non-conducting variety. This cuts off the current, and after a few seconds is itself transformed into graphite as the temperature falls; this enables contact to be re-established and the cycle recurs. Unfortunately, Dr. Ludwig does not give any data as to the temperature at which this or other phenomena take place, and excuses this omission on the ground of the undoubtedly great, but not invincible, difficulty of making such temperature determinations. It is, nevertheless, stated that the melting point of carbon falls rapidly with rising pressure, and that the non-conducting variety was stable down to a red heat when "under pressure"—presumably about 1,500 atmospheres. The current density necessary to convert carbon into the non-conducting variety varies between 14 and 18 amperes per square millimetre sectional area according to the pressure. If a small rod of carbon or a pair of carbon points is heated in an atmosphere of hydrogen at 3,000 atmospheres pressure and allowed to cool, it is found that the resulting graphite does not differ from that formed at 1,500 atmospheres. All attempts to cool the transformed carbon by a jet of hydrogen compressed to 2,600 atmospheres, and blowing into the pressure vessel (at presumably 1,500 atmospheres), did not result in the formation of diamond, though in this case the graphite crystals were of "regular" form, and one of them measured 5 mm. at its greatest length. Suddenly discharging the hydrogen from the pressure vessel so as to drop the pressure as quickly as possible only resulted in the formation of graphite.

The most successful attempt was made at a pressure of about 1,200 atmospheres, a carbon rod being arranged in the pressure vessel for resistance heating, and was provided with a lagging of some refractory nonconducting substance. The current is gradually raised till the interruption occurs, and this is allowed to take place two or three times. If no cooling is applied, soft pure graphite results. If, on the other hand, water at 2,000–3,000 atmospheres is squirted in, a product consisting of carbon in non-conducting transparent form is obtained, but Dr. Ludwig does not give the yield.

I think it is a fair inference from this work that carbon can be converted "into the non-conducting variety" at pressures not necessarily exceeding the moderate amount of 1,200 atmospheres, and at temperatures which are known to be quite easily attainable by resistance heating. The difficulty consists in preventing the reconversion into graphite as the temperature or pressure falls—the most rapid cooling attainable apparently only operating successfully on very small fragments of material.

In the spring of 1901, and in ignorance of Ludwig's work, I gave some attention to the question of converting carbon into the "non-conducting" variety. I purposely use this definition because to make crystals large enough to be of value clearly introduces considerable difficulties compared with the production of a "glass" such as the one described by Ludwig.

As I approached the subject in rather a different way, I may perhaps be pardoned for referring to it here.



The accompanying diagram is the well-known diagram from Van't Hoff's "Lectures on Theoretical and Physical Chemistry" (Vol. I., p. 27, of the English translation by Dr. Lehfeldt), and refers to the equilibrium of octahedral and monoclinic sulphur.* The figure is merely a diagram, and has no pretensions to be to scale. It is an ordinary pressure temperature diagram—pressures being measured in atmospheres (ordinates) and temperatures in absolute degrees centigrade (abscissæ). The line O A, the vapour tension line of octahedral sulphur (of course vastly magnified as to the scale of ordinates), separates the region of octahedral sulphur (above) from the region of sulphur vapour (below). A is the point at which octahedral is converted into monoclinic sulphur at nearly zero pressure—the pressure of sulphur vapour at this temperature—*i.e.*, A should be practically on the axis of temperature if the diagram were correctly drawn. A B is the vapour pressure line of solid monoclinic sulphur, which melts at the point B. The continuation of the vapour pressure curve of melted sulphur does not concern us and is not filled in—except that it ends at the point C—the critical temperature of sulphur. Knowing the change of volume of unit mass of sulphur (say, 1 kilo) in passing from the octahedral to the monoclinic form, and also the thermal value of the reaction—in this case an absorption of heat—it is possible to calculate the rise in temperature of the point of conversion as the pressure increases. This is found to be 0·05°C. per atmosphere, and has been verified by experiments in carbon dioxide under pressure. In this way the line A D can be sketched in. I have shown it as a straight line, but probably this would not be the case in reality. The melting point of monoclinic sulphur is also raised by pressure, and in a perfectly similar manner, and on certain assumptions as to the constancy of the latent heat, specific heat, &c., it can be filled in as another straight line for diagrammatic purposes only. In this case the lines from A and B meet at D. The co-ordinates of the point D were given by Roozeboom (*Zeitschrift für Physikalische Chemie,* Vol. II., p. 475), but no information is given as to how these calculations were made; at all events, I could find none. The line FB is the vapour pressure line of undercooled melted sulphur, and AF of untransformed octahedral sulphur. The point F is the melting point of octahedral sulphur, and FDE is the line exhibiting the change of this melting point by increasing pressure—this line is of not much importance up to D—representing a phenomenon that can have no permanent existence, but above D it is the boundary between the regions of liquid and octahedral sulphur.

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* A diagram on a more rational scale is given by Van't Hoff, in his "Studies on Dynamical Chemistry," French edition, p. 157.

Looking at the areas, we have to the left of OAD the region of octahedral sulphur, below OABC the region of sulphur vapour. ABD is the area of monoclinic sulphur, and to the right of BD an unexplored area of the several modifications of liquid sulphur. In practical use the lines of the diagram are best regarded merely as the boundaries of the several regions. I feel that I ought to apologise for this elementary description, but my excuse is that I do not keep these matters always ready for use in my own mind, and there may, perhaps, be others in a like predicament.

I now proceed to answer the question which is no doubt in several minds, What has all this to do with diamonds?

The diagram suggested to me to try to answer the question, What is the diagram for graphite and cubic carbon? There are, of course, no data except those given by Ludwig (imperfect for lack of temperature information), and consequently we cannot make the carbon diagram. We are, therefore, reduced to guessing, and the first thing that strikes us is the close general analogy between the relations of the two forms of carbon and those of the two forms of sulphur, the third or amorphous state being set aside for the moment in both cases. Van't Hoff calls attention to the curious fact that octahedral sulphur, which occurs freely in nature, has not been prepared artificially. Now, the diagram shows that if we have sulphur in the condition represented by some point, say H—*i.e.*, liquid at a temperature and pressure both higher than D—we can obtain octahedral crystals at once by cooling it at constant pressure. When we have got it cooled to some temperature to the left of A we can release the pressure, keeping the temperature constant. The succession of states may be represented by the dotted lines HK and KL. This will give us octahedral sulphur at ordinary temperatures and pressures, and if the cooling while the line DE was being crossed was slow enough we should have good big crystals. If the sulphur was not molten, but only in the solid monoclinic form, we should start from some point within the triangular area ADB, and on crossing the boundary AD we should get a more or less slowly occurring transition to octahedral sulphur—this sulphur would not exist in crystals of even microscopic size, but the optical properties of octahedral sulphur would be possessed by the product. This transition is the one usually observed when monoclinic crystals are kept for some time; and in fact the large crystals may appear unaltered to the eye, except in so far as they become more opaque, though the optical properties of octahedral sulphur are exhibited by thin sections. This kind of sulphur I have called "aged monoclinic" (*Phil. Trans.*, A., 1896. Threlfall and Brearley).

Diamonds resemble octahedral sulphur in being occasionally found in Nature, but only capable of preparation in the laboratory under high temperature and pressure. Moissan, Crookes and others have given reasons for thinking that diamonds occur in Nature only as a constituent of material coming from a great depth, and Ludwig has tried to show that there is independent evidence of rapid cooling as well. In a general way, if one melts sulphur one gets monoclinic crystals though the diagram shows how this may be avoided; and Ludwig and Moissan have shown how much easier it is by similar means to get graphite than diamonds; Ludwig especially, in the experiments quoted, shows that at 1,500 atmospheres one can get graphite crystals of diamond-like shape, but nevertheless pure graphite—the exact analogue of my "aged monoclinic" sulphur. We are, therefore, encouraged to take the sulphur diagram and to write "diamond" for octahedral sulphur and "graphite" for monoclinic sulphur. We now know, thanks to Ludwig, that the non-conducting variety is stable at a red heat—say 700°C. absolute and 1,200 atmospheres pressure. Ludwig also points out that the stability increases with increasing pressure (*i.e.*, the higher the pressure the more can the crystals be cooled without transforming). It looks, therefore, as if in the carbon diagram also the line AD slopes up to the right like the same line in the sulphur diagram. If this is true it means that heat is absorbed when the diamond passes over to graphite, which is in accordance with the usual statements, though Ludwig quite properly criticises the evidence. We have a limit for a point in the line AD from Jacquelain's observation that in the arc the diamond turns into graphite. According to Sir William Crookes (*Phil. Proc.*, Series A, 76 458, 1905), and on evidence not known to me, the boiling point of carbon is 3,870deg. absolute. The diamond turned into graphite in the arc would perhaps have a temperature of 3,000°C., but this is merely a temperature at which the transformation is so rapid that it can be observed before the carbon burns. I do not know how rapid the change is, but Moissan, in his repetition of the experiment does not refer to its being especially rapid; and the graphitisation of amorphous carbon is decidedly slow both in Moissan's experiments and in Mr. Acheson's factory; in fact, in the latter it is necessary to use a catalytic agent. In view of Ludwig's observations of the extremely rapid transformation at lower temperatures though at much higher pressures, it looks as if the velocity of the change was increased by pressure. I am not aware of any experiments on the rate of transformation of allotropic substances at different points on the pressure temperature transformation curve.

Referring to the diagram again, suppose we have molten carbon at the point H and try to get diamonds, Ludwig's experiments seem to show that graphite is reformed on cooling even at pressures of 3,000 atmospheres. This I take to mean that D is above 3,000 atmospheres. If my view is correct, then to make large diamond crystals it will be necessary to go to still higher pressures, though how much higher one cannot say: still, on the view here presented there must be some point at which the rapidity of cooling will be immaterial, except in so far as it influences the size of crystals. I understand from a great artillery authority that it is possible to make a pressure vessel to stand any pressure below the maximum crushing strength of steel. Steel can be got which will stand a crushing stress of 70 tons to the square inch—say, 10,500 atmospheres—but its other properties are not very certain; so we may regard a pressure of 50 tons per square inch as the practical maximum for long-continued pressure for one vessel, and 75 tons if we put the working vessel inside another vessel also under high pressure. But 50 tons per square inch is 7,500 atmospheres—more than double Ludwig's highest pressure; and according to Sir William Crookes, Sir Andrew Noble has reached a pressure of 95 tons per square inch for a fraction of a second. There is obviously room and opportunity for an extension of Dr. Ludwig's work by any one who has sufficient time and money at his disposal.

The problem of making a useful abrasive, though not in perfect crystals, of cubic carbon is simpler. In this case it is only necessary to cool so rapidly from any point to the right of the triangular area ADB, that the time is insufficient for a complete transformation in crossing the area. This is therefore a question of yield, and the best conditions will become clearer only after the velocity of transformation has been seriously studied at various temperatures and pressures. I see no reason except the practical complication why the cooling might not be accelerated by squirting liquid hydrogen on to the fused carbon.

The diagram gives no information as to the possible production of diamonds from carbon vapour, but we know that this does not happen at all events at low pressures—otherwise I take it the inside of overrun incandescent lamps would look more like the upper part of a camphor bottle than a piece of smoked glass. It is obviously possible that at high enough pressures carbon vapour *might* condense to cubic carbon. Van't Hoff raises the pertinent question as to what happens to the line DE as the pressure rises. Does the line continue indefinitely or does it end at a sort of "critical temperature" and pressure like the line OABC? By all analogy the answer would be that the line stops somewhere, and at that point there would be no distinction between melted carbon and highly-heated diamond.

Carbon is the only element which can exist in various forms, and the transformations of boron and silicon and selenium would form an interesting chapter in chemistry if they were worked out. There is, in fact, a vast and unexplored field of investigation open to any one who will try the combination of high temperatures and pressures on simple substances, and I am glad to note that such researches are being taken up in the electro-chemical department of the Victoria University. According to my personal view the most interesting phenomena may be expected to occur only after the pressure is high enough to produce a material change of volume in the compressed substance.

(*To be concluded.*)

## BOARD OF TRADE REPORT ON THE ISLE OF THANET LIGHT RAILWAYS ACCIDENT.

We have just received a copy of Lieut.-Col. P. G. von Donop's report on the accident which occurred on August 3rd on the Isle of Thanet Railways, and the following is the substance of it:—

In this case as a car, containing six passengers, was running down Madeira-hill, Ramsgate, towards the Harbour, the driver lost control of it, and after passing round a sharp curve the car left the rails; it then ran across the road, mounted the kerb, crossed the pavement, broke through a railing on the inside of the pavement, and fell over the cliff, a height of about 32 ft. Two of the passengers jumped from the car, but the remaining four were injured, and in one case the injuries are stated to be of a serious nature. The conductor of the car escaped with slight injuries, but the driver was seriously injured, and the submission of this report has been delayed until he was in a state to give evidence. The car itself was of course wrecked by the fall over the cliff, the upper body of it being entirely broken away from the truck, and it is surprising that the injuries to the passengers and the staff were not of a still more serious nature. The car was a single-truck double-deck car; it was fitted with a hand brake, a rheostatic brake and a slipper brake, the latter being applied by a lever from either end of the car. The total length of the car was 28 ft., and its wheel base was 6 ft.; it was fitted with a motor on each axle.

Madeira-hill, where this accident occurred, is a road about 230 yds. in length, leading from Wellington-crescent to Ramsgate Harbour. The gradient in Wellington-crescent for a car travelling towards Madeira-hill from the Plains of Waterloo is, for the first 200 yds., mostly a falling one of 1 in 170; it then falls for a distance of about 100 yds. at a gradient varying from 1 in 16 to 1 in 27, and Albion House, which may be regarded as the top of Madeira-hill, is situated on the latter gradient. It is at this point—viz., opposite Albion House, that, according to Board of Trade regulations, a stop has to be made by all cars before descending Madeira-hill. From this point down to the end of Madeira-hill, a distance of about 230 yds., the gradient is a continuously falling one, varying from 1 in 13 to 1 in 16. In addition to the gradients above mentioned, there are a number of sharp curves in Madeira-hill; the only one, however, concerned in this accident is a reverse curve, which commences at a point about 35 yds. below Albion House. At this point there commences a left-handed curve of

66 ft. radius, and about 30 yds. in length. Almost immediately at the termination of this curve there commences a right-handed curve of 73 ft. radius. There is practically no straight at all between the two portions of this reverse curve. Owing to the gradient and curves speed down Madeira-hill is restricted to 3 miles an hour. In this case the front wheels of the car ran round the above-mentioned left-handed curve successfully, but immediately that they met the commencement of the right-handed curve they were derailed towards the left of the line, and the accident as described above occurred. The superelevation at the point where the wheels left the line was $\frac{1}{2}$ in. in the wrong direction; that is to say, the rail on the inside of the curve was $\frac{1}{2}$ in. higher than the outer one instead of the outer one being the higher of the two. With the authorised speed of 3 miles an hour this want of superelevation would however have been immaterial.

The evidence is conclusive that the car to which this accident occurred did not come to a stand at the regular stopping place opposite Albion House at the top of Madeira-hill. The evidence as to the speed of the car when opposite Albion House is contradictory; motorman Lloyd, who was the driver of the car, estimates its speed at 6 miles an hour, while conductor S. F. Jones, who was acting as conductor states that when running along Wellington-crescent he thought that the speed was excessive; on that account he himself applied the slipper brake before reaching Albion House, but, in spite of his doing so, the car, to use his own words, flew past the usual stopping place. There can, therefore, be no doubt that the car approached this spot at such a high rate of speed that driver Lloyd was unable to bring it to a stand before commencing to descend Madeira-hill and this must be regarded as the first cause of the accident. The wet state of the rails would undoubtedly have contributed to make it more difficult for the driver to control his car, but for this it was his duty to have made due allowance. It is evident that when the car shot over the brow of the hill Lloyd had lost control of it, and on reaching the steep portion of the hill the speed doubtless increased. All witnesses agree that the wheels at this time were skidding and that they continued to do so until the derailment occurred. Lloyd maintains that he did not apply the hand brake at all, but unless he did so it is difficult to understand how the skidding was caused, as while the wheels were skidding the rheostatic brake would have been inoperative and could not therefore have caused it. One witness, however, who saw the accident, states that Lloyd was pulling back with all his weight on a circular wheel, and this can only have been the wheel by which the hand brake was applied. It seems probable, therefore, that Lloyd did apply his hand brake fully and that he thereby caused the wheels to skid and deprived himself of the use of the rheostatic brake. The slipper brake was, however, applied all the time, and Lloyd appears to have been gradually gaining control over the car, though he did not do so quite in time to prevent the derailment.

The front wheels of the car appear, as stated above, to have taken, without derailment, the left-hand curve which commenced 35 yds. beyond Albion House, but as soon as they reached the commencement of the right-hand curve they were derailed towards the left of the line, and the car ran across the roadway and footpath and fell over the cliff. The car was, it will be remembered, 28 ft. in length, whilst its wheel base was only 6 ft.; the front wheels were probably swung off the line to the left by the momentum gained by the two ends of the car in running at a high rate of speed round the sharp left-hand curve. The actual derailment was, therefore, due to the sharpness of the curve, and the high rate of speed at which the car ran round it; and with this high speed the derailment was further facilitated by the want of proper superelevation at the point where the wheels left the line. The rails of the line down Madeira Hill were in fairly good order, but owing to the constant use of the brakes their surface was worn very smooth, and this would undoubtedly have facilitated the skidding of the wheels on them. The wheels of the car, which were of chilled cast iron, were examined after the accident; it cannot be said that they were in very good order, as their flanges were considerably chipped; some of these defects may certainly have been caused by the wheels fouling the kerb, but in any case I doubt whether the condition of these wheels can have practically contributed to cause this accident. The car itself was so badly wrecked by its fall over the cliff that it was impossible to ascertain subsequently whether the brakes had been in efficient order. Motorman E. P. Jones, who had taken that car three times down Madeira-hill on that same morning, states, however, that they were in good order, and that he had had no difficulty in controlling the car. Conductor S. F. Jones, who was on the car at the time of the accident, states that he had made use of the brakes when descending Bellevue-road a few minutes previously, and that they had worked well. There seems, therefore, to be no grounds for connecting this accident with a failure of the brakes.

For the excess of speed in approaching Albion House, the whole responsibility must rest on motorman Lloyd. The only excuse which he can give for himself is that the rails above Albion House had not been sanded. But the gradients along Wellington-crescent and between that crescent and Albion House were not steep enough for this excuse to be a valid one, and for the failure to stop the car at Albion House Lloyd must be held greatly to blame. As regards Lloyd's action after the car passed Albion House, all that can be said is that he does not appear to have used his brakes judiciously; it is probable, however, that he lost his head, and it is not surprising that he did so, considering the circumstances in which he found himself placed and the brief experience which he had had of driving. The record of Lloyd's services with the company was given to me in a statement submitted by the manager. From this it appears that Lloyd's training as a conductor commenced on April 10, 1905, and that five days later he commenced acting as such. On April 28th he was granted permission to practise driving, and on June 19th he was, after examination, certified by the assistant engineer of the line as qualified to act as motorman. On July 13th he was given half a day's work as motorman, and on the 16th, 20th and 24th a full day's work as such; on July 29th he commenced as a regular driver, and it was on August 3rd that this accident occurred. Lloyd had thus been employed as a motorman for only nine days previous to the accident, and the company inform me that from the very first of those nine days he had been permitted to take cars up and down Madeira-hill. The gradients on Madeira-hill vary, as stated above, from 1 in 13 to 1 in 16; these are not excessive, and provided the brakes are in good order, there is no reason why a car should be allowed to get out of hand in descending them. Owing, however, to the curves of the hill, there is no doubt that if a car does get out of hand it will probably result in a derailment, and that may possibly, as in this case, lead to further disaster. For this reason it is essential that none but experienced drivers should be placed in charge of cars ascending or descending this hill. From this instance it appears to be customary with the company to allow drivers, immediately that they have completed their training, and without any further practical experience, to take charge of cars negotiating this hill. To permit this to be done is simply courting disaster, and I consider that great responsibility for this accident rests on the company for having allowed a driver of so little experience as Lloyd to have charge of a car which had to ascend and descend this hill. The arrangement of the lines on Madeira-hill where this accident occurred is susceptible of improvement, and it is understood that the company intend to take steps at an early date to carry out certain alterations with that object. The only other point which calls for remark is the method of applying the slipper brake on the car which met with this accident. It is usual on tramcars for the slipper brake to be applied by means of a circular wheel, and the driver can thereby regulate the pressure with which the wood blocks are applied to the rails, and, if the blocks are worn, he regulates the pressure accordingly. On this car the slipper brake was applied by means of a lever which had, when brought into use, to be moved completely over, thus fully applying the brake; but the pressure with which the blocks were applied to the rails would clearly depend on whether they were worn or not, and a brake which was effective at the commencement of a journey might not be so at the end of it. There was certainly a screw by which the driver could alter the adjustment, but it was a very crude arrangement, and one which could not be made use of in an emergency. I do not, therefore, consider that it is a satisfactory arrangement, though it does not appear to have contributed in any way to this accident.

## PARLIAMENTARY NOTICES.

We conclude this week the particulars of the notices of applications to be made to Parliament and to the Board of Trade in the 1906 session in regard to proposed new electricity supply schemes, electric railway and tramway undertakings, extension of existing undertakings, &c.

### Electricity Supply Provisional Orders.

Lanarkshire County Council (for *Bellshill*, *Bothwell*, *Shettleston* and *Tollcross*, and *Uddingstone*).

*Dorchester* (amend previous order, &c.), *Dunfermline*, *Dunoon* and *Exeter* (for Heavitree) Corporations; *Abercarn*, *Bettws-y-Coed*, *Calverley* (transfer of powers, &c.), *Farsley*, *Foot's Cray* (transfer of powers, &c.), *Horsforth* (transfer of powers, &c.) and *Market Harborough* Urban District Councils; *Yardley* Rural District Council (transfer of powers, &c.).

North Metropolitan Electrical Power Distribution Co. (for *East Barnet Valley*, *Cheshunt*, *Wealdstone*, *Wembley*, and *Edgware*); Newcastle-upon-Tyne Electric Supply Co. (for *Castle Ward*, *Weetslade* and *Cramlington*); Christy Bros. & Middleton (for *Bude*); National Provincial Electricity Corpn. (for *Tiverton*, and *Inveresk*); Slough & Datchet Electric Supply Co. (to extend to *Burnham*, *Farnham Royal*, *Horton*, *Langley Marish*, *Stoke Poges* and *Wexham*, and *part of Iver*); S.M.H. Tramways Synd. (for *Seaham Harbour*); Brush Electrical Engineering Co. (for *Maryport*, and *Workington*); Hexham & District Electric Supply Co. (for *Hexham Rural District*); Bournemouth & Poole Electricity Supply Co. (for *Swanage*); Mutual Electricity Supply Co. (for *Henley-on-Thames*, and *Aylesbury*); Kidderminster & District Electric Lighting & Traction Co. (for *Stourport Urban* and *Kidderminster Rural Districts*); County of Northampton Electric Light & Power Co. (for *Higham Ferrers*, *Rushden*, and *Wellingborough* Rural District); Camberley Electric Supply Co. (for *Frimley*, Surrey and parishes of *Sandhurst* and *Crowthorne* in Easthampstead Rural District, Berks.); *Charing* & District Gas Works (Ltd.) (for supply of electrical energy and gas). Strathclyde Electricity Supply Co. (*Eastwood* and *Cathcart*, and *Kilpatrick*). Duke of Richmond and Gordon (for *Fochabers*).

### Electricity Supply Bills.

*London County Council*, to supply electricity in bulk in the County of London and portions of Kent, Essex, Surrey and Middlesex.

*Shoreditch* and *Stepney* (*London*) *Councils*, to enter into agreements with one another and with any local authority authorised to supply electricity in Bermondsey, Bethnal Green, Hackney, Islington and Poplar.

*Hackney* (*London*) *Council*, to enter into agreements with councils of Bethnal Green, Islington, Poplar, Shoreditch, West Ham, Leytonstone and Walthamstow for supply of electricity in bulk, &c.; to supply electric motors, fittings, lamps, &c., on hire, and to exempt same from distress or execution; to make provision in regard to supply of energy to premises having separate source of supply, &c.

*St. Pancras Council*, to exempt Council from indictments and proceedings for nuisance and to repeal or render inapplicable all or some of provisions of certain acts, &c., rendering the Council liable to indictments or proceedings or otherwise restricting use of lands used for generating stations, &c.

In the general powers bill of *London County Council* authority is again sought to empower the metropolitan borough councils to provide, sell, let for hire, fix, alter, repair and remove wires, lamps, motors, meters, and all kinds of electrical machinery and apparatus, to expend moneys upon wiring and fitting and supplying with wires, fittings, machinery and apparatus of premises of consumers or prospective consumers of electrical energy; to make provisions with respect to charges to be made by such councils with a view to securing that their expenditure in the exercise of such powers shall not exceed the receipts therefrom, to provide and require that the charges for wiring and fitting premises and supply of wires, fittings, motors and apparatus shall be stated on demand notes by any such council separately from the charge for electrical energy supplied, to make provisions with respect to the manner of preparing statements of accounts of councils in connection with the expenditure on and the receipts from the exercise of such powers; to empower such councils or any of them to borrow in same manner and subject to same conditions as if such expenditure were for purposes of the Electric Lighting Acts, 1882 and 1888, and upon such terms and conditions as to repayment or otherwise as may be specified in the bill such moneys as may be required by such councils for defraying expenditure incurred in exercise of said powers.

*Westminster Electric Supply Corpn., St. James' & Pall Mall Electric Light, Kensington & Knightsbridge Electric Lighting, Notting Hill Electric Lighting, Metropolitan Electric Supply, Chelsea Electricity Supply, Brompton & Kensington Electricity Supply* and *Central Electric Supply Companies*, and the councils of *Hampstead, St. Pancras, Hammersmith* and *Fulham*, to associate together and supply one another with electricity, &c., to make provision as to terms and conditions of supply and as to supply to consumers having separate source of supply, &c.

*Charing Cross, West End & City Electricity Supply Co.*, to supply electrical energy in bulk in Kensington, cities of London and Westminster, boroughs of Holborn, St. Pancras, Islington, Finsbury, Shoreditch, Bethnal Green, Stepney, Poplar and Hackney, and in West and East Ham, Buckhurst Hill, Woodford, Wanstead, Leyton, Ilford, Barking Town, Romford, Epping, Loughton, Waltham Holy Cross, Brentwood and Grays Thurrock, and rural districts of Epping, Ongar, Billericay and Orsett.

*London Electric Supply Corpn.*, to extend area of supply to London district south of the Thames not already within company's area, and north of the river Thames and east of the boroughs of St. Pancras and Holborn, and to the City of Westminster; to lay mains through the Holborn Council's district; to supply current by agreement within the counties of London, Kent or Surrey; to supply current in bulk to authorised undertakers in any part of the company's existing or proposed extended area, or in any adjoining area; to transfer to the St. James' & Pall Mall Electric Light Co., the Westminster Electric Supply Corpn. and the Chelsea Electricity Supply Co. portions of undertaking of London Electric Supply Corpn. in Westminster and Chelsea, &c.

A bill, entitled the *West London Electric Undertakers' Association* bill, is to be introduced to confer additional powers upon the Brompton and Kensington Electricity Supply, Central Electric Supply, Charing Cross, West End & City Electricity Supply, City of London Electric Lighting, County of London Electric Supply, Kensington and Knightsbridge Electric Lighting, Metropolitan Electric Supply, Notting Hill Electric Lighting, St. James' and Pall Mall Electric Lighting, South Metropolitan Electric Light and Power and Smithfield Markets Electric Supply Companies, and the London Electric Supply, Westminster Electric Supply and South London Electric Supply Corporations in regard to the supply of electrical energy, to enable the companies to enter into agreements and combinations with one another for taking and giving a supply of electrical energy, to make provision as to joint management and working, &c.

*South Metropolitan Electric Light & Power Co.*, to enter into agreements with authorised undertakers to supply electric energy in the counties of London, Kent and Surrey; to combine with any company for mutual assistance or joint working of whole or part of undertakings, and for supply of energy in bulk to or for taking energy from one another; to supply electrical energy in bulk to, or to take such supply from, any local authority or company; for further powers to lay mains and open streets, &c., and for amalgamation or joint working with electric supply companies, and for further powers as to supply energy for power.

*Twickenham & Teddington Electric Supply Co.*, to authorise company and Edmundson's Electricity Corpn. to enter into agreements with Hampton and Teddington Councils in regard to Hampton and Teddington Electric Lighting Orders, 1901, and to confer further powers as to supply of electric energy in Twickenham, Hampton, Teddington, Hampton Wick, Sunbury, Feltham, Hanworth, Ashford, Shepperton, Ham, East and West Molesey, and Esher and the Dittons, &c.

*Newcastle-upon-Tyne Electric Supply Co.*, to acquire transfers of electric lighting undertakings and orders; to enter into agreements with and to confer powers upon Government departments, local authorities, companies, &c., in regard to electrical supply; to extend company's powers for supplying energy in Tynemouth; to enter into agreements with Newcastle & District Electric Lighting Co. and other companies for supply or interchange of electricity; to confer further powers to lay electric mains, &c., within or without company's area of supply; to exempt company and County of Durham Electrical Power Distribution Co. from restrictions as to associating with other companies, &c.; to supply North-Eastern Railway Co. with energy.

*West Cumberland Electric Tramways Co.*, to take transfers of and enter into agreements as to electricity supply in Whitehaven, Workington or Maryport; to enter into agreements as to supply of waste furnace gases and products, and as to supply of electric power to local authorities, railways, tramways, &c.; to extend time for construction of authorised tramways, &c.

*Bacup Corporation*, to refuse supply of electrical energy in certain cases; to let electric motors, fittings, &c., on hire, and to exempt same from distress, &c.

Power is sought to incorporate a company to establish electricity supply and power gas works in parts of *Cumberland*, &c.

*Lancashire Electric Power Co.*, to exempt engines, fittings, &c., from distress or execution and from being deemed fixtures; to authorise transfer of provisional orders; to subscribe for shares in companies, &c.; to enter into agreements with local authorities, companies, &c., in regard to supply of electrical energy, &c.

*Kent Electric Power Co.*, to enter into agreements with S.E. and L.C. & D. Ry. Cos., to confer powers as to supply of current to and by adjoining local authorities, companies, &c.; to use overhead wires; to exempt generating stations from building regulations, &c.

In *Surbiton* Improvement Bill, the Council seek further powers in regard to their electric lighting undertaking to purchase electricity in bulk and to supply electrical energy without the district; to sell, let on hire, &c., electric motors, fittings, &c., and to exempt same from distress; to provide that consumers give notice before removing, &c.

*Huddersfield Corporation*, to construct additional tramways; to supply electricity in bulk to neighbouring authorities; to sell and let on hire, fix, &c., wires, lamps, motors, &c., and to exempt same from distress or execution; to use sinking or redemption funds for any purpose for which Corporation is authorised to borrow money, &c.

*Newport (Mon.) Corporation* ask for authority to refuse supply of electricity to persons in debt; to sell or let for hire, fix and repair lamps, meters, fittings, motors, &c.; to alter and amend provisions of Newport 1901 Order as regards rights of consumers to demand supply of electricity; to exempt engines, motors, dynamos and fittings from distress or execution, &c.

*Todmorden Corporation*, to provide that consumers give notice before removing; to empower Corporation to make bye-laws as to the "strength and quality" of consumers' plant and fittings, &c.

*Wallasey District Council*, to supply electricity in bulk for railways or tramways outside district; to compel consumer to give notice before removing, &c.

*Bournemouth Corporation* seek powers to supply and use electricity for working lifts and other purposes, &c.

*Rathmines and Rathgar* Urban District Council, to acquire free wiring undertaking of the National Electric Construction Co.

### Electric Traction Provisional Orders.

*Dewsbury* and *Ossett* (to revive and extend 1904 orders) and *Edinburgh* Corporations.

Electric Supply Corporation (for *Dumbarton*), National Electric Construction Co. (for *Edinburgh*), Falkirk and District Tramways Co. (for *Falkirk* and district), *Musselburgh* and District Electric Light and Traction Co. (Extensions), *Ardrosson, Saltcoats & District* and *Dunfermline* and District Tramways Companies.

### Traction Bills.

Power is sought to incorporate a company to construct the *Hammersmith, City & North-East London Underground (Tube) Railway.*

Power is sought to incorporate a company to construct tramways in *Folkestone, Sandgate, Cheriton* and *Hythe.*

*Southport & Lytham Tramroad Co.*, extension of time of Southport tramways, &c.

*Sandgate & Hythe Electric Power Co. (Ltd.)*, to acquire existing tramways in Sandgate and Hythe, to construct new tramways in Folkestone, Sandgate and Hythe and in Romney Marsh Rural District, &c.; to adapt existing tramways for electric traction, &c.

Power is sought to incorporate a company to construct tramways and tramroads in *W. R. of Yorks* (Huddersfield, Brighouse, Elland, Greetland, Hipperholme, &c.); to acquire powers of Huddersfield Corporation for portion of lines; to obtain running powers over portion of Halifax and Huddersfield Corporation tramways, &c.

Power is sought to incorporate a company to construct railways, &c., in *Cork City*, worked by electric traction; to obtain electric energy from Cork Electric Tramways & Lighting Co.; to enter into working and other agreements with certain railway companies, &c.

*Preston, Chorley & Horwich Tramways Co.*, to abandon portions of lines, &c.

*North Metropolitan Tramways Co.*, to dissolve and wind up company; to surrender lease of tramways and powers to London County Council, &c.

Power is sought to incorporate a company to construct electric tramways in *Mansfield* and *District.*

### Miscellaneous Bills.

In the bill of the *London & South-Western Railway Co.* power is sought to enable company to sell and distribute electrical energy to any lessee or tenant of the company; to make provision in regard to sale and distribution of electrical energy; to authorise company to provide, work and use in connection with or in extension of their railway system omnibuses, coaches, &c.

*Mid-Oxfordshire Gas Light & Coke Co.*, to apply for provisional electric lighting orders, &c.

Power is sought to incorporate a company to construct a "motor way" in *Surrey* and *Sussex*; to acquire lands for generating stations; to enter into agreement with local authorities and others as to supply of mechanical or other power, &c.

*Watford Gas & Coke Co.*, to empower company to make application for powers to generate and supply electrical energy, &c.

*Bromley Corporation*, to run motor omnibuses, &c.

Power is sought to dissolve and re-incorporate the *Crediton* Gas Co. (Ltd.), to supply electrical energy and gas within and outside area of supply.

In *Corsham* Gas Co.'s provisional order, authority is sought to supply engines, dynamos, motors and other apparatus, &c.

*Dowlais* Gas & Coke Co. (Ltd.) want power to apply for provisional order to supply electric energy, &c.

*Brixham Gas Co.*, to generate and supply electricity in Brixham and Churston Ferrers; to repeal Brixham Electric Lighting Order, 1903, &c.

*Ascot District Gas Co.*, to generate and supply electricity in parts of Old Windsor, Easthamstead and Cookham (Berks.), Chertsey (Surrey), &c.

Power is sought to incorporate a Board of Commissioners for constructing across the *River Thames* a dam, locks and weir at Gravesend, to generate electricity for purposes of the work, &c.

Power is sought to incorporate a company to construct a Channel ferry, railway and quay at *Dover*.

Power is sought by *City of London Corporation* to widen Blackfriars bridge, and to construct a tramway and other works over same, &c.

### LIGHT RAILWAYS.

*Lindsey Light Railway Synd.* are applying for authority to construct about 8½ miles of light railway from Ferryford to Cirencester.

*Mid-Suffolk Light Railway Co.* wish to amend the Mid-Suffolk Light Railway Order, 1900; to empower Halesworth District Council and the Treasury to advance money to the company, &c.

Application has been made to the Light Railway Commission by the Llanelly & District Electric Lighting & Traction Co. (Ltd.) to construct and work electric light railways in *Llanelly* and district; to enter into agreements as to supply of electricity, &c.

Messrs. C. S. Watson and C. E. Straker are applying for an order to construct a light railway between *Middlesbrough* and *West Hartlepool*.

*Canterbury & Herne Bay* Light Railway Co. want an extension of time for purchase of land and completion of works authorised by 1903 order.

The Right Hon. Lord Alington, Mr. T. B. Scott and Sir J. W. Burt are applying for an order to incorporate a company to construct the *Branksome Park & Swanage* Light Railway.

Messrs. H. Kaye and C. Wray seek authority to incorporate a company to construct the *Clayton West & Darton* Light Railway.

*Portmadoc, Beddgelert & South Snowdon* Railway Co. want an order to authorise the construction of two short additional lines, &c.

*Bath Electric Tramways (Ltd.)* are applying for an order to construct two additional lengths of line; to extend and modify borrowing powers.

## LEGAL INTELLIGENCE.

### Fulham (London) Council v. National Electric Construction Co. (Ltd.)

On Tuesday Mr. Justice Bigham heard as a special case the award of the arbitrator (Mr. James Swinburne) in the dispute between Fulham Borough Council and the National Electric Construction Co., which arose out of an accident at Fulham Baths in December, 1902, by which two men were killed.

Mr. BAILHACHE (for the company) said the question to be decided was whether or not the company was liable to reimburse the Council £1,173 which the Council had paid by way of compensation to the relatives of two deceased men who were accidentally killed by electric shock at the baths. The amounts paid as compensation by the Council were admitted to be reasonable, but the company, who were the contractors for the electrical installation at the baths, repudiated liability. The Council contended that the company had committed a breach of contract which resulted in the deaths of the two men, and they were, therefore, liable to indemnify the Council. In June, 1901, Fulham Council employed the company to carry out the installation. There were a number of separate baths, and the system adopted by the architect and engineer of the Council, under whose specifications the company worked, was what was known as the non-continuous system, which meant a separate electrical circuit for the separate sections of the baths. The wires were insulated in the ordinary way and then conveyed by small iron tubes throughout the building; but there was not a continuous system, contact being broken at certain points. It was agreed that where they had a continuous system, and if that system was connected with earth in one or two places, the whole of the system was connected to earth. But where there was a non-continuous system it was agreed that in every section they must have contact with earth, by a water pipe or otherwise. The two men who were killed were in little cubicles or bath rooms divided from each other by slate slabs 8 ft. or 10 ft. high, on the top of which the electric light wires were carried in an iron tube. The first man killed (Line) was found hanging with both hands to the top of the dividing slab where the wire was. He could not be released until the current was turned off, and he died shortly afterwards. The other man (Brown) was found dead in his cubicle about an hour afterwards, and it was supposed that he had met his death in the same manner. It was admitted that the wires in both the sections where the men were found were not earthed. It was contended that the company were liable under clause 20 of the contract, because it was their duty to earth each section of the circuit, and that it was a breach of duty not to earth it. The arbitrator had found, as a fact, that the accident which caused the deaths referred to was caused by the fact that certain iron pipes forming part of the installation were not earthed; and had also found that the Council had spent £1,173 odd on the matter in dispute. The question now was whether, on the facts as stated, the Council was entitled to recover that amount from the contractors. He (counsel) submitted that the case disclosed no liability on the part of the Fulham Council, who had paid in haste. He denied that the company had committed any breach of contract. It was said that the installation should be according to the rules of the Phœnix Assurance Co., but these only provided that "when it is desirable the metal tubes shall be earthed." The award found that the earthing would not have been "desirable" in so far as the risk from fire was concerned, although it would perhaps have been desirable so far as risk to life was concerned. He urged that if negligence was material to the case it had been negatived by the award. It was said that the maintenance period had not expired when the accident happened, but the arbitrator had found the works were in fact completed. All the contractors' liability, he argued, terminated in April, 1902, eight or nine months before the accident. Having regard to the state of electrical knowledge at the time of the accident, nobody could have had any cause to expect damage to life and limb from the installation. The Council was not liable to compensate the relatives of these men, and the contractors were not liable because they were not the injurers.

Mr. DANCKWERTS, K.C. (for the Council), submitted that judgment should be given for the Council. He relied on the paragraph in the contract which said that the whole of the works were to be carried out in accordance with the rules of the Phœnix Fire Office, and because those rules were not complied with there had been a breach of contract on the part of the company. He contended that unless it was shown that it was "undesirable" the contractors were bound to connect the wires to earth, and the arbitrator had not found that the earthing was "undesirable" in that sense to relieve the contractors of responsibility.

Mr. Justice BIGHAM held that there had been no breach of contract or negligence on the part of the contractors, and that the work was done in accordance with the rules of the Phœnix Fire Office. There was no evidence of neglect on the part of the company.

Judgment accordingly.

### Re Letters Patent No. 14,006, 1903.

An action came before the Court of Appeal (Lords Justices Vaughan Williams, Stirling and Cozens-Hardy) on Saturday on the appeal of the owners of the above patent from a decision of Mr. Justice Buckley.

Mr. HALDANE, K.C., said the question to be decided arose on a petition for revocation of the patent, which was for a new process of purifying flour by means of electricity, and thus increasing its nutritive value. The machine consisted of two parts. By means of the first a powerful current was passed through air altering its chemical qualities, and the air so treated was then passed into another machine, where the flour was subjected to treatment. The process was said to be one of enormous commercial value. The owners of the patent recognised that some of the clauses of the specification as they now stood were invalid, and they asked Mr. Justice Buckley for leave to apply at the Patent Office to disclaim that part of the invention which related to a suggested chemical action which it was now known did not take place. The petitioners opposed the application, and pressed for the revocation of the patent. They submitted that what the applicants proposed to do was not to disclaim but to correct the specification by striking out incorrect statements and leaving the invention as wide as it was before. The real invention claimed was for making glutin out of starch by electricity. Mr. Justice Buckley held that the word "disclaimer" in sec. 19 of the Act of 1883 was to be read strictly, and did not include corrections or such explanations as might be required for the purpose of defining the claim. The patentee said that claim 2 would not produce the result claimed, and therefore he wanted to disclaim by striking it out. It seemed to him that that was not a disclaimer, as it would leave the process just where it was and would not reduce the ambit of the claim. What the patentee sought to do was not within sec. 19 of the Act, and therefore he would not grant the liberty asked. By consent it was agreed that the application should be treated as a summons and dismissed with costs. Hence the present appeal. His Lordship fixed Nov. 29 for the trial of the petition, so that the applicants might have time to appeal from his present order should they so desire. The learned counsel said that if the decision in the court below was upheld they must go to trial with a bad claim in their patent.

At the conclusion of the arguments judgment was reserved.

On Tuesday Mr. Justice BUCKLEY postponed the hearing of the petition for revocation which had been fixed for Wednesday until after judgment was given in the above appeal.

### D. Stewart & Co. (Ltd.) v. Heckmondwike District Council.

The hearing of this case (reported in our last issue) was continued before Mr. Pollock, K.C., Official Referee, on Thursday, Monday and Tuesday last.

Mr. E. M. DOWNIE, director of plaintiff company, attributed the poor results of a test of the boiler at Heckmondwike to the fact that there was insufficient draught. His firm had given up boiler making because recently it had become the work of specialists. His company had neither the appliances nor the room to go into the business in a proper way to make it commercially successful. They had sufficient plant to make good boilers, but not to make them cheaply.

Mr. BURSTALL, C.E., who was present at the test of the boiler conducted by Mr. M. Longridge, said had the draught been greater the coal could have been burned perfectly. He denied that he had ever said the boiler would not evaporate the guaranteed amount of water.

Other evidence was given regarding the alleged want of draught, the analysis of the coal, &c., and this concluded the plaintiffs' case.

On Tuesday Mr. ACLAND, K.C. (for plaintiffs) announced that a settlement had been arrived at. The record would be withdrawn, and each party would pay their own costs.

### British Pioneer Electric Light & Power Co. (Ltd.)

On Tuesday Mr. Justice Buckley heard the petition of S. T. Biggs and another for the compulsory winding up of this company, and in the end his Lordship found that the petitioners has failed to make out their case, and the petition was dismissed, with costs.

### British Electric Traction Co. (Ltd.) v. Croydon Corporation.

This case was before Mr. Justice Farwell on Friday last. The award made by the arbitrator was in the form of a special case, and related to the various agreements entered into by the Corporation and the company. Mr. Thomson, for the company, announced that the parties had arranged that the questions which had been submitted to the Court should be answered in the negative; and Mr. Warmington (for Croydon Corporation) said the award was in favour of his clients, and, as he understood it, now the opposition to the award had been withdrawn. His Lordship then made an order as to costs, and the action was settled.

### Rating of Light Railways.

Wakefield and District Light Railways Co. were summoned before Wakefield City justices last week by Wakefield Corporation for non-payment of rates, amounting to £40. 2s. 2d. The company refused payment on the ground that, like ordinary railways, they were liable under Sec. 211 of the Public Health Act, 1875, to be rated only at one-fourth of the assessment.

For the Corporation, Mr. MACKENZIE contended that prima facie the Corporation were entitled under the 1875 Act to charge the full amount of the rates, but the company claimed to come under the exemption which provided that "lands used only as a railway" should pay only on one-fourth of the net value. He contended that, as the lines of rails were laid along the public highway and the public had free and unrestricted use of the land on which they were laid, it was not land used only as a railway, and that, therefore, the exemption did not apply. Railways, moreover, were exempted from full payment because they did not partake of all the benefits of a district rate—*e.g.*, lighting and scavenging, but that was not the case with light railways. He also urged that the company were not owners of a railway within the meaning "a railway constructed under the powers of an Act of Parliament," and that the exemption could not apply for that reason.

For the company, Mr. W. C. RYDE argued that the order of the Light Railway Commission was equivalent to an Act of Parliament. The only question remaining was as to whether the Act or 1875 was a general enactment relating to railways, and he submitted that it was. It was the enactment which enabled local authorities to make a rate on railways. As to the contention that the land on which the rails were laid was not used only as a railway, he pointed out that the company used the property in a way in which nobody else could use it, having an absolute right to the exclusive use of the groove for the flanges of their wheels to run in. It was, in fact, just because the use of the lines was exclusive that they were rateable at all.

The Bench decided in favour of the Corporation on all points, but agreed to state a case for appeal.

### Manchester Carriage & Tramways Co. (Ltd) v. Swinton & Pendlebury District Council.

This appeal, which involved a question as to whether the Council, in purchasing the company's undertaking, was liable to purchase a depot situated outside the Council's district, and also a question as to the proper construction of sec. 43 of the Tramways Act, 1870, came on Monday before the House of Lords (Lords Macnaghten, Lindley and Robertson). The proceedings in this case before Mr. Justice Channell, and in the Court of Appeal, were reported in our issues of May 20 and Dec. 2 and 9, 1904. After hearing the arguments of Mr. Fletcher Moulton, K.C., M.P. (for the company), and Mr. Balfour Browne, K.C. (for the Council) their lordships reserved judgment.

### Swansea Corporation v. National Telephone Co.

In the Court of Appeal (Lords Justices Vaughan Williams, Stirling and Cozens-Hardy) on Saturday, Mr. R. J. Parker applied for an order that this appeal under the Telegraphs Act, 1899, dealing with the question of intercommunication between the Swansea municipal telephone system and that of the National Telephone Co. at Swansea, should be expedited, and their lordships decided that the case should come into the list on Dec. 11.

### Electrical Engineering Apprentices.

At North London Police Court on Monday, Mr. Edward L. Joseph was summoned by five apprentices who had been indentured to him to learn electrical engineering to show cause why he should not pay damages for breach of covenant.

The lads were all apprenticed by the East London Apprenticeship Fund, and £25 was, it appeared, paid with each lad. Defendant signed the contract to teach them the business of electrical engineering, but they complained that in three or four years they had learned practically nothing, although they had studied at the Northampton Institute and worked in defendant's shops at Canonbury.

Defendant denied liability, as he had handed over the apprentices to a reconstructed company (the Consolidated Supply Co., Ltd.). He said the lads had had every opportunity of doing well, and some of his apprentices had got good situations. The company, however, would not accept any but the best apprentices, and discharged the five plaintiffs. He admitted that he had received the premiums, but he considered he had earned those sums by the trouble he had taken with the lads.

The MAGISTRATE (Mr. Rose) found that defendant was personally liable, and ordered him to pay £6 in each of four cases and £2 in the fifth, with £1. 1s. costs in one case and 3s. in each of the others.

### Re L. M. Waterhouse and the Patent Acts (Patent No. 28,632 of 1903).

In regard to the report of the above action which appeared in our last issue, p. 237, Messrs. Glynne, Jones & Co., solicitors for the Simplex Steel Conduit Co. (Ltd.), the defendants, write us as follows :—

"With reference to the report of the petition brought in respect of the above patent against our clients, the Simplex Steel Conduit Co. (Ltd.), we only wish to add that, on the advice of Mr. Fletcher Moulton, K.C., and Mr. A. J. Walter, we have already given notice of appeal, and that the Order was suspended in the meantime. Prior proceedings had been taken for the revocation of the Bayliss Patent referred to at the instance of our clients, and the petitioners in the present case then consented to the Order being taken against them, whereas the validity of the above patent was supported by such well-known experts as Mr. Swinburne and Mr. Barnes."

**Lloyds v. Marconi International Marine Communication Co. (Ltd.)**—This case was before Mr. Justice Kekewich on Saturday last. As announced in our last issue, an arrangement was come to between the parties, the result being that all proceedings are stayed in the two actions.

**Walker v. Ingleton Electric Light & Power Co. (Ltd.), and Others.**—On Saturday Mr. Justice Swinfen Eady was asked in a debenture-holder's action to appoint a receiver and manager. Defendants did not appear, but one of them consented. His Lordship appointed a receiver, with liberty to act as once.

**Private Wire and Telephone Installation Co. (Ltd.) v. Portman & Co.**—The further hearing of this case (in our issue of Nov. 10) has been adjourned by the Westminster County Court judge to Dec. 19.

## AN ELECTRICAL CONTRACTOR'S REFERENCE BOOK.

It is difficult to convey to our readers in the small space at our disposal the merits of the complete G. E. catalogue of electrical plant, machinery, apparatus, instruments, materials and general supplies of which we have received a copy. Perhaps the best method of calling attention to the scope of this handsome book will be by a few statistics. The complete catalogue comprises 1,500 pages, the book is 3 in. thick, weighs 10 lb., and comprises 148,500 sq. in. of paper for each copy of the catalogue, and put end to end, the pages would be over a quarter of a mile in length. The book comprises 13 different sections and is a veritable mine of information and illustration concerning almost every article required by the contractor in connection with the installation of electrical plant, &c., for lighting, heating, cooking, power, traction, medical work, automobilism, and, in fact, every branch of industry to which the application of electrical working can be made. The index, with which is included a quantity of useful information, is a small volume in itself, comprising 60 large quarto pages, and we shall not be surprised if the company receive numerous applications for this section separate from the volume,

Perhaps of even more importance than a comprehensive index is the arrangement of the articles set out in the various divisions of the book, and the General Electric Co.'s long experience in connection with catalogue compilation has enabled their staff to adopt a system by which the busy man comes to the goods he requires in regular sequence. This branch of the work has certainly been carried out in a very comprehensive and thorough manner. There appears to be no limit to the facilities which the company possesses for supplying goods for all classes of work, from electric bells to supply station equipments, from a hair curler to a 3,000 kw. steam dynamo It may be well to set out the sections into which the book is divided, and these are as follows : Plant (P.), switchboards, &c. (X.), electric light supplies, switches, &c. (S.), instruments, &c. (M.), engineering supplies (H.), fittings and glassware (F. and G.), wires and cables (W.), conduits (C.), bells, indicators, &c. (E.), telephones (K.), electro-medical apparatus and automobile accessories (O.).

The General Electric Co., by the issue of such a compendium, have once again shown their complete grasp of the situation in relation to electrical contract work, especially in connection with electric lighting and electric driving, which is becoming a very closely-cut branch of work, and it is an essential for those who have the compiling of specifications and cost quotations to have before them lists which will furnish the estimater with all required information to enable him to prepare his documents in the shortest possible time; those, therefore, who are engaged in this work will find themselves under a debt of gratitude to the compilers of this volume, who have carried out the scheme of the work with much care. The foredge indexing of the book and the colourings adopted represent, we think, the best method of guiding the user of the book to the various sections. Beyond this it is only necessary to say that the thousands of illustrations will prove of the greatest value to contractors, who by their aid are enabled to satisfy their clients' requirements straightway, and so avoid the trouble and expense of obtaining samples and much other work for which there is no charge allowed in the estimate. The binding of the book is distinctive, and altogether the publication of the General Electric Co.'s complete catalogue is an event of importance to all branches of the electrical trades. The company are anxious to get the catalogues in circulation, and invite applications from contractors, architects and others to whom the book will be of interest.

# MUNICIPAL, FOREIGN & GENERAL NOTES.

## APPOINTMENTS VACANT.

Applications are invited for the newly vacated professorship of electrotechnics at the South African College, Cape Town. Commencing salary £600 per annum. Applications must be sent by Dec. 15 to the Agent-General for Cape Colony, 100, Victoria-street, London, S.W., from whom further particulars can be obtained. See an advertisement.

An examination will shortly take place for appointments as second-class engineers in the Engineer-in-Chief's Department, G.P.O. Jan. 11 is the latest date for receiving applications. Forms from the Secretary, Civil Service Commission, Burlington-gardens, London, W. See also an advertisement.

An assistant shop manager is wanted for large shop doing light and medium repetition work, high class machine work and switch parts, &c. Applications to Works Manager, Crompton & Co., Chelmsford. See an advertisement.

A practical instructor, a capable man with college training, is wanted for large engineering workshops, to give practical and theoretical instruction to students, and generally supervise testing and analysing materials, &c. Applications to Brush Electrical Engineering Co., 108, Belvedere-road, London, S.E. See an advertisement.

An electrical mechanician is required for the Federated Malay States railways. Candidates should have a thorough practical knowledge of three-phase motors as applied to driving machine tools, &c., in a railway workshop. Salary £225 per annum, with free second-class passage out and home on satisfactory completion of engagement. Applications to the Crown Agents for the Colonies by Dec. 12. See also an advertisement.

A junior demonstrator is wanted in the physical laboratories of Birmingham Municipal Technical School. Salary £80. Applications by 13th inst.

A principal is wanted for Smethwick Evening Technical School. Salary £150.

## EDUCATIONAL NOTICES.

**Glasgow and West of Scotland Technical College.**—The official opening of this college takes place on Dec. 21, the Secretary for Scotland (the Marquis of Linlithgow) having accepted an invitation to perform the opening ceremony. Last week the chairman of the Governors (Mr. W. R. Copland) presented diplomas and medals to the successful students during the past session, including the following in electrical engineering: John A. Allan, George W. Anderson, David H. Brown, James W. Brown, Frank Carruthers, Robert H. Gardner, John H. M'Minn, James Mirrey, George H. Stevenson (with Sir John Pender gold medal and bursary), and John Young.

**Northampton Institute (Clerkenwell, E.C.).**—Sir William Preece, K.C.B., F.R.S., will present the prizes at the annual prize distribution and conversazione on Friday next at 8 p.m.

**Merchant Venturers' Technical College, Bristol.**—Sir Alexander Binnie will distribute the prizes on Dec. 21.

**Accident.**—On Tuesday an electrician named John Curry met his death while engaged in wiring work at a shop at Pelton Fell colliery.

A fitter named Robson was engaged in fitting up the shop and deceased was holding an electric hand-lamp to enable Robson, who was working on a ladder to do some work on the roof. In some unaccountable way Curry's arm came in contact with a live wire and he was killed by electric shock before his assistant could switch off the current.

**Award.**—The award of the arbitrator in the dispute between Middlesex County Council and Wm. Griffiths & Co., contractors for the Lordship-lane and Bruce-grove tramways has been issued.

The arbitrator held that the Council was not entitled to any penalties, and that Messrs. Griffiths & Co. were not entitled to any damages.

**Bangkok (Siam).**—The electric tramways, about 12½ miles in length, which have been constructed by Dick, Kerr & Co., were opened for traffic by the King of Siam on Oct. 1.

**Barnsley.**—An unopposed inquiry was held last week into the Council's application for sanction to a loan of £3,000 for meters, house services, &c.

**Barnstaple.**—At the last meeting of the Council a scheme of discounts to be allowed to electric lighting consumers was approved. An application by the Ilfracombe Electric Light & Power Co. for a supply of current for all purposes at power rate for a branch they intend opening in Barnstaple was not entertained.

**Barry.**—The Council have decided to proceed with the application for a provisional electric lighting order.

**Beckenham.**—The Council have instructed the Clerk to make preparations for taking over the management of the electricity supply and refuse destructor works, and to treat the electricity and destructor undertakings as separate departments.

For the present the dust destructor is to be credited with £143 per annum, the estimated value of the steam supplied for the generation of electricity, and the electric lighting account will be debited with £150 per annum, the amount hitherto charged to British Insulated & Helsby Cables (Ltd.) in respect of cost of collecting electric lighting charges, &c.

**Belfast.**—On Tuesday Major Pringle, R.E., and Mr. Alex. P. Trotter, representing the Board of Trade, commenced their official inspection of the Corporation's new tramway system. A descriptive account of these tramways will be found in another portion of this week's issue of *The Electrician.* Major Pringle, during his inspection, paid a visit to the school established by Mr. Blackburn, at the Falls-road depot, for training the motormen, and expressed his appreciation of the facilities afforded for the purpose.

**Boston.**—The National & Provincial Electricity Corpn. has applied for the Council's consent to their application for a provisional order. Consideration of the application has been deferred. The Council have an order dated 1902.

**Brighton.**—An inquiry will be held on 12th inst. into the application of the Council for permission to borrow £6,294 for extensions of the electricity undertaking.

**British Columbia.**—The British Columbia Telephone Co. commenced operations in Victoria in 1880, and was therefore one of the first to enter into the general telephone exchange business. The company has now 1,400 subscribers at Victoria, and the Victoria exchanges are worked on the central-battery system. The company serves the island of Vancouver, and by means of sub-aqueous telephone cables the intervening islands. The head offices of the company are at Vancouver, the company operating the whole province of British Columbia.

The British Columbia Electric Railway Co., of Victoria and Vancouver, uses water power in both places for power and light, and a correspondent, writing us recently on the subject of the development of electricity supply in that country, points out that there are numerous streams and undeveloped water powers in British Columbia ready to be harnessed as soon as business developments warrant this being done. There are already indications of considerable activity in this department of industrial enterprise. Mines and other works are constantly installing electrical machinery, steam or water-power driven.

**Brussels.**—During the storm of Sunday night the new municipal electricity station buildings, which was approaching completion, were wrecked. The loss is estimated at £12,00.

**Camborne.**—The Board of Trade have consented to the use of overhead wires for the supply of electricity by the Urban Electric Supply Co. from Carn Brea Station to Camborne.

**Cape Town.**—The Cape Government Railway Department's electricity undertaking, which was established in 1904 for lighting the railway premises and Government buildings, has now a total connection equivalent to 30,000 8 c.p. lamps, which is in excess of the total plant capacity of the station. The department is the only consumer. There are about 100 Brockie Pell open arcs and also a few enclosed arc lamps employed in lighting, the farthest lamp from the station being five miles away. In addition to the station equipment there are about 50 sets of steam oil and accumulator apparatus in use for train lighting.

**Carnarvon.**—An inquiry was held here last week into the application of the Council for permission to borrow £1,000 for electric lighting extensions.

**City of London.**—At the Court of Common Council meeting yesterday a proposal to withdraw the notices to the City of London Electric Lighting Co. to remove their standards until the Gas Co. had proved that they could provide better light at a cheaper rate was negatived. It was pointed out that the former electric lamps were old and out of date, and that an opportunity should be given to the Electric Lighting Co. to show what could be done with up-to-date lamps.

**Coventry.**—The Council are advised by the Electric Lighting committee to apply for sanction to a loan of £5,000 for the purchase of electric motors to be let on hire.

**Croydon.**—The Council have decided to supply electric current for power, heating and lighting in basements at a flat rate of 2½d. per unit.

**Cuba.**—The electricity works of the Havana Electricity Co. (of London and Havana) commenced supply on Jan. 1 last, and are equipped on the alternating-current system, the total plant capacity of the works being equivalent to 95,000 8 c.p. lamps. The equivalent of 15,000 lamps is already connected to the mains, there being 700 consumers. The charge for lighting varies from 17 to 10 cents per unit and for power from 8½ to 5 cents.

**Dundee.**—The manager of the Corporation tramways (Mr. Peter Fisher) has drawn up regulations for an interchange of traffic between the Dundee system and the Dundee, Broughty Ferry & Monafieth Tramways Co.

**East Ham.**—The Council have adopted an estimate of the electrical engineer and manager (Mr. W. C. Ullmann) for cable extensions, &c., at a cost of £20,000. It is proposed to put in electric motors for pumping at the sewage works, and the engineer (Mr. A. H. Campbell) has decided to use the engine and generator recently superseded at the electricity works for supplying electric energy.

Mr. Campbell says that energy required for working the centrifugal pumping plant will be generated at the destructor works, but it is considered desirable to have an alternative source of supply from Nelson-street station. The advantages of electric pumping were its power of immediate application in times of sudden storm, &c., economy of management and maintenance, ease of distribution throughout the works, including also power for workshops.

Mr. Ullmann has promised to co-operate with Mr. Campbell in preparing a specification for inviting tenders.

It has been decided to proceed with the duplication of the tramways in Manor Park at an estimated cost of £5,000.

**Edinburgh.**—Owing to complaints of the quality and illuminating power of the gas supplied from the municipal gas works at Granton, the Corporation recently decided to obtain a report on the whole lighting of the city from Mr. Simmance.

The general conclusion Mr. Simmance arrives at is that the quality of both gas and electric light is excellent. The variation in the standard of the gas is not due to manufacture, but to other causes. In many streets where electric light was largely used, there is in the gas mains a considerable quantity of gas in repose, and this stagnation has a greater tendency to deteriorate in lighting power than would be the case were there a constant current passing. Mr. Simmance favours the lowering of the candle-power, and an extension of incandescent gas for street lighting. In regard to the electric lighting, Mr. Simmance regards the quality as excellent, but he draws attention to the variation in the pressure of the current in certain parts of the city, notably Portobello, where the high-tension system is employed, the variation sometimes varying from 232 to 250 volts.

**Frauds on Electrical Firms.**—One of the longest and most important prosecutions for fraud and conspiracy ever tried in the Courts of this country came to a close on Saturday, Nov. 25, when William Leslie, George Webber, Richard Thomas Rosenberg and Alice Frances Cheesman were found guilty, at the Central Criminal Court (London), by a jury of conspiring to defraud numerous firms dealing in electrical fittings and appliances to the extent of over £30,000.

The trial, which commenced before the Recorder (Sir Forrest Fulton) on the 16th ult., extended over nine days. A great number of witnesses, including members of the victimised firms, tendered incriminating evidence, and a clerk from the London & County Bank, Southwark branch, produced a copy of an account opened by Cheesman in July, 1904. At one time there was only 8d. standing to the credit of the account, but between March and July, 1905, the account increased considerably, deposits rising rapidly so, that there were thousands of pounds to its credit. Between May 15 and July 20 £18,650 was withdrawn in Bank of England notes and gold, Cheesman explaining that she had to meet several large accounts due to certain Frenchmen, who preferred these Bank notes and gold to cheques on London bankers. The following particulars were given of the cheques drawn by the various firms in favour of the "Electrical Accessories Co.," the name under which the prisoners carried on their fraudulent practices. Some of the minor cheques have been omitted :—

| 1905. | | | | |
|---|---|---|---|---|
| April 14, | £352 | 0 | 1 | Falk, Stadelmann & Co. |
| ,, 28, | 72 | 0 | 0 | —— |
| May 5, | 150 | 0 | 0 | Veritys Ltd. |
| ,, 6, | 356 | 10 | 0 | General Electric Co. |
| ,, 8, | 150 | 0 | 0 | Croggon & Co. |
| ,, 8, | 72 | 0 | 0 | —— |
| ,, 15, | 225 | 0 | 0 | Evered & Co. |
| ,, 20, | 200 | 0 | 0 | Veritys Ltd. |
| ,, 22, | 146 | 5 | 0 | G. Braulik |
| ,, 29, | 245 | 14 | 0 | Edison & Swan |
| ,, 29, | 169 | 13 | 0 | Electrical Co. |
| ,, 29, | 24 | 11 | 5 | Strode & Co. |
| ,, 30, | 192 | 0 | 0 | Brush Co. |
| ,, 30, | 222 | 10 | 0 | Smethurst & Co |
| ,, 31, | 628 | 13 | 0 | Edison & Swan |
| ,, 31, | 92 | 1 | 7 | Electrical Co. |
| June 1, | 212 | 1 | 3 | International Electric Co. |
| ,, 8, | 202 | 10 | 0 | A. Emmanuel & Sons |
| ,, 10, | 220 | 0 | 0 | Hands & Co. |
| ,, 10, | 200 | 0 | 0 | F. Suter & Co. |
| ,, 14, | 262 | 10 | 0 | A. Emmanuel & Sons |
| ,, 22, | 1,867 | 2 | 3 | Edison & Swan |
| ,, 22, | 100 | 0 | 0 | W. McGeoch & Co. |
| ,, 24, | 336 | 7 | 6 | J. Sperati |
| ,, 24, | 180 | 0 | 0 | Hale Bros. |
| ,, 26, | 2,000 | 0 | 0 | J. Bolding & Sons |
| 1905. | | | | |
| June 27, | £218 | 7 | 0 | Hands & Co. |
| ,, 27, | 661 | 4 | 0 | Evered & Co. |
| ,, 27, | 401 | 2 | 0 | A. Emmanuel & Sons |
| ,, 29, | 202 | 16 | 0 | Croggon & Co. |
| ,, 29, | 232 | 15 | 9 | Strode & Co. |
| ,, 29, | 337 | 10 | 0 | J. Milne & Co. |
| ,, 29, | 450 | 8 | 9 | H. F. Joel & Co. |
| ,, 29, | 992 | 2 | 0 | Electrical Co. |
| ,, 29, | 500 | 0 | 0 | Smethurst & Co |
| ,, 29, | 329 | 7 | 0 | Purcell & Nobbs |
| ,, 29, | 337 | 15 | 9 | Rashleigh Phipps & Co. |
| ,, 30, | 210 | 0 | 0 | Croggon & Co. |
| ,, 30, | 132 | 10 | 0 | W. McGeoch & Co. |
| ,, 30, | 2,000 | 0 | 0 | J. Bolding & Sons |
| ,, 30, | 17 | 15 | 3 | —— |
| ,, 30, | 76 | 1 | 0 | —— |
| ,, 30, | 100 | 0 | 0 | —. Webber |
| July 1, | 329 | 1 | 3 | Maple & Co. |
| ,, 1, | 324 | 0 | 0 | Falk, Stadelmann & Co. |
| ,, 1, | 610 | 13 | 0 | Roger Dawson, Ltd. |
| ,, 5, | 606 | 18 | 9 | Gent & Co. |
| ,, 6, | 220 | 17 | 6 | Purcell & Nobbs |
| ,, 6, | 206 | 0 | 0 | Sunbeam Lamp Co. |
| ,, 10, | 200 | 0 | 0 | —— |
| ,, 10, | 232 | 0 | 0 | —. White |

Among the electrical witnesses were Mr. Oscar T. Banks (O. T. Banks & Co., Mortimer-street, London, W.), who deposed that in June last an order was given him for 600 sparking plugs. It was represented to him that the plugs were required immediately, and that the only place where he could get them was from the Electrical Accessories Co. The plugs were stated to be for use at the Fulham Theatre, London, S.W. Witness sent to the Electrical Accessories Co., and was subsequently informed that the plugs had been delivered. A few days later the Electrical Accessories Co. asked him for payment of the account, but he declined to pay it as he was not satisfied that the plugs had been delivered. Rosenberg called upon him and requested payment of the account, but witness told him that he was not satisfied that the goods had been delivered, and that he should have to make further inquiries. Rosenberg said it would have to be paid, and he left. A day or two afterwards witness received a writ issued on behalf of the Accessories Co. for the amount, and he placed it in the hands of his solicitors. He made an affidavit stating that his defence to the action was that there had been no delivery. He heard no more of the action.

Mr. W. H. Bowley (manufacturers' agent, Hatton-garden, London) stated that on June 9 he met Webber and Leslie at his office. He had known Webber for 15 years as a customer. Webber gave him an order for 600 sparking plugs, and said he would give the witness a sample if he would send to his place of business. Webber stated that the plugs were required for the Grand Theatre, Fulham, for a secret stage effect, the secret being known only to himself and the electrician at the theatre. Leslie took no part in this conversation. Witness procured 600 plugs from France and delivered them to Webber, who signed for them. By Webber's instructions they were sent to the stage-door entrance of the theatre. Webber said he did not quite understand how the plugs were to be used; he did not understand the adaptation of sparking plugs to electric lighting purposes.

Other witnesses gave similar evidence, and it was also stated that in Webber's bankruptcy the liabilities were £30,000, £25,000 of which was represented by sums owing to electrical engineers.

Evidence of arrest, &c., was given by the police. Detective Inspector Willis deposed that on Sept. 16 he went to Aberystwith and saw Leslie at the railway station. Witness and Detective Thorpe took him to the local police station. Leslie was searched, and in his possession were found two three-stone diamond rings, a single-stone diamond ring, a single-stone diamond pin, and a gold watch, chain and sovereign purse. Accompanied by other officers, witness went to a house in Aberystwith and saw Cheesman. In a small handbag in that young person's room witness found a purse containing a sovereign (which the prisoner said belonged to her), two diamond cluster pins and a receipt for luggage left at the railway station. In a room witness found two bags wrapped in rags in a box. The bags contained £1,982 in gold, and in another bag were £330 in Bank of England notes. Witness went to the railway station luggage office, and, presenting the luggage receipt, was given a large basket. On opening it with a key found on Leslie he discovered, wrapped up in straw and other material, a small bag in which were two canvas bags containing exactly £4,000 in gold. Witness conveyed Leslie and Cheesman to London. It was found that the price given for the diamond ornaments was £1,500. Witness found that £7,450 in Bank of England notes had never reached the Bank of England, but he had not been able to discover where they were.

At the conclusion of the evidence for the prosecution, the prisoners Rosenberg, Webber and Cheesman gave evidence on their own behalf.

Leslie, who was not called as a witness, said that Rosenberg and Cheesman were entirely innocent of any wrong.

After speeches by counsel on behalf of Rosenberg, Webber and Cheesman,

The Recorder, summing up the case, said that in regard to Webber the question was whether he was the dupe of Leslie or whether he was an active participator in that gigantic fraud, well knowing at the outset wha the circumstances were. Rosenberg only came upon the scene at a late date, and, if the jury considered that there was any case against him at all, they might think that a verdict on the conspiracy counts only would meet the justice of the case. Cheesman took a most prominent part in the matter, and they might think that she was a necessary instrument. She was a person eminently fitted to inspire confidence. Her defence was that what she did was under instructions. The jury would have to consider that.

The jury found Leslie, Webber and Cheesman guilty of conspiracy and false pretences, and Rosenberg guilty of conspiracy only, recommending him to mercy.

Mr. Bodkin (for the prosecution) said there was reason to believe that the £7,000 in notes, the whereabouts of which could not be ascertained, did in fact pass into Webber's possession. He did not know whether any course could be taken which would give Webber an opportunity of revealing where they were or what had become of them. The £6,000 found in Leslie and Cheesman's possession at Aberystwith unquestionably came directly from Cheesman's banking account, and as to a small quantity of goods and the proceeds of cheques mentioned in the indictment, he would ask the Recorder to make an order of restitution.

The Recorder intimated that he would make an order of restitution as to the goods and proceeds of the cheques mentioned in the indictment.

The Recorder then sentenced Webber and Leslie each to five years' penal servitude, Rosenberg to nine months' imprisonment with hard labour, and Cheesman to 12 months' imprisonment in the second division.

**Electricity in Cotton Mills.**—The Hope weaving shed, Burnley, formerly driven by steam engines, is now fitted with electric motors, current being obtained from the steam dynamo at the Trafalgar Mills (about 150 yds. distant) by overhead wires carried across the canal. It has been found that electric driving is more economical, and that the working of the looms is steadier and more regular. The atmosphere of the mill is, of course, much purer and healthier for the workpeople.

**Electricity Supply in Sweden.**—The Swedish electricity supply companies have pledged themselves not to compete with each other in cutting prices for electrical energy.

**Folkestone, Hythe & Sandgate Tramways.**—The National Electric Construction Co. and the Folkestone, Hythe & Sandgate Tramway Co. have submitted proposals to Folkestone, Hythe and Sandgate Councils for the construction of a system of electric tramways in this district. Hythe Council have already discussed the subject, and both companies have been asked to submit further particulars.

**Fremantle (W. Australia).**—The local electric tramways were inaugurated at the end of October. The contractors (Noyes Bros.) are to work the system until April 26 next, when the lines will be taken over by the Town Board.

**Hammersmith (London).**—On Wednesday the Council decided that it was inadvisable to participate in the promotion of a bill to confer powers upon a number of electric lighting companies in the west of London and the Hammersmith, St. Pancras and Hampstead Borough Councils to supply electricity to one another.

**Holyhead.**—An unopposed inquiry has been held here into the application of the Council to borrow £3,000 for electric lighting extensions.

**India.**—Bangalore, which has a population of 180,000, has been supplied with electric current by the Mysore Government since 1902, and there is now a total connection to the mains of an equivalent of 283,000 8 c.p. lamps. The station supplies current to a very large number of motors on the Kola Goldfields and to the city of Bangalore for lighting and power. It is expected that current for these purposes will also be furnished to Mysore City during 1906, transmission being on the three-phase system from the generating station 40 miles distant.

**Inquest.**—The City Coroner (Dr. Waldo) held an inquest on Friday last into the cause of death of a youth named Glass, who was killed at the offices of the "Central News," New Bridge-street, London, E.C., on Nov. 21.

Deceased worked an electric lift and was found dead in the well of the lift. It appeared that the lad had gone into the basement of the building to turn off the electric current, had ascended to the first floor, and was in the act of turning off a switch in the lift, when, in some unexplained way, it descended and caused his death.

Mr. Burdes, electrician to Archibald Smith & Stevens, makers of the lift, said he found the current on and the fuses blown. He attributed this to the boy's body stopping the lift. The peculiar kind of switch used was designed so that the fuse would go if anything went wrong. In his opinion the boy was working the lift from the outside, and was not quick enough in stepping away. The current was on, and the lift would certainly have worked had the fuses not blown. He considered that all the appliances were thoroughly safe. The lift stopped automatically. A boy should not have touched the mechanism of the lift. The endeavour of lift manufacturers was to make a lift of such a kind that a boy could work it safely. He considered that a boy of 15 might be taught in a few hours to work an up-to-date electric lift. The boy had been instructed in the working of the lift and was proficient.

Mr. J. Good, Home Office expert, said the lift was provided with a number of safety appliances, and was in good working order. He could suggest nothing that would make the lift safer, except that the handle working the lift from the inside should be capable of being removed. The fact that the fuses were blown gave the impression that the current was off. In certain lifts the doors had to be closed before the lift could be moved.

Mr. Burdes said the handle should have been taken out.

The jury returned a verdict of death from accidental causes, adding a strong recommendation that a boy of 15 should not be employed on a passenger lift. In addition they called attention to the fact that the boy was working for 11½ hours a day.

**Ipswich.**—At the meeting of the Ipswich Engineering Society on 20th ult., the newly-elected president (Mr. Frank Ayton, chief engineer of the Corporation electricity works) delivered an address to a large audience upon "Present day Features in the Generation, Distribution and Utilisation of Electric Power."

Mr. Ayton referred to the machinery and plant required for the equipment of an up-to-date generating station, and pointed out that in nearly all large power stations the water-tube type of boiler is used and superheaters provided. He said that artificial methods of induced draught had not made the headway expected. The diversity of practice in regard to pumping feed water into the boilers, coal-handling plant, systems of steam mains, &c., were touched upon. The steam turbine (Mr. Ayton said) seemed to have taken first place for large stations. A little over 20 years ago it was a toy of a few horse-power, running at a terrific speed, and most notoriously greedy in coal consumption; to-day the steam turbine was with them as a unit of 7,000 H.P. with an efficiency which, under certain conditions, it was difficult for any form of steam engine to equal. The advantages offered by the turbine were thoroughly explained. With regard to the distribution of electric power, the lecturer stated that the pressures employed in this country generally varied between 5,000 and 11,000 volts, but schemes were on foot where it was proposed to use still higher pressure, notably one in Scotland for the transmission of 5,000 H.P. to the Vale of Leven from a hydro-electric station 22 miles distant, supplied with water from Loch Sloy. In that case the pressure mentioned was 40,000 volts. Since 1897 there have been at least four plants started in North America, transmitting from 3,000 to 10,000 H.P. over distances varying from 100 to 218 miles, at 60,000 volts. He thought they might safely look forward to seeing in the near future large electric power stations, located in situations favourable for obtaining cheap coal and a sufficiency of water, transmitting electric power at high tension along overhead lines to the great cities. The companies would probably have their own private rights of way for the overhead lines, just as railway companies had for their tracks. Extra high-tension currents could not well be carried into cities—the high cost of underground cables for such purposes would probably render that impossible. The lines would accordingly terminate at sub-stations where the power would be transformed to a lower pressure, and be sent in to the towns to other secondary sub-stations where it would be further transformed down and sent into the mains at low tension. Mr. Ayton deplored our antiquated and cumbrous legislative system which killed many promising schemes in the bud by reason of the enormous waste of time and money involved before working powers could be obtained, while it doubtless prevented hundreds of schemes being brought forward which, were they started, would add to the commercial prosperity of the country. The application of electric power within the last decade to railways and street tramways was then referred to, and Mr. Ayton prophesied a still greater development in this direction, with a reservation that there was not likely to be any considerable electrification of the main lines of railway in this country. It was doubtful whether the advantages gained, unless greatly increased speed was the only end desired, would repay the enormous additional outlay that such a change would involve. With the service accelerated and the stops frequent, the circumstances were altogether different, and there electric traction could show financial results which would justify the capital expenditure required for the change. No less important was the use of electricity in driving machinery in workshops and factories. It was safe to say that in the majority of industrial operations, the use of electricity had in a large measure revolutionised the cost of production. In many instances the saving effected had been the means of changing a losing concern into a prosperous undertaking. There was not an important works put down to-day which did not utilise electric driving—even spinning mills in Lancashire were being driven in that way, a new mill of 70,000 spindles near Manchester having recently been started entirely equipped with electric power. He was not exaggerating when he said that there were many firms in Ipswich which were wasting a great deal of money every year which they might save if they would use electric power. He could cite numerous instances where the introduction of electricity had shown a considerable saving. One of the largest ironmasters of the Midlands (Sir Alfred Hickman) had recently stated that, in "scrapping" 26 steam engines, and putting down a central electric power-station, with motors in the various shops, he found that he was making a saving of £7,500 a year on the coal bill alone. In conclusion, Mr. Ayton dealt with the advantages of electric lighting. It was the only method of artificial illumination, he said, which would be tolerated by anyone (having a choice in the matter) who had the slightest respect for the state of his lungs and his general health. There was no doubt that the universal use of electricity for lighting would have three most important results—the average span of life would be increased, insurance premiums would go down, and so much would not be heard of physical degeneration.

An interesting discussion followed, and a hearty vote of thanks was passed to Mr. Ayton for his excellent address.

**Japan.**—There was recently held in Tokyo a conference of the United Chambers of Commerce of Japan, and amongst the recommendations made for the development of Japanese commerce and industry, were included the development of the telephonic system of the Empire, the extension of railways, and the holding of an International Exhibition.

**Johannesburg Mining Plant.**—Newtons Limited, of Taunton, are this week shipping to the Jubilee Gold Mining Co., Johannesburg, a large generator and two motors of their well-known "Mawdsley" type, together with main switchboard and two controlling panels. This is the third repeat order Messrs. Newtons have received from the Jubilee Company during the last few years, proving conclusively that these machines are well suited for mining purposes generally in South Africa.

**L. & N.W. Railway Electrical Department.**—The London & North-Western Railway Co. are centring their electrical and telegraph staff in the new offices at Crewe. The electrical and telegraph staff at Stockport will take up their duties at Crewe next week. When the alterations in progress are complete, Crewe will, it is claimed, be one of the finest electrically-equipped stations in the world.

**Lancaster.**—A syndicate has applied for sanction of the Corporation for the purchase of the horse tramways of the Lancaster & District Tramways Co., and also for the construction of a new tramway to Skerton with a junction to the Morecambe line. The whole system would be electrically equipped and energy would be taken from the Corporation. The Tramways committee have submitted an alternative proposal to the syndicate, and it is under consideration.

**Lecture.**—At Belfast last week Mr. A. A. Blackburn, A.M.I.E.E., tramcar superintendent of the Corporation, gave an interesting lecture on the equipment and running of the electric cars.

The lecture was supplemental to the course of instruction given to the motormen, &c., of the new system. The lecturer, after describing the origin and development of tramways and electric railways in various places, said the rate of mortality from accidents was less in connection with electric than with horse tramways. In the latter it was 1 in 5,000,000, whereas in the case of electric cars the figure was only 1 in 10,000,000.

Mr. Blackburn described in detail the equipment and fittings of the cars. The Belfast cars, he said, were constructed to carry 22 passengers inside and 32 outside, the length from fender to fender being 28 ft., width 6 ft. 10 in. and height 6 ft. 9 in. The gauge was that adopted in most of the principal cities. The framing of the car was of well-seasoned oak, and the platforms of pitch-pine and oak with channelled steel supporters, The outside frame was of mahogany, and the roof of pitch-pine. The trolley plant was on the centre of the car, and the upward pressure fixed upon was 25 lb. The route indicators were, he said, the best ever placed upon any cars. These route indicators were lighted by 16 c.p. lamps. Steel tyres were a great improvement upon those in use two or three years ago. The lifeguard attached to the truck was perfectly automatic and simple in operation. The working of the brakes and motors having been dealt with, the measurement and transmission of electrical force in connection with the working of the cars was explained and illustrated, and drivers and guards were advised what to do in cases of certain possible accidents or mishaps to their cars. Many hints of a practical character were given, and, after showing how the controller, pocket telephones, &c., should be used, the lecturer concluded by describing in detail how the drivers in particular should carry out their duties.

**Littleborough.**—The Council are recommended by the Tramways and Electricity Committee to obtain a supply of electricity in bulk from Rochdale. The Littleborough provisional order was obtained in 1900.

**London County Council.**—At Tuesday's meeting it was resolved to loan Southwark £5,942 and Battersea £10,891 for electric lighting purposes.

Battersea Council asked for a loan of £12,031, and the Finance committee commented on the high price for mains which are to be laid simultaneously with the widening works in course of execution by the Council. The local authority state that the reason for the high cost is that the Council wish the mains laid at a depth of 3 ft. 6 in. when passing under the route of tramways, but the committee pointed out that, although additional cost may be incurred by reason of the increased depth, yet there will be a saving in trenching and reinstatement.

*Tramways.*—It was announced that the report of the Highways committee recommending the reconstruction for electrical traction of the first section of the Northern Tramways at a cost of £803,600 would be withdrawn, as the Finance committee still had the financial side of the matter under consideration.

The Highways committee reported that the agreement with the London Electric Supply Corpn. for the temporary use by the Council of a portion of the company's premises at Deptford and for a supply of steam for the company's boilers for working certain generating plant placed there by the company could now be terminated, as the first portion of the Greenwich generating station would be completed by April next, and would be sufficient to work the whole of the existing southern tramways and a portion of the northern tramways. The committee suggested, however, that a further agreement should be entered into with the company which would enable them to meet the demands consequent upon the electrification of further portions of the northern tramways, and they recommended that the amended agreement with the Corporation provide for the supply to the Council, for a period of three years, of electric power to Greenwich electricity station, where it will be measured, with a minimum of 1,500,000 units a year, at 1d. per unit for the first 2,000,000 units, and for any quantity beyond 0·75d. per unit, the agreement to be subject to the company holding sufficient plant at the disposal of the Council to allow of a maximum demand of 1,500 kw., and purchasing the plant now installed by the Council at Deptford station for £13,000.—Agreed.

**Metropolitan District Railway Co.**—The company announce that all steam trains will be withdrawn after to day (Friday). Important reductions of fares are also announced.

**Middlesex.**—A bill is being promoted to authorise the County Council to construct a tramway from the terminus in Edgware-road to Kilburn, near Bridge-street. The proposed tramway to Sudbury is to be continued along the Harrow-road. Application is to be made to the Light Railway Commissioners for an order authorising the construction of a line linking the lines terminating at the junction of the Watford and Edgware roads, and the line from Watford to Bushey Heath.

**Nantyglo.**—The Council have asked the South Wales Electrical Power Distribution Co. to submit terms for supply of electrical energy.

**Poplar (London).**—The Electricity committee has given the Public Health committee a site at the generating station for the erection of plant for the manufacture of disinfectants by electrolysis.

**Potteries Electric Tramways.**—The section of the Potteries Electric Tramways from Market-street, Longton, to Sandford-hill, is open for traffic.

**Salford.**—The borough electrical engineer (Mr. Chas. D. Taite) has issued a circular announcing that from Jan. 1 users of electricity for power will be allowed to use current for lighting at the power rate up to 15 per cent. per quarter of their power consumption.

**Sheffield.**—The Corporation electric supply department announce a reduction in the charge for electric energy for heating and cooking to 1d. per unit from Jan. 1. An illustrated circular is being issued by the department to householders, calling attention to the advantages of electricity for cooking, heating, &c.

**Swansea.**—The work of laying the electric lighting cables in Sketty and Morriston districts is making rapid progress and it is anticipated that supply will be available by Christmas.

**Sydney (N.S.W.)**—For some time past negotiations have been proceeding between the City Council and two electric lighting companies, which have been supplying electricity in portions of the city, as to the purchase of the companies' undertakings. A report prepared by the city electrical engineer (Mr. T. Rooke) showed that the actual cost of the purchase of the undertakings would be about £72,000, and £37,000 would be required for rewiring of installations, extensions of mains, &c. The report has been referred back.

**Torquay.**—The L.G. Board have authorised the Council's scheme for an extension of the electricity works to enable a supply of current being given to the Dolter Electric Traction Co., and sanction has been received for the borrowing of the necessary moneys.

**Tramways and Motor 'Bus Competition.**—Owing to the introduction of the new electric tramway system at Hastings and St. Leonards the motor 'bus service in these towns has been stopped, and the entire stock of 11 cars has been sold to a London company.

**Uganda.**—A telephonic service for connecting up all the Government offices at Entebbe has been established, and there is a telephone service open to the public on payment along the telegraph lines established in the Protectorate.

**Victoria.**—The construction of the track of the St. Kilda-Brighton (Victoria) electric railway (3 miles) has been commenced. The Victorian Parliament has voted £18,500 for track and electrical equipment and £5,000 for cars.

**Victorian Electrical Association.**—The first business meeting of this Association was recently held at Melbourne, Mr. Hy. Noyes presiding over an attendance of about 40 representatives of the electrical engineering industry.

The report of the sub-committee appointed to draft rules and regulations was presented and the rules were, with slight amendment, approved. The entrance fee has been fixed at £1 1s. per year, and £1 1s. per year for subscription; country members are admitted at half these rates. A provisional council, consisting of Messrs. W. F. Clements, H. R. Harper, A. U. Alcock, A. E. Woodhouse, W. H. Alabaster, Noel Murray, H. Clement Newton, with the secretary (Mr. T. L. Coleman), was appointed to classify candidates as members and associates. The whole of the business transacted at the preliminary meetings will be submitted to a general meeting of the members shortly to be held, when the election of officers will take place. It is expected that the Association will start with a roll of about 80 members.

**Walthamstow.**—Application has been made for sanction to a loan of £10,000 for electric lighting extensions. Woodford has been offered a supply of electricity from Walthamstow provided Woodford will pay the consulting engineers' fee (25 guineas).

**West Ham.**—On Tuesday the Council had before them an elaborate report from the town clerk (Mr. F. E. Hilleary, LL.D.), on the L.C.C.'s electric power bill and the rival scheme proposed by certain of the borough councils in the North and East of London. Ultimately the Council decided that it was undesirable to identify itself at present with any particular undertaking, and that it was best for the borough to retain complete freedom until full particulars of the various proposals were before them.

The Board of Trade has consented to the placing on the back arm brackets of the tramway poles electric wires for lighting certain thoroughfares. The Board, however, reserve the power to review the situation at the end of five years.

**Western Australia.**—The electricity works of the South Perth Electric Supply & Power Co. in Coode-street, South Perth, were opened in May last to serve a population of about 2,000. At Oct. 30 41 consumers were connected to the mains, which are carried overhead. Both private and public supply is given, the street lighting being effected by 156 16 c.p. incandescents. The charge for current for lighting is from 8d. to 6d. per unit, and for power 6d. to 4d. No other illuminant is used at South Perth.

At Subiaco the Municipal Council is supplying current, and is putting down additional plant, bringing up the station capacity from 72 kw. to 184 kw.

**Wireless Telegraph Note.**—In a report upon the trade of the year 1904-5 the Governor of Trinidad and Tobago (Sir H. M. Jackson) states that among the public works which were taken in hand was a scheme prepared by the Electrical Engineer for experimental work in connection with the establishment of wireless telegraphy.

A receiving and transmitting station was erected in Port-of-Spain, and endeavours were first made to obtain direct communication with a station erected at Scarborough in Tobago, across the intervening lofty northern range of wooded hills in Trinidad. Communication was obtained, but not sufficiently distinct to justify the belief that a satisfactory system could be established direct between the two places. A temporary experiment station was, therefore, erected at the lighthouse at Chacachacare, and between this point and Tobago—a distance of 68½ miles, with no land intervening—communication proved easy and reliable. The Port-of Spain station has now been transferred to the North Post Signal Station, a spot on the north-west coast, about nine miles from Port-of-Spain and connected by telephone with the capital, and as soon as the installation is completed it is hoped that a regular and satisfactory system of communication will be opened to public use between Trinidad and Tobago.

**Woolwich (London).**—The Council have decided, in view of the large number of men unemployed in the district, to proceed with the laying of electric lighting mains in several streets for public lighting. Every man is receiving the trade union rate of wages. For January, February and March a special vote of £4,000 on account of works is to be spent, principally in wages.

**Worcester.**—The Council have decided to adopt electric motors in lieu of gas engines for driving part of the pumping plant at Bromwich if the Electricity committee will supply current to the sewage department at ¾d. per unit.

Ald. WHITEHEAD said the Council might be surprised at the question of gas v. electricity being again raised. The Water and Sewerage committee had provided for doing the whole work by gas engines, two of 100 H.P. and one of 80 H.P. The Electricity committee asked them to replace the 80 H.P. engine by two electric motors of 35 H.P. and 45 H.P. The Electricity committee had provided at Tybridge-street sufficient power for a much larger demand by the Tramway Company than was actually required, and they proposed to utilise that plant to supply the sewage works.

The city engineer (Mr. CAINK) calculated that the cost of pumping by gas would be £410 per annum, whereas the borough electrical engineer (Mr. C. M. Shaw) put the gas-engine pumping at £600. The Water committee had taken a mean for their calculation. The cost of pumping by electricity at ¾d. per unit would be £850.

**Workhouse Lighting, &c.**—Chell workhouse has been provided with an electric light installation. The work has been carried out to the specification of the Burslem borough electrical engineer (Mr. Ashton Bremner).

The plant is in duplicate and consists of two Stirling water-tube boilers, which are fed by two duplex Worthington pumps, and a sirius injector has also been installed. The whole of the feed, steam and exhaust piping, with the feed tank, pumps and water heater were supplied and erected by W. Boulton (Ltd.). Two Alley-MacLellan engines drive McClure & Whitfield dynamos generating continuous current at 220 volts when running at 550 revs. per min. A motor-driven booster by McClure & Whitfield is used to charge the battery of 130 cells (supplied by the Tudor Accumulator Co.) capable of carrying all the lighting from 9 p.m. until lighting-up time next day. The switchboard was supplied by the Electric & Ordnance Accessories Co., and the wiring work has been carried out by Mr. E. M. Evans, of Burslem. A 10 B.H.P. electric motor by Messrs. McClure & Whitfield has been installed in the laundry.

A committee of Southampton Guardians is considering a suggestion by the borough electrical engineer (Mr. H. F. Street) to wire a portion of the workhouse buildings for the electric light. Current will be taken from the Corporation.

Hackney Guardians last week considered an offer by the borough electrical engineer (Mr. L. L. Robinson) to instal electric motors at the workhouse and run the Board's machinery for a month free of cost. The experiment was suggested in order to convince the Guardians of the cheapness of electricity compared with gas.

Father DUNN said he understood electrical power would be given at ½d. per unit.

Mr. T. CHAPMAN said £500 a year had been saved at the Eastern Hospital by the introduction of electricity.

The matter was referred to a committee.

**Xmas Boxes, &c.**—The following circular has been issued by the National Electrical Manufacturers' Association :—

DEAR SIR : I beg to inform you that at a recent meeting of the members of the above Association it was unanimously decided that, owing to the enormous increase in the number of applications, they must reluctantly discontinue, as from this date, the practice of subscribing to annual beanfeasts, Christmas boxes, New Year gifts, &c. In consequence thereof the members of the above Association have unanimously agreed to discontinue this custom.—WALTER DAVENPORT, Secretary.

## TRADE NOTES AND NOTICES.

### TENDERS INVITED.

The Guardians of *Poplar* (London) Union invite tenders for supply and erection at the Children's Home and Schools (now in course of erection at Hutton, Essex) of steam engines, dynamos, pipework, &c.; main switchboard, wiring, motors, &c.; fire alarms, telephones and electric bells. Tenders to the clerk, Mr. G. Herbert Lough, 45, Upper North-street, Poplar, before 6 p.m. Dec. 13.

*Glasgow* Corporation invite tenders for supply of (1) 1,000 kw. motor generators and (2) high and low-tension sub-station switch gear. Offerers must be able to show plant similar to that for which they tender. Tenders to the town clerk (Mr. John Bowers), City-chambers, Glasgow, on or before Dec. 4.

*Ilford* District Council invite tenders for supply of 0·5 in. triple concentric armoured cable. Tenders (addressed to the Chairman), to the clerk (Mr. John W. Benton), Town Hall, Ilford, by 4 p.m. Dec. 12.

The Directors of the *North-Eastern Railway Co.* invite tenders for stores during six or 12 months from Jan. 1, 1906, including telegraph apparatus, telegraph wire and line stores. Tenders to the secretary (Mr. R. F. Donell), York, by 9 a.m. Dec. 2.

*Derby* Tramways committee want tenders by 9 a.m. 5th inst. for materials and works in connection with the reconstruction of conversion of Deadman's-lane and Navigation Bridge tramway from single to double track.

*Bradford* Corporation want tenders by 2nd inst. for supply of stores for Tramways department, including cables and wires, trolley poles and accessories, insulating material, overhead equipment, &c.

*Castlerea* (co. Roscommon) District Council want tenders by noon 23rd inst. for supply and erection of plant, &c., for the electric lighting of Ballaghaderreen.

*Southwark* (London) Council want tenders by Dec. 6 for wiring and fittings for Greenmore Wharf stables.

*Powell-Duffryn Steam Coal Co.* want tenders by 10 a.m. 11th inst. for stores, including electrical fittings, steam tubes, ironmongery, indiarubber and asbestos goods, &c.

*South Indian Railway Co.* want tenders by noon 12th inst. for electrical stores and sundries, leather and rubber goods, &c.

*Bombay, Baroda & Central India Railway Co.* want tenders by 5th inst, for stores, including electric generators.

*Dublin* Lighting committee want tenders by noon Dec. 11 for electric lighting and ventilating of Green-street Court House.

Tenders will be opened at noon, Jan. 30, at the offices of the Director of Public Works, Madrid, for a concession for the construction and working of an electric tramway between *Santander* and *Astillero*. The Nueva Montana Iron and Steel Co., of Santander, have already made application for this concession and will enjoy certain preferential terms. A deposit and the usual general conditions which apply to Spanish Government tenders are operative in this case, and tenderers can obtained further information from the "Madrid Gazette" of Nov. 26.

### TENDERS RECEIVED AND ACCEPTED.

West Ham Corporation received the following tenders for 12 arc lamps :—

Crompton & Co. (*accepted*) **£4. 12s.** per lamp, **15s.** line resistances; Brockie Pell Arc Lamp (Ltd.) £4. 18s. 6d.; Johnson & Phillips, £5 per lamp and 18s. 6d. for line resistances; British Thomson-Houston Co. £5 per lamp, 17s. 6d. line resistances.

Fareham Guardians have accepted the tender of Trick & Co. for wiring the sick wards of the infirmary.

Worksop Council have accepted the tender of Chamberlain & Hookham for electricity meters, and that of the Pulsometer Engineering Co. for water softening plant at £200.

Westminster Public Libraries committee received six tenders, varying from £73 to £119. 10s., for altering and repairing the electric lighting installation at St. Martin's-lane library, and the lowest (that of T. Potter & Co. at £73) was accepted.

Middlesex County Council have placed an order with Dick Kerr & Co. to construct a tramway along the Great North-road from Whetstone to Herts boundary at the same schedule of prices as the firm is constructing the line along Ballard's-road, N.

The export department of the D.P. Battery Co. have recently booked orders for a 100 kw. battery for Australia, and a small 15 kw. battery for New Zealand.

The Key Engineering Co., Manchester and London, have booked the following within the past week or two :—

For Manchester Electricity committee, supply and erection of a Harris-Anderson feed-water purifier for their Bloom-street works, and also 6,000 yds. of fibre conduit. For Melbourne Corporation, 10,000 yds. of 3in. fibre conduit. For Salford Electricity committee, 6,000 yds. of fibre conduit. For Oldham electricity department, 3,000 yds. of 2½ in. fibre conduit.

London County Council have accepted the tender of Siemens Bros. & Co. at £99. 16s. 6d. to erect a 30 H.P. electric motor at Old Montague-street School, Whitechapel.

Dartford Council have accepted the tender of W. Dickenson & Co. for wiring the tramcar sheds at £117.

Sydney (N.S.W.) Council are recommended to accept the tender of Noyes Bros for paper-insulated lead-covered cables at £5,247. 18s. 4d., delivery to be made within 14 weeks. There were six other tenders.

East Ham Council have placed an order with the General Electric Co. for a ventilating fan for £12. 5s.

Yarmouth Guardians have accepted the tender of Cooper & Cunningham for telephone work at the workhouse.

Dartford Council have accepted the tender of the Western Electric Co. for house service cable.

Walthamstow Council have placed an order with the Westminster Engineering Co. to re-insulate four armatures at £45 each.

West Ham Corporation have accepted the tender of Glenfield & Kennedy for four water meters at £55. 10s. each.

The tender of Banfield & Co. for supply of 10,000 to 12,000 tons of coal at 22s. 6d. per ton for the Brighton electricity department has been accepted.

## BUSINESS NOTICE.

G. F. Frizell and E. C. Louis (trading as Frizell Bros. and Louis), electricians, 79, Denmark-hill, London, S.E., have dissolved partnership.

## BANKRUPTCIES, LIQUIDATIONS, &c.

On Monday the examination took place of Ernst Emil Donat, engineer and agent, Albert-road, Withington, lately carrying on business as Donat & Co., at Spring-gardens, Manchester. Debts were £1,578, with a deficiency of £1,354. Bad trade in 1904, heavy business expenses, a wrongful claim against him for commission, and loss of commission were stated to be the causes of failure. Examination adjourned.

G. & J. S. Robson (trading as Robson, Robson & Co.), electrical engineers, Newcastle, were examined on Nov. 23. Liabilities £5,441, deficiency £3,040. Debtors denied that they had traded recklessly or had undercut prices. They had lost £700 on a Liverpool contract upon which a profit of £600 was anticipated. Examination adjourned.

An application for the discharge of Gerald Algar (trading as Gerald Leslie) electrical engineer, &c., 5, Denning-road, London, N.W., will be heard on Dec. 15 at Bankruptcy-buildings, London, W.C.

The trustee (Mr. L. J. Sharp) in the bankruptcy of Jas. Marsden, electric fittings maker, 39 and 40, Woodcock-street, Birmingham, has been released.

A receiving order has been made against Wm. Geo. Leather (trading as Windus Electric Co.) 25, Howard-street, Sheffield.

Claims against Dr. F. H. Bowman, 39, Victoria-street, London, S.W., to Mr. E. L. Hough, Bankruptcy-buildings, London, W.C., by Dec. 13.

Claims against Alex. Holmes and Alex. McCallum, electrical engineers, Darwen, to Mr. T. Hindle, District-chambers, Darwen, by Dec. 13.

Claims against British Miller Signal Synd. (Ltd.), to Mr. E. H. Stringer, 110, Cannon-street, London, E.C., by Dec. 30.

General Water Power (Ltd.) is being wound up voluntarily and Messrs. T. D. Pillans and M. F. Armstrong are liquidators.

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**Plant for Sale.**—Messrs. White Bros., engineers, Stratford, London, E., have for disposal a Ruston Proctor engine and Crompton dynamo; also two 100 kw. Belliss Morcom–Mather & Platt sets. See an advertisement.

Offers are invited by Leeds Electricity committee for the purchase of all or any part of about 1,000 electricity meters in good working order. Particulars from manager of electric lighting department (Mr. H. Dickinson), 1, Whitehall-road, Leeds. See an advertisement.

Mr. A. M. Wild, 13, High-street, Sheffield, has for sale a combined Westinghouse engine and generator.

Messrs. Cox & King, 5, Suffolk-street, Pall Mall, London, S.W., have for sale a 10 H.P. Westinghouse gas engine, a 6 kw. dynamo, a battery of 55 13-plate Hart storage cells, switchboard, &c.

**Alternator Wanted.**—Messrs. J. G. Childs & Co., Willesden-green, London, N.W., require a 15 kw. to 40 kw. second-hand alternator, any voltage, 50 to 100 periodicity.

**Premises to Let, &c.**—Mr. H. E. Smith, 59, Hamilton-square, Birkenhead, advertises for sale (or letting) a conveniently situated warehouse or factory in Liverpool.

Mr. Tilley, 87, Forest-road, Dalston, London, N.E., has some business premises to let, opposite Agricultural Hall, Islington, suitable for engineers, &c.

Mr. Woollett, 56, Cloudesley-road, Barnsbury, London, N., has a factory or warehouse near Islington Green, N., to let.

**New Improved "Stewart" Arc Lamps.**—The Electric & Ordnance Accessories Co. (Ltd.), Stellite Works, Chestonroad, Aston, Birmingham, write us as follows:—

Our attention has been called to certain notices and circulars now being advertised, and we beg to inform you and all interested in arc lamps that the term "new improved Stewart arc lamps" is applied by us, as manufacturers, in virtue of our having purchased from the liquidator of the late Stewart Electrical Synd. (Ltd.) the goodwill of that Syndicate. So that intending purchasers may not in any way be misled, we particularly point out that the "New improved Stewart arc lamp," manufactured and sold by us, is constructed at our works in Birmingham, the whole of the parts being British made and guaranteed of superior material and workmanship. . . . . . . . .

We beg to give notice that we will indemnify anyone purchasing from this company the "new improved Stewart arc lamps" of our manufacture against any claim that may arise from any action that may be taken against the purchaser.

We guarantee interchangeability and no difficulty or delay exists, as hitherto, in obtaining any spare parts, repairs or replacements, because, being British made, you have the manufacturers here in your own country to fall back upon.

**"Coats" Magneto Ignition Apparatus.**—We have received a pamphlet descriptive of this system from the General Electric Co. The apparatus comprises a direct-current generator, a condenser and a transformer. The armature of the generator is of the "H" type and the commutator is so arranged that the brushes are only in metallic contact with it during the peak of the E.M.F. curve. Thus the condenser is charged twice per revolution. It is claimed that with this system it is possible to obtain much more powerful sparks from a given size of coil than is possible with an accumulator.

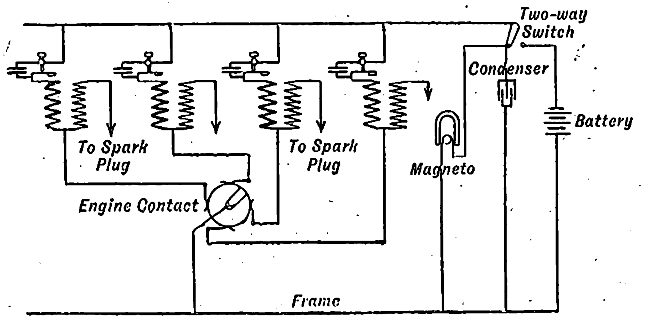


DIAGRAM OF CONNECTIONS FOR 4-CYLINDER CAR.

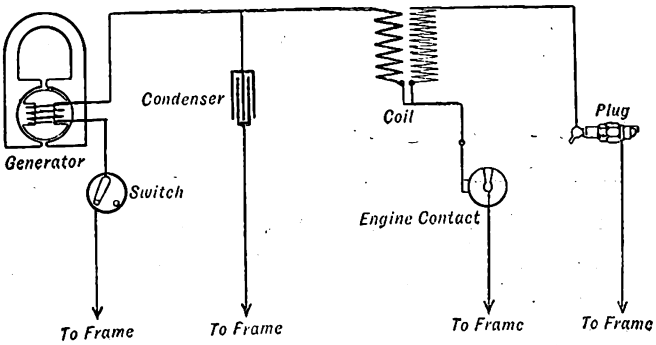


DIAGRAM OF CONNECTIONS FOR SINGLE CYLINDER CAR.

**Catalogues.**—Elliott Bros., Lewisham, S.E., have prepared a new Leakage Indicator pamphlet (No. 56), describing a type of these indicators designed to comply with the new Home Office regulations, governing the supply of electricity in mines. The instrument is intended for direct-current completely insulated circuits, and consists of a sensitive pivoted moving-coil milliammeter, calibrated with a centre zero and graduated in sectional divisions. A terminal block is fixed to the bottom of the instrument, having three insulated ebonite terminals (+, −, and earth) and two push buttons. When required an extra pair of terminals can be fitted to the top of the case for connection to a strong and well-made bell, actuated by a sensitive relay fitted inside the case of the instrument, this indicating any dangerous leak that may develop in either main. The instrument, which is made in three sizes, can be left permanently coupled up, and gives a continuous indication of the insulation of the circuit; will show which main the fault is on should a leak develop; determines the insulation of each main by means of a table supplied with each instrument; and gives the total leakage current to earth by simple calculation. These leakage indicators are also supplied for single-phase and three-phase alternating currents.

The British Thomson-Houston Co. have issued a series of new pamphlets, Nos. 185, 186, 187 and 188, dealing with the following subjects: Flexible ear for grooved trolley wire; portable electric measuring instruments; ammeters, voltmeters and wattmeters for switchboards; and miscellaneous switchboard instruments. The device dealt with in the first-mentioned pamphlet was illustrated in our issue for Nov. 10, page 150.

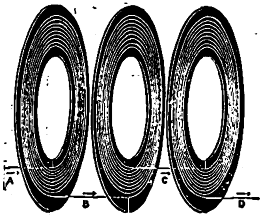
In our last issue we referred to the publication by Ferranti Ltd. of a new price list of single-pole switches. A new list (No. 51) of double-pole, single-throw, quick-break knife switches for from 25 to 1,400 amperes has now been issued.

Mather & Platt, Salford, have issued a fourth edition of their catalogue of two-cycle gas engines. Some good illustrations of a number of combined engine and dynamo plants by this firm are given.

A new list of variable speed drills is issued by the Armorduct Mfg. Co. We have recently had occasion to call attention to the "Little Hustler" drill supplied by this company.

F. Darton & Co., 142, St. John's-street, London, E.C., whose stand at Olympia attracted a large crowd of visitors owing to the varied articles on show and their novelty and suitability for popular work in connection with electrical experiments, &c., have just issued a catalogue of small electrical motors, dynamo castings, armature stampings, gas and oil engines, lamps, torches, telephones and other items, making up a very complete novelty list. Beside being of trade interest, the catalogue is seasonal and lists a large number of articles for which a demand can easily be created at the present time.

Mr. Leslie Miller, 93, Hatton Garden, London, E.C., who is well known as a manufacturer of X-ray outfits for the London hospitals, &c., has patented a jointless-section winding for induction coils and ransformers. One of these windings (that of the secondary of an induction coil or a transformer) is shown in the accompanying Fig. A. Mr. Miller explains in a circular list just issued that, owing to the invention of a special wire-winding machine, it has become possible to wind fine wires as theory dictates, in flat discs only one wire thick, without making any joint where one disc is continued to the next. Each of these discs is compressed between sheets of paper as between the leaves of a book, and it is so impossible for the wires to shift. The tension between neighbouring wires is a minimum, and the consequence is that internal leakage is much reduced, the efficiency raised, and internal breakdowns are quite unknown both during workshop tests and after. The wire is wound on a revolving horizontal table. A disc of insulating paper (shown black in the figure) is fixed on the table, and the wire wound on to it by the new machine, from the inner edge to the outer; then another disc of paper is fixed on the wire, and the winding continued from the outside to the inside edge, and so on indefinitely, as long as any wire remains, without a joint being made. Each of these discs is said to be capable of standing 10 times the strain upon it, and no means is known by which the insulation between the sections of the winding can, even intentionally, be broken down, while the tension between neighbouring turns of wire, owing to the perfect regularity of tho winding, is so small that it is possible to use bare wire, although silk-covered is actually employed. In the second figure is shown an example of the ordinary form of jointless-section coil for use with mercury motor or an electrolytic break. These coils are claimed to be specially suitable for use in hot climates, because the insulation does not depend on wax.



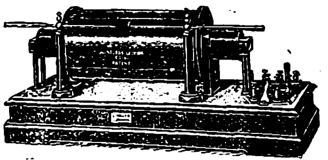


FIG. A.—SINGLE WIRE DISC. FIG. B.—JOINTLESS-SECTION COIL.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Nov. 22 to 28, with the ports of destination :—

*Africa.*—Alexandria, £19; Cape Town, £333; Delagoa Bay, £710; Durban, £2,133; East London, £380; Port Elizabeth, £1,149; Port Said, £17; Simon's Bay, £800. *Argentina*—Buenos Ayres, £180 (including £155 telegraph material). *Australasia*—Adelaide, £101; Fremantle, £112; Lyttelton, 6 tons (tramway points); Melbourne, £997 (including £917 telegraph wire); Nelson, £21 (telegraph material); Otago, £63; Perth, £412 and 147 cwt. (copper cable); Sydney, £6,320 (including £205 telegraph material); Wellington, £52. *Canada*—Halifax, £11. *Ceylon*—Colombo, £219. *Chili*—Antofagasta, £288 (telegraph instruments); Valparaiso, £173,971 (including £173,800 submarine cable). *China*—Shanghai, £67; Tientsin, £116. *France*—Marseilles, £5; Paris, £135. *Germany*—Hamburg, £18. *Gibraltar*, £700. *Holland*—Amsterdam, £286 (including £211 telegraph material). *India*—Bombay, £389; Calcutta, £3,574; Karachi, £130; Madras, £2,127. *Japan*—Tokyo, £319; Yokohama, £1,034. *Malta*, £6. *Portugal*—Beira, £61; Lisbon, £245. *Siam*—Bangkok, £192. *St. Helena*, £182 (telegraph material). *Straits Settlements*—Penang, £79; Singapore, £68 (including £28 telegraph material). *Surinam*, £95. *Sweden*—Stockholm, £120 (telegraph material). *U.S.A.*—New Plymouth, £16. *West Indies*—Trinidad, £18. Total, £198,270, against £67,960 in the corresponding week last year (Nov. 23 to 29).

## NEW COMPANIES, MORTGAGES AND CHARGES.

### NEW COMPANIES.

**AUTOMATIC ELECTRIC BLOCK SIGNALLING CO. (LTD.)** (86,590.)—Reg. Nov. 24, capital £1,000 in £1 shares, to adopt agreement with Electric Railway Signalling Synd. (Ltd.), to acquire patents and inventions, and to carry on the business of electricians, engineers, suppliers of electricity and electrical installations and machinery for light, motive power and other purposes, manufacturers of electrical apparatus, &c. Reg. office, 302, Finsbury-pavement, London, E.C.

**CRAWFORD ELECTRIC LAMP SYND. (LTD.)** (86,578.)—Reg. Nov. 23, capital of £30,000 in £1 shares, to carry on the business of manufacturers, sellers and suppliers of electric lamps, suppliers of electricity, contractors for construction, equipment and maintenance of electric lighting stations and electrical works, electricians, electrical, mechanical, metallurgical and chemical engineers, &c.

**STRATFORD-ON-AVON ELECTRICITY CO. (LTD.)** (86,502.)—Reg. Nov. 16 capital £15,000 in £1 shares, to acquire rights to supply electric light or power in Stratford-on-Avon or elsewhere in the United Kingdom, to adopt an agreement between Stratford-on-Avon Corporation and the Birmingham Installation Co., and to carry on at Stratford-on-Avon and elsewhere the business of electrical and general engineers, electricians, manufacturers of and dealers in electrical apparatus, suppliers of electricity, &c First directors, G. M. Bird, J.P. (chairman), O. F. Freeman and S. Flower.

### MORTGAGES AND CHARGES.

**BRITISH ELECTRIC CO. (LTD.)**—Issue on Oct. 13 of £50 debentures, part of series created same date, to secure £250, charged on company's undertaking and property, present and future, including uncalled capital. No trustees.

**ELECTRICAL CORPN. (LTD.)**—A charge on book debts and sums of money due to Corporation and its undertaking and property, present and future, including uncalled capital, dated Oct. 31, 1905, to secure £272. 2s. 6d. and further advances up to £800, has been registered. Holders, E. S. Parker and A. H. H. Richardson.

**HOPPER & CO. (LTD.)**—£2,900 debentures, created and dated Nov. 9, 1905, charged on company's undertaking and property, present and future, including uncalled capital, have been registered. No trustees.

**KEYNSHAM ELECTRIC LIGHT & POWER CO. (LTD.)**—Issue on Nov. 9 of £1,104 debentures, part of series created same date to secure £1,500, charged on certain land and buildings occupied by company at Keynsham, Somerset, and company's undertaking and property, present and future, including uncalled capital, subject to £1,500 first debentures. No trustees.

**MARCONI INTERNATIONAL MARINE COMMUNICATION CO. (LTD.)**—Issue on Nov. 20 of £8,000 debentures, part of series created same date, to secure £25,000, charged on company's undertaking and property, present and future, including uncalled capital. No trustees.

## CITY NOTES.

**MEMORANDA** (Nov. 30).—Bank rate 4 per cent. (since Sept. 28, 1905) Price of silver 30$\frac{5}{16}$d. per oz. Consols 89$\frac{15}{16}$—90$\frac{1}{16}$ for money, 90$\frac{5}{16}$—90$\frac{7}{16}$ for account; 2½ per cent. annuities 89¼—89½. Consols Pay Day, Dec. 1; Stocks and Shares Continuation Day, Dec. 12; Ticket Day, Dec. 13; Pay Days, Dec. 14 and 29; Mining Share Carry-over Day, Dec. 11.

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**ARON ELECTRICITY METER (LTD.)**—The report for the year to Sept. 30 states that, after providing for general charges, depreciation and share of expenses and discount on issue of debentures, the net profit was £11,724. 4s. 4d., making, with £412. 9s. 4d. from last year, £12,136. 13s. 8d. Of this £2,500 is set aside for debenture sinking fund, and the directors propose to pay 4½ per cent. on account of preference dividend in arrear, absorbing £5,620. 6s. 5d., leaving £4,016. 7s. 3d. to be carried forward. Trade in Germany and Austria has (the report states) been very healthy throughout the year. The factories in Schweidnitz and Charlottenburg are giving every satisfaction. The business in France and England is still in a somewhat unsettled condition; the outlook is, however, distinctly hopeful, and the directors will continue their policy of economy and care.

The transfer books and register of members will be closed from Dec. 4 to 23 inclusive.

**BRITISH SOUTH AFRICA CO.**—At the meeting of this company last week the chairman (the Duke of Abercorn) referred to the great importance the board attached to the Victoria Falls, and their expectations in connection with them had been fully justified by facts. During the year a number of visitors had been attracted to the Falls. In September there was a gathering of great importance, when Prof. Sir G. Darwin opened the new bridge across the Falls in the presence of a large gathering of visitors, among whom were many of the leaders of the scientific world. The visit of the British Association to Rhodesia, in its present early stage of development, had been an eventful and remarkable fact. He referred to the project of the African Concessions Synd. to generate and transmit electric power from the Falls to the Witwatersrand mines. He was informed that the highest engineering authority had been obtained in support of the immediate realisation of this enterprise, and, though it would be premature to say much more upon the point, he understood that negotiations for the sale of power were already proceeding, and that there was good hope of success. If so, their company, as owners of half the capital of the syndicate, would have an important direct interest and would also reap the indirect results which might be expected to flow from the carrying out of such an enterprise in the heart of Rhodesia.

**COMPANIES TO BE STRUCK OFF REGISTER.**—The "London Gazette" of Nov. 28 contains a list of companies which will be struck off the Register of Joint Stock Companies in three months unless cause be shown to the contrary. Amongst these are the following :—

Atlas Electric Appliances Co.
British Electrical Mfg. Co.
British Spiral Telephone Wire Synd.
City & Suburban Electric Carriage Co.
Electrical Insulator Mfg. Co.
Electric Carbon Storage & Apparatus Mfg. Co. of Scotland.
Electric Portable Battery & Gas Igniting Co.
Elwell-Parker (Ltd.).
French Electrical Power Storage Co
Morecambe Electric Launch & Power Synd.
Mutual Telephone Co.
Railway & Domestic Electric Lighting Co.
St. George Telephone Co.
South Kensington Mutual Electric Lighting & Supply Co.

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. No. of weeks. | Aggregate. Amount. | Aggregate. Inc. or Dec. (a) |
|---|---|---|---|---|---|---|
| | | £ | £ | | £ | £ |
| Aberdeen Corporation | Nov. 25 | 1,133 | + 73 | 26 | 87,645 | - 1,463 |
| Airdrie | ,, 17 | 208 | + 12 | 46 | 9,469 | + 143 |
| Anglo-Argentine | ,, 25 | 14,886 | - 697 | 46 | 629,849 | + 38,487 |
| Ayr Corporation | ,, 25 | 173 | + 11 | 27 | 9,611 | - 141 |
| Barcelona Trams Co. | ... | ... | ... | ... | ... | ... |
| Barcelona, Ensanche, Gracia | ... | ... | ... | ... | ... | ... |
| Barnsley | ,, 17 | 155 | - 10 | 46 | 7,415 | - 836 |
| *Barrow | ,, 17 | 208 | + 15 | 46 | 11,160 | + 2,167 |
| Bath Electric Trams, Ltd. | ,, 22 | 578 | + 58 | 47 | 33,236 | + 2,099 |
| Birkenhead | ,, 26 | 901 | + 26 | 8 | 7,595 | + 256 |
| Birmingham Corporation | ,, 25 | 373 | + 60 | 34 | 12,856 | + 1,512 |
| *Birmingham & Mid. | ,, 17 | 1,350 | - 122 | 46 | 73,014 | - 31 |
| Blackpool Corporation | ,, 23 | 249 | - 29 | 21 | 43,820 | + 1,760 |
| Blackpool and Fleetwood | ,, 25 | 152 | - 18 | 21 | 19,348 | - 1,076 |
| Bolton Corporation | ,, 26 | 1,727 | + 151 | 85 | 67,575 | + 2,626 |
| Bournemouth Corporation | ,, 22 | 1,124 | + 382 | †33 | 48,848 | + 9,403 |
| Bradford Corporation | ,, 25 | 8,880 | + 639 | 84 | 151,684 | - 6,328 |
| Brighton Corporation | ,, 26 | 719 | + 50 | 35 | 806,763 | + 432 |
| Bristol Trams & Carriage | ,, 24 | 4,840 | - 14 | 15 | 78,989 | + 845 |
| Buenos Ayres & Belgrano | ,, 26 | 3,483 | + 1,240 | 47 | 168,152 | + 8,210 |
| Buenos Ayres Elec. Trams | Oct. 28 | 1,175 | ... | 43 | 49,995 | ... |
| Burnley Corporation | Nov. 25 | 1,034 | + 122 | 34 | 48,192 | + 2,205 |
| Burton Corporation | ,, 26 | 237 | - 11 | §34 | 10,910 | - 1,349 |
| Bury Corporation | ,, 19 | 665 | ... | §33 | 24,648 | ... |
| Calcutta Tramways Co. | ,, 25 | R13,730 | + R2,405 | 21 | R889,853 | + R113,078 |
| Camborne-Redruth | ,, 25 | 91 | - 9 | 4 | 397 | - 47 |
| Cardiff Corporation | ,, 25 | 1,681 | - 23 | 34 | 71,106 | + 109 |
| Carlisle Tramways Co. | ,, 25 | 151 | - 10 | 47 | 8,658 | - 618 |
| Central London Railway | ,, 25 | 7,206 | - 28 | 21 | 131,184 | - 963 |
| Chatham & Dist. Lt. Rys. | ,, 23 | 495 | + 47 | 47 | 80,939 | + 3,268 |
| *City of Birm'gh'm Tram Co. | ,, 17 | 5,116 | - 146 | 46 | 247,287 | + 274 |
| City & South London Rly. | ,, 26 | 3,[illegible]75 | - 79 | 21 | 53,821 | + 208 |
| Colchester Corporation | ,, 23 | 151 | - 22 | 17 | 4,761 | - 1,3[illegible]0 |
| Cork Electric Trams Co. | ,, 23 | 883 | + 2 | 47 | 22,759 | + 632 |
| Devonport & Dist. Trams | ,, 17 | 375 | - 94 | 46 | 21,262 | - 3,272 |
| Dover Corporation | ,, 25 | 173 | + 27 | 34 | 8,076 | - 60 |
| Dublin & Lucan Railway | ,, 24 | 83 | + 4 | 21 | 2,710 | - 26 |
| Dublin United | ,, 24 | 4,297 | + 270 | 21 | 107,499 | - 898 |
| Dudley—Stourbridge | ,, 17 | 784 | + 23 | 46 | 41,420 | + 1,382 |
| Dundee Corporation | ,, 22 | 869 | + 91 | §27 | 25,003 | + 1,867 |
| East Ham Council | ,, 25 | 712 | + 165 | 34 | 28,549 | + 3,177 |
| Gateshead & Dist. Trams | ,, 17 | 943 | + 53 | 46 | 42,490 | + 848 |
| Glasgow Corporation | ,, 25 | 14,637 | + 1,867 | 26 | 391,820 | + 19,719 |
| Glossop | ,, 18 | 119 | + 10 | 47 | 5,765 | + 588 |
| | ,, 25 | 126 | + 80 | | | |
| Gloucester Corporation | ,, 22 | 205 | ... | 34 | 10,448 | ... |
| Gravesend—Northfleet | ,, 17 | 202 | + 16 | 46 | 10,722 | - 926 |
| Gt. Northern & City Rly. | ,, 25 | 1,810 | + 304 | 21 | 32,341 | + 7,402 |
| Greenock & Port Glasgow | ,, 17 | 541 | + 37 | 46 | 29,732 | + 8,171 |
| Halifax Corporation | ,, 15 | 1,376 | + 69 | 33 | 53,885 | + 2,900 |
| Hartlepool Tramways | ,, 17 | 245 | + 6 | 46 | 12,833 | - 1,198 |
| Hastings Elec. Trams Co. | ,, 23 | 320 | ... | 16 | 8,985 | ... |
| Huddersfield | ,, 25 | 1,288 | + 183 | 34 | 46,892 | + 1,713 |
| Hull Corporation | ,, 25 | 2,105 | + 62 | 34 | 76,129 | + 628 |
| Ilford Dist. Coun. | ,, 25 | 861 | + 38 | 34 | 16,624 | + 871 |
| Ipswich Corporation | ,, 25 | 292 | + 1 | 34 | 15,459 | - 1,864 |
| Isle of Thanet Co. | ,, 25 | 239 | + 17 | 8 | 2,394 | - 447 |
| Kidderminster & District | ,, 17 | 91 | - 5 | 46 | 5,632 | - 3[illegible]7 |
| Kilmarnock Corporation | ... | ... | ... | ... | ... | ... |
| Kirkcaldy Corporation | ,, 23 | 189 | - 12 | 12 | 2,439 | - 90 |
| Lanarkshire Trams Co. | ,, 23 | 785 | + 191 | 47 | 85, 13 | + 34,425 |
| Leamington | ,, 17 | 120 | + 19 | 18 | 3,507 | + 1,273 |
| Leeds Corporation | ,, 25 | 5,486 | + 468 | 34 | 208,095 | + 41,450 |
| Leicester Corporation | ,, 25 | 1,863 | + 831 | 47 | 97,479 | + 29,206 |
| Liverpool Corporation | ,, 18 | 9,927 | - 148 | 46 | 486,517 | + 8,508 |
| Liverpool Overhead Rly. | ,, 26 | 1,401 | - 25 | 21 | 83,890 | - 1,467 |
| *London County Council | ,, 18 | 13,416 | + 1,893 | 33 | 496,703 | + 68,813 |
| Lowestoft | ,, 25 | 181 | + 1 | 8 | 1,255 | - 50 |
| Maidstone Corporation | ,, 23 | 75 | - 16 | 31 | 4,476 | ... |
| Manchester Corporation | ,, 25 | 11,957 | + 1,537 | 34 | 442,425 | + 18,088 |
| Mersey Railway | ,, 25 | 1,615 | + 64 | 21 | 32,976 | + 1,981 |
| Merthyr | ,, 17 | 176 | - 20 | 46 | 8,753 | - 492 |
| *Metropolitan Elec. Trams | ,, 17 | 2,503 | + 918 | 46 | 128,080 | + 52,829 |
| Middleton | ,, 17 | 289 | + 14 | 46 | 15,682 | + 641 |
| Musselburgh | ,, 16 | 144 | ... | 48 | 10,663 | ... |
| Nelson Corporation | ,, 25 | 115 | + 17 | 35 | 4,635 | + 483 |
| Newcastle-on-Tyne Corp. | ,, 25 | 3,246 | - 242 | 34 | 130,194 | + 2,612 |
| Newport (Mon.) | ,, 18 | 497 | - 1 | 8 | 4,277 | + 305 |
| | ,, 25 | 527 | + 86 | | | |
| Northampton Corporation | ,, 24 | 320 | + 8 | 33 | 14,296 | + 4,491 |
| Oldham, Ashton & Hyde | ,, 17 | 550 | + 38 | 46 | 25,760 | + 569 |
| Oldham Corporation | ,, 26 | 1,524 | + 245 | 35 | 57,752 | + 14,982 |
| Perth (W. A.) Elec. Trams. | ,, 24 | 1,419 | + 154 | 47 | 64,482 | + 8,821 |
| Peterborough | ,, 17 | 100 | - 5 | 46 | 6,297 | - 600 |
| Pontypridd Dist. Council | ,, 25 | 125 | ... | 34 | 5,605 | ... |
| Portsmouth Corporation | ,, 25 | 1,321 | + 92 | 34 | 71,420 | + 1,020 |
| Potteries | ,, 17 | 1,814 | + 75 | 46 | 78,685 | + 601 |
| Preston Corporation | ,, 22 | 509 | - 79 | 8 | 4,721 | ... |
| Reading Corporation | ,, 28 | 507 | - 47 | 8 | 4,547 | - 299 |
| Rotherham Corporation | ,, 23 | 410 | + 28 | 34 | 15,611 | - 642 |
| Rothesay | ,, 17 | 41 | + 4 | 46 | 9,425 | + 2,668 |
| Salford Corporation | ,, 27 | 4,337 | + 1,015 | 35 | 150,280 | + 8,093 |
| Sheerness | ,, 15 | 54 | - 4 | 46 | 3,254 | + 286 |
| Sheffield Corporation | ,, 26 | 4,704 | + 609 | 35 | 172,816 | + 8,184 |
| Southampton Corporation | ,, 22 | 775 | - 20 | †8 | 6,650 | - 507 |
| Southend Corporation | ,, 22 | 223 | + 24 | 34 | 14,040 | + 680 |
| Southport Tramways | ,, 17 | 221 | - 21 | 46 | 14,517 | - 182 |
| S. Staffordshire Trams. | ,, 17 | 811 | + 139 | 46 | 34,048 | + 1,361 |
| Stockport Corporation | ,, 21 | 690 | + 282 | 34 | 26,124 | + 6,017 |
| Sunderland Corpn. | ,, 26 | 1,116 | + 53 | 34 | 45,962 | + 1,415 |
| Swansea Trams | ,, 17 | 730 | + 252 | 46 | 38,293 | + 8,353 |
| Swindon Corporation | ,, 12 | 148 | + 6 | 34 | 6,849 | ... |
| Taunton | ,, 17 | 44 | + 14 | 46 | 1,034 | - 234 |
| Tynemouth and District | ,, 17 | 166 | - 21 | 46 | 12,049 | - 1,609 |
| Tyneside Trams Co. | ... | ... | ... | ... | ... | ... |
| Wallasey District Council | ,, 25 | 652 | + 66 | 34 | 27,211 | + 777 |
| Walsall | ,, 25 | 459 | + 69 | 47 | 23,073 | + 879 |
| Warrington Corporation | ,, 28 | 308 | + 32 | 34 | 11,624 | + 575 |
| West Ham Corporation | ,, 23 | 1,670 | + 699 | 34 | 61,226 | + 25,736 |
| Weston-super-Mare | ,, 15 | 28 | - 11 | 46 | 6,703 | + 597 |
| Wolverhampton Corpn. | ,, 22 | 697 | ... | 8 | 6,013 | ... |
| Wolverhampton District | ,, 17 | 400 | + 38 | 46 | 18,271 | + 256 |
| *Worcester | ,, 17 | 239 | - 12 | 46 | 14,056 | + 422 |
| Wrexham | ,, 17 | 88 | - 4 | 46 | 4,655 | - 385 |
| Yorkshire W.R. Trams | ,, 26 | 660 | + 289 | 47 | 83,596 | ... |
| Yorkshire Woollen District | ,, 17 | 709 | + 224 | 46 | 80,484 | + 8,577 |

(a) These comparisons are with the corresponding period last year. † Minus 8 days. § Plus 2 days. * Partly electrical.

**ELEKTRIZITATS AKTIENGESELLSCHAFT VORM. SCHUCKERT & CO.**—This company, which is now associated with the Siemens & Halske A.G. as the Siemens-Schuckert Werke A.G., has declared a dividend of 4 per cent. for the past year. There was no dividend the previous year.

**MACKAY COMPANIES.**—It is announced that the Mackay companies have completed arrangements by which the dividends of the Commercial Cable Co. and the Postal Telegraph Co. and other allied cable, telegraph and telephone companies, to be issued to the English and Continental shareholders, are, at the option of the shareholder, to be payable through the Union of London and Smiths Bank, London, at 4s. 01-12d. per dollar.

**NEWQUAY ELECTRIC LIGHT & POWER CO. (LTD.)**—This company is inviting applications for 15,000 shares of £1 each, payable 5s. on application, 5s. on allotment and the remainder in instalments not exceeding 5s. each at intervals of not less than two months.

**STOCK EXCHANGE NOTICE.**—The Stock Exchange committee have been asked to appoint special settling days in and to grant quotations to 60,000 £10 6 per cent. cumulative preference shares and £600,000 4½ per cent. debenture stock of the *Bombay Electric Supply & Tramways Co. (Ltd.)*

**STRATFORD-ON-AVON ELECTRICITY CO. (LTD.)**—This company is inviting applications for 9,000 shares of £1 each, payable 2s. 6d. on application, 2s. 6d. on allotment, 7s. 6d. on June 25, and 7s. 6d. on Sept. 29, 1906.

**WESTERN TELEGRAPH CO. (LTD.)**—The directors have declared an interim dividend payable on Dec. 21 of 3s. per share (or at the rate of 6 per cent. per annum tax free) for the quarter ended Sept. 30. The transfer books will be closed from Dec. 14 to 20 inclusive.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Nov. 29. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business, Week to Nov. 29. Highest. | Business, Week to Nov. 29. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | | | | |
| 5 | 3/0 | Anglo-Argentine Ord. Shares | 8½—8¾ | 4 11 6 | Ap, Oct | 8¾ | 8⅝ |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞—6⅛ | 4 9 8 | — | 6 1/32 | 5 15/16 |
| St. | 6% | Do. Permanent 6% Deb. Stock | 142—145 | 4 2 8 | — | .. | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 105—107 | 4 13 5 | — | 106 | .. |
| 10 | 12/0 | Barcelona Tramways Ord. | 13¾—14¼ | 4 4 0 | — | .. | .. |
| 10 | 5/0 | Do. 5% Cum. Pref. | 9½—10 | 5 0 0 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock (red.) | 97—102 | 4 8 3 | — | .. | .. |
| 100 | 5% | Do. 5 per Cent. Debs. | 93—101 | 4 19 0 | — | .. | .. |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1—1½ | .. | .. | 1 3/16 | 1 5/32 |
| 5 | 2/3 | Do. 5 per Cent. Cum. Pref. | 4—4¼ | 5 18 3 | — | 4 5/32 | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 95—98 | 4 12 0 | .. | .. | .. |
| St. | 6% | British Columbia Elec. Rlwy Def. Ord. | 124—127 | 4 14 6 | — | 25¼ | .. |
| St. | 5% | Do. Pref. Ord. Stock | 113—116 | 4 7 9 | — | .. | .. |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock | 105—109 | 4 11 8 | — | .. | .. |
| 4 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%—105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 102—105 | 4 5 9 | .. | .. | .. |
| [illegible] | 2/6 | Buenos Ayres and Belgrano Ord. | 8½—8¾ | 5 6 8 | — | 8 21/32 | .. |
| [illegible] | 8/0 | Do. 6 per Cent. "A" Cm. Pref | 5 11/16—5 15/16 | 5 2 0 | — | 5 13/16 | 5¾ |
| [illegible] | 3/0 | Do. "B" | 5—5½ | 5 9 1 | — | .. | .. |
| St. | 5% | Do. 5 per Cent. Debs. | 107—109 | 4 11 8 | — | 108½ | 107½ |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102—105 | 4 16 3 | — | .. | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 98—100 | 5 0 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 101—105 | 5 4 9 | .. | .. | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 103—107 | 5 12 0 | .. | .. | .. |
| 5 | 8/6 | Calcutta Tramways (Nos. 1 to 105) | 8¼—8¾ | 4 7 2 | — | 8 9/16 | .. |
| 5 | 0/3 | Do. Nos. 105,001 to 137,610 | 8½—9 | .. | .. | .. | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 107—109 | 4 2 7 | — | .. | .. |
| 1 | 0/6 | Cape Electric Tram Shares | ⅞—1⅛ | 4 8 10 | — | 1 1/16 | 31/32 |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 101—103 | 4 17 2 | — | .. | — |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 97—99% | .. | .. | 98¼ | .. |
| 1 | .. | Lisbon Elec. Trams Ord. | 1 5/16—1⅜ | .. | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛—1¼ | 4 13 0 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 101—104 | 4 16 3 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 103—105 | 4 15 3 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101—104 | 4 16 2 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102—104 | 4 6 7 | — | 103¾ | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 104—107 | 4 18 5 | .. | 107 | — |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 144—147 | 5 8 9 | .. | .. | .. |
| .. | .. | Do. 5% 1st Mt. $100 Dbs. | 99—101 | .. | .. | .. | .. |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | .. | Adelaide Elec. S'ply Co. 6% Cu. Pr. | 5—5½ | — | .. | 5 3/16 | 5 1/8 |
| [illegible] | 3/3 | †Calcutta Elec (1-50,000) | 9—9½ | 4 6 9 | — | 9⅜ | .. |
| [illegible] | 2/3 | † Do. (60,001-80,000) | 9—9½ | 4 6 9 | .. | .. | — |
| 10 | 5% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50—52 | 4 16 1 | .. | .. | .. |
| .. | .. | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 96—98 | .. | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½—3 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Debs. | 85—90 | 5 11 1 | — | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | 9—10 | — | — | .. | .. |
| 100 | 15/6 | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 94—96 | 5 4 2 | .. | — | .. |
| St. | .. | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. 50% pd. | 60—62 | .. | .. | .. | .. |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞—1 | 6 0 0 | — | 31/32 | — |
| 1 | 1/0 | Rand Electric | 1¼—1⅜ | .. | — | .. | — |
| 1 | .. | River Plate Electricity Co. Ord. | [illegible] | .. | .. | [illegible] | .. |
| 1 | [illegible] | Do. 6% Non. Cum. Pref | [illegible] | .. | .. | [illegible] | 1 |
| St. | 5% | Do. 5% Deb. Stock | 103—105 | 4 15 0 | .. | .. | .. |
| 5 | 8/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5¼—5¾ | 5 4 4 | .. | .. | .. |
| 5 | 9·13d | Do. (12,001-20,000) | 5—5½ | 3 8 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100—103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 10/9 | Shawinigan Water and Power 5% Bds., Scrip | 99—101 | 4 19 0 | .. | 100½ | .. |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Share. | Last Dividend | Name. | Price Wed. Nov. 29. | Rate per Cent. Yielded. £ s. d. | Dividend Due | Business, Week to Nov. 29. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| 1 | .. | Bath Elec. Trams Pref. Ord. | 15/16—1 | .. | .. | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16—1 1/16 | 4 14 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 102½—105½ | 4 5 0 | .. | 105½ | 105 |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 103—105 | 4 5 9 | .. | .. | .. |
| 10 | 9% | Bristol Tramways and Carriage Ord. | 17—17½ | 5 2 11 | Feb, Aug | .. | – |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10—10½ | 8 18 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Debs. | 105—107 | 8 14 10 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 9¾—10½ | 5 17 0 | – | 10⅛ | 9 13/16 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 11—11½ | 5 4 4 | Feb, Aug | 11¼ | 11 1/16 |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 121—126 | 4 1 0 | .. | 123½ | – |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 98—100 | 4 10 0 | .. | 99½ | 98¾ |
| St. | 4% | Central London Ordinary Stock | 93—95 | 4 4 0 | June, Dec | 94½ | 94 |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 101—103 | 8 17 8 | .. | 103 | 102 |
| St. | 4% | Do. Deferred Stock | 85—88 | 4 11 0 | .. | 87¾ | 86¾ |
| 100 | 4% | Do. 4 per Cent. Debs. | 110—112 | 3 11 5 | .. | .. | .. |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 4⅞—5⅛ | 4 17 6 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 100—108 | 3 17 8 | .. | .. | .. |
| St. | 2% | City and South London Rly. Con. Ord. | 46—48 | 8 18 6 | Feb, Aug | 47⅜ | 45 |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 119—122 | 4 2 0 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 117—120 | 4 8 4 | .. | .. | .. |
| St. | 5% | Do. (1901) | 114—117 | 4 5 6 | .. | 116½ | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 105—108 | 8 14 1 | May, Nov | 108 | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13½—14½ | 4 2 8 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½—15½ | 3 17 3 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5—5½ | 7 5 6 | .. | 5 9/16 | 5 5/16 |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8—9 | 4 8 11 | .. | 8½ | .. |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 101—103 | 4 7 6 | .. | .. | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 17—18 | 5 0 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 13¾—14¼ | 4 4 2 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 108—110 | 4 1 10 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼—2¾ | 9 8 6 | – | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 83—88 | 4 10 11 | – | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8⅛—8⅝ | 8 13 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾—10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99—102 | 8 19 8 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 10—10½ | 4 15 0 | – | 10¼ | 10⅛ |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 100—108 | 8 17 8 | – | .. | .. |
| St. | .. | Mersey Con. Ord. Stock | 7—9 | – | – | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8—11 | – | – | – | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32—9/32 | .. | – | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1—1 1/16 | 4 14 1 | – | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106—108 | 4 8 8 | – | 106¾ | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum. Pref. | ½—1½ | .. | May | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾—9¼ | 5 5 8 | .. | .. | – |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9½—10 | 5 0 0 | Feb, Aug | .. | .. |
| St. | 4½% | † Do. 4½ per Cent. Deb. Stock | 101—104 | 4 6 4 | – | .. | – |
| 100 | .. | Sunderland Dist. Elec. Trams. 5% 1st Mort. Debs. | 95—99 | .. | .. | .. | .. |
| .. | 5% | Underground Elec. Rys. Co. of London | 99½—100½ | 4 19 6 | .. | 99⅞ | .. |
| St. | 3% | Waterloo and City Ord. | 94—97 | 8 2 0 | June, Dec | 96 | 94 |
| St. | 12/11 | Yorkshire W. R. Elec. Trams Co. 4% 1st Debs. | 96—98 | 4 1 6 | .. | 97 | 96¾ |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | * African Direct Tel. 4% Mrt. Deb. (red.) | 99—102 | 8 13 5 | Jan, July | – | .. |
| 10 | – | Amazon Telegraph | 3¾—4¼ | .. | Jn, Dec | .. | .. |
| 100 | .. | Do. 5% Debs. (red.) | 85—90 | 5 11 0 | .. | 87¾ | 86½ |
| St. | 15/0 | Anglo-American | 62—64 | 4 14 0 | F,My,Ag,N | .. | .. |
| St. | 30/0 | Do. Preferred | 109½—110½ | 5 4 1 | F,My,Ag,N | 110¾ | 109¾ |
| St. | 2/0 | Do. Deferred | 17½—17¾ | .. | F,My Ag,N | 17 13/16 | 17⅝ |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 96—98 | 4 1 8 | Jn Ap,Jy,O | 97½ | 96¾ |
| 10 | 5/0 | Cuba Submarine Ord. | 8¾—9¼ | 5 8 8 | Feb, Aug | 9⅛ | 8¾ |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17—18 | 5 11 2 | Feb, Aug | .. | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅝—3⅞ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 9½—9¾ | 5 2 6 | April, Oct | .. | .. |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 100%—103% | 4 7 5 | Jan, July | .. | .. |
| 20 | 8/0 | Direct United States Cable. | 13¼—13¾ | 4 18 2 | Ja,Ap,Jy,O | 13⅜ | 11⅜ |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 100½—102½ | 4 8 2 | Jn, Dec | .. | .. |
| St. | 25/0 | Eastern Ordinary | 144—147 | 4 15 8 | Ja,Ap,Jy,O | 146⅞ | 144½ |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 89½—91½ | 8 16 6 | Ja Ap,Jy,O | 90⅝ | 90⅛ |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 106—108 | 8 14 1 | May, Nov | 107 | 106 |
| 10 | 2/6 | Eastern Extension | 14½—15 | 4 13 4 | Ja,Ap,Jy,O | 14 13/16 | 14⅝ |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 106—108 | 8 14 1 | Feb, Aug | 107¼ | 106¾ |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 99½—101½ | 8 18 8 | Feb, Aug | .. | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 100%—102% | 8 18 8 | May, Nov | .. | .. |
| 10 | 5/0 | G. N. (of Copenhagen) | 85—86 | 6 17 6 | Jan, July | 33 | .. |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 100½—102½ | 4 8 2 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57½—59½ | 5 9 2 | May, Nov | 59 | 58¼ |
| 100 | $1 | Mackay Companies Common | 52 15/16 | 3 14 3 | Jan, July | .. | .. |
| 100 | 4% | Do. Preference | 75 | 5 6 8 | Ja,Ap,Jy,O | .. | – |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1¼—1¾ | .. | .. | 1 9/32 | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 100—103 | 8 17 8 | June, Dec | .. | .. |
| 10 | 5/0 | West African Telegraph Shares | 10—10½ | 4 15 8 | .. | .. | .. |
| 2½ | .. | West Coast of America | 1 9/16—1 11/16 | .. | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100—102 | 8 18 5 | Jan, July | 100¼ | .. |
| 10 | .. | West India and Panama | ½—¾ | .. | May, Nov | .. | .. |
| 10 | 5/0 | Do. 6% 1st Pref. | 8½—9 | 6 13 4 | May, Nov | 8½ | .. |
| 10 | – | Do. 6 per Cent. 2nd Pref. | 6½—7½ | .. | May, Nov | .. | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 101—104 | 4 16 2 | Jan, July | .. | .. |
| 10 | 5/0 | Western Telegraph xd & bonus | 14—14½ | 4 16 7 | Mr,Jn,O,D | 14 5/16 | .. |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 102—104 | 4 16 0 | June, Dec | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 103—105 | 3 16 0 | .. | 101½ | .. |
| | | **TELEPHONES.** | | | | | |
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 102—104 | .. | .. | – | .. |
| 6 | 5/0 | Chili Telephone (fully paid) | 7⅝—7⅞ | 5 1 8 | August | 7¾ | 7 21/32 |
| 1 | 0/9¾ | Monte Video Telephone Ord. | 1 1/16—1⅛ | 3 14 5 | – | .. | .. |
| 1 | 1/0 | Do. 6% Pref. | ⅞—1 | 5 0 0 | .. | .. | .. |
| St. | 6% | National Co. Pref. Stock | 111—112 | 5 7 1 | – | 111¾ | 108⅜ |
| St. | 5% | Do. Def. Stock | 108—110 | 4 11 0 | – | 109⅞ | 109½ |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13—15 | 4 0 0 | Feb, Aug | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 11—13 | 4 12 4 | Feb, Aug | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅝—5⅞ | 4 5 2 | Feb, Aug | 5 13/16 | 5¾ |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 97½—99½ | 3 10 4 | June, Dec | 99 | 97 |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 104—106 | 3 15 6 | – | .. | .. |
| 1 | 0/7½ | Oriental | 1¼—1⅜ | 3 12 9 | April, Oct | .. | .. |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1 3/16—1 5/16 | 4 11 6 | – | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 102—105 | 4 5 9 | .. | .. | .. |
| 5 | 5/0 | United River Plate | 7—7½ | 5 6 8 | July | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝—5⅞ | 4 8 10 | June, Dec | 5 7/16 | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 110—112 | 4 10 8 | June, Dec | .. | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 4¾—5¼ | 5 14 4 | .. | .. | .. |
| 10 | 2/0 | Globe Telegraph and Trust | 10½—10¾ | 5 0 8 | Ja,Ap,Jy,O | 10⅝ | 10½ |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14⅛—14⅜ | 4 8 0 | Ja,Ap,Jy,O | 14 5/16 | 14⅛ |
| 10 | 6% | Submarine Cables Trust (Cert.) | 125—128 | 4 13 9 | April, Oct | .. | .. |

| Share. | Last Dividend | Name | Price Wed. Nov. 29. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Week to Nov. 29. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12¼—12¾ | 5 9 10 | .. | .. | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10⅜—10⅝ | 4 4 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11¼—11¾ | 4 18 0 | .. | .. | – |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 107—109 | 4 2 6 | .. | .. | – |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 102—105 | 4 5 9 | – | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 9¼—9¾ | 5 2 6 | – | 9 9/16 | 9½ |
| 5 | 8/6 | Do. 7 per Cent. Pref. | 9—9½ | 8 14 5 | Mar, Sept | – | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 104—107 | 2 14 4 | – | – | .. |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 6—7 | 4 12 8 | Feb, Aug | 6 11/16 | 6⅝ |
| 5 | 2/8 | Do. 4½ per Cent. Pref. | 5¼—5¾ | 8 18 8 | Feb, Aug | 5 11/16 | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 103—105 | 8 16 2 | – | 101¾ | .. |
| 5 | 2/8 | Do. City Undertaking 4½% Cm. Pref. | 4¾—5 | 4 10 0 | – | .. | .. |
| 5 | 2/8 | Do. Do. (1908) | 4¾—5 | 4 10 0 | .. | .. | .. |
| 5 | 2/3 | Chelsea Electric Supply Ord. | 5¾—6¼ | 4 16 0 | March | 6 1/16 | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 110—112 | 4 0 4 | Jn, Dec | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 11¾—12¼ | 4 18 0 | Feb, Aug | 11 11/16 | 11¾ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13¾—14¾ | 4 4 2 | Jan, July | 13⅜ | 12½ |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 124—128 | 8 18 1 | Jn, Dec | .. | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 104—106 | 4 4 10 | .. | .. | .. |
| 5 | .. | County of Durham Elec. P.D. Ord. £2 pd. | 2 1/16—2 7/32 | .. | April, Oct | 2 1/16 | .. |
| 5 | 0¾d. | Do. Do. 5% non cum. pref. | 5¼—5½ | .. | April, Oct | 5½ | 5 7/16 |
| 10 | 4/0 | County of London Elec. Supply Ord. | 9¼—9¾ | 4 2 0 | – | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅜—12⅞ | 4 13 2 | Mar, Sept | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 112—116 | 8 18 8 | .. | 113½ | 113 |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 102—104 | 4 6 7 | – | .. | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5—5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101—104 | 4 6 6 | – | .. | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8¼—8¾ | 4 17 2 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100—103 | 4 7 5 | – | .. | .. |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 11¾—12¾ | 5 0 0 | .. | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½—7 | 4 5 9 | Jan, July | .. | .. |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98—101 | 3 19 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101—103 | 8 17 8 | .. | .. | .. |
| 8 | 1/9⅜ | London Electric Supply Ord. | 1¾—2¼ | 4 0 0 | .. | 2 1/16 | 2 |
| 5 | 8/0 | Do. 6 per Cent. Pref. | 4¾—5¼ | 5 14 4 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 99—102 | 8 18 5 | Mr,Jn,S,D | 100¾ | 100½ |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 9½—10½ | 5 4 9 | April, Oct | 10 9/16 | 10¼ |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5½—5¾ | 3 16 8 | Jan. July | 5⅝ | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 109—113 | 8 19 7 | Jn, Dec | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 97—99 | 8 10 8 | – | 98½ | .. |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 101—103% | 4 7 5 | – | 102¼ | 101¾ |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 12¼—12¾ | 5 9 6 | Feb, Aug | .. | .. |
| 100 | .. | Do. 4½% Deb. | 104½—105½ | .. | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8—8⅛ | 4 19 5 | Feb, Aug | 8⅛ | 8 1/16 |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6¼—6½ | 8 16 11 | Feb, Aug | 6⅜ | 6¼ |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99—100 | 4 0 0 | Jan, July | .. | .. |
| 1 | 8% | Northern Counties Elec. Sup. 17/- paid | 13/16—27/32 | 3 1 1 | Mar, Aug | [illegible] | .. |
| 100 | .. | Do. 4½% Deb. | 100¼—101½ | .. | Jan, July | 101 | 100¾ |
| 10 | 6/0 | Notting Hill Electric Ord. | 14½—15½ | 8 17 6 | March | .. | – |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98—100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅝—6⅞ | 5 1 6 | March | – | .. |
| St. | 4% | Do. 4% Deb. Stock | 100—102 | 3 18 5 | – | .. | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 13—14 | 5 3 7 | Feb, Aug | 13⅜ | .. |
| 5 | 2/6 | Do. 7 per Cent. Pref. | 8—9 | 8 17 9 | Feb, Aug | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 98—100 | 3 10 0 | – | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2—2½ | 8 0 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76—80 | 5 0 0 | – | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 3¼—3¾ | 6 2 0 | .. | .. | .. |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | 1 3/16—1 5/16 | .. | .. | .. | .. |
| 1 | 0/8¾ | Do. 7% Cum. Pref. | 1 5/16—1 7/16 | 4 17 2 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105—108 | 4 8 8 | – | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4½—4¾ | 5 5 8 | – | .. | .. |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5—5¼ | 4 15 8 | – | .. | .. |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 104—106 | 4 4 10 | .. | .. | .. |
| 5 | 6/6 | Westminster Elec. Sup. Ord. ex rights | 11¾—12¼ | 5 14 0 | Mar, Sept | 11⅜ | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref ex rights | 6—6½ | 8 16 11 | .. | .. | .. |
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d. | Alliance Elec. Co. 6% Cum. Pref. | ⅝—⅞ | 5 6 6 | – | .. | |
| 1 | 6d. | Aron Elec. Meter 6% Cum. Pref. | 7/16—9/16 | .. | .. | .. | |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 2¾—3 | 5 0 0 | .. | .. | |
| 1 | 7½d. | Do. Pref | 1 7/16—1 9/16 | 3 18 10 | .. | .. | |
| 5 | 4/0 | British Insulated & Helsby Cables Ord. | 6¾—7¼ | 5 10 8 | July, Feb | .. | |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾—6¼ | 4 18 0 | Jan, July | .. | |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103—106 | 4 4 11 | .. | .. | |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98—100 | 4 10 0 | .. | .. | |
| 5 | .. | British Westinghouse 6% Pref. | 2—2⅝ | .. | .. | 2 5/16 | |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 85—89 | 4 9 11 | .. | .. | |
| 2 | .. | Brush Electrical Engineering | ½—¾ | .. | March | .. | |
| 2 | 2/4¾ | Do. 6 per Cent. Pref. Non-Cum. | 1½—2 | 6 0 0 | Mar, Sept | .. | |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 93—97 | 4 12 10 | Mar, Sept | .. | |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 78—81 | 5 11 6 | Jan, July | 80½ | |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11—12 | 5 0 0 | Jan, July | 11½ | |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝—5⅞ | 4 5 2 | Jan, July | 5 11/16 | |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 109—111 | 4 1 1 | Nov, May | 109 | |
| 1 | 4⅛d. | Castner-Kellner Alkali Co. | 1—1⅛ | 5 7 0 | .. | .. | |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 97—102 | 4 8 8 | – | .. | |
| 1 | 5⅜d. | Chadburn's (Ship) Telegraph Ord. | 1—1¼ | 8 0 0 | .. | 1 1/16 | |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1 1/16—1 3/16 | 5 2 7 | .. | .. | |
| 8 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 1⅞—2⅛ | 3 10 6 | Jan, July | 2 | |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 94—99 | 5 1 0 | Jan, July | .. | |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8½—9 | 5 11 1 | Sept | .. | |
| 5 | 8/0 | Do. 6% Cum. Pref. | 5¾—6¼ | 4 18 0 | Sept | 6⅛ | |
| St. | 4½% | Do. 4½% Deb. Stock | 106—108 | 4 4 1 | .. | .. | |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅛—1⅝ | – | Feb, Aug | 1 7/16 | |
| 5 | 2/6 | Do. (£5 paid) | 2—2½ | .. | Feb, Aug | .. | |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 85—90 | 4 8 11 | June, Dec | .. | |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92—97 | 5 8 1 | .. | .. | |
| 5 | 4/6 | Edmundson's Elec. Corp. Ord. | 5¼—5¾ | 6 1 9 | H'lf-yearly | 5 5/16 | |
| 5 | 8/0 | Do. 6 per Cent. Cum. Pref. | 5⅞—6⅛ | 4 18 0 | .. | .. | |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 108—110 | 4 1 6 | .. | .. | |
| 2 | 1/7½ | Electric Construction Co. | ½—¾ | 9 6 0 | July | .. | |
| 2 | 2/9¾ | Do. 7 per Cent. Cum. Pref | 1⅞—2⅜ | 5 18 8 | July | .. | |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 92—95 | 4 4 2 | Jan, July | .. | |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9½—10 | 5 0 0 | .. | .. | |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96—100 | 4 0 0 | .. | .. | |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 12½—13½ | 5 11 1 | Feb, Aug | 12⅝ | |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5⅛—5⅜ | 4 3 9 | Feb, Aug | .. | |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | – | 4 1 1 | Feb, Aug | .. | |
| 10 | 5/0 | India Rubber, Gutta Percha, &c., Wrks. | 16—17 | 2 18 9 | Feb, Aug | 16⅝ | |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99—102 | 8 18 5 | Mar, Sept | .. | |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¼—11¾ | 4 5 1 | Mar, Sept | .. | |
| 12 | 12/0 | Telegraph Construction & Mainten'ce. | 32—34 | 5 5 10 | Mar, July | 32 | |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 102—104 | 3 16 11 | Jan, July | 103 | |
| 5 | – | Willans and Robinson Ord. | 1½—2 | – | Apr, Oct | .. | |
| 5 | – | Do. 6 per Cent. Cum. Pref. | 2½—3½ | – | Apr, Oct | .. | |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 85—90 | 4 8 11 | May Nov | .. | |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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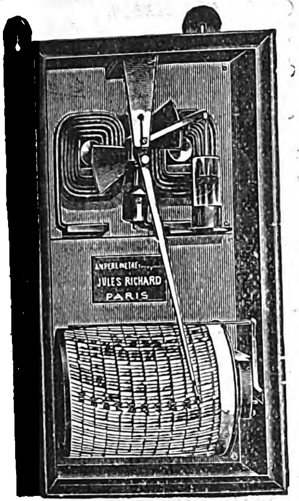

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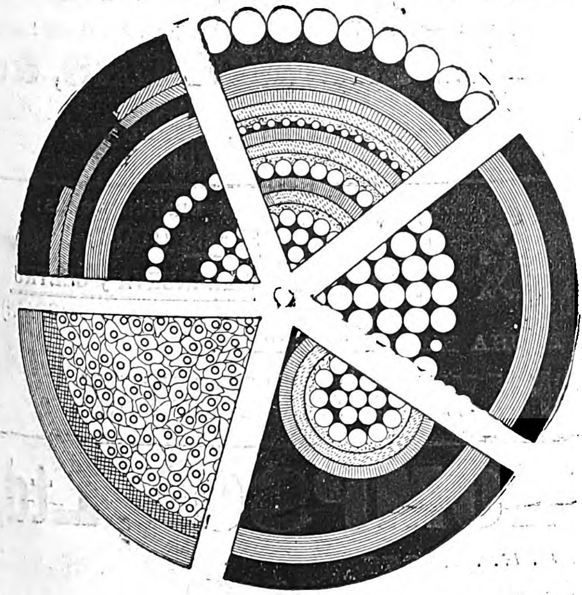

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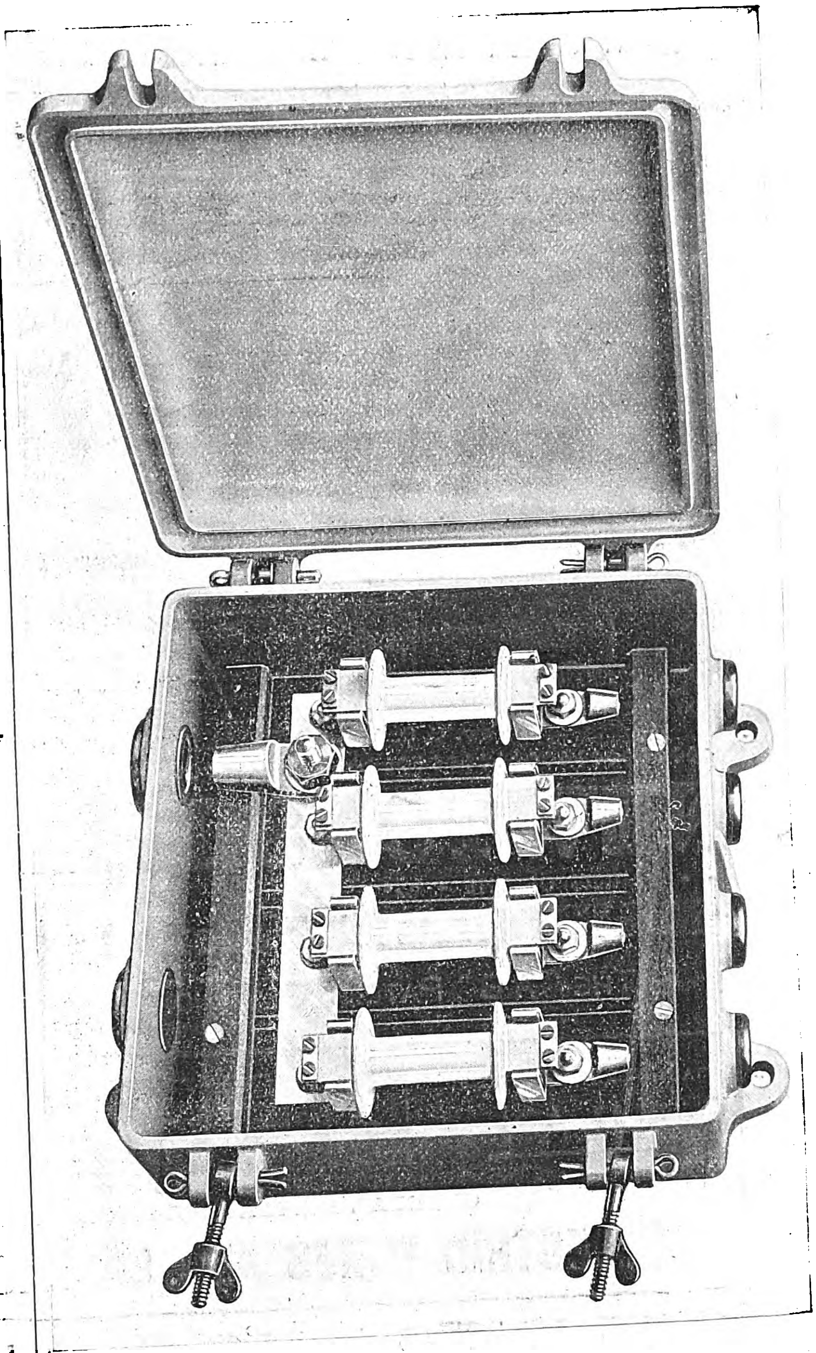

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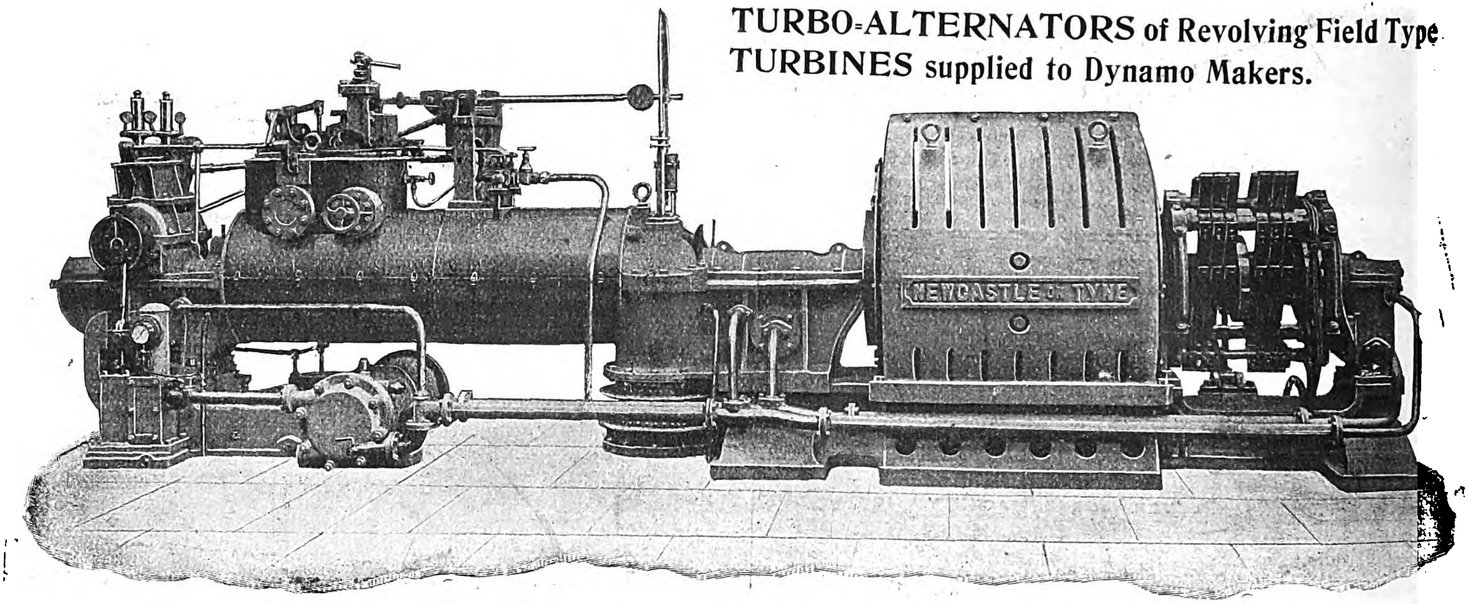

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## SALE BY AUCTION.

MESSRS. HORNE & CO., 8, Delahay-street, Storey's Gate, Westminster, S.W., will SELL by PUBLIC AUCTION at the Royal Arsenal, Woolwich, on TUESDAY, 19th December, 1905, by order of the Secretary of State for War, at 11 o'clock in the forenoon precisely, the following **UNSERVICEABLE** and **OBSOLETE STORES, &c.:**—2 tons Ashes (Lead); 217 tons Iron, Wrought, Cast and Steel (old); 49 tons Brass (C.M.G., C.M.B. and miscellaneous); 3 tons Copper; 12 tons Gunmetal; 7½ tons Mixed Metal; 15 tons Lead; Phosphor Bronze; Aluminium; 12 tons Manganese; Bronze Turnings; 5 tons Cupro Nickel and Lead; Pewter; Tin; 11½ tons Zinc Cylinders; White Metal; Tinplate; Machinery; three Lathes, centre; one Ring Press; two Milling Machines; 1,000 Fenders (cast-iron); 150 Axletrees; 33 Iron Grapnels; Bedsteads; 80 Anchors; Electric Cable and Lamps; three Levels (Telescope); 50 bags Bullion; Filters and Parts; Instruments (Telegraph); Diving Helmets; Tools; Luting; Canisters and Cases; Tinplate; Jute; Rope; Animal Charcoal; Canvas; Paper; Waterproof Sheeting and Material; Saddle Covers; Indiarubber; Leather (Cuttings, Hosepipes, Miscellaneous, &c.); 3,000 Bed Straps; Harness; 1,027 Neck Collars; Mule Harness; three 12-ton Sling Wagons and Limbers; ten Horse Drugs; Wagon Poles; Shafts; 104 Wheels of Sorts; Boxes; Casks; Barrels; Wood, &c., &c., &c. The Lots may be viewed at the Royal Arsenal, Woolwich, from 10 to 1 o'clock and from 2 to 4:30 o'clock on the Friday and Monday previous to and on the morning of the Sale. Catalogues may be obtained at the War Office, Pall Mall; at the Ordnance Office, Tower; and at the Ordnance Office, Royal Arsenal, Woolwich.

## MISCELLANEOUS PLANT, &c., WANTED.

WANTED, 20 kw. ALTERNATING SET, 100 periods, 2,000 volts, fixed armature.—J. G. CHILDS & CO., LTD., Willesden Green, London, N.W.

WANTED, a small ELECTRICAL PLANT for lighting. Secondhand would do if in thoroughly satisfactory condition. The light required would be 80 16 candle-power lights.—Write, H.A., care of Bates, Hendy & Co., 81, Cannon-street, London, E.C.

OLD IRON, STEEL and METAL, also old ELECTRICAL MACHINERY and PLANT purchased for cash.—Apply to SAMUEL ISAACS & SONS, Phœnix Iron Wharves, 50-52, Bankside, London, S.E.

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## MISCELLANEOUS PLANT, &c., FOR SALE.

ELECTRIC LIGHT GENERATING PLANTS: One, Engines by Ruston & Proctor, compound, 10 by 17 by 24, and dynamos by Crompton, 380 amperes by 110 volts by 880 revs.; also two 100 kw. sets, Belliss & Morcom triple-expansion engines, and Mather & Platt dynamos; SELL CHEAP to save second removal.—Particulars of WHITE BROS., Engineers, Stratford, London.

PLANT FOR SALE.— Westinghouse 10 H.P. Gas Engine, 6 kw. Dynamo, 55 13-plate Hart Accumulators and Switchboard, with automatic cut in and out. To be seen Devonshire.—Apply, COX & KING, 5, Suffolk-street, Pall Mall, London, S.W.

WESTINGHOUSE COMPOUND ENGINE and GENERATOR combined; cost £525; almost new; will accept £325 for quick sale.—ARTHUR M. WILD, 13, High-street, Sheffield.

FOR SALE.—Three Siemens-Browett Lindley ARC LIGHTING SETS, 10 amperes, 1,500 volts. In good condition.—Apply, BOROUGH ELECTRICAL ENGINEER, Ful.-street, Derby.

ACCUMULATORS.—57 Cells in Glass Boxes, 50 ampere-hour capacity, in good working order.—SPENSER & CO., Stratford-on-Avon.

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## METROPOLITAN BOROUGH OF ISLINGTON.

ELECTRICITY DEPARTMENT.

**PURIFICATION OF WATER.**

The Council invite SUGGESTIONS from chemists and others, particularly those expert in the purification of water for boiler feed purposes, as to the best means of eliminating injurious salts and other matter from the water obtained from an Artesian well. The Council do not bind themselves to accept any of the suggestions which may be offered, and will require from three to six months' free trial as to the efficiency of any apparatus before incurring liability in respect of it.

Full particulars and analysis or samples of water may be obtained on application to the Electrical Engineer, 50, Eden-grove, Holloway, N., on or before JANUARY 1st, 1906.

By order,
WM. F. DEWEY, Town Clerk.

Town, Hall, Upper-street, N.,
4th December, 1905.

## BUSINESS FOR DISPOSAL.

GENERAL Ironmongery. Electrical and Gas Contractors' Business, Surrey; good connection; stock, plant and Fixtures about £750; turnover £3,000; net profit £600. Valuable LEASE may be PURCHASED by arrangement; investigation invited; owner retiring.—Apply, SHEPHERD & HAWARD, 369, Birkbeck Bank Chambers, Holborn, London, W.C. Fo. 1985.

ELECTRICAL BUSINESS.—Retail shop in busy street FOR SALE.—Address 5974, *Electrician* Office, Salisbury-court, Fleet-street, London.

## TENDERS INVITED.

## COUNTY BOROUGH OF GRIMSBY.

ELECTRICITY DEPARTMENT.

The Grimsby Corporation are prepared to receive TENDERS for **PLANT, BUILDINGS AND CABLES** to the following Specifications:—

| | |
|---|---|
| Specification No. 35. | ENGINE and DYNAMO, 500kw. Continuous-current Dynamo d.c. to High-speed Double-acting Engine. |
| Specification No. 36. | WATER-TUBE BOILER & UNDERFEED STOKERS. |
| Specification No. 37. | EXTENSION of SWITCHBOARD. |
| Specification No. 38. | Condensing PLANT, Surface Type. |
| Specification No. 39. | BUILDINGS—Bills of Quantities for Extension of Engine Room, New Coal Bunkers and New Store. |
| Specification No 43. | PIPEWORK. |
| Specification No. 44. | COAL CONVEYING PLANT—Two Scraper Conveyors and One Elevator. |
| Specification No. 45. | SUPPLY of CABLES (Lead Covered Paper Insulated). |

A Pamphlet, giving full particulars of the above, will be sent to any firm on receipt of a stamped addressed foolscap envelope.

Copies of the respective Specifications, General Conditions, and Drawings (if any) can be obtained from the undersigned on payment of a deposit of One Guinea on each Specification, which will be returned upon receipt of a bona fide Tender. Extra copies of the Specifications may be purchased at 2s. 6d. each, except Specification No. 39, Bill of Quantities, which may be purchased at 5s. each, extra copies of Drawings, 2s. 6d. each.

Tenders on the prescribed form, in sealed envelopes, must be delivered to the undersigned not later than the first post FRIDAY, January 5th, 1906.

W. A. VIGNOLES, Borough Electrical Engineer.

Corporation Electricity Works,
Grimsby, December 7th, 1905.

**TENDERS INVITED** continued on next page.

**Royal Doulton Potteries.**

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## TENDERS INVITED—*continued.*

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**ELECTRICITY DEPARTMENT.**

The Electricity Committee of the Manchester Corporation invite TENDERS for the Supply, Delivery and Erection of the following:—

(*a*) One Group of THREE SINGLE-PHASE TRANSFORMERS of 200 kw each, constituting one complete 600 kw. Three-phase Transformer.

(*b*) HIGH and LOW-TENSION SWITCHBOARDS for Three-phase Transformer Sub-station.

Specifications, Drawings and Forms of Tender may be obtained from Mr. F. E. Hughes, Secretary, Electricity Department, Town Hall, Manchester, on payment of a fee of One Guinea for each Specification, which amount will be refunded on receipt of a bona fide Tender.

Tenders, duly endorsed and addressed to the Chairman of the Electricity Committee, must be delivered at the Town Hall not later than TUESDAY, the 19th instant.

The Corporation do not bind themselves to accept the lowest or any Tender.

Town Hall, Manchester,
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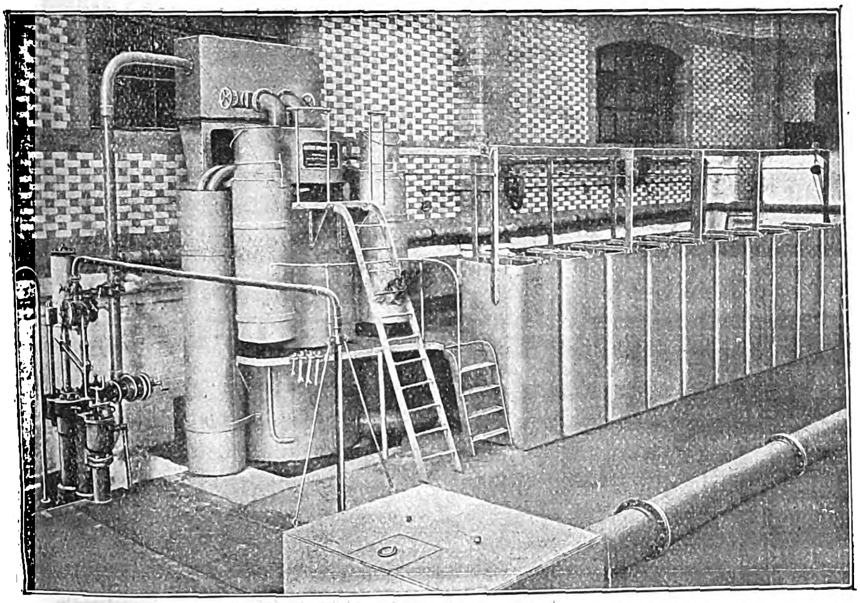

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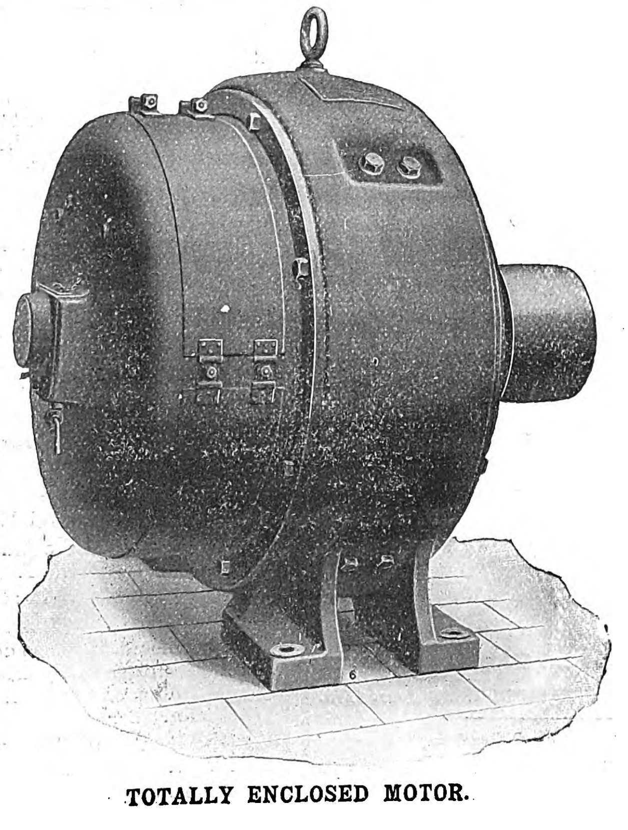

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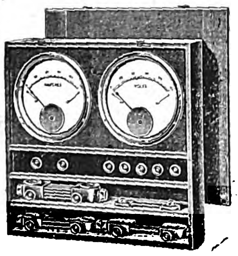

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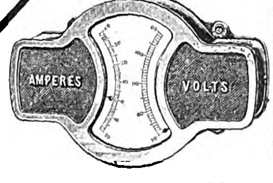

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"Report on Standard Locomotives for Indian Railways." By the Locomotive Committee of the Engineering Standards Committee. Second issue revised. 10s. 6d.

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# THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,438. [No. 8. Vol. LVI.] FRIDAY, DECEMBER 8, 1905. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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## NOTES.

THE Paper read last night by Mr. W. H. PATCHELL at the Institution of Electrical Engineers contained full and interesting details of the Charing Cross Company's City of London works at Bow, close to the Great Eastern Railway main line. Mr. PATCHELL has only just returned from a journey to America, and in consequence the proofs of the Paper only come to hand from the Institution just as we are going to press. For the benefit of those of our readers who could not attend the meeting we give a résumé of the principal contents.

◆

THE pressure of 10,000 volts three-phase was chosen for the transmission mainly on account of its being the highest voltage which could be generated without the use of step-up transformers, the absence of which caused a great saving in switchgear. Plans of the arrangement of the station are included in the Paper. Two sizes of units were first adopted, slow-speed Sulzer engines having been preferred for the larger sets and Belliss high-speed engines for the small sets. Mr. PATCHELL drew attention to the method of firing the larger boilers, which have two separate grates, only one of which is used at light loads, the other being rapidly fired up in case of sudden demands caused by fogs, &c. Full details were given of the new 4,000 kw. sets with vertical Sulzer engines, and particularly clear drawings are contained in the Paper of the Lahmeyer 1,600 kw. and 4,000 kw. alternators. Referring to Mr. J. S. HIGHFIELD'S discovery of the formation of nitric acid in high-tension machines (see *The Electrician*, Vol. LIV., p. 573), Mr. PATCHELL stated that a careful examination had failed to reveal any signs of this phenomenon, and he expressed the opinion that the acid is due to impurity in the insulating materials rather than the action of ozone.

◆

IN view of the rapidly-increasing adoption of turbo-generators, these 4,000 kw. machines are interesting as being probably likely to remain the largest machines of the slow-speed type in this country. Mr. PATCHELL alluded to steam turbines as a fashion: this is all he said about them. Passing on to the trunk mains, Mr. PATCHELL said that at the time the cables were ordered, some uncertainty existed as to whether the Board of Trade high-tension regulations applied to extra high-tension, and therefore ½ in. insulation was provided between conductors and between conductors and earth, the latter so that the cables could be worked either with the middle point of the generators earthed or unearthed as might be found most desirable. The author does not, however, regret the extra paper, as out of over 70 miles of cable there has been so far only one fault. One or two small induction motor-generators are used in each sub-station in addition to the synchronous sets, as starting up is thereby facilitated, and the advantage of the better power factor of synchronous machines is retained. After giving some curves of coal consumption since the starting to work of the plant in May, 1902, the Paper concluded with an account of the spark-gap protective devices in use on the system, which are the modified horn type. It is interesting to note that a reliable substitute has not been found for the liquid resistances used in connection with these, and the author invites manufacturers to give attention to the production of a high resistance of small bulk which can be relied on under working conditions. Altogether the Paper is an admirable example of a clear and well-arranged description of a generating system. The adjournment of the discussion until next week will give those who are interested in the subject an opportunity of studying the Paper, and we may look forward to an interesting and instructive discussion of a practical nature.

◆

We conclude the publication of Col. Holden's Institution Paper this week. It was universally agreed in the tea-room after the meeting that, although the Holden magnetic clutch is a good thing, there was too frequent reference to it in the Paper. Excepting for this perhaps pardonable defect, however, this contribution to the literature on the subject of works driving was a valuable one, and we regret that the discussion upon it was so poor. Had the Paper been read at one of the local sections in the north it would, we feel sure, have been accorded a debate. Not the least interesting part of the Paper were the parenthetical remarks of the author as to the magnitude of the saving and increased speed which resulted from electric driving, and we trust that these will be added when the Paper is printed in the *Journal* of the Institution. The poorness of the discussion may possibly be due to the lateness of the advance proofs; these were only in the hands of members on the day preceding the meeting, and it is to be regretted that, in spite of the delay in preparing them, so many of Col. Holden's interesting facts were omitted.

◆

Mr. Potter's Paper on electric railway equipment is a highly-compressed statement of practical experience of equipments under severe conditions and the lessons in design and working practice to be drawn therefrom. Sparking from uneven wear of copper and mica commutator segments is a rare trouble nowadays on this side, and the remedy suggested by Mr. Potter strikes one as being dangerous. Probably the use of a softer quality of mica would be advantageous, but from the remark as to the larger number of commutator segments now used it seems likely that manufacturers have been driven to the use of thinner mica of harder kinds, such as Indian mica. The suggestion of using a cooling fan to assist the ventilation of traction motors is highly significant of the near approach to the practical limits of the power that can be applied to a standard gauge axle within the usual wheel heights. The space in locomotives is not so severely limited, and it would seem practicable and more economical to make the motor do its own fanning in every case.

◆

Armature bindings are often a source of trouble, but we believe that it is the bindings over the end windings that fail most frequently in English practice. Certain manufacturers have found where *not* to put these bindings, and with greater care in the selection of wire and better workmanship generally the frequency of such faults has greatly diminished. In the United States it would seem that every advance in design leads to demands for greater power, higher speeds and more severe conditions of operation generally, and motors are consequently run much closer up to their limit of endurance than is the case here.

◆

The reference to circuit-breakers for "1,000 amperes or more" is an illustration of this tendency, and the preference for fuses of such high capacity suggests that the trouble must be a very real one, as it is not a light matter to put the replacement of fuses upon a driver. The diagrams of test runs with the great New York Central locomotives (described in *The Electrician*, Vol. LIV., p. 384) hauling a train are well worthy of study. The technical Americanese of the whole Paper is a development which we trust will not be extensively copied here, though it has some virtues.

◆

Attention may usefully be given to Mr. Threlfall's Presidential Address to the Birmingham Section of the Institution of Electrical Engineers the publication of which we conclude this week. The discourse seems to us to be of unusual merit, and in spite of its rather formidable length is eminently readable. It is fortunate that the work of Ludwig on the formation of a non-conducting carbon or carbon glass—vitreous diamond in fact—should be lifted from an undeserved obscurity, and the author's own speculations on the relations which govern the transition of one form of crystalline carbon to another form are certainly suggestive. His discussion of the possible ionisation of carbon necessary for the device of a carbon cell is good and clear, and his plain-spoken condemnation of the tedious, barren theses put forward under the guise of electro-chemistry, useless in themselves and overwhelming the would-be inquirer by their number and prolixity, is a welcome change from the solemn acceptance and decorous praise which has been bestowed on much laborious rubbish. The whole address is full of good things, and it is a pleasant duty to commend it to our readers in its entirety.

◆

The article which we publish this week on the electricity supply question in Paris discloses a peculiar condition of affairs. Apparently, the municipality of Paris has always held the monopoly of electricity supply, and the practice has been to let it to the highest bidder. The concessions granted to the six companies are all expiring shortly, and the municipality has been recommended to do a fresh deal with a new company. There is no Provisional Order with a 42-years' purchase clause as in the case of the companies in London; still more onerous conditions are to be imposed on the company. It will have to pay to the City funds 8 per cent. of its gross receipts for the sale of current and 45 per cent. of its net profits, the *minimum* payment being fixed at £160,000, until the year 1938, when the whole system will pass into the hands of the municipality without payment. No wonder the tariff charged to consumers is high; the only wonder is that any company could be found to undertake to work the electricity supply monopoly on such terms. Fortunately, such a condition of affairs would be impossible under our own Electric Lighting Acts, imperfect as they are.

◆

It is impossible not to admire the ingenuity and perseverance shown by MM. Rougé and Faget in evolving from the crude arrangements of earlier inventors the highly-developed converter with rotating brushes which is described by Dr. C. V. Drysdale elsewhere in this issue. The "permutator," as the new converter is called, offers a number of advantages in the way of compactness, cheapness and ease of starting, but these properties are unfortunately only gained by the adoption of rotating brushes. This is evidently a drawback, and one which will seriously handicap the invention as a competitor with the rotary converter. Not only is it impossible to inspect and replace the brushes while the machine is running, but the loud buzzing noise produced by the rapidly rotating brush gear is anything but agreeable. The absence of automatic lubrication, mentioned as a further disadvantage by Dr. DRYSDALE, ought to be easy of rectification, even if the vertical shaft is retained for the purpose of economising in floor space. Altogether it is not likely that "permutators" will oust rotary converters and motor-generators in plants of any considerable size, but there seems an opening for this kind of apparatus for small plants where cheapness and compactness are essential, and where the objections referred to above are not of such great moment.

### Cable Interruptions and Repairs.

| | Date of Interruption. | | Date of Repair. |
|---|---|---|---|
| Tarifa—Tangier ............ | Jan. 18, 1904 | .. | — |
| Jamaica—Colon ............ | Jan. 10, 1905 | .. | — |
| Cadiz—Teneriffe............ | July 20, 1905 | .. | — |
| Tangier—Cadiz ............ | Oct. 30, 1905 | .. | Dec. 1, 1905 |

**Supply Interruption at Battersea.**—With reference to our note with this heading in our last issue, Mr. W. A. Kemm, the chief electrical engineer to the Battersea Borough Council, writes to inform us that no interruption has occurred on his system since the accident on October 14th, which was duly recorded at the time. We much regret our error and hasten to rectify it.

**International Telephony.**—The Rome correspondent of the *Daily Mail* states that the new telephone between Rome and Paris will be opened early next year.

According to a Reuter telegram, the Roumanian Postmaster-General with his staff was present last Friday at the official opening of the telephone line connecting Bucharest and Budapest.

**A Large Bequest to Owen's College, Manchester.**—The will of the late Mr. John Edward Taylor, of 20, Kensington Palace-gardens, London, who was the principal proprietor of the *Manchester Guardian*, contains a number of legacies to public institutions. Amongst these the sum of £20,000 is bequeathed to Owen's College, Manchester, which is to be paid after the death of Mrs. Taylor.

**London Electrical Contractors' Association.**—A meeting has been arranged for Tuesday next, the 12th inst., at eight o'clock, at Frascati's Restaurant, Oxford-street, when a Paper will be read on the comparative cost of the electric and gas lighting. Mr. Alger, of Newport, the author of the Paper, has gone very carefully into the comparative costs of the two systems, and it is anticipated that the Paper will prove of great interest to electrical engineers.

**Electric Locomotives on the District Railway.**—The new electric locomotives for hauling the London & North-Western trains on the District Company's system, which were described in our issue of November 17th (p. 178), have now been put into service. We hope that the disappearance of steam traffic on this part of the line will remove the chief cause of delay and that the much-needed acceleration of service will soon become an accomplished fact. The improvement in starting, compared with the steam locomotives is very noticeable by the smart way in which these trains now get away from the platforms.

**The Benjamin Franklin Centenary.**—The centenary of the birth of Benjamin Franklin, January 17, 1906, is to be celebrated with much distinction in the United States. Owing to the number of functions on hand for the evening of that day the New York Electrical Society, the oldest electrical society in America, has decided to hold its "Franklin Night" on the 16th. Mr. Marconi, who had engaged to lecture before the Society in January, has expressed his desire to render his tribute to the memory of the great electrical inventor, and his address has, therefore, been fixed for that evening.

**Patent Amendment.**—According to a notice in the *Illustrated Official Journal* (*Patents*) of November 29th Messrs. Sydney Evershed and Evershed & Vignoles seek leave to amend their patent specification No. 5,492 of 1903, granted to them for "Improvements in apparatus for measuring electric resistances." This patent covers important features in the design of the firm's well-known "Megger" for measuring insulation resistance. The reasons alleged by the patentees for amending the specification referred to is that they have been advised that the original claims are too wide, and it is now proposed to strike out three of them.

**Royal Institution.**—The following are among the arrangements which have been made with regard to lectures at the Royal Institution before Easter: Prof. B. Hopkinson will deliver three lectures on "Internal Combustion Engines" (with experimental illustrations). The Friday evening meetings will commence on January 19th, when Prof. J. J. Thomson will deliver a discourse on "Some Applications of the Theory of Electric Discharge to Spectroscopy"; and among the succeeding Friday evening discourses that have been arranged are lectures by Prof. S. P. Thompson, Mr. W. C. D. Whetham and Prof. P. Zeeman.

**Exhibition of Optical and Physical Apparatus.**—The Physical Society has arranged for an exhibition of electrical, optical and other physical apparatus to be held at the Royal College of Science, Exhibition-road, South Kensington, on Friday, December 15th between 7 and 10 p.m. Invitations have been issued to Members of the Institution of Electrical Engineers, the Röntgen Society, the Optical Society and the Faraday Society.

Apparatus will be shown by the following firms: R. & J. Beck, Cambridge Scientific Instrument Co., Crompton & Co., Elliott Bros.; Everett, Edgcumbe & Co., Peter Heele, A. Hilger, Marconi's Wireless Telegraph Co., Nalder Bros. & Thompson, Newton & Co., Robert W. Paul, James Pitkin & Co., Messrs. Rumney & Rumney and Messrs. Carl Zeiss.

**Iron and Steel Institute.**—The Council of the Iron and Steel Institute have arranged that the Annual General Meeting of the Institute shall be held in London on May 10 and 11, 1906. In place of the usual autumn meeting, a joint meeting with the American Institute of Mining Engineers will be held in London on July 23rd to 28th. It is intended during the week following to give the American visitors an opportunity of seeing some of the ironmaking districts. It is anticipated that the visiting party will include many of the leading ironmasters who entertained the Iron and Steel Institute in America in 1890 and 1904. The Lord Mayor of London has kindly consented to act as chairman of the London Reception Committee, and to give an evening reception at the Mansion House.

**Engineering Standards Committee.**—We have received a copy of the second issue of the Report of the Locomotive Committee of the Engineering Standards Committee on standard locomotives for Indian railways. The first issue of this report was made in November, 1903. Since its publication the first standard engines have actually been built, and in the light of the experience obtained from them, certain revisions have been found necessary in the report. The present re-issue embodies the necessary alterations. The committee have also been requested by the Secretary of State for India to consider the advisability of standardising three more types of locomotives of a heavier class than those dealt with in this report, and they are now giving their consideration to this request.

**Olympia Exhibition Souvenir.**—An interesting item in the programme of the next Electro-Harmonic Smoking Concert will be the presentation of souvenirs to the members of the Electrical Exhibition Executive Committee. The success of the show at Olympia was largely due to the good work of Mr. Cunliffe Owen and his committee, and the exhibitors, desiring to express their thanks and appreciation, have chosen this method. Mr. John Gavey, C.B., president of the Institution of Electrical Engineers, has consented to make the presentation. The concert will be held at the King's Hall, Holborn Restaurant, on Friday, the 15th inst. It begins at 8 p.m., and the presentation will take place during the interval. Tickets of admission to the concert have been furnished to all contributors, through the courtesy of the Electro-Harmonic Society.

**Borough Polytechnic.**—On Monday evening the annual prize and certificate distribution to the students at the Borough Polytechnic took place at the Institute, Mr. J. L. Spicer presided, and Sir Norman Lockyer and Lady Lockyer were present.

> From the report of the Principal it appears that the accommodation afforded in the Institute is insufficient for the growing needs of the district, the total number of applications being nearly four hundred more than in the previous year. The greatest increase of applications was as regards the science classes. The percentage of passes in the examinations were slightly higher than in the previous year.

Sir Norman Lockyer then made a short speech, in which he stated that the best education was to teach us how to think, to observe and to use our hands, eyes and brains. Lady Lockyer afterwards presented the prizes and certificates.

**Electricity and Fire Risk.**—In view of the frequent cases in which fires are popularly attributed to, "the fusing of an electric wire" and similar causes, the following figures, quoted by the *Electrical Review* of New York, will be of interest. In the city of Worcester, Mass., during a period of 12 months, there were 943 alarms, only 15 of which—that is, less than 1·6 per cent.—were due to electrical causes; of the remainder 23 were caused by the misuse of illuminating gas and 71 by accidents with oil lamps. Of the 23 electrical fires only two were due to defective electric light wires, four to "burning out" of motors, and the remaining nine to trolley-wire troubles. We think this last figure somewhat high, but the very small number due to faulty lighting circuits should certainly reassure those who are timid in this direction.

**Wireless Telegraph Notes.**—We have received the following communication from the Gesellschaft für Drahtlose Telegraphie:

> The notice which has appeared in various newspapers that the Mexican Government has adopted the Marconi system is perhaps based on the fact that representatives of Mr. Marconi have been to Mexico and have submitted to the Government a proposal for the erection of several stations on their system. The Mexican Government have, however, decided in favour of the "Telefunken" system, and have placed with our company an order to install stations for the establishment of a wireless connection between Mazatlan (Sinaloa) and San Jose del Cabo, the distance between these two points being about 325 km. At the request of the Government, the stations in question are arranged for different wave-lengths, as they are designed not only for intercommunication with each other, but also with moving ships. Wireless telegraph stations were installed on the "Telefunken" system in Rosalia and Guaymas already in the year 1902, and since that time the Mexican Government has practically tested our system, and has, furthermore, trained a staff of operators, in consequence of which the erection of a large number of stations on this system can confidently be expected.

**Obituary.**—The death of Sir Clinton Dawkins, K.C.B., last week at an early age recalls the proceedings that were indirectly responsible for the appointment of the Royal Commission on London traffic. In 1902, when Messrs. Morgan and Mr. Yerkes were in competition for tube railway routes in London, Mr. Clinton Dawkins (as he then was), as the English manager and partner in the firm of Messrs. Morgan, gave evidence before Lord Windsor's Committee of the House of Lords, which considered a large number of tube railway bills that had been introduced into Parliament that year. By offering a direct guarantee that the capital for a tube railway from Hammersmith to the City and the north-east of London, amounting to some £16,000,000, would be forthcoming, Mr. Dawkins, on behalf of his firm, secured the consent of Lord Windsor's Committee to his Bill in the face of opposition from Mr. Yerkes. At that time an alliance had been formed with the London United Tramways Co., which eventually broke down, and the Bill was withdrawn. It was partly in consequence of this that the Royal Commission on London traffic was appointed. Sir Clinton was also a director of the Electric Traction Construction and Equipment Co.

**Electrical Enterprise in China.**—An investigation has recently been made by an agent of the United States Government on the field which China offers for the development of electrical enterprise. The consular report issued, after calling attention to the fact that a few British, Japanese and German firms are already to some extent at work in China, points out that agencies for American firms are mostly wanting, and continues by giving a few details of such work as has already been accomplished. Two British and three German firms appear to be established in Shanghai, but none of these are doing a large business, and in some cases they only adopt electrical contracting as a small adjunct to business in other directions. Electric light stations are at work in Tientsin, Shanghai, Canton, Hong Kong and Pekin, and are in progress at other places. Some of these are said to be paying well, and electric tramways are being started in most of these towns. Enterprises are much handicapped by the lack of firms carrying a stock of electrical supplies. A good deal of uncertainty exists as to the attitude of the authorities towards new electrical schemes, but it is believed that no serious obstacles will in the future be placed in the way of new proposals for electrical construction if such can be shown to be advantageous to the various municipalities.

**Royal Society.**—The anniversary meeting of the Royal Society was held at Burlington House on Thursday last week. The retiring president, Sir William Huggins, was in the chair.

> The annual report of the Council after referring to other matters, stated that the first international convention in connection with the Society's catalogue of scientific Papers and the international catalogue of scientific literature assembled in the rooms of the Royal Society on July 25th and 26th. Nineteen delegates, representing 14 countries were present. India had one representative, Italy and Belgium had two and the United Kingdom had three delegates. The delegates decided unanimously that it was imperative to continue the publication of the catalogue for at least a further five years and that a sum not exceeding £2,000 (exclusive of the director's salary) should be spent annually for carrying on the work of the Central Bureau. The report also referred to the work of the National Physical Laboratory. It was pointed out that the receipts for instruments tested and experiments undertaken at the Laboratory had increased from £4,000 in 1903 to nearly £6,000 in 1904. The Government had raised its grant to £5,500, and there was a prospect of a further £500. The Government had also made a grant of £5,000 for buildings during the present year, and had intimated that for the next four or five years it might be able to provide a similar amount. An anonymous donation of £2,000 had also been made last year for further equipment.

Sir William Huggins then delivered a brief address, and the Society's medals, the award of which was announced in our issue of November 10th, were distributed. The council previously nominated, a list of which was published in our issue of November 10th, was then formally elected.

**Personal.**—On Friday, the 24th ult., Mr. R. Heywood Claxton, who is retiring from the position of Superintendent of the North-Western Province of the National Telephone Co., which he has held since May, 1893, was entertained at dinner by his old colleages at the "Trocadero" Restaurant, and presented with a handsome silver tray. Mr. Claxton was in many ways one of the pioneers of the telephone movement in this country, and has been actively engaged in telephone work for upwards of 26 years, a period covering almost the whole of the development of the telephone industry in the United Kingdom. The Liverpool system was inaugurated by him in 1879 and the first multiple switchboard in Europe was installed at the same place in 1884 under his auspices. Amongst other telephone enterprises owing their inception to his labours was the laying of the first dry-core paper cable, through the Mersey tunnel. It is interesting to note that Mr. Claxton was the first to employ female exchange operators, who at the present time number some 7,500. The growth of the Province which was under his management to its present proportions, comprising over 58,000 telephones and a staff of about 2,300, must have been in many ways a unique experience. Mr. Claxton is well known in the Liverpool district, and, on his retirement, has been made a member of the Lancashire and Cheshire Local Board of the National Telephone Co.

**American Inventors and German Patent Law.**—The *Electrical World* of New York publishes an article dealing with the treatment which American inventors receive from the German Imperial Patent Office. This question is one about which feeling appears to run high in the United States. Dr. Alfred Müller, who is well known in New York in connection with patent law, entered into correspondence some months ago with the authorities of the German Patent Department with a view to removing some of the difficulties which have arisen. The reply obtained from President Hauss points out that some of the complaints of unfair treatment of American inventors are exaggerated, and gives statistics to show that the percentage of patents granted in the case of American applications is actually higher than to applications of German origin. Much of the difficulty and delay complained of appears really to be due to the differences in procedure under American and German law. American inventors, he writes, in many cases prepare their applications in a form suitable to be dealt with under the laws of their own country to which they are accustomed, and extensive alterations and rearrangement of claims are necessary to conform with German practice. The definition of what really constitutes a new invention is also much stricter in Germany. We are afraid that the official expression of the German point of view has by no means satisfied the Americans, and that the difficulties are not as yet explained away.

**Neepsend Electricity Works of the Sheffield Corporation.**—Mr. S. E. Fedden, the engineer and manager of the Sheffield Corporation Electricity Department, has sent us at our request the following information relating to the working of the new power station at Neepsend during the last 12 months. Recently this station has been used to its full capacity (3,000 kw.) during the period of heaviest demand in the evening, the surplus being taken up by the plant at the old Sheaf-street station which runs in parallel with it when required. The tests and particulars of the plant, together with the results taken over a period of 10 weeks running, were quoted in our issue for March 10, 1905. The machines, we are informed, have given satisfaction in working and been very free from failure of any kind.

COSTS AT NEEPSEND STATION AVERAGED OVER A PERIOD OF 12 MONTHS.

*From week ending Nov.* 20, 1904, *to week ending Nov.* 12, 1905.

| | | |
|---|---|---|
| Units generated | | 4,039,020 |
| Working hours (six 16-hour days per week) | | 4,992 |
| Coal consumed | Tons | 6,310 |
| „ Cost | | £1,787. 16s. 8d. |
| „ Cost per unit | | 0·1062d. |
| Water consumed per kilowatt | lb. | 22·55 |
| Water (make up), 819,000 gallons at 6d. per 1,000 | | £20. 9s. 6d. |
| „ cost per unit | | 0·0012d. |
| Oil, waste and stores | | £45. 13s. 6d. |
| „ „ cost per unit | | 0·0027d. |
| Salaries and wages | | £1,301. 0s. 8d. |
| „ „ cost per unit | | 0·077d. |
| Light and power for auxiliaries, at 0·5d. per unit | | £1,124. 3s. 0d. |
| „ „ „ cost per unit | | 0·066d. |
| Total works cost | | £4,279. 3s. 4d. |
| „ „ per unit | | 0·25d. |

**The Accident at Charing Cross Station.**—With regard to the collapse of the roof of Charing Cross Station on Tuesday, Sir Benjamin Baker has authorised the statement to be published that the collapse was due to the breakage of a tie bar, and that the cause could in no possible way be connected with the tunnelling of the Baker Street and Waterloo Railway, as has been suggested in some quarters. When the roof collapsed the four trunk mains leading from the London Electric Supply Corpn.'s generating station at Deptford were carried away and broken when the supporting wall fell. The "Sparklet" fuses on these mains at Deptford blew in quick succession. It is interesting to note that in the illustration in the *Daily Mirror* of the wreckage on one side of the bridge the London Electric Supply Corpn.'s mains are seen prominently in the foreground. It may be mentioned that the cables in question were the old iron-encased Ferranti mains, which are still in regular operation. Fortunately at 3:40 p.m., the time of the accident, each of the West End sub-stations were being supplied through two 0·25 sq. in. cables along a new route over Westminster Bridge, completed 18 months ago, and the mains over Hungerford Bridge were merely connected up as a stand by and for supplying some less important circuits on the south side of the river. These latter circuits were soon switched over, so that there was practically no interruption of any sort. The two mains in question are just heavy enough for the supply to be maintained temporarily, but Mr. Partridge, the company's engineer-in-chief, is losing no time in laying two additional cables over the new route, and he expects to have these in operation temporarily next week. Incidentally it may be mentioned that the Electrical Engineers (Royal Engineers) Volunteer Corps did good service after the accident by bringing two of their large searchlights to bear on the scene, which helped considerably the removal of the wreckage.

## ARRANGEMENTS FOR THE WEEK.

**SATURDAY, December 9th.**

INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.

*11:30 a.m.* Visit to the Bow Central Station, Marshgate-lane, E. Meet at the works.

BIRMINGHAM AND DISTRICT ELECTRIC CLUB.

*7:30 p.m.* Annual General Meeting at the Colonnade Hotel, New-street, Birmingham.

**MONDAY, December 11th.**

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture III.:—"The Measurement of High-Frequency Currents and Electric Waves," by Dr. J. A. Fleming, F.R.S.

**TUESDAY, December 12th.**

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER LOCAL SECTION.

*7:30 p.m.* Meeting at the Manchester University. Paper to be read: "Street Lighting," by Haydn Harrison.

INSTITUTION OF ELECTRICAL ENGINEERS: NEWCASTLE LOCAL SECTION.

*8 p.m.* Meeting in the Armstrong College of Science, Newcastle-on-Tyne, when the following Paper will be read: "Testing of Motors," by T. Carter.

INSTITUTION OF ELECTRICAL ENGINEERS: GLASGOW LOCAL SECTION.

*8 p.m.* Meeting at 207, Bath-street, Glasgow. Paper to be read: "Recent Advances in Wireless Telegraphy," by J. Erskine-Murray

LONDON ELECTRICAL CONTRACTORS' ASSOCIATION.

*8 p.m.* Meeting at Frascati's Restaurant, Oxford-street, when a Paper on "Gas *v.* Electric Lighting" will be read by Mr. Alger, of Newport.

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be further discussed: "The Steam Turbine," by the Hon. C. A. Parsons, F.R.S., and G. G. Stoney.

NOTTINGHAM GUILD OF MECHANICAL AND ELECTRICAL ENGINEERS.

*8 p.m.* Meeting at the Welbeck Hotel, Milton-street, Nottingham. Paper to be read: "Electric Cables," by G. Preece.

FARADAY SOCIETY.

*8 p.m.* Ordinary Meeting at 92, Victoria-street, S.W. Agenda: (1) "The Physics of Ore Flotation," by J. Swinburne and G. Rudorf; (2) "The Concentration of Metalliferous Sulphides by the Flotation Process," by Prof. A. K. Huntington; (3) "The Ions of Pure Water," by Prof. J. Walker, F.R.S.

**WEDNESDAY, December 13th.**

INSTITUTION OF ELECTRICAL ENGINEERS: BIRMINGHAM LOCAL SECTION.

*7:30 p.m.* Meeting in the Birmingham University, when a Paper on "Two New Electricity Meters" will be read by S. H. Holden.

INSTITUTION OF ELECTRICAL ENGINEERS: STUDENT'S SECTION.

*7:30 p.m.* Meeting at 92, Victoria-street, Westminster, London. Paper to be read: "Flame Arc Lamps," by L. J. Pumphrey.

WOLVERHAMPTON AND DISTRICT ENGINEERING SOCIETY.

*7:30 p.m.* Meeting at the Technical School, Wolverhampton, when the following Paper will be read: "The Locomotive of To-day," by G. Bulkeley.

ASSOCIATION OF ENGINEERS-IN-CHARGE.

*7:30 p.m.* Meeting at the St. Bride Foundation Institute, Bride-lane, Fleet-street, London. Paper: "High-pressure Gas Illumination," by J. W. Blakey.

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. Paper to be read: "The Commerce and Industries of Japan," by W. F. Mitchell.

**THURSDAY, December 14th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Ordinary General Meeting, when Mr. W. H. Patchell's Paper on "The Charing Cross Company's City of London Works" will be further discussed.

INSTITUTION OF ELECTRICAL ENGINEERS—DUBLIN LOCAL SECTION.

*8 p.m.* Meeting at the Royal College of Science, Dublin. Paper to be read: "Storage Batteries and Boosters," by W. L. Brockman.

RUGBY ENGINEERING SOCIETY.

*8 p.m.* Meeting in the Benn Building, High-street, Rugby. Paper "High Lift Pumps," by P. A. Mossay.

TRAMWAYS AND LIGHT RAILWAYS ASSOCIATION.

*3 p.m.* Visit to Lots-road (Chelsea) Electric Power Station.

*8 p.m.* Meeting at the Society of Arts, John-street, Adelphi, London. Paper to be read: "On Improvements in Trucks," by Elmer E. Cook.

**FRIDAY, December 15th.**

PHYSICAL SOCIETY.

*7 p.m. to 10 p.m.* Exhibition of Electrical, Optical and other Physical Apparatus at the Royal College of Science, Exhibition-road, South Kensington.

JUNIOR INSTITUTION OF ENGINEERS.

*8 p.m.* Meeting at the Westminster Palace Hotel, Victoria-street, Westminster. Paper to be read: "Electric Mains for Power Transmission," by Prof. J. T. Morris.

INSTITUTION OF CIVIL ENGINEERS: STUDENTS' SECTION.

*8 p.m.* Meeting at 25, Great George-street, Westminster, London. Paper: "Tests of Street Illumination in Westminster," by E. E. Mann.

## ELECTRICITY METERS.*

BY C. H. W. GERHARDI.

*(Continued from page 229.)*

### METER TESTING.

Meter testing comprises the ascertaining of the percentage errors, or verifying the constants of meters, and, if necessary, the adjustment of them so that they may be within certain limits of accuracy. The Board of Trade limit of accuracy is 2·5 per cent. on either side, and meters registering the consumption to within that amount are considered accurate. In addition to tests for accuracy other tests are necessary, such as: tests of insulation resistance, tests of shunt resistance, tests of fall of potential in main coils, tests for alteration of constant after short-circuit, tests for starting currents, &c.

The simplest method of testing the accuracy of a meter is to run it on various constant loads and compare its reading with the number of Board of Trade units passed through. This method, however, apart from possessing the disadvantage of taking a long time, especially at low loads, may probably be more inaccurate than the meter itself, owing to the facts that the error of observation of the reading may be large unless a large reading is obtained, and that unless the current is kept constant the estimated Board of Trade units may not be correct.

A more accurate method is to take the speed of a fast-moving portion (in motor meters), such as the main spindle, with a definite number of watts or amperes passing, and to calculate the watts or amperes indicated by the meter after ascertaining the relation in speed of the moving part to the units dial. The error of the meter as a percentage of the true watts passed through it is then obtained by multiplying the difference between the true watts and the watts calculated from the speed of the meter's moving part by 100 and dividing the result by the true watts.

The result is given as positive if the meter over-registers, and negative if it under-registers. In using the error for arriving at the true consumption from the consumption as shown by the meter in the case of a meter which has been out on circuit, it is wrong simply to deduct or add *n* per cent. from or to the registered consumption. The true consumption is arrived at as follows:—

If $A =$ the consumption by meter,
$x =$ true consumption,
$p =$ percentage error (as a percentage of the true watts).

$$\text{Then } A = x + \frac{p}{100}, x$$
$$= x\left(1 + \frac{p}{100}\right),$$
$$x = \frac{A}{\left(1 + \frac{p}{100}\right)}, \text{ and not } A\left(1 - \frac{p}{100}\right).$$

The above difference becomes more important as the error of the meter becomes greater. Up to a 5 per cent. error, however, the difference is only $\frac{1}{4}$ per cent.

On account of the uncertainty which occasionally arises as to whether the error has been given as a percentage of the true watts or of the watts recorded by the meter it is much more satisfactory for a "constant" to be given, this constant being the number by which the units registered must be multiplied to arrive at the true units.

The test of a motor meter is quickly and accurately carried out by noting the time by a *tested* chronograph, for a convenient number of revolutions of some quickly moving part (generally the brake disc). The number of revolutions counted is preferably a round number per ampere and such that a time of about 100 seconds or more will be taken to perform the number of revolutions selected.

If $T =$ the time in seconds in which R revolutions should be made if the meter were correct, and $T_m =$ the time actually taken for R revolutions, the constant $K = \frac{T_m}{T}$.

If a number of revolutions can be selected which, in addition to being a round number per ampere, also requires a time of 100 seconds it will be seen that a hundredth of the time $T_m$ taken is the constant K. Thus, if the main spindle of a 200 volt, 10 ampere meter should make 40 revolutions (4 per ampere or 1 per 50 watts) in 100 seconds at full load, the results of the test could be set down without any calculation thus:—

| Watts. | | No. of revolutions counted. | | Time Seconds. | | "K." |
|---|---|---|---|---|---|---|
| 2,000 | .... | 40 | .... | 98·6 | .... | 0·986 |
| 1,000 | .... | 20 | .... | 99·2 | .... | 0·992 |
| 500 | .... | 10 | .... | 99·8 | .... | 0·998 |
| 100 | .... | 2 | .... | 108·6 | .... | 1·086 |

A further advantage of varying the number of revolutions according to the load counted instead of the time for a constant number of revolutions is that the chronograph is run for approximately the same time in each test and, therefore, if compared against a chronometer for the same period as used in the tests, all errors of the chronograph such as starting errors (provided they are found not to be intermittent) do not affect the accuracy of the tests.

T, the time in which R revolutions should be made, is, of course, given by the formula $T = \frac{BR}{W_t}$, where B is the number of watt-seconds per revolution, and $W_t$ the true watts supplied.

The number of watt-seconds per revolution "B" is found from the wheel ratios between the units dial and the part of the meter counted.

Fig. 146 represents a common type of wheel train with the front plate cut away to show the gearing from the units dial to the main spindle.

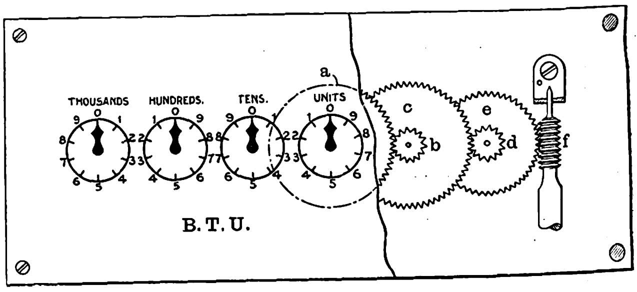

FIG. 146.

If *a*, *b*, *c*, *d*, *e*, *f* represent the numbers of teeth on the various wheels and pinions as shown, starting with the unit wheel (one revolution of which is equivalent to 10 units), then one revolution of units dial $= \frac{a}{b} \times \frac{c}{d} \times \frac{e}{f}$ revolutions of main spindle $= N$, and as one revolution of units dial $= 10$ units $= 36{,}000{,}000$ watt seconds, N revolutions of main spindle $= 36{,}000{,}000$ watt seconds, and $B =$ watt seconds per revolution $= \frac{36{,}000{,}000}{N}$.

In the case of ampere-hour meters of the motor type, B is obtained in the same way as for watt-hour meters. In fact, most ampere-hour meters have dials indicating Board of Trade units at the pressure for which they are intended. If the dials indicate ampere-hours B becomes ampere-seconds per revolution. Meters which are calibrated in the first instance by altering the ratio between the units dial and the main spindle by the insertion in the wheel train of "change wheels" having different numbers of teeth naturally have several values for B in meters of the same size, and the true time is different in each case. It then becomes necessary either to count the teeth of each change wheel in each meter, or to make a long time test at full load, at the same time to make two or three counts of the quickly moving part and thus to obtain B, which can then be used for the tests at lower loads.

In any case the change wheel ratio should be tested, as to test the meter without ascertaining that the wheel train is correct would be useless. Meters of this class should be provided with testing dials—*i.e.*, dials on which one complete revolution is 1·0, 0·1, 0·01 Board of Trade units, in which case an accurate dial test can be made in a short time.

*Connections for Testing.*—Connections for testing ampere-hour meters are simple enough. Any number may be connected in

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[*] From a forthcoming book to be published by "The Electrician" Printing and Publishing Co. All rights are reserved.

series, provided sufficient E.M.F. is available to obtain the required current in their circuit. Continuous current meters require to be connected up in the right direction; usually one terminal is marked positive into which the positive lead should be inserted.

With watt-hour meters care is required in the connections. Their main coils are connected in series similarly to ampere-hour meters. If possible their shunt circuits are disconnected from the main coils, and are connected to a common lead having no appreciable drop, to which is also connected the end of the shunt-circuit of the standard wattmeter, or the voltmeter, and the test made on an artificial load.

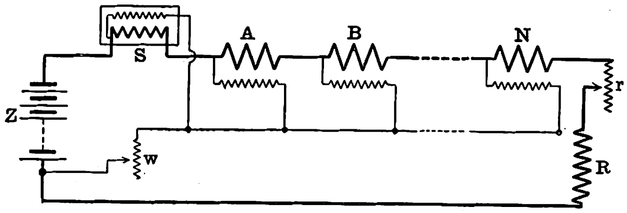

Fig. 147.—Incorrect Testing Connections.

If a number of watt-hour meters are connected in series it is absolutely necessary to proceed as above, as reference to Figs. 147 and 148 will show.

In these figures AB...N are the watt-hour meters, S the standard instrument, Z source of supply, R resistance frame, *r* carbon or other suitable rheostat, and *w* wirt rheostat for regulating the pressure. If the watt-hour meters are connected up for testing, as shown in Fig. 147, it will be seen that, owing to the shunt-circuits of the meters being left connected to the main, the standard instrument would register the current taken by all the meter shunts in addition to the main current; B would register the shunt current of ...N; A those of B to N. It is also evident that the potential across the various shunts would differ, due to the fall of potential in all the main coils of meters to the left of the one considered; this varies according to the main current, and at full load would become important, causing each meter to run slower than the one to the left of it. Inserting the standard instrument in the other main, as in Fig. 148, prevents the shunt watts of the meters being registered by it, but does not otherwise prevent inaccurate results being obtained.

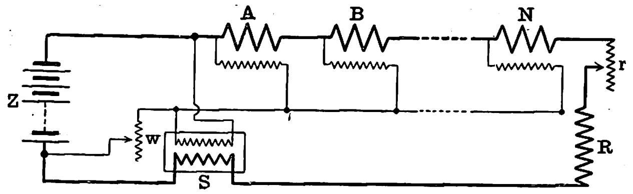

Fig. 148.—Incorrect Testing Connections.

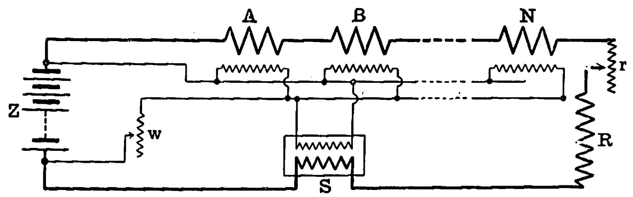

Fig. 149.—Correct Testing Connections.

If watt-hour meters are to be tested in batches in series it is essential to disconnect the potential circuit from the main, as in Figs. 149 and 150. In this manner all the shunts, including that of the standard wattmeter, are fed from a common point and none of the shunt currents are registered by the meters.

In Fig. 150 the shunts are fed from an independent source of supply, Z′, and as the main current is at a low voltage the power-absorbing resistance R may be dispensed with.

The two sources of supply may be joined as shown by the dotted line X Y Fig. 150, in which case A might be tested without disconnecting its shunt from the main; but, in order to test B in this way, it would be necessary to cut the main coils of A out of circuit, at the same time opening A's shunt and so on for each meter. It is with this object that the standard instrument is placed in the opposite main to that in which the meters are connected, and this is the general arrangement shown in the diagrams of connections given in the chapter on the "arrangement of a meter testing department."

A standard wattmeter may be replaced by a standard ampere balance and voltmeter on continuous current, or on alternating current of power factor = 1. It must be remembered however that the main coils are slightly inductive, and if the main current be taken from a low voltage transformer, without a non-inductive power-absorbing resistance in series, the power factor would not be unity. Even when the main coil circuit is supplied with current at 100 volts pressure, an appreciable power factor is obtained with a few meters in series. On alternating current circuits therefore the testing of watt hour meters should only be carried out with a good wattmeter as the standard instrument.

In Figs. 149 and 150 the shunt circuits of the meters have been assumed to be normally connected to the "station" side of the main coils which is mostly the case in practice. Connected thus, the meter registers the watts lost in the main coils, but does not register those consumed in its own shunt circuit. If the shunt be connected to the "house" terminal of the meter the latter registers the shunt watts, but not those lost in the main coils, and if friction were balanced when the shunt circuit is disconnected from the main for testing, the meter might "creep," or register on no load when the shunt lead is replaced. Meters having comparatively speaking a great deal of friction, or meters of large size could easily be prevented from creeping when so connected. The connections for testing a batch of these could still be those of Figs. 149 and 150, and if great accuracy were required, the standard wattmeter should be set to what might be called a "false" reading to compensate for the change of connections for the test, so as to make the conditions similar to when the meter is on circuit. An example will make this clearer.

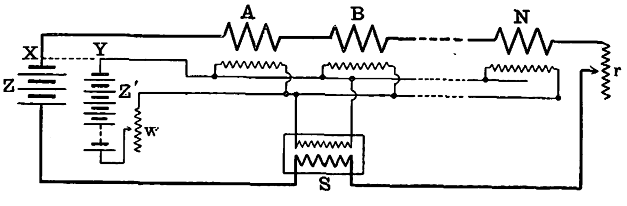

Fig. 150.—Correct Testing Connections. Artificial Load.

Suppose a batch of 100 volt 10 ampere meters, one pole of the shunts of which in the normal way are connected to the house terminals, are being tested at a load of 1 ampere, and that the shunt watts of each are about the same, say, 3 watts; then, if the watt balance is set to 103 watts, and taken as 100 watts, the correct error of each meter is obtained, for on a low load the drop will be insignificant. At high loads the drop in the main coils must be considered, and in this example at full load, assuming each meter has a drop of 1 volt, the balance would be set at 1,003 − 10 = 993 watts, and taken as 1,000 watts.

If the end of the shunt cannot be disconnected from the main, owing perhaps to the meter being guaranteed for a period by the makers subject to their seals being unbroken, it then becomes necessary to connect up each meter separately as before. The watt-balance shunt will then be connected to the supply side of the meter, whilst the meter-shunt current will be taken from the "house" side. The correct error will be ascertained if the balance is set high by the amount equal to the watts lost in the main coils of the meter which will differ for each load. In the commoner case of the shunt being connected to the "station" terminal, if for any reason it cannot be disconnected for the test, then each meter should be tested separately as at A Figs. 149 or 150 with no meters, B to N in circuit.

*(To be continued.)*

## APPLICATIONS OF ELECTRICITY IN THE ROYAL GUN FACTORY, WOOLWICH ARSENAL.*

BY COL. H. C. L. HOLDEN, R.A., F.R.S.

(*Concluded from page 261.*)

Once having introduced magnetic clutches into the workshop it is astonishing how quickly their applications seem to spread, and I propose to devote a few minutes to describing one or two special examples.

In the testing-room there is a small piece of apparatus which is used for compressing to a predetermined amount the copper cylinders employed in guns for ascertaining the pressures developed by the explosive; for instance, if a 15-ton per square inch pressure were anticipated, a copper pressed to 12 tons per square inch might be used. The pressure required is obtained by the weight of a column of mercury—the height of the column being varied by the displacement of the mercury by a piston of considerable area in a cylinder connected with the column. The piston is moved by a vertical screw, driven through gearing by an electro-motor, the copper cylinder being between two flat and hard steel surfaces interposed between the end of the screw and the piston. Means are provided for starting, stopping, and reversing the motor, but in order to get the practically instantaneous stoppage of the screw when the mercury has reached the correct height on the scale for the pressure required, a magnetic clutch is fitted as close to the screw as practicable, and is found to answer the purpose admirably, the switch controlling it being operated by the man's foot. The motor can then be stopped, reversed, clutched in, and the pressed copper removed and replaced by another and so on, the whole process taking longer to describe than to carry out in reality.

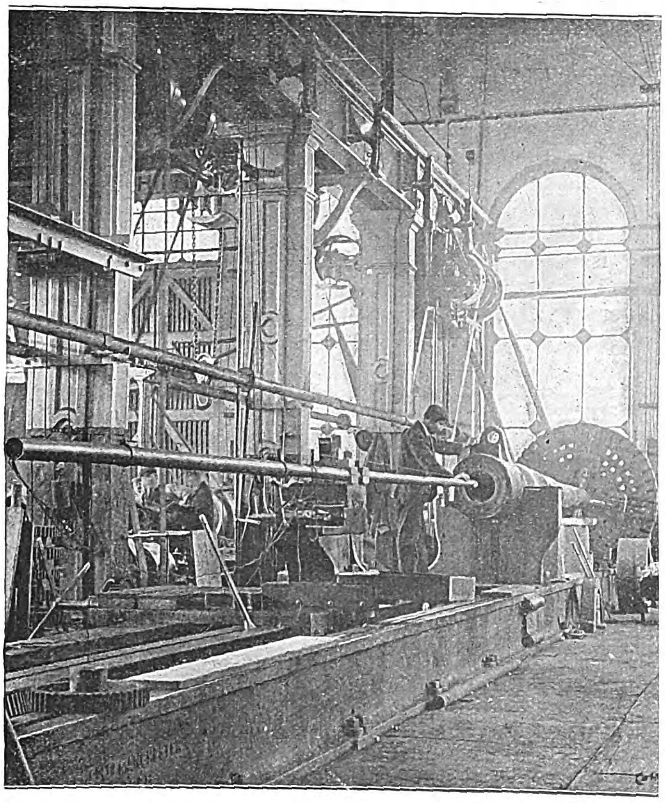

Fig. 17.

Electricity has been of assistance to us in enabling the amount of eccentricity of the bore of a gun which, as sometimes happens, has from one cause or another become bent, to be readily ascertained. You will, I am sure, appreciate the difficulty in first of all ascertaining, and secondly actually measuring, the want of truth in the bore of a gun 20 ft. to 30 ft. from the breach end, which distance it may easily be, as the 12 in. gun is 45 ft. in length. The means adopted, however, are, thanks to electricity, quite simple (Fig. 17). A tapered steel tube, stayed and tied with a single gun wire so as to bring both ends of the tube to the same level, carries at one end a knife-edged contact wheel about 2 in. in diameter, this wheel being insulated from the tube, but connected to a flexible conductor passing down the interior of it to the other end of the tube which is fixed in the slide rest; a dead beat galvanometer and a couple of dry cells complete the equipment. When the wheel touches the metal of the gun, the circuit is completed through the galvanometer, which indicates accordingly. The movement of the slide rest, necessary to make contact, reveals the amount of eccentricity.

When any billet of steel arrives in the factory, the first thing to be done is to obtain a small quanity for chemical analysis. This is generally taken in the form of fine drillings from a point midway between the centre and exterior of the billet (Fig. 18) and at both ends. Until current was generally available throughout the factory this was quite a lengthy operation, involving the loss of time taken to fix a ratchet brace, and then the time to drill the hole in order to obtain the shavings; by the aid of the electric drill the time lost in fixing is eliminated entirely, and the drilling by power is quite a short operation.

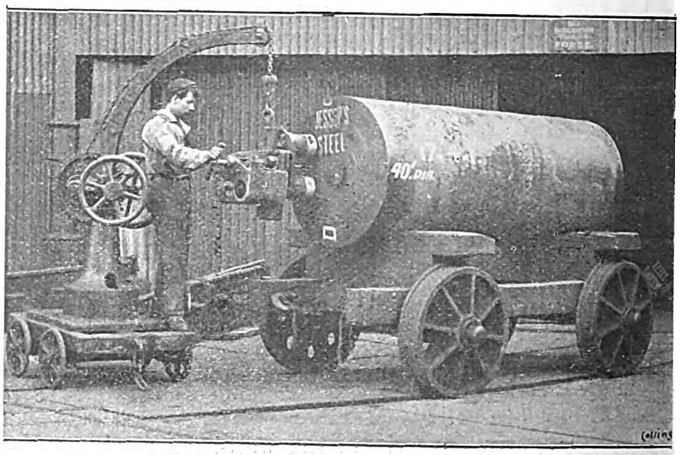

Fig. 18.

I feel that my list of applications would not be complete if I omitted to refer to the use of the electromagnet for lifting projectiles (Fig. 19), which was introduced by me many years ago when the 110-ton gun was in use. The cast-iron projectiles for proof were exceedingly awkward things to remove from the pile and sling for the crane to lift; this was made delightfully easy by substituting an electromagnet for the sling. The magnet used consisted of one piece of mild steel of ┌─┐ section, and 10 in. in length, with a single coil wound round it longitudinally—the surface magnetised was 30 sq. in., and the maximum weight it had to support 1,800 lb., the weight of the projectile of the 110-ton gun, though, as you will see, there was ample power to spare. The weight of this magnet, complete with the shackles for attaching it to the crane hook, was under 56 lb., and the electrical energy required for the maximum lifting power was 120 watts.

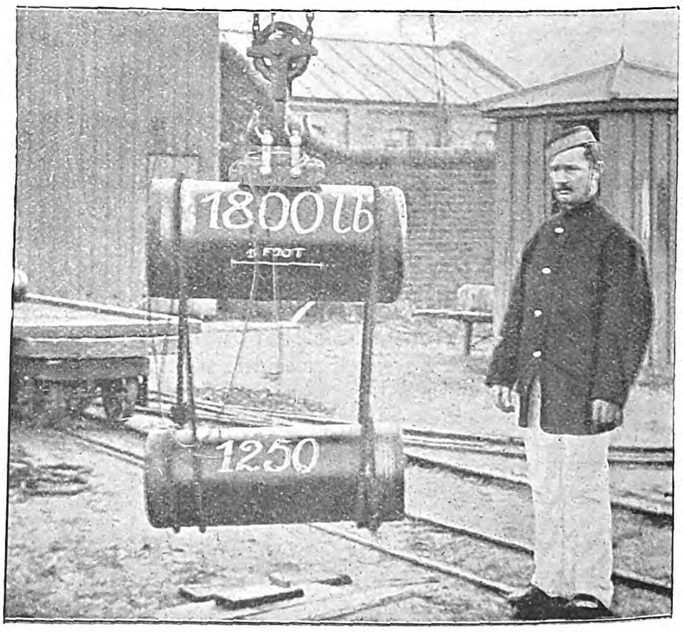

Fig. 19.

In any large gun factory, or, indeed, in any factory where large makes of steel are heated, forged and tempered, or otherwise treated, it has long appeared to be absolutely essential that some means should be provided of measuring temperatures. This is most conveniently done by electrical means, and, without going into the history of the matter and a description of the various instruments that are available for the purpose of measuring temperature electrically, I will merely say that for our purpose the measurement by means of the E.M.F. generated by a thermo couple has been found to be the best adapted.

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* Paper read before the Institution of Electrical Engineers, Nov. 23rd.

The thermo junction we use is a platinum and iridio-platinum one, in conjunction with a modified form of D'Arsonval galvanometer to measure the E.M.F. which indicates the temperature. The instruments are fixed in various parts of the factory, and connected up to the re-heating, annealing, and tempering, &c., furnaces, as also to the lead baths (Fig. 20) for tempering steel specimens, in such a manner that the temperature of any one of them can be immediately ascertained by those in charge, and regulated accordingly; but this is not all. From each of these centres, so to speak, line wires are led to the metallurgical laboratory, where there is a standard recording instrument, and by this means not only can a continuous record be taken of any operation desired, but the individual instruments can be, and are, constantly checked to ensure accuracy and uniformity with the standard, for which purpose the points are connected by telephone. The standard itself is checked by the usual method of observing the freezing points of pure metals at various points of the scale. The zero of all the instrument scales is the temperature of boiling water, which, where steam is always available, as in our case, is readily arranged for, and is in itself a check on the accuracy of the instrument.

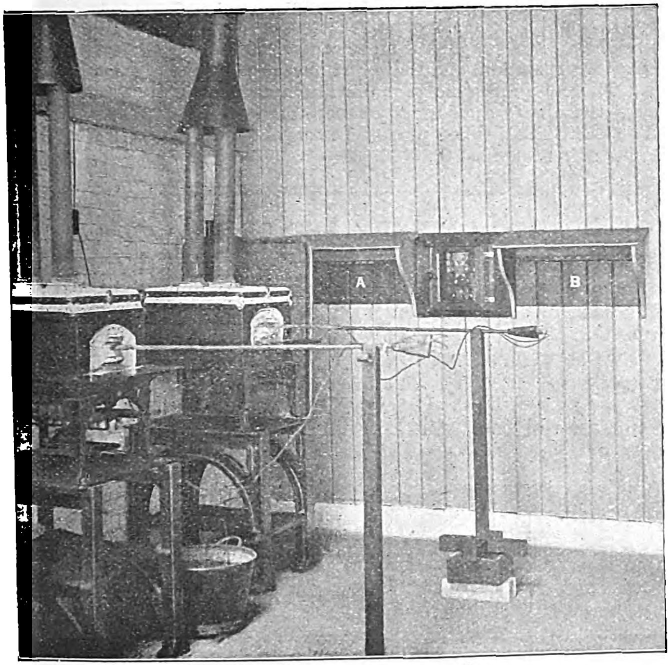

Fig. 20.

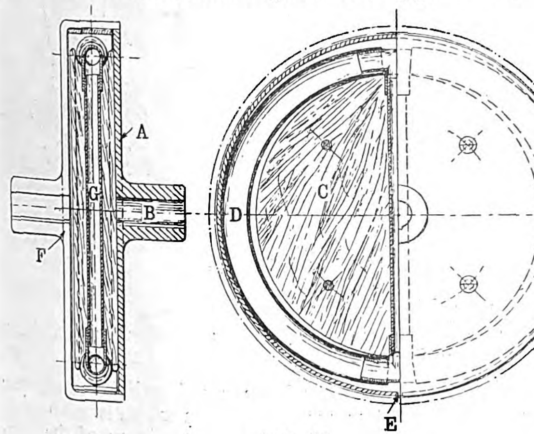

Fig. 21.

*Automatic Water Clutch.*—A difficulty arose in connection with the starting into motion of the heavy saddles of some double-ended boring lathes by the 1½ H.P. motors that had been supplied with them, and after some trouble with burnt armatures and fuses the following arrangement was tried with complete success:—

The solid coupling was removed and a disc of cast iron, A, was keyed to the motor spindle B (Fig. 21). This disc carries a block of hard wood, C, on its face, the periphery being prepared with a semi-circular groove to carry an indiarubber tube, D. This indiarubber tube is in halves, which are joined by a metal tube G let in across the diameter of the wooden disc. Outside the indiarubber tube is a split cast-iron ring, E, similar to a piston ring, attached loosely to the iron disc so that it is free to expand. The tubes are then filled with water and the whole arrangement is fitted into a cupped disc, F, keyed to the shaft to be driven. When the motor is at rest the two portions of the clutch do not touch each other, but when the motor is started, and as it gains speed, the water, acted on by centrifugal force, expands the rubber tube, and this in turn expands the split ring, which eventually rubs against and then grips and drives the other half of the clutch.

To sum up, there are at work at the present time in the Royal Gun Factory 134 motors of an aggregated horse-power of 1,903, whilst there are 61, either connected or ready to be connected, to the supply mains when current is available, of an aggregate rated power of 840 H.P. more. They consist of one motor of 100 H.P., one of 50 H.P., six of 40 H.P., 30 of 30 H.P., two of 25 H.P., 11 of 20 H.P., 29 of 15 H.P., and 39 of 10 H.P., the remainder being under 10 H.P., and ranging down to 1 H.P. The largest motors—viz., 100 H.P., 50 H.P., and 40 H.P.—are all connected to individual machines. The number of magnetic clutches in use is 117, 31 rated at 25 H.P. and 86 at 6 H.P. Of magnetic chucks and holders there are 16 in use, but fresh fields of application are continually being found for them, and their numbers are, therefore, constantly on the increase. Magnetic holders are of the greatest service in connection with surface grinding machines, and enable small steel work to be turned out with the greatest accuracy and rapidity. One instance may be given of the utility of the magnetic lathe chuck, and that is in turning obturator rings. These rings are made from extremely hard-tempered steel, so hard indeed that they can only be cut at a very low speed with specially hard tools, yet it is found that, in spite of the small surface area they afford for the magnetic attraction, and also of their somewhat low permeability, the magnetic chuck is the most effective method of holding them whilst being turned that we have yet been able to devise. There is nothing very special in the construction of these magnetic devices; they are designed with a view of taking the standard size of bobbins used in the clutches, and by filling the air-gap with brass are so made that they cannot be damaged in any way by being used in oil or water.

It may be of interest, I feel, if I add a few data as regards the amount of material removed per electrical horse-power per minute on various machines—the electrical horse-power is the gross amount required, not only to drive the motor and machine, but also to do the work. (See Table.)

| — | B.H.P. of Motor | No. of Tools | Cut In. | Feed. In. | Weight of material removed per hour. | Lb. per E.H.P. per minute |
|---|---|---|---|---|---|---|
| | | | | | Lb. | |
| Fine boring machine | 30 | 1 | 1·4 | 0·04 | 118·86 | 0·082 |
| Rough boring machine | 30 | 1 | 2·0 | 0·033 | 288·3 | 0·239 |
| Experimental lathe | 70 | 1 | 1·0 | 0·5 | 1,652·0 | 0·38 |
| ” ” | .. | 2each | 0·5 | 0·5 | 1,652·0 | 0·417 |
| ” ” | .. | 1 | 0·5 | 0·5 | 826·0 | 0·375 |
| Medium boring machine, 5·75 hole from solid | 15 | .. | .. | .. | 132·6 | 0·142 |
| Double-ended boring machine, 4 in. hole from solid | 15 | .. | .. | .. | 70·0 | 0·0956 |
| One end only working. | | | | | 140·0 | 0·147 |
| Heavy single-spindle milling machine | 15 | .. | .. | .. | 14·0 | 0·049 |
| Heavy double-spindle milling machine | 15 | .. | .. | .. | 85·0 | 0·109 |
| Radial drill. ⅝ in. high-speed twist drill | 10 | .. | .. | .. | .. | 0·115 |
| Radial drill. 1¼ in. high-speed twist drill | .. | .. | .. | .. | .. | 0·180 |
| Radial drill. ⅝ in. ordinary twist drill | .. | .. | .. | .. | .. | 0·04 |
| Radial drill. 1¼ in. ordinary twist drill | .. | .. | .. | .. | .. | 0·056 |

## DISCUSSION.

The PRESIDENT (Mr. J. Gavey, C.B.) called upon Prof. Ayrton to open the discussion.

Prof. W. E. AYRTON, F.R.S., having mentioned the importance of having more light in a workshop by the adoption of electric driving and the consequent abolition of countershafts and belting, said that he had been much interested only a month or so ago, when being taken over the workshops of the Central South African Railways in Pretoria, to find that even so far away from centres of civilisation electric driving had been adopted on a very large number of machines. He regretted that the author had not dealt at greater length on the question of single-motor drive *v.* group driving. He would also like to know Col. Holden's opinion of the method which had been adopted in America very largely of having the lathe, or whatever machine it was, made complete with the motor—*i.e.*, the motor was not an addition of any kind, but the original casting of the lathe was made to receive the motor, and the two were sold as one piece. He (Prof. Ayrton) had been told that with this arrangement it was difficult to get perfectly true running of the tool, because of the vibration

Mr. STUART A. RUSSELL, on the question of worm gearing and the very great smoothness of running mentioned in the Paper, said that at the Silvertown works they had had considerable experience in this direction and had found it very advantageous indeed. Although the initial cost of the worm gearing was great, yet the wear was so small that repairs were absolutely never required, whilst the smoothness of running was so great that the initial expense was entirely justified. This gear was now being used at Silvertown for a variety of purposes in sizes from 150 H.P. down to about 2 H.P., and in all cases satisfactory results were obtained. The thrust block which he was using was perhaps a little different from what was generally used. It was a marine thrust block, but instead of having the collars on the shaft, in one piece with the shaft, they had separate collars. There was a feather on the shaft and on this feather were slipped alternately rings (as distance pieces) and the collars. They had adopted that plan because they were able to get a much better surface on the hardened collar, and thus the wear was reduced very considerably. If the collars were all part of the shaft it was not a very easy thing to get a thoroughly good surface or to get it absolutely hard. With regard to the magnetic clutch, Col. Holden had referred to the smoothness of its working in connection with a centrifugal pump. It appeared to him, however, that the magnetic clutch must be sudden and not gradual in its action. In the case within his experience, for instance, in which cotton threads had to be put into motion it had been difficult to prevent breakage of the cotton threads when starting. Was there any appreciable slip when the clutch was drawn into action, or did the clutch and the armature come together and put the whole machine on almost at full load? In such a machine as a planer, for instance, there must be a tremendous shock unless there was some little slip, and if there was any slip, then he would have expected to hear that there was more wear in the clutch than Col. Holden had spoken of, seeing that he had referred to clutches which had been running for 15 years continuously and were in excellent condition still.

Mr. A. W. MARSHALL asked Col. Holden to explain the exact function of the demagnetising ring of the clutches. It would also be most interesting if Col. Holden would give his opinion as to the merits of driving planing machines by means of friction clutches for reversing, and by reversing the motor. A large planing machine at the recent Electrical Exhibition seemed to be working very well indeed, the motor reversing its action each time the table was reversed. Col. Holden had not emphasised the wonderful working of electric cranes. In a recent visit to the Arsenal, he had noticed a great many of these appliances which Col. Holden had so modestly described, and he was much struck with the way in which the electric motors seemed to work. It seemed to him that a very great saving of time must result. One point not mentioned in the Paper was that, in adopting such a large system of electric driving, there should be no interruption in the electric supply, and a word or two would be welcome as to whether any special precautions had been taken to prevent the current being cut off, because Col. Holden had emphasised the fact that it was exceedingly important in some of the operations at Woolwich that the tools should not stop from one week's end to another.

The PRESIDENT remarked that as it was necessary to conclude the discussion that evening, and as the hour was late, he would ask any other intending speakers to send in their remarks to the secretary for publication in the *Journal*, and

Col. HOLDEN, replying first of all to Prof. Ayrton on the question of where to draw the line between driving separate tools by separate motors and driving groups of tools by one motor, said he was afraid that this was a matter that could be decided by examining in detail each particular case. For instance, it was just as well to drive a number of lathes from shafting, provided precautions were taken to reduce frictional losses as much as possible. In such a case, with say a dozen machines, a 30 H.P. would take the load quite easily because the machines were not all working at the same time, and the motor would not be asked to do anything like its full power in many cases. There was always the objection of cost when driving machines individually. As regards the building of the motor with the machine he thought that in many cases this would work out all right. The cases in which he should like to see it employed, and should employ it himself, were those in which there was no reduction of gear at all, where the spindle of the machine was driven direct from the motor. The Paper related what he had done himself in this matter. The slow speed boring machine shown on p. 260, by which machine they were able to bore 4 in. holes in 40 ton pieces of solid steel at the rate of 5 ft. an hour, demonstrated that they could not afford to lose anything from friction away from the motor, and also that there must be means of taking up the enormous thrust in boring a hole at that rate. In this case he had intended originally to put the motor direct on to the mandril which carried the tube to be bored, and it was only the extra cost of having the motor built to run at the slow speed of about 250 revs. per min. that had made him adopt the plan shown in the illustration—viz., using the motor with a single reduction to drive the mandril, through a flexible cable, which got over the difficulty of vibration mentioned by Prof. Ayrton. He also took up the thrust due to boring by a very large ball bearing running at the full revolutions of the machine behind what practically became the face plate. He was glad to see that Mr. Russell fully bore out what he himself thought were the advantages of worm gearing. He was interested in the manner with which Mr. Russell had got over the difficulty of the thrust, which often amounted to three or four tons. As to the smooth starting of the magnetic clutch, referred to by the same speaker, the answer to this inquiry was that it took time to magnetise a magnet of that description and that the magnetisation is a gradual affair and, therefore, there must be slipping, but this slipping would not be appreciable, although it was essential that it should exist in order that there should be smooth working and no jars on the driven and driving machines. As to wear, the answer he would make about that was that the wear was slight, because the pressure per square inch was slight. He did not remember having to replace any of the demagnetising rings because of wear. These rings were merely stamped discs of steel and the two partial air-gaps that were formed on either side of them greatly assisted in demagnetising the magnet after the current has been cut off. It was essential to use something of this sort, otherwise when the current was turned off the clutch did not come off. He did not wish to enter into any discussion with regard to the merits of the two methods of driving planing machines, but would only say that if they were cutting with two tools they were doing the full work the machine was capable of running at its proper speed. It did not matter how fast the bed was returned; if it was idle during that time, time was being lost, because work was not being done. In his case, the motor ran at full speed the whole time—the same on the backward stroke as on the forward stroke—and the clutch was merely to determine which way it should go. On the question of the interruption of current mentioned by Mr. Marshall, Col. Holden replied that he did not supply himself with energy but it was supplied from a central station. Col. Bagnold was in charge of the station, and there had never been a stoppage without warning. There were ring steam mains and multiple electrical mains, and, of course, there were a good many generating sets.

The PRESIDENT then proposed a vote of thanks to Col. Holden, which was heartily responded to.

## GILBERT ARC LAMPS.

One of the most complete catalogues of arc lamps and accessories that we have seen has just been brought out by the Gilbert Arc Lamp Co., Chingford, Essex. Its extent will bring home to many central station engineers and consultants the mass of detail concerning arc lamp systems which has to be taken into account in preparing their specifications. For instance, a diagrammatic illustration of an end post with lowering gear, which we have redrawn below on a smaller scale (Fig. 1) indicates clearly the various appliances for which room must be found inside the post. By the side of the illustration in the catalogue are useful hints, for instance:—

It should be arranged that the post suppliers should make and tap four holes in the base and fit the necessary draw wires.

It should be arranged that cable suppliers should seal and end off their own cables and leave suitable ends to connect into apparatus terminals.

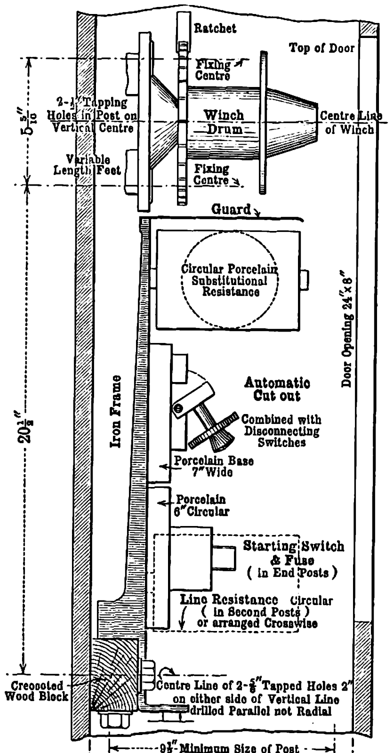
Ratchet
Top of Door
Fixing Centre
2-½" Tapping Holes in Post on Vertical Centre
Winch Drum
Centre Line of Winch
Variable Length Feet
Fixing Centre
5 5/16"
Guard
Circular Porcelain Substitutional Resistance
Door Opening 24"×8"
Iron Frame
Automatic Cut out
Combined with Disconnecting Switches
Porcelain Base 7" Wide
Porcelain 6" Circular
Starting Switch & Fuse (in End Posts)
Line Resistance Circular (in Second Posts) or arranged Crosswise
20½"
Creosoted Wood Block
Centre Line of 2-⅝" Tapped Holes 2" on either side of Vertical Line drilled Parallel not Radial
9½" Minimum Size of Post
11" Convenient Size of Post

FIG. 1.—STANDARD COMPLETE END POST GEAR WITH LOWERING GEAR. Scale, 1½ in. = 1 ft.

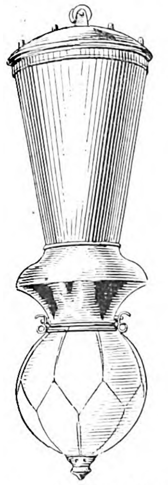

FIG. 2.—THE GILBERT FLAME ARC LAMP.

Those interested in the latest developments of arc lighting will turn at once to the section on flame arc lamps, from which it will be seen that the Gilbert Arc Lamp Co. are introducing a lamp of the converging-carbon type, whose outside appearance is shown in Fig. 2. The lamp is made on the lines of the German lamps of this class so far as its general arrangements are concerned, but, in place of a clockwork-feeding mechanism, there is the rocking lever and brake wheel which is employed in a large number of ordinary English lamps. To get over the difficulty of short life of carbons, the lamp is of the double-carbon pattern, and the two pairs of carbons are connected to the same holders. In this way, as soon as the first pair of carbons has burnt away a certain extent (for about 20 minutes), the second pair come together and strike an arc, and they take up the running until in their turn they have burnt away sufficiently. We are informed that there is only a flicker and no serious "pumping" when this occurs. The mechanism is placed in the top of the

V formed by the two carbons so that the length of the lamp is reduced as much as possible. We hope to publish a more detailed description of this lamp in a future issue.

To meet the demand for cheaper lamps, the Gilbert Company, while continuing to make their present "standard" patterns, also offer an "ordinary" or cheaper type, and the same applies to various accessories. Fig. 3 shows an "ordinary" enclosed lamp with its line resistance in a separate case above the lamp; Fig. 4 shows a neat and cheap contact hood for ceiling work. Among the newer designs of the lamps of the better class, we may call attention to Fig. 5 which represents the alternating-current lamp for side-street lighting used with success in Hammersmith. These lamps have 7 in. globes, and many of our readers will have noticed the pleasing effect of them in one of the streets between the "Tube" Shepherd's Bush station and Olympia. Fig. 6 is a simple carrier of neat design, in which the top of the carrier forms the lamp hood, and the lamp "bayonets" up into it

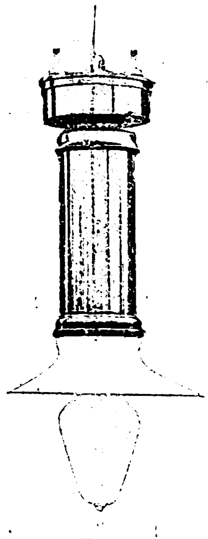
Fig. 3.
"Ordinary" Enclosed Lamp with Line Resistance in Separate Case.

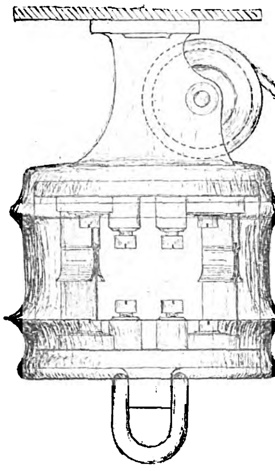
Fig. 4.
Contact Hood without Cord Relief Arrangement.

One of the drawbacks of the Gilbert series alternating system of arc lighting is its comparatively high first cost. The results are excellent, but they have to be paid for. The moving-coil transformer particularly is costly, and the company is now making a moving-coil choking coil which may be used in place of it if a suitable pressuure is available.

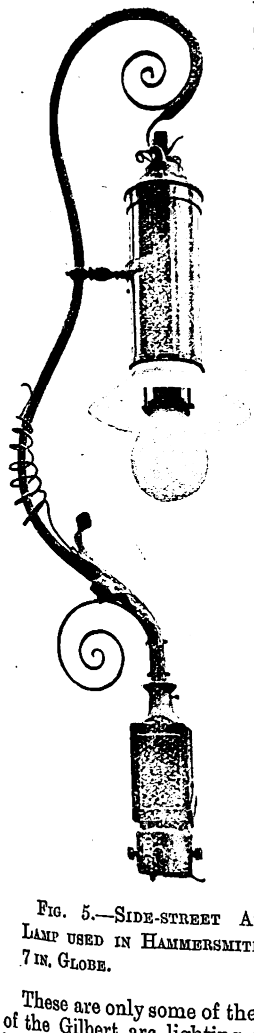
Fig. 5.—Side-street Arc Lamp used in Hammersmith: 7 in. Globe.

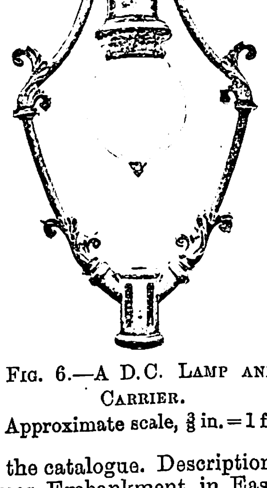
Fig. 6.—A D.C. Lamp and Carrier.
Approximate scale, ⅜ in. = 1 ft.

These are only some of the features of the catalogue. Descriptions of the Gilbert arc lighting on the Thames Embankment, in Eastbourne, Willesden and Derby have already appeared in our columns.

## A NEW AUTOMATIC SWITCH FOR ARC LAMPS.

A self-acting arc lamp starter for switching in street arc lamps automatically with an interval of time between each group is now being manufactured under Messrs. Lackie, Calderwood and McEwen's patents by Mr. James Ferguson, and is known as the Glasgow Arc Lamp Starter. The patentees are the Electrical Engineer to the Glasgow Corporation and members of his staff, and a number of these starters have been in use on the Corporation street lighting system for over eight months. The apparatus consists of two parts: a main switch proper controlled by an electromagnet, and a time mechanism which closes a secondary circuit after a predetermined interval, and thus actuates the main switch of the next starter in the series. By this means a series of lamps may be switched into circuit from any suitable point, set after set in turn with a time interval between the switching on of the various sets, so that sudden variations in the other lamps on the system are avoided.

The electromagnetic switch is actuated by a powerful electromagnet (A), Fig. 2, which rotates an armature pivoted by arms to the yoke. This armature is coupled by insulated connecting pieces at the sides to the double-pole switch which is provided with suitable carbon contacts. One of the switch-coupling pieces is fitted with an arm connected to the plunger C of the time-element mechanism. The whole apparatus is mounted on a base of insulating material with an insulating partition between the two switches, so that accidental contact between the positive, negative and middle wire terminals is impossible.

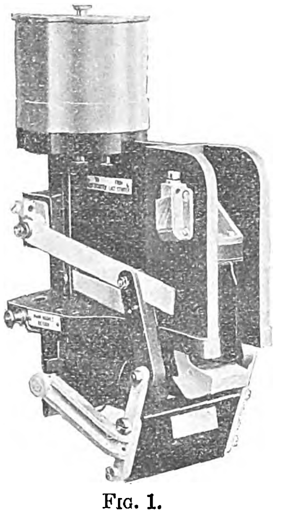
Fig. 1.
Complete Arc Lamp Starter in "Off" Position.

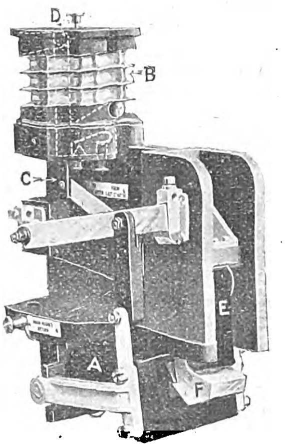

Fig. 2.—Arc Lamp Starter ("On" Position) with Cover of Time Element Removed showing Wavy Spiral. The white dotted lines indicate the travel of plunger and ball.

The time-element mechanism consists of a wavy spiral (B, Fig. 2), the axis of which is vertical, mounted on a platform forming part of the insulating base. A large hole passes through the centre of both the spiral piece and the base, which allows a plunger, C, to pass freely up and down. The function of this plunger is to elevate a smooth spherical ball, D, from the bottom of the base to the top of the spiral. The ball then descends by travelling round the spiral groove till it reaches the base, where it rolls on to the top of the contact spring and presses it down against the fixed contact, thus closing the circuit for the relay magnet of the next starter. The time taken by the ball to travel from the top till it closes the circuit for the next switch is about 11 seconds, which is sufficient to allow one group of lamps to be burning steadily before the next group is switched on. When the starter is switched out, the plunger drops to the bottom, and the ball rolls off the contact spring on to the top of the plunger ready for the next operation. A clutch, F, which can be released by the electromagnet, E, holds the switch on. As soon as the "all on" lamp in the station, actuated by the last relay of the series, lights up, indicating that all the groups of lamps in the series have been switched on, the switch for the electromagnet A may be opened, and the switches are held on mechanically. To open the switches the main magnet, or "in" switch, is first closed, thus relieving the clutches, F, which are withdrawn on closing the "off" switch, controlling the circuit for the electromagnet.

A considerable saving in labour is effected by using these starters owing to the smaller number of men employed, and in outlying districts it is not necessary to start the lamps so early nor switch off as late as when men have to go the rounds of the lamps.

The makers of the apparatus claim that in the case of a set of 850 lamps 16 men would be employed instead of 23, resulting in a saving of wages of £323 per annum, and that a further saving of £364 per annum could be effected in current consumption and carbons owing to the shorter hours of burning, taking current at 1d.

per unit and each lamp at 500 watts, and assuming that on the average the lamps would burn half an hour a day less. Allowing one starter at £10 each installed, per every 10 lamps, and allowing a reasonable rate for interest, depreciation, &c., the annual amount to be deducted from the saving given above is about £127, giving a net saving of £560 per annum for the 850 lamps, or about 13s. 2d. per lamp per annum.

## ELECTRIC RAILWAY EQUIPMENT.*

BY W. B. POTTER.

To meet the requirements of the higher voltage now more commonly used on continuous-current traction systems, and further to insure the stability of the motor as regards flashing, it is now the practice to provide a greater number of commutator segments; that is, the voltage difference per commutator bar has been reduced to a lower figure. The commutator being a revolving switch, it is important if sparking and flashing are to be avoided that the brushes should maintain good electrical contact with the copper segments. The commutator being built up of alternate sections of copper and mica, it sometimes happens that the mica does not wear evenly with the copper. In such cases the sparking becomes more pronounced, and there may even be serious trouble from flashing; the most effectual remedy in such a case is to groove out the mica between the commutator segments to a depth of about $\frac{1}{32}$ in. below the surface of the commutator. The performance of a motor for any service may be limited by its commutation, or, as is more commonly the case, by its heating. The heating of a motor is affected by the losses in both the copper and iron, but the relative heating effect of these two elements is quite different. The copper losses predominate during acceleration and the iron losses when running at the higher speeds; the effect of the iron losses is, therefore, to limit the capacity of the motor for continuous running. While the temperature of a motor under given conditions is proportional to is internal losses, the actual temperature rise may be greatly influenced by ventilation to assist in dissipating the accumulated heat. Forced ventilation by means of a blower, similar to those used with air blast transformers, may be employed. By this means the temperature of the motors in any particular service may be very much reduced, but the complication is such that it does not seem well adapted to the ordinary electric car. Forced ventilation is, however, well suited to locomotive work where the blower may be carried in the cab. As the motor commonly used depends upon its own rotation for ventilation, the arrangement of the ventilating passages must be carefully studied, not only to secure the best cooling effect, but also to prevent depositing brake-shoe and carbon dust or other injurious material upon conducting surfaces of the motor which cannot be conveniently cleaned. For this reason it is inadvisable to provide ventilating ducts just at the back of the commutator ears, for any accumulation of conducting dust at this point is sure to produce burn-outs. It has also been found advisable wherever ventilating ducts are provided through the core head to extend the slot insulation of the armature coils for some distance beyond the end of the core.

The use of oil in preference to grease for the lubrication of motor bearings seems now to be universally favoured. Of the various methods which have been tried, a waste-packed journal with an oil well, similar to the journal box of a car truck, has given the most satisfactory results. Nearly all the larger motors at the present time are designed for this method of lubrication. The mechanical injury to motor armatures usually results either from the armature striking the pole-pieces or the mechanical weakness of the armature binding. The former, where resulting from the wear of the armature-bearing linings or loose cap bolts, can be avoided by a proper system of inspection, but the latter is a question of motor design. The strains to which the armature bindings are subjected, particularly if the car is speeded above the normal by driving it with power down grade, are not ordinarily appreciated. As an illustration, the weight of the armature coils in a 125 H.P. motor is less than 200 lb., yet the radial centrifugal strain of all the coils at 1,500 revs. per min. is about 48 tons, giving a resultant strain of over 15 tons on the binding wires. Even if these wires are strong enough to hold the coils without breaking, they may stretch enough to permit a considerable movement of the coils in the armature slot, resulting in an abrasion of the insulation. An armature should be so bound that there will be no evidences of weakness at 50 per cent. above the maximum normal speed, and the ultimate strength of the binding or bursting speed of the armature should be at least double the maximum normal speed to insure the proper margin of safety.

The field coils of a motor, although subject to less potential than the armature, by reason of their location in the motor, are more subject to injury from occasional water. A distinct improvement has been made in the construction of the field coils by immersing them in a bath of hot compound under vacuum. The effect of this process is to thoroughly fill all air spaces with compound. This not only renders the coil more waterproof, but also makes it more solid and less liable to injury from mechanical vibration. More attention is being paid to the fit of commutator and oil well covers, which, being frequently opened, are now provided with machined seats in order to insure a better fit for the exclusion of dirt and water.

With the increased capacity of the motors the strains on the gearing have very much increased, particularly on the pinion teeth, which are of weaker section than the gear teeth. To meet these more severe conditions a very high grade of steel is required, both with respect to ultimate strength and elastic limit. Not only are the strains severe, but owing to the overhang of the pinion, the face of both the gear and pinion teeth, when new and doing heavy work, are not in contact across their full width. The strain is borne principally by the end of the teeth nearest the motor, with the result that a shearing action takes place, which will sometimes break out a part if not the whole of a pinion tooth. As a pinion wears the teeth become thinner on the side toward the motor, so that a pinion which has been in service until its teeth match with the gear across the full face, may prove stronger under stress than a new pinion. The solid axle gear is to be preferred to the split gear, and, were it not for the inconvenience of removing the car wheel, would doubtless be more generally used. The objection to removing the car wheel for the reason that its fit on the axle is impaired, may be overcome by the use of a wheel with an extended hub, on which the gear is shrunk, as proposed by Messrs. Doyle and Brinkerhoff and in use on the Interborough Rapid Transit Railway in New York.

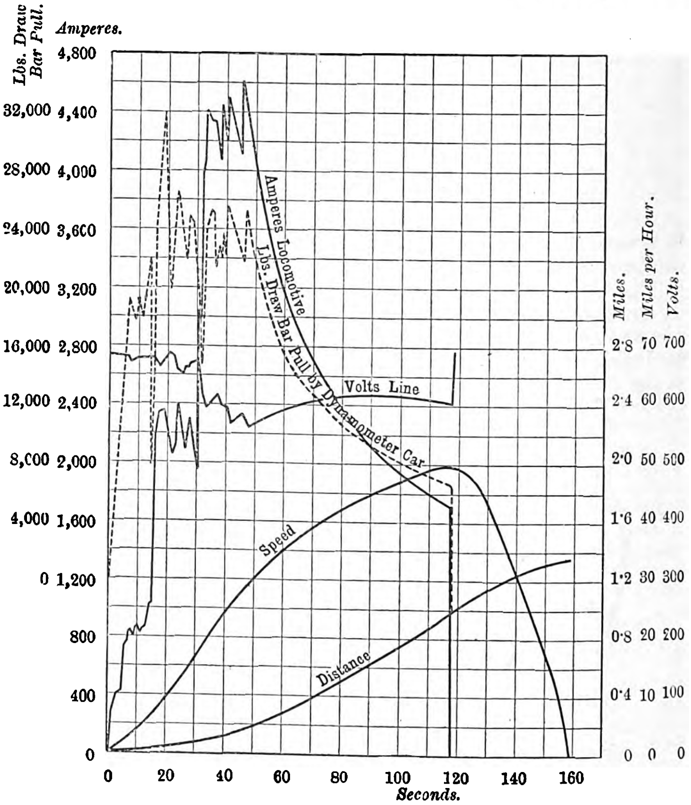

FIG. 1.—ACCELERATION TEST ON NEW YORK CENTRAL LOCOMOTIVE.

11-car train. Total weight of train, 433·6 tons. Test made Sept. 7, 1905.

On the larger equipments, where the circuit breakers have to be set for 1,000 amperes or more, it is found difficult to provide space for them in a position where the arc resulting from a short circuit would be free from danger of grounding to some part of the car. As a substitute for the circuit breaker in this heavier class of work many different forms of fuses have been tried, but none has proved thoroughly reliable, with the exception of a fuse composed of thin copper ribbon enclosed in an insulating chute and surrounded with enough iron to provide a magnetic field. This copper ribbon fuse has been quite generally used on the larger equipments for the past few years, and has given excellent satisfaction. The same type of fuse is applicable to smaller equipments, and in many cases it may be found superior to the circuit breaker, as its reliability is a strong point in its favour. A circuit breaker should have frequent inspection, and in case of several repeated short circuits it may be so injured as not to finally extinguish the arc without an amount of flame that may alarm the passengers.

The best recognised practice is now to instal all wiring in iron conduit. If properly done, with the ends of the pipes fitted with bell mouths or other provision to avoid abrasion of the wire, the car wiring should prove the most safe and permanent part of the electrical installation.

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* Abstract of a Paper read before the American Street Railway Association.

The suggested improvements in wiring apply with even greater force to the lighting and heating circuits, as these circuits have generally been given less attention than the motor circuits. As a source of fire, the lighting and heating wires are dangerous on account of their location in the roof or sides of the car, their inaccessibility for inspection and the fact that current is often left on these circuits when the cars are in the car house.

As the street railways and the steam railroads are now becoming so closely identified, a reference to some of the recent tests of the New York Central electric locomotive will not be out of place. This locomotive had now run over 21,000 miles with trains of varying weights. The maximum speed attained with a train weighing 278 tons, including the locomotive, was 71 miles per hour in a distance of about 4 miles With the locomotive alone, the maximum speed was 85 miles per hour, with the probability that the speed would have been 100 miles per hour had the run been twice the length. The accompanying curves show tests made with an 11-car train, including the New York Central dynamometer car, which were made for the purpose of checking the results obtained from the speed-torque characteristics of the motor.

Fig. 1 shows an acceleration test, all the records of which were taken with automatic recording instruments. The draw-bar curve was taken by the dynamometer car, with no damping device or dash-pot to control the fluctuations on the recording pointer. The comparative steadiness of the pull of the electric locomotive will appeal to those who have seen a dynamometer record, without the damping device, taken from a steam locomotive. Fig. 2 shows the curves of a speed run over the test track with the same train. The notch in the curve at about 190 seconds is caused at that point by the locomotive leaving an additional strip of third-rail which was fed from some distance away. The total weight of this locomotive is 97 tons, of which about 70 tons is on the drivers. The nominal rated power is 2,200 H.P., although the output during acceleration has often exceeded 3,000 H.P. The weight of the train, including the locomotive, was 433 tons.

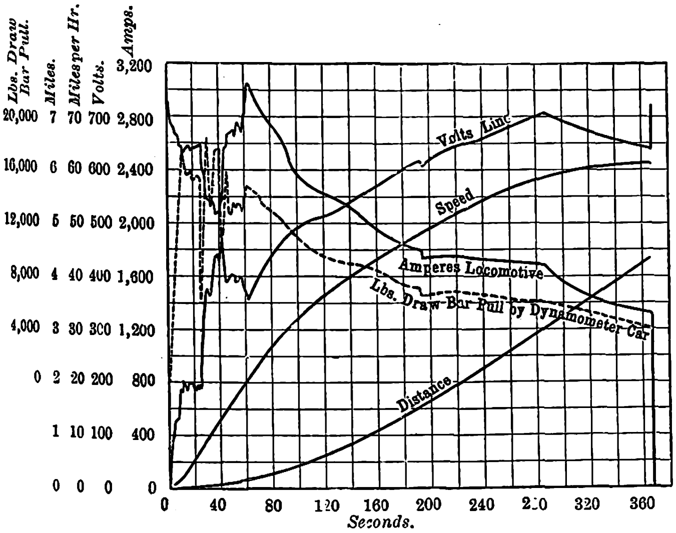

FIG. 2.—SPEED RUN CURVES OF NEW YORK CENTRAL LOCOMOTIVE.

11-car train. Total weight of train, 433·3 tons. Test made Sept. 7, 1905.

## "PERMUTATORS."

BY CHARLES V. DRYSDALE, D.SC.

Among the various methods which have been proposed for the conversion of alternate current into direct current power, but little attention has been given in this country to a device in which much interest has been taken on the Continent, and which has now been evolved to an extent which makes it a formidable rival to the other methods of conversion, by rotaries, motor generators, and rectifiers.

The "permutator," in its latest form, may best be described as a rotary converter in which the exciting field, instead of being provided by an external magnet, is produced by the primary current in a short-circuited magnetic core. This core, with the windings and commutator, may most conveniently be stationary, while collection of the direct current is made by brushes rotating round the commutator in synchronism with the alternate-current supply. The synchronism of the brushes may best be obtained by attaching them to a rotor which moves in a small rotating field leaking from the main core. This brush system being light, and having to exert no torque beyond that of friction on the commutator, can run up to synchronism as an induction motor and afterwards receive a small amount of direct current from the rotating brushes. To enable the direct current to be collected from the rotating brushes they are connected to slip rings on which a pair of stationary brushes press.

The first proposition of this kind appears to have been made in 1888 by Messrs. Zipernowski and Deri,* who started from the ordinary re-entrant Gramme ring with rotating field produced by an independent internal polyphase winding, the ring being either stationary with revolving brushes, or revolving with the double winding. No practical experience with these machines has apparently been published. Messrs. Hutin & Leblanc in France about 10 years later produced the "Panchahuteur,"† which in its earliest form consisted simply of a stationary transformer, the secondary being wound in sections which were connected to the segments of a stationary commutator provided with synchronously rotating brushes. The supply being monophase, the pulsations of the direct current were reduced by joining an inductance in series with the brushes. Two-phase and three-phase supply were also utilised either by separate transformers or by a three-core transformer. In the same year‡ the device was modified by L. Kallir, using two transformers with two-phase supply and half the number of coils, and, employing rotating commutators, contact being made to the commutator bars through slip-rings, the direct-current connections being shown in Fig. 1. In 1902‖ Messrs. Hutin & Leblanc employed a stationary commutator connected to a revolving field transformer. Synchronously revolving brushes with device for adjusting the lead were employed, and coils were introduced to compensate for the field distribution, of which more will be said later.

In the same year MM. Rougé and Faget§ took up the same problem, starting at once with the stationary core and commutator with revolving field and synchronously rotating brushes. This machine they have developed in a very thorough manner by means of several novel and ingenious devices, and many of these permutators of outputs up to 150 kw. appear to be in successful regular operation in France.¶

About four years ago the present writer, in ignorance of what had been done in this direction, hit upon the same device, and was inclined to think that it might show many advantages over the rotary converter. Facilities, however, not being then available for constructing the machine the idea was laid aside, but on hearing of the Rougé-Faget permutator no time was lost in obtaining one for the laboratories of the Northampton Institute, where it has been put under test. Before describing these tests, however, a brief description of the theory and construction of the machine will be given, based on the articles of M. Rougé** published in *La Revue Electrique* in the early part of this year. In them he points out that all electromagnetic devices for converting polyphase into direct-current power must necessarily contain moving fields which by their induction balance the difference of the voltages on the two sides of the device. When the alternating-current and direct-current fields are distinct we have the motor generator, when combined in a synchronous system the rotary converter, and when combined in an asynchronous system the permutator. The most essential difference between the permutator and the rotary converter however lies in the fact that while both make use of synchronous rotation, the permutator only utilises this rotation for collecting the direct current, and not for inducing the voltages as in the rotary.

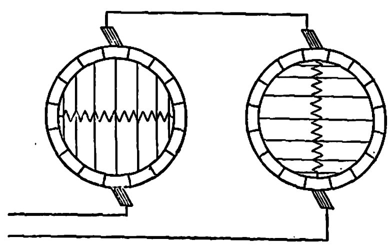

FIG. 1.—KALLIR'S TWO-PHASE PERMUTATOR.

(From *Science Abstracts*, No. 356, 1900.)

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* British Patent No. 12,856, 1888. Also J. Sahulka, "Combined Transformer and Rectifier for Polyphase Currents," *Zeit. Electrotechnik*, Wien, 16, pp. 405-409 and 429-431. 1898. *Science Abstracts*, 505. 1899.

† J. Sahulka: *Loc. cit.*

‡ L. Kallir: *Zeit. Electrotechnik*, Wien, 17 pp., 460-464, September 3, 1899. *Science Abstracts*, No. 356, 1900.

§ *Eclairage Electrique*, 30 pp., 29-38 and 51-61, January 4 and 11, 1902. *Science Abstracts*, Nos. 789 and 790, 1902.

‖ R. Rougé: *Industrie Electrique*, 11 pp., 53-56, February 10, 1902. *Science Abstracts*, No. 1,443, 1902.

¶ The writer saw three of these permutators of 150 kw. each in operation at the Liège Exhibition. He understands that they are in regular use at the Ministère Français des Postes and Télégraphes, the Bureau Central Téléphonique de Passy, at Nieq on the Seine Embankment, Paris, for operating a 15 ton electric crane, the Compagnie des Chemins de fer P.L.M. Lyons for shifting platforms for wagons, &c., &c.

** R. Rougé. *La Revue Electrique*, Tome III. Nos. 26, 28 and 31. January 30, February 28, April 15, 1905.

Fig. 2 is a half sectional elevation of a permutator of 150 kw. capacity and Fig. 3 a diagrammatic representation of the windings as a two-pole scheme. The main iron core S is thus like the stator of an induction motor, except that the slots instead of being open or closed by a thin bridge of iron, have an appreciable radial depth of iron on the inner circumference†, thus completing the magnetic circuit within the core. A small portion of the flux, however, leaks into the central space, within which is a rotor, R, wound with the equivalent of an ordinary ring winding. This winding is short-circuited at intervals of a pole pitch, so that it runs like an ordinary squirrel-cage rotor; but in addition it is tapped at points half-way between the others, which tappings are alternately connected to the direct-current terminals by means of slip rings. The rotor, therefore, runs up to synchronism as an induction motor, and as soon as synchronism is reached receives direct current, so that it drops automatically into step. This rotor carries the brushes BB, which rotate round the commutator C. The whole arrangement is vertically mounted.

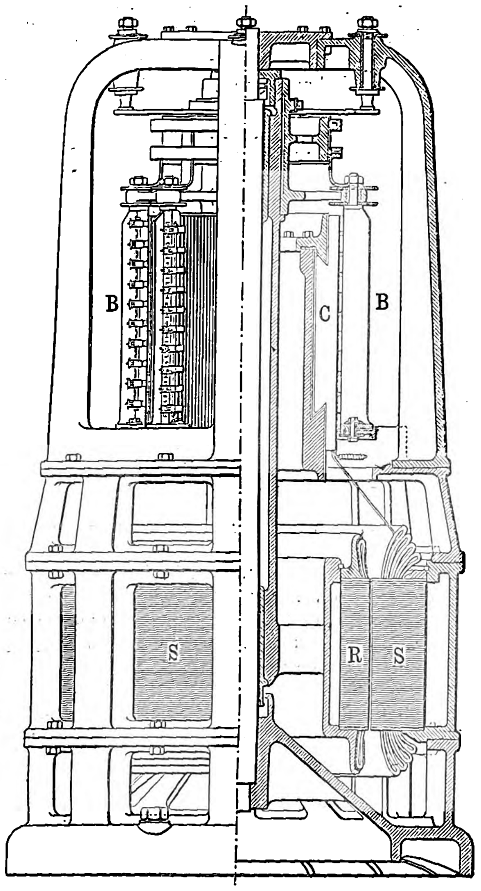

Fig. 2.—Half-sectional Elevation of 150 kw. Permutator.

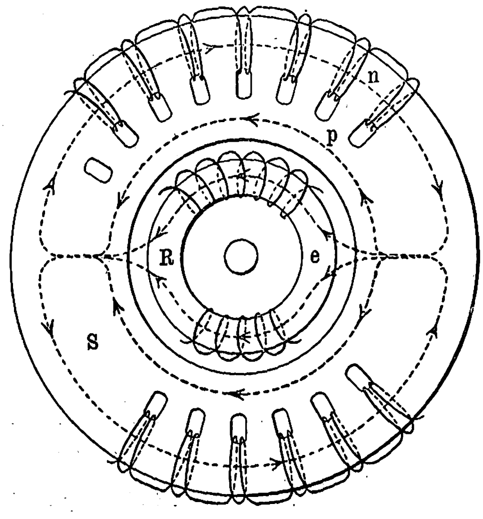

Fig. 3.—Diagrammatic Representation for Permutator Winding.

In comparing the theory of such a device with that of the rotary converter, we notice in the first place that in the permutator the magnetising current is entirely derived from the supply as a wattless current, while in the converter it is the sum of two portions, the external excitation and the wattless component of the armature current. The vector diagram of the currents for the two cases are given in Figs. 4 and 5 (assuming that the direct current balances the alternating current at all points). For the rotary (Fig 4) the total magnetising force OM is the sum of OW, the wattless component of the alternate current, and OE the external excitation. If OC is the direct current, then OA, the alternate current, will have an energy component equal to OC plus the losses in the machine. By making OE equal to OM, the whole of the magnetisation is supplied externally, and the alternate current is simply an energy current or has unity power factor, as is well known. With the permutator (Fig. 5), the moving brushes will alter their position relatively to the current distribution as the load changes, and the total magnetising force OM is made up of a wattless component of the alternate current supply OW, and a demagnetising component OC′ due to the lag of the brushes. The power-factor of the alternate current, therefore, depends simply upon the position of the rotary brushes relatively to the field.

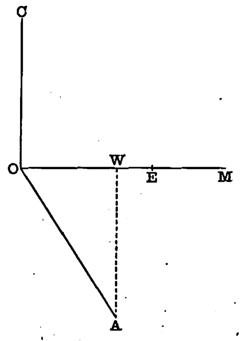

Fig 4.—Vector Diagram for Rotary.

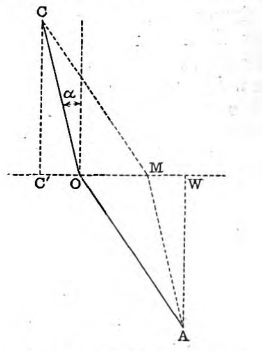

Fig. 5.—Vector Diagram for Permutator.

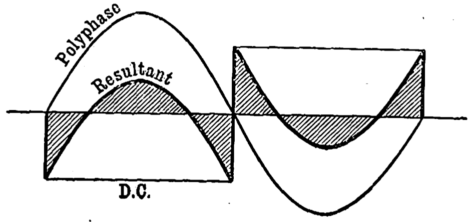

Fig. 6.—Current Distribution in Polyphase Rotary or Permutator.

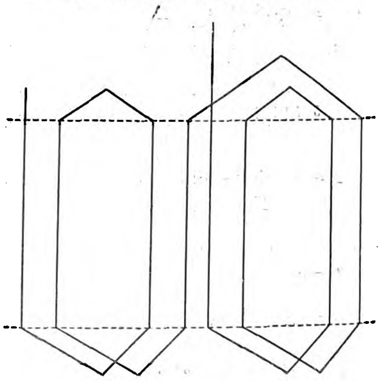

Fig. 7.—Element of Permutator Winding.

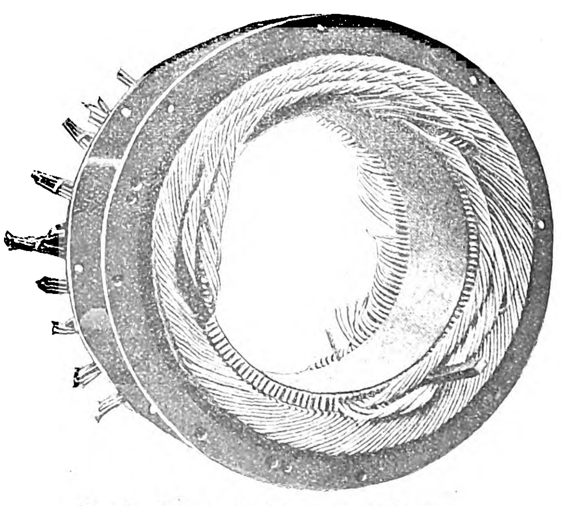

Fig 8.—Stator in Course of Winding.

Another point of difference between the rotary and the permutator is that in the former the inertia of the moving parts assists in retaining the constancy of the direct-current power during variations in the alternate-current power. If I is the moment of inertia of the rotary armature and $\omega$ its angular velocity, we have alternating-current power = direct-current power + losses + $I\omega\dot{\omega}$. In the case of the permutator, however, as the rotation produces no inductive effect we have merely alternating-current power = direct current power + losses.

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† In the single phase machine in the writer's laboratory the thickness of the iron bridge does not appear to be greater than in induction motor practice.

It follows, therefore, that irregulaties in the supply can only be compensated by displacement of the brushes relatively to the neutral position which will, therefore, take place, and care must be taken to avoid hunting being set up.

A second difficulty, which has been found serious, lies in the fact that the direct current instead of neutralising the energy component of the alternate current at all points of the winding, as assumed in the above diagrams, leaving a uniform rotating field, only does so as an average, leaving a very distorted flux distribution. If we take the case of a re-entrant winding fed by a polyphase supply of a large number of phases the distribution of current round the periphery due to the alternate current would be sinusoidal, giving rise to a sinusoidal distribution of magnetising force as is required. Whatever be the magnitude however of the direct current, since it is tapped from two points on the periphery the distribution of current in the conductors must be uniform, Fig. 6. The resultant distribution of current must be therefore as shown, giving rise to harmonics on the direct-current wave and to sparking at the commutator. Messrs. Hutin & Leblanc have surmounted this difficulty by the compensating coils above referred to, which are arranged to have currents induced in them only by the higher harmonic flux variations and compensate for them. MM. Rougé and Faget get over the difficulty in a more radical manner. They prevent the formation of irregular flux distribution by arranging each element of the ring or drum winding to produce a roughly approximate sine distribution. By combining the diametral winding with one or more chord windings of suitable pitch, or making each element of two or more laps with a small advance as in Fig. 7, this distribution may be obtained, and it is found that with two laps or four conductors per element the distribution is sufficiently satisfactory, the variation from sine flux distribution being not greater than 2 per cent.

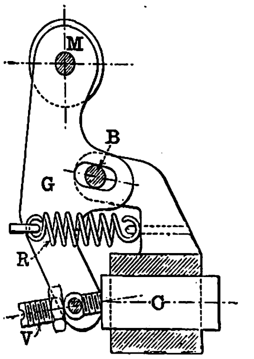
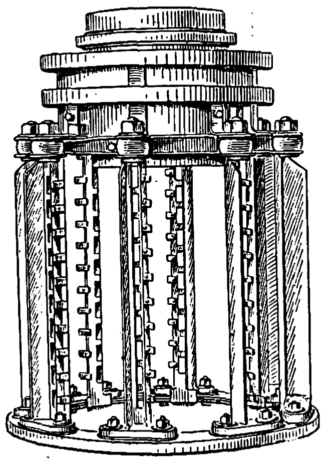


Fig. 9.—Rotating Brush Holder.



ig 10.—Rotating Brush Frame and Slip Rings.

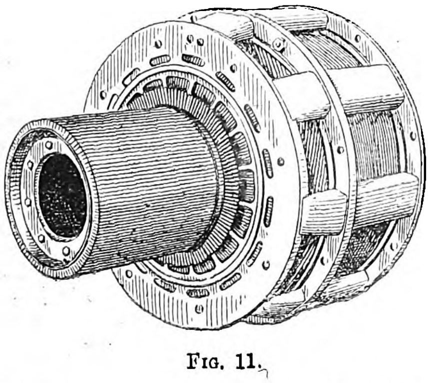


Fig. 11.

The actual winding in course of construction is shown in Fig. 8 and is effected with flexible conductors. The vertical shaft moves on ball bearings in an oil bath, while the rotor is similar in form and winding to that of an ordinary induction motor, except that it is tapped as for a two-phase scheme, the ends of one phase being short-circuited and of the other connected to the direct-current slip rings. This arrangement serves the triple purpose of being self-starting, and self-synchronising, and of forming a damping device to avoid hunting of the brushes. In the writer's opinion it has possibly another valuable application as a field system for turbo-alternators.

The only other mechanical point requiring mention is the construction of the rotating brush-holders. Fig. 9 shows the holder, from which it will be seen that the carbon brush C slides radially in a holder fixed to the rotating brush frame (Fig. 10.) As the rotation of the brushes tends to throw them outwards by centrifugal force this is compensated by a mass, M, on the end of a lever having a slot sliding over an axle at B, attached by a spring, R, and pressing by means of a screw, V, on the brush. The mass centre of the arrangement being at G, the centrifugal force of M produces greater pressure on the back of the brush as the speed rises. The arrangement is so made as to produce a nearly constant pressure between the brush and the commutator over a wide range of speed. The number of commutator segments is double that of the sections of the winding. Alternate segments only are connected direct to the winding, while each of the dead segments is connected to the active segment in front of it through a small resistance, which can be seen projecting from the base of the commutator in Fig. 11. This device is also worth consideration in connection with both direct-current and alternating-current commutator motors. Fig. 12 shows curves of efficiency and power factor for a 150 kw. three phase permutator tested by the inventors. The machines are said to run up and synchronise in three seconds.

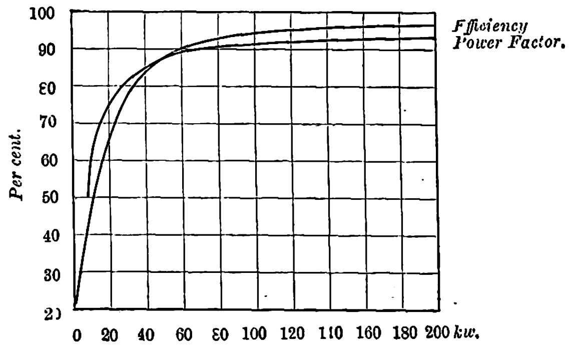


Fig. 12.

The permutator is also made for single-phase current starting on a split phase, and, in view of the importance of the conversion of single-phase current, the machine procured for the Northampton Institute was a 10 kw. single-phase permutator for 110 volt 50 ∿ single-phase current. This machine differs only from the polyphase form in having a second pair of terminals for attachment to an external phase-splitting resistance, and in having the commutating resistances graduated from a maximum to practically zero at the centres of the poles. It is a six-pole machine and therefore runs at 1,000 revs. per min. Careful tests have been made on it by the writer and his assistants, Messrs. A. C. Jolly, C. M. Dowse and F. Gerrard, using special wattmeters to measure both the alternating-current and the direct-current power as the direct current is

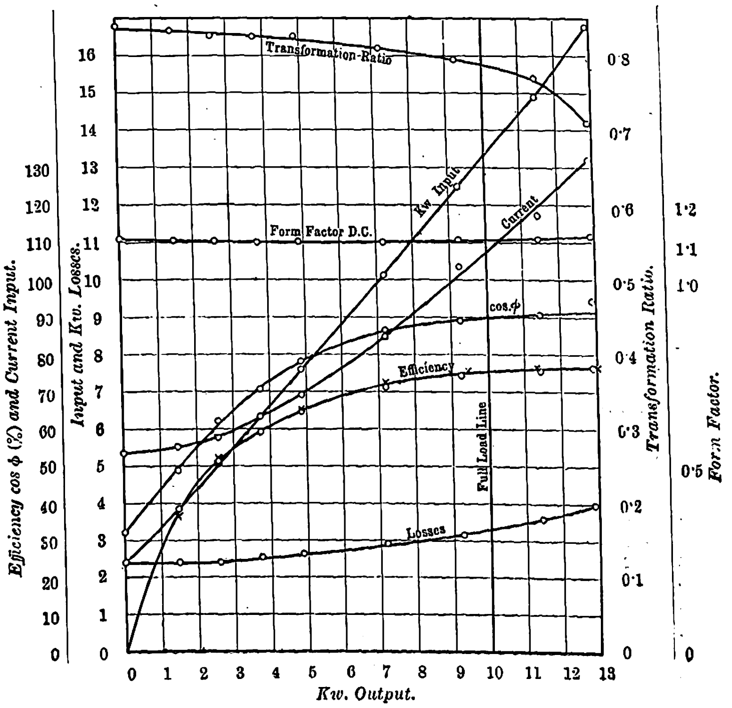
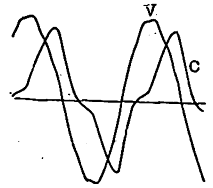


Fig. 13.—Tests on 10 kw. R.F. Single-phase Permutator.

pulsating. These tests are shown on Fig. 13, and their accuracy can be seen from the fact that two tests were taken, and in the second case the wattmeters were interchanged. One of the sets of observations are shown by crosses, the other by rings. The secondary load was on water resistances, which were practically non-inductive. Oscillograph records were also taken, as shown in Figs. 14 to 17, and it will be seen that the direct current fluctuates considerably, as is shown from the form factor determined separately and which is fairly constant at 1·1. In using the permutator for charging accumulators, it was found that the effective current as measured by a soft iron instrument was no less than *three times* the mean current, and the writer does not consider the single-phase permutator suitable for battery charging. Unfortunately, oscillograms have not yet been taken under these conditions, but should show very interesting results.

The permutator starts with about its full load current and synchronises in about five seconds. It runs practically sparklessly at all loads except when battery charging. After a prolonged trial on a battery several of the commutating resistances were damaged and had to be replaced.

The following appear to the present writer to be the principal advantages and disadvantages of the permutator as compared with the rotary converter: Self-starting and synchronising, available almost instantly, extremely simple in operation, light moving parts, small floor space (a 100 kw. machine only requires 1 metre square) lighter and cheaper (M. Rougé claims 15 kg. per kilowatt as against 33 kg. per kilowatt for rotaries, and about the same specific cost), breakage of synchronism has no effect on alternating-current side, available for either single or polyphase current and up to 50 ∾ or more, equal or higher efficiency. Against this may be set as disadvantages the rotating brushes, the absence of ring or automatic lubrication, and the non-adjustability of the brushes or power-factor.* Taking everything into consideration, however, it would seem that the permutator is worthy of very careful attention as being possibly destined to supplant other machinery for conversion of alternate to direct-current power. No trouble has as yet been found with the revolving brushes.



A.C. CURVES.

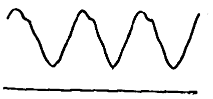


FIG. 14.—D.C. VOLTAGE, OPEN CIRCUIT. OSCILLOGRAPH RECORDS ON 10 KW. SINGLE-PHASE PERMUTATOR. NO D.C. LOAD.

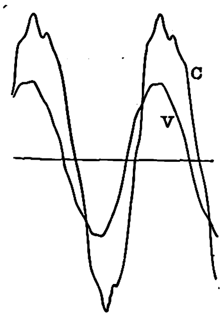


FIG. 16.—A.C. CURVES, HALF-LOAD. OSCILLOGRAPH RECORDS ON 10 KW. SINGLE-PHASE PERMUTATOR AT HALF-LOAD. A.C. SIDE.

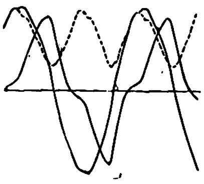


FIG. 15.—OPEN CIRCUIT. SAME AS FIG. 14, WITH SECONDARY P.D. (SHOWN DOTTED) SUPERPOSED ON PRIMARY.

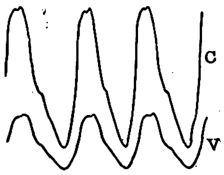


FIG. 17.—OSCILLOGRAPH RECORDS ON 10 KW. SINGLE-PHASE PERMUTATOR AT HALF-LOAD. D.C. SIDE.

M. Rougé calls attention to the fact that owing to the device requiring no skilled operation it may be possible to work long railway lines with small volume of traffic with fairly numerous substations of relatively small power. The suggestion has also been made that single phase traction may be carried out with permutator and ordinary direct-current motors on the car.

MM. Rougé and Faget must be congratulated on the masterly way in which they have attacked a new and difficult problem. The articles referred to are without exception the most perfect exposition of a new technical problem that the writer has seen.

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* In the more recent permutators, including that at the Northampton Institute, one end of the rotor winding is brought to a third slip ring, between which and one of the D.C. terminals a rheostat is connected enabling the exciting current to be varied. This, of course, alters the position of the brushes relatively to the field, and permits of adjustment to secure best commutation, but does not materially affect the power-factor.

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# ON SOME PROBLEMS OF ELECTRO AND ELECTRO-THERMAL CHEMISTRY.*

BY R. THRELFALL, F.R.S.

(*Concluded from page 279*).

## CARBON AS SOLUBLE ELECTRODE.

Carbon has long been an object of interest from another point of view—viz., from that of making a battery in which carbon is the soluble electrode. We might in this way get more mechanical work per ton of coal than we get by burning the coal under boilers. Many attempts have been made to realise such a battery, and I presume that unless we regard the gas battery of Mond and Langer as a solution we should consider the attempt of Jacques as the one most nearly approaching technical requirements. If we make use of electrodes of iron and carbon in molten sodium hydroxide, the carbon behaves as a soluble electrode, and the P.D. of the cell is of the order of about 1 volt. It has, however, been lately shown (Haber and Bruner, *Zeitschrift für Elektrochemie*, p. 697, 1904) that the cell works on the principle of a gas battery under the influence of the oxygen of the air on the one hand and of the reaction between carbon and melted caustic giving hydrogen on the carbon surface on the other. A trace of manganese in the soda makes the process permanent by acting as a substance oxidisable by air and reducible by hydrogen. It is clear, therefore, that the Jacques apparatus brings us no nearer the solution of the question, Can carbon act as the soluble electrode, and if not, why not?

In considering the possibility of a carbon cell it is clear that there are two difficulties. The power of forming a soluble electrode may be confined to those substances we know as metals, or it may be that the difficulty consists in finding a suitable electrolyte—a difficulty, in fact, which has not yet been overcome. It occurred to me that perhaps a gaseous electrolyte might serve. For instance, we might consider such a combination as carbon-ionised oxygen-gold, the oxygen being ionised, say, by radium. In this case the positive ions might be taken by the carbon and the negative ions (electrons) would possibly disappear on the gold electrode. If this were a possible phenomenon (and I am unable to see why it should not be), we should have the current running from carbon to gold outside the cell. It would be a simple experiment for any one having a little radium, though Prof. J. J. Thomson tells me the current would be infinitesimal (supposing one was formed) below a red heat—at which temperature there would be ordinary combustion. An interesting variation would be to try phosgene gas between electrodes of carbon and iron, say. If this ionised in a suitable manner one might get a cell in which both electrodes were made to yield E.M.F. in the right direction and go into combination so that the energy liberated would appear as energy of current instead of heat. Some similar remarks would apply in a general way to a cell in which carbon is replaced by silicon or boron. It is to be noted, however, that in the case of all these elements we have elements which can exist in non-conducting forms, and it might be argued that the mere transformation of the non-conducting to the conducting condition might not necessarily be accompanied by the appearance of that capability of anodic action to which Nernst has given the name of "solution pressure." In other words, the fundamental disposition to go into solution might not exist—the ions might prefer to keep to their own kind.

## ELECTRO-CHEMICAL THEORY.

As the electro-chemical industry rests ultimately upon electro-chemical theory, it should be my duty to refer to any advance in our knowledge of the general mechanism of electrolysis. I say "should be" because so far as I can judge no very definite advance has been made for several years. It is quite possible, however, that such progress has really been made, but has been buried among those portentous papers which, unfortunately, are so common in electro-chemical literature. The most pressing want at the moment among laboratory electro-chemists is a sense of humour in those who contribute accounts of their work to the various journals. Many of these Papers appear to have been written with with the idea that people interested in the subject enjoy reading for its own sake, and actually prefer 50 pages to five. I do not know how it may be with those who are exclusively employed in developing the laboratory side of the subject, but I am sure that I shall have many sympathisers with my opinion that if electro-chemists would study the art of brevity more than they do, a large number of other people would have a better knowledge of the merits of their discoveries. It is a thousand pities that the subject of electro-chemistry owes so little to French chemists—had it been otherwise we should no doubt have had a standard of exposition which would have reduced the volume of the literature in the ratio of, say, 10 to 1. Seriously, the exuberant prolixity of physical chemists is a grave and serious drawback to the study of the subject, for it makes it impossible for anyone to keep abreast of the work unless he rigidly confines himself to a small branch of the science. To pass on. I am afraid we must admit that the high hopes excited by the preliminary successes of the dissociation theory, say 10 years ago, have ended in disappointment. Those of us who can remember the dreary array of unco-ordinated and superficial experiments which formed the subject of electro-chemistry in the latter part of the last century will easily understand how eagerly a theory was welcomed which promised to reduce all to order and regularity. It did not appear too much to hope that a theory specifically limited to dilute solutions, in which domain it certainly was epoch-making, would soon receive such additions as would fit it for use with everyday solutions. No one who has tried to formulate some satisfactory account of electrolytic phenomena in the days before Arrhenius, Ostwald,

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* Inaugural Address to the Birmingham Section of the Institution of Electrical Engineers. Delivered November 22, 1905.

Nernst, and Van't Hoff can have any feeling except that of gratitude to those pioneers who appeared to have straightened out a plain path of calculation through the maze of observations. Alas! it was not to be: further investigation, particularly with solvents other than water and with stronger solutions, has shown that a theory which regards the solvent as having nothing in the way of properties except three dimensions in space is quite unable to cope with the phenomena. The simple ionic hypothesis is now little beyond a cherished memory of what is doubtless one aspect of the phenomena of electrolytic conduction—predominant in solutions of small concentration. I wish I could go so far as to say that the hypothesis in its extreme form is only a memory. Unfortunately this is not the case, for what was once a good servant has grown in its old age into a bad master. I wonder how many young minds engaged in electro-chemical research are being stunted and paralysed by the fashionable necessity of finding an ionic explanation of the phenomena they encounter? Who is not weary of the constant recurrence of chemically abhorrent reactions supposed to occur between ions often invented *ad hoc*, and promoted with all solemnity into equations of equilibrium, and that whatever the strength of the solutions? I have seen cases where ions are apparently manufactured from chemical formula on the *totidem literis* principle as expounded by Swift in the "Tale of a Tub." For instance, chlorine might be split on this system into the ions C and l.

Not only is considerable ingenuity misapplied in the determination to have an explanation of electro-chemical phenomena limited by the dissociation theory at any cost, but the real meaning of experiments is apt to be masked in the process, and the progress of inquiry arrested, by the stifling of curiosity incident on a happy conjunction of gratuitous ions. This is much to be regretted, for I suppose everybody who has worked at these subjects for any number of years must have come to the conclusion that electro-chemical phenomena are mainly chemical, and that their elucidation depends rather on the good old plan of close observation and accurate analysis than on dexterity with a pen and paper. The crying experimental need of the moment is to find a method of separating and accumulating the layer of electrolyte which is within molecular "striking distance" of the electrode. Perhaps some kind of minutely porous electrode through which the electrolyte can be drawn at a rate proportional to the current density, or some fortunate discovery in the domain of membranes used as electrodes, may supply us with the all-important instrument of investigation. Mr. W. D. Bancroft, in a Paper before the American Electrochemical Society in 1905 (of which I received an advance copy), has given many illustrations of the application of pure chemistry to electro-chemical phenomena, and has, in fact, anticipated much of what I had intended to say on this occasion. In view of this Paper I will only say here that the complexity of electro-chemical phenomena is such that a good chemist may be profitably employed for years in elucidating the all-essential detail of the chemical reactions occurring at the electrodes between intermediate products of a single electrolysis, and till this is adequately performed no theorising is of any lasting importance. It is no use to be satisfied with the remark that such and such a reaction is an "oxidation" or a "reduction" process, or that this or that effect is due to "overvoltage"; what is wanted is the purely chemical detail free from the ambiguity of cant phrases. An investigator starting on such researches as are indicated above will do well to make sure that "indifferent" electrodes are really indifferent and not catalytic agents. The discovery by Luther and Brislee (*Zeitschrift für Physikalische Chemie*, Vol. XLV., 216, 1903) of the activity of platinum in certain cases is a matter to be taken into serious consideration, and goes far to suggest an explanation of the disappointing results obtained by many observers who have attempted to apply Nernst's method of curves of current and voltage to every-day electrolysis.

Although the subject of the conduction of electricity through gases has hardly begun to claim the professional attention of the engineer, it is of so much importance that it cannot be passed over. At the present moment it is no exaggeration to say that vastly more is known of the mechanism of gaseous than of liquid conduction, and it does not require much penetration to foresee that an adequate knowledge of conduction in liquids is at least as likely to come from an extension of the principles obtaining in gaseous conduction as by loading the original ionic theory with additional hypotheses. In view of the continuity of the gaseous and liquid states it is hard to believe that som eof the properties on which gaseous conduction depends do not pass over to, and persist in, the liquid state. I know of no experiments on gaseous conduction extended over the critical point and continued into the liquid state. With a sufficient range of data covering a sufficient number of substances it is hard to believe that some insight into the mechanics of conduction would not be obtained in this way. A corresponding research covering the conduction of solutions with less and less solvent and higher and higher temperatures till ultimately the pure fused salt is alone in question would possibly—but less probably—throw light on the whole subject. It would at least be interesting to trace out how the migration velocities become equalised as we approach the state of fusion conductivity.

If we consider the case of molten sodium chloride, for instance, I am unable to understand how the rate of migration of the anions and cations could possibly be different, as there is here no opportunity for change of concentration. Unless the mechanism of conduction is entirely different in fused salts from what it is in solutions, it might be argued that differences in migration velocities depend upon the solvent more than upon the anions and cations themselves: a view perfectly consistent with the known fact that in a particular solvent water each anion and cation appears to have a relative velocity independent of the other and more or less constant.

Some work on migration velocities of a few selected anions and cations extended to a large number of solvents could hardly fail to be illuminating. The material may be actually in existence, but if so, I have failed to come across it.

### New Lamp Materials.

During the last year or two some minor inventions, which are nevertheless both interesting and important, have been reported. Amongst these stand out the magnificent series of researches by which Dr. von Bolton and his colleagues demonstrated the physical and chemical properties of the rare metal tantalum. Our information rests upon a Paper by Dr. von Bolton (*Zeitschrift für Elektrochemie*, Vol. XI., p. 722, 1905), and on a series of patents of the firm Siemens & Halske—particularly 26,775 of 1903 and 21,766 of 1904, dealing with the production of the metal; 12,163 of 1902, application of vanadium, niobium, and tantalum in electric incandescent lamps; and 3,610 of 1905, application of tantalum to cutting tools. Students of Moissan's classical work on the electric furnace, published in 1897, will remember that Moissan had great difficulty in regard to the preparation of vanadium, and did not succeed in obtaining it free from carbon. A study of niobium followed in 1901 (*Comptes Rendus*, 1901, Vol. 133, p. 20), and of tantalum in 1902 (*Comptes Rendus*, 1902, Vol. 134, p. 211), but in consequence of the method employed—reduction with carbon—it was not possible to obtain a metal free from carbon. Dr. von Bolton adopted the very original course of making a rod of brown oxide of tantalum by similar processes to those employed originally for the manufacture of Nernst glowers. Such a rod when heated by an alternating current in a space continuously evacuated is gradually converted into metallic tantalum, the oxygen being removed as fast as it is liberated. A fusion of the product in vacuo under the influence of an electric flame yields what may be considered to be pure tantalum. An alternative and more practical method is to purify the product obtained by reducing potassium fluo-tantalate ($K_2TaF_7$), by sodium, and finally fusing the metal in vacuo by the electric flame. In this purification advantage is taken of the fact that the impurity of the product obtained by reduction with sodium is mainly an oxide of tantalum. By melting the powder in vacuo the oxide is partly dispersed as dust and partly reduced to metal. The smelting must be carried out in vacuo, for at the melting point tantalum combines with oxygen, nitrogen and hydrogen, as well as carbon and most other elements, so it is hard to find an indifferent gas in practicable quantity. The tantalum powder is compressed into a block or into a Thoria or Zirconia crucible with a tantalum lining, and is made the positive electrode of an electric arc or flame; the other electrode being either a rod of tantalum or a piece of silver large enough not to melt owing to the heat being sufficiently rapidly carried away. As an alternative, two tantalum terminals act as electrodes for the arc, and the flame is directed on the compressed powder. It is convenient to heat the vertical side of a mass of compressed powder, for then the metal runs away as it melts and can be collected.

Metal obtained by this process contained nearly 99 per cent. of tantalum and was sufficiently ductile to be drawn into wire of 0·03 mm. diameter. If the metal contains carbon or hydrogen it becomes very hard, and is also hard if it is not perfectly free from its own oxygen compounds, more particularly after forging. The metal appears to withstand the action of acids (except hydro-fluoric) nearly as well as platinum, and is only acted upon by the alkalis when they are in the fused condition. The melting-point of the pure metal is between 2,250 and 2,300 deg., a fact which is turned to account in the application of fine tantalum wire as a glower in incandescent lamps. The specific resistance is not very high, however—rather more than half as much again as that of mercury—so that it is necessary to use a very long tantalum filament in incandescent lamps. The mechanical difficulties of the lamp manufacture appear to have been more or less overcome, and according to Dr. von Bolton an efficiency of 1·5 watts per Hefner candle is obtained at a temperature of the wire of 1,700 deg.; near the melting-point the 1·5 watts is reduced to 0·3. According to the tests of Bell and Puffer, if electrical power costs from 3d. to 5d. per unit it would pay better to purchase tantalum (15 c.p. ?) lamps for 4s. each than to use carbon filament lamps provided free of cost.

I have to thank Mr. Hird for the exhibition of tantalum products which are on the table, and which have been kindly lent by Messrs. Siemens & Halske through his intercession.

There are, however, some unexhausted possibilities about the carbon filament, and the General Electric Co. of America claim to have made a great improvement by graphitising the filaments at a temperature of 3,000°–3,700°C. A filament so heated is quite altered in appearance, and has a greatly-reduced resistance, but the point of greatest interest is that the filament has a positive temperature coefficient. The life of a lamp with these filaments is said to be considerably increased, and an efficiency of 2·5 watts per candle-power is claimed. The exhibit of these filaments is due to the kindness of Mr. Jackson and the British Thomson-Houston Co. (Ltd.).

According to Wedding (discussion *Elektrochemische Zeitschrift*, Vol. XXVI., p. 199, 1905) and others, the loss of efficiency experienced by a carbon filament of the ordinary kind is a real phenomenon, and the diminution of lighting power of an ordinary glow lamp is only to be partially accounted for by the blackening of the bulb, since if the filament be mounted in a clean bulb its light-giving powers are only slightly improved. It is not easy to understand why the efficiency of a filament should fall off with age. Another rival of the carbon lamp is the lamp with osmium filament, and in some ways it seems to me that the manufacture of the osmium filament is a more difficult achievement than the production of the tantalum wire. Osmium, according to Blau, is not sufficiently ductile to draw into a wire, and every chemist who has handled platinum metals regards osmium tetroxide with considerable emotion on account of its dangerously active reaction with the tissue of the eye. The usual analytical method for the separation of osmium—*viz.*, distillation with aqua regia, always a tedious process—has been set aside, and osmiridium denuded of platinum by aqua regia is alloyed with tin or zinc and the ally burned in air or oxygen, the osmium being collected probably as an osmate or osmite from the gases leaving the furnace. It is then a simple matter to obtain osmium in powder by reduction, and the powder is mixed with some organic binding material and the paste squirted through a jewel die. The filaments are then carbonised, and finally heated electrically in air and water vapour, so as to turn out the carbon and reduce the carbide of osmium. The resulting filament is, of course, very rough, and it must require great skill to avoid having spots of high resistance in the filament. The specific resistance is very low, and the lamps as ordinarily made only take 37 to 44 volts.

The efficiency for a life of 2,000 hours is about 1·5 watts per Hefner candle, so that in this respect there is not much to choose between the osmium and tantalum lamp. Personally, I have some doubt as to whether existing sources of supply of either osmium or tantalum could support a large industry, but new supplies may turn up. Neither osmium nor tantalum are as rare as thorium was when the use of that element in the incandescent gas mantle was first attempted.

### SILICA GLASS.

A simple, but useful, little invention has recently been made by Elihu Thomson, by which it is easy to make rough but practical tubes of fused silica. An interesting exhibit of tubes and sheets made by this process was shown to the Royal Society by Mr. Hutton last summer. The process is simplicity itself. A carbon tube or rod is provided with water-cooled connections, and buried in dry sand of sufficient purity, or rather of sufficiently high silica content. On turning on a heavy current for a few seconds or minutes the sand grains fuse together and shrink away from the conductor, which obligingly coats itself with a layer of carborundum for its own protection. The current and duration of heating can be varied so as to yield either a thick or thin-walled tube, though in both cases the tubes are rough and opaque, and stained internally with carborundum. The valuable properties of fused silica are, however, well marked—*i.e.*, the tubes can be heated red-hot and dropped into water without cracking. By dressing these tubes on a carborundum wheel they can be made to have the appearance of nearly white vitreous earthenware. Some years ago I accidentally made a large tube from calcined magnesite in the same way, but was not clever enough to think of making a fused silica tube by the same process.

Some very interesting and apparently successful work on the same subject has been done by the Thermal Syndicate, who have carried the manufacture of silica glass a step further forward. These inventors melt their glass-makers' sand by contact with electric resisters or by radiation from the same, and have overcome the difficulties involved in blowing out the molten mass into moulds or pulling it into tubes. The merits of fused silica were first made known to the modern world by Mr. Boys (*Phil. Mag.*, June, 1887), and in the autumn of that year I repeated Mr. Boys' experiments, and made and used some rods and tubes in the construction of physical apparatus. It is, therefore, a peculiar pleasure to me to be able to congratulate the fortunate inventors of the large scale working of silica, for I believe I have as good reason to appreciate the difficulties they must have had to overcome as any one in the world.

The following paragraph was written before I became acquainted with the work just described, but I let it stand.

At the recent exhibition at Liège there was a display of oxyacetylene blow-pipes of large size, intended to compete with thermit for repairing wrought iron. It is very probable that with silica tubes and rods (made inside carbon tubes from sand) and suitable oxyacetylene blow-pipes it will be possible, even easy, to make any kind of apparatus, large or small, out of opaque silica. The method should also be capable of generalisation for the fusion of those oxides which are reduced with difficulty by carbon—*i.e.*, zirconia, magnesia, and the alkaline earths, and the oxides of vanadium and titanium, provided they are presented in the right state of fineness.

In concluding these brief notices I wish to guard myself from the imputation of making invidious distinctions between inventions I have referred to and inventions I have not touched upon. It is the chemical industry as related to electricity which has determined the selection.

### PRIVATE BUSINESS.

I desire to devote a few minutes to the private business of the Institution of Electrical Engineers in general and of the Birmingham and Midland Local Section in particular.

In regard to our own section, we have to notice that our members are drawn from a very wide area, and it would be, perhaps, more correct to describe us as the "Midland" than the "Birmingham" Section. If this title meets the approval of the members, we might possibly approach the General Council for permission to make the change.

Last year our total membership amounted to 294, so that we are, numerically at all events, an appreciable slice of the Institution of Electrical Engineers. I think we may congratulate ourselves on the quality of the Papers we have had the pleasure of listening to during the session of 1904-1905, for the whole of the Papers, without exception, have been published at length in the *Journal* of the Institution, and that by the recommendation of the London Committee, with which we have nothing whatever to do. Indeed, I do not know who decides questions as to publication, but we in Birmingham must certainly regard him as a man of very sound judgment if he is any particular person, or, in the alternative, as a demonstration of the advantages of collective wisdom if he is a committee.

During the year 1906 it is proposed to entertain in England the Electrical Engineers of America, France, Germany, Italy and Switzerland. A guarantee fund for a substantial amount has been raised and a subscription list will shortly be opened, which I trust will show that English engineers have nothing to learn in regard to the duities of hospitality, in spite of the liberal education they have received at the hands of their foreign colleagues during the last six years.

I attended a meeting of the Committee in London which is engaged in making the arrangements, and ventured to express what I believed to be the wish of the Birmingham and Midland Section—to take a fair part in any programme of entertainment which might be proposed.

The date of the gathering cannot be finally agreed upon till the wishes of our guests are ascertained, but it seemed to us that the latter part of June and first week in July would be a good time for our friends to visit England if it suited them in other respects.

The growth of the electrical industry cannot be better illustrated than by an examination of the list of officers and members issued on August 31st last. From this it appears that our total membership now stands at the large figure of 5,679, of which just less than 1,000 are full members; associates and associate members numbering about 1,000 in each class. The total membership of the Institution of Civil Engineers on July 1, 1902, was 7,876, of which 1,158 were students. The membership of the Institution of Mechanical Engineers is 4,649, of which 490 are "graduates."

During the past year we have heard a great deal about the military weakness of the country and the danger to which such a condition of affairs exposes us. I suppose there are no people in the world less inclined to the absurd and archaic practice of war than the population of Great Britain, but experience shows that war is not always to be avoided even by the most peace-loving people. It is, therefore, quite a practical question as to how the country is to be placed in such a condition of defence—offensive defence, if you like—as will ensure due freedom for the development of the Empire at large, and avoidance of panicky conduct, with all its financial and industrial disturbance, at moments of crisis. The extreme views may, I believe, be summed up in the demand for conscription on the one hand and implicit confidence in the power of the Navy on the other. Extreme views rarely prevail in this country, so we may fairly anticipate that some middle course will be found in this as in other matters of engineering compromise. The most obvious and natural course would seem to be that all young men, in proportion to their leisure, should acquaint themselves with the first principles of soldiering. It is a good and a pleasant thing for young men to be able to ride, shoot and sleep in the open, but these things all require practice. Many things are taught in technical schools and universities nowadays which it used to be considered could only be learned by blundering along at the heels of others self-taught by long experience. For instance, I saw the other day that in America the technically-instructed mine manager is slowly and steadily replacing the old "practical" captain. I myself know a case which happened many years ago of a young man who, having mechanical tastes, was sent as a premium pupil to a firm of engineers, and spent more than a year in front of a drilling machine. Every one nowadays will admit that most of the arts of the engineer are best and most thoroughly learned by those who are definitely instructed in them in some place built and equipped primarily for the purpose of teaching, and who at the same time have access to some place where the same arts are being employed for commercial ends. It may be natural obtuseness on my part, but I must admit that I cannot see why soldiering is an art that cannot be learned to some extent on the principles of the technical school. For instance, a man can certainly be taught to shoot, to ride and to look after his horse, and also to look after himself, so as to keep in health in camp. It may be urged that such a school as I am thinking of already exists in volunteer training camps, and though I am too ignorant to say "yes" or "no" to such a contention, I would point out that a camp held at a definite time and for a definite period hardly meets the case. The University of Chicago set an example of a place free from vacations; individual teachers and students of course required and had vacations, but the place as a whole does not (or did not) shut down for several months in the year. It was (or is) a place at which education was (or is), so to speak, "on tap," and people went there when their other engagements permitted, and came away on the same principle. Now, if there was a sort of soldiering school established on these lines, I think very many young men would feel the call of duty to attend it who cannot or will not make it their business to go into a volunteer camp held at some arbitrary date. Most young men, I believe, feel that they would like to take their proper share in defending their country; but, as things are, the means are often wanting, and the struggle for existence is too severe, and nearer duties too pressing for opportunity to exist. To most people I am afraid military training means drill and little else, and no one can deny that company, or even battalion, drill is one of the most dreary and dullest occupations in the world, and it cannot be rational to suppose that young men of education should be put through a course intended for ploughboys some centuries ago. No doubt there would have to be some sort of drill, but it should be of a kind suited to sensible people, and not directed, as much volunteer drill is, to the vain emulation in matters of trivial precision of the professional soldier, who has to be kept at drill to fill up his day.

There are two organisations of young men in this country fitted above all others to initiate such a system of training as I have suggested—the universities and the engineering societies. In mediæval times the University of Oxford at all events was a centre from which national movements orignated, and in the young men of the engineering societies we have those who will in time control most of the industrial activities of the nation and form the brain of the industrial community. I hardly know how far such a training as I have indicated would go towards solving the problem of national defence, for it does not aim at making finished soldiers any more than the technical school aims at making finished engineers, but it would, I think, be the means of providing a nucleus of educated men capable of taking their place in the national defence, with a knowledge of elementary things only attainable by practice, and thereby immensely shortening the time necessary to make them efficient soldiers. I have purposely refrained from filling in any details, for I am not entitled by knowledge or experience to do so, and yet I have long felt that our present system of volunteering leaves much to be desired if soldiering be considered a serious art—and that it is I have no doubt whatever.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

*Mechanism of Radiation.*—H. A. Lorentz attacks the main outstanding difficulty of the electron theory in a Paper "On the Radiation of Heat in a System of Bodies having a Uniform Temperature." A body in a state of thermal equilibrium with its surroundings absorbs as much heat as it emits. If the emission of heat is due to the revolution or vibration of electrons, these will be subject to a severe damping, and in order to maintain their motion, a considerable E.M.F. will be necessary. The author proceeds to calculate the amount of this E.M.F. In view of the formidable mathematical difficulties involved he has recourse to a number of artifices. He substitutes for the simple vectors **E, B, H** and **C** certain complex vectors, all of which are harmonic functions of the time with the frequency $n$. Thus they contain the factor $e^{int}$, and a differentiation with respect to time amounts to a multiplication by $in$. He arrives at an important new theorem : If an electromotive action applied at a point, P, in the direction $h$ produces at a point, P′, a current whose component in an arbitrarily-chosen direction $h'$ has a certain amplitude and phase, then an equal electromotive action taking place at the point P′ in the direction $h'$ will produce a current in P whose component in the direction $h$ has exactly the same amplitude and phase. This theorem enables him to calculate the amplitude of the E.M.F. to be applied to an element of volume, $s$, in order to make it emit radiation obeying Kirchhoff's law. In any given direction this amplitude is of the form

$$\frac{4\pi c}{n}\sqrt{\frac{2ka_1 dn}{s}},$$

where $c$ is the velocity of light and $n$ the frequency. The author does not proceed for the present to the consideration of individual molecules, his object being to discover a possible mechanism of absorption and emission in the elements of volume of a substance.

[H. A. Lorentz, *Proceedings* of the Royal Academy of Sciences, Amsterdam, November 22, 1905 ]

*Inertia and Radiation.*—A. Einstein is led to some conclusions of fundamental importance by a consideration of the manner in which the velocity of light enters into several physical quantities where its influence was hitherto unsuspected. The simple operation of measuring the length of a rod in motion gives different results accordingly as it is measured by an operator at rest or by an operator moving with the rod. Problems involving moving bodies can, therefore, only be rigidly solved by referring them to co-ordinate axes moving with them, and then transforming the results to axes at rest. In doing so the author employs what he calls the "principle of relativity," which he formulates thus: The laws according to which the states of physical systems change hold equally good for two co-ordinate systems in parallel and uniform translational motion with respect to each other, and the changes of state may be referred to either of them. The length of a rod moving with the moving system, with its axis in the direction of motion, will, when measured in the system at rest, and in the moving system differ in the ratio $1:\sqrt{1-(v/V)^2}$ in the two systems. This is Lorentz's well-known ratio. A timepiece moved away from another with which it agrees, and taking through any path (say round the earth) in the time $t$, back to its original place, will be in arrear by $\frac{1}{2}t\left(\frac{v}{V}\right)^2$ seconds, $v$ being its velocity, and V the velocity of light. But the most striking conclusion is that the inertia or mass of any material body, just like the mass of the electron, depends upon its internal energy. If a body gives out an amount of energy L in the shape of radiation, its mass is diminished by the amount $L/V^2$. But the species of energy does not really matter. Whatever energy is given out diminishes the mass and vice versa. The mass of a body is a measure of its internal energy. For every erg of energy given out it loses $\frac{1}{V^2}=\frac{1}{9\times10^{20}}$ grammes of mass, so that 1 gramme of mass would represent $9\times10^{20}$ ergs. The amount of energy given out by bodies is as a rule quite insufficient to affect their mass perceptibly. But there is just a chance that the radioactive bodies, which emit comparatively enormous quantities of energy, may furnish an experimental test of these conclusions.

[A. Einstein, *Annalen der Physik*, No. 11, 1905.]

*Transit of Ions in the Arc.*—According to the most modern view, as enunciated by J. J. Thomson in one of his recent works, the phenomenon known as the Electric Arc is explained on the assumption that the positive and negative electrodes emit respectively positively and negatively electrified corpuscles or ions, which, under the influence of electric repulsion, travel across the space occupied by the arc and bombard the electrode opposite to the one from which they have been emitted. It is further supposed that the electric current is itself conveyed by these ions, and that the high temperature of the electrodes is produced by their bombardment. About a year ago it occurred to A. A. Campbell Swinton that it should be possible to test the correctness of, at any rate, some portion of this theory by deflecting—by means of a magnet—either the positive or the negative ions into a Faraday cylinder placed with its aperture just touching the centre of the arc, in a manner somewhat similar to that adopted by Perrin, for demonstrating the electric charge carried by cathode rays. The experiment was tried, but it was found that no definite results could be obtained, owing to the erratic behaviour of the arc, which proved very unmanageable, and preferred to divide itself into two arcs between the carbon electrodes and the exterior of the Faraday cylinder, which was rapidly destroyed by fusion. More recently the author has made the experiment again in a somewhat modified form, and has obtained results which appear to prove conclusively that the theory, as above described, is correct, and that positively and negatively charged carriers do actually travel from the positive and negative electrodes respectively along the arc in opposite directions, and do bombard the opposite electrodes. The Faraday cylinder was placed inside one of the carbons, which was perforated in front to let the ions pass. The lamp was enclosed in a glass tube, which was slightly exhausted. The current was reversed several times, and the charge received by the Faraday cylinder varied accordingly.

[A. A. Campbell Swinton, Paper read before the Royal Society, November 16, 1905.]

*Conductivity of Dilute Sulphuric Acid.*—As is well known, the equivalent conductivity of neutral salts when dissolved in water approaches a limiting value as the dilution is increased, and, in terms of the ionisation theory, this limiting value corresponds with complete ionisation. With solutions of acids and alkalies, however, the phenomena are different. As dilution proceeds, the equivalent conductivity reaches a maximum at a concentration of about a one-thousandth or a two-thousandth of a gramme-equivalent per litre, and then falls rapidly as the dilution is pushed farther. It has been supposed that this diminution of equivalent conductivity at extreme dilutions is due to interaction between the solute and the impurities which remain even in redistilled water. W. C. D. Whetham has endeavoured to elucidate this question by adding slight impurities to pure water, and finds that within the limits of experimental error, the equivalent conductivity of a dilute acid is not affected by boiling the water under diminished pressure, though the conductivity of the solvent is thereby much diminished. The equivalent conductivity of the acid is also unaffected by the addition of a small quantity of potassium chloride to the water, though the conductivity of the solvent is thereby much increased. But, by the addition of a little carbonic acid, the equivalent conductivity of the sulphuric acid is diminished appreciably. It is natural to conclude that, while the presence of carbonic acid would produce a diminution of equivalent conductivity of the same character as that observed, it does not explain the total effect. It is just possible that the residue may be due to slight traces of ammonia, whose effect the author has not yet studied.

[W. C. D. Whetham, Paper read before the Royal Society, November 16, 1905.]

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## THE DESIGN OF ELECTRIC SUPPLY NETWORKS.

Two Papers on the same subject, but entirely different in character, were read at the last meeting of the Manchester Local Section of the Institution of Electrical Engineers. Mr. S. J. WATSON's Paper on "Street Cable Systems," an abstract of which is published elsewhere in this issue, was as severely practical as Dr. W. G. RHODES' Paper was essentially academic. Mr. WATSON's Paper revived the controversy as to the respective merits of the three different methods of laying cables: the "direct in ground" system, the "solid" system and the drawn-in system. One of the speakers in the discussion observed that this controversy resembled the famous fight between high tension and low tension, in that each system had its good points and the choice between them had to be guided by local circumstances. The analogy is not quite complete, however, for while in the present condition of the electricity supply industry we could not do without both high-tension and low-tension systems, there would be no great difficulty in laying out any cable network entirely on one of the three alternative plans. It is an excellent testimonial to cable manufacturers and distribution engineers that three alternative systems equal in excellence have been made available. Still, there can be no doubt that in some situations and for certain purposes the engineer must be guided by circumstances. For instance, we can recall a case in which a lead-covered cable, protected only with a light armouring of galvanised iron wires, was laid directly in the ground 14 years ago, and it still carries current daily at 2,000 volts pressure, while other cases can be cited in which thick armouring and lead have been destroyed by certain soils within a couple of years of the cable being laid. As there are in any town, and in almost every district of it, a number of lead water service pipes, it should always be possible to ascertain whether the soil has any marked action upon lead. It is not difficult to lay armoured cables in the ground in such a manner that they are sufficiently well protected against mechanical damage, and we cannot but think that much expense could be saved by a more frequent employment of this simple method of laying. The objection frequently raised to this practice, that it necessitates the opening up of a great length of street at one time, applies with equal force to the "solid" system. When the choice lies solely between the "solid" and the drawn-in system—we employ the former expression to indicate only cables laid in bitumen or similar compositions and do not include the "direct in ground" systems in the category as does Mr. WATSON—then the broad principle laid down by Mr. LEONARD ANDREWS in the discussion is the nearest generalisation which can be given: feeders drawn in, distributors solid. As a matter of fact, the practice of laying feeders as well as distributors on the "solid" system is fast gaining ground, while drawn-in distributors are comparatively rare, except in particular cases. Although much of the ground in Mr. WATSON'S Paper has been gone over before, he gives some useful figures and data, and the very fact that some of these have not been accepted without discussion has added to the usefulness of the evening's work at the Manchester Local Section. The question of earthing the lead sheathing of cables was raised both in the Paper and the discussion, and on this we must join issue with Mr. WATSON. When the combined resistance of the lead sheathing and armouring is higher than that of the conductor of the cable, and when lead, with its low melting point, is an essential part of the protective covering, the sheathing should certainly be earthed as frequently as possible and through as low a resistance as possible. If the whole sheathing were insulated along its length and then earthed at definite and frequent intervals through a suitable resistance, as suggested in the Paper, this might be a better arrangement theoretically; but in practice it could not be realised, and the insertion of resistances at the earthing points would be a dangerous expedient.

Dr. S. G. RHODES' Paper on "The Calculation of Electric Feeders" was not welcomed so warmly as Mr. WATSON'S. It was a pretty example of calculus working, but like so many of such efforts, both in Papers and books, it is not very applicable to the everyday problems of the mains designer. Curiously enough the ideal "feeder" treated by the author is almost, but not quite, a distributor rather than a feeder, for he assumes a regularly-tapering current with its maximum value at the generating station. Feeders are in practice mostly employed to carry a current of uniform value from the generating to the feeding point. Sometimes, especially in tramway practice, a feeder will be tapped at a number of feeding points and will be stepped down at each so that it worked at an approximately constant current density throughout its length, and this is the nearest approach to a conical feeder that we can offer the author as a pitch surface upon which to wrap his integration signs. The greatest simplification in the design of electrical distribution systems generally is the adoption of a definite current density as a standard for each case. This current density should be that fulfilling the conditions of greatest economy for the circumstances of the particular case. Questions of permissible variation of voltage and possibility of regulation must be considered, but it is almost safe to say that if these lead to any serious and general departure from the most economical density, an investigation should be made to see whether the system of generation and distribution adopted is not unsuitable for the area served. The advantages of designing on these lines are the simple and easily remembered or tabulated relations between the current to be delivered and the weight and cost of copper per unit of length, the uniform drop in voltage per unit of length and the uniform rate of loss of energy per unit of length and of current. The limit of economical distribution as fixed by permissible voltage drop and the relative cost of regulating by boosting or other means, and of employing more than the economical cross-section of copper in any given case beyond the limits are easily dealt with from this basis.

# OBITUARY.

## SIR HENRY CHARLES FISCHER, C.M.G.

We regret to record the death of Sir Henry C. Fischer, C.M.G., a director of the Eastern Telegraph Co. and until 1898 Controller at the Central Telegraph Office of the General Post Office. Sir Henry, although of a retiring disposition, had many friends, by whom he was held in high esteem, and his death will be deeply deplored.

Henry Charles Fischer was born in 1833, and commenced his career in the Hanoverian Government service in 1852. In 1856 he came to England, entering the service of the Electric & International Telegraph Co., in which he quickly rose to the position of superintendent of the foreign department, and in 1860 the London inland branch was also placed under his charge. At the transfer of the telegraphs to the State in 1870, Mr. Fischer was deputed by H.M. Postmaster General to organise the staff and other arrangements of the new Central Telegraph Office, of which he was appointed Controller. In addition to this position over the largest and most important telegraph office in the world, a number of important special duties have at various times been entrusted to him. In 1877 Mr. Fischer went, with Mr. W. H. (now Sir William) Preece, on a special mission to America for the purpose of reporting upon the American telegraph system, and, in addition to serving on various departmental committees, he was deputed by the Postmaster-General to conduct negotiations with several foreign administrations. He also acted as one of the British Government delegates to the International Telegraph Conferences at St. Petersburg in 1875, London 1879, Berlin 1885, Paris 1890 and Budapest 1896. Mr. Fischer was in 1895 made Knight of the Order of the Dannebrog by His Majesty the King of Denmark, and on January 1, 1896, Queen Victoria conferred the honour of a Companionship of the Order of St. Michael and St. George upon him. For his services in connection with the simultaneous transmission of Her Majesty's message of thanks to her people throughout the world on Diamond Jubilee Day he was presented with the jubilee commemoration medal. His Majesty the Emperor of Austria was also pleased to command the expression of his highest acknowledgments of Sir Henry's services at the International Telegraph Conference at Budapest in 1896. On his retirement from the British Government service in 1898 he received the honour of knighthood from her late Majesty, and in 1899 the German Emperor conferred upon him the Royal Order of the Prussian Crown of the second class. Sir Henry has been a director of the Eastern Telegraph Co. since 1898, and he represented the Company as a delegate at the International Telegraph Conference of London in 1903.

Sir Henry had been ailing for some months prior to his death, but it was not until two or three weeks ago that his illness became serious. He died at his residence at Bromley (Kent) on November 30th. The funeral took place at St. Luke's Cemetery, Bromley, on Monday, and was attended by representatives of the Post Office and the Submarine Telegraph Companies and other personal friends. Among those present from the General Post Office were Mr. John Ardron, Mr. J. C. Badcock, C.B., Mr. P. Benton, Mr. H. S. Carey, Mr. A. Eames, Mr. J. W. Eames and Mr. A. F. King; the Eastern Telegraph Co. was represented by Sir John Denison-Pender, K.C.M.G. (Managing Director) and Mr. A. R. Hardie (Secretary); and among other friends were Sir John C. Lamb, C.B., C.M.G., Mr. F. Ward, of the Commercial Cable Co., and the Editor of *The Electrician*. Wreaths were sent by the Secretary's office G.P.O., the Chairman and Directors of the Eastern Telegraph Co., the Controller's office C.T.O., the lady superintendents, C.T.O., and many others.

## REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign book.)

**High-tension Power Transmission.** A series of Papers and Discussions presented at the meetings of the American Institute of Electrical Engineers. (New York: McGraw Publishing Co.) $3.

In 1902 the American Institute of Electrical Engineers appointed a committee of five of its members to collect data respecting existing practice in electric transmission at high voltages. This committee sent out printed lists of questions to the various high-tension schemes in the United States, with a request that answers to the questions be filled in and the lists returned. They also instituted discussions on chosen topics which brought forth, from engineers taking part, a large amount of information relating to the work in question. Previous to each discussion, there was read an "introduction" prepared by some member of the Institute prominently engaged in transmission work. These discussions took place at regular Institute meetings, and, together with the "introductions," they formed the substance of the volume now before us.

It would be impossible, with the space at our disposal, to give an adequate résumé of the contents of this book, but it may safely be said that it forms a most valuable work of reference regarding high-tension transmission.

**Decimal Coinage and the Metric System.** By EDWYN ANTHONY (London: George Routledge & Sons.) 2nd edition. 2s. 6d.

The full title of this book is "An Enquiry into and an Explanation of Decimal Coinage and the Metric System of Weights and Measures." After studying it for some time the reader begins to wonder whether the author is for or against the metric system, but on the whole he seems to be an opponent. This conclusion is strengthened by the fact that he quotes a large number of speakers and writers who do not advocate the adoption of the metric system, but he consigns to outer darkness all those who favour it. The chief feature of the second edition of the book, as compared with the first, seems to be the addition of Mr. Carnegie's opinion on the subject. In conclusion we may quote a short passage which gives an excellent idea of the author's style and of Mr. Carnegie's opinion. Referring to his inability to find any exposition of Mr. Carnegie's ideas, the author continues:—

> The foregoing statement appeared without comment in the first edition of this book. As soon as published I sent a copy to Mr. Carnegie, and asked permission to insert in a second edition his view of the question. Mr. Carnegie has graciously acceded to that request, and I highly esteem the privilege of being the medium of conveying to the public the opinion of this most illustrious man upon so important and difficult a subject. Mr. Carnegie thinks that Britain should decide to get gradually into line with her children across the Atlantic, with whom she must finally merge, or dwindle, relatively to the few coming great nations, into a small unimportant Power, only because of her small area—with larger area she would occupy front rank.

It would be interesting to have Mr. Carnegie's opinion as to the rank Britain now holds, in spite of her small area.

**Die zweckmässigste Betriebskraft.** By FRIEDRICH BARTH. In two volumes, 80pf. each. **Die Gleichstrommaschine.** By C. KINZBRUNNER. (Leipzig: G. J. Göschen.) 80pf.

The three booklets under review form part of the "Göschen" series of little volumes on a large variety of scientific and other subjects, intended to provide the intellectual public with an elementary, yet accurate, account of the subject considered. In the three volumes the matter is chiefly dealt with from a descriptive point of view, but simple calculations are occasionally indulged in. Clear language, well-chosen diagrams and illustrations and a neat get-up are also common to all three volumes.

Herr Barth opens Volume I. with a popular discussion on the nature of energy and its conversion from one form to another, and then deals with reciprocating steam engines, steam turbines and auxiliaries from an engineering and commercial aspect. In comparing different kinds of engines and motors commercially, the author assumes steam engines (running 3,000 hours in a year) to depreciate at the rate of 7 per cent. per annum, and electric motors to depreciate at the rate of 6 per cent. per annum. The actual difference is decidedly greater. In Volume II. all other types of motor are dealt with, including internal-combustion motors, water wheels and turbines, hot-air motors, wind motors, electric motors and so on. Some 20 pages are devoted to electric motors, and numerous tables of costs of mechanical energy from electric motors of different sizes are given. In these tables the depreciation is put down as $2\frac{1}{2}$ per cent.

Herr Kinzbrunner's volume on continuous-current generators and motors is more ambitious, inasmuch as it includes a simple method—shorn of refinements of secondary importance—of calculating continuous-current machines. A chapter at the end of the book contains advice as to the testing and treatment of electric machines. It is not quite clear to what section of readers this book is to be recommended; it is too technical for the general reader and not elaborate enough for the engineer. Perhaps it will be useful to the amateur and the dynamo and motor attendant.

## STREET CABLE SYSTEMS.*

BY S. J. WATSON.

In an electrical supply undertaking the capital outlay on feeder, distributor and service cables usually represents about two-fifths of the total expenditure. The large investment involved, coupled to the fact that the satisfactory maintenance of the supply depends so much on the absence of faults and leakages makes it necessary that careful consideration should be given to the design and arrangement of such systems. Serious breakdowns to the generating plant or accessories causing interruptions in the supply are fortunately rare, which speaks well for the attention given to this portion of the undertakings, but the technical papers almost weekly report a failure of the supply in one town or another through defective mains.

All cable systems may be divided, broadly, into two classes: (1) Draw-in systems, (2) solid systems. It is difficult, however, to classify under either of the above headings the various systems of bare copper in iron, stoneware, brick or concrete conduits. The conductors are invariably copper tape from 1 in. to $1\frac{1}{2}$ in. wide and $\frac{1}{8}$ in. to $\frac{1}{4}$ in. thick, resting on porcelain insulators fitted to the conduit every 3 ft. or 4 ft. Heavy sections are made up of several tapes laid together. When the strip is laid on edge it must be considered a solid system, as the strip is wedged to the supporting and to the jockey insulators to prevent side sag, but if laid flat and strained up into junction boxes it may be claimed as a draw-in system. To ensure the satisfactory drawing in of additional strip, the conduit must be laid reasonably straight and be provided with inspection boxes at frequent intervals. A large amount of town lighting work has been carried out in the past with bare copper, and fairly satisfactory results are still being obtained with pressures up to 460 volts. For heavy sections it is undoubtedly cheap, but owing to the increase in pressures from 110 to 220 volts and the consequent decrease in the sections required, and also on account of the large reductions in the cost of insulated cables, this advantage is not now of so much importance as it was 10 years ago. Very little new work of this kind has been put down recently probably because the Board of Trade does not look with favour on the system on account of the liability of injury to the public through explosions.

*Draw-in Systems.*—A single cast-iron pipe was probably the first to to be used for the draw-in system. It offers several advantages such as mechanical strength, long life, and is easy and convenient to lay with either spigot and socket, lead or rubber ring joints. Wrought-iron pipes have been used, but in some soils they have but a short life, and may require frequent renewal. For concentric or multicore cables either of the above-mentioned single-way pipes may be used, but with a number of single cables it is better practice either to use a separate pipe for each cable, which increases the cost, or alternatively a multiple-way conduit. Multiple-way cast-iron conduits can be obtained, but the cost is prohibitive except for quite special work owing to the difficulty in casting each way perfectly smooth and true.

Bitumen conduits with multiple ways are not sufficiently strong and rigid to maintain their shape, and with a slight increase in temperature through an overloaded cable or other cause were liable to collapse and form practically a solid system.

Probably the most largely used conduit with two or more ways are those made of stoneware. The cost is reasonable, the mechanical strength is sufficient for most positions without further protection, and its insulating properties are good. The material is, however, somewhat brittle and liable to damage when the ground is afterwards disturbed for other purposes, and as the lengths are from 2 ft. to 3 ft. it is difficult to support if a cutting of any considerable width is required under it. The type most generally used at present is provided with what is practically a bored and turned joint with the bedding faces of both spigot and socket made up of a pitch or bitumen compound. To make a watertight joint between lengths when laying the faces must be painted with a mixture of resin and tallow or of Stockholm tar and the lengths lightly hammered together. This method effects a considerable saving in time compared with either molten bitumen or cement, which delays the work while the materials set.

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* Abstract of a Paper read before the Manchester Local Section of the Institution of Electrical Engineers, November 28th, Mr. S. L. Pearce in the Chair.

Multiple way concrete conduits have been extensively used for multicore air space telephone cables, the joints being made with cement. A continuous conduit constructed of concrete has recently been designed, and has been adopted by several supply undertakings. The leading features of the system consist of light gauge iron piping which before being used for the formation of the conduit is coated with a compound possessing a low melting point and good lubricating qualities. The pipes are screwed together and laid in the trench with suitable wood spacing bearers and the concrete is filled in, under, around and over the pipes. After allowing sufficient time for the concrete to set a steam jet supplied from a small boiler through a flexible pipe, is applied to the interior of the pipes, which causes the compound to soften and permits of the withdrawal of the pipes length by length. Some of the compound is retained by the surface of the concrete, and presents a smooth surface for the cable when drawing in.

Cement-lined light gauge wrought pipes have been used largely in America, and also in this country, where work has been carried out by American contractors. The pipes are usually laid in concrete. Where cables are to be bunched together in one pipe this system may be cheap; but as this is not desirable, and the cost of several pipes would compare unfavourably with multiple-way conduits, no special advantages appear to be offered by this system.

One of the latest design of pipes for draw-in systems is made of a patent fibrous material which possesses high insulating properties. It can be obtained of a light gauge with spigot and socket joints for laying in concrete, or of a heavier gauge with screwed joints for laying direct in the ground without further protection. The material appears a very suitable one for the purpose, and its working under every-day conditions will be watched with interest.

A draw-in system of any kind is usually more difficult to construct than a solid system. Changes of level have to be arranged for to allow of the drainage of water from the ways. Boxes for drawing in or out must be provided at the corners of all the principal streets, at all changes of level and at intervals of 60 yds. to 80 yds.

A small, but important, matter with all draw-in systems is the provision of suitable ends to the ways at all street boxes. For this purpose hardwood bell mouth-pieces turned or shaped to fit the ways can be used at little expense, the wood being first treated with Stockholm tar as a preservative.

*Solid Systems.*—The least expensive of all solid systems is armoured cable laid direct in the ground with a wood board over it as a protection. In natural soil, such as gravel, sand or clay, satisfactory results may be obtained, but it is quite unsuitable without additional protection for laying in the made-up ground usually found in the main streets of our towns, as the armouring will be quickly destroyed and leave the insulation unprotected.

One of the largest-used solid systems is made up of a wooden trough, with wooden bridge pieces for supporting the cables, the whole being filled with molten bitumen. All the woodwork must be thoroughly impregnated with Stockholm tar. The usual preservative compounds used by building contractors for woodwork is not suitable for this purpose, as it has a deleterious action on the bitumen and some kinds of insulation. Wood makes a very suitable covering carefully nailed to the sides of the trough. Tiles or bricks are apt to be displaced subsequently and leave the bitumen exposed. Wood troughing might be expected to have quite a short life for underground work, but in practice little trouble has been experienced.

Troughs constructed of stoneware and of cast iron with wood or porcelain insulators for the cable supports have been used to a considerable extent, a stoneware, tile or cast-iron covering being provided. Both are suitable materials although rather rigid, and have given good results.

Another troughing that has been largely used is manufactured of asphalt in lengths of 4 ft. The joints between lengths are made by means of a hot iron, which renders the material plastic and enables the ends to be formed solid so as to make one continuous length. The cables are laid in the trough and the whole filled up with bitumen. A protective cover of asphalt is then added for protection and ironed down to the sides of the trough. A simple precaution against a bad joint between lengths can be made at little expense by inserting a piece of bitumen sheeting about 4 in. wide between the cable and the trough. This system is reasonable in first cost, the material is flexible, mechanically strong and practically imperishable.

It may perhaps be of interest to other engineers to state that the cables originally put down in the author's town, which is supplied on a three-wire direct-current system, were insulated with vulcanised rubber, all three cables making up the set being contained in a single 4 in. cast-iron pipe. After about three years' use faults became of frequent occurrence through deterioration of the rubber, and finally resulted in all the rubber cables being withdrawn and replaced with another type. To avoid the loss of selling at the price of scrap copper, the cables were thoroughly dried, re-insulated at the joints, and it has since being laid in an asphalte trough on extension work. Some has now been in use for over five years, and no trouble whatever has been experienced, except where the ends were left exposed in street boxes, and this has since been remedied.

Leaving armoured cable out of consideration, it may be said that solid systems are not so convenient to lay in some respects as draw-in systems. The filling requires the use of a boiler and takes time to melt. Work must be suspended on account of rain to keep moisture out of the trough and avoid the formation of steam bubbles when the bitumen is poured in. A considerable length of street has to be opened out at a time to enable the cables to be laid without frequent joints. Matters such as these do not necessarily increase the cost, but it means additional inconvenience to the public.

*Cables.*—The first cost of a concentric or multicore system will be less than the equivalent in single cables. Jointing is, however, much more difficult and costly to carry out, and necessitates the cutting off of the supply while the work is being done. When such care and attention is given to obtain continuity in the supply, concentric or multicore construction does not appear to offer the minimum of risk, necessitating, as it does, that conductors of opposite polarity will only be separated by ⅛ in. or slightly more of insulating material, which is invariably paper and particularly susceptible to moisture. A more reliable system is obtained by using single cables drawn into separate ways of a conduit or laid spaced apart on a solid system.

For a solid system no advantage is to be gained by using a lead-covered cable when bitumen non-lead-covered can be obtained at about the same cost. It is more difficult to choose between lead and bitumen for a draw-in system. Excellent results are obtained with both. Lead-covered have been most successful when drawn into iron pipes, but have given trouble in some instances when used in stoneware, probably due to a deleterious action between the salts used for glazing the stoneware and the lead covering.

The principal defect of all insulation containing a large proportion of bitumen is the liability of the conductors to decentralise. Many faults have undoubtedly arisen from this cause, but the bitumen now obtainable does not soften at normal temperatures. Isolated cases will, however, occur where, for instance, a cable duct or trough is laid in close proximity to a hot water or steam pipe drain from a house or works to the main sewer in the street. A leadless cable, whether laid solid or drawn into a conduit of an insulating nature, rarely gives a serious fault without warning even although the insulation is badly damaged, a leakage can consequently be localised and repaired at the most suitable time without inconvenience to consumers.

Before the advent of earth-return tramway systems no necessity existed for the earthing of all lead coverings and bonding across joint boxes, &c., but, owing to the deterioration of the lead in some localities, it has now become the general practice to do so. Where long lengths of cable run parallel with the tramway track and are connected direct with the generating or sub-station, it is doubtless a wise precaution to take, but in the event of a fault on the cable developing to a short-circuit damage may be done to the covering of all the cables in the immediate vicinity of the fault owing to the relatively poor conductivity of the lead compared with the copper, and result in further breakdowns in the near future. The best method would be to earth at frequent intervals through a fuse with a resistance in parallel as was suggested by a well-known cable company some years ago. If this is done electrolytic action will not take place, and any serious leakage on the cable is reduced to a safe limit. Such an arrangement, although effective, would probably be expensive in first cost and in upkeep.

The quantity of lead-covered cable in successful use is undoubtedly very large, and experience may not prove it more expensive to maintain than a leadless cable; still, the provision of a conductive covering at such a small distance from the copper does not deem to be the best design from a "continuity of the supply" point of view, and if equally successful leadless cables can be obtained it will only be exercising some small measure of carefulness in providing a covering that shall not be the means of assisting homeward the stray currents from our tramways, and possibly in the near future of our railway systems.

*Section Boxes.*—When the undertaking is in the hands of a company it may be difficult to obtain permission of the local authority to erect above-ground section boxes, and, in such a case, a street box must be used or a convenient cellar rented for the purpose. It will be generally admitted that a street box is not the most suitable place to fix either fuses or circuit-breakers, which should be easily get-at-able. During a frost following rain or a fall of snow the covers of the street boxes may be frozen down and take a considerable time to thaw before the apparatus can be attended to. Any receptacle for a cut-out for fixing in a street box must be watertight, and this usually necessitates the use of bitumen or wax for filling and sealing. If a fuse is used to give the desired results at times of need it must get appreciably hot at full normal load, in which case the filling may melt and leak away.

The best practice is to provide a fuse or circuit-breaker at the generating station switchboard, where the feeder connects to the 'bus bars, and an above-ground section box, where the feeder terminates at the distributing end, the outers of each set of distributors being connected to the feeder bars through fuses fixed to removable handles. An additional box of similar pattern, as required by the above regulation, can be fixed half-way between feeder points. Only an eighth of the consumers supplied by any one feeder will then be cut off through a serious fault on the distributing cables. Such boxes are convenient for taking periodic tests of the cables and of great assistance in the quick localising of faults. To provide against the unnecessary blowing of fuses through deterioration it is advisable to arrange for a weekly inspection of all fuses at the time of maximum load.

### Cost of Construction.

The following figures may be taken as the approximate cost per mile of laying a set of low-tension three-wire distributing cables of sections 0·15, 0·075, 0·15 on some of the systems enumerated. It is assumed that the set of cables will cost £450 a mile, whether single lead-covered, single bitumen-covered triple-concentric, or three-core lead-covered, also that armouring will increase the cost 20 per cent., say, to £540 a mile. The prices are not quite correct for all types of cables, as, for instance, bitumen might not cost the same as plain lead-covered, and single-armoured cables would be more than either triple-concentric or three-core armoured, but the variations would probably not be greater than about 5 per cent.

The costs given are for single cables of the size mentioned. For larger or smaller sections the cost of the cables and protection will vary, but the cost of the other items will remain the same. Further, with a draw-in system laid in concrete, a set of spare ways could be laid at the same time, and only increase the quantity of concrete by a trifle more than a half, as the covering of the lower set would be the foundation of the upper set. It must be obvious that variable circumstances will alter the cost and require the *revision* of the figures given to suit other conditions.

| System. | Protective material. | Cost of protection. | Cost of cable. | Cost of laying, &c. | Cost of street boxes. | Cost of excavation, &c. | Total cost. |
|---|---|---|---|---|---|---|---|
| Arm'rd Solid | Wood board ...... | £25 | £540 | £20 | £15 | £176 | £776 |
| Draw-in. | 1–4 in. stoneware pipe .......... | 100 | 450 | 30 | 65 | 176 | 821 |
| Solid .. | Wood trough ...... | 185 | 450 | 15 | 10 | 176 | 836 |
| Solid .. | Asphalt trough .... | 195 | 450 | 15 | 10 | 176 | 846 |
| Draw-in. | 3–2 in. w.i. pipes.. | 130 | 450 | 30 | 65 | 176 | 851 |
| Draw-in. | 3–2 in. stoneware pipes ........ | 176 | 450 | 30 | 65 | 176 | 897 |
| Draw-in. | 3-way 2 in. conduit stoneware .... | 220 | 450 | 30 | 65 | 176 | 941 |
| Draw-in. | 3–2 in. fibre pipes in concrete .... | 242 | 450 | 30 | 65 | 176 | 963 |
| Draw-in. | 1–4 in. c.i. pipe .... | 255 | 450 | 30 | 65 | 176 | 976 |

To show the cost of stranding and insulating conductors it may be remarked that the set of 0·15, 0·075, 0·15 cables, given above at a price of £450 per mile, say 5s. $1\frac{1}{2}$d. per yard, contains $4\frac{1}{3}$ lb. of copper. Taking the cost of bare rod or tape at 9d. per pound the value is 3s. 3d. per yard, so that stranding and insulation increases the cost by 1s. $10\frac{1}{2}$d. per yard, nearly 60 per cent. A set of larger insulated cables, say 0·5, 0·2, 0·5, at present prices, is worth about 14s. 9d. a yard, and contains 14 lb. of copper. At the same price, 9d. per pound, the value is 10s. 6d. per yard, giving an increased cost for the stranding and insulation of 4s. per yard, nearly 40 per cent.

It is perhaps unwise to attempt to forecast what developments in materials for street work may occur, but with present-day knowledge it is difficult to see how the cost of underground work can be appreciably reduced in the near future. The three necessaries are conductors, insulation and adequate mechanical protection. To substitute any known conductor for copper will increase the bulk and add to the cost of insulation and protection. Higher pressures than those at present allowed on consumers' premises, even if desirable, which is doubtful, would reduce the weight of copper but increase the insulation. The mechanical protection must be provided. The most encouraging direction for improvement appears to lie in the use of a mechanically strong insulating and absolutely watertight duct or trough, so that bare copper rod or tape can be used, surrounded with a suitable filling. The expense of stranding conductor and of cable insulation, which is at present considerable, will then be saved. The materials at present on the market most suitable for the purpose suggested are the asphalt trough and the patent fibrous material already alluded to as being used for the construction of pipes for drawing-in purposes.

In conclusion, the author would again refer to the revised Board of Trade regulations, which for the first time officially recognise the possibility of bare copper conductors on poles being used for general light and power distribution. The low cost of this method of construction has been pointed out in interesting Papers read before the Institution, in London, by Mr. G. L. Addenbrooke, and more recently by Mr. A. B. Mountain, of Huddersfield, at the meeting of the Municipal Electrical Association in Edinburgh. Although such construction is not likely to be tolerated in large centres of population, it should be found useful in enabling a supply to be given in outside and country districts, which, on financial grounds, would otherwise be left isolated.

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A Paper by Dr. W. S. Rhodes, upon which we comment in our leading article, was also read, and the two Papers were discussed together:—

The CHAIRMAN (Mr. S. L. Pearce) criticised Dr. Rhodes' assumption that the current in any feeder is proportional to the distance measured from the end furthest from the generating station, and also a formula given for finding the sectional area of conductor based upon this assumption. He thought that Mr. Watson had underestimated the cost of excavation at the rate of 2s. per lineal yard. In Manchester the rate would be more than this.

Mr. T. L. MILLER thought it a wise idea to combine theory and practice as in the Papers heard. He agreed with Mr. Pearce that Dr. Rhodes had based his Paper upon a wrong assumption, and protested against the loose wording in calling such distributing cables "feeders." This was a cause of confusion, and had led him astray in reading the Paper. He thought that the mathematics were not necessary, and considered that the funicular theory, as applied to architectural engineering in bending calculations, would be much simpler and more practical for working out distribution problems. In any case, it was impossible to get exact data beforehand as to loads upon a network, and therefore engineers must assume a considerable amount without touching mathematics. Lord Kelvin's law was interesting, but it could not be used with accuracy, owing to the conditions being unascertainable.

Mr. L. ANDREWS, referring to Mr. Watson's notes on earthing, said that he knew of a number of cases where cables were bonded and earthed, but were badly attacked by moisture at the points of contact with bridge pieces. Bonding, of course, prevented electrolytic action being concentrated at certain points; but where the bonds break or are omitted, the action was intensified. There was a tendency at present to insulate the lead as much as possible, but this insulating was a very difficult problem. As to lead-covered cables in cast-iron pipes, this might be satisfactory where universally employed upon a network, but he could not recommend it for occasional situations, such as crossing roads and bridges. An instance of this arrangement over a bridge in conjunction with a system of stoneware conduits, had caused strong electrolytic action to the ruin of the lead-covered cables in the cast-iron pipes. This was explained by the cables being fairly well insulated from earth in the stoneware conduits, but being well earthed in the cast-iron pipes. The question of solid-laid versus draw-in might be compared to the old-time discussions upon H.T. versus L.T.; they each had their good points for special situations. Feeders should always be drawn in and distributors should be laid solid. He did not think the draw-in system could be satisfactorily used for distributors. Laying a large number of feeders solid meant either filling up the whole width of the street if laid in one layer, or having the lower cables practically inaccessible for repairs, &c., if laid in a group. Lead-covered cables seemed to attract the greatest amount of invidious distinction through electrolytic trouble advertisement, but bitumen cables also had their troubles, such as decentralisation, &c. He agreed with Mr. Watson as to the advisability of using separate conductors instead of multiple-conductor cables; the former were often dearer in *first cost*, but cheaper in the long run, and safer. The table of costs was useful, as it was so hard to get these comparative prices. Excavation might be said to cost anything from 6d. to 6s. 6d. per yard. It depended on the surface. The cost of laying asphalt troughing at £15 per mile seemed low compared with the other systems, which were all shown dearer. As to the fibre conduit being placed on the same mark as to cost of laying with stoneware and cast-iron pipes, he would like to make a laying match with Mr. Watson on those terms. With regard to the author's suggestion of asphalt trough or fibre conduit for using on bare copper systems, he did not think that there was much chance of factory-insulated cables being ousted from their present sphere of usefulness, however good the street insulated system might be.

Mr. C. J. BEAVER, referring to Mr. Watson's suggestion as to possible development of the bare copper question, remarked that any kind of pipe used for that would stand the same risks as to flooding, which it was admitted the Crompton system was liable to. The most likely system would possibly be a solid-laid, such as the asphalt trough recommended. A disadvantage of cement conduits was that, if water got inside, the result was an alkaline extract, which in the case of lead-covered cables acted as an electrolyte, and with vulcanised bitumen cables had a direct chemical action, and failures had been caused through this. The want of permanence in vulcanised rubber cables under certain circumstances was due to them being employed on L.T. work, where the thickness of rubber generally used was insufficient to withstand the action of copper on the one side and atmospheric influence on the other. On H.T. rubber mains the thickness, being greater for electrical reasons, resulted in a stronger mechanical job being made. He knew a case of a concentric V.R. cable working at 2,000 volts for 10 years which was found to be good after examination for at least another 10 years. Where lead-covered cables had given trouble in stoneware ducts this had sometimes been attributed to the glazing material used, but from his own testing and examination into the circumstances attending such troubles he could say that the glaze used was generally very inert from a chemical point of view, and that such faults were mainly due to electrolytic action.

Mr. B. WELBOURN said that the safe rule in choosing between the drawn-in and the solid systems appeared to be to take the conditions to suit the circumstances. He did not approve of so much solid laying, and thought the fashion would die out shortly. Armoured cables seemed to be passed over much too lightly for the merits of the system, although a lot of rubbish had been put on the market. With properly chosen preservative material and efficient machinery, armoured cables should last as long as any other system at present in vogue. He knew of some 14 years old and still running. The cheapness of armoured cables was a further advantage. He preferred multiple conductor cables to singles; many towns were being supplied throughout with the former with satisfactory results. Services could be made upon multiple conductor cables when alive with ease and safety. As to house services, he preferred these to be solid joints, instead of being connected to the leads through fuses.

Mr. A. G. COOPER thought that if Dr. Rhodes' formulæ were used designers of mains would be no better off, and it was largely a matter of chance what load came on. He disagreed with the solid system, and thought that one had to lock up copper and capital for use a long time ahead or pay for additional excavating every year or so. He had seen some troughs made of flower-pot material with jam-pot bridges moulded on, and could not recommend them. He related some incidents of fault finding, and when he described taking an earth off his middle and putting 300 amperes through the fault, he caused much merriment. He contrasted the careful tests for a multiplicity of megohms at the commencement of work, and the thousand ohms or so obtained on a network after services, feeder pillars, &c., had been jointed up.

Mr. J. CONNOLLY said Mr. Rhodes' Paper had had scant justice meted out to it. If of no other value, it would be of use to students. Vulcanised rubber failures were mostly on direct-current, and on the negative main. He therefore recommended, especially for colliery work, that the inner conductor be the negative pole.

Mr. J. MOSS asked some questions.

Mr. H. T. WILKINSON contrasted Mr. Watson's mention of draw-in boxes being placed at 60 yd. intervals with the practice at Sheffield, where 60 men or a traction engine hauled in up to 200 yds. at a time. Relaying old rubber cables solid he thought a capital idea. Overhead mains were all right in Switzerland or America, where the undertakers drew a straight line across the country and seemed to have no difficulties in keeping to the line. In his experience in England, however, the arranging for such lines gave enormous trouble. Obtaining wayleaves meant not only interviewing owners of land, but their agents, who lived in towns 20 miles off. Then awkward conditions were made as to following the hedges, &c. A ¾-mile E.H.T. line in the neighbourhood of Manchester crossed a river, a canal, a road, a football field, telephone and telegraph wires for each of which extensive arrangements had to be made to suit the requirements of various authorities; and although the line itself cost less than the same length of underground cable, he thought that the extra time spent on it by expensive officials would about balance the matter.

Dr. RHODES replied to some of the points raised regarding his Paper.

Mr. WATSON, in reply to the discussion upon his Paper, pointed out that excavation was a fluctuating figure, but he thought that the 2s. mentioned was suitable for most cases, especially as the flags were permanently reinstated as the trench was filled in. He did not recommend solid over draw-in system as both had their uses. Earthing could be talked about all night, as opinions were so different. He disconnected the lead covering in his system of mains at every service, the cables being laid in iron pipes. He had noticed some bare copper systems at Olympia, but was not struck with the concrete arrangement, as it seemed brittle and a piece broke off easily. Also it might suck up moisture. The wood system of bare mains he knew nothing of. Armoured cables in good soil were quite satisfactory, but if laid in made-up ground or containing ashes they were of no use. He agreed that negative conductors always gave trouble first, his experience being four faults on the negative to one on the positive with V.R. cables. He adhered to his point that 60 yds. was the best distance for drawing-in, as the extra strain of drawing-in lengths like 200 yds. would tend to damage them.

A vote of thanks to the authors was accorded on the motion of Dr. Bowman.

## THE STEAM TURBINE.*

BY THE HON. C. A. PARSONS, C.B., F.R.S., AND G. G. STONEY.

The evolution of the steam turbine was traced from the time of Hero of Alexandria. The general theory of the working of the steam turbine was given, and the chief features of the flow and expansion of steam and the conditions essential to economy were touched upon. After describing and discussing the chief characteristics of the three types of steam turbine, which practically cover the whole field of useful turbine inventions—viz., the Parsons turbine, introduced in 1884, the De Laval turbine in 1888, and the Curtis turbine in 1902, the development of the Parsons turbine was dealt with. A table showed the progress made in the reduction of steam consumption since the first turbines had been built, and various diagrams illustrated the manner in which steam consumption was influenced by the size of the plant and the degree of vacuum attained. The importance of a good vacuum to the economical working of steam turbines was urged, and the authors pointed out certain special conditions and arrangements which must be observed in order to obtain a vacuum of 27½ in. to 28 in. The authors' "vacuum-augmenter," described in the recent Paper by the same authors at the Institution of Electrical Engineers, was again described. It consists of a steam jet placed in a contracted pipe between the condenser and the air-pump. With this apparatus, a total net reduction of steam-consumption of about 8 per cent. at full load had been obtained. Various applications of steam-turbines for driving pumps, and for working fans for colliery-ventilation and blast-furnace work were then briefly alluded to. The remainder of the Paper dealt with the application of the steam-turbine to marine propulsion.

## PHYSICAL SOCIETY.

At a meeting of the Physical Society on Friday, November 24th, Prof. J. H. Poynting, F.R.S., President, in the Chair, a Paper on

### "The Dielectric Strength of Air"

was read by Mr. A. Russell. The dielectric strength of air, at a given barometic pressure, is generally deduced from the results of experiments made on the disruptive voltages between equal metal electrodes at given distances apart. It is assumed that the electric field surrounding the two electrodes just before the disruptive discharge takes place is similar to that round the electrodes at low voltages. Schuster has shown that this assumption is untenable. The author has found that in certain cases the dielectric has broken down before the final discharge takes place. Hence the boundaries of the Faraday tubes are no longer the surfaces of the metal electrodes, but the boundary of that part of the dielectric surrounding the two electrodes which has ceased to insulate and has become a conductor. It is known that for various gases there are certain minimum sparking P.D.s between the electrodes. The electrostatic equations fail to take this into account. The author, therefore, makes the assumption that for distances apart greater than about a millimetre when the disruptive voltage is $V$ kilovolts the effective P.D. between the ends of the Faraday tube which is subject to the maximum stress is $V - \epsilon$, where $\epsilon$ is the minimum sparking voltage. Applying formulæ which he has deduced, using this assumption, to tests of Heydweiller, Steinmetz, Algermissen, &c., the author finds that they agree in making the dielectric strength of air 38 kilovolts per centimetre approximately. A knowledge of this quantity enables us to find not only the disruptive voltages between electrodes of many geometrical shapes, but it also enables us to find the "critical" pressure for overhead electric-power transmission at high pressures. The author gives a complete proof by Kelvin's method of images of the Kirchhoff series-formula, and shows how its numerical value can be readily found both by ordinary algebra and by elliptic function series.

Dr. H. A. WILSON expressed his interest in the author's explanation of the brush discharge and the formation of coronas. There were, however, one or two points in the Paper which required some alteration. The author stated that according to Strutt the minimum sparking P.D. was 767 volts when the barometric pressure was 72·4 cm. The pressure in Strutt's experiments was, however, 72·4 mm. When the distance between the electrodes was not too small it was known that the sparking P.D. could be expressed as $V = \alpha + \beta d$, where $d$ was the distance between the electrodes and $\alpha$ and $\beta$ were constants. This constant $\beta$ the author had called the dielectric strength of air, but he did not think he was justified in doing so.

The CHAIRMAN, referring to Table V. in the Paper, asked if the rise in value of the dielectric strength as the distance apart of the electrodes increased was due to the formation of coronas.

Mr. RUSSELL, in reply, thanked Dr. Wilson for pointing out that in the Paper the atmospheric pressures at which Mr. Strutt had obtained his results were quoted in centimetres instead of millimetres. Mr. Strutt had shown that the P.D. between the cathode and the negative glow was 341 volts whatever the atmospheric pressure. We were therefore quite justified in assuming that at ordinary pressures the electric pressure on the Faraday tube subject to the maximum stress is $V - \epsilon$, where $\epsilon$ is greater than 341. The experimental results analysed in the Paper indicate that $\epsilon$ is 0·8 of a kilovolt. In answer to Prof. Poynting, he stated that the slight rise in the values of the dielectric strength in Table V. was probably due to the potentials of the electrodes not being $V$ and zero at the instant of discharge.

A Paper by Dr. H. A. Wilson and Mr. E. Gold,

### "On the Electrical Conductivity of Flames for Rapidly-Alternating Currents"

was read by Dr. Wilson. This Paper contains an account of a series of experiments on the electrical conductivity of a Bunsen flame containing various alkali-salt vapours for alternating currents with frequencies from $7 \times 10^4$ to $11 \times 10^5$ alternations per second. The conductivity was measured between two platinum electrodes immersed in the flame, and the variation of the conductivity with the amount of salt present and with the nature of the salt was investigated. The variation of the conductivity with the frequency of alternation, the maximum E.M.F., and the distance between the electrodes was also examined. The results obtained enable a comparison to be made between the conductivities of various alkali-salt vapours for alternating currents and their conductivities for steady currents as previously determined. The conductivity was measured by means of a Wheatstone's bridge, three arms of which consisted of small air condensers and the fourth of the electrodes in the flame. One of the condensers could be adjusted until a balance was obtained. The following is a summary of the results :—(1) For rapidly alternating currents a flame containing an alkali-salt vapour behaves like an insulating medium of high specific inductive capacity. (2) The conductivity of different alkali-salt vapours in a flame for rapidly alternating currents, as measured by the apparent capacity of platinum electrodes immersed in the flame, varies as the square root of the conductivity of the same salt vapours for steady currents. This result confirms the view that the negative ions from all salts have the same velocity. (3) The apparent capacity varies nearly inversely as the square root of the maximum applied P.D. (4) The apparent capacity is nearly independent of the number of alternations per second. (5) The apparent capacity is nearly independent of the distance between the electrodes. (6) The results (1) to (5) are in agreement with the ionic theory of the conductivity of the flame for rapidly alternating currents when the velocity of the positive ions and the inertia and viscous resistance to the motion of the negative ions are neglected in comparison with the effects due to the number of ions per cubic centimetre. (7) The apparent capacity per square centimetre area of the electrodes is equal to $\sqrt{ne/8\pi V_0}$, where $n$ is the number of positive ions per cubic centimetre, $e$ the charge on one ion, and $V_0$ the maximum applied P.D. (8) Not more than 1 molecule in 10 of salt molecules is ionised at any instant, but each molecule is probably ionised and recombines several million times per second. (9) The steady currents observed through salt vapours in flames are very far from the maximum possible currents corresponding to the number of ions produced per second.

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* Abstract of a Paper read at Institution of Civil Engineers on Tuesday.

Mr. W. DUDDELL expressed his interest in the method of measurement, and referred to the fact that although the Paper was entitled "The Electrical Conductivity of Flames," the authors had not measured conductivities, but a complex quantity which was equivalent to a resistance shunted with a condenser. He drew attention to one of the tables given in the Paper, in which numbers referred to as constant varied by over 50 per cent.

Dr. WILSON said the quantity which they had measured was the apparent capacity of the electrodes,

## STANDARDS OF MUTUAL INDUCTION.

BY G. F. C. SEARLE, M.A., F.R.S., AND J. R. AIREY, B.Sc.,
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§ 1. In magnetic tests of iron, a standard of mutual induction is very frequently used as a means of standardising the ballistic galvanometer, the secondary coil being connected in series with the ballistic galvanometer, while an accurate amperemeter is placed in the primary circuit. When the galvanometer is to be standardised, the primary current is reversed and the throw of the galvanometer is observed. If M be the coefficient of mutual induction, and $i_1$ the value in C.G.S. units of the current which is reversed, the change of induction through the secondary circuit is $2Mi_1$; by observations of the throws of the ballistic galvanometer, the changes of induction due to the iron under test are compared with $2Mi_1$.

§ 2. An approximate calculation of the value of M is easily made when the arrangement ascribed to Lord Kelvin is employed. Here the primary coil is uniformly wound upon a circular cylinder, the length of the coil being great in comparison with its diameter. The secondary coil is of fine wire, and is wound on the outside of the primary coil or, far preferably, on an accurately-measured cylinder placed within the cylinder carrying the primary coil and coaxial with it. The secondary coil in each case occupies a central position and its length is small in comparison with that of the primary coil.

In the latter case, if there be N turns on a length 2L cm. in the primary coil, and if the secondary coil of $n$ turns be wound on a cylinder of radius $a$, and if the length of the primary coil be great in comparison with its diameter, then, approximately,

$$M = 2\pi^2 N n a^2 / L.$$

When the length of the primary is finite, M will differ from this value by an amount which can be calculated.

In the following Paper we explain the method of calculating M to any desired degree of accuracy, when the secondary coil lies inside the primary coil. This theory enables the value of M to be found accurately for coils which are much more compact than those sometimes employed.

§ 3. A most important advance in the theory of helical coils was made by the late Prof. J. V. Jones.* Lord Rayleigh† has since shown that the result follows in the simplest manner from the general theory of lines of force. A helix is supposed to be formed upon a circular cylinder and to make an *integral* number of revolutions about the axis. The circuit is supposed to be completed by a wire of any form, lying in the plane which contains the axis and passes through the two extremities of the helix.

Then, if there be any circle with its centre on the axis of the cylinder and its plane perpendicular to the axis, Jones's theorem is that the number of lines of force which pass through the circle, and are due to the circuit containing the helix, is the same as the number which pass through the circle and are due to a uniform cylindrical current sheet of the same radial and axial dimensions as the helix, if the currents per unit of axial length in helix and sheet be the same. In the current sheet the lines of flow are circles whose planes are perpendicular to the axis of the cylinder. If the helix make N turns per unit of axial length, and if it carry a current $i$, then the current in the sheet is N$i$ per unit of axial length.

§ 4. So far the current has been supposed to flow in an infinitely thin wire. But a uniform helical wire of finite thickness can be split up into helical filaments, and hence a current in a helical wire of finite thickness can be replaced by a system of currents flowing in the space between the two cylinders which touch the helical wire. The exact distribution of current in this space depends upon the distribution in the helical wire, but what that distribution is it is not easy to settle. Even if the wire had been initially a circular cylinder of homogeneous metal, it would not be easy to determine its section after it is wound into a helix, or to find out how much the specific resistance at any point of the section has been changed. But we may be sure that the thinner the wire the more nearly may the current in it be replaced by an infinitely thin current sheet in the cylinder which passes through the centres of the cross-sections of the wire.

§ 5. In the actual standards of mutual induction we do not have one helix and one or more circles, but two helices, and hence Jones's theorem is not now strictly applicable. But when the secondary coil is wound with very fine wire, so that the number of turns per centimetre is several times the number per centimetre on the primary, the mutual potential energy will be very nearly the same as if the current in the secondary were replaced by a current sheet, especially if the shortest distance between the primary and secondary is several times the pitch of the primary helix. The mutual potential energy of the two helices, which is equal to $-Mi_1i_2$, may then be taken as equal to that of two current sheets. A small effect arises from the mutual action of the components, parallel to the axis, of the currents in the helices, but this may be practically eliminated by arranging the leads properly (see § 16).

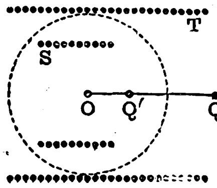

Fig. 1.

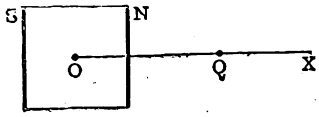

Fig. 2.

§ 6. The mutual potential energy of the two current sheets is found in the following manner :—

(I.) Let S (Fig. 1) be any system of currents having an axis of symmetry OX. If any point O be taken as origin, it is known that the magnetic potential due to S at a distant point Q on the axis OX can be calculated in the form of the series

$$V = i_2\left(\frac{g_0}{s} + \frac{g_1}{s^2} + \frac{g_2}{s^3} + \ . \ . \ .\right), \qquad \text{(i.)}$$

where $s = OQ$, the series being "absolutely" convergent when Q is farther from O than any other part of S.

(II.) Let T be a system of currents having OX as an axis of symmetry. Then it is known that at a point Q′ on OX, at a small distance from O, the magnetic potential can be written in the form

$$U = i_1(G_0 + G_1 t + G_2 t^2 + \ . \ . \ .), \qquad \text{(ii.)}$$

where $t = OQ'$, the series being "absolutely" convergent when Q′ is nearer to O than any part of T.

In both (I.) and (II.) the axis extends from O to infinity in *one* direction—viz., OX, only.

(III.) Then, if W be the mutual potential energy of the two systems, W is given by the series

$$W = i_1 i_2 (g_0 G_0 + g_1 G_1 + g_2 G_2 + \ . \ . \ .), \qquad \text{(iii.)}$$

the series being "absolutely" convergent provided every part of T is further from O than any part of S.

If M be the coefficient of mutual induction, we have $W = -Mi_1i_2$. Hence

$$M = -(g_0 G_0 + g_1 G_1 + \ . \ . \ .). \qquad \text{(iv.)}$$

Theorems I., II., III. may be derived from the results given by Maxwell in Arts. 694 to 700, Chap. XIV., Vol. II. of his "Electricity and Magnetism." (Second or Third Edition.)*

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* *Proceedings* of the Royal Society, Vol. LXIII. (1897), p. 192.

† *British Association Report* (1899), p. 241.

* For an elementary proof of III. see G. F. C. Searle, "On the Coefficient of Mutual Induction for a Circle and a Circuit with Two Parallel Sides of Infinite Length." *Proceedings* Cambridge Phil. Soc., Vol. XI., Part V., pp. 398 to 406.

§ 7. The condition, that every part of T must be further from O than any part of S, at first sight requires that the secondary coil should be capable of revolution about O without coming into contact with the primary coil. But the primary coil of length 2L can be treated as the resultant of a continuous infinite solenoid, and an infinite solenoid having a gap of length 2L, the current in the broken solenoid flowing in the opposite direction to that in the primary coil. The mutual potential energy for the secondary coil and the broken solenoid can be found by the infinite series (iii.), which will be valid provided that the secondary coil could turn about O without coming into contact with the broken solenoid.

The magnetic field due to the continuous infinite solenoid is uniform, and hence the potential energy of the secondary coil in this field is the same as if the uniform field were *infinite* in extent. Since the magnetic force due to the continuous solenoid is $2\pi N i_1/L$, if $U_0$ be the magnetic potential due to it at a point on the axis at a distance $r$ from the origin, and if the current in the primary coil flow in the direction specified in § 8,

$$U_0 = -\frac{2\pi N i_1}{L} \cdot r.$$

If we add this expression to the series for the potential $U_1$ due to the broken solenoid, the coefficients in the resulting series may be used in (iii.), provided the secondary coil could turn about O without coming into contact with the broken solenoid.

§ 8. Let the length of the primary coil be 2L cm. and let its radius be A cm., the total number of turns being N. Let the length of the secondary coil be $2l$ cm. and let its radius be $a$ cm., the total number of turns being $n$. Let the coils be placed so that their centres and axes coincide and let the origin O be taken at the common centre, and let the direction of the current in each coil be related to the direction of the axis in the same way as the rotation is related to the translation of a right-handed screw working in a fixed nut.

§ 9. Now, at points outside it, a solenoid of $p$ turns per centimetre, the current in each turn being $i$ C.G.S. units, behaves as a uniformly-magnetised cylinder, the surface density of magnetism at the two ends being $\sigma$, where $\sigma = pi$.

If $\Omega$ be the magnetic potential at a point on the axis of a circular disc of radius R, at a distance $h$ from its centre.

$$\Omega = \int_0^R \frac{2\pi\rho\sigma d\rho}{\sqrt{h^2+\rho^2}} = 2\pi\sigma(\sqrt{h^2+R^2} - h). \qquad \text{(v.)}$$

§ 10. If the potential at Q (Fig. 2) at a distance $r$ from O, the centre of the secondary coil, be V, since the north end of the coil is the nearer to Q we have by (v.)

$$V = \frac{\pi n i_2}{l}\left(\sqrt{h^2+a^2} - h - \sqrt{k^2+a^2} + k\right),$$

where $h = r - l$ and $k = r + l$.

By the binomial theorem,

$$\sqrt{h^2+a^2} = h + \frac{1}{2}\cdot\frac{a^2}{h} - \frac{1\,.\,1}{2\,.\,4}\cdot\frac{a^4}{h^3} + \frac{1\,.\,1\,.\,3}{2\,.\,4\,.\,6}\cdot\frac{a^6}{h^5} - \ldots,$$

If, now, we replace $h$ by $r - l$, expand $(r-l)^{-1}$, $(r-l)^{-3}$ . . . in powers of $l/r$ and collect together the terms involving $r^{-1}$, $r^{-2}$, $r^{-3}$ . . ., we find

$$\sqrt{h^2+a^2} - h = \frac{1}{2}\cdot\frac{a^2}{r} + \frac{1}{2}\cdot\frac{a^2 l}{r^2} + \frac{a^2}{r^3}\cdot\frac{4l^2-a^2}{8} + \frac{a^3 l}{r^4}\cdot\frac{4l^2-3a^2}{8} + \ldots$$

For the second square root we change the sign of $l$, and then we find by subtraction

$$V = i_2\pi n a^2\left\{\frac{1}{r^2} + \frac{1}{r^4}\cdot\frac{4l^2-3a^2}{4} + \frac{1}{r^6}\cdot\frac{8l^4-20l^2a^2+5a^4}{8} + \ldots\right\}$$

$$= i_2\left(\frac{g_1}{r^2} + \frac{g_3}{r^4} + \ldots\right).$$

Thus,

$$g_1 = \pi n a^2, \qquad g_3 = \frac{(4l^2-3a^2)}{4}g_1$$

$$g_5 = \frac{(8l^4-20l^2a^2+5a^4)}{8}g_1$$

$$g_7 = \frac{(64l^6-336l^4a^2+280l^2a^4-35a^6)}{64}g_1$$

while all the even coefficients, viz., $g_0 \,.\, g_2$ . . ., are zero.

§ 11. We must now find the magnetic potential due to the broken solenoid. Making use of (v.), we find for the potential at Q′ (Fig. 3) at a distance $r$ from O, the centre of the gap.

$$U_1 = \frac{\pi N i_1}{L}\left[\sqrt{(L-r)^2+A^2} - (L-r) - \sqrt{(L+r)^2+A^2} + (L+r)\right],$$

since the end nearer to Q′ is a north end.

The necessary expansions are most easily made in this case by Taylor's theorem.

If $\quad C' = \sqrt{(L+r)^2+A^2},$

$$C' = (C')_0 + \frac{r}{1}\left(\frac{dC'}{dL}\right)_0 + \frac{r^2}{1\,.\,2}\left(\frac{d^2C'}{dL^2}\right)_0 + \ldots,$$

where the suffix $_0$ indicates that $r$ is to be put zero after the differentiations. Since $r$ and L always appear together in the form $L + r$,

$$\left(\frac{d^nC'}{dL^n}\right)_0 = \frac{d^nC}{dL^n},$$

where $C^2 = L^2 + A^2$. Hence,

$$\sqrt{(L+r)^2+A^2} = C + \frac{r}{1}\cdot\frac{dC}{dL} + \frac{r^2}{1\,.\,2}\cdot\frac{d^2C}{dL^2} + \ldots$$

Performing the differentiations and replacing $C^2$ by $L^2 + A^2$ when necessary, we find

$$\frac{dC}{dL} = \frac{L}{C}, \qquad \frac{d^2C}{dL^2} = \frac{A^2}{C^3}, \qquad \frac{d^3C}{dL^3} = -\frac{3A^2L}{C^5}.$$

$$\frac{d^4C}{dL^4} = \frac{3A^2(4L^2-A^2)}{C^7}, \qquad \frac{d^5C}{dL^5} = -\frac{15A^2L(4L^2-3A^2)}{C^9}.$$

For the other square root, we have only to change the sign of $r$.

Since $U = U_0 + U_1$, we have, by addition,

$$U = -\frac{2\pi N i_1}{C}\left\{r - \frac{A^2}{2C^4}r^3 - \frac{A^2(4L^2-3A^2)}{8C^8}r^5 - \ldots\right\}$$

$$= i_1\{G_0 + G_1 r + G_2 r^2 + \ldots\}.$$

Thus,

$$G_1 = -\frac{2\pi N}{C}, \qquad G_3 = -\frac{A^2}{2C^4}G_1, \qquad G_5 = -\frac{A^2(4L^2-3A^2)}{8C^8}G_1,$$

$$G_7 = -\frac{A^2(8L^4-20L^2A^2+5A^4)}{16C^{12}}G_1,$$

while $G_0 = G_2 = G_4 = \ldots = 0$.

§ 12. Hence, by (iv.), we find for M, the coefficient of mutual induction,

$$M = -(g_0G_0 + g_1G_1 + g_2G_2 + \ldots)$$

$$= \frac{2\pi^2 N n a^2}{C}\left(1 - \frac{A^2}{2C^4}\cdot\frac{4l^2-3a^2}{4} - \frac{A^2(4L^2-3A^2)}{8C^8}\cdot\frac{8l^4-20l^2a^2+5a^4}{8} - \ldots\right). \qquad \text{(vi.)}$$

§ 13. The use of the formula (vi.) may be illustrated by applying it to a definite example. Let the primary coil be 30 cm. long and 10 cm. in diameter and be wound with 300 turns of wire. Let the secondary coil be wound on a cylinder 8 cm. in diameter and be 5 cm. long, the number of turns being 200. This would roughly correspond to a winding of No. 36 silk-covered wire. Thus we have

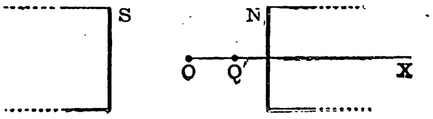

FIG. 3.

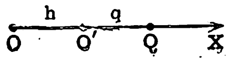

FIG. 4.

$$N = 300,\ L = 15,\ A = 5,\ C = 15{\cdot}8114.$$

$$n = 200,\ l = 2{\cdot}5,\ a = 4.$$

$$G_1 = -119{\cdot}215, \qquad g_1 = 10{,}053{\cdot}1, \qquad G_1g_1 = -1{\cdot}19848 \times 10^6,$$

$$G_3 = -2{\cdot}000 \times 10^{-4}G_1, \qquad g_3 = -5{\cdot}75g_1, \qquad G_3g_3 = 0{\cdot}001150G_1g_1,$$

$$G_5 = -6{\cdot}6 \times 10^{-7}G_1, \qquad g_5 = -50{\cdot}94g_1, \qquad G_5g_5 = 0{\cdot}000034G_1g_1.$$

Hence,

$$M = -(g_0G_0 + g_1G_1 + g_2G_2 + \ldots)$$

$$= 1{\cdot}19848 \times 10^6(1 + 0{\cdot}001150 + 0{\cdot}000034)$$

$$= 1{\cdot}19848 \times 1{\cdot}001184 \times 10^6 = 1{\cdot}19990 \times 10^6 \text{ cm.}$$

$$= 0{\cdot}0011999 \text{ henry.}$$

For all practical purposes, the calculations might have been made to a smaller number of significant figures, but the figures are given in detail here to show the rapidity with which the series converges. The rough approximation $2\pi^2Nna^2/L$ gives the value $1{\cdot}26331 \times 10^6$ cm., which is too great by about 5 per cent.

§ 14. It is easily shown that $2\pi N i_1/C$ is the magnetic force at the centre of the primary coil due to the current $i_1$. For, since the current round unit length of the coil is, in this case, $Ni_1/2L$, the magnetic force, H, at the centre of the coil is

$$H = \frac{\pi N i_1}{L}\int_{-L}^{+L}\frac{A^2dx}{(x^2+A^2)^{\frac{3}{2}}} = \frac{\pi N i_1}{L}\left[\frac{x}{\sqrt{x^2+A^2}}\right]_{-L}^{+L}$$

$$= \frac{2\pi N}{C}i_1.$$

Thus we see that the principal term in the series (vi.), viz.,

$$\frac{2\pi^2Nna^2}{C},$$

is the value which we should have obtained for M if we had assumed that, at every point within the secondary coil, the magnetic force due to unit current in the primary coil is uniform in direction and has the constant value $2\pi N/C$. The numerical calculation shows that in the case considered the assumption of a constant magnetic force leads to a close approximation.

The formula (vi.) shows that this assumption will lead to a specially close approximation when the secondary coil is designed so that $4l^2=3a^2$ or $l=0{\cdot}866a$.

§ 15. Hitherto the centres of the two coils have been supposed to coincide. But in some cases there may be a small distance between the two centres, as, for instance, when two or more secondary coils are wound on the same cylinder. The axes of the two coils are supposed to coincide as before. Let O (Fig. 4) be the centre of the primary coil, OX the axis and O′ the centre of the secondary coil and let $OO'=h$. Let Q be a point on O′X and let $O'Q=q$. Then, in order to be able to apply (iv.) to this case, we must find the potential at Q due to the primary current in terms of $q$. Putting $r=q+h$ we have for the potential at Q

$$U/i_1=G_0+G_1(q+h)+G_2(q+h)^2+\ \ldots$$

Suppose this to be expanded in powers of $q$ in the form

$$U/i_1=G_0'+G_1'q+G_2'q^2+\ \ldots$$

Then, by (iv.) we find, for the coefficient of mutual induction

$$M'=-[g_0G_0'+g_1G_1'+\ldots],$$

so that M′ is derived from $-U/i_1$ by writing $g_n$ for $q^n$ wherever $q^n$ occurs. Hence, to obtain M′ in the form of a series in powers of $h$, we need only arrange $-U/i_1$ in powers of $h$, and then substitute $g_n$ for $q^n$. Since $g_0=g_2=g_4=\ldots 0$, and $G_0=G_2=G_4\ldots=0$, we have

$$M'=-(g_1G_1+g_3G_3+\ \ldots)-\frac{h^2}{1\,.\,2}(3\,.\,2g_1G_3+5\,.\,4g_3G_5+\ \ldots)$$
$$-\frac{h^4}{1\,.\,2\,.\,3\,.\,4}(5\,.\,4\,.\,3\,.\,2g_1G_5+7\,.\,6\,.\,5\,.\,4g_3G_7+\ldots)-\ldots$$

Using the values found for the $g$'s and G's in § 13, we have

$$M'=1{\cdot}1999\times10^6[1-5{\cdot}6138\times10^{-4}h^2-3{\cdot}296\times10^{-6}h^4-\ \ldots].$$

Taking $h=2$ cm, we find

$$M'=1{\cdot}1999\times10^6(1-0{\cdot}002246-0{\cdot}000053\ \ldots)$$
$$=1{\cdot}19714\times10^6\text{ cm.},$$

so that a displacement of 2 cm. diminishes M by less than 3 per mille.

§ 16. Since the primary and secondary coils have each only one layer, some arrangements must be made for completing the circuits. A good method is shown in Fig. 5. The end A of the primary coil is joined to the terminal screw E by a short wire parallel to the axis of the cylinders. The end B is joined to the terminal D by the wire BCD, which is parallel to the axis and is placed as close as possible to the windings of the solenoid, and the terminals D and E are close together. The end F of the secondary coil is connected to the terminal M by the wire FLM, the part FL being perpendicular to the axis, and the part LM lying as nearly along the axis as possible. The end G is joined to the terminal N by the wire GHKN, the part HKN coinciding with the axis, and the part GH being perpendicular to the axis. The two coils are joined to the rest of the apparatus by twin flexible leads connected to the terminals D, E and M, N. A pair of small terminals may well be fitted at K and L, as there will then be no risk of breaking the fine wire with which the coil is wound.

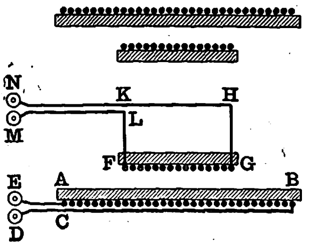

FIG. 5.

The mutual potential energy of the two circuits is $-Mi_1i_2$, and this may be expressed by Neumann's formula[‖] in the form

$$-Mi_1i_2=-\iint\frac{u_1u_2+v_1v_2+w_1w_2}{r}dV_1dV_2,$$

where $dV_1$, $dV_2$ are two elements of volume of the two circuits, $r$ is the distance between $dV_1$ and $dV_2$, and $u_1$, $v_1$, $w_1$ and $u_2$, $v_2$, $w_2$ are the components, parallel to a set of rectangular axes, of the current densities in the two systems. Taking $u_1$, $u_2$ parallel to the axis of the cylinders, the part of the integral depending on $v_1$, $w_1$ and $v_2$, $w_2$ *for the two helices*, has been taken account of in the calculations in the earlier part of the Paper. Now, very approximately, the value of $\iint u_1u_2dV_1dV_2/r$ *for the two helices* is the same as for two current sheets $S_1$, $S_2$ *with their lines of flow parallel to the axis*, the total longitudinal currents being $i_1$ and $i_2$.

Now since, in both the primary and the secondary current sheets $S_1$, $S_2$ the current flows *along* circular cylinders, the effects of equal filaments of current in the primary sheet $S_1$ upon the secondary sheet $S_2$ are equal. Hence the effect of the primary sheet $S_1$ upon the secondary sheet $S_2$ is exactly compensated by the effect of the current $i_1$ in the wire BC. Similarly the effects of the primary sheet $S_1$ and the current $i_1$ in BC upon the current $i_2$ in HK exactly neutralise each other.

Further, since the currents in GH and FL are perpendicular to the axis, they contribute nothing to the integral when taken in connexion with either the current sheet $S_1$ or the current in BC. Finally, since the primary coil is wound on a circular cylinder, it follows from symmetry that neither GH nor FL contributes anything to the integral when taken in connexion with the component of the current in the helix parallel to a plane perpendicular to the axis.

Thus, when the connexions are completed, as in Fig. 5, the coefficient of mutual induction has the value which has been calculated from the action of two current sheets, in which the currents flow *in circles round the cylinders*.

§ 17. A few words may be added as to the practical construction of the standard. For the primary coil, the first essential is that it should be uniformly wound, and this is best secured by winding the wire in a screw-thread cut in a cylinder. It is not enough to know the *average* number of turns per centimetre; the winding must be *uniform* if an accurate value is to be obtained. The first essential for the secondary coil is that the cross section of the cylinder on which it is wound should be accurately known. In each case the coil must have an *integral* number of turns, so that the helix begins and ends on a line parallel to the axis of the cylinder. The radii A and $a$, which are used in the calculation of M, are found by adding half the thickness of the covered wire to the radius of the cylinder on which it is wound. If the instrument is to be used in experiments with alternating currents, the cylinders should be of non-conducting material, such as ebonite, stabilit, or better, marble, and no large pieces of metal should be employed in the construction. Iron should, of course, be avoided altogether.

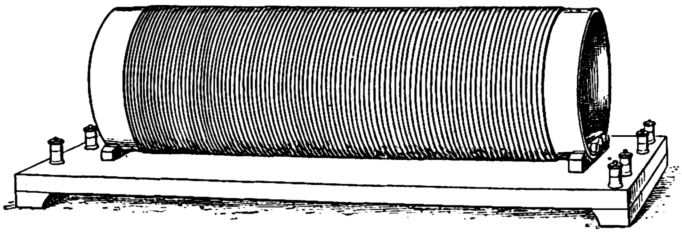

FIG. 6.

In the construction of the standard ampere balance at the National Physical Laboratory bare wires have been wound in helical grooves cut in marble cylinders, and a special measuring machine has been employed to determine the diameter of the helices. This instrument could be used to determine the diameters of the helices of a standard of mutual induction, and in this way a very accurate value might be obtained for the coefficient of mutual induction.

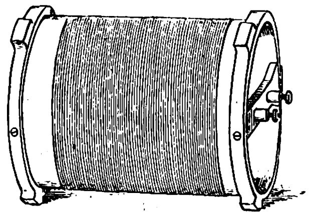

FIG. 7.

§18. The standard of mutual induction, shown in Figs. 6 and 7, was constructed by Messrs. W. G. Pye & Co., Cambridge, on the lines recommended in this article. The primary and secondary coils are both wound in screw threads cut in cylindrical brass tubes. Inside the primary cylinder (Fig. 6), at the right-hand end, is seen an ebonite block fitted with screws. These screws are represented by A and C in Fig. 5, and by them connexions are made between the windings of the primary coil and a pair of working terminals attached to the baseboard. For the purpose of illustration the secondary coil (Fig. 7) is shown separate from the primary coil, and on a larger scale (about one half full size). An ebonite ring is fitted to each end of the brass cylinder, on which the secondary coil is wound, and these rings fit the inside of the primary cylinder, so that, when the secondary is placed inside the primary cylinder, their axes coincide. The secondary cylinder carries *two* coils, one of 200 turns and the other of 20 turns, and at each end of the cylinder a pair of small terminals is fitted, the coils being connected to them in the manner indicated in Fig. 5. When the apparatus is put together this secondary cylinder is held in place by stops, and the terminals on it are connected to two pairs of working terminals on the baseboard by twin flexible wire. The

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[‖] Maxwell, "Electricity and Magnetism," Vol. II. § 423.

dimensions of the primary and of the two secondary coils are as follows:—

$N = 200$   $L = 15{\cdot}0$ cm.   $A = 5{\cdot}18$ cm.   $C = 15{\cdot}87$ cm.
$n_1 = 200$   $l_1 = 3{\cdot}11$ cm.   $a_1 = 4{\cdot}10$ cm.
$n_2 = 20$   $l_2 = 0{\cdot}31$ cm.   $a_2 = 4{\cdot}10$ cm.

Taking only the first term $2\pi^2 Nna^2/C$ in (vi.) and neglecting, as we may do to this approximation, the small correction due to the distances between the centres of the primary and secondary coils (see § 15) we find that the coefficients of mutual induction for the primary and each of the two secondary coils are approximately:—

$$M_1 = 836000 \text{ cm.} = 0{\cdot}000836 \text{ henry.}$$
$$M_2 = 83600 \text{ cm.} = 0{\cdot}0000836 \text{ henry.}$$

Since the standard is furnished with *two* secondaries, the change of induction, $2Mi_1$, due to a reversal of the primary current $i_1$, can be made to have a large range of values for a moderate range of values of $i_1$, and thus, in any set of experiments, $i_1$ will probably be measurable on the same amperemeter throughout. In using the standard in magnetic tests of iron it will be convenient to place a resistance in series with the secondary of lower resistance, so as to bring the total resistance of both secondaries up to the same value. If the added resistance be formed of *copper* wire the resistances of the two secondaries will remain equal in spite of changes of temperature.

## ELECTRICITY SUPPLY IN PARIS.

An interesting report has been issued with regard to the future of the electricity supply system for Paris. Those who remember the article in our issue of March 3rd last will be fully acquainted with the nature of the deadlock that has arisen between the six electric lighting companies and the Paris Municipal Council. The companies have held concessions on somewhat onerous terms, and these concessions expire at different dates from April 8, 1907, to December 11, 1908. At this date, in each case, the cable network of the company in question will become the property of the Paris Municipal Council, but the service wires, meters and generating plant remain the property of the company. It is thus seen that unless some new arrangement is arrived at between the Municipal Council and the companies, it will be extremely difficult to secure continuity of the supply when the concessions expire.

A technical committee was appointed to consider part of the question, and it was the report of this committee that we reviewed in the article above referred to. This committee confined itself, however, to outlining the best system of supply for Paris in the future, without taking account of the present conditions of supply there. The committee recommended a 2 × 110 volts three-wire system in the central portions of the city and the four-wire three-phase system in the parts in which the load would not be so dense. Generation was to be by three-phase steam turbine units of 5,000 kw. capacity placed in three generating stations, and the total initial capacity of these stations was put at 80,000 kw. It was estimated that the total works costs would be 1·18d. per unit, that the management charges would be 0·3d., interest and sinking fund 1·1d., and the cost of renewals 0·58d., the total being, therefore, 3·16d. per unit. The tariff proposed was 5d. per unit for the first 400 hours per annum, not of maximum demand, but of the nominal rating of the meters and 1·05d. per unit afterwards.

The report now before us was presented last month to the Paris Municipal Council by the Prefect of the Seine, M. J. de Selves, and it includes a report by M. P. Lauriol, engineer-in-chief of the general lighting service of Paris. M. de Selves' first endeavour was to come to an arrangement with the companies, by which concessions would be extended for short periods differing in length, so that all might expire simultaneously at the time that the proposed new municipal electricity works would be ready; in exchange for being granted a longer period of life, the companies were to allow a reduction of tariff. It may be mentioned in passing that the present tariff in Paris is extremely high in view of the conditions under which the companies have been working. In fact, we believe that it is by far the highest in any of the big cities in western Europe. The various companies were asked to make proposals on this basis, but only three out of the six replied. Of the three companies who did not avail themselves of the invitation, one was the Edison Co., whose concession expires in April, 1907, and as the area of this company is in one of the most important districts, the scheme necessarily fell through.

Alternative offers were made by four companies however. Two of these were existing supply companies, viz., the Edison Company [Compagnie Continentale Edison] and the Secteur Electrique de la Rive Gauche; the other two were from a new company (L'Est Lumière) and a syndicate formed by the two large electrical companies Schneider & Co. and Mildé & Co. The last mentioned of these has appeared to M. de Selves to be the most practical, and he recommends its acceptance.

This company, the full title of which is Société d'Etudes pour l'Exploitation de L'Energie Electrique à Paris, offers to commence running each of the six companies' districts directly the concession in question expires, and it offers to be responsible to the city for all the details of the change over, and to guarantee against any difficulty which may arise between the municipality and the companies. The company would be granted a monopoly for electric supply, except for public traction service, and the concession would expire on December 31, 1938. Provision is made, however, for the Municipal Council taking over the service at the end of 1923, 1928, or 1933 on certain conditions. The systems would be gradually converted, so that by the end of 1912 they would form one entire system complying with the conditions indicated in the technical report referred to in our issue of March 3rd last—viz., one, two or three works outside Paris generating three-phase current at 10,000 volts and 50 cycles, with the conditions of distribution already indicated. The company would pay the city 8 per cent. of the gross receipts from the sale of current (as compared with the 5 or 6 per cent. paid by the existing companies), 45 per cent. of the yearly profits, and 5 per cent. would in addition, be set aside as bonus for the staff. It is to be understood, however, that all these payments should never be less than 4,000,000 fr. (£160,000) per year. At the end of the period mentioned, the whole system would become the property of the City without payment. The company would undertake to lay down 400 km. (250 miles) of new network, in addition to the 370 miles in use, before the end of 1912.

It is proposed that the consumer shall have the choice between a two-rate tariff and the maximum demand system. Up to the year 1912 the charges would be 90 centimes and 35 centimes per unit (8·6d. and 3·4d.) from 1913 to 1922, 70 centimes and 20 centimes per unit (6·7d. and 1·9d.) and from 1923 onwards 60 centimes and 15 centimes (5·8d. and 1·4d.). The current supplied to the municipality itself will be subject to a reduction of 30 per cent.

To avoid the danger of the company not developing its system properly during the last years of its concession the following financial scheme is proposed: After the 8 per cent. of the gross receipts payable to the municipality has been deducted, 4 per cent. is to be set aside as interest and sinking fund on the capital expenditure made during the first 15 years of the concession, 5 per cent. is to be set aside as a reserve fund to defray the cost of any extraordinary renewals; a further 5 per cent. is then to be placed to a special fund which is to be allowed to accumulate until the 15th year of the concession, to furnish capital for the extensions which are necessary during the latter part of the company's term of life. It may be mentioned that the £160,000 guaranteed as a minimum payment to the municipality is about three times what is paid to the municipality yearly by the present electric light companies, and under present conditions there is no minimum guaranteed, the payments being at the rate of 5 per cent. or 6 per cent. of the gross receipts as already stated.

The hours during which the higher of the two tariffs given above is to apply are as follows:—

January, 4:15 p.m. to 10 p.m.; February, 4:45 p.m. to 10 p.m.; March, 5:45 p.m. to 10 p.m.; April, 6:30 p.m. to 10 p.m.; May, 7:30 p.m. to 10 p.m.; June, lower tariff only; July, lower tariff only; August, 7 p.m. to 10 p.m.; September, 6 p.m. to 10 p.m.; October, 4:45 p.m. to 10 p.m.; November, 4 p.m. to 10 p.m.; December, 3:30 p.m. to 10 p.m.

The prices are exclusive of meter rents, and the company proposes to charge from 1 fr. to 3 50 fr. per month (9½d. to 2s. 9½d.), according to the size of the meter, but if the consumer likes to have a quantity meter half the above prices are charged. An extra 50c. (4¾d.) per month will be charged for double-tariff meters. It appears, also, that the consumer will have to pay the company for the service lines and main fuse in each case in accordance with a tariff to be approved by the Prefect of the Seine. The company is also to have the right to demand from the consumer a deposit at the rate of 20 fr. per kilowatt capacity of the meter.

## THE MEASUREMENT OF HIGH-FREQUENCY CURRENTS AND ELECTRIC OSCILLATIONS.

In commencing his second Cantor lecture on the above subject before the Society of Arts last Monday evening, Prof. J. A. Fleming, F.R.S., referred to the fact that each spark consisted of a train of oscillations which decayed at a greater or smaller rate according to the constants of the circuit. The frequency of the oscillations could be calculated from the formula $n = 5{,}000{,}000/\sqrt{CL}$, C being the capacity in microfarads and L the inductance in centimetres. A convenient way of making such oscillations visible, providing the frequency was not too high, was by means of Duddell high-frequency oscillograph. A number of oscillograms were then thrown on the screen, and it was gathered from them that the frequency, &c, varied as indicated by theory; indeed, the agreement between the calculated and the observed values was very close. By connecting the tops of successive oscillation waves a logarithmic curve was obtained, and the decrement $\delta$ (for a whole period) was the Naperian logarithm of the ratio of two successive oscillations in the same direction. The greater the damping the quicker the decay. If $I_1$ was the amplitude of any one wave and $I_2$ the amplitude of the next oscillation, then $I_1/I_2 = e^{\delta}$. This decrement $\delta$ can be calculated from the constants of the circuit and equals $R10^9/4nL$, L being given in centimetres. Although the oscillations lasted some time, it was usual and sufficiently accurate for practical purposes to consider the train of waves to have finished when the amplitude of the oscillation had died down to 1 per cent. of the amplitude of the first oscillation. The number of oscillations of practical importance was then given by the expression $M = (4{\cdot}606 + \delta)/2\delta$. Several methods were used for measuring the R.M.S. value of high-frequency currents. If the effective current was fairly large, a hot-wire instrument could be used, being calibrated by continuous current. For more sensitive measurements, the Riess combination of a resistance coil and an air thermometer could be employed with advantage. In order to show the actual working of this instrument, the lecturer proceeded to measure the R.M.S. of a high-frequency current discharging through an oscillatory circuit on the table. The R.M.S. current was found to be 1½ amperes, but the maximum value of the current was calculated as 390 amperes. For measuring very small currents, thermo-junctions were very suitable, the most sensitive arrangement being that in which a thermo-junction (heated by radiation from a hot wire) sent a current through a small loop of wire which was free to rotate in a suitable magnetic field under the action of this current. Turning to the question of the voltage necessary to break down the spark-gap, the author quoted a number of experiments which prove that this voltage depends to a great extent on the diameter of the spark knobs, as also on a number of other things. A phenomenon which had to be carefully taken account of when carrying out experiments related to the fact that ultra-violet rays promoted the discharge. This was proved experimentally by screening alternately one of two spark-gaps (which were connected in parallel) from the light of an arc lamp; the spark across the unscreened air-gap was invariably brighter than the spark across the screened gap. The methods employed by Rutherford, Bjerknes and Drude for determining experimentally the logarithmic decrements were next explained, and diagrams were thrown on the screen. In answer to the question as to how much energy was actually radiated, it was mentioned that the ratio of the energy radiated to that spent in the oscillatory circuit was approximately 10 to 1. The available energy, in watts, was given by the expression $nCV^2/(2 \times 10^6)$, $n$ being the frequency, C the capacity in microfarads and V the voltage. At present a considerable amount of energy was dissipated in the induction coil, and the lecturer thought that this coil would be replaced before very long by a more efficient means. The synopsis for the third lecture on Monday next is given below :—

Measurement of frequency and resonance.—Time period and oscillation constant of a condenser circuit—Closed and open circuit syntonic circuits—Theory of resonance—Experiments illustrating resonance—Resonance curves—Determination of the total decrement from resonance curves—The cymometer—Its use for determining small capacities and inductances—Theory of the oscillation transformer—Analysis of the phenomena of the oscillation transformer by the aid of the cymometer.

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Report on Standard Locomotives for Indian Railways." By the Locomotive Committee of the Engineering Standards Committee. 2nd issue revised. (London: Crosby Lockwood & Son.) 10s. 6d.

"Baku: an Eventful History." By J. D. Henry. (London: Archibald Constable & Co.) 12s. 6d.

"The Practical Telephone Handbook and Guide to the Telephonic Exchange." By Joseph Poole. 3rd edition. (London: Whittaker & Co.) 6s.

"Alternating Currents: their Theory, Generation and Transformation." By Dr. Alfred Hay. (London: Harper & Brothers.) 6s.

"The Proceedings of the Royal Society." Series B. No. B 514. Vol. LXXVII. (London: Harrison & Sons.) 3s.

"Proceedings of the American Institute of Electrical Engineers." November, 1905. No. 2. Vol. XXIV. (New York: The Institute.) 50c.

"La Théorie Moderne des Phénomènes Physiques Radioactivité, Ions, Électrons." By Prof. Augusto Righi. Translation of the second Italian edition by Eugène Néculcéa, with preface by Prof. G. Lippmann. (Paris: L'Éclairage Électrique.) 3 fr.

## LIGHT RAILWAYS.

During November 17 applications were lodged with the Light Railway Commission for Light Railway Orders, compared with 18 in May last. We give below a list of the electrical schemes :—

| Title, length of line, &c. | Promoters. | Engineers. | Agents. |
|---|---|---|---|
| Aldershot & Farnborough (revival and extension of time) ........ | Aldershot & Farnborough Light Railway Co. | .. | .. |
| Bath Electric Tramways (Extension, ½ mile) .................. | Bath Elec. Trams (Ltd.) .. | G. Hopkins & Sons | Lees & Butterworth. |
| Blackpool & Fylde (extension of time) .................. | Blackpool & Fylde Lt. Ry. Co. | .. | Bircham & Co. |
| *Branksome Park & Swanage (13¼ miles) .................. | Lord Alington, T. B. Scott & Sir J. M. Burt | Eady & Frech, W. Cobbett | Batten, Proffitt & Scott. |
| *Burton & Ashby (amendment, 1½ fur.) .................. | Midand Railway Co... .... | W. B. Worthington, C. H. Gadsby | Sherwood & Co. |
| County of Middlesex (5¼ miles) .................. | Middlesex County Council . | H. T. Wakelam .. | Sir R. Nicholson. |
| Halesowen (transfer and extension of time) .................. | Empire E.L. & P. Co, .... | .. | Lees & Butterworth. |
| Mansfield & District (extension, 7 miles) .................. | Mansfield & Dist. Lt. Rly. Co. | Bramwell & Harris | W. & W. M. Bell. |
| *Middlesbrough & West Hartlepool (7½ miles) .................. | C. S. Watson & C. E. Straker | Eady & Frech.... | Batten, P. & S. |
| Warrington & Northwich (amendment for extension of time) ...... | Warrington & N. Lt. Ry. Co. | .. | Baker & Co. |
| Llanelly & District (6¾ miles) .................. | Llanelly & Dist. E.L. & T. Co. | Bramwell & Harris | W. & W. M. Bell. |
| †Portmadoc, Beddgelert & S. Snowdon Railway (extension, ½ mile) .. | Portmadoc, Beddgelert & S. Snowdon Railway Co. | Harper Bros. & Co. | Paines, Blyth & Huxtable. |

* These lines will be constructed to a 3 ft. 6 in. gauge. † This line will be on 1 ft. 11½ in. guage, the remainder being to standard gauge.

# CORRESPONDENCE.

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## THE BELFAST ENGINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In connection with the new Belfast electric tramways we notice reports have appeared in the Press which are not only misleading to the public, but very detrimental to our interests, and which we now take the opportunity of explaining and laying the facts of the case before your readers. The main point at issue is the running of the engines non-condensing, and from the specification issued by Mr. V. A. H. McCowen, city electrical engineer, we give you the following extracts:—

> Each engine shall be arranged to drive one 1,000 kw. dynamo. It must be capable of giving continuously the required power for its dynamo output with steam pressure at the stop valve of the engine of 170 lb. per square inch.
>
> The engines shall be capable of working up to 25 per cent. overload by bye-passing steam or other approved means, and the flywheel shall be sufficiently heavy to deal with momentary overloads of 50 per cent.
>
> The engines shall be capable of giving the above duty when working condensing with a vacuum of 25 in.
>
> The following tests will be made: The engine will be run for 12 hours continuously, driving its own dynamo at full power. The engine shall run steadily, quietly and without knocking or heating, at the specified power and speed. Indicator cards and electrical readings will be taken during the run. The engine shall also be tested at three-quarter load, half load, quarter load, and dynamo excited for steam consumption, both condensing and non-condensing; governor tests will also be carried out.
>
> The guaranteed results shall be filled in on the attached schedule by the party tendering, and it must be distinctly understood that the figures given as to efficiency, steam consumption and governing are to be guaranteed by the contractor, and shall form part of this contract and shall be the subject of a test.
>
> The economical operation of the steam dynamos is most important, and the figures guaranteed by parties tendering shall be obtained subject to a bonus or deduction of £250 per engine for every pound of steam per kilowatt-hour, and pro rata for every one-tenth part of a pound of steam below or above that guaranteed when the engine is working full load condensing.
>
> This will be the subject of a test to be carried out in the presence of and to the satisfaction of the engineer.

The only other reference as to how the engines are to run is in the schedule of guarantees, where the steam consumption is specified at full load, three quarter load, half load and quarter load, condensing and non-condensing. There is no other reference whatever to running the engines non-condensing. In accordance with the specification, therefore, the engines were designed for the most efficient running when working condensing. At the same time, the engines are capable of working up to full load, and have been running with full load and up to 10 per cent. overload when working non-condensing.

The main contention between ourselves and the city electrical engineer is the length of time the engines should run in this way. We maintain that we were only called upon to run non-condensing in the case of an emergency, such as the breakdown of the condensing plant. On the other hand, the city electrical engineer states in his report to the Tramways committee: "I will find it necessary to run them either condensing or non condensing for long periods." The reason of this is that he now finds that the condensing plant will not be ready for some months; this is due to the fact that the pump house for the circulating pumps, which is built on the banks of the river and which is no part of the main contract, is not yet completed.

The engines are completed to carry out the full requirements of the specification, but we maintain that it is not advisable to run them for long periods with the present valve setting. We have pointed out that a slight modification will make them suitable for running non-condensing for long periods, but in that case the valve setting would have to be altered before the efficiency could be attained which we have had to guarantee when running condensing. We may point out that the engines are constructed with an automatic bye-pass valve worked by the governor, which admits steam when necessary into the middle-pressure cylinder, and are not fitted with automatic expansion valves.

In the face of this we maintain that the specification has been strictly adhered to, and the reports which have been put out are not only misleading, but are incorrect and detrimental to our interests.—Yours, &c.,

FAIRBAIRN LAWSON, COMBE BARBOUR (LTD.)
Dec. 4. Branch: COMBE BARBOUR.

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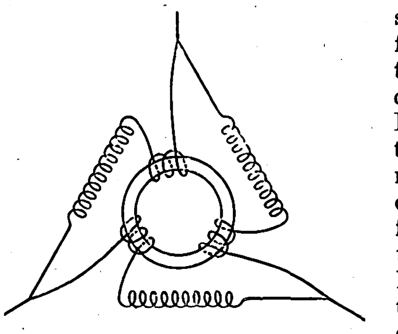
## WAVE-SHAPES AND THREE-PHASE TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—In your issue of November 10th Mr. Clinker showed that where the magnetising current of a transformer follows a sine law, and the flux is unrestricted, a triple-frequency term appears therein, and vice-versa. If, for example, three transformers be Δ-connected to a three-phase system of which the voltage between mains is sinusoidal, the magnetic flux in each transformer is restricted to the sine law, but *the magnetising current*, being to a certain extent unrestricted, exhibits a triple-frequency term. Thus triple-frequency currents circulate within the mesh. If, on the other hand, the transformers be Y-connected, the magnetising current is restricted in so far as it cannot contain triple-frequency terms, and Mr. Clinker showed that, in these circumstances, *the magnetic flux* contained a triple-frequency term. Thus, in those cases which Mr. Clinker dealt with, the current and flux always exhibited a praiseworthy desire to mutually accommodate each other. One or other had to contain a triple-frequency term: when the current found difficulties in this direction the flux would oblige, and when the flux found itself restricted, the current did not hesitate to conjure up the requisite triple-frequency component.



The question arises as to what must happen when both flux and magnetising current are similarly restricted. Mr. Clinker dealt with three-phase electric circuits and single-phase magnetic circuits. The case I suggest arises when the magnetic circuit is also three-phase Y-connected, as in the three-phase core type transformer. It is just as impossible for a triple-frequency flux to get through the "breeches" as for the triple-frequency current to pass the Y, unless, indeed, some outlet be provided at the point of bifurcation (*e.g.*, magnetic leakage through air) analogous to the neutral main of a three-phase electric system. If we take the case of a three-phase core type transformer of ordinary design and neglect air leakage (on no load) as insignificant, and consider the three windings Y-connected to a supply having a sinusoidal voltage between mains, it is quite certain that the magnetic flux in each limb can only follow a sine law, and equally certain that no triple-frequency term can exist in the magnetising current. It looks, therefore, at first sight, as though the ordinary relations between the magnetising current and the flux in the closed-circuit transformer are here modified.

The explanation is probably to be sought in the fact that *a three-phase Y magnetic frame is not entirely a closed iron circuit*; in fact, as regards triple, sextuple, &c., terms it is an open-circuit type, resembling in this particular the historic hedgehog transformer, the above-mentioned components of the current tending to magnetise it as a whole, north pole at one end, south pole at the other, and so on alternately.

Another point suggested by Mr. Clinker's article is the following: Suppose the three transformers of a Δ-connected system are replaced by independent choke coils containing iron, each being in series with a separate primary winding, all three of which primary windings are placed upon a single closed magnetic circuit. The fundamental terms of the magnetising currents will produce no resultant magnetism in the common magnetic circuit, but the triple frequency terms, all having the same phase, will produce magnetism. If we now provide the magnetic circuit with a single secondary winding we have a frequency transformer, *converting from three-phase to single phase of triple frequency*, even though the supply voltage is purely sinusoidal. The load in the three-phase supply system is, moreover, balanced. In the secondary system the fundamental will be three times the frequency of the supply, it may, of course, also contain harmonics 9, 15, &c., times the frequency of the supply. With a five-phase system we could similarly obtain a 1:5 frequency transformer.—Yours, &c.,

Manchester, Dec. 2. M. B. FIELD.

## WAVE MEASURERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In No. 1,430 of your esteemed journal of Oct. 13th, 1905, we find in your report of the Electrical Exhibition at Olympia, a detailed description with drawings of the Fleming Wave Measurer (Cymometer) of the Marconi Company, a patent having been applied for on this apparatus on June 17th, 1904.

In the specification and claims we find that the description of the apparatus in question corresponds to the wave measurer protected by our company under British patent No. 1,818 of August 22, 1903, as well as in U.S. application No. 763,164 of September 15th, 1903, in the German application of 149,350, filed April 3rd, 1903, and also in our applications for patents in several other countries.

Our wave measurer possesses as typical characteristic an oscillatory circuit with indicator, the self-induction or capacity of which or of both of these together is variable. The claims of the said British patent No. 1,818 read as follows :—

1. An apparatus for determining the length of the waves and observing the oscillations in electric oscillation systems utilising a closed oscillation circuit to be coupled with the system examined, with variable electric values, characterised by the capacity or the self-induction of the oscillation circuit, or both these values undergoing a gradual alteration within wide compass, whilst the adjusting device employed therefor is connected with a reading off device indicating the length of the waves corresponding to the actual adjustment, and by the oscillation circuit itself being directly or inductively connected with a current meter (heating wire instrument) so that by the simultaneous use of a current meter for the strength of current of the oscillations and an indicating device for the length of waves, an exact determination of the latter and judgment of the working of the oscillation system to be examined, and more particularly the sharpness of the wave formations is rendered possible, substantially as described.

2. A form of construction of the apparatus described in Claim 1 characterised by a considerable enlargement of the measuring capacity beyond the limits afforded by the alternation of one of the electric values (capacity) being attained by altering the other electric value (self-induction) in definite stages which are so calculated that the gradual alternation of the one value for the progressive or continued enlargement of the measuring capacity may be utilised within the limits enlarged by the added amounts of the said alteration, substantially as described.

3. The improved apparatus for determining the length of the waves and observing the oscillations in electric oscillation systems, comprising the several parts constructed and designed to co-act, substantially as described with reference to and shown in the annexed drawings.

Our U.S. Patent No. 763,164 protects in general a closed oscillatory circuit, the frequency (and wave lengths) of which is variable, and in which an indicatory device is provided for the purpose of ascertaining resonance. Especially characteristic are claims 1-3, as follows :—

1. An electrical measuring instrument, consisting of a closed resonator calibrated to wave lengths substantially as described.

3. An electrical measuring instrument, consisting of a closed resonator, means for changing the natural period of the circuit and means for indicating the resultant wave lengths, substantially as described.

Whilst in the British and U.S. patents and claims, the variation of the frequency (and wave lengths) of an oscillatory system by the variation of the capacity or the self-induction of the oscillatory circuit or of both is protected in broad principle, the Fleming construction admits only of the possibility of varying the self-induction with the capacity (see illustration and description, p. 1,041, in No. 1,430 of *The Electrician*).

In our practical construction of this apparatus we employ as indicating device an air thermometer, as the same enables quantitative measurements to be correctly attained. Thus with our wave measurer we are in a position not only to determine the wave-lengths of open or closed oscillatory systems, but also to carry out the measurements for self-induction or capacity as well as for damping, these measurements being of course out of the question, when, as mentioned by Fleming, a "vacuum tube" is employed as indicator.

In considering the above, it is evident that the Fleming cymometer represents only a special form or construction of the method or system protected by us of varying the frequency of an oscillatory system. Moreover the Fleming apparatus does not appear to be a technical improvement, but on the contrary, from an electrical point of view, an unfavourably operating limitation of our much more universal apparatus.

Thanking you beforehand for your trouble in the matter.
—Yours, &c.,

GESELLSCHAFT FÜR DRAHTLOSE TELEGRAPHIE.

Berlin, Nov. 29.

# LEGAL INTELLIGENCE.

### South-Western Electrical Co. (Ltd.) v. Neale.

In the City of London Court on Monday, before Judge Lumley Smith, K.C., plaintiffs sought to recover £65 from Mrs. M. J. Neale as the price agreed upon for certain assets of the company. The claim was admitted, but defendant made a set off of £141. 18s. 9d. It appeared that defendant's husband was an electrical engineer, and in 1903 was carrying on business as the South-Western Electrical Co. He sold the business to a limited company, remaining managing director. The business was not a very flourishing one, and in December, 1903, the sheriffs came in. In January, 1904, the company went into liquidation, and a Mr. Peebles was appointed liquidator pro. tem. Mr. Salomon was afterwards appointed, and he brought the present action on behalf of the company. Mr. Neale was made a bankrupt. As Neale was the man who knew most about the business, it was desirable to save the goodwill of the concern as far as that could be done, the intention being to float a fresh company out of the ruins of the old. Neale acted partly for the liquidator and partly in managing the business for his wife, who had taken over the business from the liquidator. That went on for some time, Neale receiving two guineas a week from his wife. It was then arranged that the liquidator should pay the defendant a guinea a week for the services of her husband in assisting in the winding up of the company. Subsequently it was arranged that instead of paying Mrs. Neale the liquidator should set the payments off the £65 which Mrs. Neale had agreed to pay for the business, which she brought back from the liquidator. Those payments were, with others, now set off against the company's claim. The company had four apprentices, three of whom had paid £30 premium each and one £40. They had still about three years to serve.

Mr. GEORGE NEALE said the arrangements relied upon by him were made with the liquidator's clerk. He had lost over £900 by selling the business to a company.

Mr. SALOMON said the clerk had no authority to make any such arrangement.

Judge LUMLEY SMITH said any claim of the apprentices would be against the company in the liquidation, the same as any other debt. He would allow £7. 10s. for the work which Neale did in helping the liquidator and judgment would be given for plaintiffs' company for £65 (less the £7. 10s.) and costs.

### Davies v. J. E. Spagnoletti & Co.

Mr. Justice Channell heard this case yesterday.

Mr. NEWBOLT (for plaintiff) said defendants were contractors and manufacturers of electrical appliances and agents for the Rex fire extinguisher and on July 9, 1901, an agreement was made and defendants engaged plaintiff to sell the extinguishers and also to obtain manufacturing orders for general electrical work. The terms between the parties were arranged by letter, and at an interview. Plaintiff's case was that in pursuance of the contract he introduced to defendants six or seven firms, including the British Thomson-Houston Co., R. W. Blackwell & Co., and the Great Central Railway Co. He now alleged that defendants had refused to pay him any commission after November, 1904, and had not rendered him any account of sales. In February, 1905, plaintiff received notice from defendants terminating the contract. Plaintiff claimed a declaration that he was entitled to commission as to defendant's dealings with his customers by reason of the employment and for those that he had introduced after he was dismissed without notice.

Defendants alleged that up to Feb. 28, 1903, there had been a settlement, but they did not agree that plaintiff had any accounts. Defendants further said that in January, 1904, they paid plaintiff £17. 18s, which was admitted, and they had delivered an account containing a complete statement of all sales and for manufacturing orders. Defendants also pleaded that the manufacturing orders were at such a price that defendants could not afford to pay any commission. Plaintiff sold nothing after February, 1903, and they paid £30 into court in respect of the past commission due and plaintiffs' right to further commission.

In the result his LORDSHIP found that plaintiff was entitled to £30 commission, but as defendants had paid that amount into court, judgment would be for defendants, with costs.

### Holland v. Ryland Bros.

At Liverpool Assizes on Saturday the hearing of this case, which extended over four days, was concluded. The action was brought for damages for breach of contract in respect of 150 tons of galvanised telegraph wire supplied by defendants. A number of technical witnesses gave evidence. Plaintiffs contended that the wire was defective and did not stand the necessary tests. The jury answered three out of five questions in favour of plaintiffs, but did not answer a fourth.

Mr. HORRIDGE, K.C., for plaintiffs, said he was quite content with the jury's findings as they stood, and upon them he asked for judgment for plaintiffs for £451. 9s. 9d.

His LORDSHIP entered judgment for plaintiffs for this amount and costs.

### Lamont v. Lanarkshire Tramways Co.

At Edinburgh on Monday Lord Salvesen closed the records and ordered issues for the trial of this action for the recovery of £750 for personal injuries. On June 7 last pursuer was a passenger on one of defenders' electric cars from Wishaw to Motherwell. At a bridge near the boundary line of the burgh of Wishaw the trolley pole became detached. When the car passed the bridge the trolley pole swung round and struck pursuer violently on the head. Pursuer avers that the car was being driven recklessly and at an excessive speed, and that for the safety of outside passengers the conductor should have guided the trolley pole when passing under the bridge. Defenders admit that pursuer was struck by the trolley, but they aver that pursuer's injuries are greatly exaggerated. The accident, they allege, was the result of a pure misadventure, which no care on their part could have averted.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT AND FILLED.

An experienced lead burner is wanted, accustomed to repairing secondary batteries and, preferably, competent to supervise generally the regular examination and working of batteries, Chloride and Tudor types chiefly. Wages 40s. a week (averaging 48 hours). Applications to the electrical engineer, H.M. Dockyard, Devonport. See an advertisement.

A telegraph linesman is required by the Government of Sierra Leone. Engagement for three to six months. Salary £20-£25 a month. Applications to the Crown Agents for the Colonies, Whitehall-gardens, London, S.W., up to Dec. 18. See also an advertisement.

Applications are invited for the newly vacated professorship of electrotechnics at the South African College, Cape Town. Commencing salary £600 per annum. Applications must be sent by Dec. 15 to the Agent-General for Cape Colony, 100, Victoria-street, London, S.W., from whom further particulars can be obtained.

An examination will shortly take place for appointments as second-class engineers in Engineer-in-Chief's Department, G.P.O. Jan. 11 is the latest date for receiving applications. Forms from the Secretary, Civil Service Commission, Burlington-gardens, London, W.

An electrical mechanician is required for the Federated Malay States railways. Candidates should have a thorough practical knowledge of three-phase motors as applied to driving machine tools, &c., in a railway workshop. Salary £225 per annum, with free second-class passage out and home on satisfactory completion of engagement. Applications to Crown Agents for Colonies by Dec. 12.

Mr. Henley L. Howard, A.M.I.Mech.E , A.M.I.E.E., of Manchester, has been appointed engineer and general manager of Barkchester, has been appointed engineer and general manager of Barking municipal electricity and light railway undertakings, in succession to Mr. A. H. Seabrook, who was recently appointed borough electrical engineer at West Ham. The following six candidates were selected to appear before the Council in committee:—Messrs. H. Howard (Manchester), S. D. Jones (Batley), W. T. Robson (Hull), J. Senior (Mexborough), R. J. J. Swan (Chesham) and A. E. Wilkins (Chepstow). Mr. Swan was selected for the position, but as the Empire Electric Light & Power Co. offered him an increased salary, he declined the appointment, and the Council then selected Mr. Howard.

Mr. Frederick H. Andrews, of the East London Technical College, has been appointed head of the department of art and crafts at Battersea (London) Polytechnic.

Mr. W. E. White, of Brighton, has been appointed by Marylebone Electric Supply committee as their representative to deal with electricity consumers' accounts.

Mr. R. J. Roberts, of Merthyr Tydvil, has been appointed junior charge engineer at Cheltenham electricity works.

Mr. Wm. Ward has been appointed switchboard attendant at Paisley.

Bolton Council have appointed Mr. C. Barry as engineer-in-charge at the electricity works.

Mr. J. C. Whiteley, of Huddersfield, has been appointed manager of Gloucester Council light railways at £220 a year.

Mr. R. E. Heygate has been appointed shift engineer at Dover.

**Aberdeen.**—The Gas and Electric Lighting committee have requested the convener (Councillor Kemp) and the burgh electrical engineer (Mr. J. Alex. Bell) to prepare materials for a handbook to consumers, giving particulars of the most economical method of using current, &c. During October 455,969 units of electricity were generated, of which 266,746 units had been used for lighting and 189,223 units for traction.

**Barking.**—The promoters of the Administrative County of London & District Electric Power Bill have renewed their offer to enter into an agreement similar to that provisionally entered into with the Council last year in regard to the purchase of the Council's electricity undertaking.

The London-road is to be lighted by 8 multiple Nernst lamps (in place of incandescent lamps) at a cost of £6 each per annum.

**Belfast.**—A full service was inaugurated on the municipal electric tramways on Tuesday.

**Bermondsey (London).**—The borough electrical engineer (Mr. W. E. J. Heenan) recommends the laying of two further distributor cables at a cost of £1,327.

**Birmingham.**—On the vexed question of breaking up streets for cable laying, &c., a conference of delegates from the various interested departments was held last week at the Council House to consider the best means of arranging concerted action. The Public Works, Water, Gas, Tramways, and Electric Light committees were represented. The city electrical engineer (Mr. R. A. Chattock), the tramways manager (Mr. A. Baker) and the city surveyor (Mr. J. Price) were present, but no report has yet been issued.

The reduced charges for the supply of electrical energy, given in our issue of Oct. 20, have been adopted by the City Council. The charges come into force on Jan. 1 next.

The Chairman of the Electric Supply committee (Councillor Ellaway) said the prices had not hitherto compared favourably with those in other large towns, although there had been considerable reductions since the Council took over the electricity works. The revised scale meant a loss of revenue of about £9,770. The net profit last year was £10,789, so that on the same consumption the net profit would only be about £1,000. The committee were prepared to face a deficit at the close of the year of something like £5,000. In the following year the deficit would be about £15,000. But that deficiency of £20,000 would be met out of reserve, which now amounted to about £49,000. The next year their troubles would be over. When Summer-lane station was opened a few months hence they would be able to deal with a much larger demand than previously.

**Blackpool.**—The Council have applied for sanction to a loan of £4,000 for mains, extensions, &c.

**Bolivia.**—La Paz is, it is stated, the only town in Bolivia which has an electric lighting system in operation, and this only for public lighting. Gas is also entirely unknown in the country, where the oil lamp reigns supreme.

**Boston.**—The Board of Trade are making inquiries as to what the Council propose to do with their provisional order, 1900.

Ald. Buhler moved that steps be taken to establish electricity works, but after discussion an amendment that the best possible terms be made with the National Provincial Electricity Corpn. was carried by 14 votes to 6.

**Brazil**—The plant at the electricity works at Rio Claro of Messrs. Theodor Wille & Co. has recently been added to to meet the increased demand for current. The number of equivalent 8 c.p. lamp connections is now 10,500 and the consumers have increased to 460.

**Brighton.**—The National Telephone Co. has applied to the Council for permission to place their wires underground. The total expenditure is estimated at between £40,000 and £50,000. The General Purposes committee, in recommending the refusal of the request, are reported to have expressed regret "that the company should make the necessities of the unemployed an excuse for forwarding their own interests."

The resident electrical engineer (Mr. J. Christie) has been authorised by the Lighting committee to invite quotations for carbons (in accordance with specification) from the same firms who have tendered during the past few years.

Mr. Christie said that the value of the carbons used during one year averaged about £800, but he did not recommend publicly advertising, as it would entail being flooded with dozens of samples from manufacturers' agents. They had not the time to efficiently test these, and it was much more satisfactory to deal direct with the manufacturers.

**British Central Africa.**—Electric lighting was established at Zombe in the early part of 1904, and is now used to light a number of bungalows, mission houses, &c. Current is generated by water power from the River Mlungusi, a stream about half a mile distant from the power house at Zombe. There are about 350 8 c.p. and 16 c.p. lamps installed, the number being increased as new buildings are erected. Motors are being employed for driving machinery in the shops of the Public Works Department, at the large printing works established here and for other machinery. The station is worked by locally-trained natives, and is said to be self-supporting. Some telegraph and telephone work has been completed, connecting up Livingstonia with the Cape to Cairo telegraph line. Some very difficult pieces of line were met with on the precipitous descent to the lake.

**Cleethorpes.**—The District Council have purchased the power station of the Grimsby Tramways Co., and are negotiating for the company to take over the lease of the station for five years.

**Cowes.**—The Council have entered into an agreement with the National Telephone Co. by which the latter will place their wires underground.

**Crediton.**—The Council have rescinded a resolution in favour of allowing Crediton Gas Co. to apply for electric lighting powers, and it has now been decided to actively oppose the company and to support an application by Christy Bros. & Middleton.

**Derby.**—At the Council meeting on Wednesday the chairman of the Electric Lighting committee (Ald. Butterworth) stated, in reply to questions as to the condition of the plant at the electricity works,' that

Since March last plant had been removed from the works which originally cost about £3,600. About half the amount had been written off. Some of the machinery had been sold for £265, and other parts had been exchanged for machinery worth £320. Four sets of engines remained on hand and would be sold. The machinery of the department had cost £200,000, and it was only to be supposed that from time to time there had to be renewals and improvements. During the past year all the arc lamps in the town had been renewed at a cost of £1,200, which had been paid for out of revenue,

**Dorking.**—The Council have sealed the agreement for the transfer of their electric lighting order to Edmundson's Electricity Corpn.

**Dublin.**—An inquiry was opened on Tuesday into the application of the Corporation to borrow (inter alia) £100,000 for electric lighting extensions and £4,900 additional for utilising the tramways in connection with the cleansing system of the city.

The chairman of the Electric Lighting committee (Mr. Irwin) said the committee were anxious that electric power should be used in pumping at the sewage tanks, but it was thought better that the original drainage scheme should be carried out. The inquiry was adjourned until Wednesday, when Mr. I. O'Brien, K.C., opened the case for the loan of £100,000 for the extension of the electric lighting undertaking. During the past year (he said) there did not appear to be any loss on the electric lighting department, and the price of electric current had been reduced. Extensions of mains would have to be made to the North and South Circular-road areas, where there were several institutions. If the loan were sanctioned it would mean a saving of £11,000 a year, which represented interest on a large capital.

The inquiry was again adjourned.

**Edinburgh.**—The question of the lighting of the side streets was debated at the Council meeting on Tuesday. The Electric Lighting committee have been experimenting with Nernst lamps, and the electrical engineer, having completed his experiments, offers to provide Nernst lamps at 47s. each per annum. The convener of the Cleansing and Lighting committee held that the Nernst lamps had not been satisfactory, but the Electric Lighting committee contend that the Nernst lamps had been a success, and that, in any event, the committee ought to be allowed to continue experiments with other lamps in the side streets. Ultimately it was agreed to recommit the matter.

**Electrical Progress in India.**—Through the courtesy of Mr. J. W. Meares, the electrical adviser to the Government of India, we are able to give the following list of applications (to date) for authority to establish electrical undertakings in India. The list is fairly complete, though there may be other applications to some of the Local Governments, particulars of which are not yet available:—

PUBLIC ELECTRICAL UNDERTAKINGS (in Operation or in Progress).

*Bengal Province.*

Calcutta (general supply).
Calcutta (tramways separate).
Dacca (general supply).
Darjeeling (general supply).
Barrackpore (licence applied for).
Howrah (general supply, *in progress*).
Howrah (tramways applied for).

*United Provinces.*

Cawnpore (general supply and tramways, *in progress*).
United Provinces Power Association (transmission over large area, under consideration).
Allahabad (tramways applied for).
Benares (tramways applied for).

*The Punjab Province.*

Bari Doab Canal scheme (under consideration).
Simla (under consideration).

*The Punjab Province*—(continued).

Lahore (general supply and traction, *in progress*).
Delhi (general supply and traction, *in progress*).

*Bombay Province.*

Bombay (general supply and tramways, *in progress*).
Poona (under consideration).

*Central Provinces.*

Nagpur (general supply and traction, *in progress*).

*Madras Province.*

Madras (general supply, *in progress*).
Madras (tramways separate).
Coonoor (electrification of hill railway, under consideration).

*Province of Burma.*

Rangoon (general supply and tramways, *in progress*).
Mandalay (tramways).

**Electric Driving in Weaving Sheds.**—In our last issue we referred briefly to the electric power plant at Trafalgar Mill, Burnley. This plant was supplied by Mather & Platt (Ltd.) and consists of a generator of their standard multipolar type driven by ropes from the main shafting of the Trafalgar Mill, and supplying the lighting of that mill as well as power for driving the Hope weaving shed across the canal.

The generator has a capacity of 264 kw. at 440 volts when running at 435 revs. per min. It is of the three-bearing type, mounted on massive box type bed and fitted with rope pulley arranged with 16 grooves for 1¼ in. diameter ropes. A large rope drum mounted on the main shaft transmits the power from the mill engine to this dynamo, and a set of rails are provided for adjusting the tension of the ropes. The motor driving the Hope weaving shed is capable of developing 180 B.H.P. at 545 revs. per min. and is connected by spur gearing. The arrangement of the gearing has some novel features. The pinion is not mounted directly on the motor shaft, but is carried by a short independent shaft revolving in two bearings mounted on a separate base plate. The two portions of shafting are connected by flexible coupling, which entirely frees the motor armature from any vibration set up by the gearing.

**Electricity in Mining.**—In the report of the Champion Reef Gold Mining Co. for the past year it is stated that the company's share of the additional supply to the mines on the Kolar Gold Field of electric power under the Cauvery power scheme was commenced early in 1905, and had efficiently driven the 900 H.P. air compressor. Negotiations with the Mysore Government are in progress for a still further supply of electric power from the falls. Under this arrangement about 500 H.P. will be available for the company.

**Exeter.**—The Council desire to enter into arrangements with a firm for the supply of electric motors to be let on hire.

**Fulham (London)**—The Finance committee concur in the suggestions of the district auditor on the electric lighting accounts that the electricity revenue shall be charged with an appropriate share of the central establishment expenditure, and that such amount be fixed at £200 instead of £100 per annum; that the electricity revenue shall also be charged with the actual cost incurred by its overdraft on cash account. The committee are opposed to any alteration in the system of collecting the electric lighting accounts. In view of the auditor's attitude in cutting out from the accounts the loan of £3,600 from the electricity reserve to the works department for wood paving, the borough treasurer is to be instructed to adopt a different method in transactions of this nature in future, and he is to keep an independent account of these loans with a view to paying same back by way of contributions from the rates.

**Gloucester.**—Electric energy supplied to the light railways is to be charged for at 1d. a unit. The tariff for current supplied for power has also been revised, and from Jan. 1 the charge will be 2d. per unit for the first 200 units per quarter, 1½d. for the next 1,000, 1¼d. for the next 10,000, and 1⅛d. for all beyond 11,200 units.

**Hackney (London).**—On Wednesday the Council decided to proceed with their bill to enter into agreements with adjoining local authorities for the supply of electricity in bulk and for linking up the electricity supply systems of various municipal electricity undertakers.

**Halifax-Huddersfield.**—The National Electric Construction Co. have published particulars of their scheme to construct tramways between Halifax and Huddersfield, via Elland. The intended route is by West Vale, and through Elland to Rastrick.

**Hamburg.**—A number of additional electric tramways is to be constructed in the city and suburbs at an estimated cost of £2,000,000.

**Holyhead.**—The Council have stated, in reply to a request by the Board of Trade, that they will supply electric current at 4d. per unit for use on the mail jetty and other portions of the Board's property. About 120 lamps will be erected by the Board.

The expenditure of the electricity department during the past year, including interest and sinking fund, was £1,890. The units sold were 127,632.

**Horsforth.**—The Council have decided to transfer their provisional order to the Yorkshire Electric Power Co.

**Huddersfield.**—The Corporation have decided to obtain power to construct a tramway in Gasworks-street to St. Andrews-road. Since the Tramways committee introduced coal haulage it had been the desire if possible to serve the gasworks. During the last few weeks Reed, Holliday & Sons have made an application in regard to coal haulage to their works, and probably there will be further similar applications from industrial concerns on the route.

**Inquest.**—An inquest was opened on Saturday on the body of John T. Curry, a fitter's assistant, who was killed while handling an electric lamp in the blacksmith's shop at Pelton Fell Colliery on 28th ult.

It was stated that deceased picked up a lamp which was attached to the circuit by a flexible, and in some manner he received a shock. The voltage of the current was 120. The lampholder and globe were found detached.

The inquiry was adjourned.

**Islington (London.)**—The Council's strong rooms are to be heated by electric radiators at an estimated cost of £42.

The Lighting committee will recommend the extension of the arc lighting.

The borough treasurer stated at the last Council meeting that the charge upon the rates for each arc lamp for the half-year ended March 31, 1903, was £32. 15s. 9d., compared with £37. 12s. 11d. in March, 1905.

**Italian Telegraphs.**—It is announced that the Italian Minister of Posts and Telegraphs is seeking authority to create fresh telegraphic lines between Upper and Lower Italy at an estimated cost of 2,000,000 lire.

**Kendal.**—A special committee has been appointed to inquire into and report upon the best method of increasing the consumption of electricity for power and lighting in the district.

**Kirkcaldy.**—The Town Council have decided to double a portion of the tramway line, and to construct additional loop lines at an estimated cost of £1,500.

**Leith Tramways.**—In reference to the description of the Leith Corporation electric tramways, which appeared in our last issue (pp. 253-255), we should have intimated that the rails were rolled by the North Eastern Steel Co., Middlesbrough, and were a very excellent piece of work, being thoroughly true to section and uniform in analysis. The Dicker joint was well fitted, and altogether very satisfactory. The tie bars and fish bolts were made by Guest, Keen & Nettlefolds, West Bromwich, and were also most satisfactory. The setts were supplied from the quarries of Wm. Wilson, Kilsyth, Stirlingshire.

**Leyton**.—The Council have increased the salary of the electrical engineer (Mr. F. Harman Lewis) by £150 per annum.

**Liversedge.**—The Council on Tuesday decided to postpone their electricity scheme and to ask the Board of Trade to extend the period of the provisional order for another 12 months

**London County Council.**—At Tuesday's meeting it was agreed to invest £16,200 of the tramways renewal reserve fund in L.C.C. 3 per cent. stock. The total amount now standing to the fund is £83,041. 19s. 10d. It was agreed to loan Woolwich £820 and £7,500 for electric lighting.

**Market Harborough.**—The Council decided on Tuesday to proceed with their application for a provisional electric lighting order.

**Marylebone (London).**—The Electric Supply committee report that additional generating plant will shortly be required as follows: (*a*) A ninth Parsons turbine at the generating station, £10,000; (*b*) storage battery at North street sub-station, £10,000; (*c*) storage battery at Rathbone-place sub-station, £5,000; (*d*) two boilers at generating station, £9,000.

**Middlesbrough.**—On Wednesday the Electric Lighting committee considered a communication from the Cleveland & S. Durham Electric Power Supply Co. asking for permission to supply electric energy for power within the borough, and intimating that the shipbuilding firm of Sir Raylton Dixon & Co, the Grand Opera House Co. and Richardsons, Westgarth & Co. had agreed to take a supply from the company.

The chairman (Councillor C. DORMAN) pointed out that the letter expressed a wish to supply other consumers. The company must make specific application in each case. Therefore, what they had to consider were the applications in regard to the three firms specifically named. The committee decided, in these three cases, to withhold their consent to the Company giving a supply on the ground that the Corporation was already supplying power on reasonable terms.

**Middlesex Tramways.**—The tramway from Green Lanes, via High-street, Hornsey, to the Alexandra Palace was opened for traffic on Wednesday.

**Motor Omnibuses.**—The directors of the London Road Car Co. have issued a circular to their shareholders in regard to certain statements which have been published in *The Times* concerning the newly-formed motor omnibus services in London. These statements (which are published on the authority of the motor omnibus companies) are apparently intended to lead the public to suppose that only these new companies can place serviceable motors on the streets of London, owing to their alleged monopoly of all the available makes of reliable chassis. The directors of the London Road Car Co. point out that already they have 50 motor omnibuses in their service, and that an additional 200 of these are contracted for to be delivered during next year. As the London General Omnibus Co. are probably similarly situated, it is pointed out that the statements published concerning these new motor vehicle services are not in accordance with the facts of the case.

**Newcastle-on-Tyne.**—The Council have authorised the construction of a double line of tramway to connect up certain existing lines.

**Northern Tramways.**—Negotiations have been completed between Islington (London) Council and the Metropolitan Electric Tramways (Ltd.) (as lessees of Middlesex County Council) for working a short line of tramway from the Archway Tavern to the Archway, Highgate. The track had been laid for this short piece of line for some months, but arrangements had not been completed between the parties until recently. The tramcars are expected to be running over this extension to the company's Whetstone–Highgate system in a few days.

**Persia.**—For the past 10 years the main arteries of Teheran have been traversed by a tramway, which is now showing satisfactory profits. A report from M. Maulion, attached to the French Consulate at Teheran, is of opinion that there is much room for development in the tramways of Persia. The Teheran Tramways Co. also work a telephone service in that city, of which little use is made by merchants, and, consequently, the service does not pay. M. Maulion is, however, of opinion that an efficient telephonic service linking up the principal towns in Persia would meet a real want. It appears that a concession for such a service was granted in May, 1904, to a Persian subject named Mamaleck, who disposed of it to the Russian Discount Bank. As the Persian Government has contested the legality of the transfer, those who want the telephone may have to wait some little time, as diplomatic matters move slowly in Persia. There is in course of construction in the centre of the City of Teheran (a particularly unfavourable situation far from coal mines or any source of water supply) an electricity generating station, and M. Maulion considers that some years must elapse before electric energy can be distributed from this station. The concession is in the hands of a wealthy Persian merchant, who can hardly be expected to be up to date in such matters. This station is being constructed on land which were originally gas works. These were erected 12 years ago by a Belgian subject and were closed within a few months of their inauguration, due, in M. Maulion's opinion, to incompetent management. From M. Maulion's report it would appear that a large number of industrial undertakings have been started in Persia, but very few have survived a month or two's actual operation.

**Personal.**—Mr. M. M. Gillespie, until recently a prominent member of the staff of the British Westinghouse Co., was on Friday last entertained to a complimentary dinner at the Midland Hotel, Manchester, by his old friends and colleagues. The proceedings bore witness to the popularity of a gentleman who has been associated for over 17 years with the Westinghouse Companies on both sides of the Atlantic. In future Mr. Gillespie will be found at his offices, Amberley House, Norfolk-street, Strand, W.C., where he will represent (among other firms) Browett, Lindley & Co. for London and the south and west of England.

**Presentations.**—On Nov. 24, at Sheffield, Mr. J. McNamara, who for the past two years has held the post of works superintendent in the electrical department of Vickers, Sons & Maxim, was presented by the members of the staff with a kit-bag and a case of razors on the occasion of his leaving to take up an important appointment in Egypt.

On Nov. 25 Mr. W. Baxter was also presented by the members of the staff of Vickers, Sons & Maxim with a silver cigarette case, a travelling flask and a fountain pen on the occasion of his departure from Sheffield to take up an appointment as manager of the electrical stamping department for Mr. E. Stevens, Stour works, Cradley Heath. For the past 2½ years Mr. Baxter has been assistant designer in the electrical department of Vickers, Sons & Maxim.

Mr. W. L. Spence, A.M.Inst.C.E., M.I.M.E., was the recipient on Friday last week of a presentation from the employés of the British Electric Plant Co. (Ltd.) on the occasion of his retirement from the managing directorship of the company. The testimonial was subscribed to by every employé at the works. The present took the form of a large combined filing and card indexing cabinet and a framed enlargement photograph of the staff and workmen. Mr. Spence has commenced practice as a consulting electrical and mechanical engineer in Glasgow.

In recognition of long services, the old Dover Electricity Supply Co. have presented illuminated addresses to Mr. L. W. Woodman, chief electrical engineer, and Mr. J. W. Broad, chief clerk.

**Reigate.**—The Council offer to supply electric current to a local firm (Love & Malcolmson, printers) for power at 2d. per unit, provided the firm guarantee a minimum return of £400 a year.

**Robbing Telephone Boxes.**—At the Guildhall (London) on Monday Thomas Green, who was caught in the act of breaking open one of the boxes in a call office at Moorgate-street Station, was committed for trial. It was stated that during the past year 170 call boxes had been broken open.

**Shoreditch (London).**—From Jan. 1 next the charge for electrical energy for heating will be 1d. per unit.

**South Africa.**—Electricity supply, electric traction, telephonic extensions and other applications of electricity are making satisfactory progress in British South Africa if the latest reports to hand can be taken as a reliable guide.

At *Cape Town* during the past year the supply of current given by the the Table Bay Harbour Board to the docks has increased to the extent of the equivalent of 17,000 8 c.p. lamps. There are now 34 electric cranes in operation at the docks, the installation being chiefly established for supplying these cranes, transporters, capstans, the workshops, and for lighting.

At *Johannesburg* the number of consumers taking current from the Council's undertaking has increased to 2,420, and the total equivalent 8 c.p. lamp connections from 88,830 to 129,790. The reconstruction scheme, for which Messrs. Mordey & Dawbarn are consulting engineers, is expected to be in operation early in 1906. The municipal electric tramways at Johannesburg, which are in course of construction on the overhead system, and for which Messrs. Mordey & Dawbarn are also consulting engineers, are making satisfactory progress.

At *Germiston*, where the mines controlled by the Consolidated Goldfields of South Africa are situated, the General Electric Power Co. are erecting the following additional plant: One 1,000 kw. Curtis' turbine and one 500 kw. ditto, a 250 kw. Belliss high-speed engine (for local current supply), a 500-tube economiser, three Hall condensers and three Hall compound feed pumps, three Edwards air pumps, a new cooling tower, and six Babcock and Wilcox boilers equal to 212 H.P. (these have been taken over from a neighbouring property). Mr. E. W. Gaskell has recently been appointed resident engineer at Germiston.

At *Pretoria*, where supply has been given by the municipality since 1892, an increase in the connections equivalent to 5,000 8 c.p. lamps has been made during the past year, bringing the total up to 40,000 with 1,200 consumers.

At *Bloemfontein*, where at present the C. S. A. Railways operate the entire telephone system, the Postal Department are installing a system of about 400 lines. The subscription to the telephone at Bloemfontein is £7 per annum, and there are about 100 subscribers.

The main line of railway in the *Orange River Colony* has recently been rebuilt for a distance of 330 miles, and the owning company are installing Tyer's absolute and permissive train tablet apparatus throughout the main lines in the Colony. Steam power has been practically abolished in the railway workshops, nearly all machinery now being driven by electric motors.

**Southwark (London).**—The electrical engineer (Mr. D. M. Kinghorn) has reported on the working of the electricity undertaking for the first six months of the current financial year. The equivalent of 31,237 8 c.p. lamps for lighting and 9,583 8 c.p. for power were connected.

**Stourbridge.**—The Council have decided to sell or lease their provisional electric lighting order, and the Board of Trade have been asked to grant a further extension of time.

**Sunderland.**—The borough electrical engineer (Mr. J. F. C. Snell) has reported to the Electric Lighting committee on further extensions of plant required at Hylton-road power station. Mr. Snell recommends the installation of four new boilers and other plant at an estimated cost of £16,000. There is also to be some alterations to existing machinery, to cost about £2,000.

**Torquay.**—We stated in our last issue that the Local Government Board had sanctioned a loan for extensions of the electricity works in order to provide electrical energy for the tramways at present under construction.

The amount applied for was £9,500, but the Board have only sanctioned £8,099, as the balance (£1,400) will be represented by superseded plant. In communicating its decision, the Board advised that public lighting by electricity should not be extended, and that, in view of the fact that the station will almost certainly have to be removed a few years hence, it is absolutely essential that the Corporation should take care to husband its financial resources.

Application has been made for sanction to a loan of £2,060 for mains extensions and for extensions of condensing plant and purchasing water-purifying plant.

**Underground Telegraph Cables.**—It was reported to the Newcastle Chamber of Commerce on Wednesday that the Postmaster-General hopes the trunk telegraph cable would be complete from London to Glasgow by the end of the current financial year.

**Wallasey.**—A well-appointed club for social and athletic purposes for the employés of the Council's electricity and tramways departments was opened last week. The club premises are situate over the messroom at the car depot

The following are the officers: Trustees, Dr. Napier (chairman of the Tramways committee), Mr. J. Kiernan, Major R. R. Greene (manager of the tramways), and Mr. J. Farley; *president*, Major R. R. Greene; vice-presidents, J. Braithwaite, J. R. Lloyd, H. Coventry, F. F. Scott, J. A. Crowther and C. Hagan; chairman, Mr. J. A. Butler; vice-chairman, Mr. G. Starkey; hon. secretary, Mr. W. Britton; assistant secretary, Mr. G. Disay; hon. treasurer, Mr. H. C. Wightman; and auditors, Messrs. H. Caunce and J. Bell.

**Wisbech.**—The Council have decided to apply for a provisional electric lighting order.

**Workhouse Lighting.**—The extension of the Paddington workhouse buildings is to be lighted electrically.

Fareham Workhouse is to be wired for the electric light.

**Dinner.**—The employés of the Mount Pleasant Cable Department (P O.) held their annual dinner and concert on Saturday evening, Mr. F. R. Huggins in the chair. After dinner a lengthy musical programme was gone through under the direction of Mr. E. Darkins.

## TRADE NOTES AND NOTICES.

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### TENDERS INVITED.

*Manchester* Electricity committee invite tenders for the supply, delivery and erection of: (*a*) One group of three single-phase transformers of 200 kw. each, constituting one complete 600 kw. three-phase transformer; (*b*) high and low-tension switchboards for three-phase transformer sub-station. Specifications, &c., from the secretary of the electricity department (Mr. F. E. Hughes), Town Hall, Manchester. Tenders, addressed chairman of the Electricity committee, must be delivered at the Town Hall by 19th inst. See an advertisement.

*Grimsby* Corporation invite tenders for a 500 kw. continuous-current direct-coupled high speed double-acting engine, water-tube boiler and underfeed stokers, extension of switchboard, condensing plant (surface type), buildings, pipe-work, coal conveying plant and lead-covered paper-insulated cables. Copies of specifications, &c., from the borough electrical engineer (Mr. W. A. Vignoles), Corporation Electricity Works, Grimsby, to whom tenders by first post Jan. 5. An advertisement contains further particulars.

The Guardians of *Poplar* (London) Union invite tenders for supply and erection at the Children's Home and Schools (now in course of erection at Hutton, Essex) of steam engines, dynamos, pipework, &c.; main switchboard, wiring, motors, &c.; fire alarms, telephones and electric bells. Tenders to the clerk, Mr. G. Herbert Lough, 45, Upper North-street, Poplar, before 6 p.m. Dec. 13.

*Ilford* District Council invite tenders for supply of 0·5 in. triple concentric armoured cable. Tenders to the Chairman, Town Hall, Ilford, by 4 p.m. Dec. 12.

*Barry* Railway Co. (Barry Docks, Cardiff) require tenders by 10 a.m. 15th inst. for 12 months' supply of stores, including incandescent electric lamps, electric wires and sundries, tools, &c.

*Heckmondwike* Electric Lighting committee invite tenders for water-purifying apparatus. Tenders by 10 a.m. Dec. 14.

*Islington* (London) Council invite suggestions from chemists and others (particularly those expert in the purification of water for boiler-feed purposes) as to the best means of eliminating injurious salts and other matter from water obtained from an artesian well. Further particulars and analysis or samples of water from the borough electrical engineer (Mr. Albert Gay), 50, Eden-grove, Holloway, N., on or before Jan. 1, 1906. See also an advertisement.

### TENDERS RECEIVED AND ACCEPTED.

The following tenders have been received by Shoreditch (London) Council for the electricity department:—

*Three water-tube boilers, superheater, &c.*

| | | | |
|---|---|---|---|
| Stirling Boiler Co. (*accepted*) | **£6,605** | Babcock & Wilcox ........ | £7,150 |
| J. Fraser & Son .......... | 9,873 | | |

*Steam and water pipes, valves, &c.*

| | | | |
|---|---|---|---|
| Stirling Boiler Co. (*accepted*) | **£1,175** | Babcock & Wilcox ........ | £1,395 |
| Bennett, Sons & Shears .. | 2,050 | Aiton & Co............... | 1,375 |
| J. Wilson & Co. .......... | 1,472 | E. Le Bas & Co........... | 1,176 |
| John Spencer (Ltd.) ...... | 1,408 | | |

*Wrought-steel flue.*

| | | | |
|---|---|---|---|
| J. Fraser & Son (*accepted*) .. | **£531** | Mechan & Co.............. | £796 |
| Westwood & Wrights ...... | 875 | Fraser & Fraser............ | 786 |
| Stirling Boiler Co........... | 872 | Babcox & Wilcox .......... | 750 |
| Pierson & Co.............. | 810 | | |

Marylebone (London) Electric Supply committee have accepted the tender of the Phœnix Dynamo Mfg. Co. for a milking booster and switchboard at £82. Siemens Bros. & Co. and Electromotors Limited both tendered at £103. The same committee have accepted the tender of the British Thomson-Houston Co. for two spare motor armatures at £135 10s., and that of Babcock & Wilcox for work in connection with the foundations, &c., for two boilers at £850.

The following tenders have been accepted by the Mersey Dock and Harbour Board: F. Morton & Co., wrought-iron enclosures; Everitt & Co., hydraulic pressure pipes; H. Davison & Sons, boiled linseed oil; M'Tear & Co., roofing, &c., felt; Glasgow Electric Crane & Hoist Co., electric transporter cranes; Royce (Ltd), electric roof cranes.

Leyton Council have accepted the tender of Chas. Allan & Co. for tramway lay outs at £1,660, and that of Troup, Curtis & Co. (out of seven tenders) for wiring the Lea Bridge branch library at £135. The accepted was the lowest tender, the amount of the highest being £178.

Torquay Town Council have accepted the tender of Siemens Bros. & Co. for a combined 250 kw. d.-c. traction steam generator set, one 200 kw. motor generator, an automatic reversible booster, switchgear and connections, at £5,168. 15s.; and that of the Tudor Accumulator Co. for a traction battery at £1,966.

Cardiff Asylums committee have accepted the following tenders for plant for Whitchurch Asylum:—

Siemens Bros. & Co., engines and generators, £1,998; Electric Power Storage Co., battery and booster, £956. 11s. 9d.; General Electric Co., switchboard, £527.

Fulham (London) Council have accepted the tender of Westwood & Wright for condenser pipes at £427; that of the General Electric Co. for meters; and that of Spittle & Co. for electric light fittings at £299.

The Key Engineering Co., Ltd, have recently received the following orders:—

Main switchgear for dynamos and circuits for H.M.S. "Britannia," "Hibernia," "Warrior," "Africa," and "Cressy"; feeder switchboard for Greenock; 13 sets A.-C. Andrews' discriminating apparatus for G.W. Railway (per Electric Construction Co.); main switch gear for H.M.S. "Dreadnought," the reverse current devices for this contract being Andrews' patent "Manchester" type direct-acting circuit breakers; equipment of three additional A.-C. generators with Andrews' patent discriminating cut-outs of the inductive balance type previously supplied (for Bournemouth Corporation). In regard to this company's contract at Salford, referred to in our last issue, the figure should be 13,000 (and not 6,000) yds. of fibre conduit.

Newtons Limited, Taunton, have received a repeat order for a number of "Mawdsley" motors from the G.W. Railway Co. for driving machinery in their locomotive workshops at Swindon.

Stoke-on-Trent guardians have accepted the tender of Blackburn, Starling & Co. for wiring work at the workhouse.

Warrington Council have accepted the tender of W. Rouse & Sons for four tramcar top covers at £259. 18s. 6d.

Luton Council have placed an order with the Horsfall Destructor Co. for a refuse destructor cell and apparatus at £461.

Bedford Education committee have appointed Wilson Bros. to do electrical work at the Council school during the next half-year.

**Boiler-House Economies.**—The growing appreciation of machine stoking in effecting boiler-house economies is well attested by the following orders recently placed with Ed. Bennis & Co., Little Hulton, Bolton, patentees of the "Bennis" machine stoker, and compressed air furnace, and manufacturers of coal and ash handling plant, and elevating and conveying machinery for the economic handling of material in bulk:—

Wimbledon Town Council, repeat order for four stokers and compressed air furnaces for water-tube boilers for the electric lighting station.

Swadlincote (Derby) Council, two stokers and compressed air furnaces.

Rugby Council, two sets of stokers and natural draught furnaces for Babcock & Wilcox boilers for the electricity works.

Clarke, Chapman & Co. (Gateshead-on-Tyne), one set of Bennis and Miller-Bennett chain grates.

Patent Shaft & Axletree Co., 46 stokers and compressed air furnaces, with complete coal and ash-handling plant for their various works at Wednesbury.

Babbington Coal Co., repeat order for six stokers and compressed air furnaces, making 23 supplied to this firm.

## BUSINESS NOTICES.

Owing to greatly-increased business Messrs. Bruce Peebles & Co. have transferred their London office from Westminster to 1, London Wall-buildings, E.C., which will be the headquarters of Mr. Roland S. Portheim, managing director, with Mr. Morton Beales as manager, and Mr. W. J. W. Bullock as chief engineer of the contract department. All communications should be addressed to 1, London Wall-buildings, E.C., instead of 25, Victoria-street, S.W.

Mr. D. McNaughton, 79, Mark-lane, London, E.C., who has for nearly nine years been the sole representative of M. Fabius Henrion (of Nancy) for the sale of his carbons, &c, in the United Kingdom, has retired from business, and M. Henrion has arranged with Messrs. Geipel & Lange, 72A, St. Thomas'-street, London, S.E., to represent him in future. Mr. McNaughton will collect outstanding accounts and execute existing contracts and orders. Messrs. Geipel & Lange have secured the services of Mr. A. C. Ashworth, who was manager of the carbon department for Mr. McNaughton.

Mr. James Ferguson, late manager of the electrical department of Kelvin & James White (Ltd.), has started business on his own account as an electrical instrument maker and engineer, and has taken works and offices at 61, Pollock-street, Pollokshaws, Glasgow. The equipment of the works is of the most modern kind and adapted for the manufacture of light electrical and mechanical apparatus generally.

Owing to the development of their business in Wales, Messrs. C. A. Parsons & Co. have found it necessary to arrange for permanent representation there, and they have opened offices at 102, St. Mary-street, Cardiff.

Mr. G. Wüthrich, who has hitherto discharged the duties of London resident engineer to the Maschinenfabrik Oerlikon, has now been appointed manager of the British, Irish and Colonial department and London resident engineer of the company. Mr. Wüthrich's new offices are at Oswaldestro House, Norfolk-street, London, W.C.; telegraphic address "Oerlik London."

Messrs. L. E. Wilson & Co. have commenced business as telephone experts and engineers at 20, Cross-street, Manchester. Mr. Wilson was formerly chief electrician of the National Telephone Co. in the Manchester District, and has a wide and varied experience in telephone work.

Lawrence Ludwig Hermes & Wallis Arthur Wallis (trading as L. Hermes & Co.), electrical engineers and contractors, 29, Uxbridge-road, and 205, High-street, Acton, London, W., have dissolved partnership. Debts by Mr. Wallis.

Mr. Geo. A. Goodwin, M.Inst.C.E., Wh Sc., consulting engineer and technical expert, has removed from 28 to 25, Victoria-street, London, S.W.

After the 11th inst. the offices of the Nernst Electric Light (Ltd.), in voluntary liquidation, will be 5, London Wall-buildings, London, E.C.

## BANKRUPTCIES, LIQUIDATIONS, &c.

In the bankruptcy of Wm. Geo. Leather (trading as Windus Electric Co.), 25, Howard-street, Sheffield, the first meeting of creditors will take place on Dec. 13 at the O.R.'s, Figtree-lane, and the public examination on Jan. 11 at the County Court Hall, Sheffield.

Jas. Wood Smith, electrical engineer and contractor, 55, Bolton-road, Darwen, has been adjudicated bankrupt.

The discharge of Arthur E. Brooks, electrical engineer, is suspended for two years.

A meeting will be held on Jan. 3 at 58, Coleman-street, London, E.C., to receive an account of the winding up of the Pioneer Power Co. of London (Ltd.).

The British Pioneer Electric Light & Power Co. of India (Ltd.) is being wound up voluntarily.

**Winding-up Petition.**—A petition for winding up the Electrical Ore Finding Co. (Ltd.), presented by Mr. A. Anderson, Scads Hill House, Orpington, will be heard in the High Court on the 12th inst.

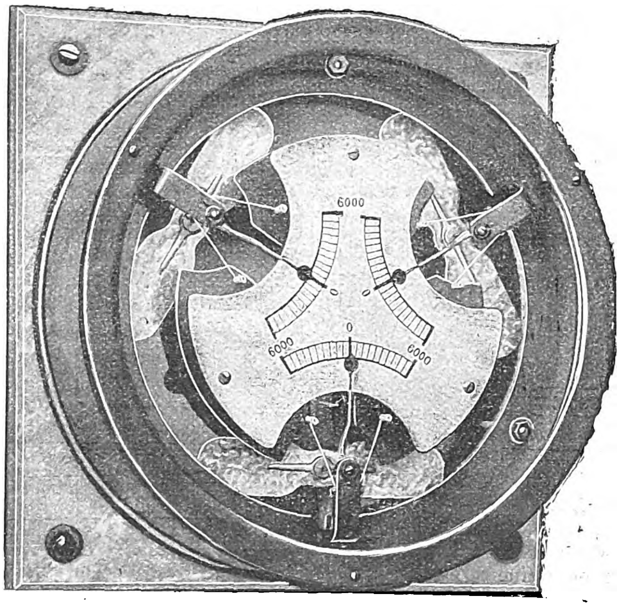
**Plant for Sale.**—Three Siemens-Browett Lindley arc lighting sets, in good condition, are advertised for sale. Applications to the Borough Electrical Engineer, Full-street, Derby.

**War Office Stores for Sale.**—Messrs. Horne & Co., 8, Delahay-street, Storey's Gate, Westminster, S.W., will sell by public auction, at the Royal Arsenal, Woolwich, on Dec. 19 (by order of the Secretary of State for War), at 11 a.m., a quantity of unserviceable and obsolete stores, including lead ashes, iron, brass, copper, gunmetal, &c., also some lathes, tools, electric cables and lamps, telegraph instruments, &c. Further particulars are given in an advertisement. Catalogues at the War Office, Pall Mall; the Ordnance Office, Tower, E.C.; and the Ordnance Office, Woolwich, S.E.

**Business for Sale.**—An electrical and gas contractor's and general ironmongery business in Surrey is advertised for sale. Applications to Messrs. Shepherd & Haward, 369, Birkbeck Bank-chambers, Holborn, London, W.C.

**Agencies Wanted.**—Mr. W. Liole Dryden, P.O. Box 459, Johannesburg, advertises for agencies in metals, machinery and goods required by gold and coal mines.

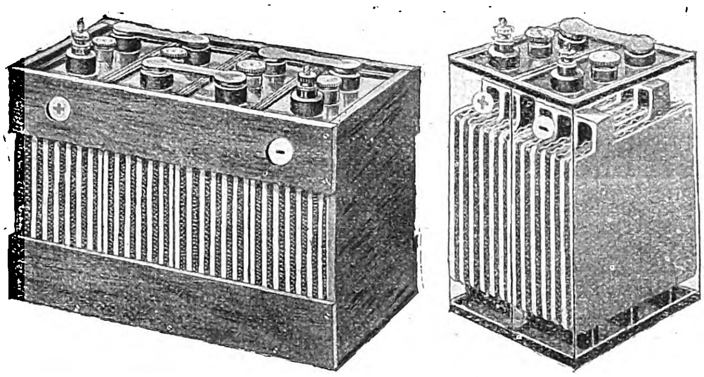
**Electrostatic Ground Detector.**—The accompanying illustration shows a type of three-phase electrostatic ground detector manufactured by the British Thomson-Houston Co. It has three sets of vanes and three needles entirely independent of one another. When no earth exists the three needles point towards the centre. When an earth occurs on one of the lines the two adjacent needles are deflected towards the segment to which the earthed line is connected. Should an earth occur on two lines, the needle between the segments connected to the earthed lines will be deflected towards the one having lower resistance earth, and the two remaining ones will be deflected towards the earthed segments. These detectors are similar in construction to the company's electrostatic voltmeters. The low-voltage detectors are of multicellular construction, and were especially designed to meet the requirements of the Home Office regulations for the use of electricity in mines. No harm is done if the moving mechanism is damaged or displaced so that the vane is brought in contact with the quadrant.



B.T.-H. ELECTROSTATIC GROUND DETECTOR.

**Combination of Continental Electrical Firms.**—It is reported that an agreement has been arrived at between Ganz & Co. and the Union Electricitäts Gesellschaft of Vienna, by which the electrical department of the former firm will be converted into an independent company, whose shares will be partly held by Ganz & Co. and partly by the Union Co.

**Catalogues.**—A new list of "Hart" ignition batteries in celluloid boxes has just been issued by the Hart Accumulator Co., Marshgate-lane, Stratford, London. The cells are supplied with special lids, sealed down to prevent spilling of the electrolyte, and the larger sizes are fitted in a varnished teak crate, as shown in the accompanying illustration. Owing to the rise in price of raw materials, it is notified that prices are increased 5 per cent. on the company's 1905 catalogue.

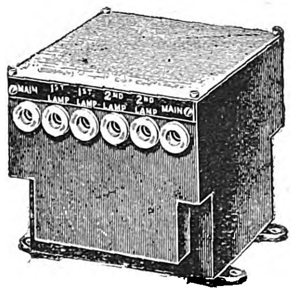

"Hart" Ignition Cells in Celluloid Boxes.

Following on price lists 50 and 51 of single-pole and double-pole switches, Ferranti Limited have now issued a new list of treble-pole single-throw quick-break knife switches for 25 to 1,000 amperes. Copies of the list can be obtained on application to Hollinwood.

A good list of labour-saving machines and tools for electrical engineers has been compiled by Neville Bros., James-street, Liverpool, including dry and impregnating chambers for armatures, coils, covered wires, &c., coil-winding machines, tissue-papering machines, hydraulic presses, regenerative gas muffle furnaces, &c.

The Simplex Steel Conduit Co. are issuing a show card (No. 112) giving a list of contracts where "Simplex" material has been employed during the first eight months of 1905. Copies of this card, together with a new large trade mark show card 21 in. by 15 in. (which the company's customers can use for display purposes) can be obtained on application. The list of contracts sets out some very important works, factories, hospitals, institutions, &c., where Simplex conduit has been put in.

A new booklet giving fresh particulars of the "Angold" arc lamp is issued by the General Electric Co. The price of this lamp and also for arc lamp accessories have been considerably reduced. A new pattern of twin carbon continuous-current lamp is shown, suitable for indoor or outdoor lighting on high voltage, where lamps are required to run singly or independently of each other. There is also described in this list a new type of balancing coil for use with alternating-current enclosed arc lamps. This coil is shown in the accompanying illustration.



G.E. Balancing Coil.

The General Electric Co. have ready a new abbreviated price list of continuous-current motors.

A new catalogue (D 38) has been issued by Charles Winn & Co., Granville-street, Birmingham, dealing with boiler mountings and engine fittings, metallic packings, automatic water gauges and glass protectors, &c.

Some excellent parallel slide stop valves of an improved type are illustrated and described. In these valves a pair of wedges and a spring are employed in combination with other parts. The spring is fitted in a casing in the usual manner, and two hollow rectangular wedges are hung loosely upon the casing, one on either side of the main spindle. The wedges in no way interferfere with the free opening and closing of the valve, as they only come into operation when the bore of the valve is closed and operate upon the valve gates in such a manner as to ensure the valve closing tightly without overstrain, entirely obviating the objectionable tendency to jamb or lock which valves of this type are frequently liable to when operated. The company have had many years' experience as makers of engine and boiler fittings, and their manufactures are extensively used in electricity generating stations, by the railway companies, &c.

A catalogue of electric light fittings, bell fittings, and accessories is issued by D. Hulett & Co., 55 and 56, High Holborn, London, W.C. A large range of brackets, cord suspensions, hall and vestibule lights, electroliers (plain and artistic), shade lights and standards are included in the list, as well as a good assortment of outside lamps and brackets for electric lighting.

An excellent catalogue of "Prometheus" electric heating apparatus is to hand describing 56 different patterns of convectors and eight radiators, as well as a combined convector and radiator. This apparatus is shown in a number of art designs with antique finish and made of the finest metal. Included in the catalogue is a list of Prometheus electrically-heated cooking appliances which can now be obtained from the company, 18, London-road, Kingston-on-Thames.

Messrs. B. J. Hall & Co., 39, Victoria-street, London, S.W., have ready a new bargain book of drawing offices requisites.

A new circular price list of Groves ingenious network ohmmeter has been issued by Elliott Brothers, Lewisham, London, S.E.

**"Annealing of Non-Ferrous Metals."**—An interesting booklet on the above subject has been issued by the British Insulated & Helsby (Ltd.), Prescott, Lancs. The particular process described is the Bates-Peard automatic system of annealing metals. It is pointed out that the softening of all non ferrous metals can now be done by automatic apparatus at a minimum of expense for the labour item and quite free from oxides or scale. It is claimed that the Bates & Peard process of automatic annealing is now adopted by all the most up-to-date manufacturing firms in the chief countries of the world. The results obtained by the process have surpassed the most sanguine anticipations of the inventors, and the saving effected where a large quantity of copper wire is treated daily is given as 10s. per ton. Fuel consumption, whether gas or coal, is less than by other method, as the annealing chamber proper is never open to the atmosphere. The British Insulated & Helsby Cables Co. own the English patent rights for this apparatus.

**Machine Stoking.**—Persons interested in the subject of machine stoking, and requiring reliable information on the subject, are invited by Ed. Bennis & Co. (Ltd.), Little Hulton, Bolton, to apply for a free copy of a reprint of a lecture recently delivered by Mr. A. W. Bennis, entitled "Is Machine Stoking Economical?"

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Nov. 29 to Dec. 5, with the ports of destination:—

*Aden*, £100 (telegraph material). *Africa.*—Cape Town, £113; Delagoa Bay, £673 (including £410 telegraph cable); Durban, £1,769 (including £115 telegraph cable); East London, £143; Mombasa, £19; Port Elizabeth, £16; Port Said, £68. *Argentina*—Buenos Ayres, £86 (including £54 telegraph material). Rosario, £1,033 (telegraph material). *Australasia*—Adelaide, £1,646; Auckland, £3,338; Fremantle, £487; Hobart, £1; Lyttelton, £16; Melbourne, £1,610 (including £18 telegraph material); Perth, £657; Sydney, £426; Wellington, £255. *Belgium*—Antwerp, £137; Brussels, £350. *Brazil*—Rio Janeiro, £24. *British Guiana*—Demerara, £24 (telegraph material). *Canada*—Halifax, £11,487 (telegraph cables). *Ceylon*—Colombo, £83. *Channel Islands*, £25. *Chili*—Valparaiso, £2,652 (including £2,623 telegraph material). *China*—Shanghai, £153. *Cuba*, £228. *Gibraltar*, £30. *Holland*—Amsterdam, £250 (including £104 telegraph material); Flushing, £60; Terneuzen, £22. *Hong Kong*, £215 (including £180 telegraph cable). *India*—Bombay, £537; Calcutta, £825; Karachi, £76; Madras, £49. *Italy*—Genoa, £147. *Japan*—Yokohama, £721. *Maderia*, £70. *Malta*, £43. *Mauritius*, £54. *North Atlantic*, £225 (telegraph material). *Portugal*—Oporto, £75, *Russia*—Kure, £3,377; St. Petersburg, £44. *Siam*—Bangkok, £504. *Spain*—Bilbao, £90 (telegraph material). *Straits Settlements*—Penang, £2,647; Singapore, £62. *Sweden*—Stockholm, £23. *United States*—Boston, £104. *Zanzibar*, £26 (telegraph material). Total, £37,905, against £94,417 in the corresponding week last year (Nov. 30 to Dec. 6).

# PATENT RECORD.

## APPLICATIONS FOR PATENTS.

Note.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specification. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

October 25, 1905.

21,683 Merritt. Prepayment electricity meters.
21,687 Cushman & David Moseley & Sons. Trolley and like wheels.*
21,707 Edge. Protecting device for shunt field windings of electrical machines where shunt regulators are used.*
21,739 Highfield. Electric heating or cooking apparatus.
21,752 Kuhn. Mechanism for circuits in connection with clocks, &c.
21,753 B.T.-H. Co. (G.E. Co, U.S.) Resistances.

October 26, 1905.

17,402a Stern & Engisch. Switching apparatus. (Date applied for, Aug. 28, 1905.)*
21,761 Bonsor. Electric conductor-rail insulators.
21,795 Chandler & Bonniksen. Electrically synchronised clocks.
21,798 Clements. Armoured insulated conduit for uninsulated conductors

21,804 Phelps & Bowie. Production of violet or ultra-violet rays, X-rays or other rays by induction on low-tension currents.
21,833 McIntyre. Electro-magnetic apparatus. (Date applied for, Oct. 29, 1904.)*†
21,834 McIntyre. Ruhmkorff coils. (Date applied for, Dec. 8, 1904.)*†
21,842 Gercke. Neutralising deflecting forces acting magnets.*
21,845 Parsons & Stoney. Steam turbines.
21,846 Baronio & Muirhead. Telegraphy.
21,850 Mordey & Fricker. Service apparatus for electric supply.
21,851 Dutton & Brush Electrical Engineering Co. Alternating-current motors.
21,855 Arcioni. Electric power measuring and recording instruments for alternating currents. (Date applied for, Oct. 27, 1904.)*†
21,856 Bowell. Electric clocks.

### October 27, 1905.

21,870 Lines. Attaching a wire supplying electricity to a terminal.
21,882 Parry & Barrett. Electrically-driven bicycles and like vehicles.
21,898 Baumer. Releasing pawl-locking devices in telephone instruments.*
21,931 B.T.-H. Co. (G.E. Co., U.S.) Arc lamps.
21,947 Von Ammon. Dynamo electric machines.

### October 28, 1905.

21,949 Digby. Manufacture of hypochlorite solution by electrolytic methods.
21,975 Grant. Supporting and mounting of shafting of ship's and analogous telegraphic apparatus.
22,005 W. T. Henley's Telegraph Works Co. & Savage. Insulated electric conductors.
22,011 Dickson. Brushes for dynamos and motors.

### October 30, 1905.

22,037 Ewbank & Barnes. Electric switch for internal combustion engines.
22,061 Oppenheimer. (Aktien-Ges. Mix & Genest, Germany.) Folding-up telephone stations.
22,086 Brown. Candlestick to be used for electric lighting.
22,088 Cummins. Life guards on tramway vehicles.
22,119 Boddam. Controlling lifts electrically.
22,121 Magnetzünder-Gesellschaft Unterberg & Cie. Actuating devices for magneto-ignition apparatus. (Date applied for, 2/23/05.)*†
22,127 Parsons & Stoney. Turbines, rotary compressors, &c.
22,129 Berry. Alternating-current distributing systems.
22,130 Hadfield. Magnetic materials. (Date applied for, 6/8/05.)*†
22,132 Davy. Arc lamps.

### October 31, 1905.

22,139 Mansbridge. Treating foiled paper for electrical purposes.
22,149 McMillan. Telephone receivers.
22,156 Mitchell. Lamps for tram cars.
22,195 Braun. Braking polyphase induction motors.
22,197 D'Urbino. Electrical safety device against burglary.
22,198 Day. (Fabrik Elektrischer Zunder, G.m.b.H., Germany.) Contact apparatus for electrical igniters.
22,231 McLeod. Apparatus for controlling the supply of energy from alternating-current generators to alternating-current motors.
22,261 B.T.-H. Co. (G.E. Co., U.S.) Systems of electrical distribution employing rectifiers.
22,262 B.T.-H. Co. (G.E. Co., U.S.) Alternating current dynamo electric machines.
22,263 Mitchell. Self-testing safety code for telegraphing and cabling.

### November 1, 1905.

22,317 Miller. Small spark coils worked with street current.
22,334 Wright. Auto-regulation for dynamo-electric generators.
22,343 B.T.-H. Co. (G.E. Co., U.S.) Transformers.
22,349 Baxter. Starting and driving mechanism for gas engines, electromotors, &c.
22,353 Thompson. (Deutsche Gasglühlicht Aktien-Ges. (Auergs) Germany.) Incandescent lamps with metallic filaments.*
22,357 Gardiner. Electric signalling system for railways.

### November 2, 1905.

22,404 King. Incandescent lamps.
22,419 Pierson. Electric-magnetic mechanism giving a signal, actuating a switch under certain conditions in an electric circuit.
22,450 West. Electrical measuring instruments.

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## SPECIFICATIONS PUBLISHED, price 8d. each.

### PUBLISHED November 9, 1905.

#### 1904 Specifications.

22,164 Berry. Distribution of alternating-electric current.
22,369 Berry. Regulating difference of potential in distributing systems.
22,522 Wellington & Daniell. Arc lamps.
22,631 Latour. Exciting electromagnets by alternating currents. (Date applied for, Oct. 20, 1903.)
22,962 Gresham, Gresham, & Kiernan. Vacuum brake apparatus for electric trains.
23,205 B.T.-H. Co. (A.-E.-G.) Regulation of alternating distributing systems.
24,620 Parsons & Ball. Electric clocks and the like.
25,331 Hargreaves. Treating the contents of electrolytic cells.
26,588 B.T.-H. Co. (G.E. Co., U.S.) Systems of electrical distribution.
26,589 B.T.-H. Co. (G.E. Co., U.S.) Switches.
26,594 Warwick Machinery Co. (G.E. Co., U.S.) Turbines.
26,849 Bailey. Electrodeposition of metals.
27,201 Wilson. Electrostatic wattmeters and watt-hour meters.
27,285 B.T.-H. Co. (G.E. Co., U.S.) Emergency brakes for vehicles or trains.
27,325 Mattinson. Machines for grinding tramway rails.
29,138 Day (Empire State Dry Battery Co.) Dry batteries.
29,231 Gunning. Opening and closing electric circuits at pre-determined times.

#### 1905 Specifications.

1,009 Elieson. Connections for accumulators.
1,224 Earll. Trolley retrievers for electric tramcar.
1,400 B.T.-H. Co. (G.E. Co., U.S.) Incandescent electric lamp sockets.
2,579 Wilhelmi. Cover for electric conductors, pipes or the like.
2,789 B.T.-H. Co. (G.E. Co., U.S.) Protective devices for electric circuits.
3,049 Stokes. Combined electric coupling and two-way plug.
4,858 E.-A.-G. vorm. W. Lahmeyer & Co. Compensating poles for dynamo-electric machines. (Date applied for, April 16, 1904.)
4,881 B.T.-H. Co. & Larzelere. Electromagnetic brakes.
5,042 Weber. Electrically-operated pianos.
5,049 Bloxam (Goffin). Electric insulators.
7,036 Weiss. Electrically-propelled vehicles.
8,524 Thorne. Safety appliances for exposed conductors.
8,631 Weatherill. Dry battery.
10,669 Callender's Cable & Construction Co. & Ward. Combined switch and fuse.
11,036 Conrad & Bradshaw. Alternating-current measuring instruments. (Date applied for, May 27, 1904.)
11,862 Hubbell. Galvanic battery plates.
13,383 B.T.-H. Co. (G.E. Co., U.S.) Conductors and insulating same.
13,425 Fairweather (Benjamin Electric Mfg. Co.) Cluster electric-lamp sockets.
15,591 Carbone. Electromagnetically influencing arcs of lamps working with alternating current.
17,146 Veritys Limited & Gott. Particular type of rheostat.
17,170 Smith. Conveying telephonic messages to the interior of submerged submarines

### PUBLISHED November 16, 1905.

#### 1904 Specifications.

16,258 Weintraub. Transforming electric currents. (Date applied for, July 23, 1903.)
23,253 Phillips. Section insulator for trolley wires.
24,874 B.T.-H. Co. (G.E. Co., U.S.) Alternating-current generators.
25,282 Siemens & Halske Akt.-Ges. Electrode for radiant electrical energy. (Date applied for, Nov. 24, 1903.)
25,636 B.T.-H. Co., Meyer & Hopps. Electric power transmitting mechanism
26,283 Imray. (Soc. pour l'Exploitation de Compteurs Electriques Rittener & Co.) Electricity meters.
26,772 Lake. (Schwarze & Kells.) Electro-magnetic apparatus for electric belts.
27,082 Crawford. Electrical counting apparatus for ships' logs.
27,083 B.T.-H. Co. (G.E. Co., U.S.) Control of electric motors and apparatus therefor.
27,317 Jackson. Reflection in connection with electric light.
27,399 Hamilton & Ferranti Limited. Electricity meters.
27,926 Lewis & Reason Mfg. Co. (Ltd.). Electric demand indicators.
28,044 Matthews. Electricity meters.
28,062 B.T.-H. Co. (G.E. Co., U.S.) Treating carbon and producing same.
28,129 Hirtz. Permeable diaphragms for use in electrolytic cells.
28,252 Strode & White. Switches, plugs and the like.
28,278 Thornton. Instruments for indicating charged or uncharged condition of electric cables or other electric appliances.
29,343, 29,345 and 29,346 Down & Wiseman. Electrical gas-igniting and extinguishing apparatus.

#### 1905 Specifications.

954 Churchward. Vapour electric apparatus. (Date applied for, 1/18/'04.)
1,926 B.T.-H. Co. (G.E. Co., U.S.) Motor-driven air compressors.
3,918 B.T.-H. Co. (G.E. Co., U.S.) Electric fans.
4,040 Burke. Electric motors.
4,321 Lewis, Hill & Whitfield. Sparking plugs for internal-combustion engines.
4,354 Lübeck. Electric time switch. (Rights not granted.)
4,883 Birnbaum & Bell. Common battery central-station telephone systems.
6,987b Whitney. Fallers for electric stop-motion mechanism for looms. (Date applied for, April 3, 1905.)
7,082 Skinner. Electrical alarm mat.
8,196 Perkins & Jackson. Multiple-unit control for electric motors. (Date applied for, June 6, 1904.)
13,384 B.T.-H. Co. (G.E. Co., U.S.) Electric conductors and insulating same.
13,473 Stodola. Explosion gas turbines. (Date applied for, July 4, 1904.)
13,587 Siemens Bros. & Co., Berry & Toplis. Starting switch for three-phase motors having resistance in series with rotor.
13,954 Harrison. (Electric Railway Improvement Co.) Electrical testing devices.
14,131 Haddan. (Akt.-Ges. Industrie für Holzverwertung.) Sound proof telephone chambers.
14,208 Siemens Bros. & Co. (Siemens Schuckertwerke G.m.b.H.) Switch apparatus for supplying current-consuming devices on several motor cars of electric trains.
17,740 Schneider. Exploding mines by electrical waves. (Date applied for, Oct. 25, 1904.)
17,741 Schneider. Explosive coherer powder. (Date applied for, 10/27/04.)
18,013 Povah & Livett. Means of rectifying alternating electric currents

PUBLISHED NOVEMBER 23, 1905.

1904 SPECIFICATIONS.

23,726 WIRT. Rheostats. (Date applied for, Nov. 6, 1903.)
23,952 ARMSTRONG & ORLING. Telegraphic apparatus.
24,699 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control.
25,386 VON ZWEIGBERGK. Single-phase commutation electric motors.
26,290 B.T.-H. Co. (G.E. Co., U S.) Alternating current motor control.
26,391 SMITH. Mechanism for use in conjunction with apparatus for utilising electro-magnetic or "Hertzian" waves.
27,683 FLEMING. Instruments for measurement of wave-lengths in wireless telegraphy.
28,749 LACEY & HOLMAN. Telephones particularly for divers.
29,057 MEIROWSKY. Electric insulation.
29,065 BUTLER. Electric dry batteries.
29,377 FIELD & FERRANTI LIMITED. Fuses for electrical circuits.
29,448 KÖNITZER. Arc lamps.

1905 SPECIFICATIONS.

1,563 FIELD. Electrical measuring instruments.
3,347 TOURTEL. Switch apparatus for coin-freed electricity meters.
5,149 CUTMORE. Telephone and like transmitters.
9,991 ELECTRIC IGNITION CO. & HALL. Switches.
11,036A and 11,036B CONRAD & BRADSHAW. Alternating-current measuring instruments. (Date applied for, May 27, 1904) (Originally included in No. 11,036 1905.)
11,702 B.T.-H. Co. (G.E. Co., U.S.) Dynamo electric machines.
12,424 KITSEE. Telegraphy.
13,036 RAUSCH & GONDOLF. Electric clock and alarm systems.
13,093A BOULT. (Duntley.) Electric drills. (Date applied for, June 24, 1905.)
14,663 SCALES. Central battery telephone transmitters.
16,772 SIEMENS BROS. & CO. & HUDDLESTON. Electric coupling boxes for electric machines.
20,371 SIEMENS BROS. & CO. (Siemens Schuckertwerke, G.m.b.H.) Apparatus for sound transmission by electrically-produced light and heat rays.

## NEW COMPANIES, MORTGAGES AND CHARGES.

### NEW COMPANIES.

**ADVANCE ENAMEL & VARNISH CO. (LTD.)** (86,629.)—Reg. Nov. 28, capital £15,000 in £1 shares, to acquire and carry on the businesses of enamel and varnish and of insulating compound manufacturer, &c., carried on by T. Pittman at Plymouth, &c. First directors, H. Brooking, G. F. Watson, H. T. Robins and W. K. Youlden. Reg. office, 1, Station-road, Plymouth.

**BRITISH, FOREIGN & COLONIAL AUTOMATIC LIGHT CONTROLLING CO. (LTD.)** (86,662.)—Reg. Nov. 30, capital £100,000 in £1 shares, to adopt an agrement and to acquire patents, licences, inventions, &c., and to carry on the business of mechanical engineers, manufacturers of electrical and other machinery and apparatus, metal workers, machinists, electrical and gas engineers and merchants, hardwaremen, contractors for supply of machinery and apparatus relating to electricity, gas, &c. First directors are Sir Edward P. Wills, Bart., K.C.B., J. Gunning, C. J. Haydon and H. L. Riseley. Reg. office, 55, Broad-street, Bristol.

**BRITISH UNITED ENGINEERING CO. (LTD.)** (86,682.)—Reg. Dec. 1, capital £10,000 in £1 shares, to carry on the business of mechanical, electrical and general engineers, manufacturers, buyers and sellers of and dealers in all kinds of vehicles, manufacturers of and dealers in electrical, telegraphic, telephonic and other apparatus, &c. Reg. office, 175, Piccadilly, London, W.

**MIDLAND COUNTIES RAILWAY SYND. (LTD.)** (86,585.)—Reg. Nov. 23, capital £1,000 in £1 shares, to carry on the business of tramway, railway, omnibus and van proprietors, carriers of passengers and goods, constructors of and dealers in tramway and railway carriages, trucks, locomotives, accumulators, dynamos and equipments, suppliers of electricity, &c.

**SHARPE & CO. (LTD.)** (86,474.)—Reg. Nov. 14, capital £2,000 in £1 shares, to acquire business carried on at Devonport and Stonehouse, as M. Sharpe, and to carry on the business of electrical engineers, electricians, suppliers of electricity, &c. First directors, M. A. Sharpe (managing), F. Maxwell and J. H. Starkey.

**H. E. STEEL (LTD.)** (86,628.)—Reg. Nov. 27, capital £10,000 in £1 shares, to carry on the business of electrical, automobile and general engineers, automobile, omnibus and public carriage manufacturers, agents, dealers and proprietors, electric wiring and electrical appliance manufacturers, &c. Mr. H. Ripley is first chairman, and Messrs. H. E. Steel and H. E. Ripley are first managing directors. Reg. office, 27, Regent-street, Cheltenham.

**TRACTION UNIFICATION (LTD.)** (86,695.)—Reg. Dec. 1, capital £10,000 in 1s shares, to undertake any business relating to the application of mechanical or other power, or to traction, haulage, conveyance or other similar operations.

### STATUTORY RETURNS.

**BRITISH PROMETHEUS CO. (LTD.)**—According to return to Sept. 15, capital is £5,000 in £1 shares, all of which have been taken up. £2,500 has been received and £2,500 is considered as paid. Mortgages and charges, £3,000.

**MEXICO ELECTRIC TRAMWAYS (LTD.)**—Return to Oct. 11 gives capital as £1,000,000 in 500,000 ordinary and 500,000 preference shares of £1 each, all of which have been taken up. £500,000 has been paid on the preference and £500,000 is considered as paid on the ordinary. Debentures created prior to 1900, £400,000. Debentures created since 1900 £500,000 (issued, £200,000).

**MONTE VIDEO TELEPHONE CO. (LTD.)**—Return to Nov. 9, gives capital as £160,000 in 87,000 preference and 73,000 ordinary shares of £1 each, of which 86,492 preference and 72,680 ordinary have been taken up. £159,172 is considered as paid. Mortgages and charges, nil.

**NEW CENTURY ARC LIGHT CO. (LTD.)**—In return to Oct. 30, capital is £30,000 in 25,000 ordinary and 5,000 preference shares of £1 each, of which 14,306 ordinary and 5,000 preference have been taken up. £1 per share has been called up on 2,506 ordinary and £2,506 has been received. £16,800 is considered as paid on 11,800 ordinary and 5,000 preference. Mortgages and charges, £7,500.

**PRESTED MINERS' GAS-INDICATING ELECTRIC LAMP CO. (LTD.)**—Return to Nov. 13, gives capital as £20,000 in £1 shares, of which 16,500 have been taken up. £1 per share has been called up on 7,500 and 5s. per share on 1,500 shares, and £7,872. 10s. has been received, leaving £2. 10s. in arrears. 7,500 shares are considered as fully paid. Mortgages and charges, nil.

## CITY NOTES.

**MEMORANDA** (Dec. 7).—Bank rate 4 per cent. (since Sept. 28, 1905) Price of silver $29\frac{7}{16}$d. per oz. Consols $89\frac{9}{16}$—$89\frac{11}{16}$ for money, $89\frac{3}{4}$—$90\frac{7}{8}$ for account; $2\frac{1}{2}$ per cent. annuities $88\frac{5}{8}$—$88\frac{7}{8}$. Consols Pay Day, Jan. 4; Stocks and Shares Continuation Day, Dec. 12; Ticket Day, Dec. 13; Pay Days, Dec. 14 and 29; Mining Share Carry-over Day, Dec. 11.

**ALLGEMEINE ELEKTRICITATS GESELLSCHAFT, BERLIN.**—The report for the year ended June last states that there have been satisfactory increases in orders and business in hand. The construction of steam turbo-dynamos and steam turbines for ships has proved a successful departure, while good progress has also been made in the electric lighting of railway carriages. The business done by the cable department was 20 per cent. greater than in the previous year. It has been found that low-voltage continuous-current Nernst lamps can, by simplification of the burner, be made at such a price that they will give an illumination equal to that of the carbon filament lamps at no greater cost, having regard to the fact that they only consume half as much current. Smaller towns are now adopting the policy of establishing municipal electricity works, in view of the lower capital cost and greater economy of working under modern conditions. The gross profit is 12,331,530m. (against 10,438,703m. in the previous year), and, after payment of working expenses, rates and taxes and allowance for depreciation, the net profit is 10,951,676m. (against 8,566,623m.), of which 8,600,000m. will be paid in dividend (10 per cent., against 9 per cent. on previous year).

**BRITISH COLUMBIA ELECTRIC RAILWAY CO. (LTD.)**—During the week this company invited applications for 185,000 £1 5 per cent. cumulative perpetual preference shares at £1. 0s. 10d.

**BULLERS LIMITED.**—The directors report for the year ended July 31 states that after paying directors' fees and managing directors' salaries, the profit was £35,588, or with sum brought forward £36,369. Interest and dividends of $7\frac{1}{2}$ per cent. on the ordinary shares have been paid, and the directors propose to pay a further $2\frac{1}{2}$ per cent. on the ordinary shares (making 10 per cent. for the year), to place £5,000 to reserve, to pay a bonus of 5 per cent. on the ordinary shares, and to carry forward £1,369.

**CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)**—The transfer books and register of holders of the £400,000 5 per cent. first debenture stock and £300,000 $4\frac{1}{2}$ per cent. second debenture stock will be closed from the 16th to the 30th inst. inclusive.

**GENERAL ELECTRIC CO. (LTD.)**—The transfer books of the 5 per cent. preference shares will be closed from 18th to 30th inst. inclusive.

**GENEVA TRAMWAYS CO. (LTD.)**—The report for the year ended Sept. 30 states that the gross profit on the working of the Swiss company was 469,776·76 fr., and including 56,390·45 fr. from previous year, the total was 526,167·21 fr. After making provision for contributions to amortisation, renewal and reserve (158,030·35 fr.) and for sundry expenses (5,518·40 fr.) the balance was 362,618·46 fr., out of which a dividend of 1 per cent. (200,000 fr.) has been paid, leaving 162,618·46 fr. to be carried forward. Additional rolling stock having become necessary, this balance, together with a further amount from the current year's earnings, has been set aside. Consequent upon the continued inability of the Compagnie Genevoise des Tramways Electriques to pay adequate dividends on its capital with which to meet the company's indebtedness, the revenue account shows a loss of £34,270. 18s. 5d., increasing the amount standing to debit of revenue account to £151,559. 12s. 5d. The directors have every reason to be thoroughly satisfied with the assistance received at the hands of the directors of the Swiss company and also with the services rendered by the general manager and staff.

**MERSEY RAILWAY CO.**—The debenture stockholders last week passed a resolution approving the company's proposed bill extending the period during which payment of interest on the debenture stocks (other than the new debenture stock) shall be contingent on the revenue available therefor in each separate year. The chairman (Mr. James Falconer) said that for the last complete year under steam power the gross receipts

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. | | |
|---|---|---|---|---|---|---|
| | | | | No. of weeks. | Amount. | Inc. or Dec. (a) |
| | | £ | £ | | £ | £ |
| Aberdeen Corporation | Dec. 2 | 1,165 | + 51 | 47 | 58,831 | − 1,412 |
| Airdrie | Nov. 24 | 200 | + 13 | 47 | 9,670 | + 155 |
| Anglo-Argentine | Dec. 2 | 16,519 | + 1,021 | 47 | 645,108 | + 39,468 |
| Ayr Corporation | ,, 2 | 172 | − 2 | 29 | 9,987 | − 132 |
| Barcelona Trams Co. | ... | ... | ... | ... | ... | ... |
| Barcelona, Ensanche, Gracia | ... | ... | ... | ... | ... | ... |
| Barnsley | Nov. 24 | 150 | ... | 47 | 7,565 | − 336 |
| *Barrow | ,, 24 | 190 | + 10 | 47 | 11,851 | + 2,177 |
| Bath Electric Trams, Ltd. | ,, 29 | 594 | + 144 | 48 | 32,830 | + 2,153 |
| Birkenhead | Dec. 3 | 901 | + 26 | 9 | 8,496 | + 262 |
| Birmingham Corporation | ,, 2 | 889 | + 52 | 35 | 12,745 | + 1,564 |
| *Birmingham & Mid. | Nov. 24 | 1,285 | − 4 | 47 | 74,329 | − 535 |
| Blackpool Corporation | ,, 30 | 279 | + 20 | 22 | 44,099 | + 1,784 |
| Blackpool and Fleetwood | Dec. 2 | 158 | − 24 | 22 | 19,507 | − 1,099 |
| Bolton Corporation | ,, 3 | 1,841 | + 122 | 36 | 69,417 | + 2,749 |
| Bournemouth Corporation | Nov. 29 | 1,217 | + 511 | †34 | 50,065 | + 9,914 |
| Bradford Corporation | Dec. 2 | 4,056 | + 448 | 35 | 155,740 | − 5,880 |
| Brighton Corporation | ,, 3 | 744 | + 23 | 36 | 37,603 | + 456 |
| Bristol Trams & Carriage | ,, 1 | 4,363 | + 188 | 16 | 8,708 | + 1,033 |
| Buenos Ayres & Belgrano | ,, 3 | 3,570 | + 712 | 48 | 166,722 | + 9,607 |
| Buenos Ayres Elec. Trams | Nov. 4 | 1,679 | ... | 44 | 51,174 | ... |
| Burnley Corporation | Dec. 2 | 1,058 | + 125 | 35 | 49,250 | + 2,330 |
| Burton Corporation | ,, 3 | 258 | − 15 | §35 | 11,168 | − 1,365 |
| Bury Corporation | Nov. 26 | 761 | ... | §34 | 25,409 | ... |
| Calcutta Tramways Co. | Dec. 2 | R45,815 | + R6,466 | 22 | R945,168 | + R119,544 |
| Camborne-Redruth | ,, 2 | 102 | + 4 | 5 | 18,198 | − 43 |
| Cardiff Corporation | ,, 2 | 1,777 | + 38 | 35 | 72,884 | + 70 |
| Carlisle Tramways Co. | ,, 2 | 150 | − 14 | 48 | 8,603 | − 627 |
| Central London Railway | ,, 2 | 6,939 | + 2 | 22 | 136,123 | − 961 |
| Chatham & Dist. Lt. Rys. | Nov. 30 | 546 | + 112 | 48 | 81,484 | + 3,379 |
| *City of Birm'gh'm Tram Co. | ,, 24 | 4,850 | − 7 | 47 | 252,087 | + 567 |
| City & South London Rly. | Dec. 3 | 7,594 | + 97 | 22 | 58,815 | + 300 |
| Colchester Corporation | Nov. 30 | 140 | + 7 | 18 | 4,895 | − 1,303 |
| Cork Electric Trams Co. | ,, 30 | 586 | + 2 | 48 | 23,146 | + 634 |
| Devonport & Dist. Trams | ,, 24 | 870 | − 88 | 47 | 21,632 | − 3,509 |
| Dover Corporation | Dec. 2 | 172 | + 19 | 35 | 8,249 | − 40 |
| Dublin & Lucan Railway | ,, 1 | 88 | ... | 22 | 2,798 | − 26 |
| Dublin United | ,, 1 | 4,555 | + 199 | 22 | 112,054 | − 618 |
| Dudley—Stourbridge | Nov. 24 | 821 | + 105 | 47 | 42,241 | + 1,487 |
| Dundee Corporation | ,, 29 | 856 | + 109 | §28 | 26,839 | + 1,477 |
| East Ham Council | Dec. 2 | 753 | + 181 | 35 | 29,202 | + 3,358 |
| Gateshead & Dist. Trams | Nov. 24 | 584 | + 22 | 47 | 43,375 | + 570 |
| Glasgow Corporation | Dec. 2 | 14,986 | + 1,314 | 27 | 406,806 | + 21,068 |
| Glossop | ... | ... | ... | ... | ... | ... |
| Gloucester Corporation | Nov. 29 | 218 | + 40 | 35 | 10,666 | ... |
| Gravesend—Northfleet | ,, 24 | 180 | + 2 | 47 | 10,902 | − 924 |
| Gt. Northern & City Rly. | Dec. 2 | 1,802 | + 264 | 22 | 84,143 | + 7,666 |
| Greenock & Port Glasgow | Nov. 24 | 625 | + 115 | 47 | 30,356 | + 8,286 |
| Halifax Corporation | ,, 22 | 1,266 | + 170 | 34 | 56,5 1 | + 8,838 |
| | ,, 29 | 1,201 | + 263 | | | |
| Hartlepool Tramways | ,, 24 | 230 | + 3 | 47 | 12,563 | − 1,201 |
| Hastings Elec. Trams Co. | ,, 30 | 346 | ... | 17 | 9,831 | ... |
| Huddersfield | Dec. 2 | 1,337 | + 152 | 35 | 48,229 | + 1,594 |
| Hull Corporation | ,, 2 | 2,160 | + 94 | 35 | 78,289 | + 1,722 |
| Ilford Dist. Coun. | ,, 2 | 383 | + 54 | 25 | 17,008 | + 425 |
| Ipswich Corporation | ,, 2 | 315 | + 22 | 15 | 10,751 | − 1,831 |
| Isle of Thanet Co. | ,, 2 | 216 | − 17 | 9 | 2,610 | − 464 |
| Kidderminster & District | Nov. 24 | 83 | − 7 | 47 | 5,715 | − 334 |
| Kilmarnock Corporation | ... | ... | ... | ... | ... | ... |
| Kirkcaldy Corporation | ,, 29 | 187 | − 13 | 13 | 2,626 | − 103 |
| Lanarkshire Trams Co. | ,, 30 | 791 | + 221 | 48 | 16,004 | + 4,645 |
| Leamington | ,, 24 | 131 | + 48 | 19 | 3,638 | + 1,316 |
| Leeds Corporation | Dec. 2 | 5,606 | + 326 | 35 | 213,601 | + 4,880 |
| Leicester Corporation | ,, 2 | 1,950 | + 348 | 48 | 99,420 | + 29,554 |
| Liverpool Corporation | Nov. 25 | 9,799 | + 626 | 47 | 496,316 | + 8,765 |
| Liverpool Overhead Rly. | Dec. 3 | 1,351 | − 78 | 22 | 84,741 | − 1,545 |
| *London County Council | Nov. 25 | 13,140 | + 1,963 | 34 | 609,844 | + 70,777 |
| Lowestoft | Dec. 2 | 132 | − 5 | 9 | 1,387 | − 26 |
| Maidstone Corporation | Nov. 30 | 60 | + 1 | 35 | 4,557 | ... |
| Manchester Corporation | Dec. 2 | 12,527 | + 1,183 | 25 | 454,652 | + 19,709 |
| Mersey Railway | ,, 2 | 1,690 | + 19 | 22 | 84,666 | + 2,000 |
| Merthyr | Nov. 24 | 161 | − 16 | 47 | 8,917 | − 608 |
| *Metropolitan Elec. Trams | ,, 24 | 2,885 | + 791 | 47 | 125,465 | + 58,620 |
| Middleton | ,, 24 | 271 | + 80 | 47 | 15,953 | + 671 |
| Musselburgh | ,, 23 | 126 | ... | 21 | 5,217 | ... |
| Nelson Corporation | Dec. 2 | 124 | + 21 | 36 | 4,759 | + 454 |
| Newcastle-on-Tyne Corp. | ,, 2 | 3,661 | + 124 | 35 | 138,860 | + 2,874 |
| Newport (Mon.) | ,, 2 | 509 | + 17 | 9 | 4,786 | + 322 |
| Northampton Corporation | ,, 1 | 547 | + 40 | 24 | 14,048 | + 4,821 |
| Oldham, Ashton & Hyde | Nov. 24 | 529 | + 58 | 47 | 26,259 | + 627 |
| Oldham Corporation | Dec. 3 | 1,602 | + 291 | 36 | 59,353 | + 15,274 |
| Perth (W. A.) Elec. Trams | ,, 1 | 1,404 | + 45 | 48 | 65,866 | + 3,866 |
| Peterborough | Nov. 24 | 58 | − 5 | 47 | 6,885 | − 665 |
| Pontypridd Dist. Council | Dec. 2 | 139 | ... | 35 | 5,745 | ... |
| Portsmouth Corporation | ,, 2 | 1,869 | + 97 | 35 | 72,788 | + 1,116 |
| Potteries | Nov. 24 | 1,713 | + 59 | 47 | 60,397 | + 660 |
| Preston Corporation | ,, 29 | 587 | ... | 9 | 5,308 | ... |
| Reading Corporation | ,, 20 | 580 | + 18 | 9 | 5,077 | − 281 |
| Rotherham Corporation | ,, 30 | 416 | + 42 | 25 | 16,037 | − 601 |
| Rothesay | ,, 24 | 39 | + 6 | 47 | 9,464 | + 2,674 |
| Salford Corporation | Dec. 4 | 4,092 | + 319 | 36 | 151,822 | + 8,412 |
| Sheerness | Nov. 22 | 45 | − 6 | 47 | 8,299 | + 279 |
| Sheffield Corporation | Dec. 3 | 4,791 | + 404 | 36 | 177,686 | + 8,588 |
| Southampton Corporation | Nov. 29 | 887 | + 113 | 19 | 7,387 | − 593 |
| Southend Corporation | ,, 29 | 223 | + 80 | 25 | 14,264 | + 711 |
| Southport Tramways | ,, 24 | 207 | − 3 | 47 | 14,724 | − 634 |
| S. Staffordshire Trams. | ,, 24 | 745 | + 185 | 47 | 34,793 | + 1,496 |
| Stockport Corporation | Dec. 1 | 717 | + 345 | 39 | 26,889 | + 6,360 |
| Sunderland Corpn. | ,, 3 | 1,256 | + 145 | 35 | 47,188 | + 1,560 |
| Swansea Trams | Nov. 24 | 692 | + 245 | 47 | 33,985 | + 8,603 |
| Swindon Corporation | ,, 29 | 161 | + 35 | 35 | 7,010 | ... |
| Taunton | ,, 24 | 39 | ... | 47 | 1,072 | − 234 |
| Tynemouth and District | ,, 24 | 161 | ... | 47 | 12,210 | − 1,609 |
| Tyneside Trams Co. | ,, 29 | 332 | + 27 | 48 | 19,781 | + 1,066 |
| Wallasey District Council | Dec. 2 | 689 | + 75 | 35 | 27,900 | + 851 |
| Walsall | ,, 2 | 483 | + 49 | 48 | 23,566 | + 429 |
| Warrington Corporation | Nov. 30 | 335 | + 65 | 35 | 11,961 | + 642 |
| West Ham Corporation | ,, 30 | 1,511 | + 581 | 36 | 68,037 | + 26,616 |
| Weston-super-Mare | ,, 22 | 22 | − 4 | 47 | 6,725 | + 593 |
| Wolverhampton Corpn. | ,, 29 | 725 | ... | 9 | 6,738 | ... |
| Wolverhampton District | ,, 24 | 365 | + 40 | 47 | 18,636 | + 274 |
| *Worcester | ,, 24 | 207 | − 34 | 47 | 14,263 | + 389 |
| Wrexham | ,, 24 | 82 | + 5 | 47 | 4,736 | − 380 |
| Yorkshire W.R. Trams | Dec. 3 | 681 | + 176 | 43 | 84,277 | ... |
| Yorkshire Woollen District | Nov. 24 | 681 | + 219 | 47 | 31,166 | + 3,826 |

(a) These comparisons are with the corresponding period last year. † Minus 3 days. § Plus 2 days. * Partly electrical.

amounted to £61,404, and for the last complete year under electric working (ended June 30 last) the total receipts were £85,484. In the two years preceding the change there was a falling off of £16,000 in earnings, but in the two years following the adoption of electric traction the receipts rose by £24,000.

**MACKAY COMPANIES.**—In the note which appeared under the above heading in our last issue (p. 291), the rate at which dividends will be paid by the Union of London & Smiths Bank should have been given as 4s. 1½d. to the United States dollar (not 4s. 01-12d.).

The regular quarterly dividend of 1 per cent. on the preferred shares and the semi-annual dividend of 1 per cent. on the common shares in the Mackay companies will be paid on Jan. 2. The transfer books will be closed from 17th inst. to Jan. 1 inclusive.

**RAND CENTRAL ELECTRIC WORKS (LTD.)**—The result of working for November was 866,000 units generated, yielding as gross revenue £8,100, against 795,000 units and £7,450 revenue for the corresponding period last year.

**SIEMENS & HALSKE A.G.**—At the meeting on the 21st inst. a dividend of 9 per cent. (against 7 per cent. in previous year) will be recommended for the past year. Ample provision for depreciation, reserve, &c., has also been made.

**STOCK EXCHANGE NOTICE.**—The Stock Exchange committee have ordered £100,000 4 per cent. redeemable debenture stock of the *Oriental Telephone & Electric Co. (Ltd.)* to be quoted in the official list.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Dec. 6. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Dec. 6. | |
|---|---|---|---|---|---|---|---|
| | | | | £ s. d. | | Highest. | Lowest. |
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | | | | |
| 5 | 8/0 | Anglo-Argentine Ord. Shares | 8¼–8½ | 4 14 0 | Ap, Oct | 8 21/32 | 8⅜ |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞–6⅛ | 4 9 8 | — | 6 1/32 | 5 15/16 |
| St. | 6% | Do. Permanent 6% Deb. Stock | 142–145 | 4 2 8 | — | .. | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 105–107 | 4 13 5 | — | 107 | .. |
| 10 | 12/0 | Barcelona Tramways Ord. | 13¾–14¼ | 4 4 0 | — | .. | .. |
| 10 | 5/0 | Do. 5% Cum. Pref. | 9½–10 | 5 0 0 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock (red.) | 97–102 | 4 8 8 | — | .. | .. |
| 100 | 5% | Do. 5 per Cent. Debs. | 93–101 | 4 19 0 | — | .. | .. |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1–1¼ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 4–4¼ | 5 18 3 | — | 4⅛ | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts | 95–98 | 4 12 0 | — | 96¼ | .. |
| St. | 6% | British Columbia Elec. Rlwy Def. Ord. | 124–127 | 4 14 6 | — | 126½ | 12[illegible]½ |
| St. | 5% | † Do. Pref. Ord. Stock | 111–114 | 4 7 8 | — | .. | .. |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock | 103–109 | 4 11 8 | — | 107¾ | .. |
| 40 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%–105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 102–105 | 4 5 9 | — | 8½ | 8 7/16 |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | 5⅜–5⅝ | 5 3 0 | — | .. | .. |
| 5 | 8/0 | Do. 6 per Cent. "A" Cm. Pref | 5 11/16–5 15/16 | 5 2 0 | — | .. | .. |
| 5 | 8/0 | Do. "B" | 5–5½ | 5 9 1 | — | .. | .. |
| St. | 5% | Do. 5 per Cent. Debs. | 107–109 | 4 11 8 | — | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102–105 | 4 16 3 | — | .. | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 98–100 | 5 0 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 101–105 | 5 4 9 | .. | 103 | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 103–107 | 5 12 0 | .. | .. | .. |
| 5 | 8/6 | Calcutta Tramways (Nos. 1 to 105) | 9¼–9¾ | 4 7 2 | — | 9 7/16 | .. |
| 5 | 0/3 | Do. Nos. 105,001 to 137,610 | 8½–9 | .. | .. | 8⅝ | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 107–109 | 4 2 7 | — | . | .. |
| 1 | 0/6 | Cape Electric Tram Shares | ⅞–1⅛ | 4 8 10 | — | [illegible] | .. |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 101–103 | 4 17 2 | — | 102 | 101 |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 97–99% | .. | .. | — | .. |
| 1 | .. | Lisbon Elec. Trams Ord. | 1⅜–1⅝ | .. | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛–1⅜ | 4 7 4 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 101–104 | 4 16 3 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 103–105 | 4 15 3 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101–104 | 4 16 2 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102–104 | 4 6 7 | — | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 104–107 | 4 18 5 | .. | 106¾ | 106½ |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 141–144 | 5 11 0 | .. | .. | .. |
| .. | 5% | † Do. 5% 1st Mt. $100 Dbs. | 96%–98% | 5 2 0 | .. | .. | .. |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | — | Adelaide Elec. S'ply Co. 6% Cu. Pr. | 5–5½ | — | .. | .. | .. |
| 5 | 8/3 | Calcutta Elec (1–60,000) | 9–9½ | 4 6 9 | — | 9¼ | 9 3/16 |
| 5 | 8/3 | Do. (60,001–80,000) | 9–9½ | 4 6 9 | .. | 9 | — |
| 10 | 5% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50–52 | 4 16 1 | .. | 51⅜ | .. |
| .. | .. | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 96–98 | .. | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½–3 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Debs. | 88–90 | 5 11 1 | — | .. | — |
| 10 | .. | Havana Electricity Co. Shares | 9–10 | — | — | .. | .. |
| 100 | 5% | † Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92–94 | 5 6 8 | .. | — | .. |
| St. | .. | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. 50% pd. | 60–62 | .. | .. | .. | .. |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞–1 | 6 0 0 | — | [illegible] | — |
| 1 | 1/0 | Rand Electric | 1¼–1⅜ | .. | — | .. | — |
| 1 | .. | River Plate Electricity Co. Ord. | [illegible] | .. | .. | .. | .. |
| 1 | 1/2⅔ | Do. 6% Non. Cum. Pref | [illegible]–1 1/16 | .. | .. | .. | 1 |
| St. | 5% | Do. 5% Deb. Stock | 103–105 | 4 15 0 | .. | 104 | 103½ |
| 5 | 8/0 | Rosario Elec. Co. 6% Pref. (1–12,000) | 5¼–5¾ | 5 4 4 | .. | .. | — |
| 5 | [illegible]3d | Do. (12,001–20,000) | 5–5½ | 3 8 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100–103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 10/9 | Shawinigan Water and Power 5% Bds., Scrip | 101–102 | 4 18 0 | .. | 101⅜ | 100⅝ |

* In calculating the yield, allowance has been made for accrued interest but not for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Share. | Last Dividend | Name. | Price Wed., Dec. 6. | Rate per Cent. Yielded. | | | Dividend Due. | Business, Week to Dec. 6. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | £ | s. | d. | | High est. | Low est. |
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | | | |
| 1 | .. | Bath Elec. Trams Pref. Ord. | ⅞—1 | .. | | | .. | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | ⅞—1⅛ | 4 | 14 | 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 105½—107½ | 4 | 5 | 0 | .. | — | .. |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 103 — 105 | 4 | 5 | 9 | .. | .. | .. |
| 10 | 9% | Bristol Tramways and Carriage Ord. | 17 —17½ | 5 | 2 | 11 | Feb, Aug | .. | .. |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10 —10½ | 3 | 18 | 0 | .. | .. | — |
| St. | 4% | Do. 4 per Cent. Debs. | 105 —107 | 3 | 14 | 10 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 9¾—10½ | 5 | 17 | 0 | .. | 10 | 9⅞ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 11 —11½ | 5 | 4 | 4 | Feb, Aug | 11¼ | 11 |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 121 —123 | 4 | 1 | 0 | .. | 122¼ | — |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 98 —100 | 4 | 10 | 0 | .. | 99¼ | 99 |
| St. | 4% | Central London Ordinary Stock | 93 —95 | 4 | 4 | 0 | June, Dec | 93⅞ | 93¼ |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 101 —103 | 3 | 17 | 8 | .. | 102¼ | 101¾ |
| St. | 4% | Do. Deferred Stock | 85 —88 | 4 | 11 | 0 | .. | 87¼ | 86½ |
| 100 | 4% | Do. 4 per Cent. Debs. | 111 —113 | 3 | 10 | 3 | .. | 112¼ | 111¾ |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 4⅞—5⅛ | 4 | 17 | 6 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 100 —103 | 3 | 17 | 8 | .. | .. | .. |
| St. | 2% | City and South London Rly. Con. Ord. | 46 — 48 | 3 | 18 | 6 | Feb, Aug | 48 | 47 |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 119 —122 | 4 | 2 | 0 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 117 —120 | 4 | 3 | 4 | .. | .. | .. |
| St. | 5% | Do. (1901) | 114 —117 | 4 | 5 | 6 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 105 —108 | 3 | 14 | 1 | May, Nov | .. | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13½—14½ | 4 | 2 | 8 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½—15½ | 3 | 17 | 3 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5 —5½ | 7 | 5 | 6 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8 —9 | 4 | 8 | 11 | .. | .. | .. |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 101 —103 | 4 | 7 | 6 | .. | .. | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 17 —18 | 5 | 0 | 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 13¾—14¼ | 4 | 4 | 2 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 108 —110 | 4 | 1 | 10 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2½—2¾ | 9 | 8 | 6 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 83 —88 | 4 | 10 | 11 | — | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 3⅛—3⅜ | 3 | 13 | 0 | Feb, Aug | — | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾—10¼ | 4 | 15 | 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99 —102 | 3 | 19 | 3 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 10 —10½ | 4 | 15 | 0 | .. | 10⅜ | 10⅛ |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 100 —103 | 3 | 17 | 8 | — | 101¾ | 101¼ |
| St. | .. | Mersey Con. Ord. Stock | 7 —9 | — | | | — | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8 —11 | — | | | — | .. | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32—9/32 | .. | | | — | .. | .. |
| 1 | 0/6 | Do. 5% Cum, Pref. | 1 —1⅛ | 4 | 14 | 1 | — | 1 | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106 —108 | 4 | 3 | 3 | — | 107 | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½—1½ | .. | | | — | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾—9¼ | 5 | 5 | 3 | May | .. | .. |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9¾—10¼ | 4 | 17 | 6 | Feb, Aug | 10 | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 101 —104 | 4 | 6 | 4 | .. | .. | .. |
| 100 | .. | Sunderland Dist. Elec. Trams. 5% 1st Mort. Debs. | 85 —89 | .. | | | — | 98 | 97¾ |
| .. | 5% | † Underground Elec. Rys. Co. of London | 97 —98 | 5 | 2 | 0 | .. | 99⅞ | .. |
| St. | 3% | Waterloo and City Ord. | 94 —97 | 3 | 2 | 0 | June, Dec | 95 | 94 |
| St. | 12/11 | Yorkshire W.R. El. Trs. Co. 4% 1st Debs. | 96 —98 | 4 | 1 | 6 | .. | 97 | .. |
| | | **TELEGRAPHS.** | | | | | | | |
| 100 | 4% | * African Direct Tel. 4% Mrt. Deb. (red.) | 99 —102 | 3 | 13 | 5 | Jan, July | — | .. |
| 10 | — | Amazon Telegraph | 3¾—4¼ | .. | | | Jn, Dec .. | .. | .. |
| 100 | .. | Do. 5% Debs. (red.) | 85 —90 | 5 | 11 | 0 | .. | .. | .. |
| St. | 15/0 | Anglo-American | 62 —64 | 4 | 14 | 0 | F,My,Ag,N | 63½ | 62 |
| St. | 20/0 | Do. Preferred | 109½—110½ | 5 | 4 | 1 | F,My,Ag,N | 110½ | 109 |
| St. | 2/0 | Do. Deferred | 17⅛—17⅜ | .. | | | F,My Ag,N | 17 9/16 | 16⅞ |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 96 —98 | 4 | 1 | 8 | Jn Ap,Jy,O | 97¾ | 96¾ |
| 10 | 5/0 | Cuba Submarine Ord. | 8¾—9¼ | 5 | 8 | 8 | Feb, Aug | .. | .. |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17 —18 | 5 | 11 | 2 | Feb, Aug | .. | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜—3⅝ | 5 | 11 | 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 9½—9¾ | 5 | 2 | 6 | April, Oct | .. | .. |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 100%—103% | 4 | 7 | 5 | Jan, July | .. | .. |
| 20 | 8/0 | Direct United States Cable. | 13⅞—14⅛ | 4 | 9 | 0 | Ja,Ap,Jy,O | 14⅛ | 14 |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 100½—102½ | 4 | 8 | 2 | Jn, Dec .. | .. | .. |
| St. | 25/0 | Eastern Ordinary | 144 —147 | 4 | 15 | 8 | Ja,Ap,Jy,O | 146½ | 145 |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 89½—91½ | 3 | 16 | 6 | Ja Ap,Jy,O | 91 | 89½ |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 106 —108 | 3 | 14 | 1 | May, Nov | 107⅜ | 106 |
| 10 | 2/6 | Eastern Extension | 14½—15 | 4 | 18 | 4 | Ja,Ap,Jy,O | 14 13/16 | 14 9/16 |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 106 —108 | 3 | 14 | 1 | Feb, Aug | 107½ | 107 |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 100 —102 | 3 | 18 | 3 | Feb, Aug | 101 | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 100%—102% | 3 | 18 | 8 | May, Nov | .. | .. |
| 10 | 5/0 | G. N. (of Copenhagen) | 85 —87 | 6 | 9 | 8 | Jan, July | 87 | 85½ |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 100½—102½ | 4 | 8 | 2 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57½—59½ | 5 | 9 | 2 | May, Nov | 58¾ | 58 |
| 100 | $1 | Mackay Companies Common | 52½ | 3 | 16 | 8 | Jan, July | .. | .. |
| 100 | 4% | Do. Preference | 73 5/16 | 5 | 8 | 10 | Ja,Ap,Jy,O | .. | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1½—1¾ | .. | | | .. | .. | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 100 —103 | 3 | 17 | 8 | June, Dec | .. | .. |
| 10 | 4/0 | † West African Telegraph Shares | 9¾—10¼ | 4 | 17 | 6 | .. | .. | .. |
| 2½ | .. | West Coast of America | 9/16—11/16 | .. | | | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100 —102 | 3 | 18 | 5 | Jan, July | .. | .. |
| 10 | — | West India and Panama | ½—¾ | .. | | | May, Nov | .. | .. |
| 10 | 6/0 | Do. 6% 1st Pref. ex on a/c of arrears | 8½—9 | 6 | 2 | 8 | May, Nov | 8 7/16 | 8¼ |
| 10 | — | Do. 6 per Cent. 2nd Pref. | 6½—7½ | .. | | | May, Nov | 6½ | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 101 —104 | 4 | 16 | 2 | Jan, July | .. | .. |
| 10 | 5/0 | Western Telegraph | 14 —14½ | 4 | 16 | 7 | Mr,Jn,O,D | 14⅜ | 14 |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 102 —104 | 4 | 16 | 0 | June, Dec | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 103 —105 | 3 | 16 | 0 | .. | 103½ | .. |
| | | **TELEPHONES.** | | | | | | | |
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 102 — 104 | .. | | | .. | — | — |
| 5 | 5/0 | Chili Telephone (fully paid) | 7⅝—7⅞ | 5 | 1 | 8 | August | .. | .. |
| 1 | 0/9¾ | Monte Video Telephone Ord. | ⅞—1 | 4 | 0 | 0 | — | .. | .. |
| 1 | 1/0 | Do. 6% Pref. | ⅞—1 | 5 | 0 | 0 | .. | .. | .. |
| St. | 6% | National Co. Pref. Stock | 110½—111½ | 5 | 7 | 7 | — | 111½ | 110¼ |
| St. | 5% | Do. Def. Stock | 108 —110 | 4 | 11 | 0 | — | 109¼ | 107½ |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13 —15 | 4 | 0 | 0 | Feb, Aug | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 11 —13 | 4 | 12 | 4 | Feb, Aug | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅜—5⅞ | 4 | 5 | 2 | Feb, Aug | 5 13/16 | 5⅝ |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 98 —100 | 3 | 10 | 0 | June, Dec | 99 | 98¾ |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 104 —106 | 3 | 15 | 6 | — | .. | .. |
| 1 | 0/7½ | Oriental | 1¼—1⅜ | 3 | 12 | 9 | April, Oct | 1 3/32 | .. |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1 3/16—1 5/16 | 4 | 11 | 6 | — | .. | .. |
| St. | .. | Do. 4% Red. Deb. Stock | 97 —99 | .. | | | .. | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 102 —105 | 4 | 5 | 9 | .. | .. | .. |
| 5 | 5/0 | United River Plate | 7½—8 | 5 | 0 | 0 | July.... | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅜—5⅝ | 4 | 8 | 10 | June, Dec | .. | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 111 —113 | 4 | 8 | 6 | June, Dec | 112 | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 4¾—5¼ | 5 | 14 | 4 | .. | .. | .. |
| 10 | 5/0 | Globe Telegraph and Trust | 10½—10¾ | 5 | 0 | 8 | Ja, Ap,Jy,O | 10⅝ | 10 7/16 |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14⅛—14⅜ | 4 | 3 | 0 | Ja, Ap,Jy,O | 14 5/16 | 14⅛ |
| 10 | 6% | Submarine Cables Trust (Cert.) | 125 — 128 | 4 | 13 | 9 | April, Oct | 126 | — |

| Share. | Last Dividend | Name | Price Wed., Dec. 6. | Rate per Cent. Yielded. | | | Dividend Due. | Business Week to Dec. 6. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | £ | s. | d. | | High-est. | Low-est |
| | | **ELECTRICITY SUPPLY.** | | | | | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12½—12¾ | 5 | 9 | 10 | .. | 12 9/16 | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10½—10⅞ | 4 | 4 | 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 12¼—12¾ | 4 | 13 | 0 | .. | 11⅞ | — |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 107 —109 | 4 | 2 | 6 | .. | .. | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5½—5¾ | 4 | 15 | 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 102 —105 | 4 | 5 | 9 | — | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 9 —10 | 5 | 0 | 0 | .. | .. | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 9 —9½ | 3 | 14 | 5 | Mar, Sept | .. | .. |
| St. | 4% | † Central Elec. Sup. Co. 4% Guar. Db. Stock | 102 —105 | 3 | 16 | 3 | — | 103¼ | .. |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 2¼—2½ | 5 | 4 | 0 | Feb, Aug | 6⅛ | .. |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5½—5¾ | 3 | 18 | 3 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 103 —105 | 3 | 16 | 2 | — | .. | .. |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4¾—5 | 4 | 10 | 0 | — | .. | .. |
| 5 | 2/3 | Do. Do. (1908) | 4¾—5 | 4 | 10 | 0 | .. | .. | .. |
| 5 | 2/3 | Chelsea Electric Supply Ord. | 5 —6 | 5 | 0 | 0 | March .. | 5½ | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 110 —112 | 4 | 0 | 4 | Jn, Dec .. | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 11½—12½ | 4 | 16 | 0 | Feb, Aug | 11⅝ | 11½ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13¼—14¼ | 4 | 4 | 2 | Jan, July | 13⅞ | 13⅝ |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 124 —128 | 3 | 18 | 1 | Jn, Dec .. | .. | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 103 —105 | 4 | 5 | 8 | .. | 104 | .. |
| 5 | .. | County of Durham Elec. P.D. Ord. £2 pd. | 2 3/16—2 7/32 | .. | | | April, Oct | .. | .. |
| 5 | 6¾d. | Do. Do. 5% non cum. pref. | 5¼—5½ | .. | | | April, Oct | 5 7/16 | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 9¼—9¾ | 4 | 2 | 0 | — | 9½ | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅝—12⅞ | 4 | 13 | 2 | Mar, Sept | 12⅝ | .. |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 112 —115 | 3 | 18 | 8 | .. | 113 | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 102 —104 | 4 | 6 | 7 | .. | .. | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 2¼—2¾ | 4 | 15 | 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5 —5¼ | 4 | 11 | 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101 —104 | 4 | 6 | 6 | .. | .. | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8¼—8¾ | 4 | 17 | 2 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100 —103 | 4 | 7 | 5 | — | .. | .. |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 11¼—11¾ | 5 | 0 | 0 | .. | 11½ | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½—7 | 4 | 5 | 9 | Jan, July | — | — |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98 —101 | 3 | 19 | 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101 —103 | 3 | 17 | 8 | .. | .. | .. |
| 8 | 1/9⅜ | London Electric Supply Ord. | 1¾—2¼ | 4 | 0 | 0 | .. | 2 1/16 | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 4¾—5¼ | 5 | 14 | 4 | — | 5¼ | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 99 —102 | 3 | 18 | 5 | Mr,Jn,S,D | 101¼ | 101¼ |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 9¼—10¼ | 5 | 7 | 0 | April, Oct | 10 5/16 | 9 11/16 |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5⅜—5⅝ | 4 | 0 | 0 | Jan. July | 5½ | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 109 —113 | 3 | 19 | 7 | Jn, Dec .. | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 97 —99 | 3 | 10 | 8 | — | 98¾ | 98¼ |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 101 —103% | 4 | 7 | 5 | — | .. | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 12⅛—12⅜ | 5 | 9 | 1 | Feb, Aug | .. | .. |
| 100 | .. | Do. 4½% Deb. | 104½—105½ | .. | | | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8 —8½ | 4 | 13 | 5 | Feb, Aug | 8¼ | 8 1/16 |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6¼—6½ | 3 | 16 | 11 | Feb, Aug | 6⅜ | 6¼ |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99 —100 | 4 | 0 | 0 | Jan, July | .. | .. |
| 1 | 8% | Northern Counties Elec. Sup. 17/- paid | 1⅜—1⅞ | 3 | 1 | 1 | Mar, Aug | 1¾ | 1⅝ |
| 100 | .. | Do. 4½% Deb. | 100½—101½ | .. | | | Jan, July | — | — |
| 10 | 6/0 | Notting Hill Electric Ord. | 14½—15½ | 3 | 17 | 6 | March.... | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98 —100 | 4 | 0 | 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅜—6⅞ | 5 | 1 | 6 | March .. | .. | .. |
| St. | 4% | Do. 4% Deb. Stock | 100 —102 | 3 | 18 | 5 | — | .. | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 13 —14 | 5 | 3 | 7 | Feb, Aug | .. | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 8 —9 | 3 | 17 | 9 | Feb, Aug | 8½ | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 98 — 100 | 3 | 10 | 0 | — | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2 —2½ | 8 | 0 | 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76 —80 | 5 | 0 | 0 | — | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 2½—3½ | 5 | 2 | 0 | .. | 3¼ | .. |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | 1⅛—1⅜ | .. | | | .. | .. | .. |
| 1 | 0/8¾ | Do. 7% Cum. Pref. | 1 5/16—1 7/16 | 4 | 17 | 2 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105 —108 | 4 | 8 | 8 | — | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4½ 4¾ | 5 | 5 | 8 | — | .. | .. |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5 —5¼ | 4 | 15 | 8 | — | 5⅛ | .. |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 104 —106 | 4 | 4 | 10 | .. | 105 | 105 |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 11½—12½ | 5 | 12 | 0 | Mar, Sept | 12¼ | 11⅞ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5¾—6¼ | 4 | 0 | 0 | .. | 6¼ | 5⅞ |
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝—⅞ | 5 | 6 | 6 | — | .. | .. |
| 1 | 6d. | Aron Elec. Meter 6% Cum. Pref. | 9/16—11/16 | .. | | | .. | .. | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3⅜—3½ | 5 | 0 | 0 | .. | 3⅜ | 3⅜ |
| 1 | 7½d. | Do. Pref | 1 1/16—1 3/16 | 3 | 16 | 10 | .. | 6⅝ | .. |
| 5 | 6/0 | British Insulated & Helsby Cables Ord. | 6⅛—7 | 5 | 14 | 0 | July, Feb | 6⅛ | .. |
| 5 | 6/0 | Do. 6 per Cent. Pref. | 5¾—6¼ | 4 | 19 | 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103 —106 | 4 | 4 | 11 | .. | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98 —100 | 4 | 10 | 0 | .. | .. | .. |
| 5 | .. | British Westinghouse 6% Pref. | 5½—5⅝ | .. | | | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 85 —89 | 4 | 9 | 11 | .. | .. | .. |
| 2 | .. | Brush Electrical Engineering | ⅜—⅝ | .. | | | March .. | .. | .. |
| 2 | 2/4½ | Do. 6 per Cent. Pref. Non-Cum. | 1½—2 | 6 | 0 | 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 94 —98 | 4 | 11 | 9 | Mar, Sept | .. | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 80 —83 | 5 | 9 | 0 | Jan, July | .. | .. |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11 —12 | 5 | 0 | 0 | Jan, July | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝—5⅞ | 4 | 5 | 2 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 109 —111 | 4 | 1 | 1 | Nov, May | .. | .. |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1 —1⅛ | 5 | 7 | 0 | .. | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 97 —102 | 4 | 8 | 8 | — | .. | .. |
| 1 | 5½d. | Chadburn's (Ship) Telegraph Ord. | 1 —1¼ | 8 | 0 | 0 | .. | .. | .. |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1 1/16—1 3/16 | 5 | 2 | 7 | .. | 2 | .. |
| 8 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 1⅞—2⅛ | 3 | 10 | 6 | Jan, July | .. | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 94 —99 | 5 | 1 | 0 | Jan, July | .. | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8½—9 | 5 | 11 | 1 | Sept —— | 6⅛ | .. |
| 5 | 3/0 | Do. 6% Cum. Pref. | 5¾—6¼ | 4 | 18 | 0 | Sept —— | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106—108 | 4 | 4 | 1 | .. | 1½ | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅜—1⅝ | .. | | | Feb, Aug | 1⅛ | .. |
| 5 | 2/6 | Do. (£5 paid) | 2 —2½ | .. | | | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 85 —90 | 4 | 8 | 11 | June, Dec | .. | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92 —97 | 5 | 3 | 1 | .. | [illegible] | 5⅜ |
| 5 | 4/6 | Edmundson's Elec. Corp. Ord. | 5¼—5¾ | 6 | 1 | 9 | H'lf-yearly | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5⅞—6⅛ | 4 | 18 | 0 | .. | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 108 —110 | 4 | 1 | 6 | .. | 108 | 107¾ |
| 2 | 1/7½ | Electric Construction Co. | ½—¾ | 9 | 6 | 0 | July —— | .. | .. |
| 2 | 2/9⅜ | Do. 7 per Cent. Cum. Pref | 1⅞—2⅜ | 5 | 18 | 8 | July .... | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 92 —95 | 4 | 4 | 2 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9¼—9¾ | 5 | 2 | 6 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96 —100 | 4 | 0 | 0 | .. | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 12½—13½ | 5 | 11 | 1 | Feb, Aug | 13 | .. |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5⅛—5⅜ | 4 | 3 | 9 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | — | 4 | 1 | 1 | Feb, Aug | .. | .. |
| 10 | 5/0 | India Rubber, Gutta Percha, &c., Wrks. | 16 —17 | 2 | 18 | 9 | Feb, Aug | 16⅞ | 16¾ |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99 —102 | 3 | 18 | 5 | Mar, Sept | .. | .. |
| 1 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¼—11¾ | 4 | 5 | 1 | Mar, Sept | .. | .. |
| 1 | 12/0 | Telegraph Construction & Mainten'ce. | 32 —34 | 5 | 5 | 10 | Mar, July | 33½ | .. |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 102 —104 | 3 | 16 | 11 | Jan, July | .. | .. |
| 5 | — | Willans and Robinson Ord. | 1½—2 | — | | | Apr, Oct | 1¾ | 3 |
| 5 | — | Do. 6 per Cent. Cum. Pref. | 2½—3½ | — | | | Apr. Oct | .. | .. |
| .. | 4% | † Do. 4 per Cent. 1st Mort. Debs. | 84 —89 | 4 | 9 | 10 | May Nov | — | .. |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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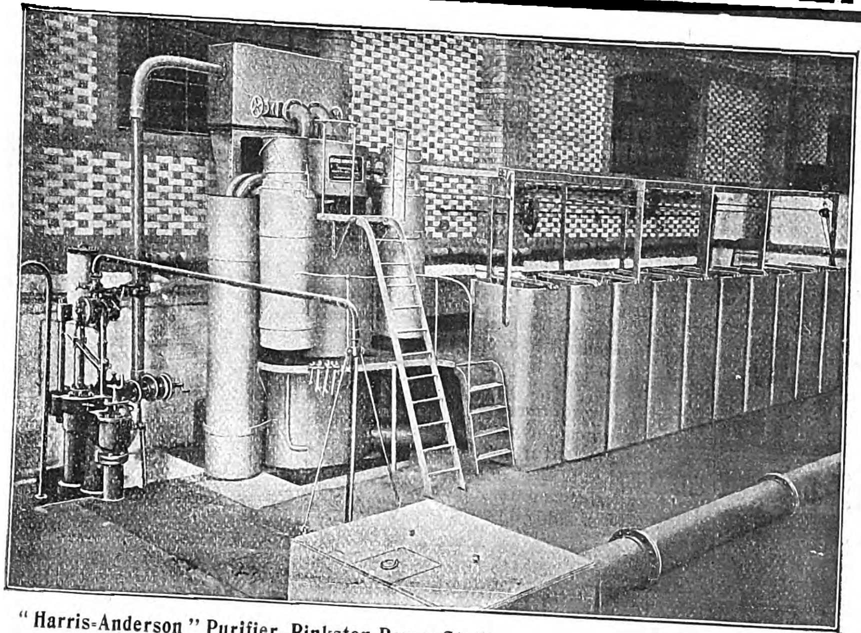

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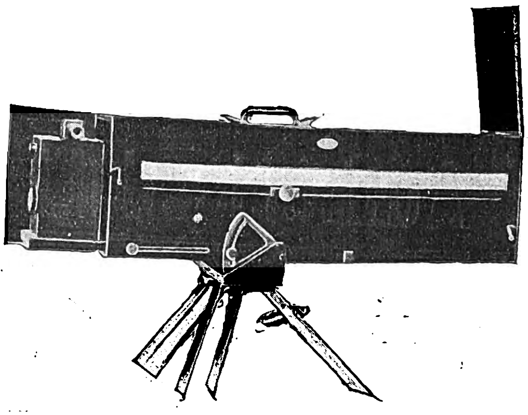

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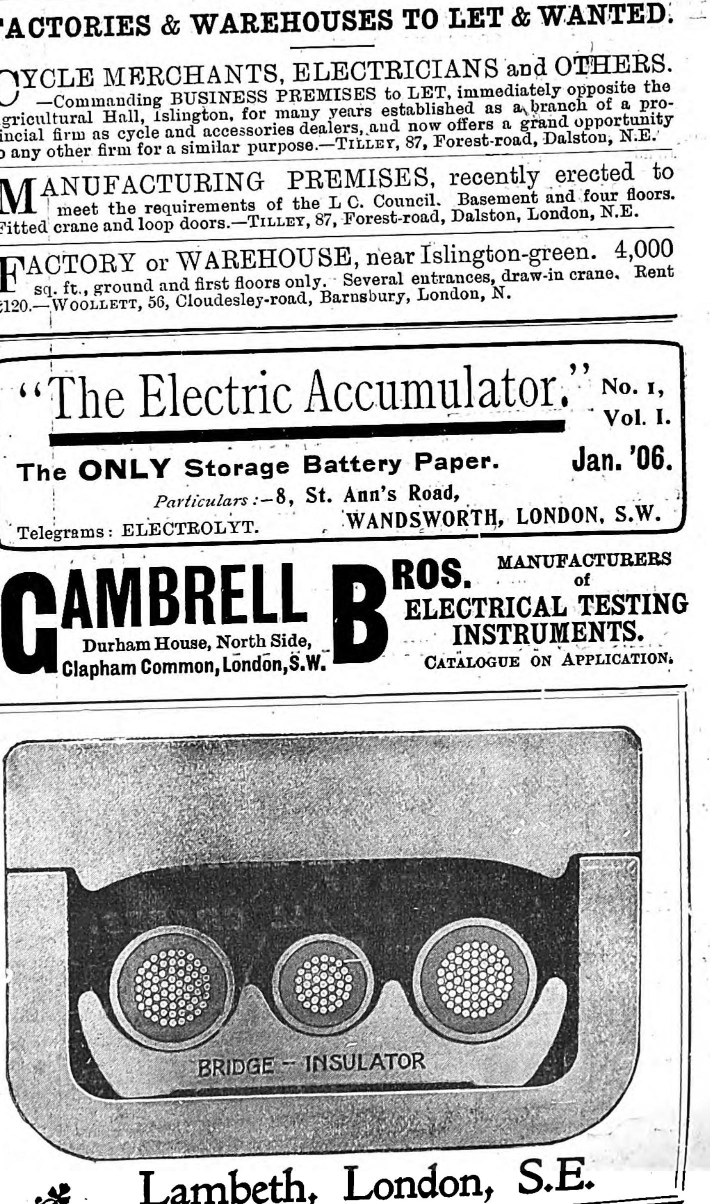

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By order,
A. R. HARDIE, Secretary.

Electra House, Finsbury Pavement,
London, E.C., 13th December, 1905.

## THE EASTERN EXTENSION AUSTRALASIA AND CHINA TELEGRAPH COMPANY, LIMITED.

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By order,
F. E. HESSE, General Manager.

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London, E.C., 13th December, 1905.

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Warrants in payment of the Interest on the Registered Debentures will be sent out on the 30th instant.

The DEBENTURE REGISTER will be CLOSED from WEDNESDAY the 27th to SATURDAY the 30th instant, both days inclusive.

By order,
H. E. PLANK, Secretary.

Electra House, Finsbury Pavement,
London, E.C., 14th December, 1905.

## THE COUNTY OF LONDON ELECTRIC SUPPLY COMPANY, LIMITED.

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By order,
H. B. RENWICK, Secretary.

Moorgate-court, Moorgate-place.
London, E.C., December 6th, 1905.

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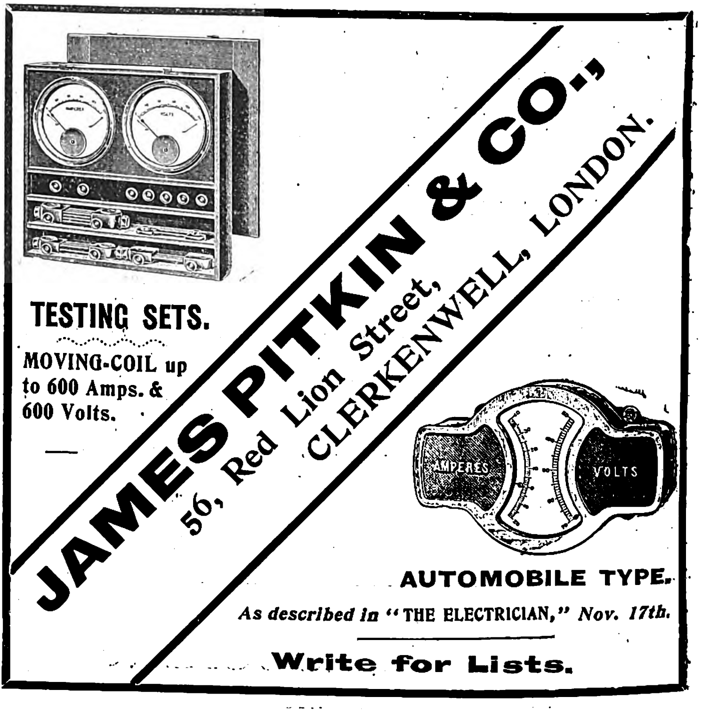
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## AND HANDBOOK

## (THE BIG BLUE BOOK).

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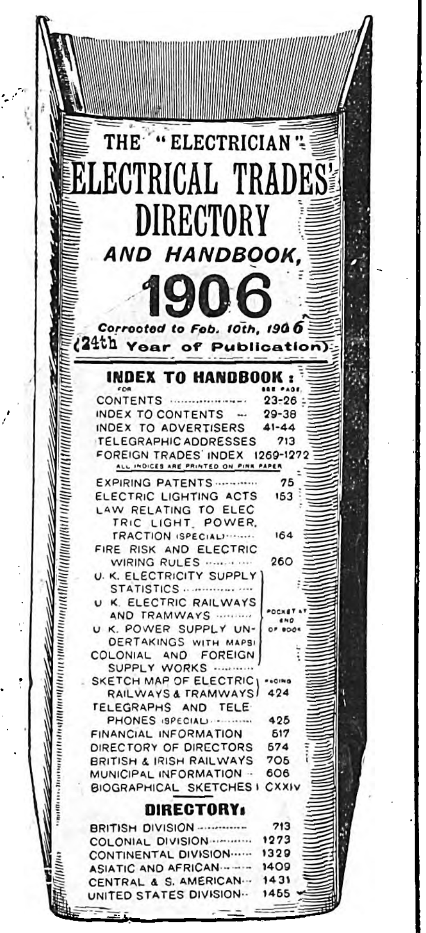

THE "ELECTRICIAN"

ELECTRICAL TRADES' DIRECTORY

AND HANDBOOK,

1906

Corrected to Feb. 10th, 1906

(24th Year of Publication)

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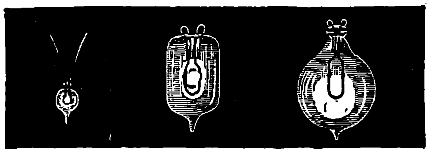

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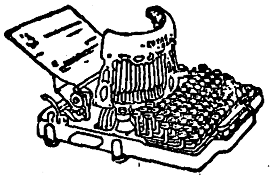

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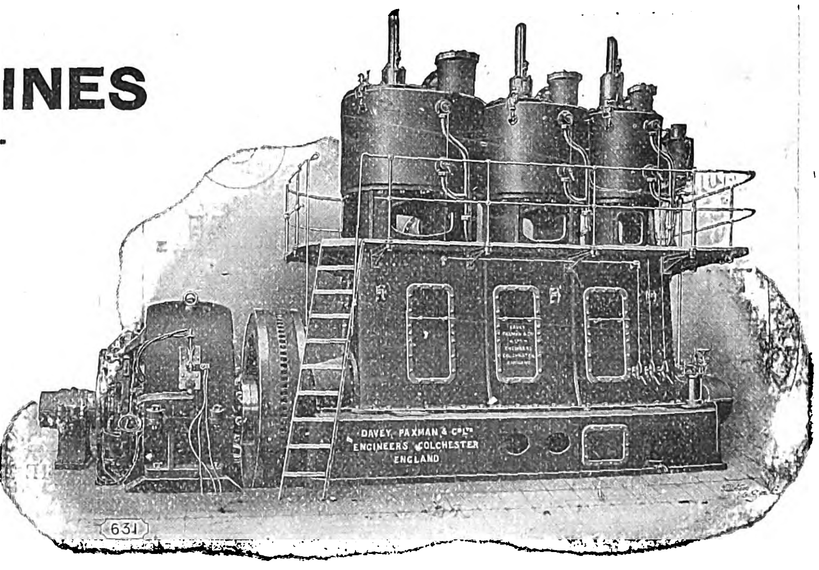

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THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,439. [No. 9. Vol. LVI.] FRIDAY, DECEMBER 15, 1905. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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## NOTES.

We are in a position to state that the award of the contract for the electrical equipment of the London Bridge, Peckham Rye, Victoria line of the London, Brighton & South Coast Railway to the Allgemeine Elektricitäts Gesellschaft of Berlin is practically settled. Negotiations are being concluded between the representatives of the company and a sub committee of the directors, and the agreement arrived at will subsequently be confirmed at a board meeting. We are informed that the company's guarantees as to efficiency, heating, power factor, acceleration and energy consumption per car-mile are all better than those of other tenderers, and that the price is also considerably lower. Except for the motor equipment of the first few trains, which will be of German make, everything is to be manufactured in this country—even the trucks, switches and switchboards. Much of the work will therefore be let to sub-contractors. It will be remembered that the single-phase system is to be adopted, similar to that erected by the Allgemeine Elektricitäts Gesellschaft between Niederschöneweide and Spindlersfeld, near Berlin. Originally it was intended to convert only the part of the line from Battersea Park to Peckham Rye to electric traction as a first instalment, but now it has been decided that the whole line—Victoria, Grosvenor-road, Battersea Park, Wandsworth-road, Clapham-road, East Brixton, Denmark-hill, Peckham Rye, Queen's-road (Peckham), Old Kent-road and Hatcham, South Bermondsey and London Bridge (about 8 miles) is to be equipped electrically. It is also now definitely settled that the company will not generate its own electrical energy, but will purchase it from a power company—from the Additional Electric Power Supply Co., we may anticipate, if its Bill should pass through Parliament this session.

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We give elsewhere in this issue an abstract of Dr. J. Erskine-Murray's Paper on Wireless Telegraphy, read before the Glasgow meeting of the Institution on Tuesday. Perhaps the chief call for remark arises out of the formulæ and theory offered to account for the propagation of electrical waves round the curve of the earth's surface. The hypothesis in question—that the spreading of the waves into space is prevented by a highly-conducting layer high in the atmosphere, so that the waves travel round the earth much as if between two parallel conducting planes—is not a new one, but now it is claimed as proved by the measurements of Duddell and Taylor. There are, it seems to us, two good arguments against the proposed theory. In the first place, the waves have to pass through layers of medium conductivity before reaching those of good conductivity; and the dissipation of the energy in these middle layers will probably bring about nearly the same result as would unrestrained expansion into space.

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In the second place, it is doubtful if Duddell and Taylor's results can be interpreted in the way set forth in the Paper, even for a plane earth, let alone a spherical one. They could be better interpreted in this way: If the energy of the air-wire current is proportional to the energy carried by the waves through the medium near the air-wire, then Duddell and Taylor's observation that the current received varies inversely as the first power of the distance would seem to show that the energy of the expanding wave-front diminishes according to the inverse square law—the ordinary law of free propagation into space. Of course, we may say that current-producing power, whatever it may be in terms of the properties of electro-magnetic waves, is shown by Duddell and Taylor's experiments to vary inversely as the distance, and thus we may escape committing ourselves to any hard and fast theory about the law according to which the energy in the wave-front is conserved. Further than that, we think, we cannot go.

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The question of technical education is undoubtedly one of the questions of the day, and however opinions may differ as to the methods to be adopted, we think that all are agreed that the young worker who, at the outset of his industrial career, has the opportunity of equipping himself with the knowledge of the principles underlying his calling, will not only substantially improve his chances of a more remunerative employment, but will, at the same time, be more likely to benefit the progress of the industry to which he belongs. Much can be said on this many-sided problem, and a valuable contribution to the literature of the subject is found in the Report of an inquiry as to the co-operation of employers and technical institutions issued this week by the Association of Technical Institutions.

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THE report contains a return of the ways in which employers of labour in various industries assist their apprentices in the matter of obtaining technical instruction, and we are pleased to note the large number of cases in which assistance in some form or another is given. In the majority of instances, the help given refers to evening classes. A large number of firms pay their men's fees, either wholly or in part,—sometimes when the classes are commenced, and sometimes as a refund to the apprentice upon receipt of a satisfactory report as to his progress. In other firms the lost time, if the classes are held in the daytime, is paid for by the employers or in the case of evening classes the student is allowed to leave work before the ordinary hour of closing without loss of pay, and in some instances even, he is permitted to be one hour late the morning following a class night. One or two firms give scholarships which include the supply of books, and many employers offer prizes of books and instruments for successful class work. Another question which is touched on is the attitude of the foreman and the workmen to the question of technical instruction. There is great variety in the information received on this point. In one town the foremen are reported as "very obstructive." In other towns, however, co-operative societies of workmen materially help; in one case they actually pay the fees of 20 evening students chosen from among their own body, and offer six scholarships covering the day-school fees. Although the older race of works managers and foremen who have not been technically educated themselves do not appear to like the idea of the younger generation knowing more than they do, no doubt, with the spread of technical instruction, the foremen of the future will be the men who have themselves profited by attendance at classes, and will be willing to extend the same advantage to those who are to come after them.

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WHILE this encouragement to workmen is to be commended, there is one danger to be avoided—viz., that of aiming at too high a standard in these classes. No object can be gained by educating the workman above his station. A good workman is more useful than a bad engineer, and while the supply of engineers to fill the lower ranks of the profession exceeds the demand, the skilled workmen is always in request.

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**Water-power Utilisation in India.**—According to a Reuter's correspondent, His Royal Highness the Prince of Wales, who is now being entertained in Cashmere, referred in appreciative terms, in the course of a speech on Friday, to a project for utilising the waters of the river Jehlem for the purposes of an electric railway.

**Street Lighting and Fog.**—Our provincial readers will be glad to learn that during the recent fogs in London the superior penetrating power of the flame arc lamps as compared with the ordinary arcs and the incandescent gas lamps was very evident.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Tarifa—Tangier | Jan. 18, 1904 |
| Jamaica—Colon | Jan. 10, 1905 |
| Cadiz—Teneriffe | July 20, 1905 |

**Tramways and Light Railways Association.**—On Wednesday, January 10, 1906, Mr. A. L. C. Fell, chief officer of the London County Council Tramways, will read a Paper on "Brakes" before this Association. The meeting will be held at the Society of Arts, John-street, Adelphi, at 8 p.m.

**Personal.**—We are glad to announce that the statement in Wednesday's *Times* to the effect that Sir Oliver Lodge is seriously ill was quite incorrect. In response to our enquiries, Sir Oliver telegraphed us on Wednesday afternoon that his illness was "slight, temporary, and not worth mentioning."

**Birmingham University.**—A gift of £10,000 has been offered to the University of Birmingham by Mr. Charles C. Harding and his sisters, Miss E. R. Harding and Mrs. Fiedler. The object of the donors, whose late father took a very deep interest in the university movement in Birmingham, is the erection of a library. A small committee has been appointed by the University to consult with the donors of the gift, and the donation has been accepted with gratitude by the University Council.

**Royal Institution.**—The following arrangements have now been made with regard to the meetings of the Royal Institution before Easter :—

Friday evening discourses at 9 p.m., January 19th, "Some Applications of the Theory of Electric Discharge to Spectroscopy," by Prof. J. J. Thomson, F.R.S.; Friday, February 2nd, "The Electric Production of Nitrates from the Atmosphere," by Prof. Silvanus P. Thompson, F.R.S.; Friday, February 16th, "The Passage of Electricity Through Liquids," by W. C. Dampier Whetham, F.R.S.; Friday, March 30th, "Recent Progress in Magneto-Optics, by Prof. P. Zeeman, of Amsterdam University. It is to be noted that during the 1906 session the lecture hour on Tuesdays and Thursdays has been changed to five o'clock. A series of lectures will be given on Thursdays, March 22nd, 29th and April 5th, by Prof. Bertram Hopkinson on "Internal Combustion Engines" (with experimental illustrations).

**The Nobel Prizes.**—A Nobel prize, amounting to about £7,700, an illuminated diploma and an inscribed gold medal, has been awarded to Prof. Philip Lenard, of the University of Kiel, in recognition of his work in connection with the cathode ray. Prof. Lenard is professor ordinarious and director of the Physical Laboratory at the University of Kiel where he has carried out considerable experiments on cathode rays and allied subjects. In 1903 he was made Doctor of Medicine *honoris causâ* by the University of Heidelberg. He was born in 1862, and was educated at the Universities of Berlin and Heidelberg where he worked under Bunsen, Helmholtz and Quincke. He has already received the Baumgartner prize, awarded by the Akademie of Vienna, the Rumford medal of the Royal Society of London, the Matteucci medal awarded by the Societa Italiana delle Scienze of Rome, and the Prix Locaze awarded him by the Academy of Paris for his cathode ray researches and experiments.

**Coal Smoke Abatement Conference.**—The Royal Sanitary Institute, in conjunction with the Coal Smoke Abatement Society, has been holding a conference and exhibition on smoke abatement in the Horticultural Hall, Westminster (London) this week. The President, Sir Oliver Lodge, F.R.S., was unable, through indisposition, to be present at the opening on Tuesday, and an address by him on "The General Problem of Combustion Reform" was, in consequence, read from his notes. On Wednesday a number of Papers, followed by a discussion, upon "Domestic Smoke Abatement," were read, and yesterday the subject of the day was "Factory and Trade Smoke Abatement." Eight Papers dealing with the various aspects of this question were submitted. To-day the questions of "Administration, Legislation and Necessary Reforms" will be discussed. Sir William Preece presided over yesterday's sitting. Visits have been paid to the Lot's-road generating station of the Underground Electric Railways Co. of London and the South Metropolitan Gas Works. A fuller report of the whole conference will be given in our next issue.

**Society of Engineers.**—The 51st Annual General Meeting of the Society of Engineers was held on Monday last, Mr. Nicholas J. West, president, in the chair. The following gentlemen were duly elected by ballot as the council and officers for 1906, viz :—

As president, Mr. Maurice Wilson ; as vice-presidents, Messrs. Richard St. George Moore, Joseph William Wilson and William Henry Holttum ; as ordinary members of council, Messrs. John Aird, Joseph Bernays, Alexander Graham Drury, George Abraham Goodwin, George Green, Edward John Silcock, Diogo Andrew Symons and Francis George Bloyd ; as honorary secretary and treasurer, Mr. David Butler Butler ; as honorary auditor, M. Samuel Wood, F.C.A.

The president announced that the Rt. Hon. Lord Rayleigh, F.R.S., O.M., chairman of the National Physical Laboratory, and Sir Alexander Richardson Binnie, president of the Institution of Civil Engineers, had been elected by the council as honorary members of the society, thus filling the vacancies created in the list of honorary members by the deaths of Sir Lowthian Bell and Mr. James Mansergh. Among the premiums awarded by the council for Papers read during the past session was the president's gold medal to Mr. Sherard Cowper-Coles for his Paper on "The Metallic Preservation and Ornamentation of Iron and Steel Surfaces."

**Birmingham and District Electric Club.**—The first annual report of the committee of the Birmingham and District Electric Club states that the membership at present amounts to 82, there having been a steady increase month by month. The following is a list of the Papers read during the first session :—

Presidential address, by John J. Inniss ; "Aluminium : Some of its Electrical Properties," by W. Smith ; "Starting and Speed Regulation of the Electric Motors," by E. Wood ; "Electric Lifting Machinery," by E. C. R. Marks ; "Lightning Conductors," by W. Whitehouse ; "Cheap Electrical Energy for Power Purposes," by Joseph A. Jeckell. Discussion on the following subjects : "Gas *v.* Electricity," introduced by J. A. Jeckell ; "Suction *v.* Town Gas for Power Purposes," introduced by Mr. Moon ; "Water Tube *v.* Lancashire Boilers," introduced by Mr. Marks ; "Electric Furnaces," by J. H. Stansbie ; "Direct *v.* Alternating-Current Motors," introduced by J. A. Jeckell ; "Copper *v.* Carbon for Motors and Dynamos," introduced by Mr. Smith ; "Telegraphy and Telephony," introduced by Mr. Whitehouse.

Two interesting visits to power stations were made during the summer months—viz., Coventry and Redditch—and the report recognises the courtesy shown to the members by the respective managers, Mr. J. A. Jeckell and Mr. Ferguson. The funds show a small credit balance, and the committee expresses the hope that an extended list of Papers and more numerous visits will result in a greatly increased membership. Mr. J. A. Jeckell, chief electrical engineer to the Coventry Corporation, has been elected President for the forthcoming session.

**The Paris Automobile Exhibition.**—The eighth annual Salon d'Automobiles is to be officially inaugurated to-day in the Grand Palais in the Champs Elysées. One of the features of electric interest in the show, apart from the very tastefully arranged illuminations, is the new petrol electric carriage shown by the Compagnie Parisienne des Voitures Electriques Krieger, which is described in our contemporary the *Motor Car Journal*. A 20 H.P. four-cylinder petrol engine of the usual type drives a compactly-constructed compound-wound dynamo which supplies current to the two driving motors, geared to the rear wheels of the carriage by the usual Krieger internal gear. A series-parallel controller with five notches is used in connection with these motors, further control being obtained by throttling the admission to the engine. A small battery is carried. This is not used as a reserve of power, however, but for providing a part of the excitation to the dynamo and for starting up the engine. In addition to the usual mechanical brakes, a pedal is provided by which the driver can first disconnect the motors and then short-circuit them progressively on the resistances. Amongst other purely electric carriages at the exhibition, a new type is shown by the Société des Voitures Electriques Vedrine, in which particular attention is paid to the springing. One motor only is employed, and the control is entirely by field regulation. With regard to ignition systems, high-tension magnetos are increasingly replacing low-tension magnetos. Accumulators are rarely employed, except as an alternative to the high-tension magneto with a simple two-way switch.

**Engineering Standards Committee.**—A report of the work of the Engineering Standards Committee from its inception to July 31, 1905, has just been issued. The booklet contains a list of all the members serving on the various committees and also a list of the publications and templates issued by the Committee.

It may be remembered that in January, 1901, on the motion of Sir John Wolfe Barry, K.C.B., the Council of the Institution of Civil Engineers appointed a committee to consider the advisability of standardising various kinds of iron and steel sections. This committee consisted of six members—viz., Sir Benjamin Baker, Sir John Wolfe Barry, Sir Frederick Bramwell, Sir Douglas Fox, Mr. James Mansergh and Prof. W. C. Unwin. At the first meeting of this committee it was decided to recommend that the Councils of the Institution of Mechanical Engineers, Institution of Naval Architects and the Iron and Steel Institute be invited each to appoint two additional members on the committee. In November, 1901, the original reference to the committee was enlarged, by resolution of the several supporting institutions, to embrace the standardisation of locomotives and of tests for engineering materials. In January, 1902, Sir William Preece, K.C.B., suggested that the standardisation of electrical machinery should be undertaken, and as a result the Institution of Electrical Engineers was invited to co-operate. In June, 1902, the reference to the committee was formally enlarged to include the standardisation of electrical plant. In this way the number of committees has gradually grown from the original single committee to 35 sectional committees and sub-committees, and the whole work is now supported by the five leading technical societies of this country, which include, of course, the Institution of Electrical Engineers. The committee is also receiving the countenance and support of His Majesty's Government, and there are serving on the different committees official representatives from most of the technical societies and trade associations of the country. Committees and sub-committees are now dealing with the following electrical standards : Generators, motors and transformers, prime movers for electrical purposes, physical standards, telegraph and telephone material, electric cables, electric tramway material, electric automobiles and electrical plant accessories.

**The Energy Consumption of Electric Drills.**—According to the *Engineering and Mining Journal* of New York, the New York Edison Co. made two series of tests with the Durkee electric drill during the early part of this year. The first test was conducted at the 121st-street station with the following results :—

| No. of holes drilled. | Depth in inches | No. of working hours. | Time lost blasting & mucking. | | No. ft. drilled per day. | Kw.-hrs. consumed. |
|---|---|---|---|---|---|---|
| | | | Hr. | Min. | | |
| 12 | 58 | 6½ | 0 | 30 | 58 | 8·7 |
| 15 | 58 | 8 | 1 | 0 | 73 | 10·9 |
| 13 | 58 | 8 | 1 | 20 | 63 | 9·4 |
| 12 | 58 | 8 | 1 | 15 | 58 | 8·7 |
| 13 | 58 | 8 | 1 | 15 | 63 | 9·4 |
| 2 | 58 | 1 | 0 | 5 | 10 | 1·5 |
| 12 | 58 | 8 | 1 | 10 | 58 | 8·7 |
| 13 | 58 | 8 | 1 | 50 | 63 | 9·4 |
| 3 | 58 | 2½ | 0 | 40 | 15 | 3·2 |
| 10 | 58 | 7 | 0 | 35 | 48 | 8·2 |
| 8 | 58 | 6 | 0 | 50 | 39 | 5·8 |
| 2 | 58 | 1 | 0 | 0 | 9 | 1·3 |
| 9 | 58 | 6 | 0 | 40 | 44 | 6·6 |
| 11 | 58 | 8 | 0 | 45 | 53 | 7·9 |
| 12 | 58 | 8 | 0 | 25 | 58 | 8·7 |
| 13 | 56 | 8 | 0 | 30 | 63 | 9·4 |
| 11 | 58 | 8 | 0 | 20 | 53 | 7·9 |
| 5 | 58 | 8 | 0 | 35 | 61 | 9·0 |
| 6 | 74 | | | | | |
| 5 | 74 | 8 | 1 | 5 | 49 | 7·4 |
| 6 | 36 | | | | | |
| 16 | 36 | 8 | 0 | 45 | 48 | 6·3 |

The average drilling per day was over 60 ft., at an average cost of 1.5c. per foot. The second test was made at the north-east corner of Twelfth-street and Fourth-avenue with the following results :—

| No. of holes drilled. | Depth in inches | No. of working hours. | No. ft. drilled per day. | Kw.-hrs. consumed. | Kw.-hr. per ft. |
|---|---|---|---|---|---|
| 17 | 48 | 8·0 | 68 | 8·09 | 0·131 |
| 17 | 48 | 8·0 | 68 | 8·35 | 0·123 |
| 18 | 48 | 8·0 | 72 | 8·06 | 0·120 |
| 3 | 48 | 1·5 | 12 | 0·05 | 0·04 |
| 11 | 48 | 6·0 | 44 | 4·05 | 0·92 |
| 20 | 36 | 8·0 | 60 | 6·45 | 0·107 |

At both 121st-street and Twelfth-street the rock is of mica schist and muds easily.

**The Preservation of Niagara.**—On November 1st the U.S. Acting Secretary of War sent a letter to the Governor of New York, calling to his attention the resolutions adopted by the International Waterways Commission at Buffalo regarding the movement started by President Roosevelt to save Niagara Falls from obliteration. The letter reads as follows :—

> At a meeting of the International Waterways Commission, held at the office of the American section at Buffalo, on October 28, 1905, the following resolution was adopted : "Resolved that this commission recommends to the Governments of the United States and Canada that such steps be taken to prevent any corporate rights or franchises being granted or renewed by either federal, state or provincial authority for the use of the waters of the Niagara river for power or other purposes until this commission is able to collect the information necessary to enable it to report fully upon the conditions and uses of these waters to the respective Governments of the United States and Canada." In bringing this resolution to your attention I have the honour to suggest that it receive your most careful consideration with a view to carrying out as far as may be practicable the recommendation of said commission.

According to the *Railway and Engineering News* of Chicago, it is said that this action of the Waterways Commission has the hearty approval of the President. The communication was referred to the Attorney-General, who gave an opinion that the encroachments of power companies on Niagara river could not be prevented unless the navigation laws were violated. Mr. Moody suggested, however, that much might be accomplished by diplomatic negotiations between the United States and British Governments. It has been decided to take up the subject in this way through the International Waterways Commission, treating the river, falls and rapids as an international stream, and therefore subject to international jurisdiction, the rights of the State of New York and the Province of Ontario being wholly subordinate to those of the two national Governments.

**Gas versus Electricity.**—In commencing his Paper on the above subject before the London Electrical Contractors' Association last Tuesday, Mr. C. E. Alger, of Newport, referred to the extravagant claims made by the gas interests, and expressed the opinion that these misleading statements had not yet been categorically refuted by electricians. He had, therefore, written a pamphlet comparing the two rival illuminants in all respects, and this pamphlet was to be distributed in his town, and would be placed at the disposal of electrical contractors in other places if desired. The Paper was based on this pamphlet. Electric lighting, it stated, was wholly superior to gas lighting. It was safer, cleaner, more convenient and constant, and lent itself more readily to artistic arrangements and designs. A number of figures were quoted to show the large amounts of heat produced by gas burners and the surprising quantities of oxygen consumed. For outdoor illumination, the flame arc lamp was undoubtedly the cheapest artificial illuminant existent. A large number of gentlemen took part in the discussion, and many of them lent colour to their remarks (in a literal as well as a metaphorical sense) by handing round pamphlets distributed by the gas people, and containing ridiculous and contradictory statements as to the superiority of gas over electricity for purposes of illumination. With one exception the speakers were unanimously of opinion that electric lighting was superior to gas in all respects. One speaker, however, thought that gas had greater fog-penetrating powers and was, for this reason, more suitable for outside lighting, although he conceded that for interior lighting electricity carried the palm. Other speakers maintained, however, that flame arc lamps were better for penetrating the fog, besides being considerably cheaper and more convenient. One member after another rose to quote actual cases, in which the substitution of electric light for gas light had led to considerable economies. With electrical energy at 1d. a unit, heating and cooking became also cheaper by electricity than by gas. A warning note was sounded against the purchase of cheap and nasty lamps, and attention was drawn by various speakers to the fact that considerable economy could often be effected by using lamps of small candle-power in places where high-power lamps were not wanted. Although apparently obvious, this plan was not always carried out. In other cases, such as in large halls, it might often be advantageous to instal a few arc lamps in place of hundreds of small incandescent lamps. For people suffering from lung complaints electric light amounted almost to a necessity. In the unavoidable absence of the chairman, Mr. E. L. Berry, during the first half of the proceedings, the chair was occupied by Mr. W. R. Rawlings.

**Röntgen Society.**—At a meeting of the above Society on Thursday 7th inst., Mr. J. Butler Burke read a Paper on "The Spontaneous Action of Radium and other Bodies on Gelatine Media." Some of Mr. Burke's researches in this direction were the subject of a letter to *Nature*, of which an abstract was given in our issue of June 23rd (Vol. LV., p. 385), when the striking resemblance to bacteriological forms of life possessed by the bodies which he obtained was noticed, and the possible bearing of the results on spontaneous generation was freely discussed. The lecturer, however, commenced by admitting that his results do not at present bear directly on the problem of life, and that the object of his Paper was to give an account of his own observations on the action of radium salts on organic media, and not to theorise on spontaneous generation. After some introductory remarks on the work of such previous experimenters as Du Bois, Quinke, Leymann and others who had investigated the action of a variety of salts of such metals as barium on gelatine, and had obtained cell-like structures, Mr. Burke gave an account of his own experiments, recapitulating the results described in the letter mentioned above. The bodies he obtained required a higher-powered microscope objective for their detection than those of Du Bois and others produced by barium, and were markedly different in their behaviour and growth. They cannot be simply precipitates, nor indeed can they be bacteria owing to their solubility in hot water, but they appear to be a type of body which may be described as organic crystals. The difference between crystals and the most elementary forms of life is great, but the lecturer saw no reason why the two sides of the gulf between them were not the opposite ends of a line consisting of a continuous series of forms, and that in the past the original protoplasm may have gradually been evolved in this way. There was something, however, in the conditions that was different, possibly some much more unstable elements than radium then existed ; at any rate, the gap exists, the intermediate forms have not survived, and the new bodies which Mr. Burke's experiments have brought to light, although possibly indicating where the gap commences, have certainly not bridged it over. A brief discussion followed the reading of the Paper, in which Sir William Ramsay and others took part, and although there are are several workers experimenting on similar lines no one appears to have obtained results of quite the same nature, and there appears some doubt as to how far the phenomena are really due to the effects of radium at all.

**The Measurement of High-frequency Currents and Electric Waves.**—The third Cantor lecture on the above subject by Prof. J. A. Fleming, F.R.S., before the Society of Arts last Monday, was devoted to the measurement of frequency and resonance, the latter phenomenon being made clear to the audience by the mechanical analogy of two pendulums hung side by side from a piece of stretched cord. If the two pendulums were of the same length, the swinging of one caused the other to swing also, but if the pendulums had different periodicities, there was no such inter-action. By placing the pendulums nearer together, or further apart, the time taken for the movement of one to be communicated to the other could be reduced or increased, and this corresponded, in wireless telegraphy, to a strong and weak coupling. The lecturer's cymometer, an illustrated description of which is to be found in *The Electrician*, Vol. LV., p. 1041, was then explained, and an actual experiment was carried out, in the course of which it was found that there were two oscillations of quite different frequency in the circuit tested. This, the lecturer explained, was the case with every wireless telegraph transmitter. The current flowing in the cymometer circuit varies constantly as the handle of the instrument is shifted from one extreme position to the other, and this change in current can be readily traced by inserting a thermo-junction in the cymometer circuit and connecting it to a galvanometer. This test was carried out in view of the audience, and it was observed how the current first rose to a maximum, and, after dropping to a certain extent, rose to a second maximum, after which it finally fell off. The curve thus obtained was called the resonance curve. In addition to measuring frequency, the cymometer could be used for the speedy determination of capacity and inductance and the methods of such measurements were experimentally shown. It was very often thought that the wave length was four times the height of the transmitting air-wire, but it has been found by actual measurement that it approximated more nearly five times the length of the antenna. A very neat illustration of the fact that high-frequency currents occurred on the surface of conductors only, and did not penetrate into the metal, was obtained by measuring successively the oscillation constants of three similar squares of copper, iron and galvanised iron wire respectively. The readings were practically identical in the first and third cases, but in the second case no reading could be obtained because of the magnetising effect of the iron through which the high-frequency currents had necessarily to pass. Hence galvanised iron wire can well be used as a cheap substitute for copper, but iron wire should not be employed. As a last example of the many-sidedness of the cymometer, it was mentioned that the instrument could also be used for calculating the decrement of electric waves. The synopsis of the fourth, and last, lecture of this series, at the Society of Arts next Monday evening, is given below :—

Stationary waves on wires—Velocity of propagation—Mechanical model —Loops and nodes of potential and current—Special qualities of spirals—Methods of detecting loops and nodes—Radiation from aerial wires—Velocity of free waves—Relations of free-wave length to antenna length —Direct and inductively coupled aerials—Determination of the wave-length and damping of the waves radiated from antennæ—Methods of syntonising coupled circuits with the cymometer.

**Annual Prize Distribution at the Northampton Institute.**—The annual presentation of prizes at this institute was performed by Sir William Preece, K.C.B., F.R.S., last Friday, in the presence of a large number of parents of the students and other well-wishers of the institute.

After a few appropriate opening words by the chairman of the evening, Mr. L. B. Sebastian, Dr. R. MULLINEAUX WALMSLEY, principal of the institute, reviewed the general progress made during the session 1904-1905, pointing out that the limits of accommodation had been reached, and that, unfortunately, a number of would-be students had to be turned away. The only way, then, to increase the work done by the institute was to urge the remaining students to put in as many hours as possible, and he was glad to say that the average hours of attendance per student had greatly increased. During the session in question the aggregate hours of working had been between 140,000 and 150,000. In the course of his further remarks, he referred to the success of the optical convention held at the Northampton Institute this spring, to the establishment of a metallurgical department, and to the fact that they had found no difficulty in placing all their students with manufacturers for a six months' workshop practice without having to pay a premium. He also spoke of the splendid social work done by the 16 clubs and societies of the institute.

Before proceeding to distribute the prizes, Sir WILLIAM PREECE paid a warm tribute to the institute, and, *en passant*, also to the London County Council for its progressive policy in regard to educational matters. He deprecated the idea that Great Britain was behind other nations in respect to engineering skill and commercial activity.

After the prizes had been distributed, a tour of inspection was made through the laboratories and workshops in which, as in former years, much of the work done by the students was exhibited to advantage, demonstrations of all kinds being also carried out by the teaching staff and the students. Of special interest were the demonstrations given and explained by Dr. Drysdale and Mr. Jolley in the electrical engineering laboratory. Besides showing the more familiar methods of testing electric apparatus of all descriptions and explaining the instruments and connections employed for this purpose, these two gentlemen had a number of novel and ingenious devices on view. One was a handy instrument for determining the acceleration curve of electric machines. It can be used for a number of other purposes also. It consists of a tuning fork to the upper end of each limb of which is fixed a thin metal plate provided with a narrow slit parallel to the axis of the fork. The two metal plates overlap, and when the fork is set vibrating, the slits move in quick succession opposite to one another and back again. In the instrument shown, the slits come behind one another 6,000 times a minute. A disc, having 30 bold and equi-distant dots marked on its periphery, as well as a square and other suitable polygons about its centre, was fixed to the shaft of the machine under test. If this machine is running at 200 revs. per min., the time taken for a dot to move from one position to the next is 1/6,000th of a minute. Hence, the disc will appear stationary at this speed, or a multiple of it, when viewed through the oscillating slits. In determining the acceleration curve, all the observer has to do is to give a sign to an assistant every time the dots appear stationary. The assistant notes the various times, and the time-speed curve can be plotted—in this example a point being obtained at intervals of 200 revs. per min. The addition of the polygons on the card enables determinations to be made of the actual speed. Another apparatus, for a similar purpose, and also based on the strobsoscopic principle, consisted of a small cone, driven at synchronous speed by a small alternating-current motor fed from the same alternating supply which drives the motor to be tested. A small disc, provided with a number of equidistant openings, arranged symmetrically around the centre, rests on the upper surface of the cone, and is driven by friction. This rapidly-rotating disc is interposed between a suitable source of light and a disc on the machine shaft, and the slotted disc is moved along the cone until the disc fixed to the machine shaft appears stationary. The speed and slip of the machine tested are then given by the position of the small slotted disc along the cone.

## ARRANGEMENTS FOR THE WEEK.

(To-day) **FRIDAY, December 15th.**

PHYSICAL SOCIETY.

*7 p.m. to 10 p.m.* Exhibition of Electrical, Optical and other Physical Apparatus at the Royal College of Science, Exhibition-road, South Kensington.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

*7:30 p.m.* General Meeting at the Literary and Philosophical Society, Westgate-road, Newcastle-on-Tyne. Included in the business of the evening will be the discussion on Mr. Schofield's Paper, "Pneumatic Tools as applied to Ship Construction."

JUNIOR INSTITUTION OF ENGINEERS.

*8 p.m.* Meeting at the Westminster Palace Hotel, Victoria-street, Westminster. Paper to be read: "Electric Mains for Power Transmission," by Prof. J. T. Morris.

INSTITUTION OF CIVIL ENGINEERS: STUDENTS' SECTION.

*8 p.m.* Meeting at 25, Great George-street, Westminster, London. Paper: "Tests of Street Illumination in Westminster," by E. E. Mann.

INSTITUTION OF MECHANICAL ENGINEERS.

*8 p.m.* Ordinary General Meeting, when the adjourned discussion on the seventh Report of the Alloys Research Committee will be taken. The subject of this Report is: "On the Properties of a Series of Iron-Nickel-Manganese-Carbon Alloys," by Dr. H. C. H. Carpenter and R. A. Hadfield.

ELECTRO-HARMONIC SOCIETY.

*8 p.m.* Smoking Concert at the King's Hall, Holborn Restaurant. Mr. J. Gavey, C.B., will preside.

**SATURDAY, December 16th.**

JUNIOR INSTITUTION OF ENGINEERS.

*10 a.m.* Visit to the works of Messrs. Johnson & Phillips, Old Charlton, Kent.

GLASGOW TECHNICAL COLLEGE SCIENTIFIC SOCIETY.

*7:30 p.m.* Meeting at the Glasgow and West of Scotland Technical College, George-street, Glasgow. Paper: "The Economy of Power Production—Relative Merits of Gas and Steam Engines for Various Purposes," by W. D. Hamilton.

**MONDAY, December 18th.**

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture IV.: "The Measurement of High-Frequency Currents and Electric Waves," by Dr. J. A. Fleming, F.R.S.

**TUESDAY, December 19th.**

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting, when the following Paper will be submitted for discussion: "Heat Economy in Factories," by H. A. Mavor.

**WEDNESDAY, December 20th.**

INSTITUTION OF CIVIL ENGINEERS: STUDENTS' SECTION.

*2:30 p.m.* Visit to the works for the extension of the City & South London Railway Co. to Euston. Assemble at the site of the King's Cross station, close to the Great Northern Hotel.

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. Paper to be read: "The Aerograph Method of Distributing Colour," by C. L. Burdick.

**FRIDAY, December 22nd.**

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER STUDENTS' SECTION.

*7:30 p.m.* Meeting at the Royal Technical Institute, Salford. Paper to be read: "The Electrical Equipment of Automobiles," by J. C. Ward.

## LONDON COUNTY COUNCIL ELECTRIC POWER SCHEME.

A joint report of the Parliamentary and Highways committee of the London County Council on the electric power bill which the Council proposes to introduce in Parliament next session was placed before the Council on Tuesday.

Since the committee's last reports (*The Electrician*, November 3rd and 17th, pp. 109 and 188), Mr. A. L. C. Fell (chief officer of tramways) and Mr. John H. Rider (tramways electrical engineer) have worked out the details of a scheme to be submitted to Parliament, and the services of Sir William H. Preece, K.C.B., F.R.S., Mr. Robert Hammond and Mr. John F. C. Snell have been retained to assist both in working out the scheme in its initial stages and by giving evidence before the Committees of Parliament in due course. The complete scheme submitted is, in the opinion of the Parliamentary and Highways committees of the Council, both feasible and practicable; they think it would not only be of great assistance to authorised distributors, but would also be of great public benefit.

The scheme provides for the temporary surplus of energy from the Council's tramways electricity generating station at Greenwich being supplied as required at the earliest possible date to some of the existing distributing undertakings. The erection of the second section of the Greenwich generation station is already in progress, and, in view of the arrangements which have been made with regard to the early reconstruction of the Council's (Northern) tramways, the large number of new tramways which the Council is authorised to construct, and the suggested tramway extensions, the whole capacity of both portions of the generating station—namely, 34,000 kw. normal—will not within the next five or six years be required entirely for tramway purposes. The committee's suggestion is, therefore, that advantage should be taken of this fact to press forward the work on the second section of the Greenwich generating station, in order that, as far as possible, this station may for a time, as stated, meet certain of the demands for electrical energy which cannot be dealt with by existing undertakings. In the meantime, it is proposed that a station shall be erected on land by the riverside at Battersea to be specially acquired for the purpose. This station will, in the main, serve for the supply of energy to distributing undertakings, and ultimately for the purposes of the Council's own tramways. The site suggested for the proposed new station is situated on the south bank of the Thames near Grosvenor-road railway bridge, being part of the land belonging to the Metropolitan Water Board. The site proposed to be acquired has an area of about 15 acres, and is estimated to cost £120,000, which includes all legal and other charges. A portion of the site not required for the bulk supply undertaking would be utilised for tramways purposes.

On this site, which was formerly used by one of the London water companies, the committee propose that a station of 80,000 kw. normal capacity shall be erected. The scheme provides for this station to be built in three stages as the demand for energy increases, namely, that the first two quarters comprising together 40,000 kw. normal capacity, should be put in hand as soon as the necessary parliamentary powers shall have been obtained, and that the third and fourth sections, each of 20,000 kw. normal capacity, should be added either consecutively or together, according as the increase in the demand may justify. It has always been the Council's intention to provide two generating stations for the supply of electric power for its tramways, one at Greenwich in the eastern half of the county, and the other to serve the lines in the western half of the county, such further station to be erected on a site which the Council specially acquired for the purpose at Pimlico. Other arrangements, have, however, now been made for the utilisation of the Pimlico site. It will be possible in the majority of cases to utilise the existing and proposed tramways sub-stations as bulk supply centres, a course which will effect very considerable economy both in regard to capital expenditure and cost of maintenance. "By adopting this scheme," the report continues, "it appears to us that very important advantages will be secured which would not be possible in the case of any proposal contemplating the installation of an entirely fresh undertaking. . . . . We realise that in the near future the growing demands for electrical energy within the area of supply must necessitate considerable capital expenditure in the provision of additional plant and equipment to meet such demands, and we are satisfied that such expenditure can be incurred to the greatest advantage by the Council being empowered to supply electrical energy upon the large scale proposed rather than by extensions of existing undertakings in a manner which does not permit of production on the most economical scale."

A draft bill has been prepared by the Parliamentary Committee and a copy sent to each member of the Council. Attention is directed to the following provisions:—

1. *Area of Supply.*—The total area of supply dealt with comprises 387 square miles, including the county of London (117 square miles) and an area surrounding London comprising 270 square miles.

2. *Powers of Supply.*—Powers are sought to enable the Council to supply energy (*a*) to authorised distributors, (*b*) to large commercial undertakings such as railways, tramways, canals, docks and waterworks, for use either wholly within or partly within and partly without the area of supply, provided that the Council shall not furnish a supply for use wholly within the area in which any local authority or company is authorised to give a general supply of electrical energy without the consent in writing of such local authority or company.

3. *Erection of Generating Station.*—Authority is proposed to be sought to enable the Council to erect a generating station on lands at Battersea which are scheduled to the bill for the purpose.

The inclusion of the bill of authority to acquire property for the generating station at Battersea and the necessity of depositing the bill by to-morrow (Saturday) has made it necessary to suspend the operation of certain of the London County Council's standing orders.

4. *Co-working with Tramways Undertaking.*—Necessary clauses are included in the bill to enable the Council to work the bulk supply undertaking in conjunction with its tramways undertaking.

5. *Revision of Prices.*—Provision is included in the bill for the revision, in certain circumstances, of the prices charged by authorised distributors.

6. *Financial Clauses.*—Various financial clauses have been inserted in the bill providing, inter alia, for the establishment of a reserve fund, &c., which are necessary to place the undertaking on a sound financial basis. Provision is also made for the allocation of surplus revenue from the undertaking, in such a manner as to provide, in our opinion, the greatest possible security compatible with benefit to the consumers.

After referring to the resolution passed "by a large majority" at the recent conference between the London County Council and local authorities (*The Electrician*, November 24th, p. 228), the report continues: The conference expressed the desire to have a further opportunity of meeting and conferring in greater detail upon the Council's proposals, and it was arranged that the necessary facilities should be given for this purpose, the conference either being summoned for a second meeting or a full communication being addressed to each borough council dealing in greater detail with the Council's scheme. In the event of the Council approving the bill, we propose to forward it for consideration to each of the borough councils, and, if necessary, to arrange for a further conference. We have also been in communication with the local authorities outside the county of London who are affected by the Council's proposals, and have had an opportunity of conferring with representatives of certain of the electric supply companies concerned. We are continuing our negotiations with these authorities. In framing our scheme we have aimed at providing the most efficient and cheapest possible supply at the minimum cost, and, with a view to economy and to saving the Council capital expenditure, we have so drafted the bill as to enable it to take advantage of any co-operation which existing undertakers in the proposed area may be prepared to give to the Council. It is clear that if any such co-operation is forthcoming, as it would be given largely at any rate on capital already expended by such undertakers, it should lessen the Council's capital expenditure. While we have not in our scheme counted upon any such co-operation, the saving to the Council in capital cost which might be effected thereby should not be disregarded.

The report of the Finance committee on the above report was also considered.

It recognises that a great deal has been done by the Highways committee in the limited time to furnish financial data, but points out that the Finance committee has not been afforded sufficient time to examine the estimates thoroughly.

The Finance committee notifies that, in the bill as drafted, there will be no power for any authorised distributor or other person to demand a supply, and consequently no obligation on the Council to give it. The optional nature of the powers to be sought, if that option is maintained, may be held to lessen to a certain extent the financial risks which attend the undertaking. It is pointed out that nearly the whole area is covered by local authorities or companies possessing provisional orders, and over a large part of the area bulk powers, practically identical with those proposed to be sought by the Council, have been granted by Parliament to certain power and electric companies. The Council would not, therefore, possess any monopoly in the districts over which bulk powers are possessed by companies, but would have to meet the competition of those companies. In other districts the Council would have no power to secure business except by coming to terms with the existing undertakers. In order to secure business, therefore, the Council must rely entirely on the cheapness of the price at which it can produce electricity.

The total capital powers sought by the bill may be stated in round figures at £2,500,000. The expenditure of this amount is estimated to be spread over seven years to 1913. The amounts required in the first three years are estimated at—

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|---|---|
| 1907 ............................ | £355,000 |
| 1908 ............................ | 545,000 |
| 1909 ............................ | 449,000 |

or £1,349,000 in all. The reduction of the proposed immediate capital outlay to these figures diminishes the objection which the Finance committee feels to the increase in the Council's commitments on capital account, but the addition of £1,349,000 to the sums already required to be raised in the three years (1907-9) is a matter of important concern. The committee has had before it certain estimates of working costs and the probable growth of demand for electricity, but the figures are at present only of a provisional character, and the committee is advised that the publication of any estimates at the present stage might prejudice the Council's case before a committee of Parliament. From such consideration as the committee has been able to give to these figures it anticipates that "the Council would be able from one or more large central stations to generate electricity at a cheaper rate than it is now being produced at the small generating stations of most of the existing undertakers, and, moreover, that the Council, by working the scheme in conjunction with its tramway undertaking, would be in a favourable position for supplying energy in bulk and at a reasonable price." The committee cannot at present say, however, whether the Council could supply at such low prices as would enable it to successfully compete for business with the large power and electric companies who possess powers of supply in bulk throughout a large part of the proposed area. This is, after all, the crucial question, because, as already pointed out, it does not appear that the Council will possess any monopoly, but will be mainly dependent for business upon its ability to sell at a price which would induce existing undertakers to take a supply from it. The selling price from time to time will depend upon a variety of considerations which at present are undetermined. A good deal will turn upon the load factor which can be obtained and the amount of support to be received from authorised undertakers. The Finance committee, therefore, expresses the opinion that the Council ought, before embarking capital in such an enterprise, to have some further security than it will apparently possess. It is not prepared at the moment to say what the nature of the security should be, but it would appear to lie in the direction of the Council making suitable and permanent arrangements with the existing undertakers.

Whatever conclusion may hereafter be arrived at as to the probable ultimate financial results of such an undertaking as the Council may obtain power to establish, the committee is of opinion that the Council must face the probability that, during the early years, the undertaking will show a deficiency which will have to be made good out of the rates, because from its nature some years must elapse before a sufficiently large amount of business can be secured to make the concern profitable.

Upon the financial provisions of the bill, the Finance committee makes the following observations:—

We have considered the purely financial provisions of the bill, which, speaking generally, are, in our opinion, satisfactory. There are, however, four financial clauses on which the Council will desire to have our observations.

Clause 36 (2) of the bill provides that the Council shall not be bound to commence payments into the sinking fund until the expiration of five years from the end of the financial year current at the passing of the Act. We think that the assent of the Treasury may probably be obtained to this clause.

Clause 42 provides that the Council may pay (to an amount not exceeding £105,000) out of borrowed money interest paid on capital during construction. This would be a novel power so far as the Council is concerned. We approached the Treasury with a similar proposal in connection with the Holborn to Strand Improvement in 1899, but their Lordships would not assent to it. We have, however, since our former report was before the Council, ascertained that there have been in recent years cases in which provincial corporations have obtained this power in the case of large water and dock undertakings.

The bill provides (clause 39) for the creation of a reserve fund. No limit to the amount of the fund is fixed by the bill. Under clause 38, which provides for the order in which revenue shall be applied the provision of a reserve fund follows payment of working expenses and debt charges. Provision is then made for the repayment to the County Fund of any deficiencies made good in previous years out of the County Rate, but under the provisions of the bill the Council is not bound to so repay the County Fund in the first year in which a surplus is available, it being left open to the Council to use such surplus to form a reserve fund or to reduce prices. After deficiencies met out of the County Rate have been made good, the Council may, out of any surplus, take a sum not exceeding in any year 5 per cent. on the aggregate capital expenditure for the benefit of the London ratepayer, who, we may remind the Council will, if the bill passes in its present form, bear the whole financial risk of an undertaking dealing with an area over three times that of the county of London. Any surplus remaining after this 5 per cent. must be applied to reduction of charges, the Council being entitled to carry forward such balance on revenue account as is reasonably necessary.

The last clause to which we think attention should be called is clause 43, which provides that the Council shall, after five years from commencing to supply from any generating station erected under the powers now sought, and each three years thereafter, fix the prices to be charged (other than those contained in any agreement or contract), so that as far as practicable no charge shall fall upon the County Rate.

In conclusion, and looking to all the circumstances, we are impressed with the fact that financial risks are inseparable from an enterprise of this kind covering so large an area, and that if such risks mature, the burden will fall entirely on the ratepayers of London. Bearing this in mind, we are of opinion that if on the grounds of general policy the Council should finally decide to promote the bill, every endeavour should be made to make arrangements with existing undertakers for the supply to them by the Council of electrical energy in bulk.

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At the weekly meeting of the County Council on Tuesday, Dr. NAPIER (chairman of the Parliamentary Committee) moved the adoption of the recommendations, and claimed that the Bill fulfilled the three requirements which were essential in a matter of that kind—viz., (1) that there must be a cheap supply of electricity; (2) that such supply must be obtained without injury to existing undertakings, or with as little injury to them as was compatible with a really cheap supply; and (3) that such supply should be offered by a public body, but without any permanent charge on the rates. The Council was peculiarly happily circumstanced to carry out such a scheme, because they had already had to generate electricity for their tramways, and the stations and plant set up for one supply would do for the other. They did not intend to deal directly with private consumers, nor did they intend to compete with existing companies or borough councils. In the event of the bill passing it would largely depend on the action of the borough councils whether it was put into operation or not. The Council was actuated solely by a desire to save the borough councils from the destruction which would overtake them if the bill of the Administrative County of London Co. were carried.

Mr. H. P. HARRIS said the Council was putting the cart before the horse. Business people who were not county councillors usually considered the financial results of any scheme before they embarked upon it, but here they were asked to proceed with an enormous scheme without any estimates being put before them. It would appear from the report of the Finance committee that not only would the Council not have a monopoly, but that apparently they would get very little business. He was inclined to believe that Parliament would not allow the bill to remain in its present permissive form.

Mr. SHEPHEARD said it was impossible for the Committee to give figures at the present time, because they did not know the work they were going to do.

Sir R. M. BEACHCROFT said he did not believe that even a Liberal Government would allow a matter like this to be suspended in mid-air until the County Council saw its way clear to proceed with the scheme. He was convinced that the project, if carried out, would result in a loss to the ratepayers.

Mr. RADFORD considered the last speaker showed a desire to establish a Metropolitan Electricity Board.

Mr. R. A. ROBINSON said that at the conference of local authorities held to consider the scheme the six boroughs who voted against it had a rateable value of £12,800,000, while the eight who did not vote, had a rateable value of £11,000,000.

Lord WELBY said he regretted he could not support the bill, but he had no alternative, holding the view he did that the Council at the present time was in danger of overstraining its credit. They had extraordinarily heavy commitments, and it must not be forgotten that the money market was their master. If they adopted the proposals of the committee they would be taking a leap in the dark, and he should therefore vote against them.

Mr. W. W. BRUCE (vice-chairman of the Finance committee) said in view of the fact that the Council would spend £20,000,000 on capital account during the next two or three years, they should take heed of what Lord Welby had said. He did not feel certain that the scheme of the committee was the best one for providing the cheapest electricity in bulk form.

Mr. ALLEN BAKER, M.P., said there was an absolute need for a cheap supply of electricity for manufacturing purposes. As none of the borough councils were in a position to meet that need, it was the duty of the County Council to do so.

Mr. McKINNON WOOD said that unless the Council went on with its bill; London would be given over to the monopoly of a private company.

Mr. ANSTRUTHER said as a member of the Parliament that created the London County Council, he was strongly of opinion that that body was not intended to become involved in such an undertaking as this.

On a division the recommendations were agreed to by 66 votes to 38.

# THE CHARING CROSS COMPANY'S CITY OF LONDON WORKS.*

BY W. H. PATCHELL.

The granting of a Provisional Order, which was confirmed by Parliament in 1899, to the author's company led to the construction of the works now to be described. The prospect of a large demand in the City, and also the rapidly increasing West End supply of the company, called for the provision of a plant on a somewhat unusual scale.

## SITE OF GENERATING STATION.

Careful search had been made for a site near the City and the existing areas of supply, but the most favourable that could be procured was at Bow, about four miles from the Bank of England and close to the main line of the Great Eastern Railway. Here a plot of about eight acres was found with railway and water accommodation, although the latter was not sufficient for condensing purposes.

## SYSTEM.

The demand in the City was for direct current, and the supply in the West End, which was to be augmented, was also direct current, so that the supply to the consumer was naturally settled as direct current. When the plant was projected there was no large three-phase plant working in this country, and the relative merits of multi-phase and single-phase for generation and transmission had to be closely considered. The choice fell on three-phase. In considering the question of pressure, the author decided to take the highest pressure that could be directly generated by the machines and used by the motors, as he was anxious to eliminate the complication of static transformers and to save the extra space and switchgear necessitated by them. 10,000 volts was the pressure chosen. The author has most pleasant recollections of discussions with contractors and specialists who tried to point out to him the great risk of working at 10,000 volts without transformers, and has been interested in watching subsequent developments. The Metropolitan Co. have put in all their more recent plant for generating the voltage direct, and several large traction plants since laid out in this country are now either under construction or working at 10,000 to 11,000 volts, in each case without transformers. The periodicity chosen was 50 complete cycles per second.

## GENERATING STATION.

The sizes of unit chosen for the generating plant were 800 kw. and 1,600 kw. The first portion of the plant ordered included two sets of each size. The building was laid out for a boiler room 75 ft. wide, with two rows of boilers facing each other, and an engine room parallel to the boiler room also 75 ft. wide, with 36 ft. 6 in. clear under the traveller hook.

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* Paper read before the Institution of Electrical Engineers, Dec. 7. Slightly abridged.

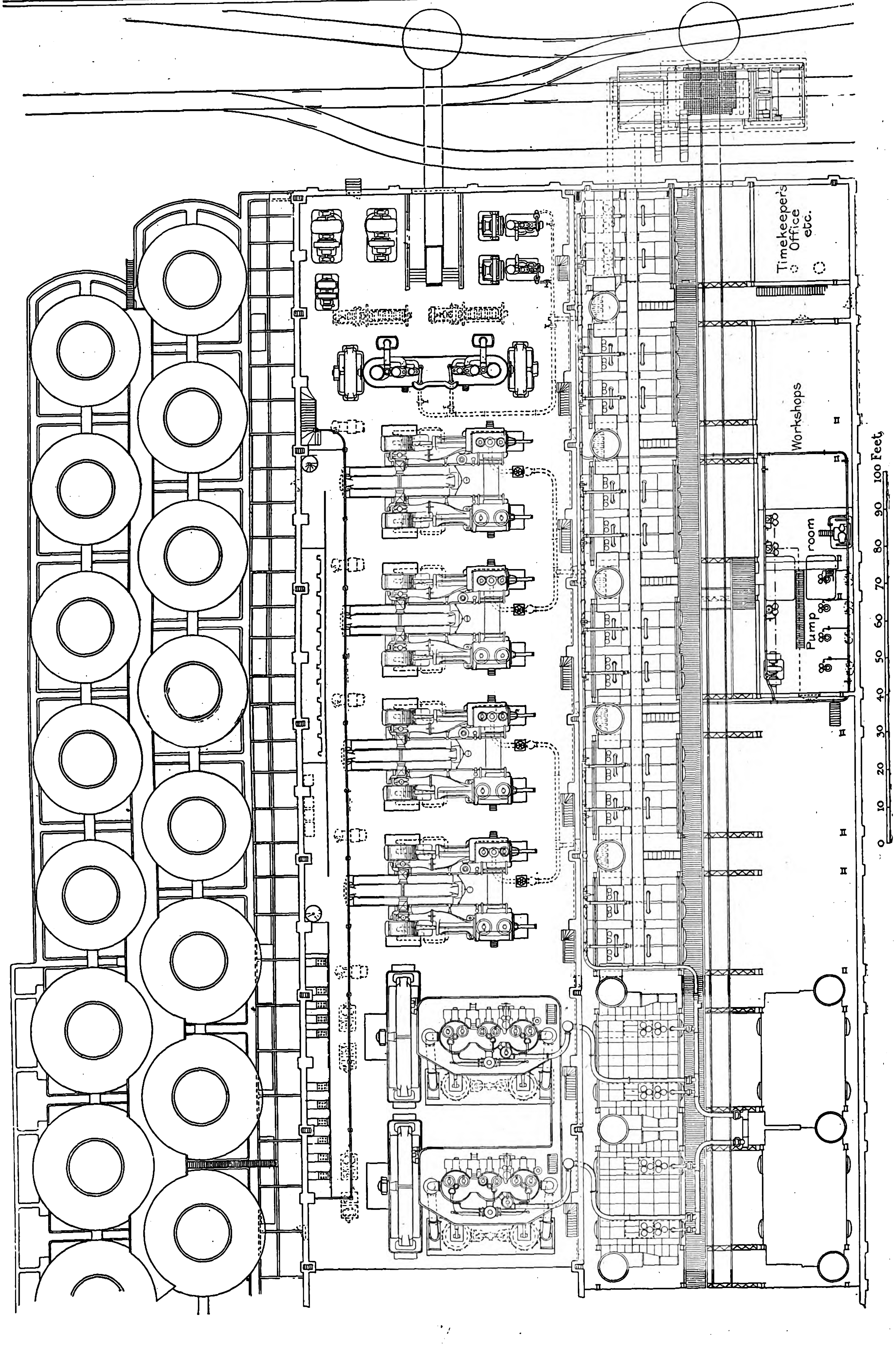
Timekeeper's Office etc.
Workshops
Pump room
0 10 20 30 40 50 60 70 80 90 100 Feet

Fig. 1.—Bow Generating Station. Plan.

The question of steam generated per square foot of ground space in the boiler room imposes much more onerous conditions upon the designer than obtain when laying out the engine room alongside; in fact, if the engine room is laid out first, it is frequently found that great difficulty is experienced in getting the necessary steam from the boiler room parallel with it. This has led to double-decked boiler houses, and also to the development of the Chicago design, in which there are several boiler rooms at right angles to the engine room, which has been developed at Carville, Newcastle, and brought before the Institution by Messrs. Merz and McLellan.*

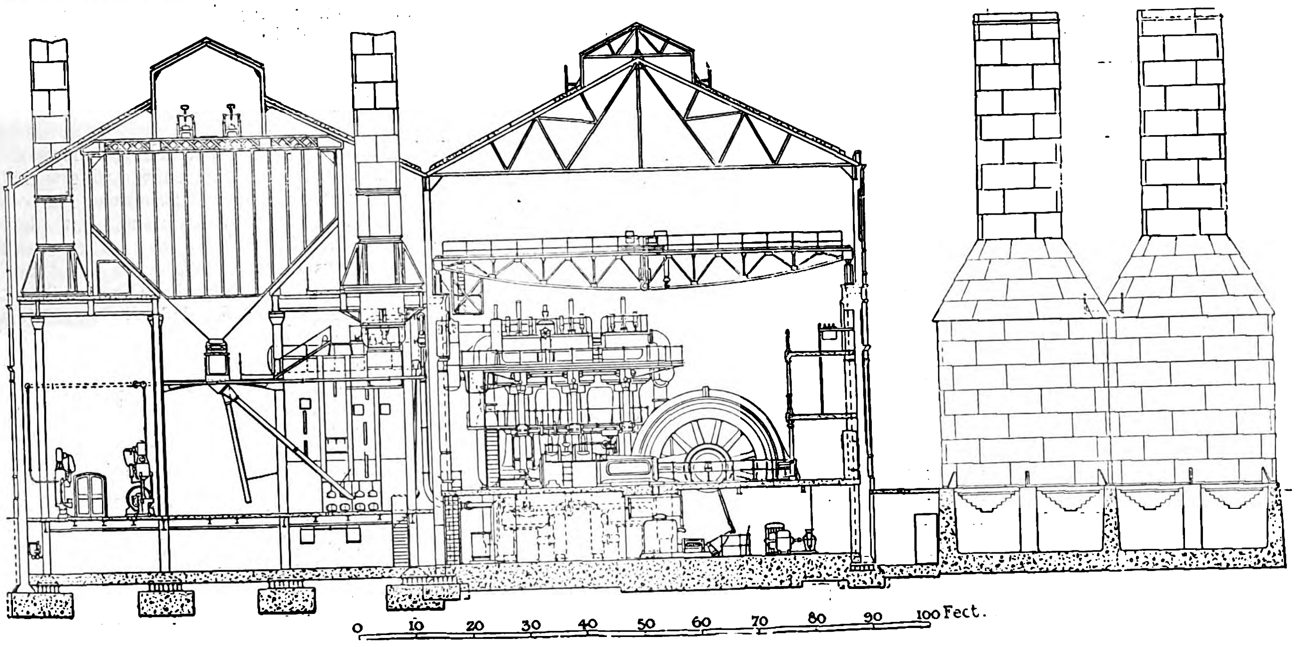

Fig. 2.—Bow Generating Station. Cross section.

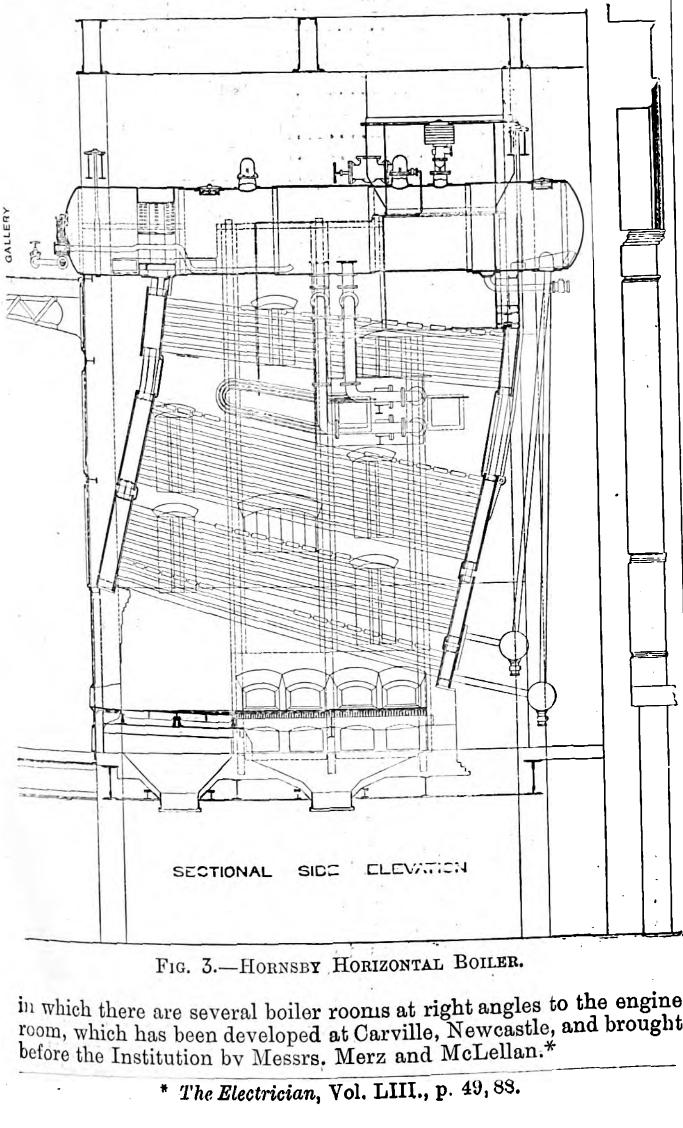

Fig. 3.—Hornsby Horizontal Boiler.

As regards the type of plant to be adopted, it was felt that the load would grow so rapidly that no risk could be run with experiments, and the author therefore felt compelled to adopt such types as could be seen in satisfactory work. The tenders for engines were submitted on the slow-speed and on the high-speed basis. The only large high-speed engine working at that time was a single representative of the Willans type in the Paris Exhibition. A consideration of the tenders led to the selection of Messrs. Belliss & Morcom's high-speed vertical engines for the 800 kw. machines, and Messrs. Sulzer Bros.' horizontal slow-speed engines for the 1,600 kw. machines. These engines would lay out well on 35 ft. centres; boiler room considerations, however, led to the adoption of 37 ft. 6 in. centres.

Figs. 1 and 2 are plan and sectional elevation of the station respectively. The existing building is 300 ft. long, and the site is sufficient for the extension of it to 500 ft. and the provision of a similar building alongside.

*Boiler House.*—The boilers adopted were of two sizes, both made by Messrs. Richard Hornsby & Sons (Ltd.), Grantham. The smaller size had already been in successful operation at the Charing Cross Company's Lambeth works for some years; the larger size was specially built for this work.

Fig. 3 is a sectional elevation of one of the larger horizontal boilers. There is one pair only of the smaller boilers, which were put in at the end of the room for light loads, these are fired in the usual way from the front only.

A novelty was introduced in the case of the larger boilers, where a grate was arranged in the ordinary way at the front and another (seen in Fig. 3) at right angles to it, which could be fired from the side. These second grates have proved to be of enormous benefit when sudden fog or a thunderstorm has called for an extra supply of steam at very short notice. The ashpits for the two grates are quite separate, and are provided with the usual doors. At times of light load the boilers are fired from the front only and the doors in connection with the side grates are all closed. A little dust falls on the bars at the back which are not otherwise protected, but do not suffer from the high temperature to which they are exposed. As soon as the demand arises coal is thrown on to the side grates, the ashpit doors opened, and the extra fires are got away with surprising rapidity. The large heating surface in proportion to the grate worked at light loads is an advantage, and the large size of boiler adopted gives much less radiating surface per square foot of heating surface than in the small sizes usually adopted. Notice is also called to the special down comers with mud drum and header for the bottom rows of tubes immediately over the fire.

As mentioned above, the boiler house was laid out for two rows of boilers in view of the larger engine units to be put in later. One row suffices to supply steam to the horizontal engines, which leaves the space opposite them available for lavatories, office, workshop and pump room. Each boiler is provided with its own superheater of the McPhail & Simpson's type, which was described by the author in his Paper on "Steam Superheating," before the Institution of Mechanical Engineers, 1896. In the small boilers they are fixed immediately under the drum, in accordance with the practice originated by Messrs. McPhail in 1893, but in the larger boilers it was recognised that in this position the gases would be so low in temperature that the amount of heating surface to get the desired effect would have to be abnormally large. They were, therefore, put in about two-thirds of the way up the boiler, as will be seen on reference to Fig. 3.

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* *The Electrician*, Vol. LIII., p. 49, 88.

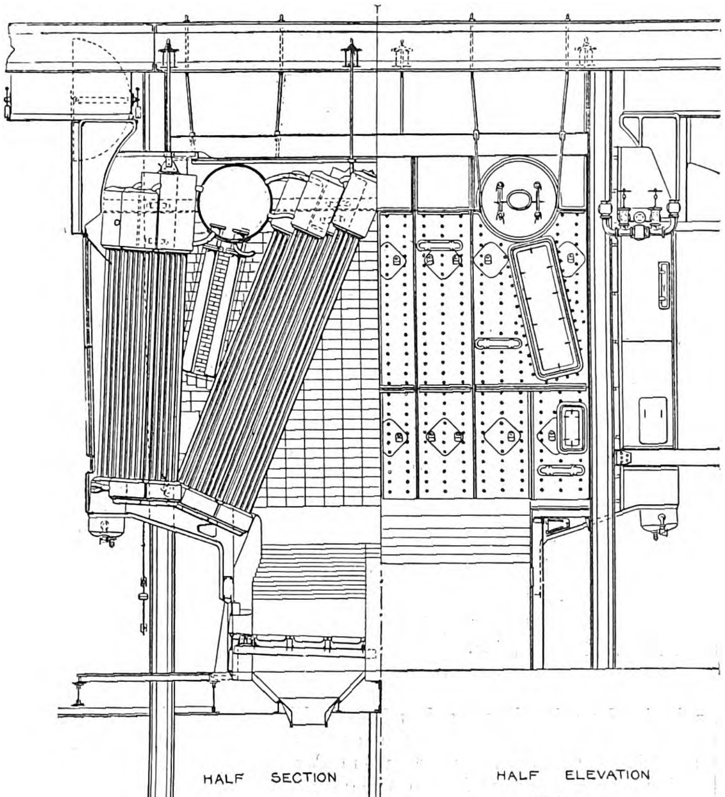


Fig. 4.
Hornsby "Upright" Boiler.

The author has always been an advocate of large boiler units, both on the grounds of economy and convenience, and considers the horizontal type boiler, Fig. 3, about the limit in size for that type. The development of Messrs. Hornsby's "Upright" type, however, presented further possibilities, which he gladly availed himself of.

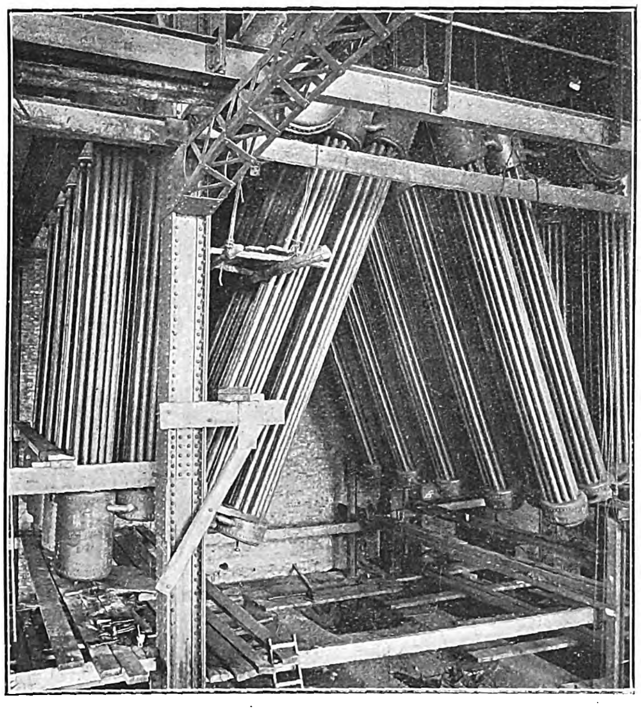


Fig. 5.—View of Boilers during Erection.

Last year a pair of these boilers were added, as shown in Figs. 4 and 5; they are erected as one steam unit, and the author believes that they form the largest steam-producing unit in existence. The type of setting to be adopted was very carefully considered. Owing to the difficulties likely to be experienced, due to the expansion of such large walls in brickwork, it was felt that even if they could be kept upright they would not be air-tight; a modification of the wrought-iron casing used for marine boilers was therefore developed, free from the restrictions as to weight which are imposed on marine engineers. The first design adopted was a composite one of brickwork in the hottest area, extending about 8 ft. up from the ground line. This has been changed in a later design to wrought-iron casing throughout. In the fire zone the fire-bricks are 12 in. thick, while higher up tiles of 6 in. in thickness are used, the brickwork being separated everywhere from the wrought-iron casing by 1 in. of magnesia.

The brickwork between the grates, which is honeycombed and carried up about 6 ft., becomes incandescent during working, and its effect, combined with the ample combustion chamber, ensures a much more perfect combustion than is obtained in the horizontal type of boiler. Coal which might give heavy smoke when burned under the horizontal boilers can, with no more care taken in the hand-firing, be burned without smoke in the "Upright" boilers. In the case of these boilers the ashpit is divided, so that only a part or the whole of the fire grate can be used as desired, with a similar benefit to that described above.

The upright tubes are a great improvement on the horizontal, both as regards external and internal cleanliness. The back sections act as water heaters or economisers with a definite circulation, any scale or sediment is deposited in them, and the front sections kept quite clean. The pair of "Upright" boilers last erected have been steamed at the rate of 100,000 lb. per hour, and so will easily provide steam under ordinary working conditions for a 4,000 kw. generating set. Superheaters were also included with these boilers, as the author has long believed that a water-tube boiler without a superheater is incomplete.

Table I. gives the leading particulars of the three different sizes of boiler.

**Table I.**—*Particulars of Hornsby's Horizontal and "Upright" Boilers.*

| Description. | Horizontal. | Horizontal. | "Upright." |
|---|---|---|---|
| Working pressure, lbs. per square in.. | 160 | 160 | 160 |
| Over-all length of boiler............ | 26 ft. | 28 ft. | 27 ft. |
| Over-all width of boiler ............ | 12 ft. 3 in. | 12 ft. 9¾ in. | 18 ft. 9 in. |
| Ground space occupied in square ft... | 318·5 | 359 | 506 |
| Height to centre of drum .......... | 17 ft. 3 in. | 27 ft. 5 in. | 28 ft. |
| Water surface in drums in square ft.. | 202 | 244 | 268 |
| Steam capacity above working level in cubic ft.......................... | 320 | 460 | 418 |
| Water weight to working level in lbs.. | 46,930 | 74,597 | 78,440 |
| Heating surface in square ft......... | 4,590 | 8,100 | 10,850 |
| Grate area in square ft............. | 62·5 | 125 | 168 |
| Ratio H.S. to G.A. ................ | 73·44 to 1 | 65 to 1 | 64·5 to 1 |
| H.S. per sq. ft. of ground space required per pair of boilers and stoking .... | 11·7 | 12·6 | 21·45 |
| Normal evaporation per hour, lbs. .. | 12,000 | 24,000 | 33,000 |
| Evaporation pr. sq. ft. H.S. pr. hr., lbs. | 2·61 | 2·96 | 3·04 |
| Superheater surface per boiler, sq. ft.. | 874 | 874 | 1,036 |

The question of economisers was considered, but it was decided that, except at times of top load, the large heating surface available in the boilers would render the necessity for an economiser very doubtful; provision, however, was made for adding them at a later date should they prove to be desirable.

(*To be continued.*)

## ELECTRIC TRAMWAYS IN SINGAPORE.

The buildings in Singapore, like those of other places in the Far East, range from substantial brick and stone structures to rudely-made huts of the native Malays. The illustration shows a typical scene in the streets of the town, which are for the most part broad, straight and level, thus being admirably adapted for electric tramways. The total population is approximately 250,000, which, besides Europeans, includes Eurasians, Chinese, Malays, Indians, Japanese and many others.

The city of Singapore was founded in 1819 by Sir Stamford Raffles, and to-day is undoutedly the most important trading centre in the south-east of Asia. The construction of the tramways was authorised by an ordinance passed by the Legislative Council of the Straits Settlements in 1902. The promoters of the scheme were the Association General (Ltd.), London, and the East India Construction Synd. (Ltd.), London, was formed for the purpose of carrying out the construction of the tramways.

The consulting engineers to the company are Messrs. Alfred Dickinson & Co., of Birmingham and London, who prepared all the detailed plans and specifications and superintended the carrying out of the work. The contractors for the whole of the work, which included the construction of a bridge over the Kalang River, were Messrs. Dick, Kerr & Co. (Ltd.), of London and Preston, to whom we are indebted for the particulars embodied in the present article.

The work was commenced in July, 1903, and the first section of the line was opened for traffic in July, 1905.

The total length of the tramways is 16 miles of route, the length of the single track being about 26 miles 4 furlongs. The track is laid to a gauge of 1 metre, with rails of the girder type weighing 95 lb. per yard. The rail joints are welded by the "Thermit" process, so that the track forms one continuous length, and, in addition, a 6/0 S.W.G. copper bond is supplied at every joint, ensuring perfect electrical conductivity.

The lines in the centre of the city and those running to the docks are for the most part double-track centre-pole construction, while the two routes leading north and north-east along the Serangoon and Gelang-roads respectively are single lines with passing places, and are equipped with side-pole construction.

Commencing near the entrance to the Keppel Docks, the route of the tramway follows Telok Blanga road to the junction of Anson-road and Tanjong Pagar-road, where it divides, one route following Anson-road, and terminating on Collyer Quay, opposite Johnston's Pier, the other following along Tanjong Pagar road to within a short distance of the bridge over the Gelang River. The route leading north commences near the Raffles Hotel, and extends as far as the Municipal boundary.

A Street Scene in Singapore.

A loopline is laid along Lavender-street, thus joining the routes along the Gelang and Serangoon-roads. There is also a short route which commences at the junction of North Bridge-road and South Bridge-road, terminating near the station of the Singapore–Kranji Railway.

The permanent way throughout is of substantial construction, the rails are laid on a longitudinal concrete sleeper 8 in. deep by 18 in. in width; the flange of the rails is embedded in the concrete to a depth of 2 in. and consequently there is a solid bed of concrete 6 in. deep under the flange of the rails. The gauge of the track is maintained by tie-bars spaced 8 ft. apart throughout. After the rails and concrete foundation were laid, the road surface, up to the rail level, has been made up with rolled and consolidated macadam.

The overhead work consists principally of the side and centre-pole system, and also some 2 miles of span-wire construction. The poles are of mild steel, 28 ft. 3 in. in length, 7 in. in diameter at the base tapering to 4 in. in diameter at the top. They are set 6 ft. in the ground, and are embedded in a solid block of concrete, each pole being provided with an ornamental cast-iron base. On the centre poles the lengths of arms are 2 ft. while those on the side poles vary in length according to the distance from the pole to the track.

The trolley wires, which are not necessarily over the centre of the track, the possible variation being about 10 ft., are divided into ½ mile sections by means of section insulators. At each of these points the main feeder cables are tapped and current is conveyed to the trolley wires by means of 37/16 rubber-covered cables, which are carried up the inside of the poles and along the side of the bracket arms. The pressure on the trolley wires is 500 volts. A lightning arrester is provided in each section pillar, as is also a telephone giving direct communication with the power house. To guard against the tropical storms which are so prevalent in Singapore, the overhead system is protected by heavy lightning arresters at every ½ mile of wire, which are fixed on the poles in cast-iron boxes.

The whole of the feeder cables were supplied by Messrs. Callender's Cable & Construction Co., and laid by them on their solid bitumen system. The system of feeders has been arranged with due regard to future requirements, as it is generally anticipated that within the near future the traffic will rapidly increase, both as regards passengers and the conveyance of goods.

The generating station and car shed occupy a position near the Rochore Canal, from which water is obtained for condensing purposes. The buildings comprise the engine room and basement, boiler house, car shed, machine shop, carpenters' shop, paint shop, smithy, offices of the general manager and his staff, and the usual outbuildings.

The engine room is 190 ft. long by 48 ft. 9 in. in width, and contains two main traction 500 kw. sets, one steam lighting set, one motor-generator lighting set, and the necessary switch gear.

The boiler house contains eight Lancashire boilers, each capable of evaporating 6,000 lb. of water per hour, with a working pressure of 175 lb. per square inch. Feed water is supplied to the boilers by four feed pumps of the duplex compound non-condensing type, taking water either from the hot well or storage tank. There are two "Green's" economisers, each containing 228 tubes.

The two main traction engines were built by Messrs. Yates & Thom, Blackburn, and are of the horizontal cross-compound condensing type, running at 100 revs. per min. and are each capable of a maximum output of 927 B.H.P., with a steam pressure of 165 lb. per square inch at the cylinders. Each engine is provided with a Worthington surface condenser, but may be worked either condensing or non-condensing. In order to leave the engine room as free and open as possible, it has been arranged so that the condensers are fixed to the basement constructed below, together with the steam pipes and other accessories.

The generators are of Dick, Kerr & Co.'s continuous-current multipolar type, compound wound; each machine is designed to give an output of 500 kw. at 550 volts when running at a speed of 100 revs. per min. Each generator is direct-connected to its engine. The lighting sets consist of one 150 kw. generator, running at a speed of 350 to 400 revs. per min., coupled to a Willans triple-expansion condensing engine, and a 50 kw. motor-generator set, designed to give a normal output of 100 amperes at 500 volts, and a maximum of 115 amperes at 550 volts. Two balancers are also installed. The switchboard is composed of a main station panel, two generator panels, five feeder panels, one B.O.T. panel, and six other panels for lighting, &c.

The car shed is 212 ft. in length by 138 ft. in width, and is built to accommodate 84 cars; inspection pits run the entire length of each track, with the exception of the curves at the entrance to the shed.

The rolling stock consists of 50 passenger cars, three bogie motor goods vans, 15 four-wheel goods vans, and 15 four-wheel goods waggons. The passenger cars are divided into two distinct types, 30 being of the single-deck single-truck open type, to seat 32 passengers, and 20 of the single-deck single-truck combination type, to seat 40 passengers. The car-bodies are mounted on Brill trucks, and each car is equipped with two four-pole series-wound motors with single reduction gearing type, suspended on bearings 4 in. in diameter. Each of these is capable of giving 25 B.H.P. for one hour at 570 revs. per min. with a temperature rise not more than 110°F. above the surrounding atmosphere. The controllers are of the metallic shield blow-out pattern, series parallel type, and are designed as to give an easy acceleration to the car and an equal division of power between the two motors in all the various combinations. The cars are fitted with Hudson & Bowring lifeguards.

The three bogie motor goods vans are each mounted on Brill trucks, the equipments being of the quadruple type. They are intended for use of a double purpose, that of conveying goods and hauling goods trucks, the general arrangement of the body being such as to provide a self-contained van with divided sliding doors on each side, which may be securely locked up, and a vestibule canopy at each end as the platform for the drivers. The 15 goods waggons are equipped in a similar manner to the passenger cars, and are 12 ft. in length and 6 ft. 6 in. in width. These waggons are for general use for the conveyance of various classes of goods up to 6 tons in weight. The frames are made of mild steel channels, stayed by longitudinal and cross stays, knees and gusset plates, and the side of each waggon is provided with strong hinges. In order to protect the goods from the weather each waggon is supplied with a detachable light angle-iron frame, upon which a tarpaulin is spread the full length of the car at a height of 7 ft. from the flooring of the waggon. They are in construction similar to that of the goods waggon as described above. Each van is fitted with double sliding doors, and is the same size as the goods waggon.

## MECHANICAL COAL-HANDLING PLANT AND BOILER-HOUSE ECONOMY.

The effect of economies in the boiler house has a large influence in the cost of manufacture of many saleable products, owing to the large proportion which the fuel bill represents of the total expenses. In a large number of cases, although a high degree of economy has been attained in the engine room, there is still plenty of room for improvement in the boiler house. Many causes of avoidable loss of efficiency exist, and we only too frequently see badly designed or constructed flues and chimneys in which an excessive coal consumption is required to maintain a proper draught. Much more attention is now paid than formerly to the choice of a quality of coal suitable to the form of furnace employed, by which means alone complete efficient and smokeless combustion is secured, but we should be glad to hear of regular periodic sampling and calorimetry of the fuel more frequently forming a part of cental-station routine. These points were very fully dealt with in a Paper read by Mr. Alfred W. Bennis on "Boiler-House Economy" before the Huddersfield Engineering Society. It is frequently found that cheap fuels, perhaps rather small, from one colliery contain nearly or quite as much heat as other fuels larger in size and much more expensive from another or even from the same colliery. The author pointed out that one of the advantages of mechanical stoking comes in here, as it makes little or no difference to a high-class mechanical stoker what the size of fuel may be; it will burn one as efficiently as the other. Actual results in several cases showed a saving of from 23 to 37 per cent. due to this cause, and in one case a saving of as much as 57 per cent. on the fuel account has been recorded since the introduction of mechanical firing. There are many other factors to which more attention than is usual may profitably be paid, such as the influence of boiler-plate thickness on heat transmission. The author also called attention to the importance of the analysis of waste gases.

It is, however, the purpose of this article to deal more particularly with another factor exerting much influence in economical working —namely, that of coal-conveying plant, an interesting example of which is found in the barge-unloading, conveying, storing, elevating, distributing, and stoking installation which Messrs. Ed. Bennis & Co. (Ltd.), of Little Hulton, Bolton, have erected for the Coventry Corporation. Several difficulties confronted the manufacturers of the plant, all of which were satisfactorily overcome. One of these was to keep down foundation and building work and to make as few structural alterations as possible. The second difficulty lay in the fact that the coal stores were originally put down for the boilers when those boilers were hand-fired. A system, therefore, had to be thought out which would adequately meet these objections and at the same time ensure simplicity in construction. There are six Lancashire boilers at this station grouped into three two-boiler batteries. The fuel for feeding these boilers is brought to the works up a canal adjacent to the boiler-house. Thence in the old days of manual labour it was raised by hand and wheeled into a store in front of the boilers. The principal features of the plant are shown in Fig. 1.

The fuel is raised out of the barge at the rate of 20 tons per hour by means of a "Bennis" improved bucket type elevator, which is carried on four parallel arms, the top arms being extended, and the load, due to the elevator, counter-balanced by means of two cast-iron balance weights which enable the elevator to be raised or lowered to the barge, or when standing, drawn in, clear of the canal, the motion of closing in and raising and lowering being similar to that of a parallel rule, so that little power is necessary for this operation. To make the elevator self-locking, that is to ensure that it may remain in position, one of the bottom arms is coupled to a worm wheel quadrant with which engages a worm, keyed on a shaft secured in bearings. By means of this shaft the apparatus is easily raised or lowered.

The elevator itself consists of two dust-proof trunks, each trunk being made up out of two 10 in. by 3 in. channels, and two 17 in. by ¼ in. plates, bolted to the flanges of the channels, making a complete box section. The outer trunk is used for the up-going full buckets, and the inner trunk for the down empties. The outer leg is provided with ladder rungs, so that the attendant has free access to all the driving gear. The elevator chain is of the double link type, the pins being held stationary in the two outer links, while the oscillation or wear is taken upon the centre link, which is 2 in. broad, and which gives ample bearing area for the pin. To these links are attached mild pressed steel buckets 12 in. in width. No boot is necessary with this type of elevator, as the buckets in revolving come into contact with the fuel in the barge, the position of elevator being adjusted as the coal is removed. On the return drum at the bottom end of the conveyor provision is made for two tension-screws for taking up the slack of the chain. The driving is effected by means of hexagonal drum and drags, through an "Ewart" type chain-drive and spur wheels. All these shafts run in solid grease lubricated bearings which are part of the castings forming the hood between the two trunks. The top of the elevator is fitted with a steel shoot arranged so that it can discharge the contents into a suitable receptacle (on the lower portion of the inclined conveyor) irrespective of its position in the barge.

The parallel levers, carrying the elevator, are supported on a pillar fixed on the wharf side, this pillar being made up of four 6 in. by 3 in. channels, strongly braced together. From the hopper the coal is conveyed and elevated by means of the conveyor and is discharged into the distributing conveyors through the "Bennis" patent automatic weighing and registering machine. The elevating conveyor is carried on two inclined lattice girders. Crossed angles and tees are provided at intervals for carrying the conveyor trough (which rests between the two girders) and these are run out for forming a gangway provided with hand railings, and a step ladder is fixed at the end so as to give ready access to the weighing machine, conveyor gearing and motor.

The drive is by means of a hexagonal drum and drags, through a spur wheel reduction gear. The gearing is carried up by means of 8 in. by 3½ in. channels built into the walls of the bunker which is run up to form a small house for the gearing and weighing machine. Power is provided for the elevator by a 4 H.P. electric motor, which drives it through a countershaft by means of a raw hide belt. A rope pulley is fixed on the countershaft for driving the barge elevator by means of a cotton rope. It may be here stated that the amount of power taken to drive this portion of the plant is about 3 B.H.P. when working at the full rate of 20 tons per hour.

The "Bennis" patent weigher consists of a semi-circular box about 2 ft. in width, carried on two steel trunnions fixed in sensitive bearings (equal to knife edges). This box is divided into two compartments, the division plate being adjustable and sufficiently heavy to counterbalance the load. In operation one of the compartments is under the discharge of the coal conveyor, the division or counterweight being on one side of the centre, and the compartment on the other; thus, when the compartment gets its discharge of coal it more than balances the counterweight, and rocks over. The impact is taken by a dashpot. When the compartment has rocked over it discharges the contents into the conveyor, through a bottom opening, while the other compartment has automatically had the opening closed and in its turn is receiving its discharge, when it rocks back again in a similar manner. Each oscillation is indicated on an ordinary "Harding" counter.

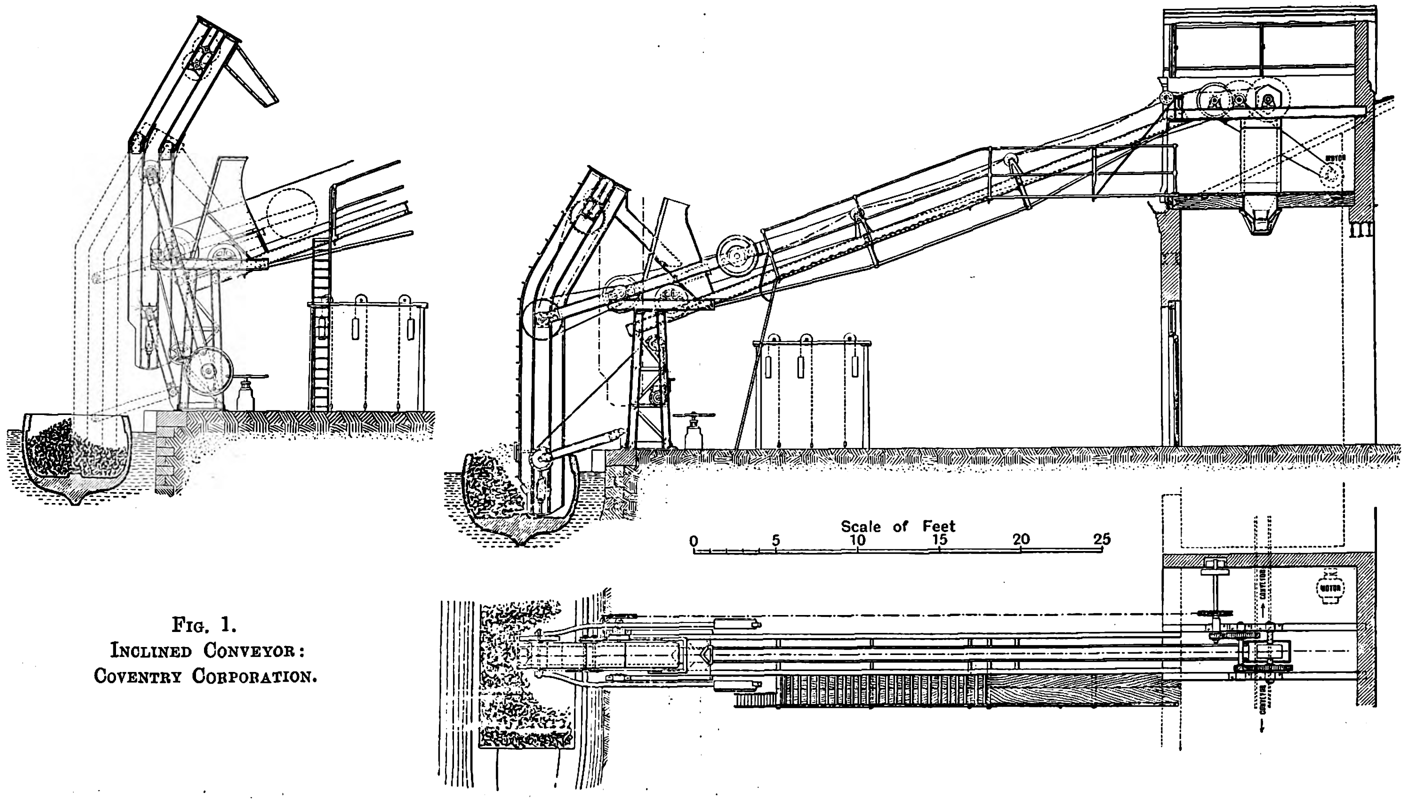
From the discharge of the weighing machine the coal is conveyed in both directions by means of the "Bennis" conveyor, where it is discharged through openings into any portion of the coal stores. These openings are provided with slides and gear, so that they can be opened or closed at will from the inside of the boiler house.

The conveyor is driven in a similar manner to the inclined conveyor by a 4 H.P. motor. Both conveyors are similar in construction, being the well-known U-link type. The conveyor trough is channel-shaped in section, 9 in. in width, 6 in. in depth, ⅝ in. in thickness. The chain consists of a series of U-shaped links made out of 2 in. by ½ in. open hearth acid mild steel flats. The links are 12 in. in pitch and secured at the joints by means of specially constructed ⅞ in. diameter rivets and washers. The return chain of the conveyors is carried on cast-iron rollers with chilled peripheries, running in solid grease lubricated bearings which form part of cast-iron brackets eventually bolted to the conveyor trough.

For re-trimming the coal from the coal stores into the mechanical stoker hoppers a small elevator opposite each boiler is used, the elevator boot being fixed in a brickwork culvert built in the bottom of the coal bunker. These elevators work in conjunction with mechanical stokers. Each is fitted with a rotary feed, which also acts as an agitator. To adjust the amount of coal delivered to the buckets to suit the boiler consumption the feed is provided with a regulating device. The elevator buckets are of pressed steel, 6 in. in width, and are secured to a similar chain to that used in the barge elevator. They are driven through a raw hide belt, on fast and loose pulleys, from the stoker driving shaft. An independent motor is fixed over each pair of boilers, which has sufficient power for driving mechanical stokers and elevators. By means of an independent countershaft, provision is made so that if any motor should fail the additional countershaft can be coupled up to another motor.

The mechanical stokers are of the well-known "Bennis" patent gold medal type, with pneumatic gear and self-cleaning compressed-air furnaces, and are specially adapted for burning a low-grade fine slack. It is interesting to notice in this connection that by the recent addition of the compressed-air bar, into which the air is forced by the aid of a minute steam blast in each bar, to the "Bennis" system of stoking, a combination of the chief benefits of mechanical firing with forced draught is obtained.

It will at once be seen that by a regulation of the steam blast the quantity of steam raised can be increased or decreased as required. The extreme value of this is that when the work is thrown off the quantity of steam can be automatically lowered, and when additional power is wanted it can be automaticlly raised, so that the pressure of the steam may be easily kept within a point or two.


Scale of Feet
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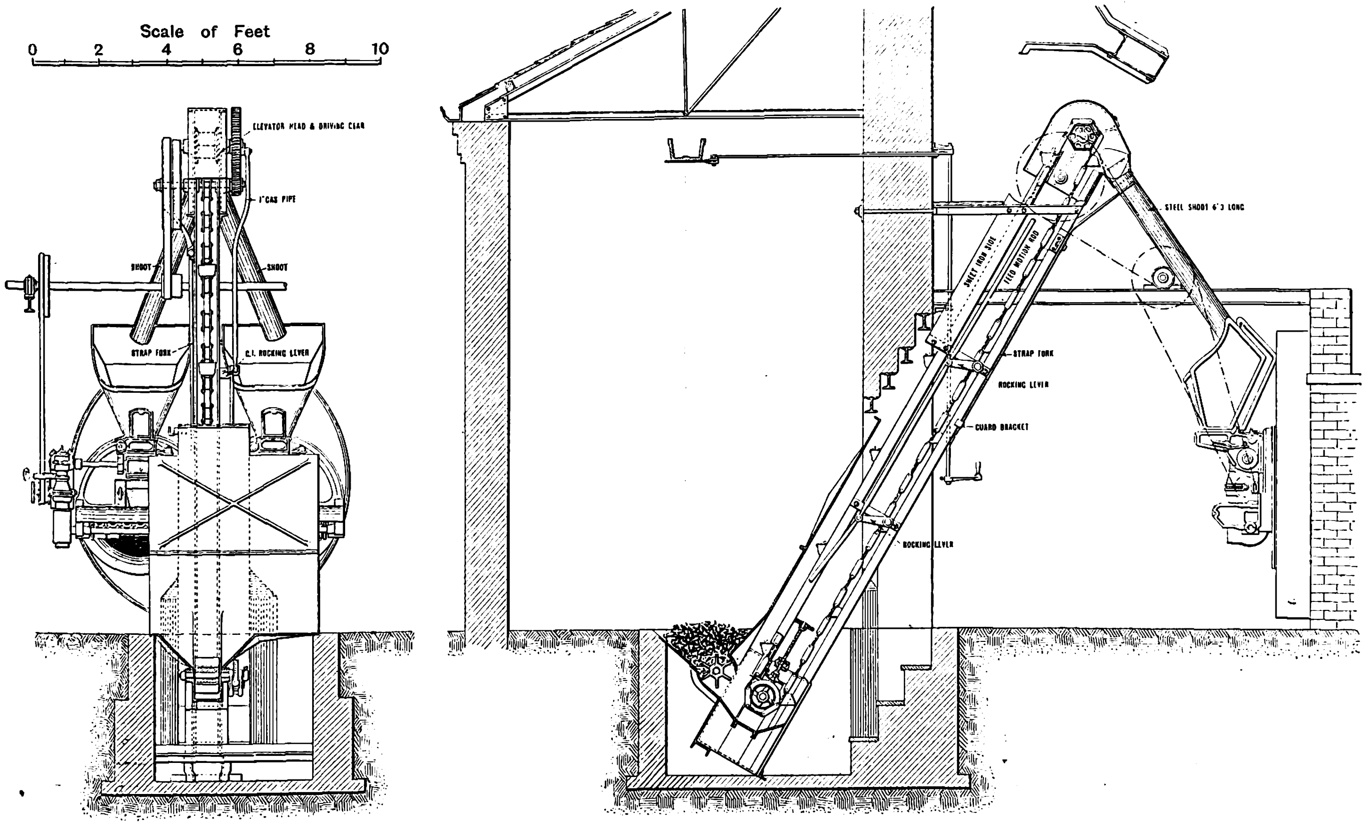
5
10
15
20
25
MOTOR

Fig. 1.
Inclined Conveyor:
Coventry Corporation.


Scale of Feet
0
2
4
6
8
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ELEVATOR HEAD & DRIVING GEAR
1" GAS PIPE
SHOOT
SHOOT
STRAP FORK
C.I. ROCKING LEVER
STEEL SHOOT 6'3 LONG
SHEET IRON SIDE
FEED MOTION ROD
STRAP FORK
ROCKING LEVER
GUARD BRACKET
ROCKING LEVER

A comparison of costs between the old system and the new shows that considerably over 60 per cent. is saved in the course of transit from barge to boiler.

Another example of a well-arranged coal-handling plant is found in the City-road station of the County of London Electric Light Co.

Here a hydraulic crane, with a nominal lifting capacity of 2 tons, removes the coal from the barges on the Regent's Canal by means of a 15 cwt. grab, and raises it to a hopper on the roof of the coal store. Sixty tons of coal are raised in 2½ hours by this means. The entire work is conducted under the superintendence of two men with the assistance of a boy who acts as trimmer.

The cost works out at 5d. per ton, including all labour, delivery into bunkers and the additional cost of the water used by the crane.

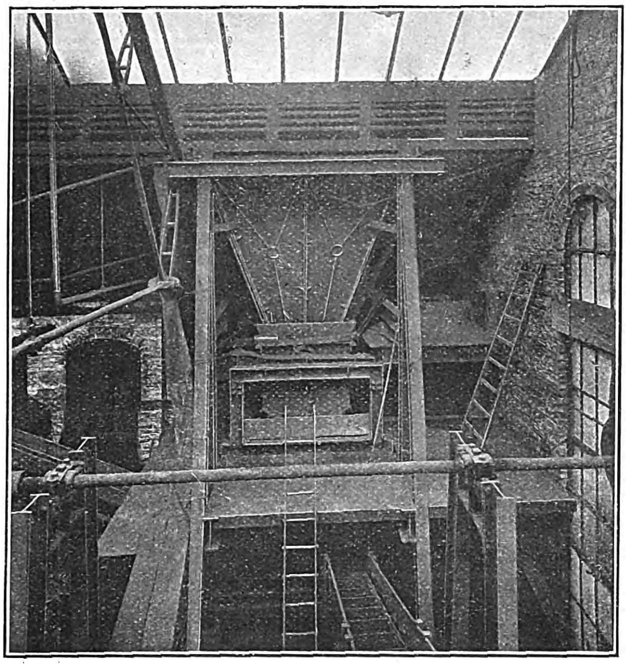

FIG. 2.—WEIGHING MACHINE AND CHAIN CONVEYOR TAKING COAL TO BUNKERS. County of London Co.'s Generating Station (City-road).

From the hopper the coal passes automatically into the weighing machine shown in Fig. 2. Thence it passes to the cross conveyor, which carries it over to the other side. The man who attends to the hydraulic crane does the whole of the repair work to the conveying gear. He packs the glands of the crane, greases the bearings, &c., and otherwise looks after the apparatus. During the three years that this barge-unloading plant has been in use it has only been necessary to remove two links of the conveyor, and the engineer reports that, so far, no breakdown or difficulty has been encountered. The next move is from the cross conveyor to the two main conveyors, which are fitted with slides at regular distances to admit of the coal being deposited in the bunkers requiring it.

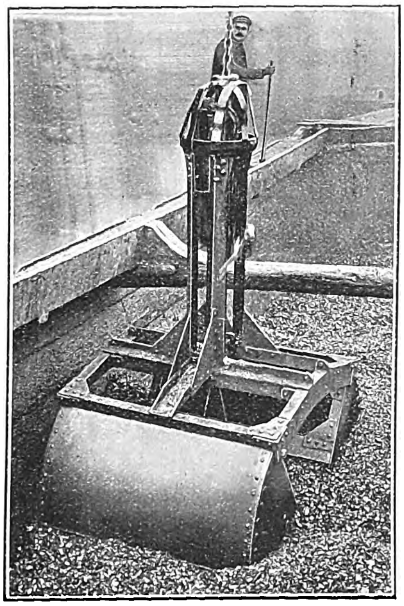

FIG. 3.—VIEW OF GRAB IN POSITION FOR LIFTING COAL FROM BARGE. City of London Co.'s Generating Station (Bankside).

From the coal bunkers, which have a total capacity of over 1,000 tons, the coal passes into a weighing truck in quantities of from 4 to 7 cwt. The trucks are run along rails extending the full length of the bunker room, the shoots to the various boilers being situated between the rails.

The conveyor is driven by a Bumsted & Chandler tandem engine, and each of the three conveyors can either be run independently of its neighbours, or all can be run together.

Another plant of the same character is in operation at the City of London Electric Lighting Co.'s generating station at Bankside. At this station 40,000 tons a year of washed nuts, Welsh and North Country coal are used. The better class of coal is found more economical in this particular case on account of the fluctuating demand for power. The installation of a complete coal-handling plant, with mechanical stokers, &c., has reduced the costs of dealing with the fuel to less than half that under the old system of coal-handling which was until comparatively recently in vogue.

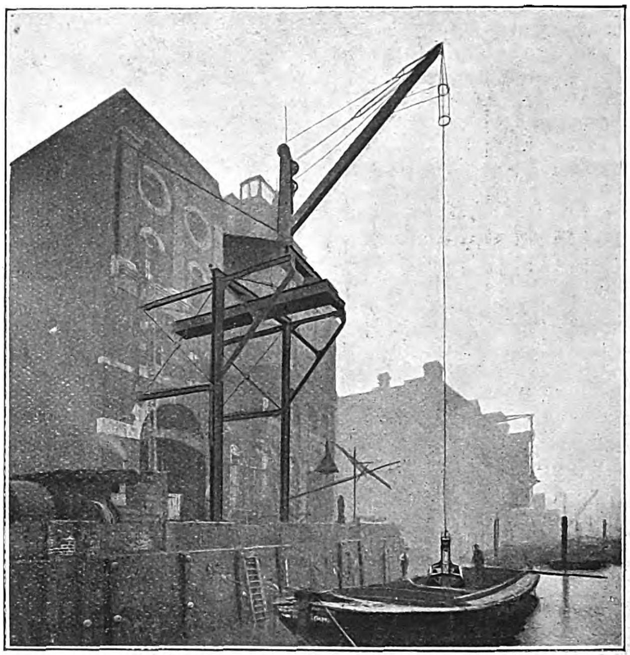

FIG. 4.—HYDRAULIC CRANE AND GRAB REMOVING COAL FROM INTERIOR OF BARGE. (Bankside.)

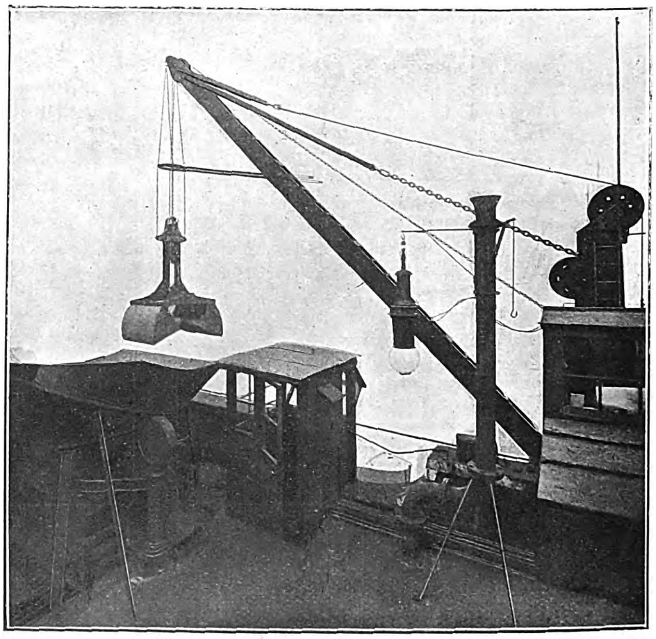

FIG. 5.—ANOTHER VIEW OF CRANE AND GRAB AT BANKSIDE STATION.

The coal is brought from the wharf side in barges, and unloaded by means of a grab, illustrated in Fig. 3, holding 15 cwt. It is thus hoisted by the hydraulic crane, of which a view is given in Fig. 4, to a height of 70 ft., and discharged into a hopper over a weighing machine, shown in Fig. 5, which automatically weighs and registers on a dial the weight of each grab-load of coal. The weighing machine discharges automatically into a bunker holding 100 tons, from which the fuel is conveyed by a "Bennis" chain conveyor across the road to the top of a long coal store situated over the boilers, holding some 4,000 tons.

Cross conveyors carry the coal to other coal stores, the total capacity in these works being no less than 10,000 tons.

Under the boilers runs a similar chain conveyor, which brings away the ashes to the boot whence they are elevated by a "Bennis" bucket elevator through a height of 20 ft., and distributed as may be desired either into the barges or carts.

The Main boiler house, that to which we first alluded, contains 48 water-tube boilers, each with a heating surface of nearly 4,000 sq. ft. These are easily capable of generating steam sufficient for 30,000 H.P. Here "Bennis" sprinkler stokers are at work feeding many of the furnaces with an almost entire absence of smoke.

## INDUCTIVE BALANCE DEVICES FOR THE PROTECTION OF ALTERNATING-CURRENT CIRCUITS.

The application of the principle of the maintenance of an inductive balance between two oppositely-wound sections of a transformer or reactance coil presents many advantages over other systems for the operation of the relays and protective devices employed in the control of high-tension switch-gear, especially in cases where "discriminating" devices are required. The system was first proposed by Mr. Leonard Andrews, in 1902, who suggested its application to the protection of duplicate feeders, in a manner described in *The Electrician*, Vol. L., p. 379. A method of operating duplicate mains circuit-breakers on this principle was also described in *The Electrician*, Vol. LIII., p. 141. The same system has been worked out with some slight modifications for ring mains in which the lead sheathing of the cable is employed to connect the two halves of the balance coils. A similar system adapted to cases where a distributing centre has an uneven number of feeders, was devised by Mr. Leonard Wilson, of the Stanley Mfg. Co. of U.S.A.

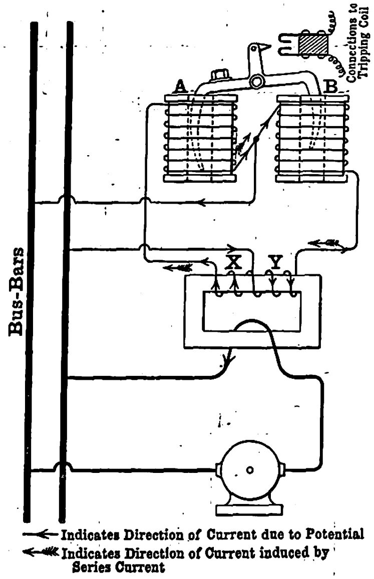
Connections to Tripping Coil
A
B
X
Y
Bus-Bars
Indicates Direction of Current due to Potential
Indicates Direction of Current induced by Series Current

FIG. 1.—INDUCTIVE BALANCE RELAY FOR CONTROLLING GENERATORS.

The inductive balance principle may be applied in practically all cases where discriminating relays are required. An inductive balance relay as applied to generator circuits is shown diagrammatically in Fig. 1.

A potential supply from the 'bus-bars, or from any transformers fed from them is connected to the centre of the secondary winding X-Y of the small series transformer. As this winding is wound entirely in one direction, and as there are an equal number of turns on each side of the point of potential connection, the current from the 'bus bars will be divided equally between the two halves, and these currents will have an equal and opposite magnetising effect upon the core of the transformer. A perfect inductive balance is by this means established. The outer connections of the secondary winding referred to are connected to two solenoids, A and B, and so long as the current in these solenoids is equal, the magnetic pull on the swinging armature will be equal and opposite. This armature is, however, normally held in the position shown by a small adjustable weight. The main current flowing from the generator into the 'bus bars will induce a secondary current in the local circuit X, A, B, Y, in the direction indicated by the full arrows, and this will so disturb the inductive balance as to cause a greater current to flow through the branch X, A, than through the branch Y, B, with the result that the pull due to gravity, tending to hold the relay in the open position shown, will be supplemented by a magnetic pull approximately proportional to the amount of current flowing from the generator to the 'bus bars. Should the generator break down, current will tend to flow from the 'bus bars into the generator, thus reversing the direction of the current through the series winding relatively to the direction of the current due to the potential supply. The series current will now induce a secondary current in the opposite direction to the full arrows round the local circuit Y, B, A, X, and as this will cause more of the potential current to flow through the side Y, B, than through X, A, the magnetic pull in the solenoid B will overcome the pull of A and will cause the armature C to move into such a position as to close the local circuit through the tripping coils, operating the main circuit breaker.

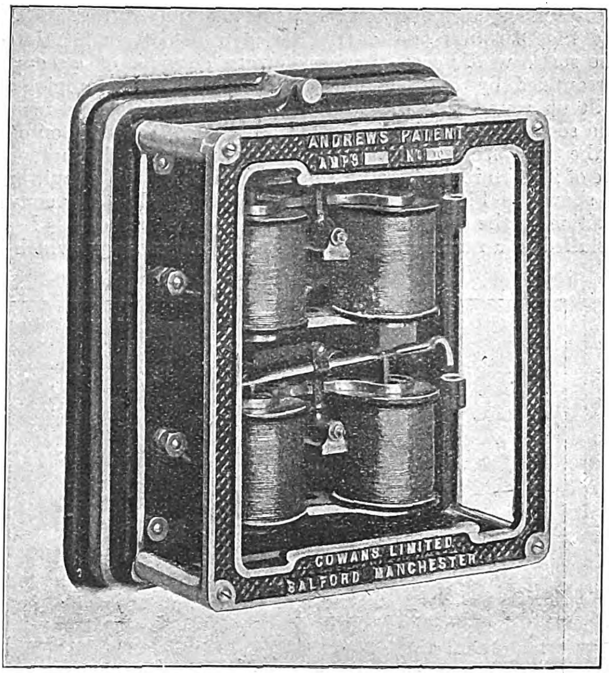

FIG. 2.—TWO-PHASE INDUCTIVE BALANCE RELAY.

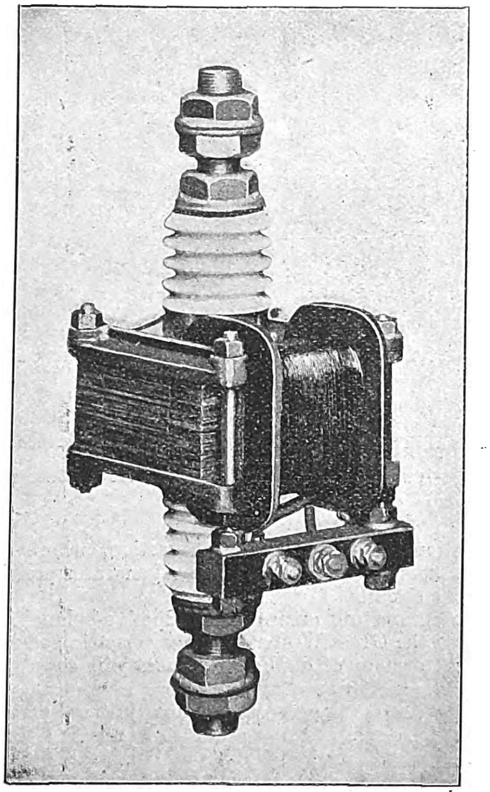

FIG. 3.—SERIES TRANSFORMER FOR INDUCTIVE BALANCE RELAY.

An important feature of the above construction is that it can be relied upon to operate with a far greater fall of potential than it has hitherto been possible to work with. It has been found, for instance, that many alternating-current discriminating relays will not operate should the potential across the shunt winding fall to less than 50 per cent. however large the reverse current. Whereas the inductive balance device described above will operate with a reverse current of less than the full-load current in the normal direction, even should the potential across the 'bus bars fall to 25 per cent. of the normal potential.

Fig. 2 shows the construction of a standard two-phase relay and Fig. 3 shows one of the series transformers for the same. The series winding of the transformer consists of a copper rod surrounded by a thick micanite tube, the iron stampings being built up round this rod and supported on porcelain insulators. The secondary winding is carried on a spool mounted on one side of the transformer core. This transformer is usually supported by one of its terminals directly from a terminal of the circuit-breaker, as shown in Fig. 4. The relay may be placed in any convenient position on the operating panel. This type of apparatus has been installed in a number of generating stations, amongst which is one of the stations of the Bristol Corporation, where discriminating circuit-breakers are used on both the generator panels and on the trunk-feeder circuits.

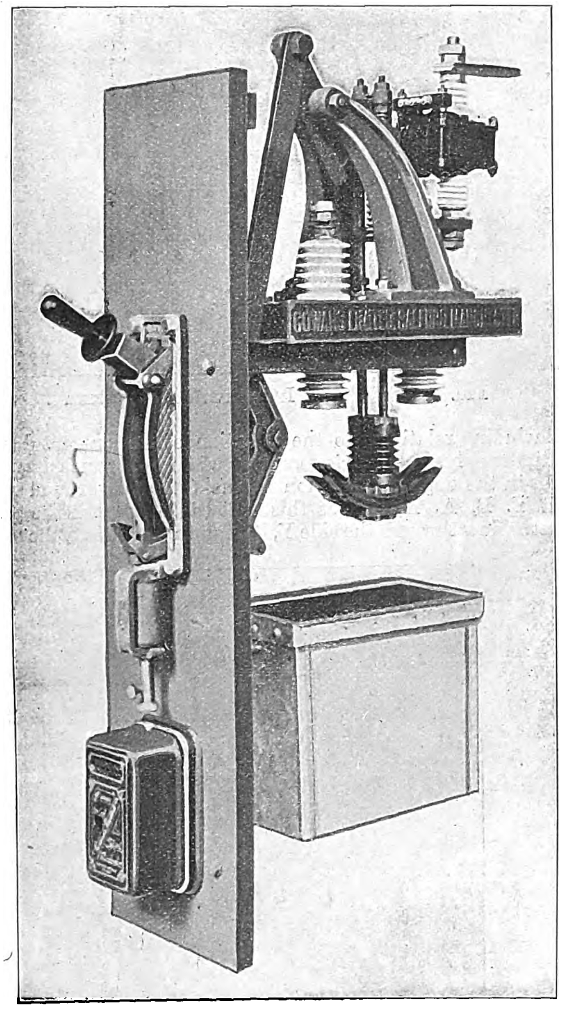

FIG. 4.—HIGH-TENSION DISCRIMINATING CIRCUIT BREAKERS. (BRISTOL TYPE.)

Another interesting example of inductive-balance relays is to be employed in the Great Western Railway electric power transmission scheme. A system of duplicate feeders will supply a number of sub-stations, and it was desired to have automatic switches at the distributing centres to serve the double purpose of isolating faults in each feeder or transformer and also to enable either transformer to be disconnected during periods of light load by merely opening one of the H.T. feeder switches in the main generating station. The arrangement first proposed is shown diagrammatically in Fig. 5. By closing the switch $S_1$, the transformer A fed by this feeder will be magnetised, and a current will be induced in the operating solenoid C, which will close the switch D, thereby completing the connection to the L.T. 'bus bars. Now, so long as these 'bus bars are only fed from this one source, the switch D will be automatically opened by opening the switch $S_1$. If, however, the L.T. 'bus bars are fed from another source, the opening of the switch $S_1$ will not then open the switch D, as the potential across C will be maintained by the 'bus bars, and the transformer A will be magnetised from its L.T. side.

It was then proposed to add discriminating cut-outs that would break the circuit through the solenoid C in the event of the current through the switch D being reversed, due to the transformer A being magnetised from the L.T. 'bus bars instead of the H.T. 'bus bars. This at first sight appeared a somewhat difficult problem, owing to the fact that the discriminating device would be required not only to carry the full-load current of the transformer controlled, but also to be able to operate with the magnetising current of transformer, which would be less than ½ per cent. of the full-load current. The difficulties were overcome by a modification of the inductive balance principle, the relays being arranged as shown in Fig. 6.

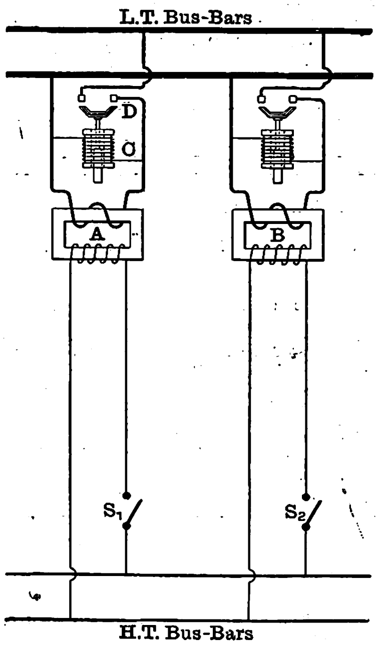

FIG. 5.—G.W.R. SYSTEM OF DUPLICATE FEEDERS.

The leads A and B from the respective transformers to be controlled are passed through the centre of the iron core D, upon which the inductively balanced potential winding E is wound. So long as the two transformers are doing useful work, the load, whatever its amount, will be divided approximately equally between them, and as the respective connection between the transformers and the 'bus bars tends to magnetise the core D in opposite directions, so long as the currents in these are equal and opposite they will not induce a secondary E.M.F. in the winding E. The potential current will therefore divide equally between the two halves of this winding E and between the two solenoids A and B, and the pull on the rocking armature will consequently be equal on both sides. Should, however, the H.T. supply to one of the transformers become interrupted, the whole of the current to the 'bus bars will be supplied by the remaining transformer, added to which, sufficient current from the 'bus bars will feed back into the idle transformer to

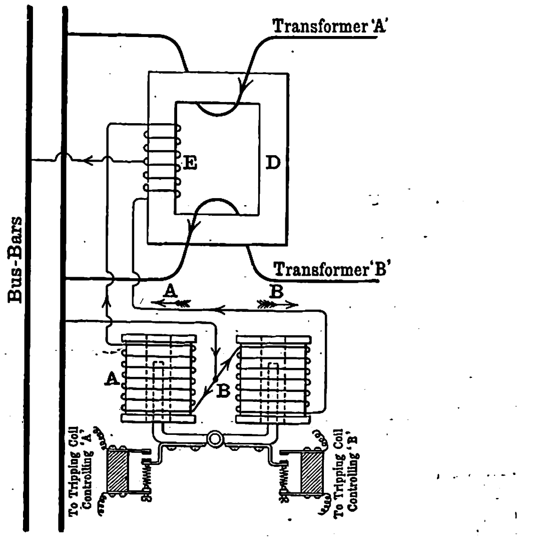
Transformer 'A'
E
D
Transformer 'B'
Bus-Bars
A
B
A
B
To Tripping Coil Controlling 'A'
To Tripping Coil Controlling 'B'

FIG. 6.—INDUCTIVE BALANCE RELAY FOR G.W.R. SYSTEM.

magnetise this. It is evident, therefore, that the core D will now be magnetised by the whole of the unbalanced current supplied to the 'bus bars from the working transformer, plus twice the idle current required to magnetise the idle transformer, and these combined currents will induce a secondary current in the potential winding E, the direction of this current being dependent upon which transformer is doing the useful work. For instance, the direction of this secondary current when transformer A is working and transformer B is idle, will be as indicated by the arrow A, whereas should A be the idle transformer, the direction of the secondary current will be as indicated by the arrow B. In the first case this secondary current will tend to make the potential avoid the path through solenoid A, and select the path through the solenoid B, thereby causing the relay to close the local circuit through the tripping coil controlling transformer B, and in the second case the relay will close on the opposite side.

The arrangement which is being actually carried out in connection with the transformers in the Great Western Railway sub-stations is similar to that shown in the figure, except that two single-acting relays are used instead of the one double-acting relay. The advantage of this lies in avoiding any risk of the action of one relay influencing the other.

## STREET LIGHTING.*

BY HAYDN T. HARRISON.

In order to arrive at any decision as to the degree of illumination which may be considered efficient for various streets it is necessary to decide first the units in which the value of illumination should be specified. I have had the opportunity of examining several reports which have been submitted by engineers to Lighting committees; in the majority of these it has been considered sufficient to state the candle-power of the lamps in the same way as Mr. Bradley does in the most valuable tests he makes periodically in Westminster; others have gone a little further, inasmuch as they state the candle-power per mile of road; others, again, have based their figures on various illumination tables given in candle-power feet at various distances from the source of light.

That none of these methods are complete enough will be obvious when an attempt is made to compare the reports. For instance, the mean illumination of a street cannot be ascertained from measurements of candle-power unless these are taken at a large number of different angles, because there is practically no source of artificial light which gives a true hemispherical candle-power; by that I mean a light of which the candle-power measured at any of the angles in the lower hemisphere will be approximately equal. Moreover, it is necessary to state the height and distance of the lamps, in order to judge the illumination derived.

In 1892 Mr. Trotter read a Paper before the Institution of Civil Engineers which dealt very fully with this matter, and his Paper is even now probably the most complete treatise on the subject extant. Mr. Trotter used an illumination photometer devised by himself, in conjunction with Sir William Preece, by which the horizontal illumination at various parts of the road could be measured; and incidentally he gave it as his opinion that the nearer this illumination could be measured to the road surface the better.

Now it is obvious that if the degree of illumination is measured on a horizontal plane, all the lamps in the neighbourhood of the photometer will assist in illuminating that plane, therefore the spacing and height of the lamps can be disregarded when making comparison, and only the measurements in candle-power feet taken into consideration; and if the mean of these measurements could be taken as a criterion of the illumination of the road, no better system could be adopted. Mr. Trotter shows at great length in his Paper how this can be done by plotting a large number of contour curves and illumination curves along imaginary lines drawn down a street; but unless sufficient measurements are made to plot these curves in every case, and a mean illumination obtained by dividing the plan of the street into a large number of sub-divisions and taking a mean of all the various degrees of illumination in all the sub-divisions, as shown by the contour curves, I fail to see how the mean degree of illumination can be arrived at.

Moreover, there are other practical objections to the use of an illumination photometer as described by Mr. Trotter. The large difference between the maximum and minimum illumination when measured on a horizontal plane, coupled with the small range of the instrument, made it only possible to survey the illumination over a very small portion of the street unless several different standard lamps are used, and even then the instrument was found to be difficult to balance when comparatively high or low degree of illumination was being measured.

Thus I came to the conclusion some time back that in order to encourage more general testing of street illumination for comparative and specifiation purposes, a simpler means would have to be adopted than has hitherto been the general practice, and that an instrument must be devised by which the degree of illumination of a street could be rapidly and accurately determined.

In order to judge the lighting of a street it is only necessary to know the minimum illumination at any point where light is required, because if that illumination is sufficient for the purpose, it obviously follows that it will be ample elsewhere; for example, the average illumination of a street brilliantly lighted in one part and left in comparative darkness in another part may be high, but it is of no practical use except that you know that by moving from one brilliantly lighted spot to another, you will travel along the street provided you do not encounter any unseen objects, or dangers, in the dark intermediate parts; therefore, I think you will agree with me in saying that the measure of minimum illumination is of primary importance, and on its value the efficiency of the lighting of the street depends.

It will probably be suggested that the value of the maximum illumination should also be measured and stated, in order that a diversity factor may be arrived at. This is to some extent true, as passengers in vehicles passing rapidly along a street having a large diversity of illumination, are liable to become dazzled; moreover, the value of the minimum is reduced if the iris of the eye is being periodically contracted by brilliant patches of light. Therefore, I think we may take it that the best lighted streets are those with the highest minimum illumination and with the lowest diversity factor, and, after having granted this definition, all that remains to be done in comparing the lighting of various streets is to state the value of the maximum and minimum illumination as measured therein.

But the unit of illumination—namely, candle-power feet—is not sufficiently definite, for it is obvious that when speaking of illumination we really mean the degree to which something is illuminated, and that will depend to a very large extent on the average angle at which the light strikes the various surfaces of that object.

You will notice that in the design of instrument I recommend an angle of 45 deg. has been chosen; if it had not been for practical reasons, I would have preferred a vertical screen. The reasons I abandoned the horizontal screen, which I used for many years in a type of instrument similar to that suggested by Mr. Trotter, may interest you; one reason was that the angle of incidence when measuring at a distance from the post became so large as to reduce the illumination on the screen to that point when it was difficult to get a balance, and, moreover, unless the screen was accurately levelled, considerable errors were liable to creep in; these faults made it practically impossible to measure the minimum illumination, which I consider the most important factor. For instance, at 100 ft. from a post 20 ft. high on which is mounted a 500 c.p. lamp, the illumination on the horizontal screen used in the instrument would only amount to 0·005 c.p. ft., whereas if the screen had been illuminated by direct rays it would have been 0·045, which is nearly 10 times as much, and could have been easily measured. With the instrument before you it is equal to 0·04 and can be measured with ease and accuracy. With a vertical screen it would have been equal to 0·047, which would have been even more easy to measure; but, on the other hand, it is obvious that directly under the post the vertical screen would be useless, and the illumination on the horizontal screen would be so high as to be out of the range of the instrument; this alone is one good reason for the use of this particular angle.

But there are two other reasons which I consider of equal importance; one is that, owing to the great variation in the spectrum of lamps used for street lighting purposes, a flicker method of obtaining a balance is essential for accurate work, and an angle of 45 deg. is found more convenient in the design of this part of the apparatus; the other is that the illumination of vertical objects in a street is of equal, if not greater, importance than that of the road and pavement. For instance, it is of more importance to be able to recognise faces and avoid obstructions than to be able to distinguish the quality of the road; it is true that in the case of road vehicles, particularly motor cars, the latter is of importance, but as these vehicles very generally carry lamps of higher candle-power than the street lamps, the comfort of the pedestrian is more to be considered. Therefore, by stating the value of the illumination on a screen at an angle of 45 deg. we are probably giving the most useful information for practical purposes. Moreover, the measurements obtained at this angle are as easily converted to measurements of candle-power as would be the case if any other angle were used, and the fact that the candle-power of the lamps in one direction only is measured simplifies this calculation considerably.

There is still another factor which must be stated, and that is the height at which the measurements are made from the ground; this should be settled by the most convenient height for making the measurement, which I have found to be 4 ft.

Having decided a definite means by which the lighting of streets can be accurately and rapidly compared, I have, from various published statements obtained the opinions of gas and electrical engineers as to the present-day requirements in this direction, and, from tests made by myself and others, am able to give a rough average of what actually occurs in practice.

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* Abstract of a Paper read on Tuesday before the Manchester Local Section of the Institution of Electrical Engineers.

The opinion of Mr. John Price, of Birmingham, was published in the *Street* (February, 1905), in which he stated that incandescent gas burners consuming 3·5 cubic ft. per hour—for which he claims 42 c.p. when new—should be erected at 50 yds. apart in the suburbs and 28 yds. apart in the centre of the city; in the very important thoroughfares two, or even three, burners may be used. This works out as follows: Centre of city, 80 c.p. at 84 ft. apart, minimum direct illumination, 0·046. Main streets, 40 c.p. at 84 ft. apart, minimum direct illumination, 0·023. Suburbs, 40 c.p. at 150 ft. apart, minimum direct illumination, 0·007.

Mr. Maxwell, of Partick, in his Paper read before the Glasgow Local Section (January, 1905), stated that the 12½ ampere open-type arc lamps (for which he claimed 870 mean spherical candle-power) when fixed on posts 60 to 80 yds. apart in the main streets and 100 yds. apart in side streets, were satisfactory in practice. In certain instances an average distance of 110 yds. apart and a maximum of 180 yds. was permissible. Allowing that the candle-power of the lamps at, say, 15 deg. from the horizontal would not exceed 600, this works out as follows: Main streets, 180 ft. apart, minimum direct illumination, 0·071; 240 ft. apart, 0·04. Side streets, 300 ft. apart, minimum direct illumination, 0·026; 540 ft. apart, 0·0082.

In St. Pancras the original 10-ampere open-type arc lamps were erected in the main streets at 330 ft. apart, but even in the less important streets they are now put at 165 ft. apart. The side streets were and are in some cases illuminated with single gas mantles at 120 ft. distance. I think we may take it that the modern practice will be maintained. The results are as follows, taking the candle-power of the arcs at 15 below the horizontal as 500: Main streets (old practice), arc lamps 330 ft. apart, minimum direct illumination, 0·017. Main streets (new practice), arc lamps at 165 ft. apart, minimum direct illumination, 0·07. Side streets, incandescent gas, 120 ft. apart, minimum direct illumination, 0·0095.

From Mr. Cramb's interesting tests embodied in a report submitted to the Corporation of Croydon in July of this year, it transpired that the main streets were lighted by arc lamps giving an average candle-power of 450 at 65 yds. apart, and the side streets by single incandescent gas burners, of which the best examples gave 52 c.p. fixed 80 yds. apart, and by Nernst and incandescent lamps (the latter being fixed with Reason reflectors), which gave an average of 57 c.p. and were fixed at a distance of 66 yds. apart, the results being as follows: Main streets, arcs, 450 c.p., 195 ft. apart, minimum direct illumination, 0·043. Side streets, gas, 52 c.p., 240 ft. apart, minimum direct illumination, 0·0036. Side streets, electric, 57 c.p., 198 ft. apart, minimum direct illumination, 0·0056.

As an example of residential suburban lighting I would take Willesden, where the main streets are lighted by means of 10 ampere open-type arc lamps, 78 yds. apart, and the side streets by incandescent gas burners, consuming 3·2 cubic ft. of gas per hour, averaging 50 yds. apart; and also Barnes, which is lighted to a large extent by ½-ampere Nernst lamps erected at 60 yds. apart. The results of these two places works out as follows: Main streets, arcs, 234 ft. apart, minimum direct illumination, 0·035. Side streets, incandescent gas, 150 ft. apart, minimum direct illumination, 0·005.

Tonbridge is a good example of a town of about 13,000 inhabitants, the street lighting of which has received considerable attention of late. The High-street is provided with 500 watt open-type arc lamps, at an average of 90 yds. apart. The residential main roads are lighted by two ¼-ampere Nernst lamps on posts erected 70 yds. apart, and single ½-ampere Nernst lamps also 70 yds. apart. The other parts of the town are lighted by incandescent gas lamps, at an average distance apart of 70 yds. This works out as follows: High-street, 500 c.p., 270 ft. apart, minimum direct illumination, 0·027. Main streets, 40 c.p., 210 ft. apart, minimum illumination (direct), 0·004. Side streets, 30 c.p., 210 ft. apart, minimum direct illumination, 0·003.

From the valuable tests taken by Mr. Pearce at Manchester, I have extracted the following figures, which give an example of the lighting of main thoroughfares of an important town:—

| Position. | Lamp. | Distance apart. | Min. distance illumination. |
|---|---|---|---|
| Piccadilly ........ | 900 watt enclosed arc.. | 76 ft. | 0·62 |
| Sackville-street .... | Intensified gas ...... | 58 ft. | 0·38 |
| Albert-street ...... | 600 wattt enclosed arc | 57 ft. | 0·54 |
| All Saints' ........ | Intensified gas ...... | 102 ft. | 0·14 |
| Piccadilly ........ | 600 watt enclosed arc.. | 66 ft. | 0·30 |
| Cheetham Hill-rd.. | Incandescent gas .... | 206 ft. | 0·013 |

A much more interesting example in this neighbourhood is that of Gorton, where Mr. Pearce has lately replaced 25 double Welsbach mantles, each taking 4 cubic ft. of gas per hour, by 22 enclosed arc lamps giving 400 c.p. each. The gas lighting in this case used to cost £150 per annum; the electric lighting is done for £176. Taking an average candle-power for the gas lamps based on the figures given by Mr. Price, of Birmingham, and measurements made by myself elsewhere, the candle-power will work out at 80 per post, therefore it will be seen from the following figures that the minimum illumination has been increased four times at an extra cost of 17 per cent. per annum: *Old system.*—Incandescent gas, 80 c.p., 90 ft. apart, minimum illumination (direct), 0·037. *New system.*—Enclosed arc lamps, 400 c.p., 100 ft. apart, minimum illumination (direct), 0·145.

As a final example, I propose to take the much disputed City and Kingsway lighting. In the case of Kingsway, the length is 4,000 ft. and the breadth 100 ft. There are 51 high-pressure gas lamps, and the measurements I had made in October averaged 670 c.p. on the lamps in good condition, and 450 on those which were in poor condition. The posts are staggered, therefore the maximum distance from any post would be 46 ft. where you would be deriving light from three sources, two of which would be available on a screen at an angle of 45 deg.; but, for the sake of comparison, I propose to consider one only. This works out as follows: High-pressure gas, 515 c.p., 80 ft. apart, minimum direct illumination, 0·206.

In the case of Fleet-street 12 10-ampere lamps in muranese globes have lately been replaced by 34 pairs of incandescent gas mantles. I have tested both of these illuminants, and am able to place before you the following figures, which require a little explanation: In the case of the gas lamps, the two mantles are placed side by side, therefore the minimum candle-power measured is across the road, where it averages 80 c.p., and this will be the point at which the minimum illumination occurs, namely, at a distance of 30 ft.

The old arc lamps were at a distance of 137 ft. apart, and, as they gave 680 c.p. when measured at a distance of 30 ft., it can be taken for granted that 600 would be a safe average to take at the greater distance. Old arc lamps, 137 ft. apart, minimum direct illumination, 0·117. New gas lamps, 48 ft. apart, minimum direct illumination, 0·08. The actual minimum illumination between the gas posts would be: 48 ft. apart, minimum direct illumination, 0·18.

I do not propose to consider the more brilliantly-lighted streets of Manchester, or the gas company's latest show in Aldwych and Kingsway, as there is little doubt that the illuminating of public buildings in the case of the former has been aimed at as much, if not more, than lighting the streets; and the latter case, as far as one can judge, is an advertisement for the gas companies, the cost of which will probably never be disclosed. Therefore, I think we may take it that in most towns the minimum direct illumination is as follows:—

| | | | | |
|---|---|---|---|---|
| Main thoroughfares, | minimum | direct | illumination, | 0·050 c.p. ft. |
| Side streets | ,, | ,, | ,, | 0·025 ,, ,, |
| Suburban streets | ,, | ,, | ,, | 0·005 ,, ,, |

These figures are averaged from actual measurements made in the street, and it is interesting to note that in many places where electric light has been installed—such as St. Pancras, Maidstone, Partick, &c.—these values have been exceeded, whereas the actual illumination obtained from gas mantles is generally much lower than that estimated by the representatives of the gas industry.

In the case of the less populated towns it will be found that the main streets are generally on a par with what I have termed the side streets of a large city, the other streets being equivalent to the suburban streets; but in many instances, such as Tonbridge, the lamps in the less important side streets can hardly be said to illuminate them at all, owing to the long distance apart at which they are placed.

And now let us see what the value of the minimum illumination is; the usual test is the possibility of reading a Bradshaw railway guide. I find, personally, that this is possible at an illumination equivalent to 0·05 c.p. ft. With 0·005 c.p. ft. you cannot recognise a face; in fact, can only just avoid running into anything. Mr. Trotter took for his comparison moonlight, which he found to be 0·028 c.p. ft. in England near full moon; thus it will be seen that in the side streets of large cities the minimum illumination approaches full moon, but in suburban streets is less than one-fifth. I would therefore suggest that, unless the value of illumination in any street exceeds, say, 0·015 c.p. ft., it could hardly come under the head of street lighting, but should be called "beacon lighting," as suggested by Mr. Trotter.

(*To be concluded.*)

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**The Sinking of the Nantucket Lightship.**—This lightship, which has played a prominent part in announcing, by wireless telegraphy, the passage of west-bound ocean liners on their way to New York, besides serving a number of other purposes, sprang a leak during the gale last Sunday, and sank on Monday night shortly after the crew of fifteen (including three telegraph operators) had been rescued by a ship which had been summoned by urgent wireless messages.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

*A New Electric Valve.*—A. Wehnelt has utilised the emissive properties of metallic oxides for the construction of a new valve tube. He showed last year that metallic oxides, especially those of calcium, strontium and barium, when incandescent, emit numerous negative ions. When they are spread over a cathode they neutralise the positive ions accumulating there during the discharge, and therefore reduce the cathode fall to vanishing point. The cathode is made of some refractory metal and heated by a special current. The anode fall is some 20 volts. The tube is highly exhausted. When the heated oxide is made the cathode, the current passes easily, but on reversing the current it does not pass with less than several thousand volts. The limit of action is reached when the current density becomes so great that at the temperature of incandescence the negative ions no longer suffice to neutralise the positive ions accumulating from the gas. This limiting current density is 2 or 3 amperes per square centimetre. An alternating current is converted into an intermittent direct current, as in the case of other valves. The author claims a high efficiency, but reserves his figures. Besides the use for charging accumulators and working lamps from drehstrom circuits, he also uses the valve for wireless telegraphy, sending both components of the wave in the same direction through the coils of a differential galvanometer.

[A. Wehnelt, *Sitzungsberichte*, Phys. Med. Soc., Erlangen, 37, 1905.]

*Electric Precipitation of Colloids.*—An essential characteristic of colloid solutions is that their particles are precipitated at one of the electrodes when a current is passed through. A. Schmauss has studied this precipitation, and found it to vary with the conductivity of the solvent. If this is less than that of pure water, three zones make their appearance, one of them being free from colloid particles, one of them containing the precipitate, and the intermediate space containing the unchanged solution. When the solvent is water, there are four zones, the additional zone being round the empty space at the cathode and containing concentrated colloid. The author used colloid solutions of gold and silver prepared by Bredig's method. He found a speed of the ions amounting to 0·00026 cm. per second, that being of the order of the usual monovalent ions. This considerable speed means the presence of high electric forces. A study of the current strength led the author to conclude that the water is decomposed into ions whose condensing capacity accounts for the additional zone, and whose charges, added to the small charges of the colloid particles produced the high speed. The ions are probably H and OH. The ions at the anode produce concentrations in the shape of rings round it.

[A. Schmauss, *Annalen der Physik*, No. 13, 1905.]

*Spark Discharge in Gases.*—The sparking length in gases and the potential necessary to produce a discharge is known to depend upon the velocities of the gaseous ions, as well as the molecular weight of the gas. The ionic velocity often becomes the determining factor. W. Voege thus quotes an instance in which the conductivity of air for the spark discharge becomes less than the conductivity of carbonic acid. This happens when the spark length exceeds 10 cm. Oxygen appears to discourage the discharge in every case, but the author cannot say whether this is due to the formation of ozone. The discharges in the various gases may be distinguished by the sound and the shape of the spark. In air, the negative electrode is a bright point and the anode a brush. The spark is white and loud, and has a zig-zag shape. The portion nearest the cathode is bright. This is not the case in oxygen. In carbonic acid and hydrogen the sparks are straight and nearly silent. The spark in hydrogen is red and in carbonic acid blue, except at higher current intensities, when the oxygen liberated makes it violet. Hydrogen or carbonic acid surrounding the cathode encourages the discharge, just as positive ions do. This is consistent with the positive charge of the hydrogen atoms in electrolysis. Chlorine, on the other hand, hinders the discharge, since each atom has a tendency to take up an additional electron and become a negative ion.

[W. Voege, *Annalen der Physik*, No. 13, 1905.]

*Propagation of Light through Matter.*—In a medium exhibiting dispersion or selective absorption, or both, a light wave always undergoes a change of form. For the only differential equation admitting a propagation without deformation—viz., the equation

$$a^2\Delta\phi=\frac{\delta^2\phi}{\delta t^2},$$

does not apply to such a medium. Poincaré, Picard and Voigt studied the deformation of the wave by means of the "telegraph equation"

$$a^2\Delta\phi=\frac{\delta^2\phi}{\delta t^2}+\frac{2b\delta\phi}{\delta t}.$$

M. Laue now gives a treatment of the problem connecting the deformation of the wave and the change in the spectrum, without limiting himself to a given differential equation. He puts the vibration into the shape of a Fourier integral of pure sine waves, and assumes that the refractive index and the coefficient of absorption vary slowly with the wave-length. He finds the conditions under which a beam may be considered elementary, and proves that such a beam cannot be perceived below a certain high temperature. The laws of propagation are the same for an elementary beam and a single wave. When the beam is propagated in a dispersive medium, every disturbance ultimately takes the form of a long train of approximate sine waves. The author's conclusions enable him to explain the apparent paradox of a propagation of light with a velocity greater than that in a vacuum. The paradox is due to an ambiguity in the definition of the intensity of radiation. The reason why at very slight absorptions the group velocity is always smaller than the phase velocity lies in the fact that the resonators contribute to the energy of the regular wave, but not to its Poynting radiation vector. Finally, the author points out that the region in which the second law of thermodynamics begins to fail is more easily attained by optical means than by the less refined thermodynamic methods.

[M. Laue, *Annalen der Physik*, November 13, 1905.]

*Porous Contact.*—K. Prytz describes a novel device for making gas connections in vacuum tubes. The vacuum tube is closed at one end with a porous plug made preferably of fire-clay. As long as the plug is kept immersed in mercury the gas cannot pass in or out through the plug, provided the pores in the plug are so small that mercury cannot be forced through them by a pressure of one atmosphere. The gas with which the vacuum tube is to be filled is contained in another tube provided with a similar plug. When the gas is to be transferred, the plugs are brought into contact under the mercury, and the pump is worked. Many difficulties are thus avoided, and the only drawback is the slow diffusion of the gas through the plugs.

[K. Prytz, *Annalen der Physik*, No. 13, 1905.]

*Plan of a Radio-active Atom.*—Lord Kelvin elaborates his scheme of positive atoms containing negative "electrions" or electrons inside them, so as to account for the prodigious velocity of these electrons when shot out as they are by radio-active bodies. He supposes that the positive atom attracts the electron with a force varying inversely as the square of the distance. This attraction holds good until the electron begins to enter the substance of the atom, and it then changes into a vigorous repulsion. As the electron works its way in, it has to overcome this repulsion and do a vast amount of work. When it penetrates to within a short distance of the centre, the repulsion changes into an attraction, so that when it arrives at the centre it is in a condition of stable equilibrium. From this it may be expelled by some shock or strong external force. On entering the region of repulsion, it is shot out with great velocity, its kinetic energy being equal to the work done in bringing it near the centre, provided we can neglect its loss of energy by motions which, while it is in the atom, it gives to the ether in the atom and outside it.

[Lord Kelvin, *Philosophical Magazine*, December, 1905.]

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## MUNICIPALITIES AND HOUSE-WIRING.

The question whether an electricity supply authority should carry out house-wiring has engaged the attention of the electrical industry from its early days. During their period of infancy it was advisable that the electric lighting companies should have house-wiring departments, for it was necessary that all the work in connection with the introduction of the new illuminant should be carried out by those who had had most experience of it. After a short time, however, regular house-wiring firms were established, and practically all the larger electric lighting companies discontinued this branch of their business, recognising that it could be dissociated with advantage from the work of generating and distributing electrical energy, and that the wiring contractor also served as a useful independent addition to the company's own canvassing staff. In the case of supply companies in smaller towns, however, it was of course expedient that the company should carry out house-wiring work, for frequently there was no other local firm competent to do house-wiring at the inception of the undertaking. There are, in fact, still a fair number of smaller electricity supply companies who also act as the chief wiring contractors in their areas.

When municipal electricity supply systems were started, it was taken for granted immediately that in this case house-wiring was outside the province of the supply authority. In one or two instances, however, local authorities have bought out electric supply companies which had not yet abandoned or disposed of their house-wiring business, and the question has arisen whether this branch should still be carried on. With but one important exception, the decision has been in the negative, and rightly so, for house-wiring has, in some respects, the nature of a retail trade, and nowadays it involves competition with firms who are ratepayers to the local authority in question. The one important exception to which we allude is that of the Sheffield Corporation electricity department. When the Corporation took over the business of the Sheffield Electric Light & Power Co. in 1898, it found that house-wiring represented a large and remunerative branch of the undertaking, and that the spare time of the Company's wiremen was occupied in the manufacture of transformers. The Corporation was loth to part with this business asset, and has continued to execute work of this description ever since, in spite of the fact that there are a number of wiring contractors established in Sheffield, and that transformers can be bought without difficulty through the ordinary channels and at fair prices. Representations have been made to the Sheffield Corporation from time to time by the local contractors, but without effect, and the question of taking legal action has also been mooted. It is expensive, however, for a small band of tradesmen to fight a rich and powerful municipal corporation, and as a final effort, an appeal has been made to the Sheffield Chamber of Commerce. The Council of this body has now expressed its sympathy with the cause in the following resolution :—

> The Council of the Sheffield Chamber of Commerce have received a deputation from the Sheffield Electrical Contractors' Association on the subject of Municipal Trading as carried on in the Electrical Fittings and Wirings Department of the Sheffield Corporation. The Electrical Traders are substantial ratepayers of the city, and by reason of the municipal competition to which they are subjected they have convinced the Council of this Chamber that it is impossible to carry on their business. This Council hereby records its disapproval of the City Council carrying on this department with public funds, and recommends that a copy of this resolution be forwarded to the City Council in the name of the Chamber, and a copy of the same be given to the Electrical Contractors' Association for their use in the legal opposition they are pursuing.

Not only is it wrong in principle for a municipal authority to execute house-wiring in competition with local firms, but it is also illegal in most cases. Some particular Local Authorities, it is true, have obtained, by means of the very convenient General Powers or "Omnibus" Bills, Parliamentary sanction to expend money on wiring houses—in most cases for the purpose of "free wiring" and "hire-purchase" schemes—but even then this sanction has been often qualified by the condition that the actual work is not to be done by the municipality itself, but is to be let out to contractors. Local Authorities who do not possess these powers have made unsuccessful attempts to obtain the approval of the Local Government Board for loans for house-wiring. Now the Sheffield Corporation has never obtained special powers of this nature, and is apparently continuing its wiring and fittings department under the mistaken idea that it is authorised to do so under Sec. 10 of the Electric Lighting Act of 1882. This section, in defining the general powers of an undertaker under a Provisional Order, includes "generally all such acts and things as may be necessary and incidental to such *supply*"—the word supply, which we have italicised, is important. We have no hesitation in stating, as we did on former occasions when this point was raised, that this definition cannot be taken to include house-wiring. We are the more confident in making this assertion from the fact that our view has received the endorsement of the Board of Trade and the Local Government Board as recently as June, 1903. The undertakers are authorised by their Provisional Orders to lay down lines as far as the consumers' terminals, and to supply meters if called upon to do so, but nothing in the Electric Lighting Acts authorises them to execute any other wiring work within the consumers' premises. In these circumstances, we advise the Sheffield contractors most strongly to persist in their campaign. We can hardly believe that the Corporation will be so ill-advised as to fight the matter through the law-courts up to the House of Lords, as we understand has been threatened. Should this be the intention of the Corporation, however, we would suggest that the Electrical Contractors Association (Incorporated) to which the Sheffield Electrical Contractors' Association is affiliated, should take up the case, for the decision will be of general and not merely of local importance. It is, we believe, only lack of a sufficiently large common fund that has prevented the Sheffield contractors from taking legal action already, and the parent Association should exist mainly for purposes such as this. The Association did good work last year in its successful opposition to the attempt of the London County Council to obtain wiring powers for the Metropolitan Borough Councils, and their organisation should be on such lines that this activity in similar directions may be extended.

## RECENT ADVANCES IN WIRELESS TELEGRAPHY.*

BY J. ERSKINE-MURRAY, D.Sc.

Marconi's untuned coherer system has been in use commercially on board a large number of passenger ships, and with certain variations and under many names appears to be the common system in most of the navies of the world. No doubt untuned systems are being displaced by tuned systems, but their comparative simplicity and ease in working are recommendations which in many cases outweigh their disadvantages. Marconi's untuned system is mainly used for distances under 150 miles, the reason for this limitation being that at such distances the lines of force from the charge on the aerial wire have time to reach the receiving station before the spark occurs at the transmitter. Under these circumstances an electrostatic charge suddenly discharged with or without oscillations is thus all that is necessary. About 50 sparks occur each second, and each spark lasts not more than a hundred-thousandth part of a second. Thus the horse-power of a discharge is about two thousand times that of the current supplied to the induction coil. As the latter is usually about 50 watts, each impulse sent out works, for a very short time, at 200 H.P. or 300 H.P. Thus, even if the receiver be at a considerable distance, the fraction of the impulse which reaches it is quite appreciable. No ordinary telegraph instrument, however, is able to detect a current which lasts for so short a time, hence the necessity for the coherer, which does.

What happens, then, in the sending of a signal is as follows :—(1) The aerial wire is charged, say positively, and lines of electric force spread out from it having their negative ends on the earth surface all round, some of them ending on the aerial wire of the distant receiver. (2) When the electrical pressure has become so great that the spark jumps across the gap between the aerial and the earth wire there is a sudden change in the distribution of the electricity. The negative spread out over the earth or sea and on the aerial of the receiver rushes in towards the positive, producing a current of quite appreciable voltage, though of very short duration. It is this current which actuates the receiver in passing through it from the aerial wire to the earth.

The first impulse is no doubt followed by a very short train of rapidly-decreasing waves; but the decrease is so rapid that they are of but little use in transmission. The coefficient of damping, experimentally determined, is about 0·6—*i.e.*, the amplitude of the second wave is 0·6 of that of the first, while the third wave has only an amplitude of 0·36 and the fourth of 0·21. There was little hope of preventing interference between neighbouring instruments as long as the first impulse predominated so very strongly and was capable of actuating any receiver by itself.

The methods of discrimination or tuning now employed in almost all systems depend on the principle of the superposition of small motions. In wireless telegraphy, tuned systems, and, indeed, long-distance transmission in general, depend on this phenomenon. The moving masses are masses of electricity, and the dimensions regulating their frequency of oscillation are the inductance, capacity and resistance of the circuits in which they move. Thus, if a series of small electrical impulses or waves arrive at a receiving station, each impulse being timed so as always to increase the motion of electricity in the receiving conductors, an oscillatory current will be generated of rapidly-increasing amplitude, which stores up the energy arriving until the current becomes great enough to actuate the receiving mechanism. The most obvious application of this principle to telegraphy is the discrimination between a group of sending and receiving stations by giving the members of each pair, which are intended to communicate, the same electrical dimensions, so that a transmitter, and the receiver it is intended to communicate with, have the same natural frequency. This plan has been adopted by almost all inventors, and works well. The principle has been wonderfully developed, the most strikingly successful result being that obtained by Capt. Jackson, R.N., who this year, while receiving messages from a ship at a moderate distance on the mainmast of H.M.S. *Vernon*, was simultaneously transmitting messages from the foremast to another vessel 500 miles off. This result was rendered possible by an alteration in the original Marconi receiver, which, though apparently small in itself, was of far-reaching importance. In the old receiver the coherer formed a gap of enormously high resistance between the aerial and earth wires which effectually prevented any oscillation in the receiver except the small current which might occur through the coherer plugs acting as a condenser. The coherer was simply cohered by the voltage produced in the aerial. In the new receiver the aerial wire was connected to earth through the primary of a small transformer, thus providing a path of low resistance in which oscillations could grow in amplitude as the impulses from the transmitter arrived, and a secondary circuit which could be made exactly equi-frequent with the oscillations arriving from the distant station. It rendered discrimination practicable, while at the same time it enormously increased the distance over which transmission could take place, by utilising the energy of all the waves arriving instead of only that of the first. The transmitter was next improved by the introduction of more capacity and inductance, enabling it to give out a much longer train of waves, of which, perhaps, 30 or 40 are of useful amplitude, instead of two or three in the earlier form.

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* Abstract of a Paper read before the Glasgow section of the Institution of Electrical Engineers on Tuesday.

In almost all modern tuned systems the oscillations are generated in a separate circuit by Tesla's method, and are impressed upon the transmitting aerial either by induction or conduction, the method of connection being called the "coupling," which is said to be strong or weak, according as much or little of the Tesla circuit is included in the aerial.

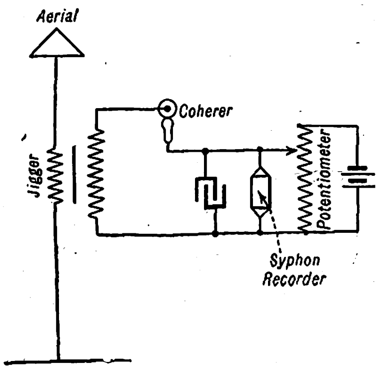

FIG. 1.

One of the first patents for a syntonic or discriminating system was that taken out by Prof. Lodge in 1897. The transmitter was practically a Hertz radiator on a large scale with some inductance introduced—*i.e.*, two equal conductors placed one above the other in a vertical line with a spark-gap between them, the connection to the spark-gap being through a few turns of thick wire. Similar conductors were used for receiving, but in place of the spark-gap was introduced the primary of a small transformer, the secondary of which was in the coherer circuit. In a somewhat modified form this apparatus has been installed at Heysham by the Midland Railway for communication across the Irish Channel.* In this case two large horizontal surfaces of conductor about 80 ft. square are placed, one at about 3 ft. above the ground and insulated from it, and the other 80 ft. above the first. Wires reach upwards from the lower sheet and downwards from the upper to the spark-gap. This forms a very persistent oscillator, and at first sight would appear to radiate free Hertzian waves. I shall show, however, later that, like all other practical wireless systems, it has in reality an excellent earth connection, which is obtained in this case by induction.

In another type of Lodge-Muirhead transmitter the lower end of the aerial is connected to a condenser, which in turn is conductively earthed through a wire having some inductance. The aerial of the receiver is connected conductively to earth through the primary of a jigger. The receiver circuit contains the secondary of the jigger, the coherer, and a condenser in series, while a syphon recorder and a source of current are in parallel with the condenser. This form has been used for military signalling and other purposes.

Mr. Marconi, early in 1900, invented a discriminating system which apparently has great possibilities both in regard to exact tuning and to reduction in height of aerial. In fact, signals were received over a distance of 30 miles with an apparatus only about 4 ft. high. *Fig.* 1 shows the apparatus employed. Its action is as follows: The metal cans form a condenser, which is charged by the induction coil; the discharge then takes place across the spark-gap, oscillating a large number of times owing to the considerable inductance and capacity in the circuit; a portion of the oscillating current is transmitted to the earth by the earth wire, since this wire is connected to a point of the circuit at which there is considerable variation of the potential during each oscillation. It is this unsymmetrical position of the earth coupling which renders transmission of energy possible. The receiver is exactly similar to the transmitter, the primary of the jigger taking the place of the spark-gap.

There is a very large number of ways in which one or two condensers and inductances may be combined with an earth and air wire to form an oscillating circuit. Transmitters of this kind, however, may broadly be divided into two classes, firstly, those in which the natural oscillation frequency of the aerial wire is utilised, and, secondly, systems in which the oscillation in the aerial is a forced one, its frequency being determined by a very persistently oscillating circuit coupled to the aerial. This latter method is becoming more and more general, as it is much more easy to obtain the persistent oscillations necessary for sharp tuning in a closed circuit than in the "open" circuit, partly conductor and partly dielectric, formed by the aerial and the earth.

At Poldhu and in his other transatlantic stations—the most recent being that in course of erection near Roundstone, Co. Galway—Mr. Marconi employs a large number of aerial wires, arranged like an inverted pyramid, all being connected at the vertex to the generating circuit and to earth. A very large electrified surface and capacity is thus obtained with the use of a very moderate quantity of conductor. At the same time the electric lines of force commence at a considerable elevation above the earth, thus facilitating their wide distribution and ensuring a sufficiently long wave-length. The wires are spread out, which gives a free path for the lines of force from each to earth, giving practically a greater capacity to the system than if they were bunched together, in which case the inner wires of the bunch would be nearly useless. The generating system contains a Tesla circuit operated by an alternator and coupled to the aerial. The receiver generally used for long distances is the form of magnetic detector, based on Rutherford's experiments and designed by Mr. Marconi. This receiver is very sensitive, and, as it contains a completely closed circuit, should be susceptible of very accurate tuning leading to a further increase of sensibility.

Mr. Fessenden uses a single aerial conductor, a great sheet-iron tube like a factory chimney about 420 ft. high. Long trains of waves of what may, for wireless telegraphy, be called low voltage, are transmitted, and receiver and transmitter have frequencies which are very exactly equalised. The transmitter to be used for transatlantic work is apparently that most recently patented by Mr. Fessenden. It is practically an alternator with one terminal connected to the aerial and the other to earth. Possibly other circuits may be introduced, but no information has so far been published. The advantage of this transmitter is that an indefinitely long train of waves of equal amplitude may be emitted. If the receiver be exactly equi-frequent, the energy of each wave may be very small as their effect is cumulative. Another patent of Mr. Fessenden's describes a system in which two trains of waves of different frequency are transmitted by one aerial, the receiver being only actuated when waves of both frequencies are simultaneously received. This system opens up great possibilities in regard to discrimination between different stations, as the combinations of two variable quantities—*i.e.*, the frequencies of both sets of oscillations—are involved instead of only the frequency of one set. A similar system has been patented by Braun.

Sir William Preece's electromagnetic system is in use between Rathlinn Island and the North Coast of Ireland. Among other systems in commercial use the De Forest, Popoff, Slaby-Arco and Braun may be mentioned. The Slabo-Arco aerial is in the form of an arch having two earth connections. The others somewhat resemble the Marconi system.

*More Recent Systems.*—Many patents for complete systems and for improvements have been taken out in the past two or three years One of these is Artom's system of polarised waves. Two separate aerials, which together form a St. Andrew's cross, are set up. They are insulated from one another and connected to earth through generators which give oscillating currents differing in phase. A circularly-polarised wave is thus sent out in a line perpendicular to the plane of the cross. The idea is that this wave will retain its form and will travel mainly in one line—*i.e.*, towards the receiving aerials. These are similar to those of the transmitter. The receiver is only actuated when oscillations with the proper phase difference between them take place in both aerials. In a more recent system on the same plan, the inventor uses three aerials with angles of 60 deg. between them. It is somewhat doubtful whether at long distances the polarised waves may not become seriously distorted by the earth's action as a conductor. At short distances, however, the arrangement seems a feasible one, and may provide a useful means of discrimination between various stations.

Marconi has patented a system in which a **U**-shaped aerial formed of two wires connected at the bottom by an inductance and spark-gap is used. An earth-connection is made to one side of the **U**.

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* *The Electrician*, Vol. LV., p. 626.

This arrangement gives a much longer train of waves than a simple aerial, and is thus susceptible of tuning. Blondel has patented a somewhat similar arrangement of two aerials, the distance in this case between the aerials being regulated to the wave-length and phase of the oscillations, so that they interfere and annul one another in a vertical plane through the wires; thus transmission mainly takes place at right angles to the plane of the aerials.

*The Action of the Coherer.*—The coherence of metal filings or surfaces was supposed at first to be due to electrical oscillations, and to be a test for their presence. I have never held the view that oscillations were necessary, believing that all that is required is merely an electrostatic field or difference of potential which causes the particles to join up in chains as do iron particles in a magnetic field. That small particles do so in an electrostatic field has been shown by Robertson and others. When the ends of the particles come within a very small distance of one another a spark passes even if the voltage be low, and the welding takes place. The action is facilitated by very gentle intermittent mechanical shocks (rapping) just as in the case of iron filings in a magnetic field. Severe shaking, of course, prevents any chains from forming, or breaks up such as have been formed.

The action of a filings coherer thus takes place in two stages—first, the movements of the particles and, second, the welding. That this view is correct has been amply proved by Dr. W. H. Eccles in an able experimental research which he undertook at my suggestion. He has also deduced a mathematical theory of the action which fits the results of experiment, and invented a method for testing coherers in the laboratory without the use of telegraphic apparatus.

*Transmitters.*—The main essential in wireless telegraphy is that the transmitter must cause a difference of potential at two ends of the receiving apparatus sufficient to cause an appreciable current to flow for however short a time through it. In most modern systems the current in the receiving apparatus flows to or from what might be called the dead end of a conductor were it not for the fact that it is very much alive. The circuit is, in fact, completed by the dielectric (the atmosphere), and in a circuit such as this, though a continuous current is impossible, an alternating one may, of course, exist and convey energy. Now the maximum potential received is definite, owing to the methods of producing it in the transmitter; it follows that the amount of electricity made to move in the receiver by the first impulse from the transmitter is also fixed, since the possible change depends on the voltage and capacity of the receiving conducting system. Now, the quantity of electricity thus being limited, it is clear that the more rapid its motion the larger its current. Thus, if a maximum value of the P.D. arriving at the receiver be, say, 1 volt, it is all-important that its rate of change should be great. If it takes a comparatively long time all the electricity movable under the circumstances may flow gently through the receiver as a very small current which does not actuate the receiver. If, on the other hand, the potential rises rapidly to its maximum, the electricity will not have had time to move appreciably before the maxium voltage is attained, and thus the current will be very much greater, though of course of less duration.

A comparatively short period and wave length is thus advantageous if but little power is available. This is realised in Hertz's radiator, which is charged comparatively slowly by an induction coil, and then discharges itself with extreme rapidity when the voltage has risen sufficiently to cause a spark across the gap between the conductors. The current in the radiator oscillates with very high frequency, and dies out in a very short time. The emitted waves are thus of great energy while they last. In the systems most in use at present the method of obtaining this sudden and energetic discharge is that of Hertz—*i.e.*, the spark. It is Hertz's method of obtaining a sudden and oscillating discharge that is the essential in wireless telegraphy, not the fact that free radiations may be produced thereby. An alternator would be quite as suitable if it were capable of giving the voltage and frequency.

Modern wireless telegraphy is not true radiation, and in the systems now in use direct radiation is a dead loss; nor is it exactly space telegraphy, for this term seems to indicate a course independent of the earth; a course which, owing to the curvature of the earth, leads straight into outer darkness. True Hertzian waves—*i.e.*, electric waves travelling unguided through space—have been used for telegraphs only to a maximum distance of a mile or two. One might almost as well try transatlantic telegraphy with a searchlight as with these.

When Marconi connected the lower ball of his Hertz radiator to the earth, he made the whole earth the lower ball. The earth and the aerial are the two conductors of the oscillator, which luckily is so unsymmetrical that it radiates very little indeed; in fact, the oscillations simply spread from their point of generation over the two conductors.

Remember direct *radiation* is dead loss in wireless telegraphy, since it means waves going straight off into space and not following round the curve of earth to their destination on this globe.

*Earth Connections.*—For the intense currents of very high frequency, which are used in wireless telegraph, a good and widespread earth-connection is most essential. It is not necessary that it should be a conducting connection, however; an inductive connection, in which the earth's surface plays the part of one plate of a condenser, is quite as effective for high frequency currents.

Wireless telegraphs may thus be divided into two large classes: (1) Conductively earthed; (2) inductively earthed. In the first class come practically all the systems mentioned except some forms of Lodge-Muirhead apparatus. To improve the earthing, Fessenden uses a large number of thick wires radiating from the lower end of the transmitter to earth plates at some little distance. He calls this arrangement a wave-chute.

In the Lodge-Muirhead station at Heysham the earthing is inductive. One large insulated plate is about 3 ft. above the earth, the other plate is 80 ft. above the first. Taking the average difference of potential between the earth's surface and the lower plate as roughly one-half of that between the plates, we find that the dielectric current between the earth and lower plate is ten times as great as it would be through the spark gap between the plates if the earth were not near. A conduction current in the earth's surface is thus induced by the proximity of the lower plate, and the waves are guided by the earth's surface as in conductively earthed systems. Radiations approximately resembling on a large scale those used by Hertz would not be obtained by this transmitter unless it were placed at least 800 ft. or more above the earth's surface on a perfectly insulating support.

If Hertz had placed one end of his vertical oscillator within a small fraction of an inch of a horizontal sheet of copper, he would not have obtained free radiations, but a result which on the proper scale would resemble the transmission at Heysham. As it is, it seems probable that the inductive earthing in this case will prove as effective as an elaborate conductive system, and at the same time the advantages of a very persistent oscillator will be retained.

*The Limit of Distance in Transmission.*—The propagation of a hemispherical electric wave, in which the lines of force have their ends on a conducting plane surface has been investigated by Heaviside, and from a wireless telegraphist's point of view by Blondel. Neglecting the curvature of the earth, the form of the wave is approximately the same as would be produced by removing the earth and putting another wire downwards from the spark-gap, this wire being equal in length to the aerial, and oppositely charged at every moment. If the electric waves used in wireless telegraphy retained this form we should find that the currents resulting from their action on the receiving aerial would vary inversely as the square of the distance. This does not, however, agree with Duddell and Taylor's measurements—the only definite measurements as yet published—of the variation of the received current with distance. They find* from experiments made between a station at Howth and H.M.T.S. "Monarch" in the Irish Channel, that the current at distances beyond 10 or 15 miles varies in almost exactly simple inverse proportion to the distance between the stations. This result admits of no question, the experiments having been carried out most carefully and with wonderfully concordant results. We must, therefore, accept the fact and look for an explanation in some circumstance which modifies the hemispherical waves originally given out by the transmitter when they attain a radius of about 10 miles.

I find that there is an explanation lying ready to our hand, which is based, not upon theory, but on the well-ascertained facts of the nature of our atmosphere. Put briefly, it is as follows: If the earth were surrounded by a spherical shell of conducting material it is a well-known fact that the waves would not die away in proportion to the square of the distance, but would vary, for moderate distances, in inverse proportion to the distance itself. Now, recent researches on auroræ by Danish observers have proved that these occur sometimes as low as 6 miles above the earth's surface and never at a greater height than 60 miles. An aurora is an electric conduction current; hence the layer of air between 6 and 60 miles above the earth is conductive. Here we have, then, the explanation of Duddell's law of variation with distance. The approximately spherical wave given out by the oscillator rises till it touches the conducting layer, then becomes annular, and travels outwards with a wave-front, the area of which no longer increases as the square of the distance, but only in proportion to the distance itself, since the wave is confined by the parallel conducting surfaces above and below. Thus the only space variation which causes diminution in strength is the increasing radius. There is, of course, in addition, a frictional loss of energy which we shall consider later.

If we take the curvature of the earth into account, and proceed to trace the variation of the wave front at greater distances than those of Duddell's experiments, which only extended to 60 miles, we find from simple mathematical, or rather geographical, considerations that the radius of the circle in which the wave-font cuts the globe is directly proportional to the sine of the angle at the earth's centre subtended by the arc of the surface between the transmitter and the wave-front. This agrees with Duddell's law because for small distances sin $\theta$ is nearly equal to $\theta$. For greater distances, however, the divergence becomes less and less, and at distances beyond 6,000 miles—*i.e.*, beyond $\theta=\pi/2$, the waves converge, and the current should increase with distance. This is true on any theory, as the wave-front is becoming a smaller and smaller ring, continually converging from all sides towards the antipodes of the transmitting station.

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* *Journal* of the Institution of Electrical Engineers, July, 1905.

The equation for the received current is thus of the form

$$c=\frac{C}{\sin\theta}; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (A)$$

where $c$ is the received current, $\theta$ the angle defined above, and C a constant. Fig. 2 gives a rough representation of the lines of electric force as they spread from the transmitter outwards.

The above law of variation of the received current with distance is obviously not complete. We have so far supposed that the lowest layer of the atmosphere is a perfect dielectric, and that the earth and upper atmosphere are perfect conductors, *i.e.*, that no dissipation of energy is involved, the decrease of current being simply due to increase in area of the wave-front. We must now take account of frictional losses, in order to complete the law as far as possible; though with the data at present available only a rough approximation can be attempted. It will be possible to amplify the equation when further measurements have been made, and to determine more exactly the functions and constants involved.

The first indication of a true frictional dissipation of energy in transmission was found in Mr. Marconi's discovery that messages could be received at much greater distances during the night than by day. There cannot be much difference between the divergence variations by night and day, as the earth does not change its shape; this phenomenon has therefore to be explained by some difference in the electrical properties of the transmitting media. Now the conductivity of the earth cannot be seriously altered by the sun's rays; the atmosphere, however, may be much affected. Cosmical science has made many striking advances lately, and it is now practically certain that streams of electrified particles, resembling the cathode rays, are ejected from the sun with a very high velocity. These penetrate the earth's atmosphere on the day side, electrifying it, and at the same time ionising it, thus rendering it more conductive. During the night equilibrium becomes slowly restored, and towards 5 o'clock in the morning a very marked minimum of atmospheric electrification has long been known to exist. The time at which signals go furthest thus coincides with a minimum conductivity of the lower layers of the atmosphere, while greater conductivity of the lower layers during the daytime coincides with greater difficulty in transmission.

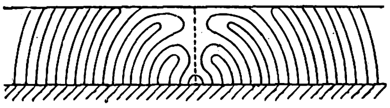


FIG. 2.

Now an electric wave must have either an all-dielectric medium or a dielectric bounded by conductors; it cannot penetrate far through a conductor. Thus if all the atmosphere were conductive the wave would travel only a very short distance before being dissipated by resistance, and transmission to a great distance would be impossible. The conditions would be similar to an attempt to transmit current along a concentric cable with bad insulation between the conductors. The good insulation is just as essential as the conductors. We may take it, then, that during the night the lowest 10 miles of the atmosphere is a good dielectric, while during the day it becomes slightly conductive. To obtain a rough estimate of the amount of this dissipation we may take Mr. Marconi's statement that 500 miles during the day is equivalent to 1,000 by night. The variation is not so noticeable at short distances, being in this case so very much less important than the divergence, though it is distinctly traceable in Duddell and Taylor's results. Let us assume that the law of divergence is that given above (equation A)—*i.e.*, that the undissipated current would vary inversely as the sine of the angle between the places, or approximately, for the distances under consideration, inversely as the distance along the earth's surface.

We then have Duddell's law $C\times D=\text{constant}$ where C is current received, and D is distance between the stations.

Now assume as a first approximation that there is no dissipation at night; then the current lost by divergence only, between 500 and 1,000 miles at night is all spent by dissipation during the day before 500 miles is reached. Again, the divergence alone between 500 and 1,000 miles would reduce the current to one half, since 1,000 is twice 500. Therefore the current at 500 miles during the night is twice the current which will just work the receiver. The current lost by dissipation during the day throughout 500 miles is therefore equal to that which will just work the receiver. We have thus obtained an approximate value of the dissipation from Mr. Marconi's experiments. If we call the minimum working receiver current of Mr. Marconi's receiver M then the current lost through dissipation is roughly M/500 mile.

This dissipation is no doubt a function of the distance, the form of which I hope to be able to determine later. It is also, of course, a function of the state of the atmosphere, as regards electrification, and varies from a minimum in the very early morning to a maximum in the evening. In the meantime we may take M/500 as a rough approximation to its average mid-day value under the circumstances considered.

The approximate equation $c=C/\sin\theta$ for propagation of signals then becomes

$$c=\frac{C}{\sin\theta}-\frac{M}{500}d \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (B)$$

where $c$=received current, C=a constant, M=minimum current which will actuate receiver, $d$=miles distance, and $\theta$=angle subtended at centre by arc $a$.

Now since $d/3{,}500=\theta$, approximately, since the earth's radius is 3,500 nautical miles. $\therefore d=3{,}500\theta$. To determine C from (A) we notice that $c=C$, if $\sin\theta=1$—*i.e.*, if $\theta=\pi/2$. C is thus the value of $c$ at 5,400 nautical miles, or an earth quadrant from the transmitter during the night—*i.e.*, when *no* dissipation. We may state it as $C=kM$ if we like to take M as a unit—*i.e.*, the undissipated current at 5,400 nauts. is $k$ times that necessary to work the receiver.

The equation then becomes

$$c=M\left(\frac{k}{\sin\theta}-7\theta\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (C)$$

To find the limit of distance with any given power we must have $c=M$—*i.e.*, the current at the receiver is just the smallest possible working current.

The equation (C) then becomes

$$1=\frac{k}{\sin\theta}-7\theta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (D)$$

or

$$k-\sin\theta\,(7\theta+1)=0. \quad . \quad . \quad . \quad . \quad . \quad (D^1)$$

The number 7 in this equation is only a rough approximation, suitable to the case under consideration. It should properly be replaced by some function of $\theta$.

Let us now consider Duddell and Taylor's results for shorter distances in the light of this explanation. Remarking on the slight decrease in the product C × D at long distances, they suggest reflection from the Hill of Howth as a cause, mentioning that another possible, but apparently less probable, explanation is that the cross-channel runs were made in damp, misty daylight, while the up-and-down channel course was made in the night and early morning with a clear frosty atmosphere. To me this latter suggestion is far more probable than the first. We know that such a difference exists from Marconi's results. It is worth while to attempt to derive it from Messrs. Duddell & Taylor's measurements. We may take from their curves the following data, comparing the day and the night experiments.

1. *Night.*—"MONARCH" COMING SOUTH TOWARDS HOWTH.

| | | | |
|---|---|---|---|
| Distance off Howth | 18 | 36 | Miles. |
| C × D | 3,850 | 3,820 | Microamperes × miles. |

Thus at 18 miles the current was 214 m.a. and at 36 miles 106·1 m.a.

Now, by divergence alone the current would at 36 miles have been one half that at 18 miles—*i.e.*, 107 m.a. The dissipation loss is thus 0·9 m.a. in 18 miles, or roughly 0·05 m.a. per mile on 214 m.a.

2. *Day.*—In a similar way we may obtain by averaging curves, representing the same quantities on the voyage to Holyhead and back during the day, the value 7·2 m.a. lost between 30 and 60 miles off Howth. This amounts roughly to 0·24 m.a. per mile on a maximum current of 120 m.a. Reducing the result given in (1) to suit this maximum current, we see that the dissipation by night is to that by day in the ratio of about 0·025 to 0·24—*i.e.*, the dissipation during the day is approximately 10 times as much as at night. Messrs. Duddell & Taylor attempted to measure the day and night variation between Howth and Kingstown, but did not find as much as 1 per cent. difference. This was natural, as these points are only about 6 miles apart, hence the total dissipation was very small in both cases. The difference of the values for night and day which I have deduced above would barely amount to 1 per cent. of the total in 5 miles. Comparing the value of the dissipation determined from Marconi's experiments with that obtained from Duddell & Taylor's, we find that they are of the same order of magnitude. Nearer than this we cannot at present go, since the minimum working current of Marconi's long-distance receiver is not known.

In the present communication it is impossible to develop the subject further; I hope, however, that I may have an opportunity later of amplifying and substantiating the main framework of the theory which I have given. Doubtless it is very rough, and in many parts incomplete, but it will, I hope, form a foundation for a more thorough explanation of wireless telegraphy.

## DISCUSSION.

Prof. F. G. BAILY thought it was much better to earth the lower plates provided this was efficiently done. He was not prepared to accept the theory of the layer of conducting atmosphere, though he foretold the law of variation with the distances in a Paper recently read in Edinburgh. He pointed out that it is well known that one cannot get good results in telegraphing over dry land on account of not being able to get a good earth, and thought this was the reason of the failure in South Africa. The inverse, as distance law could only be proved over long distances by sea, and not over small distances on account of the depth. He believed the lines of force would not take the form shown by Dr. Murray, even if he abandoned his idea of the conducting layer of atmosphere, and he rather thought that they would take the form of small waves which would spread out in annular rings.

Prof. JAMIESON referred to the experiments carried out by Mr. Maskelyne in London.

Mr. MAVOR asked if Dr. Murray could give any idea of the amount of power used in telegraphing over long distances.

Dr. ERSKINE MURRAY, in reply, said that he did not agree with Prof. Baily's remarks in regard to the wave form, and he thought the more reasonable supposition was that the waves took the form indicated by him in the Paper, though he was not sure that there was very much data to go on. With regard to telegraphing over dry land, he pointed out that the Germans had succeeded in working in Demeraraland over very dry sandy land with good results, though, of course, they used very large conductors well spread out, both at the transmitting and receiving ends. Regarding the question which had been asked as to the amount of power used in telegraphing over long distances, he thought that this would be somewhere in the order of 200 H.P.

## ANNUAL DINNER OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

The seventeenth annual dinner of the Institution of Electrical Engineers was held in the Banqueting Hall of the Hotel Cecil on Friday last, the President, Mr. John Gavey, being in the chair. About 400 persons were present, amongst whom were the following:—

Lord Strathcona (*High Commissioner for Canada*), Sir Joseph Swan, Major-Gen. Sir A. E. Turner, Sir George Murray (*Joint Permanent Under-Secretary of the Treasury*), Sir Alexander Binnie (*President of the Institution of Civil Engineers*), Sir Norman Lockyer, Sir J. C. Lamb, Col. Sir H. Jekyll (*Assistant Secretary of the Board of Trade*), Sir Charles Owens (*General Manager of the L. & S. W. Railway*), Sir A. B. W. Kennedy (*Vice-President of the Institution of Civil Engineers*), Sir William Arbuckle (*Agent-General for Natal*), Sir Henry Tanner (*Architect of H.M. Office of Works*), Sir Robert Hunter (*Solicitor to the Post Office*), the Hon. John G. Maydon (*Minister of Railways in Natal*), Prof. Dr. E. Budde (*President of the Verband Deutscher Elektrotechniker, Berlin*), Mr. H. H. Conynghame (*Assistant Under-Secretary of the Home Office*), Mr. H. Babington Smith (*Secretary of the General Post Office*), Mr. T. R. Price (*General Manager of the Central South African Railways*), Brigadier-Gen. R. N. Ruck (*Director of Fortifications and Works*), Dr. T. E. Thorpe (*Director of Government Laboratories*), Lieut.-Col. H. A. Yorke (*Chief Inspecting Officer of Railways, Board of Trade*), Mr. Charles Hawksley, Mr. A. B. Kempe (*Treasurer of the Royal Society*), Capt. A. M. Field (*Hydrographer to the Admiralty*), Mr. T. Matthews (*Engineer-in-Chief to the Trinity House*), Mr. A. Ross (*Chief Engineer to the Great Northern Railway*), Mr. J. Young (*General Manager of the Metropolitan District Railway*) Mr. Leslie S. Robertson (*Secretary of the Engineering Standards Committee*), Mr. J. McDermott (*President of the Electrical Contractors Association*), Mr. O. R. H. Bury (*General Manager of the Great Northern Railway*), Dr. B. A. Whitelegge (*Chief Inspector of Factories and Workshops, Home Office*), Mr. W. Frecheville (*President of the Institution of Mining and Metallurgy*), Dr. E. Rivers (*President of the Society of Chemical Industry*), Mr. J. Ardron (*Assistant Secretary of the General Post Office*), Mr. W. Hosken (*Member of the Legislative Council of the Transvaal*), Prof. R. Meldola (*President of the Chemical Society*), Mr. Balfour Browne, K.C., Col. R. E. Crompton, Mr. Alexander Siemens, Mr. C. E. Spagnoletti, Mr. R. Kaye Gray, Mr. James Swinburne, Mr. W. H. Patchell, Dr. R. T. Glazebrook, Prof. John Perry, Mr. R. Hammond, Mr. W. M. Mordey, Mr. J. E. Kingsbury, Mr. S. Z. de Ferranti, Mr. Frank Gill, Mr. C. H. Merz, Mr. C. H. Wordingham, and the Rev. Dr. J. Gow, Headmaster of Westminster School.

After the loyal toasts had been proposed and duly honoured, the chairman announced that Mr. R. W. Perks, who was to have proposed the toast of the Institution of Electrical Engineers, was unfortunately prevented by illness from attending. This toast was, therefore, proposed by Mr. Babington Smith (secretary of the General Post Office).

Mr. BABINGTON SMITH referred to the close connection which has always existed between the Post Office and the Institution, especially in the earlier days of its history. He mentioned the well-known names of Webber, Scudamore, Preece, Gray, and, lastly, the President himself, to whose skill and judgment he paid high tribute. The speaker dwelt on the enormous advances in electrical engineering since the foundation of the Institution, as the Society of Telegraph Engineers, 34 years ago. He foresaw no limit to that progress in the future, and was assured that the Institution would continue to play a leading part in that progress which was one of the most important factors in the progress of the world.

Mr. GAVEY, in his reply, stated that in carrying his mind back through the period mentioned by the last speaker, it was difficult to realise the magnitude of the progress which has been made. At that time the telegraph engineer was almost the sole representative of electrical work, and submarine telegraphy was only in its infancy. As to the condition of electrical measurements, he did not like to say what state that subject was in. Within a few years from the founding of the Institution, however, the system of units now universally in use was devised, but it was not until these units had been used for 10 or 15 years by British engineers that they were "discovered" by Continental workers and legitimatised throughout Europe. Electrical engineering, he concluded by saying, has invaded all industries, increasing everywhere the output and diminishing the cost of production, as will be found recorded in the book of the chronicles of the Institution of Electrical Engineers.

Sir A. B. W. KENNEDY, in moving the next toast, that of "The Electrical Industries," spoke of the very sound basis upon which the electrical industries, although but young, are founded. No industry, he said, was so intimately in contact with the results of scientific experiment and discovery, and, on the other hand, no industry had done so much to advance the very science to which it owes its origin. The toast was coupled with two names, first that of Mr. E. Cunliffe Owen, to whose personal endeavours the very marked success of the recent Olympia Exhibition was due, and secondly, that of the President of the Verband Deutscher Electrotechniker. He hoped that Dr. Budde had not come over from Germany for the sake of upbraiding us over here for stealing back to these shores our old friend, Dr. Gisbert Kapp, and assured him that whatever halfpenny papers might say, we all wished success to the electrical industries of Germany as cordially as to our own.

Mr. CUNLIFFE OWEN, in his reply, attributed much of the success of the Olympia Exhibition to the prestige of the Institution of Electrical Engineers, whose influence in many ways was of valuable assistance, and who had arranged a very successful series of lectures. He was able to announce that the success of the exhibition had resulted in a surplus, out of which a return of 25 per cent. of the money paid for space would be made to every exhibitor, this absorbing more than £2,000. After this a further sum remained, the exact amount of which he was unable to announce at present, but he was pleased to say that in addition to a handsome donation to the Benevolent Fund of the Manufacturers Association, a grant of £250 would be made to the Institution's own Benevolent Fund.

Dr. BUDDE then rose and expressed in well-chosen words the cordial greetings of the German electricians, and congratulated the Institution on having been the first society of this nature to go abroad and see for itself the progress in foreign countries, as the contact between scientists and technical men in all countries could not be too close.

The toast of "Our Colonies" was proposed by Mr. ALEXANDER SIEMENS, who emphasised how important a factor submarine cables were in promoting the cohesion of the Empire; indeed, he was almost tempted to believe that the colonies were scattered about in various parts of the world solely in order to be connected by submarine cables. He knew from personal experience, both from his recent visit to South Africa and his earlier travels in Canada and elsewhere, how true was the feeling and how close were the ties which bound the Empire together.

The Hon. J. G. MAYDON (Minister of Railways in Natal), in an interesting speech, dwelt on several aspects of the Colonial question, and expressed the belief that in many cases the only danger was too much contentment with things as they are and too profound a belief in their continuance for ever and aye. He spoke of the situation in South Africa, and expressed the hope that in his lifetime the unification of South Africa would come to pass.

Mr. W. M. MORDEY, in proposing "Our Guests," welcomed so many representative men in various walks in life. He welcomed the railway men, to whom he extended his sympathy on account of the way in which their traffic receipts had been affected by the competition of electric tramways, but his sympathy was modified by the fact that they are recognising that in this case "like cures like," and he assured his railway friends that they could not do better than place themselves unreservedly in the hands of the electrical engineers. In addressing the scientific men, he said we wanted their help badly. In view of the limited nature of the coal supplies in the future it was sad to reflect that not more than 1 or 2 per cent. of the energy of the coal used in electric generating stations ever received useful application, and whereas, in the case of the glowworm 99 per cent. of the radiation was light and the rest heat, in most electric lamps only about 1 per cent. was light and the rest heat.

Sir ALEXANDER R. BINNIE replied for the guests, and declared that the great industry for which the Institution of Electrical Engineers has done so much during the last 35 years had not only caused a remarkable amount of employment which would otherwise not have existed, but had brought into more intimate relations the minds of all peoples of the world and done much, by rubbing off the rough edges of nationalities, to make us feel that we are a great concourse of human beings who should work together for each other's good.

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Proceedings of the Royal Society." Series A, Vol. LXXVI., No. A513. Mathematical and Physical Sciences. (London: Harrison & Sons.) 3s.

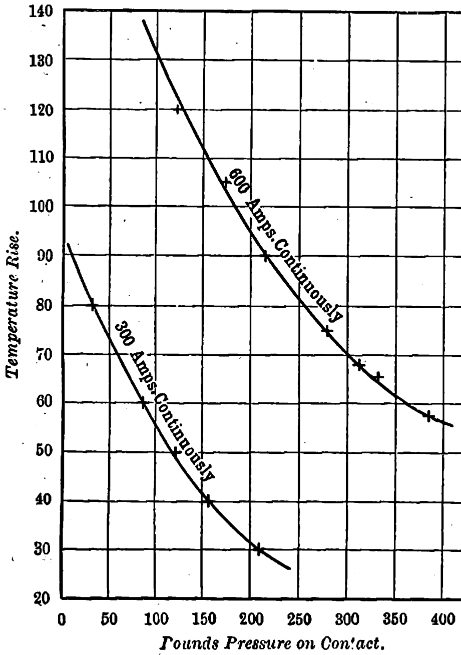
"Handbook on British Patents for Inventions; also Referring to Colonial and Foreign patents." (London: Day, Davies & Hunt.) 6d.

"Mica; its Occurrence, Exploitation and Uses." By Fritz Cirkel. (Ottowa: The Government Mines Branch.)

"Ueber den Gegenwärtigen Stand der Frage nach einer Mechanischen Erklärung der elektrischen Erscheinungen." By Hans Witte. (Berlin; E. Ebering.) 7.50m.

## AUTOMATIC TRAIN CONTROL.

An interesting Paper on "Automatic Train Control" was read at the Students' Section of the Institution of Electrical Engineers on November 29th. Detailed descriptions of the various systems were given and the Paper was well illustrated. T. H. Schoepf, of the Westinghouse Company, communicated some interesting tests on temperature rise in pneumatically-operated electric switches. He also emphasised the flexibility of this system and the power which can be concentrated in a small space, in the turret controller where the switches are operated from a pneumatic cylinder connected thereto by means of a lever, as well as in the rectangular controller where the switches are connected directly on to an extension of the piston rod. In either of these controllers the switch closes with a quick and steady motion, the contact pieces first closing at or near the tip, and as the piston rod moves forward the contacts roll and slide one on the other, finally resting at the heel and under the full pressure of the air against the piston. This motion between the switches has the effect of keeping the contact pieces perfectly clean, with the result that the carrying capacity of the switch is always a maximum.



The temperature tests shown in the curves above were obtained upon a switch having contacts 1 in. in width and with various pressures on the contact. The piston was 2¾ in. in diameter and the several pressures on the contact were obtained by varying the pressure per square inch of the compressed air admitted to the cylinder.

## PROPOSED EXTENSIONS AT THE GLASGOW CORPORATION ELECTRICITY WORKS.

At a meeting of the Special Electricity sub-committee of the Glasgow Corporation, appointed to consider the question of obtaining additional generating plant for the Corporation electricity works, it was agreed to recommend that application be made to the Secretary for Scotland for additional borrowing powers to the extent of £300,000 in order to meet the capital expenditure on the additional plant proposed, including street mains, cables, and consumers' mains and meters.

In his report on the electricity department, the present engineer (Mr. W. W. Lackie) refers to the extensions of plant now completed, which Mr. Chamen recommended in 1903, at a cost of £130,000. At the present rate of increase this provided for supply until the end of the winter, 1905-1906, and with slight additional expenditure on feeders and sub-station plant, until the end of winter 1906-1907, assuming that the tramways supply remained undisturbed. This was not the case, however, and in another year or 18 months any spare power they had would be fully taken up. The extended use of double-decked cars had necessitated a much greater demand for power. The plant now laid down aggregated practically 27,000 H.P. The demand on the generating stations during the current winter would be at least 24,000 H.P., which only left 3,000 H.P. to meet the increased demand of the winter 1906-1907. The annual increase during the last three years, however, had been more than this, amounting to nearly 4,000 H.P. Thus no spare plant will exist, and in the event of breakdowns to any of the larger generating sets, the supply would be defective.

The report proceeds to state that if the extension of plant now necessary is carried out with 4,500 H.P. turbines, there will be in 1910 54,000 H.P. available. It will then be time enough, in the engineer's opinion, to consider the installation of generating plant of 7,000 H P. or 10,000 H.P., and any other extensions of buildings at Port Dundas or elsewhere might be designed towards this end.

Two schemes are proposed for the extensions. The first is the installation of four new turbine-driven sets, aggregating 18,000 H.P. The first two sets to be laid down during the year 1907, and the second two sets in 1909. The cost of this generating plant alone would be £65,288. The total capital expenditure for buildings, plants, mains, &c., in connection with these extensions would amount to £120,000.

The second scheme is the installation of three turbo-generator sets, aggregating 22,500 H P. The first two sets to be laid down in 1907 and the third in 1910. The total cost of these would be £73,605, and the expenditure on buildings, plant, and mains about £1,000,000

The special sub-committee, having carefully considered the report, unanimously agreed to recommend that in the meantime two additional turbo-generators of 4,500 H.P. each be provided, and that the engineer be authorised to prepare specifications for the necessary additional motor-generators and switchboards, &c., required in connection therewith.

The first proposal was that £240,000 should be borrowed, but in the meantime the Tramway committee intimated that they would not be able to continue to carry out the present arrangement by which they supply a certain quantity of current to the Electricity Department. It would not be possible to continue the supply either to St Andrew's Cross station or to Waterloo-street sub-station after the winter of 1906-1907, or to the French-street sub-station after the winter of 1907-1908, as all the current generated at the Pinkston Power Station will, after the latter date, be required for tramway purposes.

The engineer thereupon reported that, in the circumstances, it would be necessary to put down, in addition to what was already recommended, another 4,500 H.P. set at the St. Andrew's Cross station. It was estimated that the capital expenditure on the plant, mains and buildings referred to would be £35,500, making the total expenditure on additional plant and buildings to meet the demand of the winter of 1906-7 and 1907-8, £275,000.

The sub-committee recommended that the engineer be authorised to obtain and submit offers for this third set with the necessary boilers, &c.

## CORRESPONDENCE.

### WAVE MEASURES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think it would have been well if the Gesellschaft für Drahtlose Telegraphie, before making an attack on my Cymometer and claiming that it is anticipated by their patents, had made themselves a little better acquainted with the facts. For the sake of your readers who may not be familiar with the invention covered by the letters patent which are mentioned merely by numbers in the letter of the Gesellschaft für Drahtlose Telegraphie in your issue of December 8th, I may mention that these specifications cover a description of the instrument commonly known as the Dönitz Wave Meter, which was described in *The Electrician* for January 1, 1904, Vol. LII., p. 407. The corresponding British patent, No. 18,181, of August 22, 1903, granted to Dr. Adolf Franke, describes the instrument as illustrated in *The Electrician* of the above date. (No. 1,818, which is the number written in their letter by mistake for 18,181, does not concern wireless telegraphy at all, but is a patent for improvements in methods of attaching ladies' hats to their heads.) Of the other patents mentioned in their letter, No. 149,350 is a German patent granted to the Gesellschaft für Drahtlose Telegraphie for the same invention, and the United States patent, No. 763,164, of September 15, 1903, includes also the same subject-matter, but is granted to Johannes Dönitz. These specifications cover a description of "Apparatus for determining the length of waves and observing the oscillations in electric oscillation systems," which consists of a condenser of variable capacity, composed of a number of plates which can be moved more or less into contiguity with each other, resembling in some degree the fixed and movable plates of a Kelvin multicellular voltmeter. Associated with this variable condenser are a number of interchangeable inductance coils and a form of hot-wire ammeter, which German writers generally describe as the Riess electric thermometer, but which as a matter of fact was originally devised by our countryman, Sir William Snow Harris, and described by him in the *Phil. Trans. Roy. Soc.*, London, of 1827. The above-described instrument is simply an oscillation circuit, the capacity and inductance of which can be varied independently in a certain manner. No patentee at the present time has any claim to monopolise a closed oscillation circuit in which the capacity and inductance can be varied independently with the object of making it resonant with any other circuit. It will be sufficient to refer to the experiment of Sir Oliver Lodge, described in *Nature*, Vol. 41, p. 368, February 20, 1890, and commonly called the syntonic Leyden jars, or to the well-known experimental researches of Bjerknes described in the *Annalen der Physik* for 1891 and 1892, or the theoretical discussion of the problem of resonance by A. Oberbeck in the *Annalen der Physik* for 1895, in proof that the mere adjustment of the oscillation period of one circuit to make it agree with that of another by varying the capacity and inductance cannot be claimed by anybody apart from a special and particular form of apparatus. All that an inventor can claim is some particular form of apparatus "substantially as described." All the claims in the British and United States patents granted to the above-named patentees are thus limited to cover the particular devices illustrated.

In my Cymometer the variable capacity consists of a sliding tubular condenser, and the inductance of a spiral of bare wire very openly wound. The particular characteristic of my instrument is that the *capacity and inductance are varied together and in the same proportion by one movement of a handle* and that the condition of resonance is determined by the employment of a sensitive Neon vacuum tube connected across the terminals of the condenser. The use of a Neon tube for this purpose is covered by a separate patent in Great Britain, No. 13,736A, granted to me as from June 17, 1904. The Gesellschaft für Drahtlose Telegraphie, in their letter to you, quote against me their United States patent No. 763,164. It may interest them to know that when I applied for a patent for my Cymometer in the United States on February 8, 1905, this particular Dönitz patent, No, 763,164, was put forward by the United States Patent Office Examiners as a possible anticipation of my application, but when the important characteristic differences between the invention of Dönitz and my own had been explained to them, the United States Patent Office granted to me almost immediately afterwards a patent, No. 804,190, on November 7, 1905, containing 11 wide claims, which are as follows:—

1. The combination of a condenser, a coil in series with the condenser and means for *simultaneously varying* the capacity of the condenser and the inductance of the coil in the same proportion.*

2. The combination of two conducting-surfaces; a dielectric between the surfaces; a coil having one end connected to one of the surfaces; a contact-maker resting on the coil and connected to the other surface; and means for *simultaneously moving* the two surfaces and the coil and contact-maker relatively to each other respectively.

3. The combination of two conducting-surfaces; a dielectric between the surfaces; a coil having one end connected to one of the surfaces; a contack-maker resting on the coil and connected to the other surface; means for *simultaneously moving* the two surfaces and the coil and contact-maker relatively to each other respectively; and a vacuum-tube carried by one of the surfaces.

4. The combination of two concentric metallic cylinders; a non-conducting cylinder fixed to and projecting beyond one of them, such cylinder being adapted to fit between the two metallic cylinders; a coil wound on the projecting portion of the non-conducting cylinder and having one end connected to one of the metallic cylinders; and a contact-maker resting on the coil and so connected to the other metallic cylinder that it always occupies the same position relatively to it.

5. The combination of two concentric metallic cylinders, a non-conducting cylinder fixed to and projecting beyond one of them, such cylinder being adapted to fit between the two metallic cylinders; a coil wound on the projecting portion of the non-conducting cylinder, and having one end connected to one of the metallic cylinders; a contact-maker resting on the coil, and so connected to the other metallic cylinder that it always occupies the same position relatively to it; and a metallic bar interposed in the circuit between the two metallic cylinders.

6. The combination of two concentric metallic cylinders; a non-conducting cylinder fixed inside and projecting beyond the outer metallic cylinder, such cylinder being free to move outside the inner metallic cylinder; a coil wound on the projecting portion of the non-conducting cylinder, and having one end connected to the outer metallic cylinder; a metallic bar connected to the inner metallic cylinder; and a contact-maker fixed to the bar and resting on the coil.

7. The combination of two concentric metallic cylinders, a non-conducting cylinder fixed to and projecting beyond one of them, such cylinder being adapted to fit between the two metallic cylinders; a coil wound on the projecting portion of the non-conducting cylinder and having one end connected to one of the metallic cylinders; a contact-maker resting on the coil and so connected to the other metallic cylinder that it always occupies the same position relatively to it; and a glow vessel carried by the outer metallic cylinder.

8. The combination of two concentric metallic cylinders, a non-conducting cylinder fixed to and projecting beyond one of them, such cylinder being adapted to fit between the two metallic cylinders; a coil wound on the projecting portion of the non-conducting cylinder and having one end connected to one of the metallic cylinders; a contact-maker resting on the coil, and so connected to the other metallic cylinder that it always occupies the same position relatively to it; a metallic bar interposed in the circuit between the two metallic cylinders; and a glow vessel carried by the outer metallic cylinder.

9. The combination of two concentric metallic cylinders; a non-conducting cylinder fixed inside and projecting beyond the outer metallic cylinder, such cylinder being free to move outside the inner metallic cylinder; a coil wound on the projecting portion of the non-conducting cylinder and having one end connected to the inner metallic cylinder; a contact-maker fixed to the bar and resting on the coil; and a glow vessel carried by the outer metallic cylinder.

10. An apparatus for measuring the lengths of electric waves, comprising a closed circuit containing inductance and capacity, the elements of the circuit being so constructed and arranged that *the movement of a single part will simultaneously vary the inductance and capacity of the circuit.*

11. An apparatus for measuring the lengths of electric waves, comprising a closed circuit containing inductance and capacity, the elements of the circuit being so constructed and arranged that *the movement of a single part will simultaneously vary the inductance and capacity* of the circuit; a pointer connected to the movable part; and a scale with which the pointer co-operates.

Nothing, therefore, could be a more conclusive proof that my invention is not anticipated by that of Dönitz than that the United States Patent Office, having his patent before them, granted me the above-mentioned claims, even in spite of the existence of the United States patent No. 763,164, on which your correspondents rely to discomfort me.

As regards their expression of opinion on the merits of my instrument in practice, that it is not a technical improvement, this is, of course, an *ex parte* statement. It may interest them to know that unbiassed authorities, experts in wireless telegraphy who have had the Cymometer under trial, have formed a very favourable opinion of it. It has the great advantage that it can be used by anyone without the slightest expert knowledge or any calculation to determine the frequency of the oscillations in a circuit, and therefore the length of waves emitted from a radiative circuit. Moreover, the Neon tube is far more sensitive than a hot-wire ammeter. A further advantage is that my instrument can be very loosely coupled with the circuit under test, as the damping in the instrument itself is very small. The opinions of those who have used the instrument do not therefore coincide with those of your correspondents, who are naturally prejudiced in favour of the instrument they own.

So far from the independent variation of inductance being a desirable thing, I take it to be a disadvantage, and that the useful characteristic feature of instruments of this kind should be that of indicating directly without any calculations the oscillation constant of the circuit under test, the wave-length emitted (if it is radiative) in feet and metres, and the frequency of the oscillations in the circuit being examined, which is achieved by my instrument.—Yours, &c.,

Pender Electrical Laboratory, J. A. FLEMING.
University College, London, Dec. 12.

## WAVE-SHAPES AND THREE-PHASE TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to Mr. M. B. Field's letter in your issue of last Friday, the enclosed oscillograms, taken from my Paper to which you referred in your number of November 17th, may possibly illustrate some of his remarks. The case of a three-leg three-phase transformer presented itself as offering certain difficulties, but the problem is solved when one considers that the iron in each leg is magnetised, not only by the coils on that leg, but also by the coils on the other two, so that there is no reason why the wave forms of the three magnetising currents should be similar. To test this, a three-core transformer was built and it was carefully arranged so that the two end cores should be symmetrical in all respects with regard to the centre core, special attention being paid to the joints in the iron. Tests with single-phase current showed that the desired symmetry had been obtained: but on applying a set of three-phase three-wire star E.M.F.s the wave-forms lost their similarity, and took the forms of Figs. 1, 2 and 3, from which it will be seen that the centre leg provided a smaller magnetomotive force than the two end cores, the ratio of the effective currents being 1 to 1·48 (the ratio of the single-phase magnetising currents was 1 to 1·25).

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* The italics in the above repetition of the claims in my U.S.A. specification are merely inserted here to draw attention to important words.

In this case the condition which determined the way in which the magnetomotive force was divided at any instant was that the algebraic sum of the three currents was zero. But if the neutral point of the star be connected to the neutral point on the generating system, the currents can arrange themselves at will, and the determining condition is that of minimum loss of energy. On making this connection, the dissimilarity of the curves became still more marked, as shown in Figs. 4, 5 and 6, which show that the middle core now does very little towards the magnetising of the cores. This, then is the secret of the "mutual accommodation."

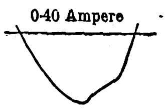


Fig. 1.

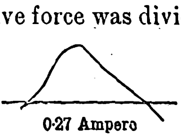


Fig. 2.

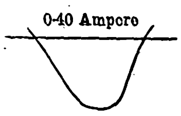


Fig. 3.

In these experiments the applied E.M.F. waves were obtained by transformation from a rotary converter, and were thus very close approximation to sine waves. If, however, we apply waves containing triple-frequency harmonics, the curves are completely altered owing to the fact that the transformer has to act as an "air-core choking coil" with respect to the triple-frequency flux. Using a monotooth three-phase generator giving a 30 per cent. triple-frequency harmonic, the curve of magnetising current to the middle core was that shown in Fig. 7 when the transformer was *three*-wire star connected (neutral insulated), the effective value of the current being only 0·28 ampere. On connecting up the neutral wire, which permitted the triple frequency components of E.M.F. to become active, the magnetising current took the form of Fig. 8, the value of the current rising to 2·4 amperes. This curve evidently consists of a small current of fundamental frequency and a large triple frequency component, the latter being required to overcome the reluctance of the air return.

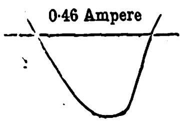


Fig. 4.

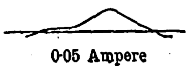


Fig. 5.

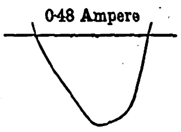


Fig. 6.

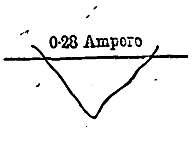


Fig. 7.

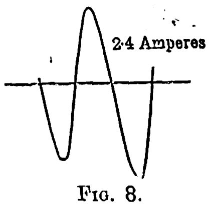
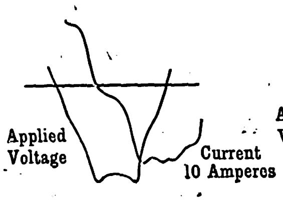


Fig. 8.

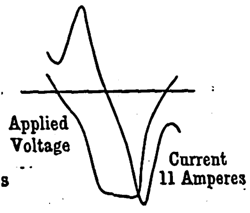
The same effect will be found in a three-phase star-wound motor if a neutral connection be used, but in this case the differences in the waves will not be so marked, since there is a considerable air gap reluctance in the path of the fundamental frequency flux. The no-load curves for a 5 H.P. three-phase motor when *three*-wire and *four*-wire star connected respectively are shown in Figs. 9 and 10, and here again the triple frequency components of current are very marked, though less so than before. Incidentally, these figures show the alteration of the applied E.M.F. waves by "straining out" the triple frequency components.

All distortion effects in multicore transformers can be avoided by using a four-core transformer, the purpose of the fourth core being to provide a return path for the triple frequency fluxes from the other three cores. Such a four-core transformer can also be used for the transmission of three-phase and single-phase currents of different frequencies down the same line wires, since if three similar primaries be wound one on each of the three wound legs and connected in series, such coils will not be affected by the three-phase fluxes whose algebraic sum is always zero. The single-phase current is then transmitted by the three-line wires in parallel, with the earth, or neutral fourth wire, as return, and is "sorted out" again at the receiving end by means of three similar secondaries in series on three legs of another four-leg transformer.



Neutral Insulated

Fig. 9.



Neutral Connected

Fig. 10.

The same arrangement will effect Mr. Field's frequency conversion, and on feeding the three-phase primaries with the above four-wire star E.M.F. waves at 100 volts between line wires, the curve shown in Fig. 11 was obtained from the three secondaries in series, corresponding to 84 volts at a tranformation ratio of 1 : 1. The frequency is obviously three times the fundamental frequency.

This system is, of course, only an extension of the principle that the triple-frequency components in each of three three-phase waves are in phase with one another; if a path be provided for these triple-frequency components, the same path will obviously serve for components of any other frequency. When this system is tried practically it is most interesting to listen to the hum of the iron, since if the frequencies are not very different, "beats" are heard which are distinctly audible all over a large room.—Yours, &c., F. J. DYKES.

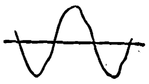


Fig. 11.—Three Coils in Series. 65 ∿, 100 volts between live wires on 100 turn coils.

Royal Naval Barracks, Portsmouth, Dec. 11.

## "EFFICIENCIES."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of December 1st appears an abstract of an address by Mr. James Swinburne on "Efficiencies." In the earlier part of the article the efficiency of a money-making business is considered, using the word efficiency in the sense known to Science. As reported, the analogy with mechanical efficiencies is not very clear, owing to the prominence given to the consideration of profits. The analogy will be more clearly understood by considering the case as follows: A trader or middleman buys goods for £7,500 and sells them for £10,000. His expenses of all kinds, including his own wages of superintendence, are £2,000, and the surplus profit is £500. As 25 per cent. is absorbed internally to meet expenses and profits, the efficiency of the business is 75 per cent. An efficient business, therefore, is one in which the combined loss due to expenses and profits is small. The reason why big businesses have of late years wiped out the smaller businesses is not because their expenses and profits are small in the aggregate, but because, owing to well-known causes, the expenses and profits are small as a percentage. Viewed in this way, a business in which the percentage of profits is large is an inefficient and bad business, condemned alike by abstract science and by social science. The man who buys cheap and sells cheap is a better business man than he who buys cheap and sells dear.

The word profit is generally used in a very elastic way. Bad debts, interest on capital, depreciation and extension funds, wages of superintendence, are all more or less necessary expenses. Profit is what remains after all contingencies, proximate and remote, have been met. A company should only be considered as doing a profitable business when it is paying more than the ordinary interest on its capital. If paying less than the ordinary interest, it is really working at a loss. But it may nevertheless be a very efficient business if the percentage of expenses is low.

A municipal business that seeks no profits, other things being equal, is clearly more efficient than a commercial company that takes all the profit that it can get. In a trading business the goods are merely bought and sold. In a manufacturing business the finished articles are intrinsically worth more than the raw materials. However the same reasoning holds: in each case the selling price is the cost price plus expenses and profits.

It may be pointed out that a perfect business, like a perfect engine, is an impossibility. Perfection must be sought elsewhere.—Yours, &c., G. BOWRON.

December 12th.

### PROF. THRELFALL'S ADDRESS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your endorsement of Prof. Threlfall's aspersions on recent electro-chemical research is an unusual departure from your appreciatory attitude towards theoretical advance. For this reason, and because of the interesting and valuable nature of the rest of his address, many workers in practical electrochemistry may well be led to lighten their labours by neglecting to read purely theoretical Papers. As these Papers are put forward under the auspices of men of the unquestioned eminence of Ostwald, Nernst, Van't'Hoff and Abegg, who have established the dissociation hypothesis in the teeth of adverse criticism, they are not in the face of it likely to be quite so futile as Prof. Threlfall would have us believe.

Prof. Threlfall would have us cease developing the dissociation hypothesis, and return to "pure chemistry" for our explanation of the more complex phenomena. Perhaps he will tell us exactly what he means by "pure chemistry," if not mere empiricism. The history of many problems in organic chemistry is a record of constantly changing opinions as to how "pure chemistry" is to explain certain reactions. The net result in many cases is a matter of opinion still, and is likely to remain so, until the subject can be approached with a fuller knowledge of the electrical phenomena, which, in spite of Prof. Threlfall's statement, nearly everyone now believes to underlie the reactions of "pure chemistry."

Prof. Threlfall's arguments are those which physicists (and a few chemists of the old school) have brought against the dissociation hypothesis from its very foundation. Dissociation itself was said to be a "chemically abhorrent reaction," and not until physicists were led to similar conclusions by their researches in other directions did Grotthus and Clausius give place to Arrhenius and Van't'Hoff in their teaching.

Electro-chemists are not, therefore, likely to abandon the theory because its application to "every-day electrolysis" often necessitates a certain degree of complexity. One might equally well abandon Maxwell's theory and its modern developments because its application to everyday electrical phenomena introduces a similar complexity. Would Prof. Threlfall have us take Faraday's laws of induction and Ewing's model as the last word on the electrical properties of iron? Physicists are usually readier to look down upon chemistry as a more empirical science than their own than to sneer at results attained by "dexterity with a pen and paper."—Yours, &c.,

Brighton, Dec. 9. H. STAFFORD HATFIELD.

[The neglect of science which is empirical in the proper sense —that is to say, based upon experiment—causes the mischievous cult of pen and paper to which our correspondent feelingly refers. No impartial person who has waded through the mass of nebulous electro-chemical hypotheses built on an experimental basis ionic in its dimensions, which too often masquerades as science, can contravene Mr. Threlfall's righteous strictures.—ED. *E.*]

## LEGAL INTELLIGENCE.

### Swansea Corporation v. National Telephone Co.

The Court of Appeal (Lords Justices Vaughan Williams, Stirling and Cozens-Hardy) on Monday commenced the hearing of defendants' appeal from a decision of Mr. Justice Buckley.

Mr. ASTBURY, K.C., for appellants, said that this was the first case that had come up for decision under the Telegraph Act, 1899, which gave the right, under certain circumstances, to holders of municipal telephone licences to apply for restricted intercommunication. Swansea Borough had obtained a licence until 1920, and had now called upon the telephone company to give reasonable facilities for restricted intercommunication. It was of extreme importance to the company that these facilities be given in such a way as would not disintegrate and ruin the system which was asked to give the facility. The learned judge, he thought, had assumed that he was entitled to judge of what was the class of facility that should be given. There were many ways in which this might be done. It was the most complicated class of work of this nature that could be conceived. There were three great telephone systems known, the Western Electric of America, the Swedish system (which was very largely used in this country), and the system that the National Telephone Co. had hitherto adopted, which was more or less a combination of the two. The different systems were worked in different ways with different sorts of battery connections. Assume that the Corporation had started a system and demanded intercommunication. All that the act said was that when that demand was made the company was to give "reasonable facilities." It provided that within six months of the passing of the act the Postmaster-General might by general order lay down the circumstances and terms and conditions upon which such facilities should be given. Whether he was unable to do it they did not know, but he did not do it. He made a general order which added nothing to the act at all, and it did not prescribe any mode or term or condition which was to be complied with. Supposing there were five well-recognised modes in which these facilities could be given, and that three out of the five were modes which would disintegrate and cause great confusion and difficulty in their working; supposing that the two other modes would give the Corporation exactly the same facilities without costing the company all this trouble and inconvenience; and supposing that the directors of the company, as they had done in this case, met and discussed it, took the very best expert opinion they could get, and came to the conclusion that they would allow it to be done in one of the two ways that they thought would alone do it efficiently and without unnecessary disturbance and without interfering with their obligations to their own subscribers: in that case the Court could not, would not, and ought not to interfere, because it had been laid down for years and years past that where a body had to give reasonable facilities for a certain thing which could be done in various ways the choice of the right way was left with the person who was called upon to give the facilities. The Corporation had demanded that they should do a particular act and that act only. They demanded intercommunication in a particular way and by a particular means, which the company said would destroy both systems, and in the honest exercise of their discretion and their powers they had come to the conclusion that that was not a proper way of giving facilities. The learned judge had taken upon himself the jurisdiction to hold that he was entitled under this act to say what reasonable facilities were and how they must be given to this extent, that he had expressed himself extremely strongly in favour of the Corporation's demand, and he had gone so far as to hold that the facilities which the company had offered amounted to a refusal to give any facility at all within the meaning of the act. The Corporation did not say that what the company proposed would have any pernicious effect. They admitted that it was the best, but said it was too expensive. The Corporation wanted it done in a rough and ready and bad and faulty way, admitting that it would have to be altered as time went on and as more subscribers came in. If their lordships came to the conclusion that what the company had offered to do was not only reasonable, but was the only sensible way of doing it, based upon their experience of very many years, then, unless they could hold that that was a refusal to give facilities, their lordships would not take upon themselves jurisdiction to order them to do something else. That was where their jurisdiction did not come in. The company had 12 exchanges in Swansea and the Corporation had now five. They said that all they were bound to do was to bring a great bundle of cables up to the company's central exchange, and demand that the company should put them on to the switchboards. Then they said that if any of their subscribers wanted to telephone to any of the company's exchanges the company would have to do that—lay the necessary junctions and do the necessary work to take their messages through the central office. They treated it as if each system had a large mouth and all they had to do was to pour their messages into the mouth of the company's system. The company, on the other hand, said the Corporation must carry their message up to the switchboard to which their subscriber was connected. He could not see how the learned judge could say that the company were trying to put on the Corporation unnecessary obstacles. Whatever the company wanted the Corporation to do the company were willing to do exactly the same. The act said that the company were to give reasonable facilities for the Corporation's subscribers to speak to the company's, and the act also said that the Corporation were to grant the same facilities.

During Mr. Astbury's argument, Lord Justice VAUGHAN WILLIAMS asked Mr. Buckmaster (for the Corporation) if the question to be decided was not very much one of expense.

Mr. BUCKMASTER: If we look at what the judge has ordered it is very difficult to see what the company are appealing for. The judge has merely declared that we are entitled to certain things, and that certain things shall be done, and that if in the course of working certain things he has described are necessary there shall be liberty to apply. It was really a question of costs and delay. If in the course of working we find it will be necessary to lay further wires, we will join in the expense that is incurred in laying them.

Lord Justice VAUGHAN WILLIAMS: Will you undertake that if, for the purpose of carrying your messages, additional junction wires are required from the telephone central that in each case you will pay the cost? The company are willing to pay the cost of the return wire.

Mr. ASTBURY: It would be ludicrous not to put an up line and a down line. We have been carrying on business in hundreds of places for many years, and it is a matter of calculation. It is not a mere matter of accommodating the people at Swansea, but it is a matter of vital importance to the Telephone Co. If the judgment stands, Corporations all over the country would say that they would have a telephone system in rivalry with ours. We want to protect ourselves against that. There was another important matter about their trunk lines. Their lordships knew that under the acts all the trunk lines from town to town were vested in the Postmaster-General, and they were bound to give preference to trunk messages from any town. There would be great confusion if the trunk lines became overloaded. The evidence was that their wires were overloaded at present.

Lord Justice VAUGHAN WILLIAMS said the question they had to decide was whether the Telephone Co. had a right of selection or not. If they decided that they had they would not take away that right even if they had made the selection in a malicious spirit.

Mr. ASTBURY said he did claim the right on the part of the company to make a proper selection, however inconvenient it might be to the Corporation. They desired to give reasonable facilities by the use of their operators and switchboards to enable subscribers to the corporation system to intercommunicate with their subscribers. The system which the company proposed to introduce might be dearer at the beginning, but it would prove cheaper in the end, because it would be at once efficient and perfect and could not possibly get out of order.

Lord Justice VAUGHAN WILLIAMS made a suggestion that the parties should agree that the two centrals should remain connected as they are, and that as soon as it was found by the Post Office engineer that there was a block between the central and any of the sub-exchanges of the company then that there should be put a sufficient number of junction lines at the joint expense of the borough and the company.

Mr. ASTBURY: I think this will be more reasonable. I agree by way of arrangement that for the purpose of trying and testing how it should be done that the junctions between the two central exchanges shall remain. I will agree to that, and, provided it is agreed that Mr. Justice Buckley's judgment is discharged, I am willing to pay my own costs both here and in the court below.

Mr. BUCKMASTER said he could not consent to the suggestion. Up to a certain limit the judgment of Mr. Justice Buckley provided precisely what his lordship suggested.

Lord Justice VAUGHAN WILLIAMS: If you take the position that whenever any works are required—additional wires and switchboards—the work is to be paid for exclusively by the company you are quite right in not agreeing to anything.

Mr. BUCKMASTER said he did not ask any such thing. He could not accept the suggestion.

Mr. BUCKMASTER opened the respondents' case, and said the company had absolutely declined to allow the Corporation's subscribers to communicate with theirs, except upon the terms that the Corporation should run from their central exchange at Swansea to each one of the company's sub-exchanges a new and totally independent route for the purpose of carrying all the messages that originated upon their system. They declined to allow the Corporation to use any part whatever of their junction lines, or, as he understood it, their local sub-exchanges except for the purpose of putting in a wire.

Lord Justice VAUGHAN WILLIAMS: It is quite true that this is the only offer they have made you, but as far as you are concerned you have made a demand, so that there is really a demand on one side and an offer on the other, and you must not leave the demand out of consideration. We might come to the conclusion that both of you are wrong, that you have no right to ask for what you have asked, and that their offer is not sufficient.

Mr. BUCKMASTER said if their lordships held that the company's offer was not sufficient, that would not meet this point. The point to be considered was whether the company had refused to give proper facilities and if their lordships held that the facilities which were offered were not facilities within the meaning of the act it was not for the present moment for the court to consider anything further, though there might be further questions to be dealt with subsequently. This was one of the first of what might prove a series of similar actions to be brought by Corporations in connection with these intercommunication facilities. The company's contention was that if a Corporation subscriber at Swansea wanted to talk to a company's subscriber at Pontardulais, the Corporation must lay a line to carry the message. The Corporation said that to do such a thing was in effect to duplicate the systems. If the Corporation's construction of what the Act of Parliament directed was the correct one, the company's proposal was most unreasonable. If the arrangement they suggested were the one that had to be adopted, the two systems would never come into communication.

Lord Justice COZENS-HARDY: I suppose you have the right to make as many sub-exchanges as you please?

Mr. BUCKMASTER: I think so.

Mr. ASTBURY: Yes, and if you take your exchange to Pontardulais, if one person demands telephonic facilities there you are bound to give them under your license.

Mr. BUCKMASTER: I do not think so. We are bound not to give a preference to one over another. The Corporation would not be at liberty to take demands for half a dozen subscribers in one village and give them telephonic communication unless it was prepared to give communication to the same number of subscribers in some other village. There was nothing to compel them to open a sub-exchange in any district where any single individual demanded it. The company's case was that the Corporation must bring their subscribers to the company's switchboard without using the company's system to bring them there. An obligation had been imposed on them by reason of the fact that their monopoly had been extended, and the object of the act was to provide that advantages should accrue to the public, and that it should not be possible for the company to withhold from the public the benefit of the use of their system simply because they had become nervous of another system.

Lord Justice VAUGHAN WILLIAMS: Supposing we decide that you must bear certain costs which you say you ought not to bear, and that the Swansea people say if they have to pay these costs it is not worth while to ask for intercommunication, and they withdraw their application, could some member of the public come forward and say the whole object of granting you the licence was that there should be intercommunication, and as a member of the public insist upon it?

Mr. BUCKMASTER: I cannot say the statute is so framed as to give the subscriber that right, but it does not follow that that was not the reason for which the statute was passed. What the act provided for was intercommunication of subscribers and not of systems. The company said that would make it difficult for them and throw expense upon them, but the act did not mind that. It only considered how it could best arrange that the two sets of subscribers should get intercommunication. It was said that the company's subscribers outnumbered the Corporation's in the ratio of 1,500 to 700. If the company put their 1,500 subscribers into communication with the other 700, the Corporation would have to provide for just twice as much traffic as the company would and if they had not made proper provision to take the increased traffic, they would have to do just twice as much work in the way of laying extra wires as the company would have to do. The company's case was that they were only compelled to put their subscribers at one of their exchanges on to a messenger whom the Corporation brought to the company's exchange. He submitted that the problem to be solved was the best way to knit up the two systems, and when that was got each one had to see that the system carried the increased traffic. The decision in the present case would apply to all cases where there was a similar contract. His case on behalf of the Corporation was that the Corporation was not entitled to one bit of the company's system, but the Corporation were entitled to the full benefit of the company's system.

Lord Justice COZENS-HARDY: Would you be satisfied with a declaration that the defendants shall not refuse to give proper facilities, without prejudice to any question as to the mode in which that should be determined?

Mr. BUCKMASTER: The important thing is that it should be made perfectly clear that it is no condition precedent of intercommunication that we should take lines from our centres to their sub-exchanges. That is the point of substance between us.

Lord Justice VAUGHAN WILLIAMS: You mean that you yourself should take the lines in that way. But you do not suggest that there is anything in the judgment which prevents the Company from doing so. Do you agree to that? Speaking for myself, I am strongly impressed with the evidence which says that the only possible way in two growing businesses like this to carry out this telephone business with convenience to both sets of subscribers is by having three direct communications between three outside stations. I think that if that is not done things will be in a hopeless muddle. What I want to know is that you do not wish to prevent them doing that?

Mr. BUCKMASTER: Of course, I do not mind that. I say that directly the load occurs they must relieve it and I must relieve it on mine.

Mr. ASTBURY said the Company had no right to go into the Corporation's exchange and put lines.

Mr. BUCKMASTER: Their proposition is that we should double our junction lines.

Mr. ASTBURY said that it was no use discussing a thing which was electrically impossible. If the suggestions of the Corporation were accepted the switchboards of both systems would have to be entirely altered. He submitted that the Corporation had proceeded on the mistake of assuming that every advantage which was derived from subscribers on the Corporation's system having communication with the company's was for the advantage of the Corporation's subscribers alone. That was not so. There must be a mutual advantage to the man who talked and the man who was talked to.

Lord Justice COZENS-HARDY asked what alteration or addition the respondents suggested to Mr. Justice Buckley's order.

Mr. PARKER said they would like a further declaration that "in order to give such facilities it will be necessary and proper in the first instance to join the exchanges at Swansea, Mumbles and Morristown respectively," an order to defendants to make such junctions, with liberty to them to apply to be relieved from the obligation of maintaining such junctions or providing some proper alternative mode of communication.

Lord Justice VAUGHAN WILLIAMS: I am not sure that liberty to apply is not beyond what the Court is entitled to deal with.

Mr. ASTBURY said their lordships were asked to affirm an order which declared that the mode of coupling up two sets of telephonic businesses, such as had been done in London with the help of the greatest experts in the world, was a breach of the company's statutory obligations. What they were proposing at Swansea was that the two systems there should be so dealt with as to give inter-communication between their various subscribers, as had been done in London.

Lord Justice VAUGHAN WILLIAMS: It may be that what you offer is perfectly reasonable, and yet your offer may have amounted to a refusal because you coupled it with an amount which they should pay for it, which makes all the difference. It might be perfectly reasonable if you are to pay for it and unreasonable if they are to pay.

Mr. ASTBURY: Our offer was that they should do their part and we should do ours. That was what was done in London. The other side wanted, if they were to speak from one system in Kensington to another in Kensington, to go round via London Wall.

Lord Justice STIRLING: We have an act saying you are to afford all proper facilities. It is impossible that any general rule can be laid down by any Court which is to apply at all times, in all places and in all circumstances. It is a matter of degree to be considered in each particular case.

Mr. ASTBURY assented to that view. He was only asking them to say that the way in which it had been found necessary to do the work in London was not so absurd as to amount to a refusal. He did not say there were not other ways, but he did not know any other which was practicable. The act said the provision of facilities was to be mutual. The act said, not that either party should lay down junctions or build exchanges, but simply afford facilities.

Lord Justice STIRLING suggested the appointment of an expert to define what were reasonable facilities.

Mr. ASTBURY said he supposed the greatest expert apart from themselves would be one from the Post Office, which was the next biggest system to that of the Telephone Co. They were opponents of the company and their rivals in London, but he had not the slightest objection to their lordships asking the principal engineer of the Post Office system in London to go to Swansea, look at the two systems, and state in his opinion what was the best way of affording facilities.

Mr. PARKER asked their lordships to decide the points Mr. Justice Buckley had decided, and if there was a reference he hoped it would not go to the chief engineer of the Post Office. Having regard to the relations which now existed between the company and the Post Office, he thought the case should not be referred to him.

Mr. DANCKWERTS thought this remark cast a reflection on the engineer of the Post Office.

Lord Justice VAUGHAN WILLIAMS saw no reflection on the gentleman at all. The Court could send its own expert. It was obvious that the judgment of the Court must stand over for the present.

Order accordingly.

### Cambridge Corporation v. National Telephone Co.

On Saturday Mr. Justice Joyce heard a motion for an order to compel defendants to remove certain poles and standards for carrying telephone cables and wires in Cambridge. Defendants had appeared to the action, but the matter now came on as a motion for judgment in default of defence. Defendants were not represented by counsel.

Mr. PATTISON said that there were a number of poles and standards which were erected in Cambridge borough under a terminable licence from plaintiffs. Notice to determine the licence had been given, but the poles and standards had not been removed. He asked for an order to compel defendants to remove them.

His LORDSHIP made an order that defendants remove the poles and standards within one month. He wished he could make the Telephone company pay, but he was not sure whether the Corporation had sustained any damage. Costs would be up to and including judgment.

### National Telephone Co. v. Griffin.

In the Appeal Court (Dublin) last week judgment was delivered in an appeal by plaintiffs from a decision by Mr. Justice Kenny that defendant was only liable for 10s. 6d. for rent of one of plaintiffs' telephones for a period between Dec. 31, 1904, and Feb. 9, 1905. On the latter date plaintiffs cut off defendant's telephone service. Plaintiffs' claim was for a year's subscription (£4. 15s.), which they urged was payable in advance under their agreement with defendant, despite the fact that the service was discontinued.

The LORD CHIEF JUSTICE, in delivering judgment, said the question had been concluded by authority, and they had no option, although the service had been cut off, but to find that there was no determination of the contract, and therefore the £4. 15s. having become due and payable on Jan. 1, 1904, defendant was liable for it. There would be no order as to costs.

The other Justices concurred, and the appeal was allowed.

### Blackpool & Fleetwood Tramroad Co. v. Thornton District Council.

On Wednesday a Divisional Court (the Lord Chief Justice and Justices Lawrance and Ridley) heard this case, which had been stated by the Lancaster Quarter Sessions upon an appeal against a rate made on July 16, 1904, by Thornton Urban Council. Appellants were rated as owners and occupiers of the tramway track in the district at £708. The company contended that they had not been allowed the deductions provided for by sec. 211 (1) of the Public Health Act, 1875, and that they had been assessed in the full net annual value for their lines of railway instead of in the proportion of one-fourth part only of such net annual value as provided by that section. The appeal was heard on Oct. 21, 1904, and dismissed, but a case was stated. (This action was reported in *The Electrician* for Oct. 28, 1904.)

Mr. DANCKWERTS, K.C., contended that the whole provisions of the Company's Act of 1896 showed that the tramroad was a railway and not a tramway, and that they were therefore entitled to be assessed at the lower rate.

Mr. E. SUTTON submitted that the tramroad was not a railway, but a tramway. Except in certain particulars the company came within the Tramways Act, 1870, and it was only for certain purposes that the tramroad was to be deemed a railway. That did not make it a railway, and only railways in the strict sense were entitled to the benefit of sec. 211 of the 1875 Act.

The LORD CHIEF JUSTICE, in giving judgment, said the appeal must fail. It was always difficult to draw a dividing line between a railway and a tramway. As to the particular structure with which they had to deal, there would be nothing absurd in calling it a railway connected at each end with a tramway. On the whole, he thought the justices were right. Sec. 2 of the Company's Act, 1896, applied certain clauses of the Railways Clauses Act to the structure, and it declared that for the purposes of the Act of 1896 the tramroad shall be deemed to be a railway. In his opinion that was inconsistent with the view that the tramroad was to be a railway for all purposes.

Mr. Justice LAWRANCE and Mr. Justice RIDLEY agreed, and the appeal was dismissed.

### J. S. Henry (Ltd). v. N. Burt & Co. (Ltd.)

At Shoreditch (London) County Court last week plaintiffs sued for the recovery of £8. 11s. 6d. for electric fittings supplied. Defendants pleaded that the goods were supplied on approval, and plaintiffs could have them back. Plaintiffs denied that the goods were supplied on appro., and said it was unreasonable to keep goods many months and when called upon for payment to offer to return them. After hearing the evidence, Judge Smyley, K.C., said it was quite clear that the electrical fittings were required for some special work which defendants had in hand, but it did not seem clear as to whether plaintiffs had had the circumstances properly explained to them before supplying the goods. Under the circumstances, he considered the best thing would be to order defendants to return plaintiffs the fittings and neither party would then be losers. Judgment accordingly.

**Re Electrical Ore-Finding Co. (Ltd.)**—A petition for the winding up of this company, which came before Mr. Justice Buckley on Tuesday, was allowed to stand over, as arrangements have been made to settle with the petitioning creditor.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT.

Brighton Corporation require two shift engineers at their Southwick power station, at commencing salaries of £2. 10s. per week. Applicants must have had experience with turbine machinery and three-phase high-tension switch gear. Applications to the engineer and manager (Mr. John Christie). See an advertisement.

A competent electrician is required for mines in West Africa, accustomed to all branches of work, including mine and surface lighting, &c. See an advertisement.

An examination will shortly take place for appointments as second-class engineers in the Engineer-in-Chief's Department, G.P.O. Jan. 11 is the latest date for receiving applications. Forms from the Secretary, Civil Service Commission, Burlington-gardens, London, W. See also an advertisement.

Atherton District Council require a competent working electrician to lay cables and do testing. Applications by 19th inst.

A telegraph linesman is required by the Government of Sierra Leone. Engagement for three to six months. Salary £20-£25 a month. Applications to the Crown Agents for the Colonies, Whitehall-gardens, London, S.W., up to Dec. 18.

### EDUCATIONAL NOTICES.

**Aberdeen Technical College.**—A conference took place last week between representatives of Aberdeen Town Council and of Robert Gordon's College, with regard to the proposal to form an up-to-date technical college in Aberdeen. The matter will be brought before the Council at an early date.

**Belfast Technical Institute.**—The annual prize distribution of the Municipal Technical Institute took place on Tuesday. The prizes were distributed by Lady Henderson, after an interesting address on technical education by Sir Wm. Mather.

**Accrington.**—The Council have rejected a recommendation to establish a municipal wiring department.

**Argentina.**—At Rosario the number of electricity consumers has increased to 1,500, and there is now a total connection equivalent to 76,000 8 c.p. lamps.

The "Review of the River Plate" states that no tenders were received by Buenos Ayres Municipality for the construction of an electric tramway between Plaza Mayo and Villas Ortuzar, Devoto and General Urquiza.

Cordoba Electric Light & Power Co. are increasing their generating plant to 8,500 H.P. The question of proving electric tramways in Cordoba is regarded locally as having fallen through for the present, owing to the exorbitant purchase price asked by the horse tramway companies for their undertakings.

Buenos Ayres Public Works committee have reported favourably on the petition of the Buenos Ayres Electric Tramway Co. for permission to extend their system.

It is stated that Mr. J. Krause, engineer, has requested the assistance of the National Deputy for Corrientes in obtaining for a German syndicate orders to instal and work electrical plants in towns of that province having 10,000 or more inhabitants.

**Australasia.**—*Melbourne* (Victoria) Corporation, whose electricity undertaking serves a population of 70,000 within the city area and over 500,000 if the suburbs are included, has now a total connection equivalent to 172,650 8 c.p. lamps, and 1,700 consumers taking current from this source. The price of gas supplied by a company is 5s. per 1,000 for lighting and 3s. for power. Electric energy is supplied at a flat rate of 4½d., or 7d. for first 1½ hours and 2d. after. For power the charge is 2d. per unit. Nearly 800 arcs and 3,340 incandescents are used for public lighting. The area of supply is 7½ square miles. A 1,750 kw. Allen-Crompton generating set is on order as well as two Babcock-Wilcox boilers.

At *Adelaide* (S. Australia) the Adelaide Electric Supply Co. are supplying current to 665 consumers, and there is the equivalent of 63,602 8 c.p. lamps connected. At port Adelaide the same company are supplying current to 115 consumers, the total connections being equivalent to 6,472 8 c.p. lamps. The company's station here is in process of changing over from direct to alternating-current supply, high-tension current being generated at the company's Adelaide works and transmitted to Port Adelaide.

At *Katanning* (W. Australia) direct current has been supplied since August, 1904, and satisfactory progress is being made with the business in this sparsely populated district. Electricity is the only artificial illuminant in this district.

At *Hobart* (Tasmania) the local gas company owns the electricity undertaking and supplies current to 134 consumers equivalent to 8,000 8 c.p. lamps including 90 H.P. for motors. By special permission of the Tasmanian Government the local tramway company are permitted to supply light and power from overhead cables. Power is charged at the rate of 5s. per week for the first horse-power and 2s. 6d. for each additional horse-power.

At *Launceston* (Tasmania) good progress has been made during the past year. The number of consumers has increased to 2,762, and the lamp connections to 54,656.

**Brighton.**—On Tuesday an inquiry was held into the application of the Corporation to borrow £38,500 additional for electricity supply and £5,909 for the purchase of a site for a sub-station.

The Town Clerk (Mr. H. Talbot) supported the application, and gave statistics as to the ratable value and financial position, &c. Electric lighting loans amounted to £598,232, and loans sanctioned but not borrowed to £159,000. For the telephones they had borrowed £49,325, and loans sanctioned but not borrowed amounted to £6,145.

The Inspector (Mr. H. Ross Hooper): What is the total indebtedness of the borough of every kind?

The Town Clerk: Up to March 31 last it was (after deducting invested sinking fund) £2,607,233, including £256,521 for education, £725,441 for water works, £482,798 for electricity and £268,286 for tramways. The total rates for Brighton were 6s. 11d. for the year ending March 31 next, and for Preston 6s. 4d., and 1d. in the £ produced £3,400 net. They asked for 40 years for repayment of the £5,909, and 25 years for the £38,500. With regard to the latter sum, he was instructed to withdraw an item of £2,650. The balance (£35,650) was made up as follows: 900 house-service connections at £10 each, £9,000; one new feeder, £2,000; 1,000 meters at £4 each, £4,000; motors for hiring, £4,000. The motors were purchased by the Corporation and let out to customers as an additional means of encouraging the consumption of electricity. The revenue produced was amply sufficient to cover all charges and to show a profit on that part of the business. Additions to the switchboard and accessories would cost £1,350. The 900 house services represented the requirements for the next three years, and was based upon the actual demand during the four preceding years.

The Inspector inquired as to the method of keeping the accounts and as to how they knew whether their estimates had been exceeded or not.

Mr. Stevens (borough accountant) said there were the various accounts to which the particular amounts expended were debited.

The Inspector: Take machinery. You have certain capital sanctioned for machinery. When it is expended that account is closed?—It is a running account.

The Inspector: How do you keep it a running account when you only have certain loans sanctioned?—We have never allocated expenditure to particular sanctions.

The Inspector: Then sanctions you have received from time to time have simply been charged to floating capital accounts?—Yes.

The Inspector: Therefore there is no means of the Council knowing, or anyone else so far as I can see, whether the applications or estimates under any one particular sanction have been exceeded. If they are exceeded they are carried to the floating capital account. Have the Council never asked questions as to whether any one particular sanction has been exceeded?—No. Our practice is that generally adopted and is the practice outlined by the Board of Trade itself.

The Inspector asked whether the accounts showed how the money borrowed was spent, and whether there was any excess. Was there any check kept?

The Town Clerk said the engineer could keep a check, and probably he did so; but he could not say whether that was so. All the public accounts were kept in accordance with the Board of Trade obligations.

Mr. Robb (for opposing ratepayers) said it might not be true of that particular undertaking, but it was undoubtedly true that owing to the manner in which the general capital account was kept, sums of money got diverted from their proper and original purpose to purposes for which they were not intended.

The Inspector said the L. G. Board should be advised what changes were made. The question was whether any sanctions had been exceeded, and what changes had been made. Had any statement been prepared as to what the position of the undertaking was: were they applying for an excess or had there been any saving; also when would they require the money?

The Town Clerk said no such statement had been prepared. He had never been asked for such information at any previous inquiry, and was not, therefore, prepared with it. None of the money now applied for had been spent. £4,000 was required for motors for hiring. The income received in that way was sufficient to keep the motors in repair, pay debt charges, and yield some profit. A loan of £6,000 had been sanctioned, £4,689. 6s. 9d. had been expended on motors and fans, and £453. 3s. 6d. on switches, spare parts, &c., making altogether £5,142. 10s. 3d. expended. An estimated annual rental of £650 was produced. The last item (£1,360) was for additions to the switchboard, and accessories and contingencies. In a statement he now handed in the progress was shown by the yearly net profits, commencing in 1893 and amounting in all to £47,622, out of which £14,244 went towards relief of rates and £33,378 to reserve. The progress had been continuous up to the present, and there was every reason to believe that a prosperous future was before it.

The Resident Electrical Engineer (Mr. John Christie) said the application to borrow £35,800 was made upon his recommendation. During the four preceding years the average number of connections was 344, and the applications for new services were coming in at rate of seven a week. The estimate of 300 per annum was not, therefore, an excessive one. As to the cost of services, they were now taking a class of consumer whose houses had long front gardens, and therefore the cost of laying on the service to those houses was higher.

The Inspector asked if £10 was not a very high price. There was no meter even, and they would be running up the price to £14 for house service. Did Mr. Christie know of many towns where there was such a high price for house service?—Mr. Christie said he thought Glasgow. He did not know much as to the cost in other places. The actual cost, excluding meters, last year was £6 or £7. It was proposed to recommend the Council to do away with the charge for services over 30 ft. beyond the kerb, because there were some customers who greatly objected to the charge and would not have the electric light on account of it. In the early days the cost was as high as £17 or £18, but great improvements had been made. Mr. Christie eventually reduced his estimate from £10 to £6. 10s., which the Inspector thought still rather high.

The Inspector said the Corporation was asking for £6. 10s. for a service, or more than double the price of many other towns, and it must be clearly shown how that estimate was arrived at.

After further evidence, the Inspector asked if Mr. Christie claimed that in the matter of electricity supply Brighton was the most highly developed town in the kingdom?

Mr. Christie said he had never made that claim personally, but he thought it was admitted that Brighton had kept well up the list. They sold nearly 50 units per inhabitant, a fact which he ascribed to the low price at which current was supplied. Brighton was peculiarly situated. There was no comparison between it and any other town.

The Inspector asked whether there was not the fear that they had reached the saturation point, and Mr. Christie replied in the negative.

On the item of £15,500 for distributing cables, the Inspector asked upon what basis they had arrived at that figure?—We have put down eight or nine miles of distributors per annum. He took the probable number of miles of each class of cable that would be required and charged the market price. The £4,000 for motors, Mr. Christie explained, was necessary to meet growing requirements. They had already had a sanction of £6,000, and he had furnished a statement of the amount expended and the number of motors purchased. They were let at such rentals as would pay all charges and keep them in repair. They did not show much profit, but by their means they were able to supply a great deal of motive power which otherwise they would not get. They first went in for purchasing motors in 1901, and commenced to let them on hire in 1902. They had allowed 14 years as the life of these motors, which was the period given for the repayment of the loan on this account, and he did not see why they should not live for that period. £250 was spent last year for repairs and renewals in respect of motors. The income was £573, which left £320 on a net expenditure of £5,000.

The Inspector asked whether the 1d. per unit charged for current for power yielded a profit?

Mr. Christie said this point was difficult to estimate, but he thought it did, because this was practically a by-product. Brighton had an enormous amount of plant which was idle during the day, and the current generated and supplied for power entailed no extra charges for machinery.

Replying to a remark made by the Inspector as to the method of keeping the electrical department accounts, Mr. Christie said the undertaking had been carried on in the same lines all along, and he thought the results were very satisfactory and would compare well with those of similar undertakings throughout the country. They had 4,256 consumers up to March 31 and they had 5,131 meters, of which 4,822 were on circuit and 309 were in stock. 5,647 meters had been bought.

The Inspector: Why should you have a loan for meters when you have nothing to represent the money expended for these meters. You have purchased 5,600 meters and spent £37,800. You have paid off £2 out of the average of £7, and £5 remains owing. Was that a satisfactory position?—I have no control over the allocation of our surplus profits.

Councillor Butt-Thompson (chairman of the Lighting committee) agreed that the position in regard to meters was not satisfactory, but the Inspector must not lose sight of the fact that they had paid for a certain proportion and there was the sinking fund.

The Inspector: You are applying for a loan for £2,000 more, when you have sold, or parted with, or scrapped a number of meters. You have been carrying on the undertaking entirely on a floating account, so you have no record of your financial position?—I am equally surprised with yourself to find that it is so.

The Town Clerk said that this was partly an application for a loan to purchase a number of new meters. He was not aware at the time the application was made that this was intended to replace meters that had been scrapped, and on which the debt had not been paid. The usual course must be taken. He should not ask the Board to sanction a loan for any work to replace work paid for out of borrowed money, the cost of which had not been written off. There were two courses open to them. They could pay out of reserve the money owing on those meters, or they could reduce the present application. He thought the best plan would be to at once apply the reserve in cancellation of the debt. He should advise that course to the Council. The same practice had been employed for 14 years with regard to these accounts, but if the Local Government Board desired that there should be an alteration, he had no doubt it would be carried out.

The Inspector said that the L.G. Board were willing to give a corporation a loan for three years in advance without asking how the money was to be expended, but if they applied, say, for £10,000 for mains, the Board asked that it should be applied to mains; or if for £5,000 for meters, that that sum should not be applied to other purposes. If they got for mains a period of 25 years' repayment, and for meters five years, and part of the money sanctioned for mains was applied to meters, in that way they got 25 years for repayment for meters, but that period would never have been granted had it appeared in the original application.

Mr. Arthur Wright (consulting engineer to Brighton Corporation) was examined as to the extent and cost of the Southwick station, &c. He denied that the station was unnecessarily costly. It was true the estimates had been exceeded by about £70,000. His estimate was to supply 6,000 kw. of plant and to remove 4,000 kw. from North-road. That removal had not taken place, and he had withheld his recommendation to that effect until he knew the saving to be effected at Southwick. He did not agree that it was necessarily cheaper to run one station than two.

After a lengthy examination of Mr. Wright as to the general basis of this scheme,

The Town Clerk asked if the matter was material to the inquiry.

The Inspector said it was difficult to say. Upon this Mr. Robb closely cross-examined Mr. Wright as to the Southwick scheme generally. Asked whether the plant at Southwick did not provide for an unprecedented consumption, Mr. Wright said the consumption of the Brighton undertaking was unprecedented. Every year was a record. He did not judge by the experience of other towns, but took the experience of that town, because Brighton had not many examples to look to in the development of electricity. The fact that there was only an increase in revenue of £1,000 last year Mr. Wright attributed to the great depression in trade, and expressed confidence that when trade revived the old increase of business would be revived.

Replying to the Town Clerk, Mr. Wright said his prediction of an increase in the sales of electricity had been more than verified, the sales in 1899 being 3,206,000 units, compared with 7,784,000 units last year. In his (Mr. Wright's) view the cost of having too much plant was so little compared with the cost resulting from insufficient plant that it was always economical to have in the electricity business more plant than one wanted rather than too little. Shortness of plant had been in the past a serious source of loss to the Corporation. It was wise to have a surfeit of plant rather than run it quite close.

After Ald. Carden had given evidence, Mr. Robb addressed the Inspector, the Town Clerk replied, and the inquiry terminated.

**Brynamman.**—This village is now lighted electrically by the Brynamman Electric Light Co. The contractors for the erection of the plant were Mills, English & Co., of Swansea. Current is generated by a Siemens dynamo driven by an Otto 40 B H.P. gas engine, supplied by Crossley Bros. The generator is capable of supplying 114 amperes at 220 volts. Gas is manufactured by a Crossley's patent suction gas producer.

**Chile.**—Don E. A. Finn has been granted a concession for supplying the city of Los Andes with electric energy for light and power. A similar concession has been granted for the city of San Carlos to Don J. E. Conchar, Don D. V. Santa Maria and Don R. C. Solar. To Don J. Pinkas, representing the Antofagasta Electric Lighting Co., a similar concession has been granted for Antofagasta. Don E. Lanz has been granted a similar concession for Buin and Linderos. In each case the concession is for 10 years.

**Clacton.**—At the last meeting the Council accepted tenders for electric lighting plant (as set out in another column). A proposal that the contract for cables only be accepted, and that consideration of the other tenders be postponed pending consideration of a contract with the Clacton & St. Osyth Light Railway Co. to supply the Council with electricity in bulk at 1½d. per unit was rejected.

**Covered Motor 'Buses.**—It is stated that the Commissioner of Police for the Metropolis has lodged an objection to the adoption of a covered roof on the vehicles of one of the principal lines of motor omnibuses now plying for hire in the West of London.

**Croydon.**—At a meeting of the Corporation on Monday it was decided not to accept the offer of the British Electric Traction Co. for an extension of the lease of the tramways. The terms of the company's offer were given in our issue of Sept. 22.

The chairman of the Tramways committee (Councillor Stapleton) said that public opinion was in favour of the Corporation working the tramways. They had spent close upon a quarter of a million on the lines and the returns showed that profits under municipal management were greater than under private control.

**Customs Decisions.**—Electrical apparatus and torpedoes for use in submarine mines are now admitted into Norway free of duty.

The Norwegian Customs Authorities have fixed a duty of 3 öre per kilog on imported lamp-posts for electric lighting, posts for electric tramways, &c.

The Italian Customs Officials have fixed a duty of £1. 0s. 4d. per cwt. (50 lire per 100 kilogs) on imported electric cables taken into Italy on reels, this duty applying to the gross weight of the cable and the reel. A duty of 3d. per pound (70 lire per 100 kilogs) is imposed upon insulating cords made up of wool, artificial wool, waste silk, &c., ½d. per pound (11 lire per 100 kilogs).

It has been the custom heretofore to allow wooden poles for carrying electric light wires to be admitted free into the United States, but it has recently been decided that such duty-free conditions apply only to the raw material and not to poles which have been partly prepared for use.

**Dublin.**—The inquiry into the Council's application for permission to borrow £100,000 for electric lighting extensions and £4,900 for utilising the tram lines for cleansing, &c., was continued on Thursday and Friday last week.

The city electrical engineer (Mr. Mark Ruddle) and the chairman of the Electric Lighting committee (Mr. John Irwin) gave evidence, and the inquiry adjourned till Feb. 15.

**Dundee.**—The borough electrical engineer (Mr. H. Richardson) has been offered an important appointment by a firm of electrical engineers in England.

**Dundee-Broughty Ferry Tramways.**—The official inspection of these lines took place yesterday (Thursday).

**East Barnet.**—The North Metropolitan Electric Power Supply Co.'s application for a provisional order will be opposed by the Council.

**Eastbourne.**—The Council have reduced the charge for electric current for private arc lighting from 5½d. to 4½d. per unit.

**Electrical Exhibition.**—A permanent electrical exhibition, at which consumers will have a good opportunity to view in actual operation a large and varied assortment of electrical machines, apparatus, appliances and materials for industrial and domestic uses, has been established by the Charing Cross, West End and City Electricity Supply Co. in a large showroom at their sub-station at 85, Fenchurch-street, London, E.C. Although a number of exhibits have been on view for some time, the exhibition was formally opened on Wednesday, when a large number of prominent city men and others were present at the invitation of the directors. A short speech was made by Mr. G. Brougham Glasier, vice-chairman of the company, welcoming the visitors and announcing that Sir J. Pound (late Lord Mayor of London) who was to have opened the exhibition, was prevented by indisposition from attending. Many of the visitors subsequently took the opportunity of inspecting the sub-station. Demonstrations were given by the engineers of the company and the various exhibitors, many interesting appliances being shown in operation. The exhibits are displayed in one room with about 6,000 sq. ft. of floor space. Some of the apparatus is permanently connected up to the company's mains, and three bare wires are carried round the top of the room on insulators, by means of which temporary connections can be made to any piece of apparatus, either across the outers or to one branch of the three-wire system by a simple arrangement of flexible leads and hooks. A representative collection of arc lamps is shown, including various double carbon lamps of the more recent types and one or two flame lamps.

J. G. Childs & Co. exhibit a small push button-controlled goods lift, suitable for clubs, private houses, hotels, flats, &c. Domestic appliances, such as knife cleaners, boot polishers, and a large collection of heating and cooking apparatus are shown by the General Electric Co., the British Prometheus Co., the Dowsing Radiant Heat Co., &c., and the apparatus for radiant heating form a large and varied class in the exhibition. Electrically-driven machine tools of various descriptions and one or two forms of friction hoists are shown, and the collection of various forms of reduction gearing is well worth study. The "centrator" gear, a sun and planet gear with friction rollers instead of spur wheels is an interesting example. A well-arranged exhibit is the boot finishing plant exhibited by Gimson & Co., and driven by a B.T.-H. motor. Another interesting piece of apparatus is the "Otto" sterilizer which the Lahmeyer Co. are introducing, and by means of which a supply of water sterilized by the action of ozone can be obtained. When the tap is turned on, contacts are closed which start a miniature rotary converter which supplies alternating current to the ozonizer, consisting of a small transformer and a condenser between the plates of which the discharge takes place. The water flowing through the tap draws the air through the condenser and thoroughly mixes with the ozone there formed. Curative apparatus in the shape of electric light baths and vibro-massage apparatus is also represented together with electrically-driven dentists' drills. Messrs. Read & Gale show an imposing collection of Röntgen ray apparatus. Displays are made of the manufactures of Electromotors (Ltd.) and the British Thomson-Houston Co. in motors; and by the Reason Mfg. Co., Mr. A. P. Lundberg, the London Electric Firm, the James Keith & Blackman Co., Drake & Gorham, the Electrical Co., and other prominent firms in the industry in connection with their manufactures. We understand that the exhibition will be constantly brought up to date, and will be open daily to inspection by any approved visitors on presentation of their cards.

An exhibition of electric light fittings, motors, radiators, pumping and heating apparatus, &c., has been held this week at Inverness, organised by the North of Scotland Electric Light & Power Co.

**Gelligaer (Glam.)**—The Council on Wednesday decided to apply for a provisional electric lighting order. Mr. Lloyd (Mathieson & Lloyd, consulting engineers), reported that it was doubtful whether current could be obtained from the South Wales Electrical Power Distribution Co., as the company's mains did not extend to the area. Failing supply from the company or from the collieries in the district a station could be equipped for £10,000.

**Hackney (London).**—Four single-grate and two double-grate boilers at the electricity works are to be equipped with chain-grate air-seal apparatus at a cost of £190. The Electric Lighting committee have taken over the lighting arrangements at the town hall. Current has been supplied for the past 10 years from an independent installation at the baths.

**Halesowen.**—The Board of Trade have been notified by the Council that an agreement has been entered into with the Empire Electric Light & Power Co. for a transfer of the Council's 1899 provisional order. The company have also agreed to apply for an amending order to authorise the construction of additional light railways in the district.

**Hampstead (London).**—The Council have decided to reduce, as from Jan. 1, their charges for power and heating as follows: *Power*—1d. per unit, with a minimum charge of £1 per kilowatt installed; or, at option of consumer, 1½d. per unit without a minimum charge. *Heating*—1½d. per unit.

**Hartlepool.**—The Council have authorised the National Telephone Co. to place their telephone lines underground, provided the company pay 13 guineas per annum for wayleaves.

**Inquest.**—At Ince, on Monday, the inquest was resumed into the circumstances attending the death, on Nov. 14, of David E. Jones, a drawer, employed in the Yard Mine of the Ince Hall Colliery, Ince. The facts were reported in our issue of 24th ulto.

Mr. H. Knight, colliery manager, explained that the electrical installation had been laid down for 3 years, and this was the first accident they had had.

Dr. Fletcher stated that deceased was a perfectly healthy man, and there was no doubt death was due to electric shock.

Mr. Hall, mine inspector, said no rule had been broken, but he thought some effective steps should be taken by using an armoured cable, or that the very best expert advice should be sought and acted upon in running the cables.

The jury returned a verdict of accidental death, no blame attaching to anyone.

**Islington.**—The Council will consider this (Friday) evening a report of the Lighting committee recommending the extension of arc lighting in 34 streets (extending over 15 miles) at an estimated cost of £21,011. At present 714 incandescent gas lamps are used and it is proposed to supersede them by 245 flame arc lamps. The total cost of this extension of the electric arc lighting is estimated to be £2,345 per annum against the present cost of gas £2,361, showing a small saving from the use of electric arc lighting, besides the immense advantage of improved illumination. The Finance committee, reporting upon this proposal, expressed the view that, under present circumstances the Council should not sanction the scheme. The matter is to be further considered in Council this (Friday) evening. A long acquaintance with the Islington district justifies us in saying that the lighting of many of the thoroughfares would be greatly improved by the substitution of electric lighting for gas.

**Llanrwst.**—The Llanrwst Electricity Supply Co. intend, on the expiry of the lighting contract in May next, to remove the overhead wires in the outer parts of the district on the ground that there is no likelihood of any demand for current for private lighting in those parts to justify the expense of either laying the cables underground or providing iron columns in place of the present wood poles. The Council have decided to ask the Board to insist upon the cables being placed underground forthwith.

**London County Council.**—At Tuesday's meeting loans for electric lighting were granted to Hackney £1,200 and Stoke Newington £16,925.

*Tramways.*—The Highways Committee recommended that £32,000 be expended upon the reconstruction of the existing tramways in Vauxhall Bridge-road and the construction of a tramway over the new Vauxhall Bridge, and that £5,300 be sanctioned for the provision of track and slot rails, &c.—Agreed.

The Committee brought up a report recommending the electrification of the first section of the Northern system of tramways (22½ miles) which was before the Council on Oct. 5 last. The estimates for the work amounted to £112,000, £12,000 and £665,000 respectively.—Agreed.

*Testing Stations.*—It was reported that negotiations had been going on with the County of London Electric Supply Co. with a view to the establishment by the company of testing stations in the south of London for the testing by the Council's inspectors of the electrical energy supplied to customers. No definite decision had yet been arrived at by the company upon the matter and it was decided to serve notices upon them to provide such stations.

*Electric Light Fittings.*—The Parliamentary committee submitted recommendations for the bringing into parliament of the General Powers Bill which, amongst other matters, authorises Borough Councils to supply electric fittings.—Agreed.

*Electric Power Supply in London.*—The reports of the Parliamentary and Finance committees on the County Council's electricity supply scheme together with the discussion thereon, are given on page 340.

**Louth.**—The Council have decided to send a deputation to the L.G. Board to urge them to re-consider their recent decision not to sanction a loan for electricity supply.

**Macclesfield.**—Application is being made for a loan of £250 to cover cost of obtaining the 1901 electric lighting order, which has not yet been put in operation.

**Menai Bridge.**—The National Electric Construction Co. have asked the Council to support their scheme for the supply of electricity on the Anglesey side of Menai Straits.

**Municipal Telephony.**—Swansea Telephone committee discussed last week a proposal to borrow a further £7,000 for extensions of the municipal telephone system. It was stated that the matter was still under consideration by the Postmaster-General.

**National Electrical Manufacturers' Association.**—Mr. Davenport, secretary of this association, forwards a copy of a circular which has been sent to the members, containing particulars concerning the Electrical Trades' Benevolent Institution, which has recently been started. At the first shot £260 was, it is stated, collected for the purpose of establishing the benevolent fund, and Mr. Davenport expects a good sum from the surplus of the late Electrical Exhibition. A committee of 15 members has been elected, with power to add 15 to their number. In addition to donations of £10 each, the committee pledge themselves to raise £100 each for the fund. Already a good number of promises have been received.

**New South Wales Electrical Association.**—The officers of the Association for the ensuing year are:—President, Mr. A. C. F. Webb; vice-presidents, Messrs. A. J. Arnot and T. P. Strickland; hon. sec., Mr. A. E. C. Burgess; hon. treasurer, Mr. G. R. Hodson; Council, Messrs. J. R. Bainton, O. W. Brain, J. R. W. Gardam, A. W. Kendall, E. F. Moates; auditors, Messrs. J. E. Donoghue and W. S. Corner.

**New Zealand.**—Electric tramways are all the go in this colony, and, in addition to the well-established and successful lines in Auckland, Wellington, Christchurch and Dunedin, the local authorities at Hutt and Petone are considering the question of introducing electric tramways. There are also considerable extensions in contemplation to the electric tramways in the suburbs of Wellington. In regard to electric lighting, developments move more slowly. Although there are a large number of small installations in the colony, most of the cities and towns still adhere to gas. At Wellington the streets and buildings are, however, nearly all lighted electrically. Electric power is fast coming into general use in New Zealand, nearly all the larger factories either employing electric driving or schemes for converting machinery to electric power are under consideration. Dunedin Corporation have lately taken over the Waipari Falls Power Co., whose generating works are partly constructed, and there is a general disposition to develop the water power of the colony by the State, which has reserved all the water rights for this purpose.

**Portsmouth.**—The Corporation have decided to purchase additional tramcars.

**Presentations.**—The staff and employés of Crompton & Co., Chelmsford, have presented a silver tray to Mr. H. C. Hawkins, who is leaving the firm.

The staff of the electricity and tramways departments at Barking have presented a marble clock with bronze reliefs to the retiring electrical and tramways engineer, Mr. A. H. Seabrook.

The staff of the electrical department of the North Staffs. Railway (Stoke-on-Trent) have made presentations to Mr. R. P. Bould, who has secured an appointment with the State railways of N.-W. India.

**Shrewsbury School Fire.**—The borough electrical engineer (Mr. C. M. Johnston) has written to the Press to state that the recent fire at Shrewsbury School was not caused by the fusion of electric wires as had been alleged. Mr. Johnston states that a thorough investigation shows that all the branch fuse wires were in order on the distributing boards and that the damage to the wires was the the effect and not the cause of the fire.

**Smoke Abatement and Mechanical Stoking.**—At the exhibition organised by the Royal Sanitary Institute and the Coal Smoke Abatement Society at the Royal Horticultural Hall, Vincent-square, Westminster, this week, Messrs. Ed. Bennis & Co. made an interesting exhibit comprising a "Bennis" and "Miller-Bennett" improved smokeless chain grate stoker, specially applicable to furnaces of steam boilers, refuse destructors and similar machines. We understand that excellent results have been obtained from the use of this grate at the works of the Kensington & Notting Hill electricity station, where it can be seen in operation. Messrs. Bennis inform us that they have a number of orders on hand from electricity supply and power stations, &c., for this grate, for the manufacture of which they hold the exclusive rights. This company's exhibit also included a Bennis patent stoker and furnace applied to a Cornish boiler in actual operation. A third exhibit was a "Darling" calorimeter, which the exhibitors claim is the simplest machine of the kind on the market, and the results obtained are as accurate as with more expensive types of this apparatus.

**South Africa.**—The accounts of Durban Corporation electricity department for the year ended July last show total capital expenditure £231,625, increase £25,697.

Revenue was £76,702. 16s. 7d., including £55,026. 10s. 7d. from private consumers, £8,100 from tramways department, £8,290 from street lighting and £5,286. 6s. for light and power for other departments of the Corportion. Working expenses were £35,848. 1s. 3d., leaving £46,845. 15s. 4d. gross profit. After meeting capital charges and providing for depreciation, &c., the net profit was £14,526. 15s. 3d. There are 2,996 private consumers for lighting (compared with 2,441 last year), 171 power consumers (against 140), 255 street arc lamps (against 230), and 1,240 street incandescents (against 902). 4,419,651 units were sold, including 1,506,703 for private lighting, 812,864 to private consumers for power, 1,548,649 to the tramways, and 551,435 for street lighting. Working expenses per unit sold were 2·399d. and total costs 5·79d. per unit.

Cape Town municipal electricity department accounts for the year ended June last show that 1,865,837 units were sold. There are 1,332 private consumers connected, with the equivalent of 95,300 8 c.p. lamps connected, and motors totalling 2,146 H.P. (an increase of 419 H.P.). Working expenses were 5·41d. per unit (against 4·354d). The revised charges for current are from 8d. to 1s. per unit for night use, half rates being charged during certain hours of the day.

The "British and South African Export Gazette" states that the whole of the plant of the Rand collieries is to be driven electrically. The electrical equipment of Roodeport United Main Reef property has been largely augmented.

Powerful electric plant has been installed for working the hoists at the Aurora West United mine.

At Greytown (Natal) electricity supply commenced on Oct. 14, 1904. There are now 70 consumers with over 2,000 equivalent 8 c.p. lamp connections. The municipality, who own the undertaking, report that a motor day load is now being developed.

At Boksburg (Transvaal) electricity supply matters are at a standstill, as arbitration is pending in connection with the undertaking owned by Messrs. Gellender & Co.

The South Rhodesian telephone system (owned by the British South Africa Co.) has now five exchanges. The subscription is 12 guineas per annum to private subscribers, the call-office fee is 6d., and the public service is on a sliding scale of 15 guineas for the first year, decreasing by £1. 1s. per annum to £12. 12s.

Cape Colony Government telephone service, which has been in operation since May, 1882, has now 13 exchanges with 3,200 subscribers in Cape Colony. The annual subscription is £10 per annum for the first mile and £1 for each additional ¼ mile; call-office fee 3d.

The Natal telephone service which, except for the Durban municipal system, is owned by the State, has four State exchanges and one municipal. Trunk telephone lines connecting up Maritzburg with Ladysmith, Dundee, Newcastle and Durban will shortly be brought into operation. The total number of subscribers to the State service on Nov. 1 was 900. The subscription is for business houses £10 per annum, domestic £5, within a 2-mile radius.

**South Shields.**—For the past three months the total revenue of the electricity department was £3,428. 10s. (including £2,430. 19s. 8d. for private lighting), against £3,664. 11s. for the corresponding period of 1904.

**Spanish Telegraphs.**—Don Frederico Laviña has been nominated Director-General of Spanish Posts and Telegraphs (Director-General de Comunicaciones) in substitution of the Duque de Bivona, appointed Civil Governor of Barcelona. Senor Laviña was Director-General of Comunicaciones under a former Liberal Ministry.

**Sunderland.**—At the Council meeting on Wednesday Ald. Bruce moved the adoption of the Electricity and Lighting committee's report recommending that the building and plant at Hylton-road station be extended at an estimated cost of £18,000.

Ald. BRUCE said they had reduced the price of current to all consumers, and were able to return a net profit of £3,000 for the year. They had not a large reserve, but they were entitled to consider the sinking fund a good reserve, and they had £46,043 in this fund. The committee would soon be able to announce a further reduction in the charge. Their output was 1,000,000 units per year, and he had no hesitation in saying they would get to 8,000,000 units in the future. The undertaking had not been a burden on the rates, but rather the reverse, and manufacturers had benefited by the cheapness of the supply.

The report was adopted.

**Swindon.**—The Council have received sanction to a loan of £2,550 for the tramways department.

**Telegram Deliveries.**—The Postmaster-General has made a regulation under which, on and after Jan. 1, the charge for the delivery of telegrams at addresses situated beyond the area of free delivery will be calculated at 3d. per mile from the boundry of that area, and not from the post office door as at present.

**Taunton.**—An unopposed inquiry was held last week into the Council's application for sanction to a loan of £4,844 for electric lighting extensions.

**Uruguay.**—The committee in charge of the matter of remodelling the Monte Video power house and the system of distribution and the laying of underground mains have agreed with the proposals of Messrs. Dick, Kerr & Co. and the Compañia Alemana Transatlantica de Electricidad of Buenos Ayres, and these companies have been asked to submit formal tenders by Dec. 31.

**Warrington.**—The charges for electric current for power have been revised as follows:—1d. per unit with a load factor of 40 per cent.; 0·94d. with a load factor of 50; 0·88d. with 60; 0·82d., 70; 0·76d., 80; 0·70d., 90; intermediate values of load factor being worked out proportionately.

**West Africa.**—At San Thomé the telephone service is owned by the State, and there are four exchanges with 73 subscribers connected. The service is being greatly extended on the island, and is becoming increasingly popular. The subscription rate varies according to distance, the call office fee being 10d. for five minutes' conversation, and 1d. for each minute in excess. An aerial telegraph line is under construction on this island.

**Winchester.**—The city surveyor has been instructed to prepare an estimate of the cost of wiring and fitting the banqueting room, Sessions Hall, and main corridor in the Guildhall for the electric light.

**Worcester.**—The Council have authorised the substitution of 12 half-night B.T.-H. enclosed continuous-current lamps for 12 of existing arc lamps, at an estimated cost of £4. 4s. for each lamp and £2. 1s. for the swan-neck fitting.

**Yarmouth.**—The Electricity committee have been authorised to establish a showroom and office in a central position for displaying electric light fittings, radiators, electric cooking apparatus, &c.

**Electro-Harmonic Society.**—A smoking concert will be held this (Friday) evening in the King's Hall, Holborn Restaurant, commencing at 8 o'clock, under the presidency of Mr. J. Gavey, C.B. We would remind our readers that in the interval presentations will be made to the members of the executive committee of the recent successful Electrical Exhibition at Olympia.

**Dinners, &c.**—The annual staff dinner of Portsmouth Corporation telephone department took place on Friday evening, and proved a successful and enjoyable function. About 60 members and friends attended. Mr. C. M. Gardner (manager) presided.

"The Staff of Portsmouth Corporation Telephone Department" was proposed by Mr. Harding, and responded to by the chairman, who spoke highly of the individual and collective efforts of the officials connected with the undertaking.

Mr. J. Teasdale, chief clerk, who also replied, attributed the success of the undertaking to the unflagging devotion to duty of the manager, and to the masterly manner in which he dealt with the various matters in connection with the department. He also referred to the services rendered by Messrs. W. J. Knox (outside superintendent), D. MacIntosh (inside superintendent), and other officials.

Mr. Morton Beales was on Saturday evening entertained at a farewell dinner by his friends in the British Westinghouse Company, upon his resigning the position of district office manager in order to take up the position of manager to Messrs. Bruce Peebles & Co. Mr. Beales had been connected with the Westinghouse Company for the last three years, and previous to that he was commercial engineer to J. G. White & Co., having resigned his position with Ferranti (Ltd.), on whose staff he had been for nearly 10 years. His address will be No. 1, London Wall-buildings, the new London offices of Bruce Peebles & Co.

On Saturday members of the "Robertson Private Fire Brigade" held their second annual dinner at Brook Green, Mr. Wilson (works manager) in the chair, and Mr. Driver (assistant manager and superintendent of the brigade) in the vice-chair.

Mr. Wilson, speaking on behalf of the firm, said the members of the fire brigade should be proud of the position they held, as they were recognised by the firm to be the most trusted of their employés. Remarking on their success at the London Private Fire Brigade competition, he thought they only missed carrying off the championship cup through over confidence, although they were to be congratulated on taking away one first prize and two seconds.

The annual dinner of the works staff of Salford electricity works took place on Saturday. The borough electrical engineer (Mr. C. D. Taite) said a year ago the undertaking was fifth among the municipalities as to works costs, and was now second. They were only beaten by the $\frac{1}{1000}$th part of 1d. on the cost. Councillor Hodgson, chairman of the Electricity committee, said the demand for current for lighting, traction and motor power was growing nearly to the full extent of the works' capacity.

The annual supper and concert in connection with the Leicester Corporation Tramway Employes Sick Benefit Society was held on Tuesday night. Mr. A. F. Lucas (tramways manager) occupied the chair, and among those present were Councillor S. Flint (chairman of Tramways Committee), Ald. T. Smith (vice-chairman), Mr. T. R. Smith (electrical engineer), Mr. W. Evans (traffic superintendent), and Mr. G. Morris (car-shed superintendent).

The Chairman, in proposing a toast, said that from the first the committee had taken a great interest in their club, which had now over 300 members and was on a firm and sound financial basis. The club had been founded about 12 years, and had been able to invest some of its funds in Corporation stock.

# TRADE NOTES AND NOTICES.

## TENDERS INVITED.

*Manchester* Electricity Committee invite tenders for the supply, delivery and erection of: (*a*) One group of three single-phase transformers of 200 kw. each, constituting one complete 600 kw. three-phase transformer; (*b*) high and low-tension switchboards for three-phase transformer sub-station. Tenders, addressed to the chairman of the Electricity Committee, must be delivered at the Town Hall by 19th inst.

*Grimsby* Corporation invite tenders for a 500 kw. continuous-current direct-coupled high-speed double-acting engine, water-tube boiler and underfeed stokers, extension of switchboard, condensing plant (surface type), buildings, pipe-work, coal conveying plant and lead-covered paper-insulated cables. Tenders to the borough electrical engineer (Mr. W. A. Vignoles), Corporation Electricity Works, Grimsby, by first post Jan. 5.

*Plymouth* Corporation invite tenders for coal-discharging and conveying apparatus. Tenders to the borough electrical engineer by 23rd inst.

*Manchester* Tramways committee require tenders by 1 p.m. 23rd inst. for supply of points, tongues and centres.

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*Islington* (London) Council invite suggestions from chemists and others (particularly those expert in the purification of water for boiler-feed purposes) as to the best means of eliminating injurious salts and other matter from water obtained from an artesian well. Further particulars from borough electrical engineer (Mr. Albert Gay), 50, Eden-grove, Holloway, N., on or before Jan. 1, 1906.

## TENDERS RECEIVED AND ACCEPTED.

Barrow-in-Furness Corporation have accepted the following tenders:—

| | | |
|---|---|---|
| Vickers, Sons & Maxim, 500 kw. combined steam engine and generator | £2,864 | 0 |
| Phœnix Dynamo Mfg. Co., balancer booster | 247 | 0 |
| Babcock & Wilcox, water-tube boiler, with superheater | 873 | 0 |
| Do. do. economiser | 355 | 0 |
| Herbt. Morris & Bastert, 5-ton travelling crane | 260 | 11 |
| Jas. Hodgkinson (Salford), Ltd., mechanical stoker | 210 | 0 |
| John Hitchen & Son, ironwork | 392 | 0 |

London County Council have received the following tenders:—

*Conductor Tee Rails.*

| | |
|---|---|
| Frodingham Iron & Steel Co. (*accepted*) | **£8,250** |
| Steel, Peech & Tozer | 9,050 |
| P. & W. MacLellan | 8,613 |
| Bolckow, Vaughan & Co. | 8,550 |

*Poplar Car Shed.*—22 tenders were received for this work, and that of C. Wall (Ltd.), at **£29,006**, was accepted.

Clacton Council have accepted the following tenders for electric lighting plant, &c.:—

Davey, Paxman & Co., steam engines and dynamos (Parker), £3,676;
J. E. Spagnoletti & Co., switchboard, £600;
Johnson & Phillips, cables, £4,098. 11s. 9d.;
D.P. Battery Co., storage battery, £1,450;
J. McKay, buildings, £1,848.

The London Electric Firm, George street, Croydon, have received an order from W. Lucy & Co. for 45 complete sets of their "One working part" arc lamp lowering gear for street lighting in Pembroke, Ireland. The consulting engineers for this work are Messrs. Robert Hammond & Son.

Birkenhead Electricity committee have accepted the tender of A. Reyrolle & Co., Hebburn, for supply and delivery of motor starters in accordance with the specification of the borough electrical engineer during the 12 months commencing Jan. 1.

The A.B.P. Accumulator Co. have recently booked orders for storage batteries for Dumbarton (480 cells), Derby (26), Oxford (55), Croydon (110), Tain, N.B. (54), Ealing (54), Newcastle (54, renewals), and South Africa (108).

Salford Corporation have accepted the tender of Cowans Limited for five reverse current circuit-breakers at £8 each, and that of Mercier's Patents (Ltd.) for telephonic communication between the model lodging house and the manager's residence.

The contract for conduits, feeder and arc lighting cables, underground boxes and lamp pillars for the Portland coaling depot has been placed by the Admiralty with Johnson & Phillips, Old Charlton, Kent.

Stafford Council have accepted the tender of Baxendale & Co. for a year's supply of wrought-iron tubes and fittings for the electricity department.

Hampstead (London) Council have accepted the tender of J. Musgrave & Sons for altering the engines at the electricity works at £600 each.

The East Indian Railway Co. have accepted the tender of Johnson & Phillips for motors, transformers and complete electrical plant for Lillooah.

The Brockie Pell Arc Lamp (Ltd.) have received an order from the Admiralty for 140 of their well-known open type arc lamps.

Canterbury Council have accepted the tender of H. Pooley & Sons for a 7-ton weighbridge for the electricity works.

Brierley Hill Council have accepted the tender of the National Telephone Co. for electric fire calls.

West Ham Corporation have placed an order with Babcock & Wilcox for four chain-grate stokers at £248 per boiler.

## BUSINESS NOTICES.

Mr. Gilbert C. Vyle, A.M.I.E.E., has resigned his position as works manager and assistant to the general manager of the telephone department of the General Electric Co.'s works at Salford, and has established himself at 14, Ridgefield, Manchester, as a consulting engineer for telephones and all systems of electric signalling. Mr. Vyle is also specialising in works organisation and the manufacturing details necessary for the economic production of light and intricate mechanical and electrical apparatus.

Mr. Bertram S. Giles, M.I.E.E., has been appointed by Messrs. Mather & Platt chief representative for London and the South of England for their electrical and hydraulic departments. Mr. Giles has been for nearly 17 years with Mather & Platt at their Salford works.

Mr. A. H. Hunt, 115-117, Cannon-street, London, E.C., notifies us that he has been appointed sole British agent for Hellesens patent dry cells, manufactured by Hellesens Enke V. Ludvigsen of Copenhagen.

## BANKRUPTCIES, LIQUIDATIONS, &c.

In the failure of Jas. Wood Smith (trading as Smith & Co.), electrical engineer and contractor, 55, Bolton-road, Darwen, the first meeting of creditors will take place on 18th inst. at 14, Chapel-street, Preston, and the public examination on Jan. 10 at the County Court House, Blackburn.

The public examination of Robert Pries (trading as Durtnall & Pries), electrical sundriesman, 75, City-road, London, E.C., is adjourned to Jan. 26, and will take place at Bankruptcy-buildings, London, W.C.

A receiving order has been made against Wm. Leslie, electrical engineer, lately of 22, Bangalore-road, and 1, Dryad road, London, S.W.

Wimshurst, Hollick & Co. (Ltd). is being wound up voluntarily. Mr. W. Cash, 90, Cannon-street, London, E.C., is liquidator.

The Otto Electrical Mfg. Co. (1905) (Ltd.) is being wound up voluntarily. Mr. E. H. Fletcher, 14, George-street, Mansion House, London, E.C., is liquidator.

The Imperial Electric Lamp & Battery Synd. (Ltd.) is being wound up voluntarily. Mr. A. Sissons, 103, Gresham House, Old Broad-street, London, E.C., is liquidator. Claims by Jan. 15.

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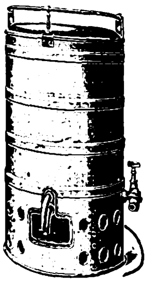
**Cable for Sale.**—Marylebone (London) Electricity Supply committee invite offers for about 40 tons of 19/16 and 7/16 old high-tension rubber cable. Particulars from the resident electrical engineer (Mr. F. A. Wilkinson), 11, Manchester-street, London, W. Offers to the town clerk (Mr. J. Wilson) by 4 p.m. 19th inst. See also an advertisement.

**Increase in Prices.**—The Electrical Co., 121-125, Charing Cross road, W.C., announce that in consequence of the continued rise in prices of raw materials used in the manufacture of their machines and apparatus, &c., they are obliged to make an extra charge of 5 per cent. on their list prices for orders received after Nov. 30. For the present this extra charge does not apply to glasses and shades for electroliers, incandescent and Nernst electric lamps, wires, cables and insulating material, or to leaflets Nos. 100, 101, 106, 107, 110 and 111. On "Luna" flame arc lamps the extra charge will be 15 per cent.

**Holden Chronographs.**—The War Office authorities have instructed James Pitkin & Co., 56, Red Lion-street, Clerkenwell, E.C., to proceed with the construction of two more Holden chronographs (of which the firm are sole makers) for use at Woolwich Arsenal. The chronograph was invented by Lieut.-Col. Holden, R.A., superintendent of the Gun Factory, Woolwich, for the accurate measurements of the velocity of projectiles. Already a battery of 12 of these important instruments has been supplied to Woolwich Arsenal. Among the foreign Governments who have James Pitkin & Co.'s chronograph in use are those of Russia, Japan and Italy.

**"Electricity in Shipbuilding Yards."**—This is the title given to a pamphlet prepared and issued by the Electrical Co., 121–125, Charing Cross-road, London, to describe and illustrate some of the numerous advantages that can be attained by the employment of properly-designed electrical equipment for machinery in the shipbuilding and similar industries. In constructing the machinery which is here described, every effort has been made to eliminate or reduce to a minimum all superfluous power consuming intermediate links between the motors and the machinery to be driven, and to attain this end individual driving has been, in the majority of cases, preferred. Most of the electrical equipment illustrated in this booklet were adopted for the conversion of Messrs. Harland & Wolff's Belfast works from steam to electric power, and we took a recent opportunity of describing the works in these columns (see *The Electrician* for March 10, 17, 24, 31 and April 7). The illustrations include some fine views of the shops in these famous yards, and a number of the largest individual machines have been selected for illustration. Amongst these is a punching and shearing machine, used for steel plates 1½ in. thick and for holes 1½ in. diameter. This machine is driven by a totally-enclosed three phase 12½ B.H.P. motor of special design at 825 revs. per min. Ingenious and effective devices are employed to avoid any heavy rushes of current on starting the large masses of this machine. Plate straightening rolls, double plate scarfing machines, radial counter-sinking and drilling machines and all other machines erected in these works, both large and small, are now driven electrically, and the publication under review gives an excellent idea of the extent of the work carried out by the Electrical Co. in connection with this contract.

**Catalogues, &c.**—A new price list of single-phase motors for 50 cycles is issued by the Lahmeyer Electrical Co., 109-111, New Oxford-street, London, W.C. Copies of the list can be obtained on application.


G.E. Auto Service Water Heater.

The sixth edition of section H of the General Electric Co.'s main catalogue dealing with heating and cooking apparatus, radiators and accessories, is now ready. The latest types of G.E. heating appliances are listed, and amongst the items now shown is the auto service water heater with a flat back, double cased to prevent loss of heat and to give greater efficiency. The accompanying illustration shows this heater, which are wired for heating up from cold and to keep water hot for washing purposes with a minimum consumption of current.

Mechan & Sons (Glasgow and London) have just issued a set of pamphlets describing and illustrating the various types of Watkinson steam superheater manufactured by the company. Steam dryers and oil separators are also listed.

Single-pole double-throw quick-break knife switches are listed in a new circular (No. 53) issued by Ferranti Limited, Hollinwood, Lancs.

The Electrical Co., 121-125, Charing Cross-road, London, W.C., have issued several sheet price lists, &c., relating to small motors, the Rignon small arc lamp for continuous current, the latest types of Nernst lamps, &c. The list relating to the Rignon lamp describe the advantages claimed for this piece of apparatus. Amongst the claims made is one that the finest shades of colour can be distinguished by the light of the lamp, for which low current consumption is also one of the advantages.

Oil separators of the Worthington type are listed in a new price list issued by the Worthington Pump Co., 150, Queen Victoria-street, London, E.C. Ask for leaflet No. 107.

Mr. Pippette, of 457, Brixton-road, London, S.W., has prepared a supply chart for electricity, gas, water, &c. This chart embodies a calender for 1906, and contains ruled spaces where meter readings can be entered up every week, together with the differences representing each week's supply. Scales are also provided so that these quantities can be plotted as curves. Some wise maxims are printed across the chart.

**Calendars, &c.**—The coming of Christmas and the New Year is forecasted by the arrival of the first batch of calendars, diaries, &c., for 1906. These include several novelties, besides useful desk and pocket companions, accompanied in several cases by accident insurance policies for considerable sums.

W. T. Glover & Co., who are usually to the front in the way of hanging pad tear-off calendars, have published their fourth example of this class of date-remembrancer. As in previous years, the tear-offs are occupied by extracts from the "Proceedings" of the Institution of Electrical Engineers, "chosen with a view of rescuing items of interest from bookshelf oblivion." A number of communications of a humorous character have been incorporated in this edition.

G. Street & Co., the well-known advertising contractors, of 30, Cornhill, London, E.C., have forwarded their useful framed and glazed calendar, which regularly finds a place in our own and many other city offices. We should miss the reminder which Street & Co.'s calendar regularly brings of the approach of the New Year.

Siemens Bros. & Co. have adopted the pocket-book type of calender and note book, and this publication is not the least acceptable of those which have been received. Its practical character is shown by the fact that it comprehends an accident insurance policy for £1,000, and is provided with pencil and sheath, a bookmark, and a good supply of paper for memos, &c.

**Imports.**—The following are official values of imports of electrical machinery, material and apparatus imported into this country during November, 1905 :—

Electrical machinery, £38,715 (a decrease of £5,814, compared with November, 1904); telegraph cable and apparatus, £2,365 (decrease, £5,893); other electrical goods, £92,479 (increase, £16,994). The values of imports of the three classes for the 11 months ended Nov. 30 were, respectively, £452,568 (decrease, £69,022); £49,155 (increase, £545); and £866,166 (increase, £161,603).

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Dec. 6 to Dec. 12, with the ports of destination :—

*Africa.*—Cape Town, £397 (including £55 telegraph material); Delagoa Bay, £1,350 (including £275 telegraph material); Durban, £618; East London, £121; Mozambique, £46; Port Elizabeth, £413; Suakim, £80 (telegraph material); Suez, £55 (telegraph material). *Argentina*—Buenos Ayres, £8,097 (including £1,284 telegraph material). *Australasia*—Brisbane, £144; Hawera, £190; Melbourne, £665, and 101 cwt. telegraph wire; Napier, £13; Perth, £310; Rockhampton, £50; Sydney, £706; Wellington, £756. *Belgium*—Ostend, £23. *Canary Islands*, £14. *Ceylon*—Colombo, £147. *China*—Shanghai, £21 (telegraph material); Tientsin, £134. *Denmark*—Copenhagen, £10. *Germany*—Dantzig, £1,075. *Greece*—Piræus, £19. *Holland*—Amsterdam, £454 (including £374 telegraph cable); Rotterdam, £1,614 (including £989 telegraph material). *Hong Kong*, £26. *India*—Bombay, £1,087; Calcutta, £706; Karachi, £97; Madras, £123. *Japan*—Moji, £200. *Java*—Balek Pappan, £13. *Malta*, £12. *Mauritius*, £1,923. *North Atlantic*, £4,700 (telegraph cable). *Portugal*—Lisbon, £37. *Spain*—Bilbao, £305. *Straits Settlements*—Penang, £613 (including £400 telegraph material); Singapore, £220. *Sweden*—Gothenburg, £10; Stockholm, £83. *United States*—New Plymouth, £50. *West Indies*—Trinidad, £11. Total, £27,738, against £74,137 in the corresponding week last year (Dec. 7 to 13).

## COMPANIES' MEETINGS AND REPORTS.

**ARON ELECTRICITY METER (LTD.)**—At the meeting on Friday last the chairman (Mr. H. Hirst) moved the adoption of the report given in our issue of Dec. 1 and said that the path they had entered on was beginning to look straight and clear. They had practically earned sufficient to pay the full 6 per cent. preference dividend, but they would like to have another year's result before them before they resumed that ratio of dividend. The results of the fairly satisfactory report were due principally to the business carried on in Berlin, at the factory in Schweidnitz, and at their branch in Vienna. In these three branches the principal profit had been made this year, because in France and England they could not claim to have made any profit; they had even made a small loss.

**BARCELONA TRAMWAYS CO. (LTD.)**—At an extraordinary meeting on Wednesday the resolution passed on the 27th ult. to wind up the company voluntarily was confirmed. The chairman (Mr. J. B. Concanon) said that the money for the sale of the company's undertaking was paid and deposited at the bank on Monday last. Mr. J. B. Glenn was appointed liquidator.

**BRITISH ELECTRIC TRACTION CO. (LTD.)**—The interim report issued by the directors states that since the date of the last report, about 17½ miles of new or re-constructed tramways or light railways have been opened for traffic by electric traction, and the Bombay horse tramways of about 17 miles, have been added to the list of associated undertakings. The total mileage of tramways, railways and omnibus routes is now 439 miles, and the total traffic receipts of all the associated undertakings for the current year are estimated at £1,400,000, compared with £1,264,061 for 1904. Electrical lines are now under construction at Penge and Croydon to Mitcham near London, at Cavehill near Belfast, in Middlesex (forming part of large system of Metropolitan Electric Tramways) and in Birmingham district. In spite of having sold its interests in several undertakings (as mentioned in last report) to local authorities and others, upon which the return for 1904 was about £12,000, the directors expect that the aggregate return for the current year upon the company's investments will be maintained. The directors also anticipate that satisfactory profits will be made before the closing of the books on March 31 next, but as the substantial profit receivable in shares of the Bombay Electric Supply and Tramways Co. has not actually been received, the directors prefer not to declare an interim dividend on the ordinary shares for the present half-year. The Bombay Co. has successfully raised £600,000 in debenture stock and £600,000 in 6 per cent. preference shares. Energetic steps are being taken to carry out the conversion of the tramways to electric traction and to enable the Bombay Co. to deal effectively with the supply of electric light and power. Two of the managing directors have visited Bombay this year, and report very favourably on the prospects of the business.

**BRITISH WESTINGHOUSE ELECTRIC & MFG. CO. (LTD.)**—The directors' report for the year ended July 31, states that the gross profit was £113,409. After providing for interest, depreciation and certain special expenditure, a loss of £15,407. 10s. 10d. is shown, after deducting the balance (£2,810) from last year. The special disbursements referred to are: Exceptional expenditure under Mersey railway contract (£43,550), balance of exhibition and sundry expenditures brought forward from 1904 now written off (£5,340), and proportion applicable to current year of excess cost and experimental expenditure on manufacture of new types of apparatus during that period (£25,000). Care has been exercised to have the works equipment efficiently maintained, and, in addition, a considerable sum has been charged to profit and loss for maintenance of large machine tools and machinery, while all patterns and drawings, together with patents acquired, have equally been charged to profit and loss. In view of this, the directors consider that the £16,500 provided for depreciation (which includes £5,000 in respect of buildings) is adequate. The balance of £225,000 of 4 per cent. mortgage debenture stock available for issue has been sold to the American Westinghouse Co., to be taken at 95 per cent. in the course of 1906. The output from the works during the past year was considerably in excess of that for the previous year, and a large saving in manufacturing costs and in selling and general expenses was effected. Competition is still very keen, and seriously affects the company's business and outlook; but it is hoped by the directors that, with the revival in trade, this condition may improve. Mr. J. W. Cloud and Sir Joseph Lawrence, M.P., have retired from the board, and Mr. Newcomb Carlton, a vice-president of the Westinghouse Electric & Mfg. Co. (Pittsburg, Pa.) has been elected a director.

**INDIA RUBBER, GUTTA PERCHA & TELEGRAPH WORKS CO. (LTD.)**—The directors' report for the year ended Sept. 30 states that the accounts show, after provision for doubtful debts, a net profit of £51,728. 17s. 2d. Adding £53,274. 7s. 1d. brought forward, and deducting £12,500 interim dividend, there is a disposable balance of £92,503. 4s. 3d. The directors recommend a dividend of 15s. a share (tax free), amounting to £37,500, making a total payment of 10 per cent. for the year, leaving £55,003. 4s. 3d. to be carried forward. The general business of the company shows an increase compared with last year, and although the price of raw material is still very high the fluctuations have not been great, and, therefore, better prices have been obtained for manufactured goods. The cable department, besides having other smaller work in hand, is at present engaged in the manufacture of 1,300 nautical miles of submarine telegraph cable, which will be laid by the company's ss. "Silvertown" between Shanghai and Manila in March next. The "Dacia" and "Buccaneer" have been employed in cable-repairing work during the year, and the latter is at present under charter. The works at Silvertown and Persan have been maintained in their usual state of efficiency, but considerable expenditure must still be made at Persan to provide for the economical production of goods for the French market. The Hon. Henry Marsham, owing to the necessity of residence abroad during a considerable portion of the year, has resigned his position as a director, and has been appointed an extraordinary director. Major Leonard Darwin has been elected chairman.

**ISLE OF THANET ELECTRIC TRAMWAYS AND LIGHTING CO. (LTD.)**—The directors' report for the year ended Sept. 30 states that the balance profit was £12,815. 18s. 11d. Traffic receipts show a reduction of £2,924, and sale of electricity an increase of £490, compared with the previous year. The directors regret that the profits have only enabled them to pay the preference dividend to March 1, 1905, and they have carried forward the balance of revenue (£1,047. 0s. 2d.). The report refers to the two accidents which occurred during the year. The company was fully insured against third-party risks, and therefore lost nothing by personal claims, but the accidents had a detrimental effect on the traffic receipts. The company have now made arrangements for exchanging drivers before arriving at the spot where the most serious accident occurred (Madeira Hill) and the other steep gradients, so that in future none but their most experienced men will operate the cars on these parts of the system.

**TELEPHOS LIMITED.**—The statutory report shows that 365 preference and 977 ordinary shares have been taken up out of a capital of £10,000 in 8,000 preference shares of £1 each and 40,000 ordinary shares of 1s. each. 10s. per share has been called up on 315 preference, £1 per share on 50 preference and 1s. per share on 970 ordinary and £256 has been received. No mortgages or charges registered.

# NEW COMPANIES, MORTGAGES AND CHARGES.

## NEW COMPANIES.

**KAMM'S ZEROGRAPH SYND. (1905), LTD.** (86,717.)—Reg. Dec. 8, capital £24,000 in 10s. shares, to acquire business of manufacturers of telegraphic and other instruments and typewriters carried on as Kamm's Zerograph Synd. (Ltd.), and to carry on the said business and that of general manufacturers of typewriters, printing machines, telegraphic, electric and scientific instruments and the like, suppliers of electricity, workers, controllers and regulators of telegraphic and telephonic exchanges and electrical works, &c. First directors, L. Kamm and F. R. Hickson. Reg. office, 27, Powell-street, Goswell-road, London, E.C.

**LENS LAMP CO. (LTD.)** (86,774.)—Reg. Dec. 8, capital £60,000 in £1 shares, to acquire and carry on the business of the Bohm Lens Lamp Co. (Ltd.), and to carry on the business of lamp manufacturers, glass blowers, electricians, &c. Reg. office, 7, Great St. Helens, London, E.C.

**LONDON & GENERAL POWER SUPPLY CO. (LTD.)** (86,791.)—Reg. Dec. 9, capital £60,000 in £10 shares, to carry on the business of generators, transmitters, distributors and suppliers of electrical energy, constructors and equippers of generating stations and electric light and power works, layers of cables and wires, company promoters, financiers, &c., and to apply for any necessary acts of Parliament or orders. The subscribers are: H. R. Russell (150 shares), J. G. B. Stone (50), R. D'Oyley Carte (50), R. Fleming (100), Lazarus Bros. & Co. (50), R. Raphael & Sons (100), Stern Bros. (100), Right Hon. G. J. Shaw Lefevre (25), Railway Share Trust & Agency Co. (50), Louis Floersheim (25), Sir J. G. Hill (25), Right Hon. J. W. Mellor (10), E. B. Merriman (10), H. Milton (50), Sir Wm. Mather (50), H. H. Bartlett (50), J. S. Bergheim (100), Sir H. Platt (50), Sir James Sivewright, K.C.M.G. (100), G. A. Touch (50), J. E. Rawlins (50), Joseph Beecham (50), E. Welton and J. W. Strange (members of Sperling & Co.) (100). First directors are Stanley C. Boulter (chairman), Geo. Kitchin and Henry A. Vernet.

**MACCLESFIELD TRAMWAYS SYND. (LTD.)** (86,775).—Reg. Dec. 8, capital £5,000 in £10 shares, to acquire, construct, maintain and work railways, tramways or light railways in the United Kingdom, and to carry on the business of railway and tramway proprietors, carriers of passengers and goods, suppliers of electricity, &c.

**SHANGHAI ELECTRIC CONSTRUCTION CO. (LTD.)** (86,795.)—Reg. Dec. 9, capital £320,000 in £1,000 shares, to enter into two contracts between the company, Bruce Peebles & Co. (Ltd.) and Dent Bros. & Co. relating to the acquisition of the benefit of two contracts relating to the construction and working of electric tramways in the foreign settlement of Shanghai, and to the constraction and equipment of the said tramways by Bruce Peebles & Co., and to carry on the business of tramway, railway, electrical, steam and mechanical carriage and van constructors and proprietors, carriers of passengers and goods, electricians, electrical and mechanical engineers, suppliers of electricity, manufacturers of dynamos, generators, lamps, accumulators, &c.

## MORTGAGES AND CHARGES.

**N. S. ELECTRIC STORAGE CO. (LTD.)**—Issue on Nov. 15 of £4,000 debentures, part of series created Aug. 10, 1905, to secure £20,000, charged on company's undertaking and property, present and future. No trustees. Previously issued of same series, £2,800.

**PERTH ELECTRIC TRAMWAYS (LTD.)**—Issue on Nov. 15 of £600 debentures, part of series created Dec. 22, 1903, to secure £50,000, charged on company's undertaking and property, present and future, including uncalled capital, subject to £200,000 first debenture stock. Trustees, Lord Arthur Butler and J. S. Austen. Previously issued of same series, £39,000.

# CITY NOTES.

**MEMORANDA** (Dec. 14).—Bank rate 4 per cent. (since Sept. 28, 1905 Price of silver $30\frac{5}{16}$d. per oz. Consols 89—$89\frac{1}{8}$ for money, $89\frac{1}{8}$—$89\frac{1}{4}$ for account; $2\frac{1}{2}$ per cent. annuities $88\frac{1}{8}$—$88\frac{3}{8}$. Consols Pay Day, Jan. 4; Stocks and Shares Continuation Day, Dec. 27; Ticket Day, Dec. 28; Pay Day, Dec. 29; Mining Share Carry-over Day, Dec. 15.

**AFRICAN DIRECT TELEGRAPH CO.**—The coupons of this company's 4 per cent. mortgage debentures, due Jan. 1, will be paid on and after that date at Parr's Bank, Bartholomew-lane, London, E.C. The debenture register will be closed from 27th to 30th inst. inclusive.

**BOURNEMOUTH & POOLE ELECTRICITY SUPPLY CO. (LTD.)**—The transfer books and register of holders of debenture stock will be closed from 18th to 30th inst., preparatory to payment of interest due Jan. 1.

**COUNTY OF LONDON ELECTRIC SUPPLY CO. (LTD.)**—The transfer books and register of holders of debenture stock will be closed from 18th to 30th inst. inclusive, preparatory to payment of interest due Jan. 1.

**EASTERN TELEGRAPH CO. (LTD.)**—Payment will be made on Jan. 15 of a dividend at the rate of $3\frac{1}{2}$ per cent. per annum (less tax) on the preference stock for the quarter ending Dec. 31, and an interim dividend of $1\frac{1}{4}$ per cent. on the ordinary stock (tax free) in respect of profits for the quarter ended Sept. 30. The transfer books of the ordinary stock will be closed from Jan. 6 to 13 inclusive.

**EASTERN EXTENSION, AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.)**—The directors have declared an interim dividend for the quarter ended Sept. 30 of 2s. 6d. per share (tax free) payable 15th prox. The share register will be closed from Jan. 6 to 13 inclusive.

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. No. of weeks. | Aggregate. Amount. | Aggregate. Inc. or Dec. (a) |
|---|---|---|---|---|---|---|
| | | £ | £ | | £ | £ |
| Aberdeen Corporation | Dec. 9 | 1,191 | + 120 | 28 | 40,021 | – 1,293 |
| Airdrie | ,, 1 | 205 | + 16 | 48 | 9,875 | + 171 |
| Anglo-Argentine | ,, 9 | 15,724 | + 958 | 48 | 660,892 | + 40,426 |
| Ayr Corporation | ... | ... | ... | ... | ... | ... |
| Barcelona Trams Co. | ... | ... | ... | ... | ... | ... |
| Barcelona, Ensanche, Gracia | ... | ... | ... | ... | ... | ... |
| Barnsley | ,, 1 | 156 | + 10 | 48 | 7,722 | – 327 |
| Barrow | ,, 1 | 202 | + 22 | 48 | 11,552 | + 2,199 |
| Bath Electric Trams, Ltd. | ,, 6 | 615 | + 95 | 49 | 33 445 | + 2,248 |
| Birkenhead | ,, 10 | 1,031 | + 91 | 10 | 9,527 | + 853 |
| Birmingham Corporation | ... | ... | ... | ... | ... | ... |
| *Birmingham & Mid. | ,, 1 | 1,363 | – 107 | 48 | 75,692 | – 142 |
| Blackpool Corporation | ,, 7 | 290 | + 12 | 23 | 44 389 | + 1,795 |
| Blackpool and Fleetwood | ,, 9 | 159 | + 1 | 23 | 19 665 | – 1,098 |
| Bolton Corporation | ,, 10 | 1,796 | + 170 | 87 | 71,214 | + 2,919 |
| Bournemouth Corporation | ,, 6 | 1,211 | + 449 | †35 | 51,276 | + 10,363 |
| Bradford Corporation | ,, 9 | 4,015 | + 429 | 36 | 159,756 | – 5,450 |
| Brighton Corporation | ,, 10 | 758 | + 39 | 39 | 38,266 | + 495 |
| Bristol Trams & Carriage | ,, 8 | 4,705 | + 171 | 17 | 78,007 | + 1,204 |
| Buenos Ayres & Belgrano | ,, 10 | 3,405 | + 19 | 49 | 160,771 | + 9,356 |
| Buenos Ayres Elec. Trams | Nov. 11 | 1,482 | ... | 45 | 53,156 | ... |
| Burnley Corporation | Dec. 9 | 1,087 | + 144 | 36 | 2,115 | + 2,474 |
| Burton Corporation | ,, 10 | 231 | – 83 | §36 | 11,4 9 | – 1,399 |
| Bury Corporation | ,, 3 | 774 | ... | §35 | 26 183 | ... |
| Calcutta Tramways Co. | ,, 9 | R45,636 | + R2,536 | 23 | R9.0,804 | + R122,080 |
| Camborne-Redruth | ,, 9 | 101 | + 8 | 6 | 600 | – 35 |
| Cardiff Corporation | ,, 9 | 1,846 | + 24 | 36 | 74,780 | + 46 |
| Carlisle Tramways Co. | ,, 9 | 151 | – 15 | 49 | 8,954 | – 643 |
| Central London Railway | ,, 9 | 7,166 | + 67 | 23 | 145,289 | – 894 |
| Chatham & Dist. Lt. Rys. | ,, 7 | 565 | + 92 | 49 | 83,050 | + 3,472 |
| *City of Birm'gh'm Tram Co. | ,, 1 | 5,215 | – 211 | 48 | 257,302 | + 56 |
| City & South London Rly. | ,, 10 | 3,295 | – 17 | 23 | 60,110 | + 283 |
| Colchester Corporation | ... | ... | ... | ... | ... | ... |
| Cork Electric Trams Co. | ,, 7 | 414 | – 17 | 49 | 23,500 | + 617 |
| Devonport & Dist. Trams. | ,, 1 | 873 | – 42 | 48 | 22,005 | – 3,352 |
| Dover Corporation | ,, 9 | 180 | + 8 | 36 | 8,430 | – 31 |
| Dublin & Lucan Railway | ,, 8 | 87 | – 18 | 23 | 2,885 | – 39 |
| Dublin United | ,, 8 | 4,770 | + 254 | 23 | 116,824 | – 385 |
| Dudley—Stourbridge | ,, 1 | 779 | + 72 | 48 | 48,020 | + 1,559 |
| Dundee Corporation | ... | ... | ... | ... | ... | ... |
| East Ham Council | ,, 9 | 771 | + 187 | 36 | 30,073 | + 3,545 |
| Gateshead & Dist. Trams | ,, 1 | 929 | + 92 | 48 | 44,303 | + 961 |
| Glasgow Corporation | ,, 9 | 15,321 | + 1,902 | 28 | 42 ,127 | + 22,965 |
| Glossop | ,, 2 | 125 | + 20 | 48 | 5,890 | + 558 |
| Gloucester Corporation | ,, 6 | 225 | + 15 | 36 | 10,890 | ... |
| Gravesend—Northfleet | ,, 1 | 194 | + 29 | 43 | 11,095 | – 695 |
| Gt. Northern & City Rly. | ,, 9 | 1,801 | + 198 | 23 | 15,944 | + 7,864 |
| Greenock & Port Glasgow | ,, 1 | 530 | + 65 | 48 | 30,886 | + 8,351 |
| Halifax Corporation | ,, 6 | 1,367 | + 201 | 36 | 57,889 | + 3,543 |
| Hartlepool Tramways | ,, 1 | 244 | + 8 | 48 | 12,807 | – 1,193 |
| Hastings Elec. Trams Co. | ,, 7 | 330 | ... | 18 | 9,661 | ... |
| Huddersfield | ,, 9 | 2,134 | + 97 | 36 | 80,424 | + 819 |
| Hull Corporation | ... | ... | ... | ... | ... | ... |
| Ilford Dist. Coun. | ,, 9 | 891 | + 51 | 36 | 17,400 | + 477 |
| Ipswich Corporation | ,, 9 | 812 | – 2 | 36 | 16,005 | – 1,897 |
| Isle of Thanet Co. | ,, 9 | 2.9 | + 28 | 10 | 2,839 | – 582 |
| Kidderminster & District | ,, 1 | 89 | + 1 | 48 | 5,804 | – 383 |
| Kilmarnock Corporation | ... | ... | ... | ... | ... | ... |
| Kirkcaldy Corporation | ,, 6 | 200 | + 4 | 14 | 2,826 | – 99 |
| Lanarkshire Trams Co. | ,, 7 | 829 | + 221 | 49 | 36,832 | + 4,865 |
| Leamington | ,, 1 | 125 | + 54 | 20 | 3,763 | + 1,370 |
| Leeds Corporation | ,, 9 | 5,600 | + 412 | 36 | 219,201 | + 5,216 |
| Leicester Corporation | ,, 9 | 1,944 | + 284 | 49 | 101,874 | + 29,904 |
| Liverpool Corporation | ,, 2 | 10,314 | + 623 | 48 | 506,630 | + 9,639 |
| *Liverpool Overhead Rly. | ,, 10 | 1,389 | + 5 | 23 | 86,180 | – 1,840 |
| London County Council | ,, 2 | 13,354 | + 1,478 | 35 | 523,199 | + 70,511 |
| Lowestoft | ,, 9 | 129 | – 4 | 10 | 1,616 | – 30 |
| Maidstone Corporation | ,, 7 | 81 | – 6 | 36 | 4,638 | ... |
| Manchester Corporation | ,, 9 | 12,626 | + 1,126 | 36 | 467,178 | + 20,171 |
| Mersey Railway | ,, 9 | 1,719 | + 202 | 23 | 86,885 | + 2,202 |
| Merthyr | ,, 1 | 164 | – 8 | 46 | 9,081 | – 511 |
| *Metropolitan Elec. Trams | ,, 1 | 2,383 | + 874 | 48 | 127,848 | + 54,444 |
| Middleton | ,, 1 | 277 | + 53 | 48 | 16,229 | + 725 |
| Musselburgh | ,, 30 | 124 | ... | 50 | 10,913 | ... |
| Nelson Corporation | ... | ... | ... | ... | ... | ... |
| Newcastle-on-Tyne Corp. | ,, 9 | 3,713 | + 210 | 36 | 137,678 | + 3,045 |
| Newport (Mon.) | ,, 9 | 516 | + 54 | 10 | 5,832 | + 379 |
| Northampton Corporation | ,, 8 | 857 | + 23 | 35 | 15,000 | + 4,854 |
| Oldham, Ashton & Hyde | ,, 1 | 581 | + 87 | 48 | 26,820 | + 713 |
| Oldham Corporation | ,, 10 | 1,589 | + 240 | 37 | 60,942 | + 15,514 |
| Perth (W. A.) Elec. Trams. | ,, 8 | 1,493 | + 43 | 49 | 67,579 | + 8,908 |
| Peterborough | ,, 1 | 93 | – 5 | 48 | 6,477 | – 670 |
| Pontypridd Dist. Council | ,, 9 | 188 | ... | 26 | 5,884 | ... |
| Portsmouth Corporation | ,, 9 | 1,449 | + 116 | 36 | 74,238 | + 1,288 |
| Potteries | ,, 1 | 1,803 | + 182 | 48 | 87,200 | + 842 |
| Preston Corporation | ,, 6 | 587 | ... | 10 | 5,695 | ... |
| Reading Corporation | ... | ... | ... | ... | ... | ... |
| Rotherham Corporation | ,, 7 | 430 | + 31 | 36 | 16,468 | – 568 |
| Rothesay | ,, 1 | 40 | + 8 | 48 | 9,504 | + 2,682 |
| Salford Corporation | ,, 11 | 4,150 | + 401 | 37 | 158,472 | + 8,814 |
| Sheerness | Nov. 29 | 46 | – 1 | 48 | 3,315 | + 278 |
| Sheffield Corporation | Dec. 10 | 4,863 | + 489 | 37 | 182,499 | + 9,076 |
| Southampton Corporation | ,, 6 | 862 | + 55 | †10 | 8,249 | – 837 |
| Southend Corporation | ,, 6 | 220 | + 18 | 36 | 14,484 | + 723 |
| Southport Tramways | ,, 1 | 210 | – 22 | 48 | 14,933 | – 1,556 |
| S. Staffordshire Trams. | ,, 1 | 784 | + 165 | 48 | 35,677 | + 1,661 |
| Stockport Corporation | ,, 8 | 759 | + 351 | 40 | 27,590 | + 6,703 |
| Sunderland Corpn. | ,, 10 | 1,178 | + 120 | 36 | 48,867 | + 1,680 |
| Swansea Trams | ,, 1 | 723 | + 279 | 48 | 31,703 | + 8,882 |
| Swindon Corporation | ... | ... | ... | ... | ... | ... |
| Taunton | ,, 1 | 44 | – 7 | 48 | 2,017 | – 226 |
| Tynemouth and District | ,, 1 | 165 | + 3 | 48 | 12,874 | – 1,606 |
| Tyneside Trams Co. | ,, 6 | 346 | + 19 | 49 | 20,129 | + 1,116 |
| Wallasey District Council | ,, 9 | 773 | + 103 | 36 | 28,622 | + 954 |
| Walsall | ,, 9 | 498 | + 78 | 49 | 24,054 | + 501 |
| Warrington Corporation | ... | ... | ... | ... | ... | ... |
| West Ham Corporation | ,, 7 | 1,897 | + 874 | 36 | 61,935 | + 27,491 |
| Weston-super-Mare | Nov. 29 | 27 | + 4 | 48 | 6,753 | + 597 |
| Wolverhampton Corpn. | Dec. 6 | 744 | ... | 10 | 7,482 | ... |
| Wolverhampton District | ,, 1 | 881 | + 60 | 48 | 19,017 | + 834 |
| *Worcester | ,, 1 | 280 | + 2 | 48 | 14,493 | + 390 |
| Wrexham | ,, 1 | 99 | + 16 | 48 | 4,835 | – 364 |
| Yorkshire W.R. Trams | ,, 10 | 826 | + 350 | 49 | 85,103 | ... |
| Yorkshire Woollen District | ,, 1 | 816 | + 358 | 48 | 81,982 | + 4,179 |

(a) These comparisons are with the corresponding period last year. † Minus 8 days. § Plus 2 days. * Partly electrical.

**ELECTRIC & GENERAL INVESTMENT CO. (LTD.)**—The directors have declared the following interim dividends: At the rate of 6 per cent. per annum on the preference shares for the six months ending 31st inst. (3s. per share); at the rate of 10 per cent. per annum on the capital paid up on the ordinary shares (1s. per share), for the six months ended 30th ult. Both dividends will be paid (less tax) on 1st prox.

**ENGINEERING IN EGYPT.**—A new company, entitled the Egyptian Engineering Co. (Ltd.), has been formed to represent in Egypt certain engineering firms, including Richardsons, Westgarth & Co., the Pulsometer Engineering Co., the Tees-side Bridge and Engineering Works, R. Hornsby & Sons, Browett, Lindley & Co., Mason's Gas Power Co. (Ltd.), Erith's Engineering Co., the British Insulated and Helsby Cables (Ltd.), Jessop & Appleby Bros., &c. The chairman is Sir Thos. Richardson, and Mr. H. K. Baynes is managing director.

**PROVINCIAL TRAMWAYS CO.**—The directors recommend a final dividend of 4s. per share on the ordinary shares, making 7s. for the year ended Sept. 30, placing £7,000 to depreciation and carrying forward £2,750.

**STIRLING BOILER CO. (LTD.)**—Mr. John Cowan has resigned the managing directorship of the Stirling Boiler Co. (Ltd.), of Motherwell, and 25, Victoria-street, London, S.W. The directors have appointed Mr. E. G. Constantine, A.M.Inst.C.E., M.I.Mech.E., of Manchester, to be managing director, and he will enter upon his duties at Motherwell on Jan. 1. Mr. Cowan retains his interest in the company, and will continue to be chairman of the directors.

**WESTERN UNION TELEGRAPH CO.**—The usual quarterly dividend of 1¼ per cent. has been declared.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Dec. 13. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business, Week to Dec. 13. Highest. | Business, Week to Dec. 13. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | | | | |
| 5 | 8/0 | Anglo-Argentine Ord. Shares | 8¼—8½ | 4 14 0 | Ap, Oct | 8½ | 8 9/32 |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞—6⅛ | 4 9 8 | — | 6 1/32 | 6 |
| St. | 6% | Do. Permanent 6% Deb. Stock | 142 —146 | 4 2 8 | — | 144¾ | 144 |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 105 —107 | 4 13 5 | — | .. | .. |
| 10 | 12/0 | Barcelona Tramways Ord. | 13¾—14¼ | 4 4 0 | — | .. | .. |
| 10 | 5/0 | Do. 5% Cum. Pref. | 9½—10 | 5 0 0 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock (red.) | 97 —102 | 4 8 8 | — | .. | .. |
| 100 | 5% | Do. 5 per Cent. Debs. | 93 —101 | 4 19 0 | — | .. | .. |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1 —1½ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 4 —4¼ | 5 18 3 | — | 4 7/32 | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts | 95 —98 | 4 12 0 | — | .. | .. |
| St. | 6% | British Columbia Elec. Rlwy Def. Ord. ex rights | 121 —124 | 4 17 0 | — | 123 | 122 |
| St. | 5% | † Do. Pref.Ord. Stk [xd & ex rights | 109 —113 | 4 7 6 | — | 110 | 109 |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock. | 103 —109 | 4 11 8 | — | 107¾ | 107½ |
| 40 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%—105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 102 —105 | 4 5 9 | — | 8½ | 8 |
| £ | 2/6 | Buenos Ayres and Belgrano Ord. | 8⅜—8⅝ | 5 3 0 | — | .. | .. |
| £ | 8/0 | Do. 6 per Cent. "A" Cm. Pref | 5 11/16—5 15/16 | 5 2 0 | — | .. | .. |
| £ | 8/0 | Do. "B" | 5 —5½ | 5 9 1 | — | .. | .. |
| St. | 5% | Do. 5 per Cent. Debs. | 107 —109 | 4 11 8 | — | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102 —105 | 4 16 3 | — | 104½ | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 98 —100 | 5 0 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 101 —105 | 5 4 9 | .. | .. | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 101 —105 | 5 5 8 | .. | 102 | .. |
| £ | 8/6 | Calcutta Tramways (Nos. 1 to 105) | 9¼—9¾ | 4 7 2 | — | 9⅝ | .. |
| 5 | 0/3 | Do. Nos. 105,001 to 137,610 | 8½—9 | .. | .. | 8¾ | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 107 —109 | 4 2 7 | — | .. | .. |
| 1 | 0/6 | Cape Electric Tram Shares | ⅞—1⅛ | 4 8 10 | — | .. | — |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 101 —103 | 4 17 2 | — | .. | — |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Corp. Bds. | 97 —99% | .. | .. | 93 | 97½ |
| 1 | .. | Lisbon Elec. Trams Ord. | 1⅜ —1⅝ | .. | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛—1⅜ | 4 7 4 | .. | 1¼ | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 101 —104 | 4 16 3 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 103 —105 | 4 15 8 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101 —104 | 4 16 2 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102 —104 | 4 6 7 | — | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 104 —107 | 4 18 5 | .. | 105 | .. |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 141 —144 | 5 11 0 | .. | .. | .. |
| .. | 5% | † Do. 5% 1st Mt. $500 Dbs. | 97%—99% | 5 1 0 | .. | 98¼ | 97½ |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| £ | .. | Adelaide Elec. S'ply Co. 6% Cu.Pr. | 5 —5½ | — | .. | — | .. |
| 5 | 3/3 | Calcutta Elec. (1-30,000) | 8¾—9¼ | 4 9 0 | — | 9 1/16 | .. |
| 10 | 1%. | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50 —52 | 4 16 1 | .. | .. | .. |
| .. | .. | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 96 —98 | .. | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½—3 | .. | .. | .. | .. |
| St. | 1% | Do. 5% Debs. | 87 —92 | 5 8 8 | — | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | 9 —10 | — | — | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92 —94 | 5 6 8 | .. | — | .. |
| St. | .. | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. 50% pd. | 60 —62 | .. | .. | .. | .. |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞—1 | 6 0 0 | — | .. | — |
| 1 | 1/0 | Rand Electric | 1¼—1⅜ | .. | — | .. | — |
| 1 | .. | River Plate Electricity Co. Ord. | [illegible] | .. | .. | .. | .. |
| 1 | 1/2 | Do. 6% Non. Cum. Pref. | [illegible]—1 1/16 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Deb. Stock | 103 —105 | 4 15 0 | .. | .. | .. |
| 5 | 8/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5¼—5¾ | 5 4 4 | .. | .. | — |
| £ | 3·23d | Do. (12,001-20,000) | 5 —5½ | 3 8 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100 —103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 10/9 | Shawinigan Water and Power 5% Bds., Scrip | 102 —103 | 4 17 0 | .. | .. | .. |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Share. | Last Dividend | Name. | Price Wed., Dec. 13. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business, Week to Dec. 13. Highest. | Business, Week to Dec. 13. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| 1 | .. | Bath Elec. Trams Pref. Ord. | 15/16—1 | .. | .. | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16—1 1/16 | 4 14 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 102½—103½ | 4 5 0 | .. | 104½ | 103¾ |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 103—105 | 4 5 9 | .. | .. | .. |
| 10 | 9% | Bristol Tramways and Carriage Ord. | 17—17½ | 5 2 11 | Feb, Aug | – | – |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10—10¼ | 3 18 0 | .. | .. | – |
| St. | 4% | Do. 4 per Cent. Debs. | 105—107 | 3 14 10 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 7½—8½ | 7 1 0 | – | 7 15/16 | 7⅝ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 10—11 | 5 8 0 | Feb, Aug | 10¼ | 10⅛ |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 119—121 | 4 2 8 | .. | 121⅜ | 120 |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 97—99 | 4 11 0 | .. | 98½ | 97¼ |
| St. | 4% | Central London Ordinary Stock | 93—95 | 4 4 0 | June, Dec | 94 | 93 |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 101—103 | 3 17 8 | .. | 102⅜ | 101¼ |
| St. | 4% | Do. Deferred Stock | 85—88 | 4 11 0 | .. | 87¼ | 87 |
| 100 | 4% | Do. 4 per Cent. Debs. | 111—113 | 3 10 3 | .. | .. | .. |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 4⅞—5⅛ | 4 17 6 | .. | 5 1/16 | – |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 100—103 | 3 17 8 | .. | .. | .. |
| St. | 2% | City and South London Rly. Con. Ord. | 45—47 | 8 19 6 | Feb, Aug | 46½ | 45 |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 119—122 | 4 2 0 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 117—120 | 4 3 4 | .. | .. | .. |
| St. | 5% | Do. (1901) | 114—117 | 4 5 6 | – | .. | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 105—108 | 3 14 1 | May, Nov | 106½ | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13½—14½ | 4 2 8 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½—15½ | 3 17 3 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5—5½ | 7 5 6 | .. | 5½ | 5 3/16 |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8—9 | 4 8 11 | – | .. | – |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 101—103 | 4 7 6 | .. | .. | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 17—18 | 5 0 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 13¾—14¼ | 4 4 2 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 109—111 | 4 1 1 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2½—2¾ | 9 8 6 | – | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 86—88 | 4 10 11 | – | .. | .. |
| 10 | 1⅓% | Liverpool Overhead Railway Ord | 8⅛—8 3/16 | 3 13 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾—10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99—102 | 3 19 3 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 10—10½ | 4 15 0 | – | 10 5/16 | 10⅛ |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 100—103 | 3 17 8 | – | .. | .. |
| St. | .. | Mersey Con. Ord. Stock | 7—9 | – | – | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8—11 | – | – | .. | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32—9/32 | .. | – | ¼ | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1—1 1/16 | 4 14 1 | – | 1 1/32 | 1 |
| St. | 4½% | Do. 4½% Deb. Stock | 106—108 | 4 3 3 | – | 106½ | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½—1½ | .. | May | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾—9¼ | 5 5 8 | .. | .. | .. |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9¾—10¼ | 4 17 6 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 101—104 | 4 6 4 | – | .. | .. |
| 100 | .. | Sunderland Dist. Elec. Trams. 5% 1st Mort. Debs. | 95—99 | .. | .. | 98¼ | .. |
| .. | 5% | † Underground Elec. Rys. Co. of London | 97—98 | 5 2 0 | .. | .. | .. |
| St. | 3% | Waterloo and City Ord. | 94—97 | 3 2 0 | June, Dec | .. | .. |
| St. | 12/11 | Yorkshire W.R. El. Trs. Co. 4% 1st Debs. | 96—98 | 4 1 6 | .. | 97 | .. |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | * African Direct Tel. 4% Mrt. Deb. (red.) | 99—102 | 3 18 5 | Jan, July | – | .. |
| 10 | – | Amazon Telegraph | 3¾—4¼ | .. | Jn, Dec | .. | .. |
| 100 | .. | Do. 5% Debs. (red.) | 85—90 | 5 11 0 | .. | .. | .. |
| St. | 15/0 | Anglo-American | 61—63 | 4 15 0 | F, My, Ag, N | 61½ | .. |
| St. | 30/0 | Do. Preferred | 109—110 | 5 4 6 | F, My, Ag, N | 110 | 109 |
| St. | 2/0 | Do. Deferred | 17⅛—17⅜ | .. | F, My, Ag, N | 17⅜ | 17 |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 96—98 | 4 1 8 | Jn, Ap, Jy, O | 97¾ | 96½ |
| 10 | 5/0 | Cuba Submarine Ord. | 8¾—9¼ | 5 8 3 | Feb, Aug | 8⅞ | 8¾ |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17—18 | 5 11 2 | Feb, Aug | .. | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜—3⅝ | 5 11 9 | April, Oct | 3⅜ | – |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 9—9½ | 5 5 0 | April, Oct | .. | – |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 100%—103% | 4 7 5 | Jan, July | .. | .. |
| 20 | 3/0 | Direct United States Cable. | 14—15 | 4 6 6 | Ja, Ap, Jy, O | 14¼ | 13⅞ |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 100½—102½ | 4 8 2 | Jn, Dec | .. | .. |
| St. | 25/0 | Eastern Ordinary | 144—147 | 4 15 8 | Ja, Ap, Jy, O | 146⅝ | 144 |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 90—92 | 3 16 0 | Ja, Ap, Jy, O | 91½ | 90⅝ |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 106—108 | 3 14 1 | May, Nov | 107¾ | 106¾ |
| 10 | 2/6 | Eastern Extension | 14½—15 | 4 13 4 | Ja, Ap, Jy, O | 14¾ | 14½ |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 106—108 | 3 14 1 | Feb, Aug | 107½ | .. |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 100—102 | 3 18 8 | Feb, Aug | 101¼ | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 100%—102% | 3 18 8 | May, Nov | .. | .. |
| 10 | 5/0 | G. N. (of Copenhagen) | 36—38 | 6 7 6 | Jan, July | 36⅝ | 35 9/16 |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 100½—102½ | 4 8 2 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57—59 | 5 10 0 | May, Nov | 58 | 57½ |
| 100 | $1 | Mackay Companies Common | 52¾ | 3 16 8 | Jan, July | – | .. |
| 100 | 4% | Do. Preference | 73⅛ | 5 8 0 | Ja, Ap, Jy, O | .. | – |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1¼—1¾ | .. | .. | .. | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 100—103 | 3 17 8 | June, Dec | .. | .. |
| 10 | 4/0 | † West African Telegraph Shares | 9½—10 | 5 0 0 | .. | 10 | 9¾ |
| 2½ | .. | West Coast of America | 9/16—11/16 | .. | .. | 11/16 | 9/16 |
| 100 | 4% | Do. 4 per Cent. Debs. | 100½—102½ | 3 18 0 | Jan, July | 101½ | .. |
| 10 | – | West India and Panama | ½—¾ | .. | May, Nov | .. | .. |
| 10 | 6/0 | Do. 6% 1st Pref. ex on a/c of arrears | 8¼—8¾ | 6 6 8 | May, Nov | 8½ | 8¼ |
| 10 | – | Do. 6 per Cent. 2nd Pref. | 6½—7½ | .. | May, Nov | .. | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 101—104 | 4 16 2 | Jan, July | .. | .. |
| 10 | 5/0 | Western Telegraph | 14—14½ | 4 16 7 | Mr, Jn, O, D | 14⅜ | 14⅛ |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 102—104 | 4 16 0 | June, Dec | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 103—105 | 3 16 0 | .. | – | .. |
| | | **TELEPHONES.** | | | | | |
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 102—104 | .. | .. | – | – |
| 5 | 5/0 | Chili Telephone (fully paid) | 7⅜—7⅞ | 5 1 8 | August | 7⅞ | 7¾ |
| 1 | 0/9⅗ | Monte Video Telephone Ord. | ⅞—1 | 4 0 0 | – | .. | .. |
| 1 | 1/0 | Do. 5% Pref. | ⅞—1 | 5 0 0 | .. | .. | .. |
| St. | 6% | National Co. Pref. Stock | 110½—111½ | 5 7 7 | – | 111½ | 110½ |
| St. | 5% | Do. Def. Stock | 108—110 | 4 11 0 | – | 108⅞ | 108 |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13—15 | 4 0 0 | Feb, Aug | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 11—13 | 4 12 4 | Feb, Aug | 12½ | .. |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅜—5⅞ | 4 5 2 | Feb, Aug | 5 13/16 | .. |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 98—100 | 3 10 0 | June, Dec | 99½ | 98¾ |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 104—106 | 3 15 6 | .. | 105½ | 104⅞ |
| 1 | 0/7⅕ | Oriental | 1¼—1⅜ | 3 12 9 | April, Oct | 1 11/32 | .. |
| 1 | 0/7⅕ | Do. 6 per Cent. Cum. Pref. | 1 5/16—1 7/16 | 4 11 6 | – | .. | .. |
| St. | .. | Do. 4% Red. Deb. Stock | 97—99 | .. | – | .. | – |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 102—105 | 4 5 9 | .. | .. | .. |
| 5 | 5/0 | United River Plate | 7½—8 | 5 0 0 | July | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5½—5¾ | 4 7 0 | June, Dec | .. | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 111—113 | 4 8 6 | June, Dec | .. | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 5—5½ | 5 9 0 | .. | 5¼ | 5 7/32 |
| 10 | 2/0 | Globe Telegraph and Trust | 10½—10¾ | 5 0 8 | Ja, Ap, Jy, O | 10¾ | 10½ |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14⅛—14⅜ | 4 3 0 | Ja, Ap, Jy, O | 14 5/16 | 14⅛ |
| 10 | 6% | Submarine Cables Trust (Cert.) | 125—128 | 4 13 9 | April, Oct | .. | – |

| Share. | Last Dividend | Name | Price Wed., Dec. 13. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Week to Dec. 13. Highest. | Business Week to Dec. 13. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12¼—12¾ | 5 9 10 | .. | .. | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10⅛—10⅝ | 4 4 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11¾—12¼ | 4 18 0 | .. | 11⅜ | – |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 107—109 | 4 2 6 | .. | – | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 102—105 | 4 5 9 | – | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 9—10 | 5 0 0 | – | 9½ | 9⅜ |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 9—9½ | 3 14 5 | Mar, Sept | – | .. |
| St. | 4% | † Central Elec. Sup. Co. 4% Guar. Db. Stock | 102—105 | 3 16 3 | – | .. | .. |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 6¼—6¾ | 4 16 0 | Feb, Aug | 6 1/16 | .. |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼—5¾ | 3 18 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 103—105 | 3 16 2 | – | .. | .. |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4¾—5 | 4 10 0 | – | .. | .. |
| 5 | 2/3 | Do. Do. (1903) | 4¾—5 | 4 10 0 | .. | .. | .. |
| 5 | 2/6 | Chelsea Electric Supply Ord. | 5—6 | 5 0 0 | March | .. | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 110—112 | 4 0 4 | Jn, Dec | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 11—12 | 5 0 0 | Feb, Aug | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 14¼—14½ | 4 4 2 | Jan, July | .. | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 124—128 | 3 18 1 | Jn, Dec | 126 | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 103—105 | 4 5 8 | .. | 104 | 103¾ |
| 5 | .. | County of Durham Elec. P.D. Ord. £2 pd. | 2 3/16—2 7/32 | .. | April, Oct | .. | .. |
| 5 | 6¾d. | Do. Do. 5% non cum. pref. | 5⅜—5⅝ | .. | April, Oct | .. | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 8½—9½ | 4 6 6 | – | 9 1/16 | 9 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅝—12⅞ | 4 13 2 | Mar, Sept | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 112—115 | 3 18 3 | .. | .. | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 102—104 | 4 6 7 | .. | .. | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼—5¾ | 4 15 8 | .. | 5½ | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5—5½ | 4 11 9 | .. | 5 3/32 | 5¼ |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101—104 | 4 6 6 | – | – | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8¼—8¾ | 4 17 2 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100—103 | 4 7 5 | – | .. | – |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 10¾—11¾ | 5 0 0 | .. | – | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½—7 | 4 5 9 | Jan, July | – | – |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98—101 | 3 19 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101—103 | 3 17 8 | .. | .. | .. |
| 8 | 1/9⅜ | London Electric Supply Ord. | 1¾—2¼ | 4 0 0 | .. | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 4¾—5¼ | 5 14 4 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 99—102 | 3 18 5 | Mr, Jn, S, D | .. | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 9¾—10¼ | 5 7 0 | April, Oct | 9¾ | 9½ |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5¼—5½ | 4 2 0 | Jan. July | 5½ | 5⅜ |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 109—113 | 3 19 7 | Jn, Dec | .. | – |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 97—99 | 3 10 8 | – | 97½ | .. |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 101—103% | 4 7 5 | – | 102¼ | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 12⅛—12⅜ | 5 9 1 | Feb, Aug | .. | .. |
| 100 | .. | Do. 4½% Deb. | 101—102 | .. | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8—8 1/16 | 4 19 5 | Feb, Aug | .. | .. |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6⅜—6½ | 3 16 11 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99—100 | 4 0 0 | Jan, July | .. | .. |
| 1 | 3% | Northern Counties Elec. Sup. 17/- paid | 13/16—27/32 | 3 1 1 | Mar, Aug | – | .. |
| 100 | .. | Do. 4½% Deb. | 100½—101½ | .. | Jan, July | – | – |
| 10 | 6/0 | Notting Hill Electric Ord. | 14½—15½ | 3 17 6 | March | .. | – |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98—100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅜—6⅞ | 5 1 6 | March | – | .. |
| St. | 4% | Do. 4% Deb. Stock | 100—102 | 3 18 5 | – | .. | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 12¾—13¾ | 5 4 0 | Feb, Aug | 13½ | 13 |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 8—9 | 3 17 9 | Feb, Aug | – | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 98—100 | 3 10 0 | – | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2—2½ | 8 0 0 | .. | .. | – |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76—80 | 5 0 0 | – | 8 1/16 | 1¼ |
| 5 | 4/0 | South London Electric Supply Ord | 3—3½ | 5 10 0 | .. | 13/16 | – |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | 1 3/16—1 5/16 | .. | .. | .. | .. |
| 1 | 0/8⅖ | Do. 7% Cum. Pref. | 1 5/16—1 7/16 | 4 17 2 | .. | .. | – |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105—103 | 4 3 3 | – | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4½—4¾ | 5 5 8 | – | .. | .. |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5—5¼ | 4 15 8 | – | – | .. |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 104—106 | 4 4 10 | .. | .. | .. |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 11½—12½ | 5 12 0 | Mar, Sept | 12¼ | 11 15/16 |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5¾—6¼ | 4 0 0 | .. | .. | .. |
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝—⅞ | 5 6 6 | – | .. | .. |
| 1 | 6d. | Aron Elec. Meter 6% Cum. Pref. | 9/16—11/16 | .. | .. | .. | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3¾—4 | 5 0 0 | .. | .. | .. |
| 1 | 7½d. | Do. Pref | 1 7/16—1 9/16 | 3 18 10 | .. | .. | .. |
| 5 | 4/0 | British Insulated & Helsby Cables Ord. | 6½—7 | 5 14 0 | July, Feb | 6 21/32 | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾—6¼ | 4 16 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103—106 | 4 4 11 | .. | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98—100 | 4 10 0 | .. | 99½ | 99¼ |
| 5 | .. | British Westinghouse 6% Pref. | 1¾—2¼ | .. | .. | 2⅜ | 1⅛ |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 80—85 | 4 14 0 | .. | 86 | 84 |
| 2 | .. | Brush Electrical Engineering | ⅜—⅝ | .. | March | ½ | .. |
| 2 | 2/4½ | Do. 6 per Cent. Pref. Non-Cum. | 1½—2 | 6 0 0 | Mar, Sept | 1½ | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 96—100 | 4 10 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 84—86 | 5 4 6 | Jan, July | .. | .. |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11—12 | 5 0 0 | Jan, July | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝—5⅞ | 4 5 2 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 109—111 | 4 1 1 | Nov, May | .. | .. |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1—1⅛ | 5 7 0 | .. | 1 3/16 | 1 1/16 |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 97—102 | 4 8 3 | – | .. | – |
| 1 | 9⅗d. | Chadburn's (Ship) Telegraph Ord. | 1—1¼ | 8 0 0 | .. | .. | .. |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1 1/16—1 3/16 | 5 2 7 | .. | .. | .. |
| 3 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 2—2¼ | 3 9 0 | Jan, July | .. | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 97—100 | 5 0 0 | Jan, July | 99 | 98 |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8½—9 | 5 11 1 | Sept | 8¾ | .. |
| 5 | 3/0 | Do. 6% Cum. Pref. | 5¾—6¼ | 4 18 0 | Sept | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106—108 | 4 4 1 | .. | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅜—1⅝ | – | Feb, Aug | .. | .. |
| 5 | 2/6 | Do. (£5 paid) | 2¼—2¾ | .. | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 85—90 | 4 8 11 | June, Dec | 85 | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92—97 | 5 3 1 | .. | .. | .. |
| 5 | 4/6 | Edmundson's Elec. Corp. Ord. | 5¼—5¾ | 6 1 9 | H'lf-yearly | 5 11/16 | 5⅝ |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5⅞—6⅛ | 4 18 0 | .. | 6 | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 107—109 | 4 2 6 | .. | 107¼ | .. |
| 2 | 1/7½ | Electric Construction Co. | ½—¾ | 9 6 0 | July | .. | .. |
| 2 | 2/9⅗ | Do. 7 per Cent. Cum. Pref | 1⅞—2⅛ | 5 18 8 | July | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 92—95 | 4 4 2 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9¼—9¾ | 5 2 6 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96—100 | 4 0 0 | – | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 12½—13½ | 5 11 1 | Feb, Aug | 13 3/16 | 12 13/16 |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5⅛—5⅜ | 4 3 9 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | – | 4 1 1 | Feb, Aug | .. | .. |
| 10 | 5/0 | India Rubber, Gutta Percha, &c., Wrks. | 18½—19½ | 2 11 3 | Feb, Aug | 19 | 18½ |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99—102 | 3 18 5 | Mar, Sept | .. | – |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¼—11¾ | 4 5 1 | Mar, Sept | .. | .. |
| 12 | 12/0 | Telegraph Construction & Mainten'ce. | 32—34 | 5 5 10 | Mar, July | 33½ | 32¼ |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 102—104 | 3 16 11 | Jan, July | – | .. |
| 5 | – | Willans and Robinson Ord. | 1½—2 | – | Apr, Oct | .. | .. |
| 5 | – | Do. 6 per Cent. Cum. Pref. | 2¼—2½ | – | Apr. Oct | .. | .. |
| | 4% | † Do. 4 per Cent. 1st Mort. Debs. | 82—87 | 4 12 0 | May Nov | 84 | .. |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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London, N.W., 18th December, 1905.

C. H. F. BARRETT, Town Clerk.

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By Order,
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**SITUATIONS VACANT, &c., continued on page xiv.**

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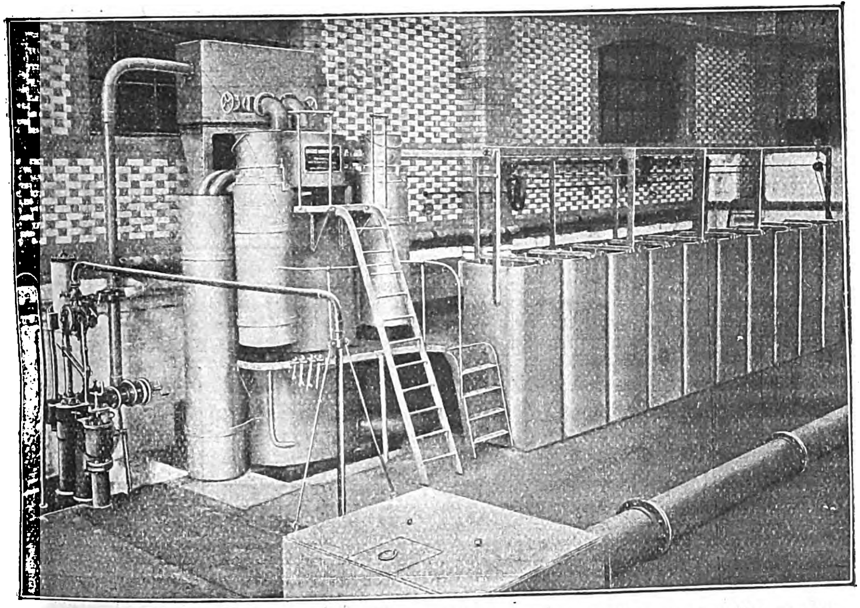

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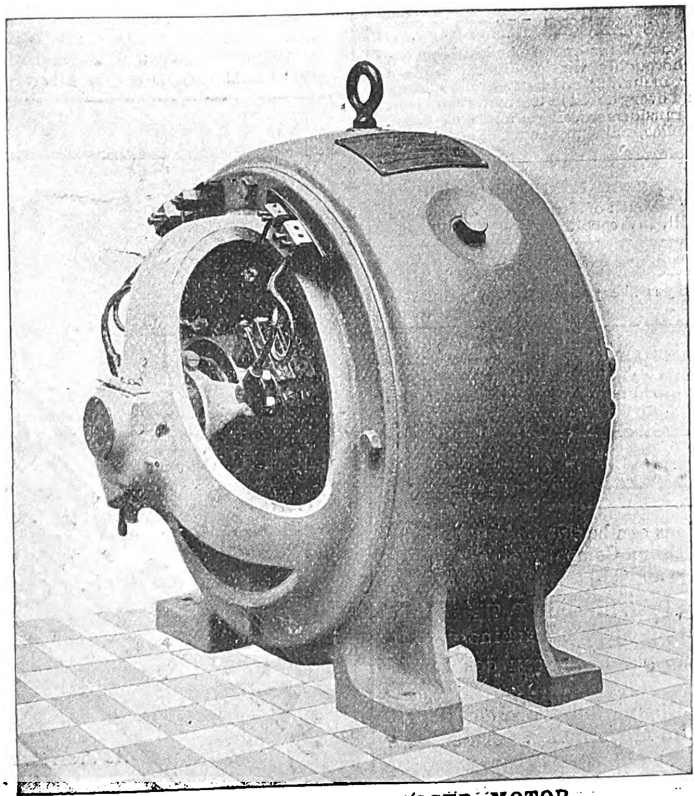

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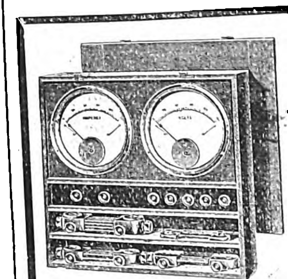

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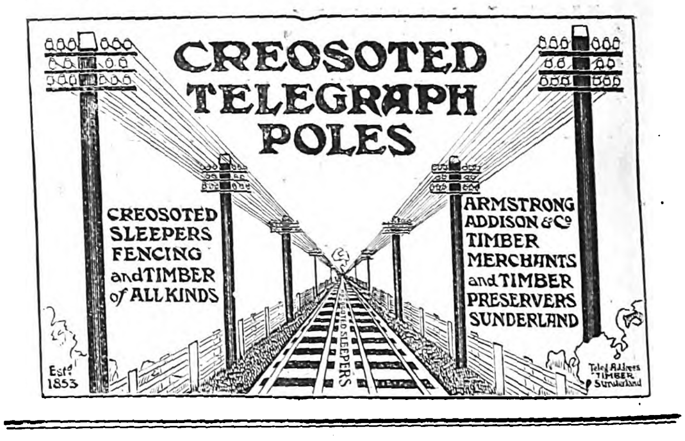
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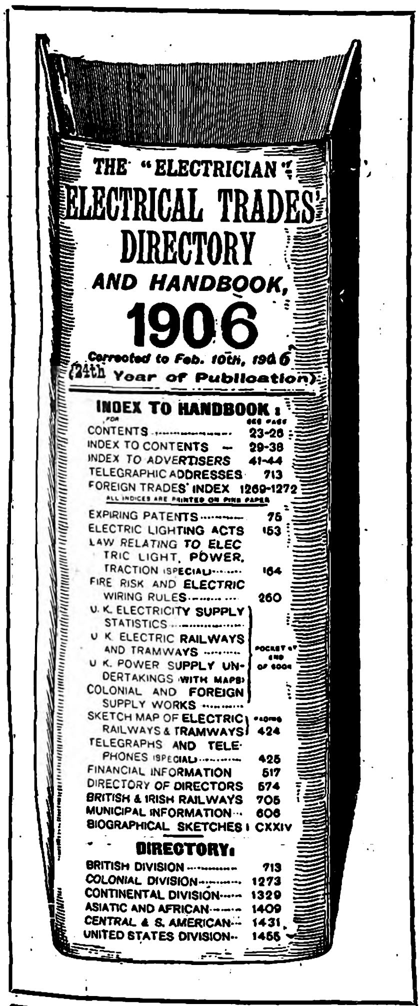

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1906
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(24th Year of Publication)

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X This valuable work will be published, as usual, at the end of January, and will contain the vast number of New Names, Corrections to old Addresses, and other matter which are only obtainable after the turn of the New Year. Alterations to old addresses are usually made in January, and form a very large percentage of the whole. X

**NEW NAMES AND ADDRESSES,**
**CORRECTIONS TO EXISTING ENTRIES,**
**SUBSCRIPTION ORDERS,**
**ADVERTISEMENT ORDERS,** AND
**MISCELLANEOUS INSERTIONS**
FOR

## The NEW (1906) EDITION of the BIG BLUE BOOK

(*THE* YEAR-BOOK OF THE GREAT ELECTRICAL ENGINEERING PROFESSION AND INDUSTRY)

Should be sent in ***AT ONCE*** (latest date will be duly announced). The book (with the vast number of new names and addresses and corrections to the entries of the last issue which occur during January) will be published as usual at the end of January (corrected to January 31st), and will form the most complete and reliable work of the kind ever published.

The Handbook Division of the 1906 issue will contain all the usual items corrected quite up to date, and, besides, a large quantity of additional matter indispensable to those engaged in the Electrical and Allied Industries.

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PRICE AFTER PUBLICATION (post free), 15/9, 17/-, 17/6, 18/6 respectively.

OF ALL LEADING BOOKSELLERS, OR DIRECT FROM
**"THE ELECTRICIAN" PRINTING & PUBLISHING COMPANY, Limited,**
SALISBURY COURT, FLEET STREET, LONDON.

NEW YORK: The D. Van Nostrand Co., 23, Murray Street.
CHICAGO: A. C. McClurg & Co.
MONTREAL: Foster, Brown & Co., 2323, St. Catherine St.
LEIPZIG F. A. Brockhaus.
H. F. Koehler.
Schulze & Co.

PARIS: Ch. Béranger, 15, Rue des St. Pères.
Gauthier-Villars, 55, Quai des Grands-Augustins.
BERLIN: Julius Springer, 3, Monbijouplatz.
LIEGE: Ch. Béranger, 2, Rue de la Regence.
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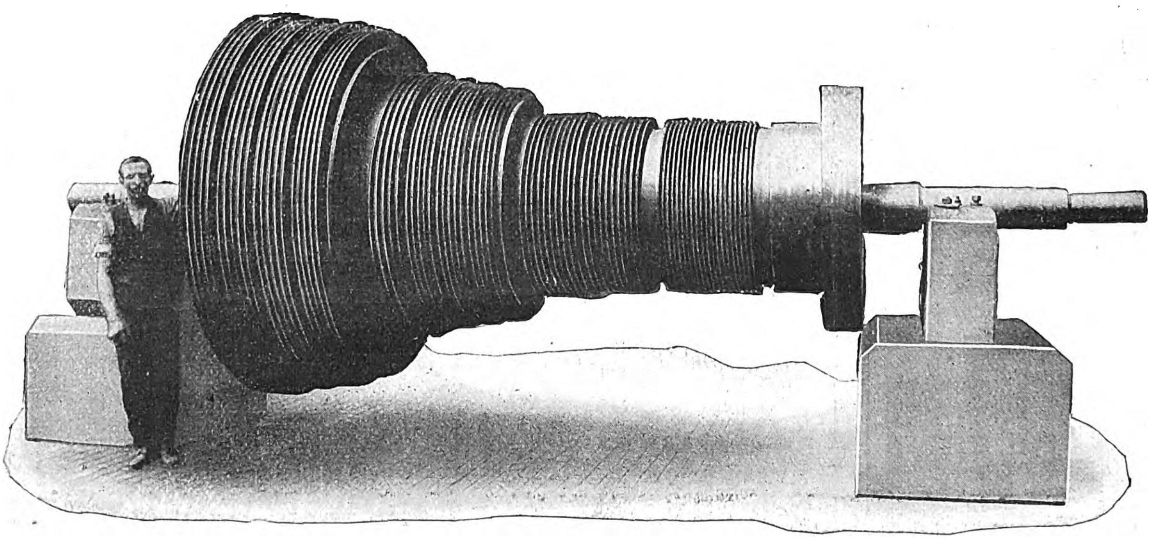

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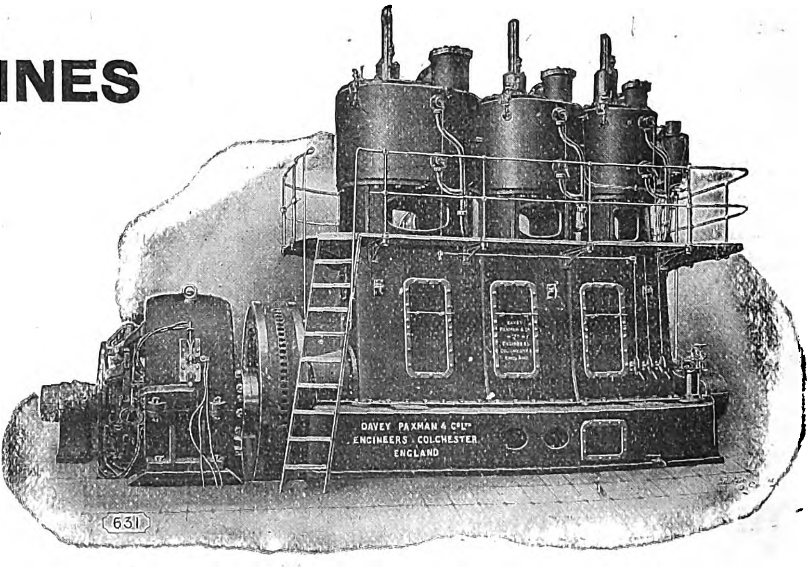
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# THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,440. [No. 10. Vol. LVI.] FRIDAY, DECEMBER 22, 1905. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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# NOTES.

THE *Morning Post* yesterday stated that it is anticipated that one of the early administrative acts of the new Government will be to recommend the appointment of a Royal Commission to consider and report on the London electric power schemes. This is a course that would have received our heartiest approbation two years ago, but if it were followed now it would delay the arrangement of proper provision for electric power supply for another two years, and in addition to the companies having been put to great expense in Parliament for two sessions to no purpose, the general public and the electrical industry as a whole would suffer by the delay. A complete summary of the Power Bills to come before Parliament next year will be found on pp. 396 and 397.

THE outcry in the daily press on account of the contract for the electrical equipment of the suburban L.B. & S.C. Railway line having been awarded to a German firm is chiefly due to ignorance of the actual facts. Neither on practical nor on sentimental grounds is there much to say against the action of the directors of the Company. In the first place it is natural that they should award the contract to the firm who gave them the best guarantees and at the same time offered to do the work at the lowest price. Secondly, the greater part of the material is to be manufactured in England, for an Anglo-American firm with works in this country (the British Thomson-Houston Co.) are owners of the British patents for the system adopted, and have a working arrangement with the Allgemeine Elektricitäts-Gesellschaft. It is to the best interests of all concerned—except, perhaps, the firms who tendered for the work and were unsuccessful—that an important piece of heavy railway "electrification" should profit by the international character of modern engineering knowledge and make use of the talent in all three countries, at the same time employing British labour for the greater part of the manufacture and construction.

WE report briefly a Paper read before the British Association of Waterworks Engineers which emphasises the importance of earthing in an effective manner, at the generating station, the negative pole of an uninsulated return system of private house wiring. If this precaution is taken, and the installation is otherwise carried out in a satisfactory manner, there is no likelihood of any electrolysis occurring, but the Paper points clearly to an effect not hitherto observed—namely, that of lead poisoning from an electrolysed pipe, which makes it of the utmost importance that the danger should be guarded against. Properly authenticated cases of electrolysis through return currents are happily rare in this country, and in no case has it yet been proved that the precautions observed in the best electrical engineering practice are insufficient.

CURIOUSLY enough another case of electrolysis, in this instance in a lighting company's own cable, is recorded in our correspondence columns this week. From a perusal of Mr. H. NALDER'S letter it will be seen that he has also omitted a necessary precaution in his network, namely, that the lead sheathing of the cables should be continuous throughout. Without details as to the condition of the whole network one cannot state definitely the precise electrical conditions that led up to the faults in question, but we would suggest that the following explanation may possibly be applicable: If, as is not improbable, there is a fault on his *neutral* conductor, the current when he earths his positive every night for "burning out" purposes will reach that fault through the lead of both cables, and will choose as a point of entry the place where the water has come through the break he refers to in the mass of bitumen surrounding the cable. Some of this cement will flow from the sheathing of the positive conductor to the sheathing of the neutral conductor and electrolyse the former. Then again, when he earths his negative pole, the neutral conductor is positive to this, and current will flow through the fault which we have assumed to be on the neutral, and along the lead, and will reach the earth at this same damp spot, electrolysing the lead of the neutral. Whether this explanation is the correct one or not, we should advise Mr. NALDER to repair the faults on his mains (the slight faults as well as the heavy ones, and those on the neutral as well as those on the outers), to bond the sheathing of his system throughout, and to connect the bonded sheathing both to his station earth and, at suitable places, to his tramway rails.

◆

THE new 200 H.P. Oerlikon traction motor, which is described on p. 390 of this issue, is, we believe, the first continuous-current traction motor fitted with auxiliary poles. The output of ordinary enclosed motors, running on a steady load for hours on end, is fixed by the permissible temperature rise rather than by considerations as to sparking, and to use auxiliary poles in such circumstances would be a mere waste of money. But traction motors, although also fully enclosed, may occupy a different position, inasmuch as they are called upon to withstand very high overloads for short periods, so that sparking in some cases becomes the limiting factor to the maximum effort of the motor. It would thus seem that the application of auxiliary poles to continuous-current traction motors depends to a large extent on the nature of the work to be performed. But the new motor also possesses one or two other features which distinguish it from the general run of traction motors. Open slots in the armature—universally adopted as affording an easy means for replacing burnt-out coils—have been discarded, for instance, in favour of totally enclosed slots, which conduce to obvious advantages in other directions. It is apparently proposed by the makers to regulate the speed by varying the number of field coils in circuit. We shall be interested to learn whether this manner of regulation gives satisfactory results in practice, for the magnetic out-of-balance of the armature, when two or three coils only are energised, is a serious thing, and most dynamo designers take pains to avoid any asymmetry in this direction as far as possible. Probably the motor is merely for experimental purposes, and we may assume that the makers do not actually propose to put it on the market in its present form.

◆

IN a Paper read before the Birmingham Local Section of the Institution of Electrical Engineers last week, Mr. S. H. HOLDEN introduced two new electrolytic meters, both of which belong to the gas voltameter type. In the first of these the weight of electrolyte decomposed by the current (the whole of which is passed through the cell) is taken as a measure of the ampere-hours, and the manner in which the amount of water electrolysed is indicated by the pointer on the dial is extremely simple. As Mr. HOLDEN points out, this meter is subject to the defects of its class, such as the large fall of potential which will restrict it to small sizes, and the necessity of refilling at intervals, with the chance of the meter running dry if not attended to in time. He explains, however, that this meter could be made to overcome one of the objectionable features of electrolytic meters generally—namely, the obliteration of the reading on refilling or resetting.

◆

IN the second meter, which is a shunted one, the amount of hydrogen liberated at the cathode by the passage of a minute fraction of the total current through dilute sulphuric acid, is taken as the index of the ampere-hours supplied to the consumer. Mr. HOLDEN furnishes the equivalent of a solid hydrogen anode by using a piece of spongy platinum coated with platinum black. This anode is partly immersed in the electrolyte, the upper portion being in an atmosphere of hydrogen.

◆

AN important objection to meters of this class, from the purchaser's point of view, is that they have, to a great extent, to be taken on trust, for they are not easily tested, especially at the lower loads. That they are liable to considerable inaccuracy due to details of construction, Mr. HOLDEN'S own results show. The permanence of the accuracy of originally good meters can only be ascertained by prolonged tests under working conditions, so that, in spite of the ingenuity of Mr. HOLDEN'S two meters, more information is necessary concerning their behaviour in such circumstances before a definite opinion can be passed as to their practical utility.

◆

ARISING out of the dispute between the Torquay Corporation and the National Electric Construction Co. with regard to the supply of current for the Company's tramways, it will be remembered that an offer was made by the Company to purchase the Corporation's electricity works. It is now rumoured in Torquay that the Gas Company has under contemplation the making of a similar offer to take over the Corporation's electric lighting undertaking. Even if the offer were made, it would probably not be considered seriously; but we may mention that, in the event of such purchase, the consent of the Board of Trade would have to be obtained for the revocation of the Corporation's electric lighting order and the grant of a new one to the Gas Company. In the public interest it is evident that this consent would not be accorded.

◆

A CASE, decided in the Newcastle County Court last week, emphasises the responsibility which rests upon an electric supply undertaker with regard to the design and maintenance of the covers of surface boxes in the pavement. A man was seriously hurt by slipping down on a cover of this nature at Newcastle on a wet day, and on proving that the cover was worn and slippery he recovered heavy damages. It is also of interest to mention that the claim was contested not by the Newcastle & District Electric Lighting Co. itself, but by the insurance company in which the lighting company is insured against such risks.

◆

IN another part of the present issue will be found a report of the first two meetings of the Congress which has recently been held in London on the subject of Coal Smoke Abatement. The first portion of the Congress dealt with matters perhaps of less direct importance to the electrical engineer than the latter part. Many points of interest, however, were brought up.

Artists, meteorologists, chemists and others joined together in denouncing the burning of coal in the manner which obtains at present, but we should have liked to have seen it made clearer still that the domestic grate probably contributes far more than the boiler furnace to the formation of fog. Sir OLIVER LODGE'S exposition of the local cooling of the portion of the flame in contact with the boiler, and the positive advantage which a smoky flame has in radiating power, certainly showed up a weak point of the system of obtaining power by boiling water. The only complete solution of the problem in this country must eventually lie in converting the coal into an available source of energy elsewhere than in large cities. Several speakers enlarged on the possibilities of the wholesale transmission of producer or power gas, and this brings us nearer to the "pit's mouth" ideal; but the substitution of gas engines, as at present constructed, for steam engines, in electric power stations, has not made the headway at one time thought probable on account of their serious disadvantage of the practical absence of overload capacity and the high initial cost. We fail to see that the case for the transmission of power by gas mains was by any means proved on a commercial basis. The remaining two days of the Conference were devoted to "Factory and Trade Smoke Abatement" and "Administration, Legislation and Necessary Reforms," which we hope to deal with in our next issue.

**A Large Bequest to Birmingham University.**—The will of the late Mr. John Feeney, according to the *Birmingham Daily Post*, contains bequests to public institutions to the amount of £89,000, of which the University of Birmingham is to receive £20,000.

**Power Transmission between Sweden & Denmark.**—According to the *Elektrotechnischer Anzeiger*, a project is being discussed at Copenhagen for utilising the two falls of the Laga River (South Sweden) for generating electricity and conveying the energy by cable to Helsingborg and thence to Denmark.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Tarifa—Tangier | Jan. 18, 1904 |
| Jamaica—Colon | Jan. 10, 1905 |
| Cadiz—Teneriffe | July 20, 1905 |
| Puerto Plata—Martinique | Dec. 15, 1905 |

**French Association for the Advancement of Science.**—The next congress of the French Association for the Advancement of Science will take place at Lyons at the beginning of August, 1906. Prof. Arloing, director of the veterinary school, is chairman, and M. Chantre, curator of the Natural History Museum, is general secretary of the local committee.

**Manchester Students' Section of the Institution of Electrical Engineers.**—The Paper announced last week in connection with the meeting at 7:30 p.m. to-night, at the Salford Technical Institute, of the Manchester Students' Section of the Institution, has since been changed. Mr. W. T. Massey will read a Paper on "The Manufacture of Electric Cables."

**Crystal Palace Company's School of Practical Engineering.**—Sir William Mather, M.P., yesterday distributed the certificates to the students of the Crystal Palace Company's School of Practical Engineering which have been gained during the winter term of 1905. This is the close of the 33rd year of the School's existence, and is the 99th award of certificates.

**Tramways & Light Railways Association.**—In our announcement of Mr. A. L. C. Fell's Paper on "Brakes" last week we erroneously stated that the meeting of the Tramways & Light Railways Association on January 10th would be held at the Society of Arts. The meeting will be held at the Institution of Civil Engineers, 25, Great George-street, Westminster, at 8 p.m.

**Iron-Smelting by Electricity.**—The report of the Canadian Commission with regard to the smelting of iron by electrical means has already had its effect, for, according to the Ottawa correspondent of the *Birmingham Daily Post*, the Canadian Government has erected an electric smelting plant at Soo, and has already produced a consignment of pig iron, the quality of which is said to be excellent. The actual cost of production in Canada has, of course, still to be ascertained.

**Indian Tour of the Prince and Princess of Wales.**—*The Times* special correspondent with the Prince and Princess of Wales in India, writing on Wednesday from Gwalior, states that the electric lighting installation in that city was opened by the Royal visitors. The streets were subsequently lighted, and the evening festivities, with the multi-coloured electrical illuminations, are described as "one of the most striking scenes of the Royal tour."

**The Brighton Inquiry.**—Mr. Arthur Wright calls our attention to an error in our report of the Local Government Board inquiry at Brighton last week. Our report of Mr. Wright's evidence contains the following sentence: "It was true the estimates had been exceeded by about £70,000." Mr. Wright informs us that he stated that the cost of the Southwick scheme, exclusive of removal of the North-road plant, had come out to £70,000 *less* than the figure sanctioned by Parliament.

**Submarine Telephony.**—In reply to a further communication from the Association of Chambers of Commerce on the question of telephone communication with the Continent, the Postmaster-General states that no definite information is available as to the limits of distance by land and sea over which telephonic conversation can take place. In fact, the limit had to be determined by practical experiment in each case. The present practical limit of speech by sea lines is that between Great Britain and Belgium, a distance of 47 nautical miles.

**An Electrical Engineer's Visit to Russia.**—An interesting account of a journey to St. Petersburg by a member of the Brush Electrical Engineering Co.'s staff appeared in last night's *Westminster Gazette.* The writer received instructions from his firm to proceed to the Russian capital in connection with the contract for the electrical equipment of the tramways there, for the award of which the Brush Company and other British firms were in competition with several Continental companies. On arriving at Uydtkuhnen, on the Russian frontier, his train was stopped, and he was not allowed to proceed, and he describes how he was only successful in arriving at his destination after several attempts by circuitous routes. His pictures of the incidents of his journey are well written, and are entertaining reading.

**London Electric Power Bills.**—The *East London Observer*, in its issue of last Saturday, publishes an interview with Councillor H. H. Gordon, who has recently been elected chairman of the Stepney Electricity Committee, in which it is stated that the Stepney Electric Power Bill will not be proceeded with. This is the reason, the interview states, why the necessary meeting under the Borough Funds Act has not been held.

A conference of London borough councils was held at the Fulham Town Hall on Monday, in connection with the London County Council Electric Power Bill, when a resolution was passed by which the delegates, subject to clauses being agreed, will recommend their Councils to support the London County Council measure. It was also decided to appoint a committee of one representative from each borough to consider the details of all the London electric power bills and to report to a future conference.

**Fire at the National Telephone Co.'s Glasgow Exchange.**—At 6:27 p.m. on Saturday, the test room belonging to the Glasgow Royal exchange of the National Telephone Co. was discovered to be on fire, and although the fire brigade arrived promptly the test room was practically burnt out. Fortunately the structure was not seriously damaged and it was possible to use the room again, thus avoiding the shifting of the line cables. The fire did not touch the switch room, but about 120 outside line cables were cut off by the fire, and over 300 inside cables. The work of restoration was commenced during Saturday night, and it was hoped to begin to join up subscribers yesterday. We are informed that, so far as inquiry has been made, there is nothing to imply the fire originated from anything electrical. Only a few operators were on duty at the time, and as they were not in the test room to which the fire was confined they were able to leave in safety.

**Electrical Equipment of the London, Brighton & South Coast Railway.**—In connection with our editorial note last week, we are now permitted to state that the British Thomson-Houston Co. is associated with the Allgemeine Elektricitäts-Gesellschaft in the latter firm's tender to the London, Brighton & South Coast Railway for the "electrification" of certain of its lines. The system it is proposed to use is the Winter-Eichberg system, the British patents for which are owned by the Thomson-Houston Company, and a large amount of work for the Brighton-road, including all the switchgear, will be carried out in its factories at Rugby. After the first few equipments, the motors and control apparatus will likewise be manufactured in Rugby. We are informed that the reason that the first equipments are to be made in Germany is not because of any lack of experience on the part of the British Thomson-Houston Co.'s own engineers, but because the equipments which it is proposed to use are to be duplicates of those already successfully built by the Allgemeine Company, and can be furnished at earlier dates than would otherwise be possible. It may be mentioned that the Thomson-Houston Company has already carried out heavy traction work on the Central London Railway, the Great Northern & City Railway, the North Eastern Railway and the District Railway, and that it has contracts, among others, for all the motors and control equipments for the various tube railways controlled by the Underground Electric Railways of London and for the equipment of the Hammersmith lines of the Great Western Railway.

**Magnetic Testing of Cast-iron by the Permeability Bridge.**—In an original communication which will be published in the next number of the Institution of Electrical Engineers *Journal*, Mr. Albert Campbell gives an account of an investigation undertaken to determine a suitable method of testing bars of widely-different magnetic properties by means of the Ewing permeability bridge. This instrument is primarily intended for the comparison of bars of nearly the same quality, errors being introduced if the sample to be tested has a very different permeability from the standard. In order to get over this difficulty, which is met with particularly in the case of cast iron (the curve for which differs in form very considerably from that of the usual soft-iron standard), Mr. Campbell utilised a number of different standard bars of various degrees of magnetic quality, and compared each successively with the cast-iron bar, using the bridge only to determine the points where the permeabilities were equal in each case—that is to say, where the $B/H$ curves of the sample and standard in question crossed. This was done by keeping the number of turns on both branches equal and varying the current till a balance was obtained, thus eliminating entirely the error due to inequality in the magnetising forces. In order to carry out effectively this method of crossing points, a large number of standards were required, and this magnetic quality had to be progressively graduated. In order to fill in the gaps which would exist with the use of ordinary materials, Mr. Campbell used, in some cases, tubes of the same external diameter and measured their apparent permeability. The curves for the series of standards were obtained by the usual double bar and yoke method (described by Prof. Ewing in "Magnetic Induction in Iron and Other Metals," 3rd edition, p. 362), and in some cases corroborated by ballistic tests of rings. The method has been used with great success over a long series of tests, carried out at the National Physical Laboratory, and some curves are reproduced in the paper.

**Physical Society.**—On Friday last at the Royal College of Science, an exhibition of physical apparatus took the place of an ordinary meeting of the Physical Society. With but few exceptions the exhibits were optical or electrical, the best firms in these branches of fine instrument work being represented. The recent Electrical Exhibition at Olympia has, however, left but few novelties on the electrical side to show. The Cambridge Scientific Instrument Co. made a special feature of Mr. Duddell's newest designs and improvements in instruments for measuring small currents. The twisted strip ammeter and the thermo-galvanometer have already been described in these columns; the Einthoven string galvanometer, which consists of a silvered quartz fibre stretched in a strong magnetic field, was exhibited, showing cardiograms. Crompton & Co. showed their new electrostatic voltmeter (in which the fixed and moving parts are portions of concentric spheres) and a pyrometer. Elliott Bros. showed a large variety of instruments for the measurement of direct and alternating current, and Messrs. Everett, Edgcumbe & Co. displayed their specialities for the photometry of glow lamps. Isenthal & Co. gave an interesting exhibition of the vacuum oscillograph, which traces the fluctuation of current by aid of the glow that appears in a vacuum tube on the electrode that is negative; and showed an electrolytic rectifier and a Grisson electrolytic condenser. Newton & Co. showed a variety of X-ray apparatus, and Mr. Paul and Messrs. Pitkin exhibited the latest forms of their measuring instruments. The Marconi Co. showed Dr. Fleming's cymometer, or electric-wave measurer, both in its orignal form and also with a recent addition. The addition consists in the replacement of the vacuum tube by a thermo-junction. This enables the damping of the oscillations induced in the instrument to be measured. Among the optical exhibits apparatus constructed with the new Jena glass Uviol, which is transparent to ultra-violet light, was a prominent feature. For instance, Isenthal had a mercury-vapour lamp made with Uviol for spectroscopic work, and various spectroscope makers exhibited instruments made with this glass. Carl Zeiss displayed an appliance for the observation of ultra-microscopic particles, the particular object shown under the microscope being gold particles, less than a millionth of a centimetre in diameter, in colloidal solution.

**National Physical Laboratory.**—A memorial has been presented to the Chancellor of the Exchequer on behalf of the National Physical Laboratory regarding the subject of an additional State grant to this institution. In it a comparison is drawn between the action of the Governments of the United States, Germany and France towards corresponding institutions in those countries and the past attitude of the British Government towards the National Physical Laboratory. The following table gives the amounts granted by Germany, Prussia, France, the United States and England:—

| Country. | Name. | Cost. |  | Annual grant. | Rcts. for work, annual. | No. of tests. | Staff. |
|---|---|---|---|---|---|---|---|
|  |  | Building. | Equipment. |  |  |  |  |
| Germany | Reichsanstalt .. | £200,000 |  | £16,000 | £2,016* | 18,951 | 80 |
|  | Aichungs-Kommission .. | 48,800 |  | 8,500 | .. | .. | .. |
| Prussia .. | Versuchsanstalt | 137,500 |  | 15,000 | 9,000* | 5,000 | 140 |
| France .. | Laboratoire d'Essais .... | 27,000§ | 20,000 | †5,500 | .. | .. | 12 |
| U.S.A. .. | Bureau of Standards ...... | 70,000 | 45,000 | 19,000 | 114† | 1,666† | 58 |
| England.. | Nat. Phys. Lab. | 19,000§ | .. | 5,500 | 5,943‡ | 28,183‡ | 50 |

* In these cases the State takes the fees; the Reichsanstalt fees are for 1900.

† For first year.

‡ Includes the Observatory Department.

§ In addition to buildings standing on the site. A further grant of £5,000 has been received for this year.

In addition to the grant of £5,000 for buildings and equipment, which the Treasury has expressed the hope of continuing during the next four or five years, the memorial states that further immediate aid is required in order to enable the laboratory to meet the requirements of the industry. The committee of the laboratory estimates the sum needed to erect and equip new buildings at £30,000, and it has expressed the view that an annual grant of £10,000 should be made. The memorial is signed by 150 members of Parliament, among the best known of whom are Mr. Haldane, K.C. (now Secretary for War), Sir Edward Grey (now Foreign Secretary), the late Sir R. C. Jebb, Sir Michael Foster, Mr. H. J. Gladstone (now Home Secretary). The object of the memorial is to bring the claims of the National Physical Laboratory before the Chancellor of the Exchequer at a time when the preparation of the Education Estimates for the ensuing Session of Parliament is under consideration.

## ELECTRICITY METERS.[*]

BY C. H. W. GERHARDI.

*(Continued from page 299.)*

*Three-wire Circuit Meters.*—The usual difference between two and three-wire circuit meters is, that the main coil is divided into two equal portions, one of which is connected into one outer and the other into the other outer of the three-wire circuit, the shunt or pressure circuit being connected to the two "station" terminals as in Fig. 151.[†] The neutral main is not, as a rule, connected to the meter. For the purpose of testing with balanced loads, the meters may conveniently be connected up as two-wire meters as in Fig. 152, the main coils being joined in series in the one main so that they assist one another, and the shunt ends connected as in Figs. 149 and 150 to the special shunt circuit. After ascertaining that the errors of the meters are within the allowable limits on balanced loads in the above manner, it is further necessary to check the effect which each half of the main circuit has on the speed. The limiting case of unbalanced load is load on one half and no load on the other. If, therefore, one main coil is cut out of circuit, the speed of the meter should be half of what it would be at the same load with the two coils in circuit. If this is found to be the case the coils are balanced.

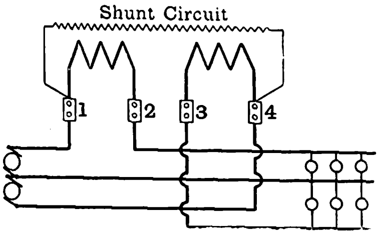

Fig. 151.—Three-wire Meter Connections.

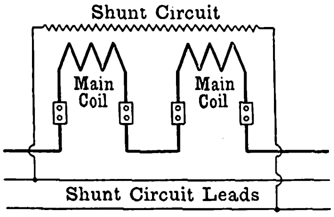

Fig. 152.—Three-wire Meter-testing Connections.

Another way of ascertaining this easily is to connect up the main coils so as to oppose one another (Fig. 153), and switch on full load or an over load (which will do no harm for a short time). If the coils are balanced, no motion of the main spindle will be noticed. If out of balance the main spindle will rotate either backwards or forwards, depending on which of the two fields is the stronger. As the difference will probably be very small, the speed will be low. It is, therefore, advisable to use an overload which makes the test more sensitive.

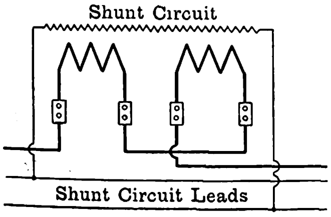

Fig. 153.—Three-wire Meter-testing Connections. Test for Balance of the Coils.

*Polyphase Meters.*—For the registration of the energy consumed in two or three-phase circuits single-phase meters may be employed, or meters specially constructed may be used.

Two-phase circuits may be, as in Fig. 154 in which case the two phases are separate and become two single-phase circuits, or as in Fig. 155 where the two phases have a common return. In either case two meters inserted as shown ($M_1 M_2$) would register the consumption, the total consumption being the sum of the two individual ones shown by each meter.

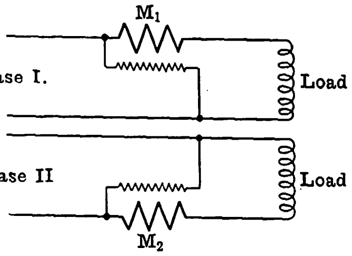

Fig. 154.—Two-phase Connections.

If the circuits are balanced as in the case of two-phase motor loads, only one meter in one of the circuits would be necessary. This meter might be provided with a counting train to indicate the total energy, or if an ordinary meter be employed a multiplying constant of 2 would naturally have to be used.

Three-phase circuits are arranged in three different ways as shown in Figs. 156, 157 and 158.

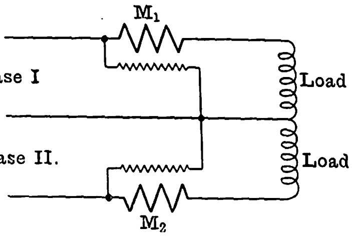

Fig. 155.—Two-phase Connections.

The measurement of the total power given to a Delta or Star system (Fig. 156) or (Fig. 157) can be made with one indicating wattmeter, provided the circuits are equally loaded. They may be inductive or non-inductive. The wattmeter main coil is inserted in one of the three leads with one pole of its shunt connected to the same lead, and the other pole of its shunt is connected to the other two leads in succession. The two readings $W_1$ and $W_2$ are taken, and the true power is: $W = KW_1 + KW_2$, where K is the multiplying constant of the wattmeter to reduce its readings to watts.

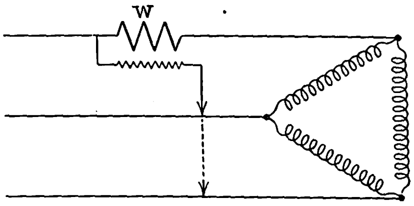

Fig. 156.—Delta or Mesh Circuit.

In the special case of the star or **Y** arrangement with a common return (Fig. 158) three wattmeters with their series coils inserted one in each main, as shown, with all their shunts connected to the common return would be used when the total watts would be $W = KW_1 + KW_2 + KW_3$, K being as before the multiplying constants of the wattmeters. If each phase be equally loaded, one wattmeter would suffice, the true power being three times that obtained by the wattmeter.

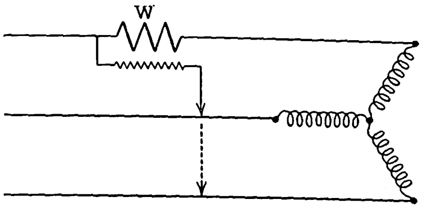

Fig. 157.—Star or **Y** Circuit.

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[*] From a forthcoming book to be published by "The Electrician" Printing and Publishing Co. All rights are reserved.

[†] Meters of different makes are connected up differently, that is to say, terminals 1 and 4 are not always the station terminals, but 1 and 3 may be, or any two.

If the circuits are unequally loaded in Figs. 156 and 157, two wattmeters would be required connected as in Fig. 159, when $W = KW_1 + KW_2$.

With an angle of lag of 60 deg. ($\cos\phi = 0{\cdot}5$) one wattmeter will read 0, the whole power being registered by the other; if $\cos\phi$ is less than 0·5, one wattmeter will read negative. The total watts in the case of an unequally-loaded system can be obtained with only one wattmeter by using a special switch, $S_1$ (Fig. 160), to throw over the series coils from one main to another. The shunt is then connected to the third main. Two readings are taken: the current on each of the two mains, and the volts reversing. Key $S_2$ may be necessary in the shunt circuit, as the wattmeter may read negatively when thrown over. When a negative reading is obtained as above, the sign of one reading must be changed, the true power being the algebraic sum of the watts obtained by each reading.

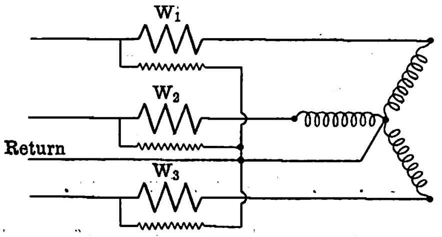

Fig. 158.—Three-phase Star Connections with Common Return.

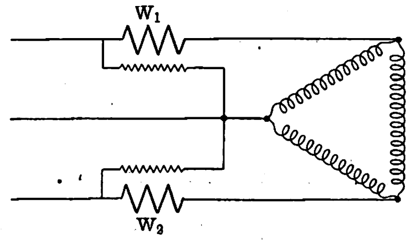

Fig. 159.—Three-phase Connections: Unequally Loaded Circuits.

From what has been said it is apparent that it is possible to meter the energy in a two or three-phase circuit by employing two single-phase watt-hour meters connected as in Figs. 154, 155 or 159. This method, however, possesses disadvantages. Firstly, two meters would take up more room than one and would be more costly; secondly, two readings would have to be taken (with the possibility of errors in reading), and their indications would have to be added algebraically, giving a further chance of mistakes being made. It is, therefore, preferable in every way to use a polyphase meter in which one set of dials gives the true consumption. Such meters are usually composed of two motors, either acting on a common disc or rotor, or on two discs carried on the same spindle; or, in the case of clock meters of the Aron type, which have their pendulums and main coils arranged as previously described. Fig. 161 shows the connections which may be used for testing a polyphase meter on a single-phase two-wire circuit, such as those previously described. The meter is tested as two separate meters, but care must be taken that both shunt circuits are connected during *all the tests*. A throw-over switch T enables either of the main coils to be put into circuit and each is tested separately. The full-load speed on one main coil should be half the normal full-load speed of the meter.

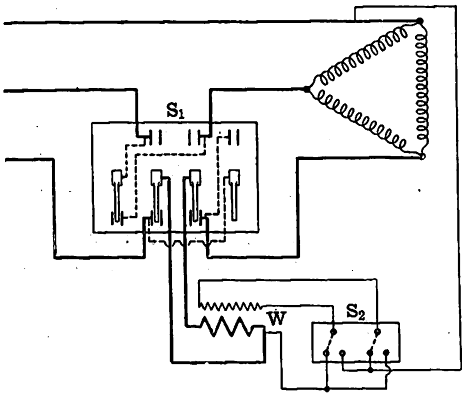

Fig. 160.—Connections for Measuring the Power in an Unbalanced Three-phase Network by means of One Wattmeter.

Meters of large capacity for alternating-current circuits are often provided with series transformers, and, if for high pressures, with step-down transformers to reduce the voltage. By this means a standard small-size meter, with a special registering train which registers the kilowatt hours, taking into consideration the ratios of transformation, is usually employed. In such cases the meter itself may be tested, and the transformer ratios verified separately. It is preferable, however, to test the meter with its series transformer connected up as in practice. When step-down transformers form part of the meter set it is important that one of the tests on the transformer should be a "pressure test" from high-tension coil to low-tension coil, and to case or core, with a pressure of one and a half times the normal high-pressure voltage on which the set is to be used.

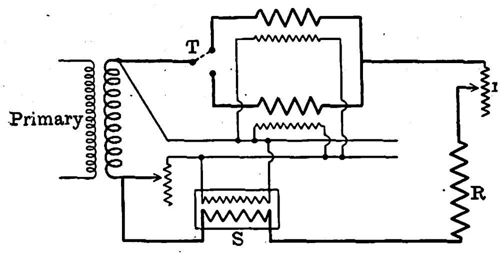

Fig. 161.—Connections for Testing Two or Three-phase Meter on Single-phase Testing.

(*To be continued.*)

## IMPROVEMENTS IN TRUCKS.*

BY ELMER E. COOK.

I do not think it can be generally known how much of the discomfort suffered by tramway passengers in this country, especially those who travel inside, is simply due to the almost universal adoption of cheap and coarsely-made underframes for the cars. I think that all, or nearly all, the defects to be found in our present trucks might be summed up in one phrase, "bad fitting." Such an important member of a car, and I might even add such a well-designed member, should never have been allowed to be put together in such an unworkmanlike manner. The failings of a bad truck are the oblong holes, the lack of symmetry in the horn block openings, the journal brasses worn to a knife edge at one end, while still retaining half the original metal at the other end; or the journal brass worn entirely through on one side, while the other side is almost as perfect as the day it was cast; or the axle journals worn taper due to uneven wear.

The average life of this type of truck is about five years, and, as that is about the length of time that has elapsed since the boom in electric traction began in this country, we can all see quite plainly that after five years' wear, the electric-traction truck heads very rapidly for the scrap-heap; and we can all see more plainly that a few extra pounds spent in assembling the various members would have led to a much longer life. Now that the London County Council in their latest specification are insistently demanding machine-fitted trucks, I feel certain that this demand will soon become general.

The question how much machining is necessary to construct a truck properly is a very pertinent one at this point. The journals and journal brasses, although they have often run hot and the manufacturer has been accused of bad workmanship on their account, owe their deficiencies to the parsimony of their buyers. The reason that they wear out at one end or one side, and taper the journals, is one and the same, namely, that the inside of the journal-box has not been properly machined, but has been fitted into the truck just as it came from the foundry, with all the imperfections to be found in rough castings, such as lumps in the top, which throw the load on to the bearing either at one end or one side, or anywhere except where the designer of the truck intended that the load should be placed; or the roughness of the outside of the boxes causes torsional strains on side frames, which not only tend to wreck the frame and destroy the journal-box guides, but seriously interfere with the action of the journal-box springs, changing the nature of the load from live to dead, which in time tends to destroy permanent way, and, by excessive vibration, to loose the truck and motor-bolts, and rack the car body and to cause pounding at rail joints. (See Figs. 1, 2 and 3 which have been exaggerated for the purpose of illustration.) In a well-made truck, not only should the points of contact between end sills, cross bars, &c., and the side frames of the truck be machined, but the bolts themselves should be machined and put into rimered holes at a driving fit, and the underside of the head and nut should be truly faced, as well as their bearing surface around the hole. This method of machining and attaching the various members of a truck not only gives you a full frictional grip of the bolts, but makes it possible at the same time to erect a truck which is in perfect square and alignment with itself, without leaving any undue strains upon any particular member, such as is invariably the case in a truck which is erected without machining, and which has to be forced into square. Special attention should be given to the various members of the brake rigging. All the wearing bolts should be carefully case-hardened and some should even be arranged with movable bushes carefully case-hardened and so arranged that they can be easily removed when excessive wear has taken place. Of course, all the bolts and pins should also be carefully machined and hardened.

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* Abstract of a Paper read December 14th before the Tramways and Light Railways Association, Mr. J. B. Hamilton in the chair.

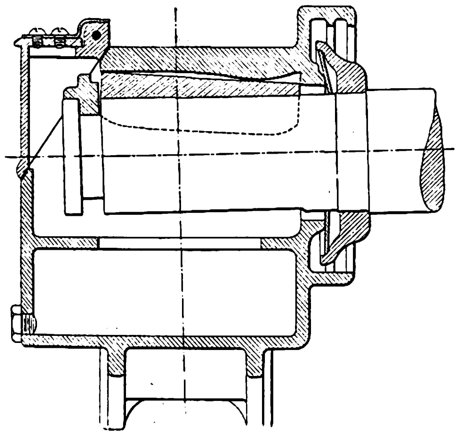

Fig. 1.

These remarks are applicable to all types of trucks, but in bogie trucks, either equal or unequal wheeled, careful attention should also be given to the perfect machining of the bolster housings where they attach to the side frames of the trucks, as well as the bolster itself; of course, the idea being to machine only those parts which actually improve the qualities of the trucks, as well as increase their life. In the case of the rigid wheel-base truck, I am not sure that it would be wise to machine either the outsides of the boxes or the inside of the horn block, for the reason that the best experience demonstrates that it is advisable to have a considerable amount of lost motion, at these points, especially if the wheel base of the truck is rather long or the radii of the curves.

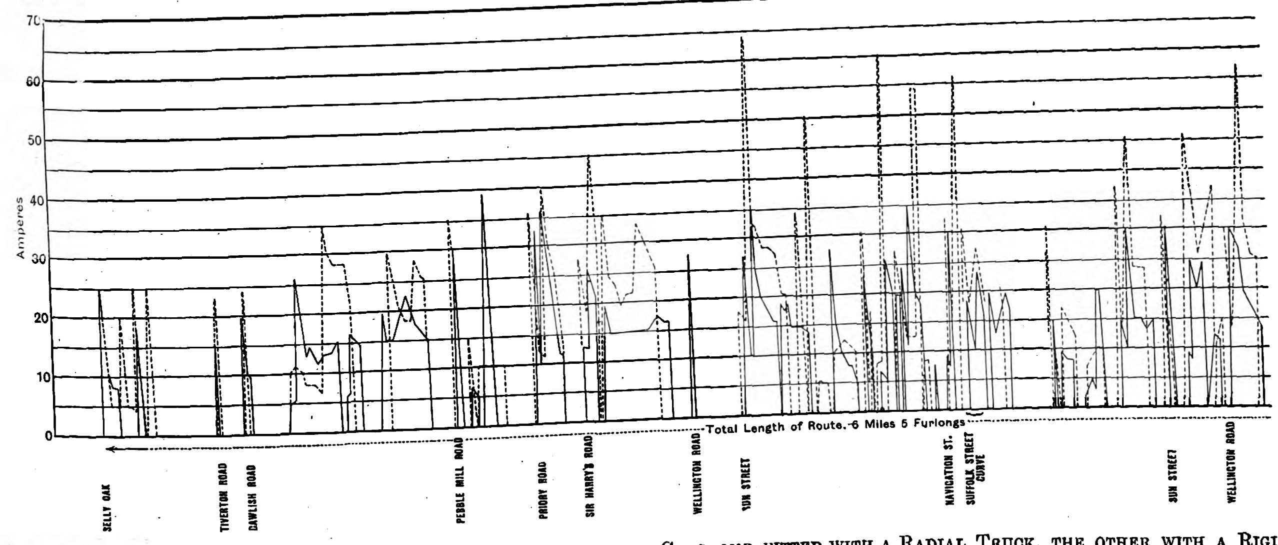

Fig. 4.—Part of a Chart showing Comparative Tests of Two similar Cars, one fitted with a Radial Truck, the other with a Rigid Truck.

The tests were carried out between Selly Oak and Birmingham and back, and it was found that the car with the rigid truck consumed 0·754 kw.-hours per car mile against 0·664 kw.-hours in the case of the car fitted with radial truck.

——— Car fitted with radial truck. ........ Car fitted with rigid truck.

Horizontal scale, 1 in. = 1,310 yds.

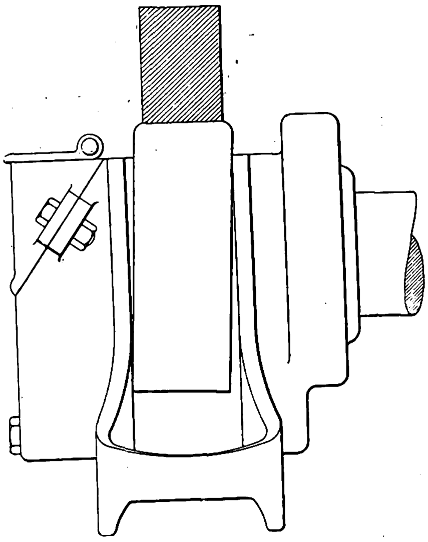

Fig. 2.

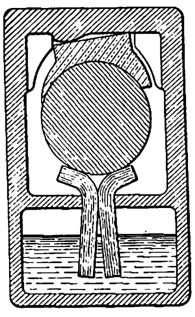

Fig 3.

This brings me to the consideration of what I consider the greatest improvement made in the last six years in electric-traction trucks. I believe that we are all agreed that, as a general proposition, the car unit, as represented by the ordinary single-truck car, is in most cases too small, and in a great many cases the car unit, as represented by the bogie or double-truck car, is too large. In the case of the rigid wheel-base truck car the incentive to get as long a wheel base as possible, and to carry as great a load as possible, results in a great deal of friction at curves, and an excessive wear and tear upon the special work as well as upon the wheel flanges; while in the case of the bogie cars it necessitates making the whole under gear very cramped, due to an attempt to keep down the size of the car in length and carrying capacity. The results often mean very imperfect brake mechanism, sanding gear, &c. Also in the case of bogie cars, the first cost has to be considered as well as maintenance, and the general rule has been to use two motor equipments, thus reducing the amount of adhesion available for traction purposes by from 20 to 30 per cent. The radial truck combines, in my opinion, the best qualities of both these types of trucks, while excluding all the disadvantages found in either type. It can be adapted to any size of car, ranging in length from 14 ft. to 32 ft.

In the case of the shorter cars, its first cost is about 75 per cent. greater than the ordinary rigid wheel-base truck; but where it displaces bogie trucks, the first cost is not only less, but it gives the full traction efficiency of the rigid wheel-base truck, and the splendid riding qualities of the bogie trucks, and by the application of only two motors. In addition to this, it has not the destructive effect on permanent way or special work unavoidable with the rigid wheel-base truck, neither is it wearing out eight wheels, four axles, eight brake shoes, or in many ways costing the same amount to maintain as in the case of the pair of bogie trucks. In the case of steel-tyred wheels, I find that on the radial truck the flanges may be thicker than upon the rigid wheel-base trucks, for the reason that the radial action gives a much better clearance at curves. This is a most important factor, as generally it is the lack of sufficient material in the wheel flanges, owing to the narrowness of the grooved rail, that causes so much annoyance and expense in the maintenance of wheels. Last, but not least, of the many advantages of radial trucks is the saving of current; the truck having no work to perform in the direction of tearing up permanent way, and by its working principle having almost entirely obviated the friction at curves and turn-outs, it logically follows that a saving in current will take place. The accompanying curve (Fig. 4) was taken, showing the comparative current consumption of a 6 ft. wheel base on an ordinary rigid truck, and an 8 ft. 6 in. wheel-base radial truck under exactly the same conditions. During the short time this truck has been on the market 34 different undertakings have ordered them.

The following is an abstract of the discussion which took place after the reading of the Paper :—

Mr. E. PECKHAM did not agree that all old trucks were as bad as Mr. Cook had represented them to be, and said that plenty of five-year-old trucks were running to-day giving satisfaction. He was of the same opinion as the author regarding the desirability of machining, and this ought to be done throughout with the aid of suitable jigs.

Mr. ALFRED B. COOK, who, on rising, was careful to mention that he was not related to the author, asked what was the minimum curve through which a radial truck could pass. He had obtained very fair results by soldering a strip of lead on top of the brasses for allowing these to adjust themselves to the deflections of the axle.

Mr. M. B. MOUNTAIN agreed with the author in his condemnation of badly fitted trucks. Undoubtedly the best bearing was the crown bearing. The life of brasses depended largely on the efficiency of the provisions adopted for keeping out grit and dirt. He advocated the machining of the horn blocks on the inside as well as on the outside.

Prof. CARUS-WILSON mentioned the case of a certain tramway which would have remained unbuilt if the adoption of radial trucks had not rendered it possible to construct the line with sharp curves, in this way conducing to low initial cost. Although he was a believer in the radial truck, he thought the present design wrong in principle, since the outward swing of the motors (when the car was passing through a curve) tended to move the radial truck in the wrong direction. A second difficulty related to the springs which were provided to bring the truck back to its normal position after the curve had been passed. It was obvious that these springs could only be adjusted for a certain speed and certain curve. For all other speeds and curves the tension of the springs was either too great or too small for the purpose stated. Hence a compromise had to be made. Radial trucks effected a saving not only in curves, but also on the straight, inasmuch as bogie cars with their four axles could be entirely dispensed with.

Mr. J. S. WARNER said the brasses ought not to be cylindrical on the outside, as shown in one of the lecturer's lantern slides, but crowned, so as to be able to adjust themselves to any deflection of the car axle. This deflection was by no means negligible.

Mr. R. L. ACLAND said that they had in Chesterfield single lines only, with numerous turn-outs. For the last 12 months they had used radial trucks exclusively, and were satisfied with them. The sharpest curve had a radius of 40 ft. to the inner rail, and the cars went through this curve at a speed of about 4 or 5 miles per hour. No difficulties had been met with in the directions indicated by Prof. Carus-Wilson.

Mr. J. B. HAMILTON, the chairman, mentioned that out of 25 trucks put in service in Leeds in 1897, only 10 had required so far any overhauling worth mentioning. He was in favour of radial trucks. He had observed the surprising fact that rail corrugations occurred essentially on the outside rail of fairly flat curves (about 100 ft. radius).

Mr. E. E. COOK, in reply to the discussion, said that curves of 40 ft. radius could well be taken by radial trucks having a wheel base of 10 ft. and for 50 ft. radius a wheel base of from 11 ft. to 12 ft. was permissible. Springs were not depended upon to bring the radial truck back to its normal position, this being done by means of an inclined plane of about 1 : 20 on top of the axle box. Springs were only employed to prevent hunting.

**The Chicago Goods Traffic Tunnels.**—The *Western Electrician* gives an account of the progress which has been made during the last year with the network of concrete-lined tunnels now being constructed in Chicago for the accommodation of the cables of the automatic telephone system of that city. These tunnels also contain an electric goods railway which is used for the carting away of earth removed in excavating for new buildings, for the transport of coal and to some extent to carry mails. The tunnels run under the principal streets in the busy part of the city, and are connected to the basements of many of the more important warehouses and business premises. The trucks are hauled by direct-current electric locomotives of the mining type, which on the greater part of the line are fed from an overhead trolley at 250 volts. On one of the steep inclines leading out of the tunnel, however, a third rail is used. This rail consists of a steel strip about 4 in. wide in the form of a rack into which a gear wheel on the locomotive engages so that separate rack rails and conductor rails are not required.

## THE CHARING CROSS COMPANY'S CITY OF LONDON WORKS.*

BY W. H. PATCHELL.

(*Continued from page 344*).

*Chimneys.*—The author decided to adopt steel chimneys supported by the steel main frame of the building and placed over the firing space between each pair of boilers. The gases from the adjacent boilers are led into the foot of the chimney by a short breeches piece, each leg of which is fitted with a regulator. Readings taken on many occasions have shown that the draught available over the grate is practically that theoretically due to the temperature and head.

*Pump Room.*—The water supply is derived from two 13 in. artesian wells on the premises, 400 ft. deep, which each yield 15,000 to 20,000 gallons per hour as required. The method of pumping adopted is the air-lift system, and the water raised is discharged into a large reservoir in the basement below the pump room. From this reservoir the water is pumped by slow-speed compound steam Woodeson pumps to a tank at the top of the building, from which it runs back by gravity through the water heaters at the various engines to a tank over the pumps into which their exhaust steam is discharged and to which all the feed-pump suction pipes are connected. There are also alternative suction pipes direct into the reservoir in the basement. The feed pumps are all slow-speed compound steam Woodeson type, made by Messrs. Clarke, Chapman.

*Engines.*—The first generating plant ordered consisted of two 800 kw sets and two 1,600 kw. sets, before referred to, but the demand arose so rapidly that before they were put to work two further 1,600 kw. sets were ordered. Last year a 4,000 kw. set was added, and a similar set has just been put to work. The engines driving the 800 kw. generators are three-cylinder triple-expansion, quick-revolution enclosed engines of Messrs. Belliss & Morcom's well-known type. They exhaust into jet condensers in the basement, the air and circulating pumps for which are driven by electric motors.

The engines driving the 1,600 kw. generators are horizontal cross-compound engines by Messrs. Sulzer Bros., of Winterthur. In details they differ materially from the usual type of slow-speed engine, inasmuch as the connecting rods and cranks are enclosed, and the oil supply is continuous and under pressure. The valves are of Messrs. Sulzer's latest four-seated pattern. The pistons are provided with tail-rods, and are supported outside the cylinders by special bearings. The cranks are set at 108 deg. instead of the more usual 90 deg., with the low-pressure crank leading. The exhaust steam from the low-pressure cylinder is divided in an oil separator and taken to two jet condensers, one on each side of the engine. These condensers stand on their air pumps, which are driven from the high and low-pressure crank pins respectively.

The engines driving the 4,000 kw. generators are verticle three-cylinder compound, with the high-pressure cylinder in the centre and a low-pressure on each side of it driving on to cranks which are equally divided. By this arrangement excessive weight or dimensions of any of the parts is avoided, and an even turning moment is obtained. The type approximates more closely than is usual in slow-speed sets to an "enclosed" high-speed forced lubricated engine. The piston rods, cross heads, and connecting rods are entirely enclosed to prevent splashing. The oil is supplied under pressure from a tank above the cylinders. After running through the engine bed to a filter tank in the basement it is returned to the tank at the top by pumps and used over again. The valves are of the four-seated type, as used on the horizontal engines. Main and safety governors are both provided, and the latter, in addition to automatically closing the main steam valve, opens an air valve to break the vacuum. This arrangement can also be operated by a lever from the driver's stand, where all the hand wheels and levers necessary for working the engines are assembled. The jet condensers are provided with separate air pumps driven from the low-pressure cross heads. A special feature is the adoption of feed-water heaters on all the engines inserted between the low-pressure cylinder and the jet condenser.

*Condensing.*—Although the Bow Back River suffices to bring freights of coal or machinery to the works, and affords an alternative route to the railway, the water supply was quite insufficient for condensing purposes. Jet condensing has been adopted throughout, due to the trouble that the author previously experienced in keeping surface condensers clean enough to ensure a good vacuum with the temperatures available when working in connection with cooling towers. The air pumps deliver into steel hot wells, and from these hot wells the water is taken by centrifugal pumps, direct-coupled to motors, and delivered into the cooling towers. The vacuum obtained under normal working conditions is between 25 in. and 26 in.

*Cooling Towers.*—The cooling towers have steel circular shells, to which considerable objection was made by some makers who had previously been accustomed to wooden shells for such plant. The steel type may not be so artistic, as it does not present such opportunities for decorative treatment as the timber, but the author considers that they are much more business-like from the engineering point of view. The standard unit of size adopted was for 25,000 lb. of steam per hour on easy working. Figs. 1, 2 and 6 show the general arrangement of the towers, which are 30 ft. in diameter, 38 ft. high to the base of the cone where the water is delivered into them, and 85 ft. high to the top of the chimney.

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* Paper read before the Institution of Electrical Engineers, Dec. 7 Slightly abridged.

*Exciter Sets.*—A small continuous-current plant has been provided to supply the energy required for the generator fields, station lighting, and the various motors which drive the circulating pumps, coal cranes, travellers, &c.

The plant consisted of two of Messrs. Belliss & Morcom's three-cylinder triple-expansion quick revolution enclosed engines driving 300 kw. Lahmeyer continuous-current 200-volt dynamos, and exhausting into the same condensers as the 800 kw. sets. These are supplemented by two 350 kw. motor generators similar to those used in the city, as will be described later, and by a Hart storage battery.

*Generators.*—Probably the most striking feature in the generators is the elegance of design combined with solidity and stiffness of construction. In each size of machine the stator is of the box-girder type cast in two or four parts held together by flanges and bolts. The frame is of sufficient stiffness to keep its shape without either radial arms from a bossed centre or stay bolts such as were lately fashionable in some types of machines. Such a construction saves weight, and if it were possible to use it in a rotor it would be excellent, but unfortunately the rotor must have weight to give the necessary steady turning, and the stator must be of such construction and so stiff that it will keep its shape under the strains which arise in working due to magnetic pull and from heating.

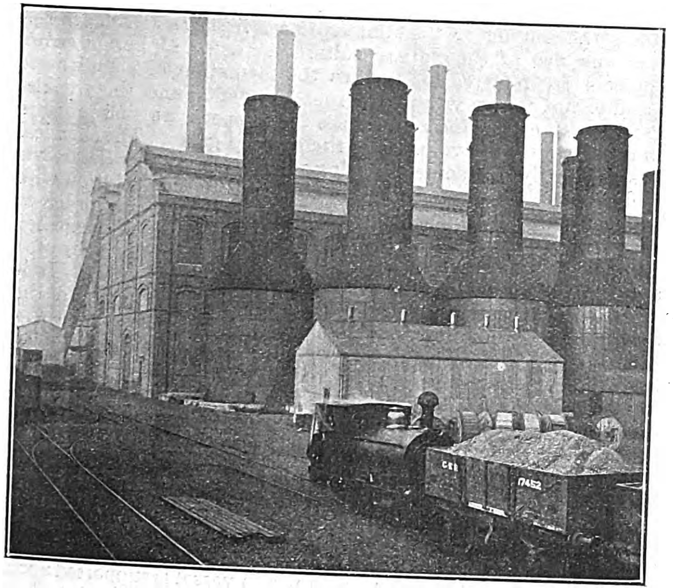


FIG. 6.—EXTERIOR OF POWER STATION.

The stator-frames are all bored out in the vertical position in which they will subsequently stand when permanently erected. The winding is in mica tubes embedded in slots which are nearly closed. Crossings of the wires are as far as possible avoided, and where the coils leave the iron core they are carefully wound over templates and covered over with insulating tape to prevent breakdown between adjacent coils or between coils and the frames. The coils are further protected from accidental contact by a strong perforated cover which also enhances the appearance of the machine.

If some of the theories which have been advanced in connection with Mr. J. S. Highfield's discovery of nitric acid in high-tension machines (vide *The Electrician*, Vol. LIV., p. 573) are correct, evidences of such acid might reasonably be expected in these machines, and it is interesting to note that even careful dissection and examination has revealed no signs of it. It appears to the author, therefore, that probably the acid is due to impurity of the insulating materials rather than the destruction of pure material by ozone. The rotors or magnet wheels which also serve the purpose of flywheels, are built up in one or four parts, and are held together by means of bolts and shrunk rings. Such rings are not only used at the hubs, but also at each side of the joints on the rim. The machines are provided with two sets of spokes or arms. The wrought-iron poles are solid, of circular shape, and bolted on to the wheels in such a manner that they may be dismantled at any time without altering the position of the stator.

No difficulty whatever has been experienced in paralleling the 800 kw. machines driven by high-speed engines with the larger machines driven by slow-speed engines; any or all the machines will run in parallel in a way that reflects the greatest credit upon the respective engine and machine builders, and gives confidence to the men who operate them.

The 4,000 kw. machines are perhaps the largest machines in this country, and if the present fashion for turbo-generators proves to be justified they will probably remain the largest. Table II. gives the leading particulars of the generators.

**Table II.**—*Particulars of Lahmeyer Generators.*

| — | 800 kw. Normal. | 1,600 kw. Normal. | 4,000 kw. Normal. |
|---|---|---|---|
| Height above floor line .......... | 8 ft. 2½ in. | 17 ft. 1½ in. | 17 ft. 8 in. |
| Centre of shaft above floor line .... | 2 ft. 1 in. | 2 ft. 9½ in. | 2 ft. 7½ in. |
| Extreme length in direction of shaft | 7 ft. 5 in. | 21 ft. 0 in. | 19 ft. 0 in. |
| Extreme width ................ | 15 ft. 1 in. | 33 ft. 0 in. | 39 ft. 4 in. |
| *Stator.* | | | |
| Outside diameter of frame ........ | 12 ft. 1½ in. | 27 ft. 0 in. | 29 ft. 2 in. |
| Outside diameter of iron core...... | 10 ft. 2 in. | 24 ft. 7 in. | 26 ft. 7 in. |
| Inside diameter of iron core ...... | 8 ft. 6½ in. | 23 ft. 0 in. | 25 ft. 1 in. |
| Width of iron core .............. | 1 ft. 3 in. | 1 ft. 1 in. | 2 ft. 1¾ in. |
| Number of slots per pole and phase. | 2 | 2 | 2 |
| *Rotor.* | | | |
| Diameter of flywheel excluding poles | 6 ft. 9¾ in. | 21 ft. 1½ in. | 23 ft. 0 in. |
| Diameter of flywheel over poles.... | 8 ft. 5⅜ in. | 22 ft. 11⅜ in. | 25 ft. 0 in. |
| Number of poles .............. | 26 | 72 | 72 |
| Type of poles.................. | Solid wrought | iron, bolted | to the wheel |
| Pole winding.................. | Wire | Flat copper edg'wound. | Flat cop'r edgewo'd |
| Flywheel effect, ft. tons .......... | 1,200 | 4,960 | 9,300 |
| Total weight of machine, tons .... | 30 | 131 | 197 |
| Revolutions per minute .......... | 230 | 83·3 | 83·3 |

*Main Switchboard.*—Reference to Figs. 1 and 2 will show that the switchboard is at one side of the engine room. It is arranged in two distinct halves, which, however, may be connected by an emergency switch. The generating plant is numbered consecutively, each of the odd numbers being connected to one half of the switchboard, and the even numbers to the other half. Fig. 2 shows that the switchboard is practically a three-decker. The resistances for the fields of the machines stand on the main engine-room floor underneath the principal switchboard gallery. The panels carrying the controlling gear are on the principal gallery. The high-tension switches are placed on the upper gallery, and are worked positively from the principal gallery by levers.

At first chimney type switches with fuses in series were used, but a little experience with them showed that, although they were very satisfactory for small machines, they were not reliable in connection with large machines and long cables. They have, therefore, been replaced by oil switches, which are also fitted with relays to act as automatic cut-outs.

The measuring of the high tension circuits is done under Messrs. Lahmeyer's Schuler patents, in which one coil of the generator is taken out to a one-to one transformer, and from the secondary side of this transformer low-tension circuits are taken to the measuring instruments.

Each machine has its own panel complete, which carries its main switch lever, synchronising lamps, field ammeter, main voltmeter, wattmeter, and watt-hour-meter. Each trunk main panel carries a wattmeter, ammeter, and watt-hour-meter. Each half of the switchboard has its own E.H.T. ring 'bus bars, which can be divided into sections by suitable links. Fig. 7 is a diagram of one-half of the main switchboard connections from the generators to the feeders, and shows the Schuler measuring transformer connections together with the two halves of the switchboard and the emergency switch by which they may be connected. The two sets of 'bus bars are kept distinct with their own allotted machines and feeders, and selector switches, by which the machines or feeders can be thrown on to either 'bus bar, are not employed.

*Cable Charging Gear.*—Cable charging gear is provided in the shape of a small motor generator and two transformers with suitable connections, so that it may either be used to run up the cables to working pressure or to test them at 15,000 volts. A three-phase generator is driven by a D.C. motor, and produces current at a normal 2,000 volts pressure. This current is then stepped up by a bank of two three-phase oil-transformers, and the pressure is varied by varying the field of the 2,000 volt generator. Special 'bus bars and switches are provided in connection with the charging gear, so that a cable may be run up and then put in parallel with other working cables, or a working cable may be taken off the main bars and discharged for testing or other purposes.

### TRUNK MAINS.

Ten trunk feeder mains at present leave the generating station; they are all three-core, lead sheathed paper cables. Six of them go to the city and four to the West End; means of interconnecting the city cables and the West End cables are provided in the city.

The cables are laid on the solid system in steel troughs, which are heavily bonded to comply with the Board of Trade requirements. The cables were ordered when it was believed that the Board of Trade regulations for H.T. applied to E.H.T., and under this rule ½ in. insulation was provided between conductors and between conductors and earth, the latter so that the cables could be worked either with the middle point earthed or unearthed as might be found most desirable. The author does not at all regret the extra paper, as, out of over 70 miles of cable, there has only been one cable fault. There was an unfortunate circumstance attending the delivery of one lot of cables, due to the makers having over-dried them to get a high insulation resistance, but the author is pleased to put on record that they were promptly replaced by the makers, and since they have been replaced there has not been a single fault upon them.

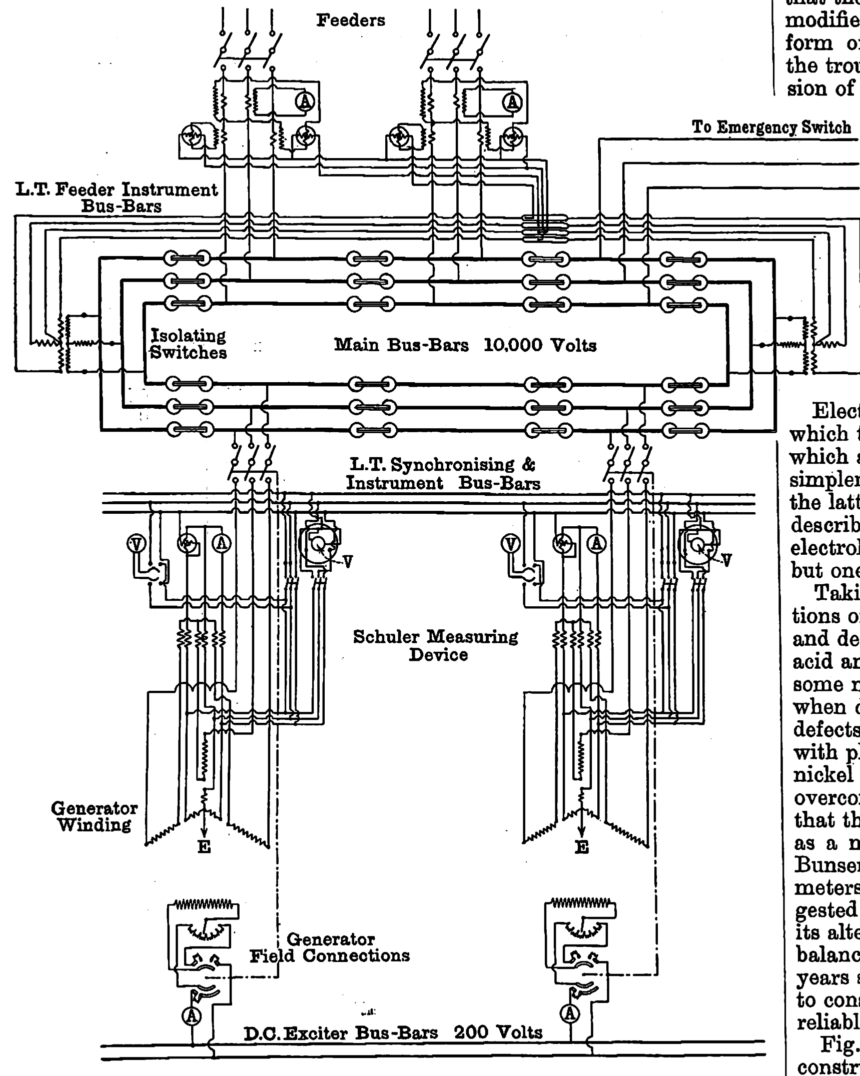
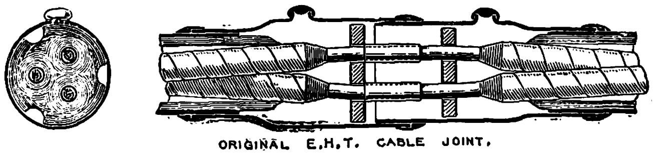

Feeders
To Emergency Switch
L.T. Feeder Instrument Bus-Bars
Isolating Switches
Main Bus-Bars 10,000 Volts
L.T. Synchronising & Instrument Bus-Bars
V
A
Schuler Measuring Device
Generator Winding
E
E
Generator Field Connections
D.C. Exciter Bus-Bars 200 Volts

Fig. 7.—Connections of Half of Switchboard.


ORIGINAL E.H.T. CABLE JOINT.

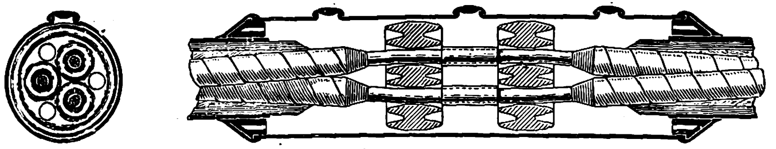

MODIFIED E.H.T. CABLE JOINT.

Fig. 8.—E.H.T. Cable Joints.

*Joints.*—No boxes were allowed to be built on the route of the trunk mains; special joints, therefore, had to be designed which could be made in the steel trough without increasing the size of the trough or unduly diminishing the thickness of bitumen between the cable and the trough. Several types were tried, and the original form selected is shown in Fig. 8. It will be noted that it consists of two ebonite discs to keep the three cores in position; short copper sleeves were sweated over the three cores and a lead sleeve wiped on over all and filled up with cable compound. Further experience showed that the ebonite discs were better replaced by porcelain discs of the modified type shown, which give a longer path for creepage, the form of lead sleeve also was improved. The heat due to filling the troughing on the solid system with hot bitumen causes expansion of the cable compound in the sleeve, and a void at the joint; this led to special precautions in the shape of short funnels, which were temporarily tacked on to the sleeve and projected above the top of the troughing. After the trough had been filled the insulating material in the sleeve was topped up, the funnel cut off, and the hole covered over.

(*To be concluded.*)

## TWO NEW ELECTROLYTIC METERS.*

BY S. H. HOLDEN.

Electrolytic meters may be divided into two classes: those in which the whole current passes through the electrolyte and those which are shunted by a metallic conductor. The former are of the simpler construction and theory, but practical considerations render the latter class the more desirable generally. The two meters to be described are each developed from the oldest and simplest form of electrolytic meter—viz., the gas voltameter employed by Faraday—but one belongs to the unshunted and the other to the shunted class.

Taking the simpler or unshunted pattern first. In all full descriptions of the use of the old gas voltameter certain inherent errors and defects are referred to, such as the formation of persulphuric acid and ozone, which vitiate the measurements, and the troublesome necessity of making allowances for temperature and pressure when determining the volumes of the evolved gases. The chemical defects are partly overcome by using phosphoric acid as electrolyte with platinum electrodes, or, better still, caustic soda solution with nickel electrodes, as suggested and used by Oettel. In order to overcome the difficulties of gas measurement, Bunsen suggested that the electrolyte should be weighed and its loss of weight used as a measure instead of the volume of the evolved gases. It is Bunsen's suggestion which has been embodied in the first of the meters. As early as the year 1882 electrolytic meters were suggested in which an electrode was suspended from a spring balance, its alteration in weight being indicated thereon, and the dial of the balance being graduated in ampere-hours or other units. Of recent years spring balances for commercial purposes have been brought to considerable perfection, and it was felt that they were sufficiently reliable for the purposes of an electricity meter.

Fig. 1 shows in diagrammatic form the working parts of a meter constructed on what may be called Bunsen's plan. A is a thin iron vessel with an ebonite lid. Within this vessel is a solution of caustic soda and a pair of sheet nickel electrodes, BB. A small hole is left in the lid for the escape of gas. The whole vessel is supported upon four springs, two only of which are shown, and marked $C^2$. Attached to the front of the iron vessel is a light rack, H, working into a pinion, F. This pinion carries a hand or pointer moving over a graduated dial. Part of this dial is broken away to show the gearing more clearly. Guide levers, *aaaa*, attached to the case and to the top and bottom of the iron vessel ensure its remaining central. Light flat springs, JJ, carry the current from the fixed terminals to the electrodes. The meter shown is intended for a current of 5 amperes, and the capacity of the vessel is such that current equivalent to 400 units at 200 volts may be registered before the meter requires refilling. The solid caustic soda to form the electrolyte is placed in the vessel A as soon as the meter is made; it is, therefore, only necessary to fill the meter with water when required for use. Since the electrolysis of a fixed weight of water corresponds to 1 unit, the accuracy of the meter may be ascertained by placing upon the vessel a brass weight which is equivalent to the amount of water that would be electrolysed by, say, 100 units at the required voltage, and then seeing that the pointer moves over 100 divisions on the scale. Calibration of the meter in the first instance may be effected either by varying the strength of the springs or by using dials having fewer or more divisions in the circle, or by varying the number of teeth in the pinion.

When a fairly large number of units has been registered, say 300, the reading is noted, and water again poured in until the hand stands at zero on the dial; registration can then go on as before. The actual weight of the vessel, when filled, is about 4½ lb., and about 1½ lb. of water may be removed by electrolysis before refilling becomes necessary. This would correspond to a total registration of 400 or 500 units.

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* Paper read before the Birmingham Local Section of the Institution of Electrical Engineers, Dec. 13. Mr. R. Threlfall, F.R.S., in the chair.

A meter such as the one just described is subject to the limitations and defects of its class—viz., relatively large fall of potential at all loads, considerable bulk and the necessity of occasional refilling. On the other hand, it is accurate, simple and easily handled. It also fulfils an object which was held in view when designing it—viz., the production of an electrolytic meter which contained no glassware and required no handling of chemicals. A number of meters of this kind have been made, and have worked satisfactorily as regards registration over a considerable period, and also the dial hands have remained perfectly stationary during a long period of rest, showing that no change in the electrolyte or springs took place.

It would obviously be fairly easy to include a ratchet-and-pawl arrangement in the counter of a spring-balance meter, so that the registration went forward continuously, instead of the hand being set back to zero at each refilling. One of the main objections to electrolytic meters could thus be eliminated. A modified form of spring-balance meter has also been made, in which change in the specific gravity of an electrolyte (produced by electrolytic removal of water) is registered upon the dial through the medium of a submerged float.

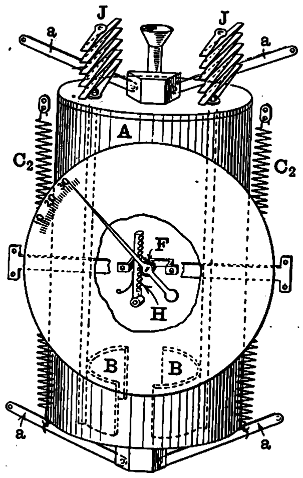

Fig. 1.

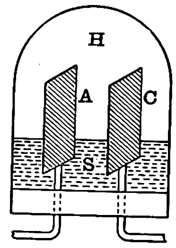

Fig. 2.

Although it is hoped that the meter just described may be of practical utility, it is not of special theoretical interest. In the one that follows, however, an electrolytic process has been employed which the author believes to be new, and which he therefore hopes may be of scientific as well as practical interest. The previous meter possessed the great practical advantages of a simple electrolytic process, and one for which the materials of electrolyte and electrodes may readily be obtained in a state of purity. An attempt was therefore made to enable such a meter to be shunted without at the same time introducing fatal complications. For a meter to be shunted, the first condition is that the current passing through it is exactly proportional to the difference of potential between its terminal electrodes; for this is the law governing the current passing through the metallic conductor constituting the shunt. Hitherto this condition has only been realised when the anode consisted of a metal which was dissolved while the same metal was deposited on the cathode, the metals employed in commercial meters being zinc, copper, and mercury. In order that a gas voltameter may conform to this rule it is necessary that gas should dissolve at one electrode and reappear at the other. A solid hydrogen anode cannot be made, but the equivalent of one may be obtained by using a mass of spongy platinum saturated with hydrogen; and if this anode is only partly immersed in the electrolyte and the remainder is exposed to an atmosphere of the hydrogen, sufficient gas will be absorbed and transfused to replace that which is dissolved away. Fig. 2 shows the arrangement in its simplest form. A and C are electrodes of platinum in dilute sulphuric acid contained in the vessel S. They are thickly coated with platinum black, and are only partly immersed. Above the electrodes is a sealed space, H, full of hydrogen gas. In such an arrangement the smallest difference of potential (say, $\frac{1}{100}$th volt) will cause a steady and continuous current to pass between the electrodes; hydrogen is evolved at the cathode, but no oxygen at the anode. Instead, the exposed surface of the anode absorbs hydrogen from the store above it, which combines with the oxygen as fast as the latter is produced. This arrangement is, therefore, comparable to a copper or silver voltameter in which the same metal is dissolved at the anode as is deposited at the cathode.

It will be seen that (within limits) it is possible to pass a current continually through an electrolytic vessel arranged as above without effecting any alteration in the volume or disposition of the electrolyte, the enclosed gas or the electrodes; it may, in fact, be hermetically sealed up and used for an indefinite time. If the electrolytic vessel thus sealed up is divided into two compartments, so that the gas evolved at the cathode does not immediately return to the general store, then the volume of the former may be used as a measure of the current passed, and being sealed up its volume is not affected by changes of external pressure or temperature. After a certain amount of gas had been thus transferred from the store to the measuring tube, and the latter had become full, it would be necessary to return this gas to the store. This can be done by tilting the tube down, by which process it is refilled with liquid and ready for a fresh start.

As explained above, the current passing through a meter of this type is proportional to the difference of potential between its electrodes, provided this current does not produce oxygen faster than the platinum anode can absorb hydrogen to combine with it. This condition is easily realised in practice. This property enables the meter to be shunted; a very small portion of the total current to be metered need be passed through it, and the amount of gas evolved during one or two years' service can be reduced to a quantity easily contained and read off in a graduated tube. The volume of gas settled upon for this purpose is about 1½ cubic in., and is measured in a graduated glass tube $\frac{5}{16}$ in. internal diameter and 15 in. long. The scale is graduated into 300 divisions 1 mm. apart—large enough to be read easily—and each division corresponds to about 5 ampere-hours passing through the meter; that is to say, one Board of Trade unit at 200 volts. To produce this volume of gas for the passage of 300 units, only $\frac{1}{50000}$th of the total current passes through the electrolyte, and an area of about 1 sq. in. of platinum anode is sufficient. The fall of pressure through the shunt of the meter is 1 volt at full load, so a resistance coil of 10,000 ohms is included in series with the electrolyte. This coil has the same temperature coefficient as the shunt, so that no temperature error exists from this cause. The added resistance coil being so large, the resistance of the electrolyte is quite negligible.

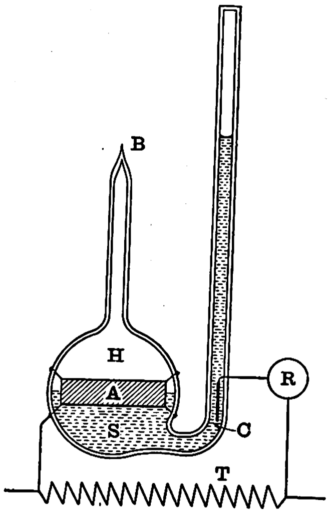

Fig. 3.

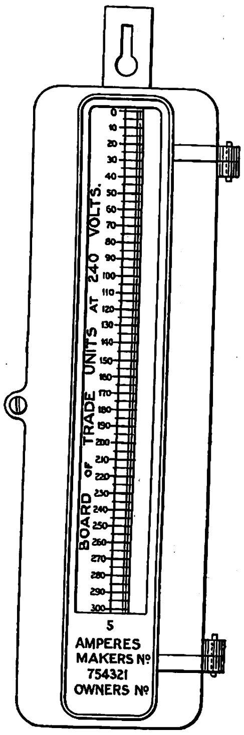

Fig. 4

Fig. 3 shows diagrammatically the essential parts of the meter in what is practically both its first and its final form. It consists of a vertical tube with bulb attached. C is the cathode—a platinum wire. A is the anode of sheet platinum, both coated with platinum black. S is the electrolyte, and H the store of hydrogen. R is the resistance coil, equal to about 10,000 ohms. T the shunt, which in a 5-ampere meter has a resistance of 0·2 ohm.

To start the meter it is held with the tube nearly horizontal and below the bulb. All the gas then collects in the bulb, while the tube fills with electrolyte, which remains in it after it is restored to the vertical position for use. When a current is passed through the shunt a steady fine stream of gas bubbles rises from the cathode, gradually replacing the liquid in the tube. Great care has been exercised, both in the experimental and in the complete meters, to use only pure materials. The hydrogen gas is produced from pure zinc and pure sulphuric acid, and is well washed before passing into the meters. Only pure acid and distilled water are used for the electrolyte, while the electrodes are treated with strong nitric acid, and are well washed after being coated with the platinum black.

The process of filling is as follows:—The short tube B (Fig. 3) is left open when the vessel is made. This tube is connected by india-rubber pipes to an air-pump, to a reservoir of hydrogen, and to a vessel containing dilute sulphuric acid. Cocks are arranged on each pipe. The air is first removed by the air-pump and hydrogen gas then admitted; this, in turn, is exhausted out, and then the sulphuric acid is allowed to flow in to the proper level. Finally, hydrogen gas is again admitted to fill up the remaining vacuum; the tube B is then sealed off in a blow-pipe flame.

Experiments have been made with various electrolytes, but none give such good results as a 10 per cent. solution of sulphuric acid. Phosporic acid is, perhaps, the next best. With solution of caustic soda and with hydrochloric acid there is a deficiency of gas produced, possibly owing to anode products getting across to the cathode, while solution of sodic sulphate had a certain amount of back E.M.F. which destroyed the accuracy with small currents. Anodes of palladium, and also cathodes both of palladium and gold, have been tried, but none appear to equal the platinum. It is remarkable that the material of the cathode is almost as important as the anode, only platinum well coated with platinum black being satisfactory. These facts seem to be connected with the phenomena of electrode excess potential, some account of which is given by Lehfeldt.* No very satisfactory explanation, however, is given of the cause of this, and perhaps there is scope for further research on the subject. Meters have been tried in which a porous partition was interposed between the anode and cathode. This was formed of a layer of fine white sand, which always collected in the bend of the tube when the meter was set upright. Such meters gave very good results, but so far have not proved themselves superior to the others.

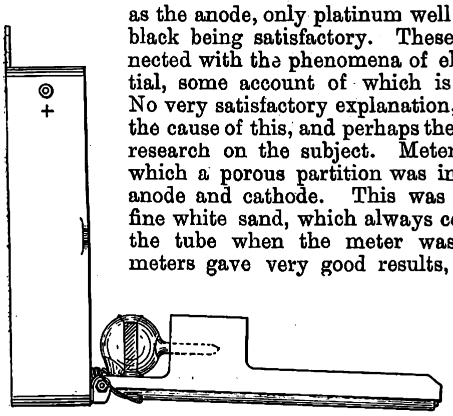

FIG. 5.

In one case an anode was tried so arranged that one side of the platinum sheet composing it was exposed to the solution and the other side to the gas. In this case the hydrogen would have to pass actually through the sheet to get to the electrolyte, instead of creeping over the surface as in the other meters. The behaviour of this meter, however, proved that practically no gas did get through, and it was useless.

Some experiments have been made of passing alternate currents through these meters. It is well known that the ordinary gas voltameter will evolve gas with alternating currents, but the amount produced is dependent very largely upon the current density and the frequency of alteration. So far as the experiments have gone, the same may be said to be true of the evolution of gas by alternating currents in this meter; and no novel feature in this respect has been noted.

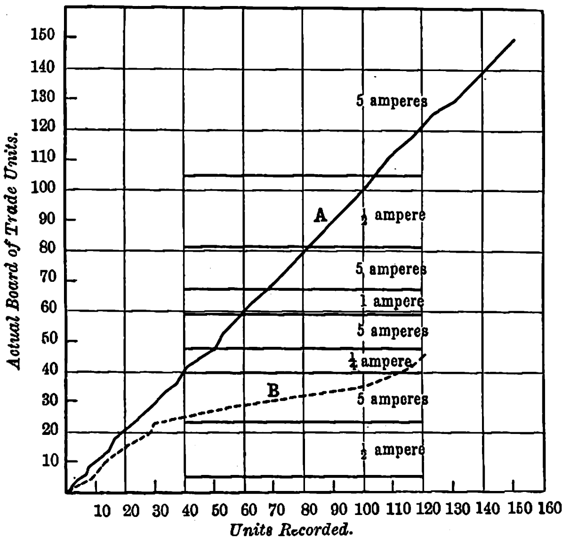

FIG. 6.

Fig. 4 is a front view of a complete meter with the case closed, and Fig. 5 a side view of the same meter, having the tube tilted forward for resetting to zero. An incidental advantage of the design chosen is that almost the entire height of the meter is available for the scale, there being very little lost space either above or below.

Fig. 6 shows curves taken over long runs, the electrolytic meters being tested against a motor meter, whose accuracy was checked for each load. The ordinates represent the actual ampere-hours passed through the meters and the abscissæ the amounts registered. The space is divided by horizontal lines showing the actual current passing. If the meters were perfect, each curve would be a straight line, and departure from this indicates that they are fast or slow for a particular strength of current. It will be seen that these meters are capable of giving very good results, as shown by curve A. In Fig 7 the curve is drawn in a more usual manner, the ordinates being percentage errors and the abscissæ current; the data were, however, obtained from long-time tests as the others. A curve of a bad meter (marked B) had been included with each for contrast, the difference being produced by the use of a polished cathode in the bad one.

Electrodes of platinum saturated with gas were employed in Grove's well-known "gas battery," which was a kind of storage cell; similar electrodes have also been employed by recent experimenters for the purpose of measuring differences of potential between metals and electrolytes. Some account of these uses may be found in Arrhenius* and in Lehfeldt's books on electro-chemistry, who give also references to original Papers. So far as the author is aware, however, no use has hitherto been made of an electrolytic process involving the continuous absorption and solution of gas at one electrode and its evolution at the other. As the process, therefore, seems to be novel, it is hoped that uses may be found for it in other directions besides electricity meters.

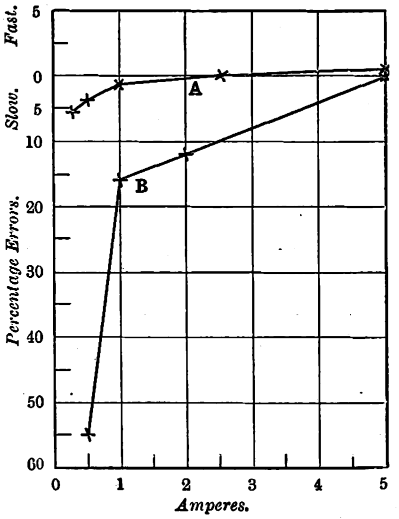

FIG. 7.

The author desires to express his indebtedness to Messrs. R. Prosser and W. S. Sprague, of Chamberlain & Hookham (Ltd.), for their skill and patience in preparing apparatus and making experiments; and to Dr. Findlay for suggestions and advice.

Experimental and final meters of each type were shown to the meeting by Mr. Holden, and their method of working demonstrated.

## DISCUSSION.

The **CHAIRMAN** (Mr. R. Threlfall) referred to Mr. Holden's discovery as being the first practical application, so far as his knowledge went, of Helmholtz's chemical investigations on the electrolysis of water and allied subjects (*Sitz.-ber. d. Akad. Wiss.*, Berlin, 1883 and 1887; and *Monatsberichte d. Berl. Akad.*, 1873, p. 584; *Pogg. Ann.*, 150, p. 483; *Phys. Soc.*, London, Physical Memoirs, Vol. I., part 1). Mr. Holden's invention was of peculiar elegance, and he trusted it would work as well in practice as it appeared to promise to do. He asked whether it might not be possible for the readings to be falsified if one limb was at a higher temperature than the other, for it appeared that in this case the concentration of the hydrogen solution would be different in the two limbs, and there might be a continuous solution of the free gas on the colder, and a corresponding evolution on the warmer side. He also asked whether there was not a temperature co-efficient of the resilience of the springs in the first form of meter described which might lead to temperature error.

Mr. R. A. **CHATTOCK** considered that the advantages claimed for the first meter, in comparison with other electrolytic meters, were rather over-estimated. The most important were that the materials used in its construction were strong, no glass being employed, and that it was a very simple matter to test the accuracy of the meter. He assumed that the drop of potential was about the same as in other spring-balance meters. The second meter was a very interesting departure, and would, he thought, prove successful in practice. Time was required to show how it would be affected by commercial usage. He would like to know if it was necessary to coat the electrodes with a certain definite quantity of platinum black. Did the electrodes remain for long periods without alteration, or was there any tendency, say, for the platinum black to peel off? What would be the effect of a short circuit on the meter? Would there be any liability for the tube to burst on account of the rapid evolution of gas?

Mr. **HOLDEN**, in reply, said that the points raised by the chairman and Mr. Chattock had had his attention. He had at first thought that hydrogen might be transferred on account of difference of pressure in the vertical tube and bulb. He had also experimented with a lamp in close proximity to the bulb, causing considerable difference of temperature.

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* "Electro-chemistry," Part I., by Dr. R. A. Lehfeldt, p. 176.

* "A Text-book of Electro-chemistry," by Svante Arrhenius, translated by Dr. J. McCrae.

There was no transfer of hydrogen due to either cause. He had also proved that there was no practical error in either meter due to change of temperature. There had been a slight error in the early meters of the first type due to the alteration in length of the springs, but by reducing the length of the springs he had entirely got rid of this error. An advantage of this meter not referred to by Mr. Chattock was that the use of a circular dial enabled a much longer scale to be used than in other types of electrolytic meters. He treated the platinum electrodes with a good thick coat of platinum black, but of no definite amount. So long as the platinum itself was entirely covered, the amount of platinum black did not affect the accuracy of the meter. He had now had meters running continuously for many months without showing any falling off in accuracy. As regards a short circuit he pointed out that the meters which he was exhibiting to the meeting were running with a current through the electrolyte of three hundred times the normal value. He was running them with the resistance short circuited in order that they might see the evolution of gas, which under ordinary circumstances was not easily detected. It was evident that no harm would be done by a short circuit.

## A SINGLE-PHASE MERCURY ARC RECTIFIER.

A considerable field of usefulness exists for a compact and reliable apparatus for converting alternating current into continuous on a small scale, especially for charging accumulators, and a new rectifier on the mercury arc system has recently been brought out by the British Thomson-Houston Co. to meet these requirements. The apparatus is particularly intended for charging electric automobiles in private garages, and consists of a switch panel shown in Fig. 1 upon which the tube is mounted in its holder, together with the necessary controlling switches and instruments, and a compensating reactance.

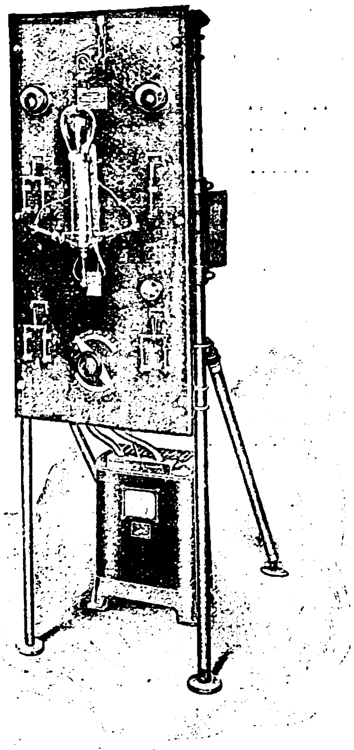

Fig. 1.—Front View of complete Panel.

The tube is an exhausted glass vessel containing two anodes, AA, one cathode, B, and one starting anode, C, as shown in Fig. 2. It is provided with metal caps for the terminals, which protect the electrodes, thus reducing to a minimum the liability to breakage and burn out. The leads from the anodes are connected to the compensating reactance; the lead from the cathode forms the positive side of the continuous-current circuit. The holder is mounted on the face of the panel and is provided with spring clips for holding the tube. By means of a single-pole, double-throw switch K (see Fig. 3) on the back of the board, the starting anode, C, may be connected to either the positive lead of the storage battery or to one of the A.-C. lines, according to the nature of the load. If the battery is used as a load, the switch K may be in either the A.-C. or D.-C. position, preferably D.-C.; but if the apparatus is not being used for battery charging the switch K is placed in the A.-C. position to obtain a starting arc. The compensating reactance is connected directly across the alternating-current supply mains and is divided into several steps. The leads from these several steps are brought out to the dial switch and connected to the brass buttons on the panel, according to the diagram. By means of the dial switch the volts and amperes may be varied within the range of the rectifier as desired. The function of the starting switch is to throw the rectifier on a resistance load on which the rectifier is to start. The function of the load switch is to transfer the rectified current from the resistance load to the storage battery or whatever may be used as load. A lamp is placed in multiple with the starting resistance. This lamp indicates whether the rectifier is operating on the resistance or on the storage battery. When the lamp is alight, the rectifier is on the resistance; when dark, on the battery only. An ammeter and a voltmeter are also provided. The apparatus is made for currents up to 30 amperes and an efficiency of 80 per cent. is claimed under favourable circumstances.

This form of rectifier will be furnished for any commercial alternating-current voltage. The standard outfits are, however, designed for operation on either 110 or 220 volt, 50 cycle, alternating-current circuits. It has been found that for batteries requiring a range of voltage from 45 to 115 volts continuous current, approximately 220 volts alternating current, will give the best results; while for smaller batteries requiring a range from 16 to 45 volts continuous current, approximately 110 volts alternating current is most satisfactory. The continuous-current voltage may be said to range from, approximately, 20 to 55 per cent. of the applied alternating supply, according to the connections used; while the alternating current, under similar conditions, is from 40 to 65 per cent. of the delivered continuous current.

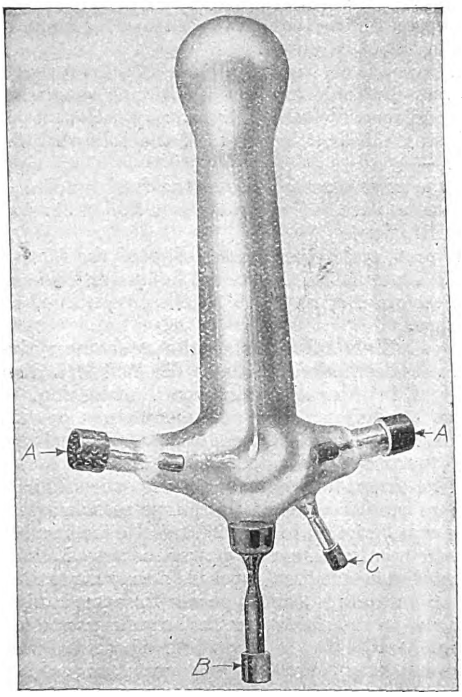

Fig. 2.—Mercury Arc Rectifier Tube.

The starting of the rectifier is effected in the following manner. The circuit breaker, A.-C. line switch, D.-C. and starting switches are closed and the tube slightly shaken. This will cause a mercury bridge to be formed and broken between the starting anode C and the cathode B. This in turn causes a slight flash and the rectifier will start, lighting the pilot lamp. A single flash should be sufficient to start the tube, but in cold weather more may be necessary. In cold weather the starting switch should be left in for at least 30 seconds before the load switch is thrown in, so that the tube may become warmed, thus preventing a sudden change of temperature, which is liable to crack the glass The load switch is then closed. If the battery voltage is higher than the rectifier voltage, the tube will cease to operate; if such is the case the load switches should be opened and the dial switch raised one step, after which the same operation should be repeated until the battery load can be held or until sufficient current is obtained, when the load switch should be left closed and the starting switch opened—the pilot lamp will then be dark.

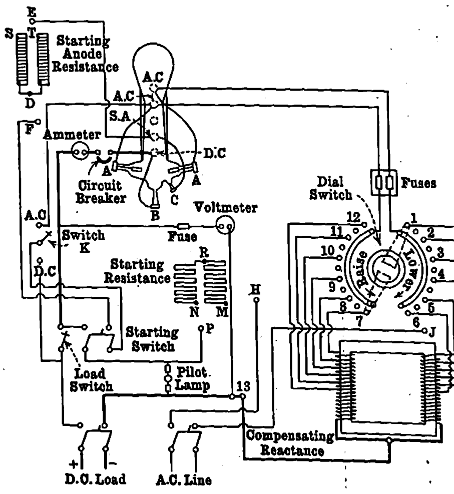

Fig. 3.—Diagram of Connections.

## STREET LIGHTING.*

BY HAYDN T. HARRISON.

(*Concluded from page 352.*)

The remainder of my Paper I propose to give up to discussing the possibilities of improving the existing state of affairs without increasing the cost in any way, and the only unit I propose to consider is the minimum illumination derived at any point. It is now several years since I came to the conclusion that the efficiency of street lighting must be judged by the minimum illumination derived at any point, and I devised fittings to increase the light at that point. The most efficient of these is now being manufactured by the Reason Mfg. Co. of Brighton.

These fittings are arranged in many different forms to suit special positions, but the most efficient is the one which is intended for straight roads, for which the bulk are requred.

In designing these fittings I took the following facts into consideration :—

1. That the rays directed above the horizontal are useless, and therefore can be diverted up and down the street to increase the distant illumination.

2. If the posts are erected on the edge of the footpaths, the rays which would illuminate the adjacent houses or fields are practically useless, unless the houses have a reflecting value, which is very rarely the case.

3. The rays of light illuminating the street near the post should be of small value compared to those directed to a distance up and down the street, in order to obtain even illumination.

The above conditions, in short, mean that practically only a quarter of the mean spherical candle-power is useful, and that the other three-quarters are wasted unless directed into the required direction. The extent to which this fitting succeeds is as follows :—

The average candle-power of the lamps measured from all parts of the street will be found to be 2·2 times the mean spherical candle-power, and the maximum candle-power measured over the width of the road some distance from the post is nearly three times the mean spherical, the minimum candle-power measured adjacent to the post being equal to the mean spherical candle-power of the lamps.

One-half of the filaments or glowers of each of these lamps is enclosed in a specially-shaped hollow hemispherical reflector, fixed at such vertical and horizontal angles that in those positions (as viewed from the street), where the reflectors are not in themselves increasing the illuminating value of the lamps to more than double the maximum of one lamp, the light of both lamps is allowed to shine. Thus at no point does it decrease the light, and over the greatest area of the street the light is increased to the maximum above stated.

These reflectors are of glass blown on to a mould of the correct shape, and in such a way as to form a bottle, the inside of which is silvered; the opening is then hermetically sealed when fixing the cap; thus a reflector of about 88 per cent. efficiency is obtained —which efficiency is practically permanent. In the reflector the whole of the hemispherical rays are deflected, whereas in previous designs in which the lamp passed through a hole in the centre of the reflector, a great number of these rays were not utilised. Another point is that the lamps are in such a position that the maximum rays are used both in illuminating the distant parts of the street direct, *and* by means of the reflector.

The table below gives the average multiplying power of the author's reflector fitting as made by the Reason Mfg. Co., the unit of light being taken as the mean spherical candle-power of the two lamps used in the fitting, the angles at which this factor is given being the useful angles for street lighting, and 0 deg. horizontal coinciding with the kerb of the pavement.

| Vertical angle. | Horizontal angles. | Mutiplying factor. |
|---|---|---|
| 30° (from horizontal) | 90° (across street) | 1·05 |
| 30° Do. | 70° Do. | 1·5 |
| 15° Do. | 50° Do. | 2·3 |
| 15° Do. | 30° Do. | 3·0 |
| 15° Do. | 10° Do. | 3·0 |
| 15° Do. | 0 (kerb line) | 3·0 |
| 15° Do. | 10 (house side) | 1·6 |
| 30 Do. | 30 Do. | 0·85 |
| 30 Do. | 50 Do. | 0·6 |

NOTE.—It will be seen by above table that, provided the lamps are adjusted correctly in the reflectors, the increase of street illumination derived by the use of the reflector fittings will be much higher than claimed, but taking into consideration extra globes, &c., the maximum multiplying factor can be taken as 2·5.

These fittings are free from what is sometimes called "the bull's eye" effect, as the maximum rays are not concentrated into anywhere near a parallel beam, but are spread over an angle of 20 deg., and rays equal to twice the mean spherical candle-power of the two lamps are spread over an angle of 40 deg., which is generally the whole width of the road at a distance equal to twice the height of the post.

In order to ascertain the type of lamp to use for the purpose when basing calculations on minimum illumination it is necessary to know the candle-power derived from the lamps at an angle of about 20 to 30 degs. below the horizontal, and about 10 degs. on the path side, and 30 degs. on the road side, of an imaginary line drawn parallel to the kerb; this is, of course, for posts erected on either side of the road, which is the present-day practice. For lamps giving an equal candle-power at all parts of the lower hemisphere, this figure will, of course, be the same as the mean hemispherical candle-power; but for lamps such as arc lamps, gas mantles, various types of Nernst lamps, and special reflector fittings, it must be taken from actual measurements made at the various angles.

The following table is based on the average of a large number of measurements made in the street under working conditions. Average mean candle-power of lamps 20 to 30 deg. below horizontal, and 10 deg. one side and 30 deg. the other side of line drawn parallel to the street :—

| Electric lamps. | Watts consum'd per hour. | Candle-power at angles stated. |
|---|---|---|
| 1. Flame type .................... | 400 | 1,300 |
| 2. Open-type arc .................. | 500 | 500 |
| 3. Enclosed arc .................. | 1,000 | 1,100 |
| 4. Do. .................. | 600 | 550 |
| 5. Reason fitting incandescent lamps | 200 | 120 |
| 6. Do. do. | 120 | 70 |
| 7. Do. do. | 60 | 30 |
| 8. Reason fitting tantalum lamps .. | 70 | 110 |
| 9. Nernst lamps, "A" type ........ | 100—120 | 40 |
| 10. Nernst lamps, "B" type ........ | 50— 60 | 15 |
| **Gas lamps.** | **Gas consumed per hour.** | **Candle-power at angles stated.** |
| 11. High-pressure mantles .......... | 30 c.f. | 515 |
| 12. Do. do. .......... | 20 c.f. | 215 |
| 13. Intensified gas, 2 mantles (City) .. | 7·5 | 130 |
| 14. 2 low-pressure gas mantles ...... | 7·5 | 75 |
| 15. 1 low-pressure gas mantle ...... | 3·75 | 37 |

In order to ascertain the gas consumption of the high-pressure mantles, Nos. 11 and 12, and of the intensified mantle, No. 13, I have had to go by the figures in the gas journals, in which No. 1 is generally stated at 1,000 c.p., giving 30 candles per cubic foot, and No. 2 as 600 c.p. of the same consumption. The candle-powers given are the average of a large number of measurements I have made, which agree very closely with measurements made by others. But I would particularly call attention to class 13, which is scheduled under intensified gas, and appears unduly high. In my opinion this is due to the mantles being renewed at more frequent intervals as it is based on measurements made in Fleet-street, which, it must be borne in mind, is what may be called, without prejudice, a test case.

It is now comparatively easy to set down the numbers of posts and fittings per mile necessary to obtain the minimum illumination generally provided for various classes of streets, but in order to facilitate this process it is well to have before you a further table, showing the direct illumination derived at various distances from a lamp giving 1 c.p. at that point; with this it is only necessary to find the figure which, when multiplied by the various candle-

*Distance apart of Lamps of Various Types to give required Minimum Illumination.*

| Type of lamp. | Main thoroughfares. Min., 0·05 c.p.f. | | Side streets. 0·025 c.p.f. | | Suburban streets. 0·005 c.p.f. | |
|---|---|---|---|---|---|---|
| | Distance apart. Ft. | Posts per 1,000 yds | Distance apart. Ft. | Posts per 1,000 yds | Distn'e apart. Ft. | Posts per 1,000 yds |
| 1. Electric flame | 300 | 10 | .. | .. | .. | .. |
| 2. Open arc .... | 200 | 15 | .. | .. | .. | .. |
| 3. Enclosed arc . | 300 | 10 | .. | .. | .. | .. |
| 4. Do. | 200 | 15 | 300 | 10 | .. | .. |
| 5. Reason fitting | 100 | 30 | 140 | 21 | 300 | 10 |
| 6. Do. | 70 | 43 | 100 | 30 | 250 | 13 |
| 7. Do. | 45 | 66 | 65 | 46 | 150 | 20 |
| 8. Do. | 90 | 33 | 130 | 23 | 290 | 10 |
| 9. Nernst lamp . | 55 | 54 | 75 | 40 | 180 | 17 |
| 10. Do. | .. | .. | 45 | 67 | 110 | 27 |
| Gas lamps. | | | | | | |
| 11. High pressure | 200 | 15 | 300 | 10 | .. | .. |
| 12. Do. | 120 | 25 | 180 | 17 | .. | .. |
| 13. Intensified .. | 100 | 30 | 140 | 21 | .. | .. |
| 14. Ordinary .... | 75 | 40 | 105 | 28 | 240 | 12 |
| 15. Do. | 50 | 60 | 75 | 40 | 170 | 17 |

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* Abstract of a Paper read on Tuesday, December 12th, before the Manchester Local Section of the Institution of Electrical Engineers.

powers, gives the required illumination, and then by turning to the distance column and multiplying it by two the resulting figure will be the distance separating the posts.

A statement worked out in this way will be found in the preceding ing table, the reference numbers relating to the lamps being the same as above.

It must be quite understood that the above table is only approximate, and that it and the following table, of which it forms a factor, are therefore simply for comparative purposes.

From the above table is is easy to calculate the quantity of electrical energy and gas consumed for illuminating 1,000 yds. of streets, up to the various standards necessary with the illuminants at one's disposal; and if electrical energy be taken at 1½d. per Board of Trade unit, and gas at 2s. per 1,000 cubic ft., a very useful table of comparative costs is arrived at. In order to make this approximately annual cost, I have taken the burning hours at 4,000; the results are given in the following table :—

| No. of system. | Electric. | Main street. | | Side street. | | | Suburban street. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Units. | £ | s. | Units. | £ | s. | Units. | £ | s. |
| 1 | 16,000 | 100 | 0 | .. | .. | | .. | .. | |
| 2 | 30,000 | 187 | 10 | .. | .. | | .. | .. | |
| 3 | 40,000 | 250 | 0 | .. | .. | | .. | .. | |
| 4 | 36,000 | 225 | 0 | 24,000 | 150 | 0 | .. | .. | |
| 5 | 24,000 | 150 | 0 | 16,800 | 105 | 5 | 8,000 | 50 | 0 |
| 6 | 20,640 | 129 | 5 | 14,400 | 90 | 0 | 6,240 | 38 | 11 |
| 7 | 15,800 | 98 | 15 | 11,000 | 68 | 15 | 4,800 | 30 | 0 |
| 8 | 9,000 | 56 | 5 | 6,440 | 40 | 5 | 2,800 | 17 | 10 |
| 9 | 24,000 | 150 | 0 | 18,000 | 112 | 10 | 7,480 | 46 | 15 |
| 10 | .. | .. | | 10,000 | 93 | 15 | 6,000 | 37 | 10 |
| | Gas. 1,000 c.f. | | | Gas, 1,000 cf. | | | Gas. 1,000 c.f. | | |
| 11 | 1,800 | 180 | 0 | 1,200 | 120 | 0 | .. | .. | |
| 12 | 2,000 | 200 | 0 | 1,360 | 136 | 0 | .. | .. | |
| 13 | 900 | 90 | 0 | 630 | 63 | 0 | .. | .. | |
| 14 | 1,200 | 120 | 0 | 840 | 84 | 0 | 360 | 36 | 0 |
| 15 | 900 | 90 | 0 | 600 | 60 | 0 | 255 | 25 | 10 |

I will now pass on to the next detail—namely, the cost of maintenance of the various types of lamps. This, again, I have gathered from various sources, but as the interest and sinking fund on mains and services is very rarely charged to the street lighting, I propose to leave out this item for the present; on the other hand, I include interest and sinking fund on all apparatus proper, including the posts. It has been difficult to obtain any reliable information regarding high-pressure gas lamps, but I have included an average of that which I have been able to obtain.

*Maintenance Charges, Including Renewals, Cleaning, Lighting and Extinguishing, Interest and Sinking Fund, but Excluding Cost of Electrical Energy and Gas. Extended Over a Period of 4,000 hours.*

| | | | |
|---|---|---|---|
| 1. | Electric flame arc (long burning) | £9 | 0 |
| 2. | ,, open arc | 9 | 0 |
| 3. | ,, enclosed arc | 4 | 10 |
| 4. | ,, ,, | 4 | 0 |
| 5. | ,, Reason fitting | 1 | 0 |
| 6. | ,, ,, | 1 | 0 |
| 7. | ,, ,, | 1 | 0 |
| 8. | ,, Reason Tantalum lamps | 2 | 15 |
| 9. | ,, Nernst lamps | 1 | 2 |
| 10. | ,, ,, | 1 | 2 |
| 11. | Gas high-pressure mantles | 7 | 0 |
| 12. | ,, ,, | 5 | 10 |
| 13. | ,, intensified | 2 | 5 |
| 14. | ,, two low-pressure mantles | 1 | 15 |
| 15. | ,, one low-pressure mantle | 1 | 10 |

If the above costs be added to those in the previous table, we get the following, which will give the average total cost per annum for all-night lighting of 1,000 yds. of streets, under the various requirements and conditions of lighting :—

*Total Cost per annum (4,000 hours) per 1,000 yds. of Street.*

MAIN STREETS.

*Electric—*

| Sy'm. | Supply. | | | Maintenance. | | | Total. | |
|---|---|---|---|---|---|---|---|---|
| | £. | s. | | £. | s. | | £. | s. |
| 1. | 100 | 0 | .. | 90 | 0 | .. | 190 | 0 |
| 2. | 187 | 10 | .. | 135 | 0 | .. | 322 | 10 |
| 3. | 250 | 0 | .. | 45 | 0 | .. | 295 | 0 |
| 4. | 225 | 0 | .. | 60 | 0 | .. | 285 | 0 |
| 5. | 150 | 0 | .. | 25 | 0 | .. | 175 | 0 |
| 6. | 129 | 5 | .. | 43 | 0 | .. | 172 | 5 |
| 7. | 98 | 15 | .. | 66 | 0 | .. | 164 | 15 |
| 8. | 56 | 5 | .. | 100 | 15 | .. | 157 | 0 |
| 9. | 150 | 0 | .. | 59 | 8 | .. | 209 | 8 |
| 10. | — | | .. | — | | .. | — | |
| *Gas—* | | | | | | | | |
| 11. | 180 | 0 | .. | 105 | 0 | .. | 285 | 0 |
| 12. | 200 | 0 | .. | 137 | 10 | .. | 337 | 10 |
| 13. | 180 | 0 | .. | 67 | 10 | .. | 247 | 10 |
| 14. | 120 | 0 | .. | 70 | 0 | .. | 190 | 0 |
| 15. | 90 | 0 | .. | 90 | 0 | .. | 180 | 0 |

SIDE STREETS.

*Electric—*

| Sy'm. | Supply. | | | Maintenance. | | | Total. | |
|---|---|---|---|---|---|---|---|---|
| | £. | s. | | £. | s. | | £. | s. |
| 1. | — | | .. | — | | .. | — | |
| 2. | — | | .. | — | | .. | — | |
| 3. | — | | .. | — | | .. | — | |
| 4. | 150 | 0 | .. | 40 | 0 | .. | 190 | 0 |
| 5. | 106 | 5 | .. | 21 | 0 | .. | 127 | 5 |
| 6. | 90 | 0 | .. | 30 | 0 | .. | 120 | 0 |
| 7. | 62 | 15 | .. | 46 | 0 | .. | 108 | 15 |
| 8. | 40 | 5 | .. | 63 | 0 | .. | 103 | 5 |
| 9. | 112 | 10 | .. | 44 | 0 | .. | 156 | 10 |
| 10. | 93 | 15 | .. | 50 | 12 | .. | 144 | 7 |
| *Gas—* | | | | | | | | |
| 11. | 120 | 0 | .. | 70 | 0 | .. | 190 | 0 |
| 12. | 172 | 0 | .. | 93 | 0 | .. | 265 | 10 |
| 13. | 63 | 0 | .. | 47 | 5 | .. | 110 | 5 |
| 14. | 84 | 0 | .. | 49 | 0 | .. | 133 | 0 |
| 15. | 60 | 0 | .. | 60 | 0 | .. | 120 | 0 |

SUBURBAN STREETS.

*Electric—*

| System. | Supply. | | | Maintenance. | | | Total. | | |
|---|---|---|---|---|---|---|---|---|---|
| 5 | £50 | 0 | 0 | £10 | 0 | 0 | £60 | 0 | 0 |
| 6 | 39 | 10 | 0 | 13 | 0 | 0 | 52 | 10 | 0 |
| 7 | 30 | 0 | 0 | 20 | 0 | 0 | 50 | 0 | 0 |
| 8 | 17 | 10 | 0 | 27 | 10 | 0 | 45 | 0 | 0 |
| 9 | 46 | 15 | 0 | 18 | 14 | 0 | 65 | 9 | 0 |
| 10 | 37 | 10 | 0 | 29 | 14 | 0 | 67 | 4 | 0 |
| *Gas—* | | | | | | | | | |
| 14 | 36 | 0 | 0 | 21 | 0 | 0 | 57 | 0 | 0 |
| 15 | 25 | 10 | 0 | 25 | 10 | 0 | 51 | 0 | 0 |

The foregoing tables demonstrate several interesting points, the importance of which, I consider, cannot be over-rated. They are as follows :—

1. The use of large units of light for general street illumination is expensive, and should be avoided where possible.

2. The cost of maintenance is very often as high, if not higher, than the cost of electrical energy or gas; it must be borne in mind that in the table electrical energy is taken at 1½d. per unit—it is very often less than this for street lighting, in which case the cost of maintenance becomes a still more important factor.

In calculating the cost of electrical energy when using carbon incandescent lamps, I have taken the lamps as consuming 4 watts per candle-power—which is reduced to 2 watts per candle-power, or even less, by the Reason fitting; but, even if no special fitting had been used, four 10 c.p. lamps consuming 160 watts are, when placed at 20 ft. apart, better than 160 c.p. lamps spaced at 80 ft., as the ratio of minimum illumination derived is 16 to 1, whereas the efficiency of the lamps is only 4 to 1.

Before concluding, I should like to give my opinion of the directions in which I believe improvements are likely to be made with existing electric lamps and apparatus for the particular purpose under consideration; these are :—

1. Improvements in the methods of connecting and controlling electric lamps.
2. Reduction in maintenance costs.
3. Correct disposition of lamps and choice of suitable fittings, &c.

Improvement No. 1 is probably the one which should be and must be dealt with when street lighting installations are being originated. It is by far too common a practice to connect street lighting across the ordinary distributors in the same way as gas lamps are connected to the existing gas mains. In the case of gas lamps, nothing could be gained by adding to the usual mains, as it is essential that each lamp should be lighted individually, without any complicated or wasteful ignition apparatus being used. With electric lamps quite another condition of affairs exists. A saving of at least 6s. per post, which sometimes amounts to 15s. per annum, can be made by using a separate network, and if this street lighting network is laid on a suitably-designed basis—such as that used by Mr. Wilkinson, of Harrogate—a considerable saving results.

Mr. Wilkinson has kindly given me particulars of the system of street lighting mains which he has recommended for Harrogate; briefly described, it consists of laying unarmoured cables in gas barrel situated underneath the flags or paving adjacent to the kerbstones. Not only does this system dispense with the cost of excavating, but also has the advantage that the pipes and mains are in a fairly dry and accessible place, and can be laid without causing street obstruction. For the purpose of comparison I have drawn up the table below giving the approximate cost of mains and services for 1,000 yds. of street providing for 38 posts placed on one side of the road only; you will notice that I have given both series and parallel systems of connecting the lamps for reasons I will describe later.

| System. | Cost per 1,000yds. | Interest and sinking fund at 6 per cent. | Interest and sinking fund per post. |
|---|---|---|---|
| Twin lead-covered armoured .... | £300 | £18 0 | say 9s. 6d. |
| Single ,, series ........ | 200 | 12 0 | 6s. 3d. |
| Wilkinson system parallel ...... | 100 | 6 0 | 3s. 2d. |
| ,, ,, series ........ | 75 | 4 10 | 2s. 7d. |
| Connecting to existing distributor | 40 | 2 8 | 1s. 3d. |

NOTE.—In the series system it is taken for granted that the street mains are connected to a distributor or feeder at each end of the street. From the above table it will be seen that, provided a suitable system of mains is used, the sinking fund will in no way approach the cost of separate switching, which point combined with the advantages of central control, tends to the conclusion, in my mind, that a separate network should be put down where possible.

The highly efficient incandescent types of lamps which are now being put on the market, such as Tantalum and Osmium, are much more suited for low voltage than high; in fact, the high prime cost and reduced lasting powers of these lamps is largely due to the attempts the makers have made (by reducing the sectional area and increasing the lengths of the filaments) to adapt them to the existing pressures of supply undertakings. These lamps, provided their lasting properties are improved, are eminently suited for street lighting, on account of their high efficiency and steady light-giving power.

I have therefore lately been experimenting with these lamps connected in series with most gratifying results, and trust shortly to be able to recommend the supply of these lamps for street lighting purposes. They will be low voltage (10 to 30), with thick filaments, intended to be run in series throughout the street, controlled at the end of each series by a magnetic relay switch connected to the previous series, in a similar manner to that used for arc lighting by Mr. Robinson, of Hackney, and others. A very simple cut-out prevents a fault in any lamp extinguishing the series. I will give an example showing the cost of installation, maintenance, and supply of energy for lighting 1,000 yds. of street on this principle.

Taking the average side street requiring a minimum illumination of 0·025 c p. ft. Using lamps giving a maximum of 40 c.p. in the required direction, 38 posts and lanterns would be necessary. If each of these is fitted with two Osmium lamps giving 10 c.p. each they will, with Reason reflectors, provide the necessary candle-power.

With a 440-volt distribution, the two lamps in each lantern would be connected in parallel, the posts being connected in series, 11-volt lamps would, therefore, be suitable.

The diminution of candle-power with the Osmium lamp is so small that 2,000 hours' burning per lamp should be satisfactory. The following estimate is, therefore, probably correct:—

Capital Charges.—Mains and services, £75; 38 posts erected, £57; 38 lanterns and reflectors, £45; relay switch and cut-outs, &c., £23; total, £200.

Running Charges (per 4,000 hours).—Interest and sinking fund on above at 6 per cent., £12; 152 lamps at 3s., £22 16s.; cleaning, &c., at 3s. per post, £5 14s.; 4,000 units at 1½d. per unit, £25; total annual cost, £65 10s.; total annual cost per post, £1 14s. 6d.

These figures show that even when including interest and sinking fund on all materials and mains, street lighting can be carried out at a profit by means of electricity at a price far below the average charge for gas when giving the same result as regards illumination. Moreover, this system of connecting and control is the best method of embodying improvement No. 2, as it permits of further economies, such as reduction of burning hours, dispensing with the lamps or some of them on moonlight nights. The erection of new posts makes it possible to space the lamps at the correct distance for the class of street which is to be lighted and the type of lamp to be used. I have taken 10 c.p. 11-volt lamps in the example, but it is quite conceivable that, say, 15 or 20 c.p. lamps would result in a further saving if the lamp renewals are to cost 3s. or more, though, of course, the diversity factor would be increased.

The author, in conclusion, wishes to record his indebtedness to the various gentlemen who have so kindly assisted him from time to time by sending him particulars of the street lighting under their control. Also to Mr. Kent, of Croydon, and Mr. Fairey, of Finchley, for assisting him when making photometric measurements in the streets, and finally to Mr. Haydon, of Faraday House, who has done much of the tabulating and similar work which has been necessary in order to lay before you the various figures of comparison.

## THE OERLIKON 200 H.P. TRACTION MOTOR WITH AUXILIARY POLES.

In a recent issue of the *Schweizerische Elektrotechnische Zeitschrift*, Dr. H. Behn-Eschenburg describes a new type of traction motor by the Oerlikon Co. The motor in question is capable of developing 200 h.p. at the one hour's rating at about 400 revs. per min. It is designed for a voltage of 700 to 800 volts. Figs. 1, 2 and 3 illustrate the details of construction, while Figs. 4 and 5 show some characteristic curves of the motor. In order to obtain a good mechanical design and to avoid binding wires, which are not always satisfactory, the armature bars are embedded in holes and not in slots, as is usually the case. These holes extend over the whole effective length of the armature, but at the ends of the armature core slots take the place of the holes, as indicated in Figs. 1 and 3.

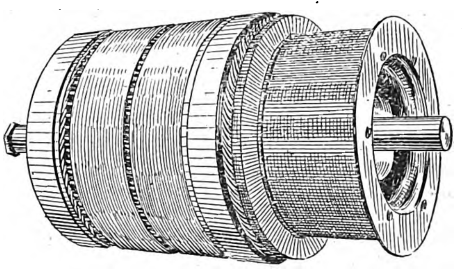

Fig. 1.—Armature of Oerlikon 200 h.p. Traction Motor.

The number of armature bars is 518, and the commutator has 259 segments, each 5 mm. (0·197 in.) wide. Auxiliary poles are provided in the manner indicated in the illustrations, and it is said that the motor operates sparklessly when fed with 300 amperes at voltages up to 800 volts and speeds ranging from 0 to 1,000 revs. per min. The motor speed can be varied, as indicated in the footline to Fig. 4, by cutting out one or two field coils, and it is stated that

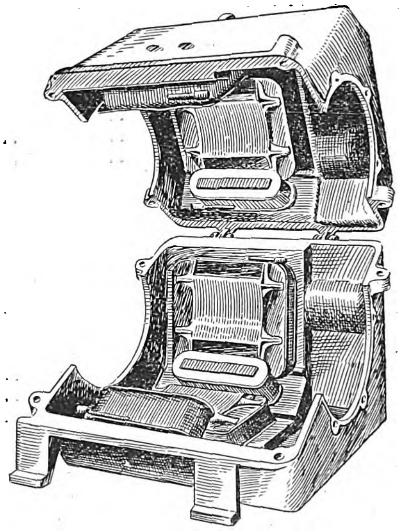

Fig. 2.—Oerlikon 200 h.p. Traction Motor with Auxiliary Poles.

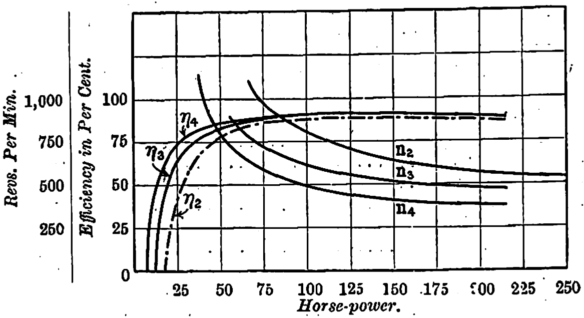

Fig. 4.—Speed and Efficiency Curves of Oerlikon 200 h.p. Traction Motor.

Curves $n_4$ and $\eta_4$ represent the efficiency and speed respectively when all four field coils of the motor are energised.

Curves $n_3$ and $\eta_3$ represent the speed and efficiency when three field coils of the motor are energised.

Curves $n_2$ and $\eta_2$ represent the speed and efficiency when two field coils of the motor are energised.

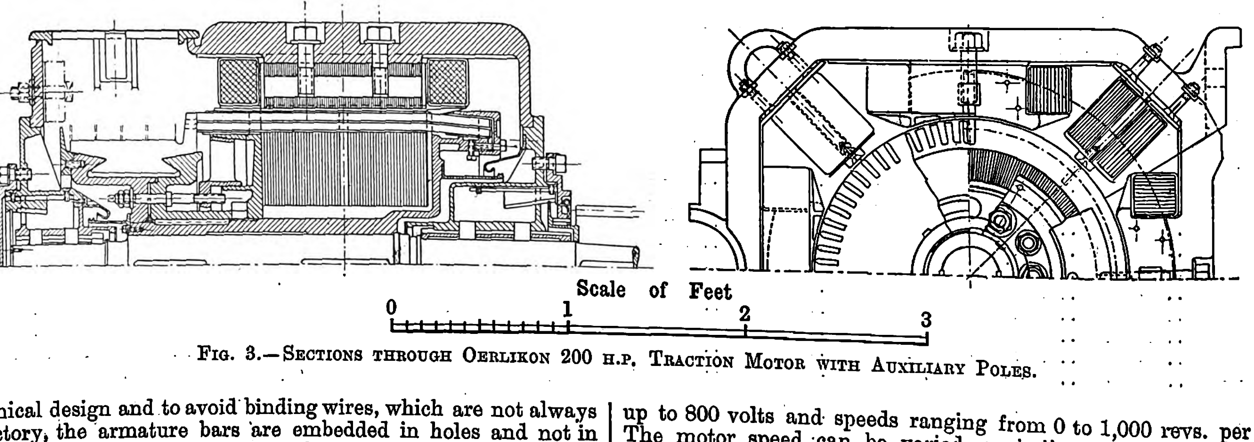

Fig. 3.—Sections through Oerlikon 200 h.p. Traction Motor with Auxiliary Poles.

such cutting out of field coils does not affect the commutation. Both field and auxiliary poles are wound with copper strip, the different turns being insulated with presspahn. The motor weighs 7,720 lb.

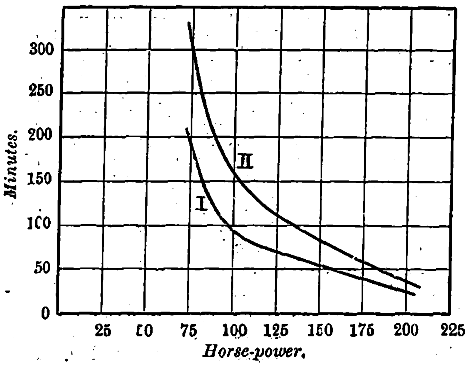

FIG. 5.—TEMPERATURE CURVES OF OERLIKON 200 H.P. TRACTION MOTOR.

Curve I. corresponds to a maximum temperature rise of 50°C.
„ II. „ „ „ „ „ 70°C.

## CONFERENCE ON SMOKE ABATEMENT.

As briefly mentioned in our last issue, a conference and exhibition on Smoke Abatement was opened on Tuesday last, December 12th, at the Royal Horticultural Society's Hall, Vincent-square, Westminster, and was continued throughout the following two days. Sir Oliver Lodge, D.Sc., LL.D., F.R.S., was President of the conference. We give below a general report of the proceedings.

*Tuesday, December 12th.*

Sir Oliver Lodge, F.R.S., who was unfortunately slightly indisposed and unable to travel to London, sent some notes on his address, "The General Problem of Combustion Reform." These notes were read by Sir William Richmond, R.A., who introduced the subject by a few remarks on the lamentable effects of smoke on works of art, architecture, &c., instancing in particular the damage which is being done to the fabric of St. Paul's.

Sir Oliver Lodge's address commenced by pointing out how very appropriate it was that the Conference should have been held under the joint auspices of the Royal Sanitary Institute and the Coal Smoke Abatement Society, for nothing could be more insanitary in the long run than the sun-obscuring atmosphere in which we artificially arrange to live. Coal smoke contains many other products besides coal tar, asphalt, manures, &c.; it contains sulphurous acid, an ingredient of most noxious character, which speedily becomes oxidised into oil of vitriol. Assuming that people are awake to the evil, the problem is to find a remedy. One remedy that has been suggested is the electrification of the air on a large scale, a plan which Sir Oliver has himself brought within measurable distance of application. He believed this to be the appropriate method of dealing with river and sea mists and in general with fogs of a non-avoidable kind, but it would need considerable capital expenditure to try it on a large scale. The right way, however, of dealing with a town fog was to refrain from producing it—that is to say, not to permit imperfect combustion in large cities, but only combustion planned and executed in such a way that no half-burned products shall escape; and likewise to insist that the material burned shall attain a moderate average of purity, the amount of sulphur especially being kept down.

The scientific and satisfactory combustion of crude coal as it is dug out of the pits, Sir Oliver continued, was an impossibility. Its solid and gaseous constituents should be first separated from one another. The solid constituents in the form of coke were of value for smelting and manufacturing operations, but it was this portion which contained the ash and dirt. The processes involving the use of solid fuel should not, in his opinion, be carried on in a big city, but should group themselves round a coalfield, so that the cost of carriage might be small. The gaseous product, on the other hand, readily lent itself to purification and chemical treatment, and could then be easily transmitted to any distance and there burned in a scientific and proper manner.

Another scientific method of dealing with coal was to turn almost the whole of it into gas—*i.e.*, all except the ash by judicious supply of air and steam. Gas of this kind, such as "producer gas," could be made very cheaply. There were advantages and disadvantages in every plan that had been suggested, but there was not one plan for the combustion of gas that did not far eclipse the uncivilised and essentially savage method of heaping a pile of crude coal together and setting a light to it.

After calling attention to the elaborate series of operations entailed in obtaining coal from a pit and burning it in a city, and the greater simplicity of the process of the production, distribution and burning of gas on a large scale, Sir Oliver pointed out how much of the prejudice against "gas-fires" was due to the very unsuitable conditions under which the gas was usually burnt. An important condition for complete combustion was that there must be no cold surfaces to interfere with the ignition. Gas must be raised to a certain temperature before it would ignite. In many domestic grates there was far too much iron. By rights there ought to be nothing but non-conducting material within reach of the flame, otherwise the portion of the flame in contact with the good conductor was necessarily extinguished, and much of the material escaped unburned. Because the products which escaped up the chimney were invisible, it did not follow that there had been complete combustion. The avoidance of cold surfaces in open fire places and stoves should not present great difficulty, but in the firing of boilers the introduction of cool surfaces into the flame seemed almost unavoidable, and it was to be hoped that gas engines would gradually replace steam engines and enable us to dispense with the primitive and unsatisfactory arrangement of obtaining power by the boiling of water. Even supposing that all the heat generated was absorbed by the boiler, the escape of unburned material already mentioned, and the drop of temperature between the furnace and the boiler would still account for a great loss of available energy for which there was nothing whatever to show.

Another condition for complete combustion was the adequate supply of air unmixed with carbonic acid or other material. In boiler furnaces, however, there was this difficulty, that if too much air was introduced, combustion was too perfect and the flame had insufficient radiating power. The only way in which heat could be conveyed from a flame to a cool surface was by radiation. It was impossible to bring a flame into contact with a cool surface, as it became extinguished where it touched and a layer of non-conducting gas intervened, across which the heat could only pass by radiation. Accordingly a luminous and somewhat smoky flame was necessary in a boiler furnace unless the walls of the boiler were so thick or so covered with studs that the surface exposed to the flame might become red hot and above the temperature of ignition. The combustion must, therefore, be completed by air introduced beyond the boiler and before the smoke stack.

A Paper was then read by Dr. W. N. Shaw, F.R.S., on "**Is London Fog Inevitable.**"

The following is an abstract:—

The consideration of this question has an important bearing upon the practical question of the abatement of coal smoke. There is nothing physically impossible in the idea of dispensing with coal smoke. To find a substitute for our accustomed methods of warming and cooking may be difficult, but is not impossible. But there may be some who are of opinion that if there are to be fogs in any case, the effort necessary to keep them clean is not worth the trouble and expense, and a review of certain facts which bear upon the question may be of some assistance. Mr. Brodie, of the Meteorological Office, in a Paper read before the Royal Meteorological Society, has given statistics to show that there has been in late years a decline in the frequency of fog in London. An investigation was made a few years ago on behalf of the Meteorological Council, with the assistance of the London County Council, by Capt. Carpenter and Mr. Lempfert. They came to the conclusion that in the winter London was never free from a smoke haze, and that many light fogs may be attributed to smoke alone. To form an estimate of what would be left if the smoke could be disposed of, we have to determine the cause of the formation and of the persistence of fog. The most frequent cause is the cooling of the surface by radiation under a clear sky. As the air gets cooled by contact with the cold surface it flows gradually downward. Fog will form in the descending air if it becomes cold enough to go below the dew point. If the ground has been saturated with rain before the cooling began the dew point will be high and the formation of fog is all the more certain. Out of the 39 cases dealt with in the winter of 1902-3 Mr. Lempfert assigns 24 to the effect of radiation of the kind mentioned, three to the slow passage during a change of weather of warm air over the surface which had been previously chilled, and four to the formation of cloud above the surface; eight he considered as consisting practically of smoke and nothing else. Thus if the figures for that particular winter can be accepted as a guide, the Smoke Abatement Society has about 20 per cent. of London fogs to deal with absolutely, as the lawyers say. The remainder depend upon physical processes which are not within our control.

*Wednesday, December 13th.*

The day was chiefly devoted to "Domestic Smoke Abatement," but among the Papers submitted were the following:—

### A RECORD OF THE WORK OF THE LEEDS SMOKE ABATEMENT SOCIETY.*

BY PROF. J. B. COHEN, PH.D., B.SC.

The Leeds Smoke Abatement Society was formed in 1890, with the following objects: (1) To determine the nature and extent of atmospheric impurities arising from coal smoke. (2) To consider the question of coal consumption in boilers, furnaces and domestic fireplaces. (3) To examine the efficiency of the present system for controlling the emission of smoke. Sulphur dioxide is a product of coal combustion, and is always present in town air in varying amounts, increasing enormously in foggy weather. It is rapidly converted into sulphuric acid, which is non-volatile, and which is deposited, and corrodes whatever it touches. The estimation of sulphur dioxide in town air was begun in Manchester about 1890, and carried out by the Smoke Abatement Society there. The results showed that in all weathers the proportion of sulphur dioxide in the centre of the town was generally double, but occasionally three or four times as much as that found about a mile from the centre. The largest quantity was present in foggy weather, when as much as 32 milligrams in 100 cubic ft. was recorded.

---

* Abstract.

It is estimated that about 4,000 tons of coal are daily consumed in Leeds, which at ½ per cent. means 20 tons of soot. This percentage has been directly estimated by aspirating large quantities of air through a carefully-weighed plug of cotton wool, with a result which approximates very closely to the above figure. Most of the 20 tons of soot is blown away, but we find that about half a ton falls in Leeds each day. The estimation of the daily soot-fall was made in the following way. In January, 1892, snow fell and lay on the ground for several consecutive days during clear, frosty weather. A square yard of snow was removed daily from the parish churchyard, the snow was melted, and the soot estimated. Of the daily soot-fall at least 25 % sticks and is not removed by rain. This was determined by means of glass plates, which were placed in exposed positions out of the immediate neighbourhood of chimneys. Every few weeks the plates were taken down, rinsed with water, and the deposit then removed, analysed and weighed. The amount of carbon calculated as soot represented the quantity mentioned above. It was interesting to observe that the plates exposed at the same time about 9 miles from Leeds remained almost as clean as when originally placed in position. In addition to estimating the quantity of sulphurous acid and soot the loss of light was also determined by making comparative observations at different stations in and outside the town. The difference was very marked, and showed a considerable loss of light in the town, which must be ascribed to the pall of smoke which remains suspended there.

Turning now to the efficiency of the method of control, the Leeds bye-law which defines the Public Health Act of 1875 limits the duration of black smoke from factory chimneys to five minutes in the hour. In Leeds we did our own inspecting for three weeks, and during that time out of 79 boiler chimneys selected indiscriminately and observed for one hour each, 51 emitted black opaque smoke for over ten minutes in the hour. Yet the average number of convictions a year for making a smoke nuisance is ludicrously small. There are on the average about half-a-dozen convictions in the year at 10s. each.

Acting on the above suggestion of Mr. A. E. Fletcher, our society decided to press for the inclusion of all factory chimneys in the Alkali Act, so as to place the whole matter of smoke in the hands of experts, just as the control of noxious fumes are under the careful supervision of the Government alkali inspectors. It would only mean an extension of the Alkali Act to bring the chimneys of all works under the same kind of control. In December, 1895, a resolution was passed that the Local Government Board should be memorialised for the appointment of Government inspectors, and the society joined forces with the Manchester Smoke Abatement League and the Sheffield Smoke Abatement Society. The memorial was very largely signed by all the principal sanitary, medical, architectural, and botanical societies in Lancashire, Yorkshire, and elsewhere, but was never presented. Those who had the duty of making arrangements for the deputation were sent from the Local Government Board to the Home Office and then sent back again, and the President of the Board finally declined to receive either deputation or memorial.

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## THE ACIDS OF SMOKE.*

BY S. RIDEAL, D.SC., F.I.C.

Figures were given in this Paper showing the quantities of sulphurous acid in the atmosphere under various conditions, and illustrating the excessive amount which is found in districts where much coal is burned. The substitution of coke for coal is only a partial remedy for the nuisance, as at present the gas industry is not restricted as to the sulphur content of coke. The sulphur in coal gas, however, is diminished by the amount of sulphur retained in the coke and also by the compulsory absorption of the sulphuretted hydrogen in the crude gas. So that the universal adoption of gas heating would do much to mitigate the evil.

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## THE DISTRIBUTION OF PRODUCER GAS AS A MEANS OF ALLEVIATING THE SMOKE NUISANCE.*

BY A. S. E. ACKERMANN.

Almost anything can be done if expense is no object, but most engineering schemes must pay for themselves, either directly or indirectly. It has been estimated by the Hon. Rollo Russell that the total cost of fogs in London is over £5,000,000 per annum. Hence we see that even one year's cost would provide capital enough for a very large scheme, and consequently I argue that a successful, even if very costly, scheme would pay. Figures, based on records made during 20 years, show that during the months from November to February, London gets only half the sunshine that southern England gets, or only about 12 per cent. of the possible amount. Between May and August the sunshine in London amounts to no less than 84 per cent. of that actually experienced by southern England, or 37·8 per cent. of the possible amount. The difference between 84 per cent. for the summer and the 50 per cent. for the winter, shows a loss of sunshine due to the excess of winter smoke over summer smoke of 34 per cent. calculated on what southern England actually receives. To combat the smoke fiend, my proposal is that producer gas should be distributed to houses for warming and cooking and to factories for industrial purposes. Producer gas is made from the cheapest coal and has a calorific value of about one-quarter that of ordinary illuminating gas and can be produced, even on a small scale for 3½d. per 1,000 cubic ft. The South Staffordshire Mond Gas Co. now have some 14 miles of producer gas mains laid, and though they started to deliver gas only six months ago, the out-put is already 12,000,000 cubic ft. per day from the generating station at Dudley Port. This gas, however, is all used for industrial purposes, so will not decrease domestic smoke. The Act of Parliament under which the company was formed does not allow them to distribute gas "for use in private dwelling houses." When I first suggested the distribution of producer gas for the purposes named, I was not aware that it had been used for cooking and warming, though of course natural gas (which has a much higher calorific value) has been so distributed and used in America for years. On making inquiries, it turned out that the Gloucester County Asylum has used producer gas for cooking during the last 22 years, while it has been used at the Walthamstow Isolation Hospital for the last five years. In the latter case it is used for driving the gas engines which generate electricity for lighting, and it is distributed for warming the blocks of buildings, for the hot water supply, and for cooking. The cooking apparatus is arranged against two of the walls, and over it there are two wrought-iron hoods which stand out from the walls, and are placed 6 ft. above the floor level. One of these was provided with an electric fan for drawing off the fumes, but very often they did not find it necessary to use this. Producer gas is also used for cooking at the works of the following firms: Messrs. Ashmore, Benson, Pease & Co. (Ltd.), Stockton-on-Tees; Messrs. Brunner, Mond & Co. (Ltd.), Winnington; and the Co-operative Wholesale Society, Irlam.

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## SMOKE PREVENTION AND COAL CONSERVATION.*

BY ARTHUR J. MARTIN, A.M.I.C.E.

The first and most obvious effect of a black fog is loss of light. The immediate consequence of this is a large expenditure on artificial light, estimated at not less than £7,000 per day. This item is, however, trifling compared with the loss entailed by the disorganisation of traffic, on which it is impossible to place even an approximate value. The damage done by smoke and other products of combustion to property of all kinds entails a further heavy loss, and, looking at the matter as a whole, the Hon. Rollo Russell has estimated the annual cost of fogs in London at from three to five million pounds. The secret of the immunity of most continental cities from the black fogs of London lies chiefly in the difference between their modes of heating and our own. The influence of the domestic heating arrangements on the atmosphere of a city is strikingly shown by a comparison of the air of New York, where bituminous coal is unknown, with that of London. The weight of coal consumed in the Metropolitan Police District of London during 1903 was over 15 million tons. Of the 6½ million people composing the population of greater London 4½ million reside within the city and the county, and it is fair to assume that the population inhabiting the smaller area burns its due proportion of the coal consumed in the larger. At this rate 10,400,000 tons per annum are burnt every year on 75,000 acres, an average of 851 lb. per acre per day. On a moderate computation the daily mid-winter consumption is probably not less than 1⅓ times the average, or say, 1,135 lb. per acre per day. The report of the Royal Commission on Coal Supplies contains the following important table, giving an analysis of the total yearly consumption of coal in the United Kingdom, with an indication of the saving which may be effected in each of its various uses:—

| | Consumption in millions of tons. | Saving in millions of tons. | Means of economy. |
|---|---|---|---|
| Railways | 12 to 14 | 5 to 7 | Gas generators and engines and electric motors and electric traction. |
| Steamers | 6 ,, 8 | — | |
| Factories | 40 ,, 45 | 20 ,, 30 | |
| Mines | 10 ,, 12 | 5 ,, 7 | |
| Blast furnaces | 16 ,, 18 | 2 ,, 3 | Gas engines and recovery ovens. |
| Iron and steel | 10 ,, 12 | 2 ,, 3 | |
| Other metals | 1 ,, 2 | — | — |
| Brickworks, potteries, glass works, chemical works | 4 ,, 6 | 1 ,, 2 | Gas generators and coke. |
| Gas works | 14 ,, 15 | — | Gas-cooking and heating briquettes and coke. |
| Domestic fires | 30 ,, 36 | 5 ,, 8 | |
| | 143 ,, 168 | 40 ,, 60 | |

The electrical transmission of power is handicapped by the necessity under which electricity labours of generating and transmitting the power at the precise rate at which it is used at any moment. The switching on of a light or motor at a remote corner of the area of supply must be responded to on the instant by a corresponding increase in the power put forth by the generator. This necessity would be done away with if electrical energy could be economically stored; but an electrical accumulator, commercially available on the scale required to be of much value in equalising the work of a large generating station, is not yet in sight. The plant for the generation of the current, the line and the converting machinery at both ends of the latter must all, therefore, be capable of working at three or four times the average rate of demand, with a corresponding increase in the initial outlay. These considerations apply with almost equal force to transmission by compressed air. Here, again, gas shows to marked advantage, in that it can be stored more cheaply and conveniently than any other vehicle for the conveyance of energy. Not only so, but the storage involves practically no loss, whereas an electrical accumulator, under the best conditions, will not give back more than about 80 per cent. of the power delivered to it. The compressing plant may, therefore, be stopped at any time for repairs either to itself or to the pipe line, or for any other reason, without interrupting the service. The importance of power transmission on a large scale from the collieries, by whatever agency, lies not merely in the avoidance of conveying, handling and distributing the coal, with their attendant costs and wastes, but also in the economies which it renders possible as regards both the quantity and quality of the fuel consumed. The wastefulness of the small steam plant is proverbial. The generating plant at the collieries enjoys a further advantage in the facilities which it possesses for the utilisation of less expensive grades of coal, particularly of the dust and smaller fragments of which no use is at present made. The following are instances of long-distance electrical transmission on a large scale: Michoacan and Guanajuato, Mexico (100 miles, 2,250 H.P., 60,000 volts), Cenischia, Italy (38 miles, 5,600 H.P., 30,000 volts), Ogden Cañon, Utah (38 miles, 5,000 H.P., 16,100 volts), Cauvery Falls, India (93 miles, 7,000 H.P., 30,000 volts), Yuba Falls, California (222 miles, 15,000 H.P., 40,000 volts). These transmissions were in all cases effected at very high tensions by means of bare overhead conductors, which it would probably not be possible to employ in this country. If insulated underground conductors had to be used, not only would the cost of the line be enormously increased, but the working potential would have to be very much lower than could safely be employed overhead. Moreover, in all the cases cited, the current was generated by water power. It is obvious, therefore, that the distances to which the energy in question was conveyed afford no criterion of those over which the transmission of electrical power from coal is commercially possible. In gas transmission, except for the ordinary city supplies, some of which are piped to very respectable distances, little has yet been accomplished. The most notable undertaking in this field is that of the South Staffordshire Mond Gas (Power & Heating) Co., which has been formed to supply the gas from which it takes its name over an area of 163 sq. miles, lying between Birmingham and Wolverhampton. The author then proceeded to give detailed figures showing the saving which can be effected by piping gas from the coalfields instead of, as at present, conveying the coal in trucks or steamers. He expected it would be possible to deliver gas in London at 8d. or 10d. per 1,000 cubic ft., and figures were quoted to show that gas would in this case be a cheaper fuel than coal for generating stations. At the conclusion of the Paper the following resolution was adopted:—

---

* Abstract.

* Abstract.

"That in view of the need for husbanding our coal resources, the deplorable and increasing evils produced by smoky fogs, and the desirability of providing a cheap smokeless fuel for domestic and industrial use, the councils of the Royal Sanitary Institute and the Coal Smoke Abatement Society be asked to join in a memorial to His Majesty's Government, setting forth the urgency of these questions, and praying that His Majesty's Government will be pleased to appoint a strong permanent committee to deal with them."

A visit was paid in the afternoon to the generating station of the Underground Electric Railways Co. of London, in Lot's-road, Chelsea. The experiments being carried out for H.M. Office of Works by the Smoke Abatement Society at 12, Delahay-steet, Westminster, were also inspected.

*(To be concluded.)*

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. FOURNIER D'ALBE.]

*Deformation of Moving Electrons.*—According to the hypothesis of Lorentz, the axis of the electron which lies in its direction of motion is shortened in the ratio $1 : \sqrt{s}$, where $s = 1 - u^2/v^2$. This shortening extends to all matter, and accounts for the negative result of the Michelson-Morley interference experiment. Now A. H. Bucherer announces that Kaufmann's latest results as to the longitudinal mass of Becquerel rays do not agree with Lorentz's deformation, but they agree with the theory of the incompressible electron as well as with a rigid electron. The author's incompressible electron is shortened in the direction of motion and expanded in all directions normal to the direction of motion, thus becoming a Heaviside ellipsoid with one axis of length $a\sqrt[3]{s}$ and two axes of lengths $a/\sqrt[6]{s}$. This also accounts for the Michelson-Morley experiment, but it has distinct advantages over the Lorentzian deformation. It is not necessary to assume new and unknown forces within the electron, and the energy of the internal forces remains constant. The new electron has no tendency to turn its longest axis into the direction of motion, and the work of the external forces equals the increase of energy of the field.

[A. H. BUCHERER, *Physikalische Zeitschrift* Dec. 1, 1905.]

*Small Spark Lengths.*—G. M. Hobbs has studied the behaviour of very small spark-gaps in order to explain the results obtained by Earhart and Carr, and to find whether Paschen's law of the constancy of the product of maximum gas pressure and sparking distance for a given P.D. applies to these small gaps. He finds that with gaps ranging from zero to 0·003 mm. ($3\mu$) the discharge is wholly independent of the gas between the electrodes. It simply depends upon the nature of the metal, and the heavy metallic ions convey the whole discharge or a considerable portion of it. Platinum requires a comparatively high voltage and aluminium a much lower voltage, the intermediate metals being antimony, silver, nickel, magnesium, zinc, bismuth and brass in order. After the distance of $3\mu$ is exceeded, the gas comes into play, but there is always a certain distance, evidently corresponding to the mean free path, through which the sparking potential remains constantly at 350 volts. With a pressure of 1 cm. of mercury in air this distance extends as far as $75\mu$. In hydrogen this constant potential is lower, and in carbonic acid it is higher than in air, being about 420 volts. When this "minimum gas potential" reaches its limiting spark-length, the potential increases steadily with a further lengthening of the spark gap, and is proportional to its length. The author operated with one spherical and one plane electrode, and measured the distances with an interferometer.

[G. M. HOBBS, *Philosophical Magazine*, December, 1905.]

*Electrostriction.*—The theories of Faraday and Maxwell assume a tension along the lines of force in a dielectric and a pressure at right angles to them. Attempts have been made at various times to prove the existence of such stresses in a material dielectric, but none are free from objections. The modern tendency is to regard these stresses as purely fictitious, and as alternative expressions for the energy stored in the medium. The immobile ether assumed by Lorentz precludes the existence of electrostriction in the ether itself, and any deformation of a dielectric would have to be due to the displacement of electrons immersed in it under the influence of electrostatic force. But that such displacements should give rise to the Faraday-Maxwell electrostriction is very improbable. L. T. More has attempted to decide the question experimentally. He constructed a pillar consisting of alternate discs of brass and dielectric. The latter was a mixture of four parts by weight of the best shellac, one of resin, and two of Venice turpentine. This compound gives a clean and smooth surface when broken, and is highly elastic. The brass plates were 5 cm. in diameter, 2·5 mm. thick, and 31 in number. The odd brass plates were charged positively and the even ones negatively. Thus the top and bottom plate were similarly charged, and they were connected by stout brass rods. An optical lever was used to determine any change of length of the pillar when charged, but no such change was discovered, even with potentials close to the limit of the insulating power of the dielectric. The author, therefore, concludes that dielectrics are not distorted by electric forces, and that all apparently positive results are due to extraneous causes.

[L. T. MORE, *Philosophical Magazine*, December, 1905.]

*Discharge through Gases.*—J. Stark reviews the present condition of research on gas discharges. These discharges he distinguishes as dependent and independent currents, meaning that in the first class the necessary ionisation depends upon the presence of an ioniser like X-rays or some other agent, whereas in the second class the discharge produces its own ions independently by collision. The first class is the better known of the two, and has been pretty fully worked out since Thomson and Townsend determined the coefficients of ionisation and recombination and the transport and absorption of ions. The independent discharges comprise the positive point discharge, the glow discharge, and the electric arc. In spite of a great accumulation of material, no mathematical theory of these discharges has yet been formulated. The author expects that much light will be thrown upon it by an investigation of spectra in vacuum tubes. A gas does not show its line spectrum unless it is both hot and ionised. The source of the line spectrum is evidently the kinetic energy of the ions. The source of the band spectrum is, on the other hand, the potential energy of ions of opposite signs, liberated during recombination. The constitution of the atom may be elucidated along this line of research.

[J. STARK, *Physikalische Zeitschrift*, November 9, 1905.]

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*All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher,* "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*

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## AMERICAN LESSONS.

Last spring Mr. A. L. C. FELL, the chief officer of the London County Council Tramways, paid a visit to America in search of information on tramway working. His account of the visit has just been published by the Council and is worth reading, even by those who have seen for themselves how street railways are worked on the other side. Mr. FELL's main object was to gather ideas applicable to London conditions from tramway systems comparable in magnitude with the London system as it will be in the course of a few years; but quite as much interest attaches to the practices that are not applicable and the differences in the conditions which make them inapplicable.

The great development of inter-urban lines is a case in point. Between cities or towns up to 20 miles apart, the electric railway laid on the side of the main road is a common connection, and is run at speeds up to 50 miles per hour with great safety. An immediate result is the development of the land along the route for residential purposes, for, with high speeds, cheap fares and a frequent service, life in the country house is as convenient and as economical as in the dingy suburb, and far more salubrious. Congestion in some English towns and cities is being slowly relieved by the spread of urban tramways, but the interurban lines are as yet few in number and not particularly prosperous. The reasons are summed up in few words: restrictive legislation and the protection of vested interests. It is perhaps futile to hope for such freedom of development in an old settled country like England as obtains in the United States, but very considerable improvement by means of legislation is clearly within the power of an energetic Government bent on improving the condition of the people. One important element in the financing of such interurban lines in America is that it is comparatively easy for those controlling them to get a good share of the land appreciation profits, so that they are by no means wholly dependent on the profits earned by the tramways. Here such a condition is hardly possible unless the landowners along a route combine to develop their property by promoting a tramway or light railway. Municipalisation of tramways is evidently an obstacle to such developments, so long as difficulties are raised against through running, and similar manifestations of jealousy are allowed to produce friction where co-operation should be the rule. There can be no doubt that the urban lines in America gain much traffic from these country extensions, and the few examples working in this country teach the same lesson.

The standard of track and paving maintenance in America is very poor. "Disgraceful" is Mr. Fell's word for some of the cities, and he adds, "it would not be tolerated here." This strikes another note of difference. In America the "street railway" is indispensable, the good paving of a street a quite secondary matter. Here, even in the best managed towns, there is a large public which considers the tramway a nuisance. Consequently the smallest defect in maintenance is pronounced scandalous, and indignant councillors threaten the company, or indignant ratepayers threaten the Council with Board of Trade inspections and dire pains and penalties. Mr. Fell found some comfort in the fact that, making allowance for differences in bookkeeping, the operating expenses in London per car mile compare pretty well with those in New York. As the London County Council paid 2·39d. per car mile for power only in the last complete year, owing to the temporary arrangements as to supply, he would seem to have good reason for his hope that the total costs will be appreciably under the New York figure when the Greenwich station is in full operation. It cannot be said that the earning capacity of the London lines is inferior. The earnings per route-mile of electric lines in London amounted last year to £20,078, whilst in New York the figure was £17,428. This tends to show that Londoners will ride as readily as New Yorkers when they get the chance, and that when London is adequately tramwayed it will be easily the first system in magnitude. It also suggests that it ought to be well nigh impossible to run the London tramways at a loss.

Turning to matters of more technical interest, rail corrugation is a serious question. We note in Mr. Fell's remarks the repetition of an error to which we have before called attention—viz., that corrugation has never appeared on steam railways. It is by no means unknown there, though not common. A recent case in Germany is described in an abstract in the last-issued *Journal* of the Institution of Civil Engineers, and an Indian case was described in the *Engineer* about a year ago. Mr. Fell figures the two rails on a curved part of the Boston Elevated Railway after one year's service. The pitch in this case is very long, 31⅜ in. on the outer and 29 7/16 in. on the inner rail. The depth of the wave is 0·016 in. and 0·015 in. respectively. The length of the wave depends on the speed of the cars, from Mr. Fell's observations. This is 40 miles per hour on the Boston line, but the figures given show no direct proportion. On tramways in this country the pitch is usually from 2 in. to 5 in. Mr. Fell suggests that the rails come from the rolls with a slightly wavy table which starts the corrugations by making the car wheels jump, and the effect becomes cumulative; he proposes that new rails should be put through a grinding machine after rolling. This theory should be easily amenable to test. Most of the theories put forward so far are clearly untenable whenever the conditions of three or four different cases are considered. The absence of corrugated rails in Buffalo, where electric welding is nearly universal, may be significant. Grinding out the corrugation by a carborundum block attached to a water-tank car has been found practicable by Mr. Fell and he hopes to get rid of the trouble by such means. In America no such remedy has been tried.

The Boston subway and the traffic organisation in connection therewith come in for considerable commendation, and both this and the New York subway were minutely examined with a view to the approaching opening of the Kingsway line. The Boston elevated car has a central door for exit only, like those on the District trains. If only passengers will fall in with the instructions, it must clearly be quicker and more orderly to have separate doors for entrance and exit, and Mr. Fell has designed his subway cars for entrance by the front and exit by the rear platform. Unfortunately, a proportion of the public will always be too stupid to notice or observe instructions, and another proportion will always be rebellious against such regulations which it takes as an affront to its liberty. This is well seen on the District and heard in the complaints of being "Yerked." Perhaps the stupid may be taught and the rebels reduced to order in the course of time, but, in any case, it would be difficult to improve upon the short stops on the Central London tube to any great extent.

The American may learn from us in the collection of fares. Nothing strikes an Englishman as more curious than the "fare indicator" in a New York car. No tickets are issued, the conductor works the indicator for every fare he collects (that is he should) and is responsible for so many 5 cents as the fingers point to. Naturally he cannot be sure of getting every fare on a crowded car, much less can the company be sure of getting every fare he takes. An extensive private detective system is employed to check the men, but it cannot be satisfactory to discharge men on the secret evidence of professional informers. It is not so many years since the omnibus companies in London issued no tickets and trusted to occasional surveillance, but it is believed that they would not care to go back to that system, although they then paid lower wages. In Boston Mr. Fell found the Railway Commissioners considering the ticket system and glad to get from him particulars of the London practice. True reciprocity!

New York and Washington remain the only American exponents of conduit tramways. There, as in London, ploughs have given trouble, but there seems to be nothing to learn from the United States in this respect. London mud has accelerated the evolution of the plough by the destruction of the unfit. Hard rubber has displaced wood; but in New York free scrapping, and in Washington absence of mud, permit wood to survive. Only those who went through the struggle know at what cost of anxiety and fatigue the South London lines were kept going through the winter and spring of 1903-4, or how near they came to practical stoppage on account of the failure of wooden ploughs running through the winter slush.

The increase in size and power of motors comes in for notice. From 40 h.p. to 75 h.p. motors are now generally put on street cars, giving more rapid acceleration and higher over-all speeds. More robust and durable design is a feature of these motors, and Mr. Fell is specifying these improvements in his new cars. More powerful motors, higher speeds, more frequent service, all call for greater intelligence and vigilance in the man who handles them, and the motormen's schools maintained by the larger American companies appeal for imitation in London. The suggestion that skilled motormen should be somewhat better paid than conductors excites some surprise that any other practice should obtain. On company tramways the motorman is always the better-paid man.

The most novel experience recounted is a run on the General Electric Co.'s single-phase Ballston line, on which a maximum speed of 43 miles per hour is attained, the average service speed being $29\frac{1}{2}$ with stops. It will be remembered that the cars on this line run into Schenectady over several miles of continuous current tramway, so that the compensated motors are in commercial use with both alternating and continuous current. The practicability so demonstrated leads Mr. **Fell** into a short discussion of the possibilities of single-phase motors on conduit tramways, doubtless only meant as educative. Somewhat more exciting was the race between one of the great New York Central electric locomotives and a steam-driven express, when the latter was easily overhauled by the former, a speed of 75 miles per hour being reached. It will be some little time ere the London County Council will be inviting tenders for such machines.

The report is clearly and concisely written, and, without being overburdened with detail, conveys the impression that the visit recorded was full of interest and instruction and well worth making for the sake of the important public service committed to Mr. **Fell's** able hands.

## REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign book.)

◆

**Synchronous and Other Multiple Telegraphs.** By A. C. Crehore (New York: McGraw Publishing Co.) 8s 6d.

Part I. of this book deals with developments of the principle of superimposing an alternating upon a direct current, in order to provide two simultaneous systems of telegraphy over one wire in the same or in opposite directions, the latter case giving the name "duplex-diplex" to the method. The alternating currents are selected by a condenser branch of the receiving circuit, and the latter must be designed so as to minimise mutual interference between the direct and alternating sides. The author worked out the application of this method, of which he may, apparently, fairly claim to be the inventor, with remarkable completeness of detail in the laboratory, afterwards applying his results to actual wires, over which the system has been in satisfactory operation for some years. This mode of proceeding from the basis of laboratory investigation probably accounts for the noteworthy absence from the book of the alternating-current formulæ. For the successful application to practice of problems in which a number of interdependent conditions have to be fulfilled, the omission or miscalculation of any one of which may be fatal to theory (as remarked in the Preface), the artificial circuits of the laboratory are peculiarly serviceable. One factor, however, as to which the artificial lines could give no information, was the disturbance of telephone circuits by the alternating current of 150 cycles frequency. This led to experiments with a frequency of 50, which was found to involve considerable modification of the receiving circuits, and to be less amenable to adjustment than the higher frequency. An approximate limit mentioned for the 150 cycles system is KR ·015 second, working in opposite directions, but more than this if the direct and alternating currents are both operated in the same direction. Loaded lines were not tested. These methods are not related to the author's sine wave transmission systems, of which accounts have been previously published.

Part II. investigates modes of obtaining synchronism at distant points, and is connected with the foregoing by the fact that the above simultaneous system of alternating currents furnishes means of synchronising by synchronous motors fed by the same wire which carries the signals. The use of a separate line for this purpose is, however, advocated.

Part III. passes on to the subject of synchronous telegraphs. It comprises a very interesting discussion of an exhaustive series of measurements made for the purpose of analysing the behaviour of synchronised multiple circuits. As these have hitherto been little used in America, the author's experience of them has been mainly confined to the laboratory. Alike, however, in this and in the previous part of the work, Dr. Crehore's methods are so thoroughly scientific, and his research so conscientious, that his investigations cannot fail to be of great value. What is equally important, his presentation of them is distinguished by an order and lucidity of statement, a literary style, and an absence of formulæ, which will render the perusal of this book a pleasure to students of telegraph engineering. We shall welcome the appearance, in a future publication, of the extension of these systematic investigations to printing telegraphs, which are not covered by the present volume.

**Le Four Electrique**: Son Origine, ses Transformations et ses Applications. By Adolphe Minet. Part I. (Paris: A. Hermann.) 4s.

The author is well known as a worker in the field of technical electro-chemistry, and it is right that the result of his labours should be received with consideration. There is sufficient ground, apart from this, for regarding this booklet with some respect. It is a meticulous account of the various devices which have been made from time to time and now constitute the modern electric furnace as an entity. M. Minet has his nation's gifts of clearness and classification and exercises them with such severity that one wishes he had been born on the east side of the Rhine. It is the amiable failing of our neighbours that a code appeals to them and the absence of a natural division is no bar. Hence it comes about that in this book the electric furnace is so mercilessly analysed that its reduction to an ultra-atomic condition is imminent. Regarding the brochure as a whole, one is glad to see that some diversion of energy occurs from the atomised electric furnace to something sufficiently solid to sustain a logical attack. Pages are covered with resistivity constants of aqueous solution, the reader being left with a free hand to correlate these with the behaviour of electric furnaces at large. Logic can be applied without stint and without appreciably impairing the facts. The publication is a dossier, not a book. Useful data are collected in it to be used by the judicious.

## ELECTRICAL ENGINEERING SCHEMES IN PARLIAMENT, 1906.

We give below a résumé of the chief contents of those private bills relating to power schemes which will be considered during the 1906 session of Parliament. The parliamentary notices of these bills were given in our issues for November 24th and December 1st. Next week we hope to give summaries of the lighting and traction bills and some miscellaneous measures of more or less direct electrical interest.

### ELECTRIC POWER BILLS.

*Additional Electric Power Supply (London) Bill* seeks the incorporation of a new company with a generating station at St. Neots, in Huntingdonshire, for the purpose, primarily, of supplying electrical energy to railways, tramways and canals for motive and other purposes, within the metropolitan area. The bill also reads, however, "and also to supply electrical energy in bulk for manufacturing and other purposes." The capital is £2,000,000, with borrowing powers to the extent of one-half of the capital authorised and at the time actually issued. The promoters are Stanley Carr Boulter, George Kitchen, Henry Augustus Vernet, Walter Raphael and Alfred Ralph Wagg. The first directors named are Stanley C. Boulter, George Kitchen and H. A. Vernet. Compulsory easements are sought along the Regent's Canal, the Hertford Union Canal and certain portions of the Lea Navigation. Powers are sought to carry electric lines over and across certain roadways adjoining the Great Northern Railway from St. Neots, and any sanction of a local authority for the erection of overhead mains is not to be unreasonably withheld; otherwise there is to be an appeal to the Board of Trade. Compulsory powers are also taken to break up an exceptionally large number of streets. Bulk supply consumers—*i.e.*, local authorities—will have to enter into a seven years' agreement, and an income equal to 20 per cent. of the total capital outlay is to be guaranteed. Interest out of capital during construction at the rate of 4 per cent. is to be paid. The maximum tariff is $1\frac{1}{3}$d. per unit, or a fixed sum of 18s. 9d. per kilowatt per quarter of the maximum power required, plus $\frac{1}{10}$d. per unit. This price is to include transformation. A schedule to the bill giving the average price with various load factors. With a 95 per cent. load factor the price is 0·503d. per unit, varying up to 1·086d. per unit for a 10 per cent. load factor; all units below this will be charged at 1·33d.

*Administrative County of London & District Electric Power Bill* revives the proposal which was sanctioned by Committees of both Houses last year, and is very similar to it. Capital is £5,000,000 in £10 shares, and one-third borrowing powers. Promoters: Right Hon. W. H. Armstrong, Baron Armstrong, Sir George Taubman Goldie, Sir Andrew Noble, Bart., Sir Lindsay Wood, Bart., John Annan, J. H. Armstrong, James Couper, John Cowan, L. Daneham Cunliffe, James Falconer, Bernard Alex. Firth, C. Eric Hambro, S. Insull, A. F. Yarrow, G. F. McCorquodale, Edward Kraftmeier, J. H. Brunel Noble, R. Spence Watson and Philip Wigham Richardson. The first directors will be J. H. Armstrong, L. D. Cunliffe and James Falconer. Land is scheduled in West Ham, Greenwich and Barking. The area of supply is again divided into an industrial and non-industrial area. The non-industrial area is: City of London, City of Westminster (except so much of the Metropoltitan Company's area as was existing at January 1, 1904), Battersea, Chelsea, St. Pancras, Wandsworth, Croydon, Kingston-on-Thames, Richmond, Wimbledon, Barnes, Carshalton, Ham, Sutton, Maldens and Coombe; parts of the urban district of Surbiton; parts of the rural district of Croydon; Bromley, Beckenham and Penge. The industrial area will consist of Bermondsey, Bethnal Green, Camberwell, Deptford, Finsbury (except so much of the Metropolitan Company's area as was existing at January 1, 1904), Greenwich, Hackney, Islington, Lambeth, Lewisham, Poplar, Shoreditch, Southwark, Stepney, Woolwich, West Ham, East Ham, Barking, Grays Thurrock, Ilford, Leyton, Romford, Wanstead, Woodford, Romford Rural (parts of), Orsett Rural (parts of), Gravesend, Bexley, Chislehurst, Dartford, Erith, Foots Cray, Northfleet, Dartford Rural (parts of), and Bromley Rural (parts of). Powers are taken to erect overhead mains, and should the consent of the local authority be unreasonably withheld there is to be an appeal to the Board of Trade. Supply is to be given to authorised undertakers, to railways, canals, docks, Government Departments, and to persons for power purposes. So far as the latter are concerned, the 20 per cent. clause is inserted—*i.e.*, 20 per cent. of the total energy may be used for lighting purposes. The Board of Trade will be appealed to in the event of a local authority unreasonably withholding its consent for the company to supply power users. A sliding scale of dividends is again proposed—viz., that if the average price for the year is less than the standard price, viz., ¾d. per unit, the dividend may be increased in the ratio of ⅛ per cent. in respect of every 1¼ per cent. by which the average price has been below the standard price. Special provision is made to enable the company to supply the Charing Cross, County of London and London Electric Supply Companies. Exemption from building acts is again asked for, and interest out of capital during construction will be paid at the rate of 3 per cent. Clause 83 provides that in the event of purchase by any authority such purchase shall be conducted under Sec. 2 of the Electric Lighting Act of 1888, at the then value of the undertaking. Twelve months' notice is to be given of the intention to purchase. The supply in contiguous areas clause excludes the area of the North Metropolitan Electric Power Co. None of the agreements entered into last session with various supply authorities are mentioned in the bill, nor are they scheduled to it. The tariff is not to exceed 1½d. per unit or £1 per quarter per kilowatt plus ½d. per unit, price to include transformation and conversion from three-phase current to the standard pressure in the case of power users, or to any class of current specified by an authorised undertaker. Powers are also taken in the bill to repay the promoters of last year's bill the expenses incurred in connection therewith.

*Charing Cross, West End & City Electricity Supply (Power Supply) Bill* authorises the company to supply electrical energy in bulk over a defined area, and to use its existing works for this purpose. Power can also be supplied for haulage, traction and the lighting of boats or vehicles drawn by such haulage. Power can be supplied to authorised distributors (on a seven years' contract as minimum) and to power consumers under the same conditions as in other bills. The area scheduled includes Kensington, City of London, City of Westminster, Holborn, St. Pancras, Islington, Finsbury, Shoreditch, Bethnal Green, Stepney, Poplar, Hackney, West Ham, East Ham, Buckhurst Hill, Woodford, Wanstead, Leyton, Ilford, Barking, Romford, Epping, Loughton, Waltham Holy Cross, Brentwood, Grays Thurrock, Romford Rural (part of), Epping Rural (part of), Ongar Rural (part of), Billericay Rural (part of), and Orsett Rural (part of). Additional land is scheduled at Lambeth. The tariff under the bill is 3d. per unit for all units not exceeding 200 hours at the maximum power and 1d. per unit after.

*City of London Electric Lighting Co.'s Bill* authorises the supply of electrical energy to railways, tramways, canals or premises situated partly within and partly without the company's area of supply, and also agreements with other authorised undertakers.

*County of Durham Electric Power Supply Co. (Further Powers) Bill* exempts the company from certain provisions of the Electric Lighting Acts. There is a general enlargement of the powers of the company, including authority for a power consumer to use a certain percentage of energy for lighting. The bill also authorises working agreements with the Newcastle-on-Tyne Electric Supply Co. and with adjacent undertakers for mutual supply. Railways, canals, Government departments, &c., are included in the company's potential consumers. Powers to erect overhead mains are asked for, with an appeal to the Board of Trade should the consent of the local authority be unreasonably withheld. It is also asked that the County of Durham Electric Power Distribution Co. should be exempt from the provisions of the Electric Lighting Acts relating to non-association with other undertakings. A new tariff is scheduled to the bill by which the company shall charge £1 per kilowatt per quarter and ¾d. per unit, including transformation.

*Cumberland Electricity & Power Gas Bill* proposes the incorporation of a company for the purpose of generating electricity and power gas in Cumberland. Lands for generating stations are scheduled at Maryport, Workington and Cleator Moor. The capital of the company will be £450,000 in £5 shares. The promoters are Arnold Lupton, William Frederick Smith, Joseph Thomas Pullen, William Hare, Thomas Smith Ritson, Joseph Highet, Richard Williamson, R. H. Williamson, Joseph Huntrodes and Thomas E. G. Marley. The first directors will be Arnold Lupton, William Frederick Smith and three others not appointed. The objects of the company are to supply electrical energy to authorised undertakers and persons requiring motive power supply, any current to be used for lighting the premises where power is supplied. The Board of Trade will be referred to in the event of any authorised consumer withholding consent to the company supplying any customer in that area. Authorised undertakers will be required to enter into a seven years' contract, whilst, as in the other power bills, in the event of any dispute as to price between the company and a power user, the Board of Trade will be asked to appoint an arbitrator. Power gas consumers will be asked to enter into a contract for five years. Interest out of capital during construction will be paid at the rate of 3 per cent. per annum to the extent of £20,000. Substantial commencement to be made with works within three years, and powers under the Bill cease after seven years if supply not then given. The charges for electric supply will be at the rate of 10s. per electrical horse-power, which the company is required to give, and a sliding scale from 3d. to ¾d. per unit, according to quantity. For gas the charge will be 10s. per indicated horse-power, with a sliding scale from 3d. to ¾d. per gas unit.

*Derbyshire & Nottinghamshire Electric Power Co's. Bill* contains some financial provisions. Authority is also sought to erect overhead mains, and the consent of the local authority is not to be unreasonably withheld, otherwise there shall be an appeal to the Board of Trade. Bulk supply to adjoining areas and to railways, tramways, &c., is also included. The bill further seeks to exempt the company's generating stations from building bye-laws, and authorises agreements to purchase the Derbyshire & Nottinghamshire tramways and the transfer of the Newark & District Light Railway.

*Hackney Electricity Bill* authorises agreements with other authorised undertakers for mutual supply, and specifically mentions Bethnal Green, Islington, Poplar, Shoreditch, West Ham, Leyton and Walthamstow. No land is scheduled. Powers are also sought to supply and fix fittings, &c., with an obligation to balance expenditure and revenue each year. Powers are also taken to enter into contracts with wiring contractors. Supply may also be given to premises partly within and partly without Hackney.

*Kent Electric Power Bill* authorises the carrying out of certain works on the riverside in connection with the undertaking already authorised. Powers are also sought to lay mains in Woolwich for the purpose of making connection with the generating station of the South Metropolitan Electric Light & Power Co., agreements with outside authorities for mutual supply are asked for, and authority is sought to supply railways, tramways, canals, &c., in and beyond the company's area. The bill further provides for the exemption of the generating stations of the company from building bye laws, the erection of overhead wires as in other Bills; and power to raise the company's remaining capital as additional capital. The transfer of other undertakings is also included in the bill.

*Kent Collieries Bill* authorises the Kent Collieries Co. to erect electric generating stations upon lands owned by it and to supply energy to railway companies, the South Eastern and Chatham & Dover Railway being specially mentioned. No area is defined, but the bill gives the power to enter into agreements with anybody requiring a supply. No capital powers are asked for.

*Lancashire Electric Power Co.* asks for an extension of its powers to enable it to supply energy to lighting authorities, to persons requiring a supply for power purposes and to railways, tramways, &c. No supply is to be given to a consumer in the area of an authorised distributor without consent, but such consent is not to be unreasonably withheld. Should this be the case, there is to be an appeal to the Board of Trade. The company also now takes powers to apply for provisional orders and to erect overhead wires under the same conditions as in other power bills this session. Any machinery, &c., which the company may hire out is to be exempt from distress.

*London County Council (Electric Supply) Bill* seeks to constitute the London County Council the electric supply authority over a large area extending considerably beyond the county boundary. The area embraces the following districts: The whole of the Administrative County of London, West Ham, East Ham, Barking, Grays Thurrock, Ilford, Leyton, Romford, Walthamstow, Wanstead, Woodford, Orsett Rural (parts of), Romford Rural (parts of), Bromley, Gravesend, Beckenham, Bexley, Chislehurst, Dartford, Erith, Foots Cray, Northfleet, Penge, Bromley Rural (parts of), Dartford Rural (parts of), Richmond, Wimbledon, Barnes, Ealing, Hornsey, Acton, Brentford, Chiswick, Finchley, Friern Barnet, Hendon, Tottenham, Willesden and Wood Green. Supply is to be given to authorised distributors and to railways, tramways, canals, docks, &c. No schedule of prices is included in the bill. No supply will be given to individuals without the consent of the authorised distributor, but should the Council come to the conclusion within three years from the passing of the act that the charges of any authorised distributor are high and excessive, it may apply to the Board of Trade, and the Board, in coming to a decision, is to take into consideration the terms and conditions upon which, and the time within which, the Council itself would be prepared to give a supply. The Bill gives the Council powers to utilise its tramway generating station and other works for the purposes of the undertaking, in connection with which land is scheduled at Battersea for an additional generating station. Overhead mains may be erected and the consent of the local authority outside the County of London must not be unreasonably withheld, the Council having the right of appeal to the Board of Trade. It is estimated that the total capital expenditure upon the undertaking will be £2,500,000, and powers to borrow this sum are taken. Only £425,000, however, may be expended by the end of September, 1907. The unusual powers to pay interest out of the borrowed capital during construction are sought, the maximum being £105,000. After five years, the Council binds itself to apply a clause resembling the "Bermondsey" and "Northumberland" clause as regards the three succeeding years and every three years thereafter. This section will not prevent long term contracts being entered into however.

*London Electric Supply Corpn. Bill* authorises agreements for mutual supply with adjoining undertakers, the powers to lay the necessary connecting mains and to supply electricity in bulk outside the company's present area of supply. The bill also empowers the company to supply to railways, tramways, canals and premises partly within and partly without its area, and exempts the promoters from the restrictions of the Electric Lighting Acts as to association with other companies.

*Metropolitan Electric Supply Co.* seeks an extension of its Power Act granted by Parliament last year. The additional districts are Northwood and Ruislip, Rickmansworth, Chorley Wood, Chesham, Beaconsfield, Eton, Slough, Amersham, Eton Rural (parts of), Wycombe Rural (parts of), New Windsor, Windsor Rural (parts of), Chertsey, Egham Rural and Thorpe. The powers under the bill are merely the supply in bulk to authorised undertakers, &c. Agreements may also be entered into for the supply of electricity in adjoining districts. An agreement with the Paddington Borough Council is also scheduled to the bill, which amends sec. 21 of the Paddington Electric Lighting Order of 1890, by which the company was compelled to keep sufficient machinery for the supply of Paddington in the borough. Under the agreement this may now be removed to Willesden, provided it is kept sufficiently distinct for the Paddington Borough Council to purchase.

*Newcastle-on-Tyne Electric Supply (Additional Powers) Bill* provides for the transfer to the company of the Whitley and Monkseaton Electric Lighting Order, 1901, and the Seghill and Tynemouth (Rural) Order of 1902 from the Northern Counties Electricity Supply Co. Working agreements with the County of Durham Electric Power Supply Co. and the County of Durham Electric Power Distribution Co. are also asked for, and agreements for mutual supply with the Newcastle & District Electric Lighting Co. General powers are also taken to enter into agreements, for supply to authorised distributors, to properties situate partly within and partly without the area of supply, to lay the necessary connecting mains and to erect overhead mains under the conditions already mentioned in connection with other bills. Exemption from the non-association clause of the Electric Lighting Acts is also sought, and the stand-by supply clause is included in the bill.

*Shropshire, Worcestershire & Staffordshire Electric Power Bill* seeks a further extension of area to include the City of Birmingham, Walsall, West Bromwich, Wolverhampton, Wednesbury, Smethwick, Amblecote, Bilston, Brierley Hill, Coseley, Darlaston, Handsworth, Perry Barr, Quarry Bank, Rowley Regis, Rugeley, Sedgeley, Tettenhall, Tipton, Wednesfield, Heath and Heath Town, Short Heath, Willenhall, Kingswinford, Shifnal and Bushbury. With these additions it is proposed to split up the total area of the company into a non-industrial and industrial portion. The latter portion will consist of Birmingham, Walsall, West Bromwich and Wolverhampton. The bill gives the Board of Tradepower to alter the division of the area after ten years. There is also to be a rural area, in which the company may supply for any purpose whatever. No supply will be given in the area of any authorised distributor without consent, but the company reserves the right to appeal to the Board of Trade should it think such consent is unreasonably withheld. Additional lands for generating stations are scheduled, and powers to erect overhead mains, on the usual conditions, are taken. Supply to railways, tramways, &c., is also provided for. The company further asks that its generating stations may be exempt from building bye-laws.

*Shoreditch & Stepney Electricity Bill* authorises agreements for the mutual supply of electricity in bulk by the borough councils of Shoreditch, Stepney, Bethnal Green, Hackney, Islington, Poplar and Stepney, to lay the necessary connecting mains, and to execute works outside area of supply. Land is scheduled at Haggerston. The stand-by clause is embodied in the bill.

*South Metropolitan Electric Light & Power Bill* gives authority for this company to combine with other undertakings, and also to enter into agreements for the supply of electricity in bulk to authorised distributors in the Counties of London, Kent and Surrey. Powers to lay the necessary mains are also sought, and the supply to railways, tramways, &c. is also included. The appointment of joint committees in the event of amalgamation is also provided for.

*South Wales Electrical Power Distribution Co.* wishes to raise additional capital to the extent of £1,000,000.

*West End Electric Undertakers' Association Bill* is promoted by a number of West London supply companies and borough councils to enable them to give a mutual supply of electricity. The promoters are the Westminster Electric Supply Corpn., St. James' & Pall Mall Electric Light Co., Kensington & Knightsbridge Electric Lighting Co., Notting Hill Electric Lighting Co., Metropolitan Electric Supply Co., Chelsea Electricity Supply Co., Brompton & Kensington Electricity Supply Co., Central Electric Supply Co., and the Hampstead, St. Pancras, Hammersmith and Fulham Borough Councils. The bill includes the supply to railways running through the areas of the promoters, and the power to lay connecting mains. Lands for generating stations are scheduled in Fulham and Westminster, and it is sought to extract water from the River Thames for condensing purposes. The stand-by clause is also in the bill.

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**"Elektrotechnik & Maschinenbau."**—From January 1st next our Austrian contemporary the *Zeitschrift für Elektrotechnik* will change its title to *Elektrotechnik & Maschinenbau*, the reason for this change being that it will in future also include articles on mechanical engineering in as far as they are of interest to electrical engineers. The periodical will remain, as hitherto, the official organ of the Elektrotechnischer Verein in Vienna and of the Austrian Union of Electricity Works.

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## PLUMBISM DUE TO ELECTROLYSIS.*

BY BALDWIN LATHAM.

There has recently occurred in the district of the South Hants Waterworks Co. a case of lead poisoning arising from the use of the company's water in a cottage on the Twyford Lodge estate at Twyford, Hants. The district in which lead was discovered in the water draws its supply from the Twyford pumping station, the waters of which are taken from a well and are softened with lime by the Haines' method. The waters are noted for their remarkable purity for chalk water, and are softened down to 4 or 5 deg. of hardness before being passed into the mains of the district.

The analysis of the water at Twyford, both before and after treatment, before the discovery of the lead in the water supply was as follows:—

*Analysis of Twyford Water by Messrs. G. H. Ogston and Moore before and after Softening.*

| —— | Well water. 4/9/1905. Grs. per gal. | Well water. 7/10/1905. Grs. per gal. | Softened water. 4/9/1905. Grs. per gal. | Softened water. 7/10/1905. Grs. per gal. |
|---|---|---|---|---|
| Total solids ........ | 19·81 | 19·46 | 11·34 | 10·50 |
| Chlorine .......... | 1·00 | 1·00 | 1·00 | 1·00 |
| Sulphuric acid .... | 0·38 | 0·33 | 0·36 | 0·38 |
| Nitric acid ........ | 1·08 | 1·08 | 1·08 | 1·08 |
| Lime.............. | 7·56 | 7·42 | 3·15 | 2·66 |
| Magnesia .......... | 0·40 | 0·35 | 0·42 | 0·40 |
| Total hardness .... | 13·16 | 12·83 | 5·20 | 4·70 |
| Permanent hardness. | 3·00 | 3·00 | 3·00 | 2·90 |
| | Parts per million. | Parts per million. | Parts per million. | Parts per million. |
| Free ammonia...... | nil | nil | nil | nil |
| Albuminoid ammonia | trace | 0·005 | 0·005 | 0·008 |
| Appearance ........ | bright | bright | bright | bright |

Dr. G. A. E. Roberts, of Twyford, the medical officer of health of the New Winchester Rural District Council, found a considerable trace of lead in a sample of water taken from the cottage even after a considerable quantity of water was drawn.

The service pipe was rather long and its diameter was $\frac{3}{4}$ in. A piece cut out of the pipe sent to the author by the manager of the waterworks contained a white deposit. The manager also explained that the company's water near the end of the lead service was cloudy, but drawn from the same service near the company's main it was quite clear. A sample of lead pipe was also sent to the above-mentioned firm of chemists, and it was found to be perfectly pure lead. A sample of water taken from the cottage was submitted to them, and was found to contain 0·14 grain of lead per gallon. The chemists reported at the same time that they had placed some pieces of pure lead in a small quantity of water at the pumping station (both the well and the reservoir), allowing them to stand for 24 hours, and when the water was tested for lead no trace was found. They then repeated the experiment, but this time allowing them to stand for 48 hours. In this case there was the faintest trace, "but not estimatable." Side by side, they made the same experiments with the water supplied to their laboratories by the New River Co., and in each case found strong evidence of lead. They concluded, therefore, that the water supplied by the South Hants Water Co. had no perceptible action upon lead.

Subsequently the author made an inspection of the site in conjunction with the manager, and he reported that he was clearly of opinion that the presence of lead in the water was entirely due to electrolysis. The water service had clearly been attacked after passing the engine-house and storage batteries used on the place for the electric lighting of Twyford Lodge. As the water was alkaline in character, it could not by any possible means of itself have become a solvent for lead—in fact, in all cases in which water has an action upon lead, the use of lime, such as was adopted in the case for the softening of the water, is often the remedy prescribed. The analyst reported that the deposit in the lead service pipe was carbonate of lead, which he stated was no doubt formed by the action of water in the pipe. Additional samples of old and new lead pipe were tested, and it was shown that with the new lead pipe solvent action was perceptible which amounted to ·02 grain per gallon when allowed to remain in contact over-night, but on the second day the action was nil. The old lead pipe gave a rather larger quantity of lead. In the interval the chemists, having received a communication from the author, passed a current of electricity through the water contained in the pipe, allowing the action to go on over-night. In the morning the water was tested, and it was found a decided action had taken place, the activity having increased from 0·005 to 0·03; on the surface of the water they noticed some white powdery substance floating, and on the inside of the pipe several white patches had appeared. On examination, the powdery substance was found to be carbonate of lead, and they had no doubt the white patches were also carbonate of lead, which was beginning to form a crust on the inside of the pipe. They were of opinion, therefore, that the pipe in question was affected by its vicinity to the electric cable spoken of by the author, and that the corrosion of the pipe was entirely due to electrolysis.

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* Abstract of a Paper read before the British Association of Waterworks Engineers on Saturday.

Dr. Roberts then discovered a feeble current of electricity from the tap in the house in which the case of lead poisoning had occurred, and he also found it in other portions of the water company's district. Messrs. Lucas & Pyke were then instructed to make an inspection of the premises and to test the mains at Twyford with a view to ascertaining what was taking place. They say in their report that the pipe in which the electrolysis had taken place was a lead pipe between 200 yds. and 300 yds. long connected to the cast-iron main of the water company. After it left the cast-iron main of the company a branch from it was carried to Twyford Lodge, the residence of the owner of the property, and it then ran away in an opposite direction from the house in question, and passed near the engine-house where the electric plant supplying the current to Twyford Lodge is situated, and a branch water-pipe was carried into the engine house, and the pipe continues thence, and is forked to supply two cottages, this latter portion of the pipe being a comparatively new pipe. It was in the most distant of these cottages that the case of lead-poisoning took place, the subject being a man who was said to be a water-drinker. Tests were made to find out any difference of potential between any section of the pipes themselves and the pipes and the surrounding earth. The result of these tests was to indicate that the earth immediately under and round the engine house showed a positive charge as compared with the pipes running away from this house, the isolated branch pipe supplying the engine house showing the biggest difference when connected with the lead pipe that was continuous to the cast-iron main. The main was proved to be negative as compared with any part of the ground in the immediate vicinity of the engine house. A distinct difference of potential was obtained, not of large amount nor exceeding 0·2 of a volt in any case, which Messrs. Lucas and Pyke state would not be sufficient in their judgment to account for the comparatively extensive electrolysis that had occurred, and they also state that it was clear, from the fact that the South Hants water main was negative in every case, that the current could not have come from that direction. They, therefore, proceeded to examine the nature of the installation supplying the current to the premises, and found that an earthed return system had been adopted. From the information obtained and the inspection of what could be seen, it appeared that a copper uninsulated strip was run back from the engine-room to the house, which strip for a part of its run was enclosed in the same bitumen trough as the positive insulated main. There was no evidence of the strip having been properly connected to earth in the engine-house. A measurement of the resistance to earth of this nominally "earthed" return was taken, and it showed as high a resistance as 8 ohms. Moreover, the potential of the ground immediately surrounding the engine-house was distinctly above that of the nominal earthed return main, but again not amounting to more than 0·2 of a volt.

Up to this point the electrical engineers reported that the results obtained indicated a slight positive leakage round the engine-house which occurred when the installation was completely cut off and no current passing through the mains, and was due to the creeping from the battery, and they did not consider that they had obtained sufficient evidence of a leak to account for the electrolysis. It, therefore, became necessary to seek for some other source of leakage, and the high resistance between the nominally earthed return and the earth itself seemed to indicate the direction of the leak. A test was then made with the house installation connected on, and a current of 30 amperes passing through the mains, when immediately an E.M.F. was detected between the earth return and the water pipe running to the house of 1·8 volts, which, in the engineer's opinion, accounted for the whole trouble which had occurred. They observed also that the small leakages through the battery it is almost impossible to eliminate, and they expressed an opinion that they did not think them harmful.

The author communicated the fact to Messrs. Ogston & Moore, and they immediately instituted a further series of experiments, causing an electric current of 1·8 volts to pass through the water in a lead pipe, and on testing it found it to contain ·7 grain of lead per gallon. Two tests were made—in one case the current was allowed to pass through the water for the whole night, and in the other case for only four hours—and in each case the amount of lead subsequently found in the water was identical, so that it was amply demonstrated that a current such as that which was shown to be leaking from the electrical installation in question is ample to produce cases of plumbism, and may seriously affect all persons using such water supply.

In the discussion which followed the reading of the Paper:—

Mr. C. E. JONES (Leyton) said they had paid too little attention to the question of lead in water, and the subject of electrolysis had been shelved at their meetings on the ground that it was not proved that electrolysis affected gas and water pipes. It was now most authoritatively proved that electrolysis did affect the lead service pipes, a danger which could not be overrated. Lead was a most dangerous substance in water. In many cases it had caused "plumbism" by merely washing a child in water that had been impregnated with lead. There was a case of an infant being so washed that was shortly afterwards paralysed. A case happened to the Royal Family of France in which one grain of lead in the gallon caused 40 persons to be seriously affected, 13 of whom manifested the blue mark across the fingers and the toes. There were other dangerous symptoms but fortunately no fatality had resulted. Therefore it was necessary that water engineers should extend their knowledge not only to hydraulics but to the chemistry of the matter. He was very much afraid that many of the cases of lead poisoning were often referred to other causes by medical men. He did not bring any charge against the medical men, but he thought there was more danger of lead poisoning than had hitherto come to light. He had made experiments with white lead and water of various degrees of hardness. He thought with water over four degrees of hardness after the first coating of the interior of the lead pipe there would not be any danger.

Mr. W. H. HUMPHREYS said Dr. Houston, of the Local Government Board, had prepared two volumes on "plumbism" in Yorkshire and Lancashire, and he should like to see Dr. Houston extend his inquiries, to see if this was not occurring all over the kingdom. He suggested that the attention of the Local Government Board and the Board of Trade should be called to the report of Messrs. Lucas and Pyke, accompanied by a report of this discussion on Mr. Latham's Paper.

Amongst other speakers were Mr. S. R. Lowcock, Mr. C. H. Priestley (Cardiff), Mr. Ashton Hill (South Staffordshire Co.), Mr. Greenslade (South Hants Co.), Mr. Wm. Geo. Peirce (Richmond), Mr. E. J. Silcock (Leeds), and Mr. Easton Devonshire (London).

# CORRESPONDENCE.

## CABLE LAYING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As most central station engineers at the present day are extremely interested in cable laying, the following may prove of interest to your readers:—About six months ago, a length of new cable failed, which was taken out and replaced. A week ago the new length of cable broke down. This piece of cable failing so soon caused close investigations to be made as to the cause of the failure. The two cables—positive and neutral—were laid side by side in a single earthenware trough covered with pitch, the bridges of which had been carefully treated by impregnation with creosoted oil and afterwards boiled for some hours in pitch.

On examining the cable which had failed, it was found that in both this cable and the adjacent cable, for a distance of about 12 yds., the lead was very considerably reduced in section opposite the joint of each trough, as though the pitch had become fractured by the traffic at the sockets and water gained admission at these points. It may be here remarked that when the tide is up the ground at which the level of the cables were laid would be waterlogged.

The lead in all other parts of the cable (except at the spot at which the fault actually broke out, which was 6 in. from a point where electrolysis had taken place, and at this point no sign whatever of electrolysis could be detected) was in perfectly good condition. The appearance of the eating away of the lead certainly points strongly to electrolysis, but it is rather difficult to understand why this should have been taking place, inasmuch as when the lead was actually pierced a current of 40 amperes passed between this length of cable to earth, the total length of the two cables being approximately 200 yds., and the lead at this part not being connected to the lead on the other part of the network. There is no question of tramway currents entering these cables as they are completely out of the direct route of any tramways, and from the fact that lead water service pipes give no trouble whatever in the soil, ordinary chemical action would not appear to account for the trouble.

The only conclusion the writer can come to is that the trouble has been caused by electrolysis, but it is difficult to understand how sufficient current could have been passing between the dielectric and the lead to cause this trouble in such a short time. It would seem as if the necessary leakage to the lead to cause this damage were taking place at one particular spot, the paper would be rapidly carbonised, and in a very short time cause the lead to be punctured, and notice of a large earth having broken out immediately indicated at the generating station.

It is our practice to run with the neutral earthed at the generating station to the tram rails, and once during the night the neutral earth is disconnected, and the positive and negative connected to earth alternatively for a period of about 15 minutes each; this is done with a view to breaking down any earth which may have developed on the neutral and which would lead to serious trouble in the event of an earth occurring on either the positive or negative, if not located.

It would be quite easy to understand how the above could have occurred had the lead been sufficiently well insulated to allow only a few amperes to pass to earth, but from the fact of 40 amperes passing when the cable failed shows it to have been anything but well insulated. It would be interesting to know whether any other engineers have experienced similar results, and what their views on the matter are.—Yours, &c.,

THE CORK ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.)
H. NALDER,
Cork, Dec. 18. Chief Engineer and Manager.

N.B.—The neutral earthed to tram rails at Station only.

[This letter is referred to in our Editorial Notes.—ED. *E.*]

## ARMATURE COILS AND NITRIC ACID.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In *The Electrician*, Vol. LIV., p. 573, Mr. J. S. Highfield wrote a short article dealing with certain troubles that had been met with about that time in the working of his 3,000 kw. 11,000 volt steam alternators at Willesden, for which my company were the contractors. Previous to such publication Mr. Highfield courteously communicated with the parties concerned, in order to ascertain if they had objections to the publicity that would be thus given to the matter, and in view of the scientific interest attached to the questions involved, no objections whatever were raised at the time.

I do not propose to deal here with the causes that led to the troubles or with the nature of the same, beyond remarking that there never was any doubt with regard to these points. Moreover, it soon transpired that many other makers in this country, the States and on the Continent had met with the same phenomena from time to time and to a greater or less extent. But it is to be particularly noted that in the above-mentioned article of Mr. Highfield's it was specially pointed out that all the materials used in the construction of the armatures were the best of their respective kinds, and I may add that Mr. Highfield's statement in this respect was based upon the reports of the independent specialists to whom the question of the quality of the materials employed had been specifically submitted. The reports made by these gentlemen, based upon their analyses and examinations, were absolutely conclusive on the point, and it became perfectly clear that the troubles were due to other causes and conditions, which those interested will find set forth in Mr. Highfield's article.

Notwithstanding the fact that nearly £60,000 worth of plant was involved, regarding which even the shortest stoppage meant inconvenience and loss, the Metropolitan Company and its engineering staff (recognising that the troubles were due to exceptional causes which could not have been foreseen) extended their sympathy and practical help to the contractors from the first to the last, and after the difficulties had been overcome and the contract closed, an amount of £4,440 was awarded to the contractors as a bonus in respect to steam consumption, efficiency and reduced heating.

The publication of Mr. Highfield's article naturally gave wide publicity to the matter, and as a result much comment has been made in many quarters in regard to the same. Throughout, and from everyone (particularly from competitors) I have received much sympathy and evidences of goodwill, and in some cases considerable help, in the shape of data and particulars of similar insulation troubles with other high pressure plants.

It remains for Mr. W. H. Patchell, in his recent Institution Paper, to be the first, as far as I know, to bring up and treat this matter in an altogether different manner. Referring to Mr. Highfield's discovery of nitric acid in the windings of the the Willesden alternators, he says: "It appears to the author, therefore, that probably the acid is due to impurity of the insulating materials rather than the destruction of pure material by ozone."

In other words, Mr. Patchell, knowing little or nothing of the facts of the case, and in face of Mr. Highfield's explicit statement to the contrary, goes out of his way to do my company and the manufacturers of the alternators a grave injury by deliberately making the wholly incorrect assertion that the troubles were due to the use of bad materials.

I feel compelled, in the interests of the manufacturers of the alternators, to protest against Mr. Patchell's action, and in doing so have little doubt but that I shall have the support of all those who like to see fair play. It may be that Mr. Patchell, when making the comments in question, did not realise that he was doing an injustice and an injury to others, and if this were the case I have no doubt that he will think it well to withdraw or amend the statements referred to above.—Yours, &c., A. C. EBORALL.

London, Dec. 19.

## INDUCTIVE BALANCE DEVICES FOR THE PROTECTION OF ALTERNATING-CURRENT CIRCUITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If you will allow your valuable columns to be further occupied with a somewhat worn discussion, I would like to express my interest in the article, under the above heading, appearing in your current issue, inasmuch as it describes an arrangement put forth as a solution of a somewhat difficult problem which was set to the electrical manufacturers in a recent specification. I allude to the arrangement illustrated in Fig. 6, p. 350.

The problem is as follows: A low-tension distribution centre has two or more transformers fed by separate feeders from a sub-station. At times of light load it is desired to switch transformers out of circuit to avoid the magnetising current losses. It was specified that this was to be done in the following manner: The high-tension side of the transformer is opened in the sub-station; the low-tension side of the transformer is then to be automatically disconnected from the low-tension distribution centre 'bus bars by the reverse current flowing into the transformer due to its magnetising current.

Referring to Fig. 6 (p. 350) we have two solenoids the magnetic fluxes in which are due to the combined action of the low-tension 'bus bar voltage V, the current given by transformer $A = c_1$ and the current given by transformer $B = c_2$. The windings are so arranged that, leaving out of account phase displacements in the relay and discriminating transformer themselves, and also the phase displacements between the 'bus bar voltage and the currents from the transformers, we get—

$$\text{Flux in solenoid } A = k_1\{V + (c_1 - c_2)\}$$

$$\text{Flux in solenoid } B = k_1\{V - (c_1 - c_2)\}$$

$k_1$ being a constant.

Taking the force on the iron plunger to be proportional to the square of the magnetic flux we get—

$$\text{Force on the rocking plunger} = k_2[\{V + (c_1 - c_2)\}^2 - \{V - (c_1 - c_2)\}^2]$$
$$= k_2\{4V(c_1 - c_2)\}$$

$k_2$ being a constant.

This expression is proportional to the difference in the amounts of "*power*" flowing from the two transformers on a non-inductive load. If we had taken the phase displacements between the voltage and currents into account we should have come to the same result, except that the cosine of the angle of phase difference would have come in, and it would have been shown that the force on the rocking plunger is approximately proportional to the difference between the powers supplied by the two transformers under all conditions. The arrangement is a kind of differential wattmeter.

In order that the device under consideration may fulfil the purpose for which it is intended, we have to consider the following state of affairs which will occur on the system in question every day—viz., all the lights are turned off and two transformers are left connected to the low-tension 'bus bars; it is, of course, then desired to switch off all but one transformer, in order to reduce the unavoidable magnetising loss to a minimum. The high-tension supply of one of the transformers is switched off in the sub-station, with the result that the reverse current flowing into this transformer from the distribution centre low-tension 'bus bars must be sufficient to cause the device to operate.

Let $C_1$ and $C_2$ represent the full load currents of the two transformers, then the magnetising currents are $0{\cdot}005\ C_1$ and $0{\cdot}005\ C_2$ respectively. Therefore, the force on the rocking plunger $= F = k_3\ \{4V\ (0.005\ C_1 + 0{\cdot}005\ C_2)\}$, the quantities between the small brackets adding as the current in the switched off transformer has reversed. This force must be sufficient to mechanically cause the apparatus to work. Taking $C_1 = C_2$, which would be the case for equal sized transformers, or, which would come to the same thing, assuming the whole arrangement is worked through current transformers, and assuming also that the voltage remains constant we get $F = k_3\ 0{\cdot}01\ C_1$ as the maximum allowable mechanical force necessary to work the apparatus.

From this it follows that if the device be delicate enough to operate under the specified conditions, it will also operate when two transformers are on load directly the currents given by the two transformers, when running in parallel, differ by 1 per cent. of their full load value. This is obviously an impossible state of affairs, as it is impossible to get transformers to run so perfectly in parallel. The mere difference in internal drop due to one transformer being cold and the other hot may cause a 1 per cent. out of balance current. Clearly, therefore, the device cannot be set so finely that it will fulfil the specified conditions. If it *is* set to do so it would be impossible to run the system with it in operation. The only thing the arrangement in question will do is to cut off the transformer whose high tension is opened at the sub-station, provided there is considerable current flowing out of the low-tension side of the transformers at the time this is done. In order to render it capable of this service it must be set so that any unavoidable difference between the currents given by the various transformers is insufficient to cause it to operate, in which case it will not be sufficiently delicate to do so with the reverse magnetising current. It will, therefore, be seen that, although there can be no doubt the arrangement described in the article is a very ingenious one, it does not fulfil the called-for conditions. Whether it is possible, in fact, to strictly fulfil the said conditions is, to my mind, a matter of some doubt.—Yours, &c., CHARLES C. GARRARD.

Manchester, Dec. 16.

## WAVE SHAPES AND THREE-PHASE TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I was much interested in Mr. Dykes' letter in your issue of the 15th inst. It would appear to me, however, that the three-core transformer experimented upon by him could not have been perfectly symmetrical, as otherwise the three magnetising currents would be precisely alike. To obtain this perfect symmetry the three cores must evidently be placed one at each corner of an equilateral triangle. If placed in the same plane, as I judge from Mr. Dykes' letter was the case, the magnetic circuits are, of course, of unequal length, and this non-symmetry is followed by unequal magnetising currents.

But with symmetrically arranged magnetic and electric circuits, the wave forms of the three magnetising currents must be precisely alike, because there is no reason why any one should differ from the other two. These currents will be devoid of triple frequency components, the absence of which will allow the flux to drop below or rise above the true sine value at certain points in the wave. But if the neutral be now connected to the *true* neutral of the system, the triple harmonics will be supplied, the fluxes will take sine forms, and the core will exhibit no external polarity.

I do not agree with Mr. Dykes' statement that "all distortion effects in multi-core transformers can be avoided by using a four-core transformer, the purpose of the fourth core being to provide a return path for the triple-frequency fluxes from the other three cores." I presume that he is considering an unwound fourth limb. This provides a less reluctive path for the triple flux harmonic and tends to *increase* the voltage distortion. With this arrangement we may consider the case as equivalent to that of three separate single-phase transformers which do produce distortion. By forcing the triple-frequency flux to pass through the air, however, we supply a (counter) M.M.F. which tends to eliminate it, and restore the main fluxes to sine form. Were the air a perfect magnetic insulator, it would apply the whole M.M.F. required to force the fluxes to sine form, and the triple flux would not exist.

The same M.M.F. can be supplied by a short-circuited winding of negligible resistance wound round the three cores, or, which is the same, a "delta"-connected secondary winding. The effect of the slight resistance of such a winding will be to allow a slight triple flux-harmonic to exist, sufficient to keep the triple-frequency current flowing. Thus there is a very slight distortion, even in "delta"-connected transformers.—Yours, &c., R. C. CLINKER.

Rugby, Dec. 16.

## TRAIN-WEIGHT AND ACCELERATION UNITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I read, with much interest and some amusement, the communication published under the above heading in your issue of November 17, 1905, pp. 192-193, and signed by "International." I will trespass upon your valuable space, if I may, again, to a brief extent, to straighten out some obvious misapprehensions on the part of your correspondent.

I found that while I readily agreed with the author of this communication and could endorse—even applaud heartily—his opening remark, I could not follow him "in phase" beyond the end of the first sentence. The truth is that I am not at all in sympathy with any proposition or attempt, on behalf of the English-speaking races, or of any other races for that matter, to "patch up" an obsolete system of units. When "International" says at the beginning of the third paragraph: "In America we find a growing willingness to change," he speaks truly, but, unfortunately, for his view, what he says is not true in the sense or in the direction that he believes, or that he would, evidently, prefer. The kind of "change" which young American engineers want, which they (almost without exception) advocate, which they hope to have, which they will have, and which they would already have (were it not for the few remaining "older" conservative "fossils" in the engineering profession), is, I need scarcely say, the metric system! I could have said this in my previous communication, and I could also have added that I myself have been, from the beginning of my professional career, an enthusiastic partisan and a zealous advocate of the metric system, as my colleagues well know in America. I did not do so, because I wished then to limit my discussion to the question raised by the reviewer of Messrs. Ashe and Keiley's book—namely, whether the particular units used in America were in reality more of a "curiosity" than those used in England for train weights and for train acceleration.

The 2,000 lb. ton, known as the American "ton" or "short ton" is not, as your correspondent's reference would make it seem, an innovation on my part, but, as is well known, is an American institution of long standing. I am not trying either by guerilla warfare or other methods to "reform" the existing absurd system. I simply wish to use it, so long as we are obliged to do so, in the simplest, or better say, the least cumbrous manner consistent with the existing units or measures. The British ton of 2,240 lb. does not excite additional enthusiasm in me on account of the fact, mentioned by "International," that it is only 1·5 per cent. "out," as compared with the metric ton. I consider this fact to be not an "attenuating" circumstance, but an "exasperating" circumstance, and one which applies to all "counterfeits" or "imitations" of really good things in science as in art.

The fact that 102 lb. of tractive effort corresponds to, and can produce, theoretically, an acceleration of 1 mile per hour per second, which "International" apparently imagines he discovered, and on which proceeds to formulate a "convenient" rule, is so well known to every electric railway engineer in America that the wonder is that anybody could think it could possibly have escaped notice here. It would scarcely be possible, indeed, to use the equation expressing *acceleration* and the force producing it (whenever our "curious" unit of acceleration is used—*i.e.*, the mile-per-hour-per-second) without coming across this fact, even if trying to avoid it, since the number of pounds in a ton enters in these equations, which, by the way, "International" will find given as equations (20) and (22) in the writer's Paper on "Speed-time Curves," presented before the A.I.E.E, June, 1902 (*Transactions*, Vol. XIX., pp. 1,115-1,116). In using these equations in America, where train weight is usually measured in short tons, we insert the figure 2,000 instead of 2,240, and our factor is, therefore, 91·1, a figure perfectly familiar to all American railway engineers.

When we have to deal with the English ton, we simply multiply our factor (91·1) by the ratio $\frac{2{,}240}{2{,}000}=1{\cdot}12$, the result being 1·12×91·1=102. We could also, of course, get this new factor (102) from the equation directly, by inserting therein the figure 2,240 instead of 2,000. We have known, and have done, these things for many years, as "International" can easily verify. Let us see now, since "International" raises the question, whether the long ton has all the advantages which he thinks it has over the short ton, because this factor happens to be 102 in the case of the long ton. His "round number" is 100, or 2 per cent. less than the actual value. The American round number is 90, or about 1 per. cent. less than the actual value. His round number, therefore, occasions an error of 2 per cent., while the American round number occasions an error of only 1 per cent.

To obviate all misunderstanding, and also because "International" has apparently not grasped the full significance of what I said in my previous communication on the subject of acceleration units, I wish to emphasise the fact that my preference for the mile-per-hour-per-second, when the English system of measure has to be used, arises from, and is wholly due to, my objection to any system, unit or measure of acceleration involving two distinct concepts or measures of velocity, when a single one will answer the purpose better. When using the metric system, I would favour, and, as a matter of fact, I prefer to use, the kilometer-per-hour-per-second, for the same reason.

Before concluding, I may be allowed to say to the "Reviewer" who commented on my previous communication, that I have no quarrel with him as to whether we should say "measure" or "unit." It is largely an academic question after all. The "Reviewer" will find, in an interesting editorial on the "unit of acceleration" in the *Street Railway Journal* of November 11, 1900 (Vol. XXVI., p. 870) some interesting remarks upon units in general, and on this "unit" in particular, and, incidentally, a very good presentation of the "case of the defendant," that is to say, the mile-per-hour-per-second. I will add that, even if his contention be true, he should rather adapt the name to the substance, than do the reverse. I prefer a logical direct "measure," if measure it must be, to an illogical roundabout "unit."—Yours, &c.,

New York, Nov. 28. C. O. MAILLOUX.

[Mr. Mailloux's line of argument is an elegant example of that process of adopting a particular measure happening to suit some particular industry, which has given us the heterogeneous collection of stones, bushels, hundredweights, rods, acres, &c., to which he properly objects. "Illogical" would not be an inapt term to qualify a "unit" which, having to include the square of a time, chooses two measures of time having a ratio of 1 to 3,600.—YOUR REVIEWER.]

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

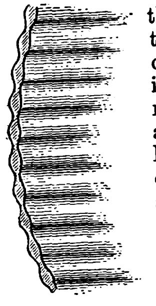
"Dynamo-electric Machinery." By Prof. Silvanus P. Thompson, F.R.S. 7th edition. Vol. II., Alternating-current Machinery. (London: E. & F. N. Spon.) 30s.

"Annuaire pour l'An 1906," publié par le Bureau des Longitudes. (Paris: Gauthier-Villars.) 1fr. 50c.

"Landolt-Börnstein Physikalische-Chemische Tabellen." By Dr. Richard Börnstein and Dr. Wilhelm Meyerhoffer. 3rd edition. (London: Williams & Norgate.) 36s. net.

"Fortschritte der Elektrotechnik." Part IV., 1904. Part I., 1905. Edited by Dr. Karl Strecker. (Berlin: Julius Springer.) 12m. and 7m.

## THE BÖHM LENS LAMP.



SECTION THROUGH GLASS GLOBE OF BÖHM LAMPS.

Mr. E. Böhm, referring to a leading article on "Lamp Globes" in *The Electrician* of Nov. 3, p. 105, in which the question of the shape of incandescent electric lamp globes was touched upon, invited us last week to inspect the Böhm "lens" lamp. The only difference between this and an ordinary lamp lies in the design of the globe, a section through which is as indicated in our sketch. It will be observed that the glass is not merely corrugated, but is shaped to form an actual lens. The object of this is to concentrate the light in a certain direction (usually in the direction of the lamp axis) and this is a valuable feature for a number of purposes where an illumination in all directions is not desired. In a test made by Mr. F. Satchwell, for instance, the vertical candle power was increased from 7·4 to 38·5 c.p. by substituting a Böhm globe for an ordinary globe, and at the same time the horizontal candle-power decreased from 16·3 to 12·8 c.p. It may be remarked that the same filament was used in both cases and that the energy consumption was also the same. It appears from a number of tests carried out by the National Physical Laboratory and Faraday House, that the watts per candle-power in a vertical direction range from about 1·87 in the case of a 45 c.p. lamp to 1·95 in the case of a 15 c.p. Böhm lamp. We were shown a very large assortment of lamps of many shapes, and were informed that a company is being formed for the manufacture of them on a larger scale than hitherto. The price of the lamp, it should be mentioned, is considerably higher than that of the ordinary lamp.

## LEGAL INTELLIGENCE.

### Manchester Tramway Arbitration.

In the House of Lords on Friday last judgment was given by Lord Macnaghten (presiding) and Lords Robertson and Lindley in the appeal by Manchester Tramways & Carriage Co. arising out of an arbitration between the company and Swinton and Pendlebury District Council (briefly reported in our issue of 1st inst.). The difficulty in the case arose to some extent from the fact that the arbitrator whose award was under consideration (Sir F. Bramwell) has since died, and therefore it was impossible to refer the case back to him to clear up a point in doubt that had been raised in the Court of Appeal as to the exact meaning of a part of his award. The question in dispute was whether a depot situated outside the Council's district, but found by the arbitrator to be suitable to and used for the purposes of the undertaking within such district, was to be taken and paid for by the Council. The purchasing authority contended that they were not liable to take and pay for anything outside their own district. The arbitrator found that the value of the tramway was £24,689; the value of the lands and buildings constituting the depot in dispute was £24,009; and the value of the fixtures and fittings at the depot £308, making altogether £49,006. Mr. Justice Channell had held that the Council, on the finding of suitability and user by the arbitrator, was bound to pay for the depot. The Council appealed, and the Court of Appeal found that, as the finding of the arbitrator was not expressed in exactly the same words as those used in the section in the Act, the company could not compel the Council to purchase the depot. The company appealed to the Upper Chamber, and

Lord MACNAGHTEN, in giving judgment, said that on receiving the necessary statutory notice the company were bound to sell to the Council "their undertaking or so much of the same as is within the district," and the purchasing authority was bound to pay "the then value"—that was in his lordship's opinion, the value at the date of notice (exclusive of any allowance for past or future profits, or any compensation for compulsory sale or other consideration whatever)—"of the tramways and all lands, buildings, works, material, and plant of the promoters suitable to and used by them for their undertaking within such district." What the arbitrator had to find was the value to the promoters, not the value to the purchasing authority. Lord Macnaghten then reviewed the award and said that the Court of Appeal had inferred from certain variation from the words of the section in the language the arbitrator had used that there was some ambiguity in the award, and that the arbitrator had it in his mind to submit to the Court some question of law which he certainly did not formulate, and which counsel for the Council candidly admitted he did not ask him specifically to state. Counsel for the company had contended that if such depot was, in fact, suitable to and used with their undertaking within the Council's district, the Council were bound to purchase it, although it was situated outside their district. That was the question which the arbitrator had submitted for the decision of the Court. The questions of user and suitability were questions of fact which he himself had answered as questions of fact in favour of appellants. The question which the arbitrator had reserved—the question depending on geographical position—had been decided in favour of the company by the learned judge of first instance. In his opinion that was the right answer, and he moved their lordships that the order appealed from be reversed, and that the order of Mr. Justice Channell be restored, with costs both in this House and in the Court of Appeal.

Lords ROBERTSON and LINDLEY concurred, and the appeal was allowed accordingly.

### Re Letters Patent (No. 14,006, 1903).

In the Court of Appeal (Lords Justices Vaughan Williams, Stirling, and Cozens-Hardy) on Saturday, judgment was delivered on the appeal of the owners of letters patent granted to one Allsop from a decision of Mr. Justice Buckley. The question for decision arose on a petition for revocation of the patent, which was for a new process of purifying flour by electricity, and thus increasing its nutritive value. The machine consisted of two parts. By means of the first a powerful current was passed through air, altering its chemical qualities, and the air so treated was passed into another machine, where the flour was subjected to treatment. The owners of the patent recognised that some of the clauses of the specification as they now stood were invalid, and they asked Mr. Justice Buckley for leave to apply to disclaim that part of the invention which related to a suggested chemical action which it was now known did not take place. The petitioners opposed the application, and pressed for the revocation of the patent on the ground that what the applicants proposed to do was not to disclaim, but to correct the specification by striking out incorrect statements and leaving the invention as wide as it was before. Mr. Justice Buckley held that the word "disclaimer" in Section 19 of the Act of 1883 was to be read strictly, and did not include corrections or such explanations as might be required for the purpose of defining the claim. He held that what the patentee sought to do was not within the section. He refused to grant the liberty asked. Hence the present appeal.

Their Lordships unanimously decided to allow the appeal. Order accordingly.

In the Chancery Division on Tuesday Mr. J. C. GRAHAM mentioned this case to Mr. Juctice Buckley. The patent is claimed to be of enormous commercial value. Counsel asked that, having regard to what had taken place in the Court of Appeal, the case might stand out of the list until the Comptroller had decided whether the patentees could amend or not.

His LORDSHIP acceeded to the application.

### Underground Electric Railways Co. of London v. Commissioners of Inland Revenue.

In the House of Lords on Friday last, the Earl of Halsbury and Lords Robertson and Lindley gave judgment in this case (reported in our issues of April 22 and Dec. 9, 1904). It was an appeal from a judgment of the Court of Appeal reversing a decision of Mr. Justice Channell. The question at issue was the amount of stamp duty payable on the sale of the old railway undertaking to the appellants.

The Earl of Halsbury and Lord Robertson intimated their agreement with the judgment which Lord Lindley was to read.

In delivering judgment Lord LINDLEY said that the words of sec. 56 of the Stamp Act, 1891, were wide enough to cover all moneys which might become payable, and the latter part of clause 2 of the section certainly favoured that construction. Sec. 57 enacted that money payable on a contingency was to be taken into account; and that removed any doubt on the matter. The contention of the Crown must be affirmed and the appeal dismissed with costs.

Judgment accordingly.

### Dickson v. R. W. Blackwell & Co. (Ltd.)

At Perth Sheriff Court on Friday last Sheriff Sym closed the record in the action for payment of £300 at common law, or £178 under the Employers' Liability Act for personal injuries. On May 22 pursuer, who was in the employment of defenders, was engaged (along with other men) lifting tramway rails on to a lorry. While pursuer, with four other workmen, was lifting one of the rails on the instructions of the foreman, it tipped, fell and injured pursuer. It was contended that if a sufficient number of workmen had been provided they would have been able to prevent the falling of the rail and the injury. At the time of the accident pursuer was earning 23s. a week.

DEFENDERS plead that the number of men was ample, and, in fact, large quantities of the rails had been safely and satisfactorily loaded by four or five men for some months prior to the accident. They further plead that the action is irrelevant, and that as pursuer's injuries are due to the fault of persons engaged in common employment with him he is not entitled to claim compensation. In any case, the damages claimed are excessive.

### Kilby v. Battersea Polytechnic Governors.

At Wandsworth County Court on Monday, Wm. Hy. Kilby, a laboratory mechanic at Battersea Polytechnic, sued the Governors for damages for injuries to his right eye, but when the case was called on Mr. Shakespeare (for defendants) consented to judgment for £25 and costs.

It appeared that on Nov. 21, 1904, Plaintiff, while passing through the engineering workshop, was struck in the eye by a splinter of steel, which had been chipped from a larger piece by one of the students. Plaintiff's wages were paid up to July 24, when the action was commenced.

**Differential Charges for Electric Energy.**—The Supreme Court of Victoria (Australia) recently delivered an important judgment in an action brought by the Melbourne Gas Co. against Melbourne City Council for an injunction restraining the Council from charging different rates for electricity for lighting and power. The company argued that the charge made by the Council to some consumers was on a flat rate, whereby payment was demanded for the actual quantity of electricity used at 5d. per unit, while other consumers were charged at 8d. per unit as to such portion of electricity supplied to them as was equal to a consumption for 45 hours per calendar month at the highest rate of consumption during the month, and as to the remainder at 2d. per unit. The Council admitted that it supplied some customers at 4½d. per unit and others at 7d. per unit for a portion of a calendar month and 2d. for the remaining part, but denied that it was acting in contravention of the Electric Light and Power Act, 1896. The Full Court held that it was a breach of the act to differentiate in the charges to various classes of clients, and an injunction restraining the Council from so charging was granted.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT AND FILLED.

An assistant manager is wanted in a large manufacturing and contracting company to take charge of general correspondence, analysis of cost, accounts, &c. See advertisement.

An improver is wanted to act as switchboard attendant at Coventry electricity works with a view to becoming a shift engineer. Applications by Jan. 3, to the manager of the electricity works, Mr. Joseph A. Jeckell. See advertisement.

An examination will shortly take place for appointments as second-class engineers in the Engineer-in-Chief's Department, G.P.O. Jan. 11 is the latest date for receiving applications. Forms from the Secretary, Civil Service Commission, Burlington-gardens, London, W.

A lecturer in physics is required at Armstrong College, Newcastle-on-Tyne. Salary £200, rising by annual increments of £10 to £250. Applications by Jan. 13.

An assistant lecturer in mechanical engineering is required at the Royal Technical Institute, Salford. Application by Jan. 10.

Mr. W. A. Chamen (of Messrs. Bramwell & Harris, and late chief engineer of the Glasgow Corporation Electricity works) has been appointed manager of the South Wales Electrical Power Distribution Co., in succession to Mr. Hill, who recently resigned.

Mr. J. P. Kemp (Messrs. Kennedy & Jenkin) has been appointed resident engineer at the Summer-lane station of Birmingham Corporation electricity department.

Mr. W. C. Acfield, of the London, Brighton, and South Coast Railway, has been appointed signals superintendent of the Midland Railway, in succession to Mr. T. W. Woodward, retired.

Mr. J. Foster has been appointed car-shed superintendent by Johannesburg Municipal Council.

### EDUCATIONAL NOTICES.

**King's College, London.**—The Lent term commences on Jan. 9. In addition to the ordinary day classes there are evening classes for electrical and mechanical engineering, architecture and building construction, drawing, mathematics, physics and other science subjects. There are also advanced evening classes in electrical and mechanical engineering. Prospectuses, &c., from the secretary, King's College, Strand, W.C.

**Swansea Technical College.**—Steps are being taken by the Swansea Educational Authority to have the technical college affiliated to the University of Wales.

**Regent-street Polytechnic.**—On Friday evening Lord Armstrong distributed the prizes and certificates won during the past session.

**Stockport Technical School.**—Dr. A. Hopkinson, K.C., vice-chancellor of Victoria University, distributed the prizes to the successful students of this school on Friday last. In the course of his address Dr. Hopkinson invited employers of labour to encourage their apprentices and young men to attend evening classes, as then it was possible they would themselves be recouped later by the greater efficiency of their workmen.

**Aberdeen.**—The Town Council have decided to appoint a general manager, at £300 per annum, to take charge of the tramway undertaking, including rolling stock, but exclusive of electrical and mechanical equipment and permanent way.

**Amersham.**—The Empire Electric Light & Power Co. recently applied for sanction to erect overhead conductors for transmitting electricity from Chesham to Chartridge, but the Council have decided to insist on underground cables being used.

**Argentina.**—The city of Cordoba, which has had electricity supply since November, 1897, has now 2,500 consumers on the mains of the Cordoba Electric Light and Power Co., with a total connection equivalent to 70,000 8 c.p. lamps.

**Australasia.**—Wellington (N.Z.) City Corporation, which has now taken over the operation of the tramways from Wellington Tramways Board, operates 22 miles of single track, 42 motor cars being employed in the service.

At Dunedin (N.Z.) the Corporation have also taken over the tramways from the Dunedin Tramways Boards. There are now 21 miles of single track in operation. The plant includes a battery of 260 Tudor cells of 400 ampere-hour capacity. 44 motor cars are employed in the service. These tramways have been running for exactly two years.

At Stratford (N.Z.) the local electrical supply company has been at work since December, 1899, and has now 280 consumers connected to the mains, with a total lamp connection on Dec. 1 of the equivalent of 55,114 8 c.p. lamps for lighting only. Generation of current is by water power with twin turbines to each generator. In this city the Okioma butter factory has been for the past five months operated by electric motors to the extent of 40 H.P., current being supplied by the Hawera County Electric Lighting Co., and at Inglewood the butter factory has also decided to adopt electric driving, and will take current from the Inglewood Electric Lighting Co. There are a large number of water powers in this part of New Zealand, and much feeling has been created by the Government having passed a measure through Parliament creating these water powers Government assets. It has now, we understand become difficult to obtain concessions for using the available waters.

At Sydney (N.S.W.) the Empire Electric Light Co. has an equivalent connection of 37,600 8 c.p. lamps. The negotiations for the supply of current by Sydney municipal electricity department in the suburb of Paddington have been satisfactorily concluded. The mains are to be exempt from taxation during the period covered by the agreement—25 years.

On the recommendation of a sub-committee Balmain (near Sydney) Borough Council has decided upon the erection of a refuse destructor and electricity works.

A statement of the views of the Victorian Railway Commissioners (Messrs. T. Tait, W. Fitzpatrick, and O. Hudson), on the proposed electrification of the steam railways in the Melbourne suburbs has been submitted to the Railway Standing committee appointed to inquire into the question. The Commissioners were not opposed to the electrification of the existing lines, always provided these would yield sufficient additional net revenue to pay the capital and interest charges on the cost of conversion. No obligation should be entered into until a most thorough investigation and full report had been made by an absolutely independent consulting electrical engineer of the highest ability and standing. The Commissioners urge that the expenditure of £256,559 for the conversion of the St. Kilda line to electric traction and for the construction of the six electric street tramways (as estimated by Mr. Bradford) should not be undertaken until all the funds were not only available but earmarked for the purpose. Developments were continually taking place in electric traction, and proposed investigation should not take place until immediately prior to the date on which the Government would be assured of possession of the requisite funds. The Commissioners report concluded as follows: "The question whether the provision of street tramways should not be left to the municipalities concerned, or, under satisfactory terms and with proper safeguards, to private enterprise, is one deserving of serious consideration."

**Ayr.**—A special committee has been formed to consider the advisability of extending the tramways.

**Barnstaple.**—An inquiry was held yesterday into the application of the Council for permission to borrow £4,000 for extension of the electricity works.

**Bermondsey (London).**—At the audit of the accounts of the Electric Lighting committee for the year ended March 31, which took place at the Town Hall on Tuesday, objection was raised to the electricity supply works and refuse destructor being under the management of one committee. It was contended that the departments should be separate and the accounts be kept distinct. The auditor reserved his decision.

**Birkenhead.**—The Council have decided to apply for an injunction against the Mersey Railway Co. to restrain them from running motor-omnibuses.

**Birmingham.**—On Tuesday the tramways manager (Mr. A. Baker) reported to the Tramways committee that he had been part of a deputation which waited upon the Board of Trade in regard to the Board's refusal to allow the Birmingham Corporation electric tramcars to be fitted with roof covers. He (Mr. Baker) pointed out that some of the company's cars running into the city were provided with covered tops. The Board's contention was that covered cars on narrow tracks were liable to be capsized by the wind; but Mr. Baker pointed out that no such accident had occurred to the covered cars which had run in the city during the last 18 months, and it was calculated that a gale of 60 miles an hour would be necessary to overturn one of the cars.

**British Electrical Friendly Society.**—At the fourth annual meeting of this society, held on the 11th inst., there were 40 delegates present, representing branches in all parts of the kingdom, under the presidency of Mr. W. G. Bond, who, in moving the adoption of the report and accounts, said the membership had increased from 1,950 to 2,142 during the year. In the same period income increased from £3,574 to £3,718, and expenditure decreased from £3,336 to £3,266. Sick pay claims amounted to £887. 12s. 6d., compared with £2,004. 2s. 10d. The available assets of the society now amount to £1,260. At the conclusion of the chairman's remarks a discussion followed, and suggestions were made for a considerable extension of the society's operations. The chairman stated that the suggestions would probably be dealt with by the Central Committee during the year.

**Burslem.**—The Council have received sanction to a loan of £5,500 for extending their electric lighting mains.

**Bury (Lancs.)**—The total revenue of the Corporation tramways for the past year was £19,544, working expenses £11,041. After paying interest and sinking fund the net balance was £510, which has been carried to reserve; 4,065,455 passengers were carried; the average revenue per car mile was 9.21d., average working expenses (including power cost) 5·20d.

**Cardiff.**—There are now 1,209 consumers connected to the mains representing the equivalent of 144,383 8 c.p. lamps against 118,930 at the corresponding period last year. The total revenue for last month was £3,826. 12s. 2d. against £2,354 for corresponding month last year.

**Chili.**—Electric traction is being introduced in Valparaiso by the A.E.G. Co. of Berlin, and it is proposed to run electric tramways between this city and Santiago and other parts of the country. Already several small towns in Chili have their electricity supply stations and we learn from a correspondent that there is an opening in Chili for all kinds of electrical goods, with the prospect of excellent business in every branch. The character of the population is, however, such that direct representation of the manufacturers is essential. Water power is being employed, and the power available throughout Chili is, it is said, almost incalculable. The subject of water-power generation of electric current in Chili is attracting much attention.

**China.**—The China Light & Power Co. (general managers, Messrs. Schewan Tomes) are supplying light and power on the alternating-current system to Canton and Kowloon. Canton has a population of 1,500,000. The population of Kowloon has not been ascertained. At Canton there are 1,500 consumers, and at Kowloon 250, the number of equivalent 8 c.p. lamps connected at the former city being 16,000 and at the latter 6,000. The supply cables are run overhead, with H.T. twin armoured cables, across the river which divides Canton from Kowloon. The stations have been equipped by the company's engineer, Mr. L. Marston (who is consulting engineer of the works and engineer-in-chief), assisted by the resident engineers, Mr. S. F. Ricketts (Canton) and Mr. G. L. Hales (Kowloon).

**Cromer.**—The Council are recommended to apply for a further loan of £11,000 for extensions of the electricity works. The new fire station is to be wired for the electric light.

"**Dividing the Spoil.**"—At the Guildhall (London) on Friday before Sir John Bell, the Commissioner of City Police (Capt. J. W. Nott Bower) was summoned at the instance of Mr. F. J. Gould, manager to James Milne & Son, for payment of £337. 10s., now in possession of the police, which formed portion of the moneys found on the prisoners Leslie and Cheeseman at the time of their arrest for certain "long firm" frauds recently exposed in the Central Criminal Court.

The application was opposed by several parties, who alleged that they had equal claims, and pointed out that Messrs. Milne had borne no part of the costly prosecution in the case referred to. After hearing Inspector Willis, Sir John Bell said it seemed to him that all the creditors should share in the moneys found. Messrs. Milne appeared to have quietly sat down while the prosecution was going on, taking no part in it, but as soon as it was over they wanted their share of the spoil. Mr. Tweedie Smith (for the official receiver) characterised the claim as an impudent one, and said his client submitted that the amount in hand ought to be equally divided among the creditors. Sir John adjourned the case for a month with a view to the parties interested coming to an understanding.

**Dolgelly.**—The Council have decided to "invite tenders from electrical engineers to prepare a preliminary report on the question of electricity supply."

**Dumfries.**—The Council have approved an agreement for transferring their provisional order to the India Rubber, Gutta Percha & Telegraph Works Co., who undertake to establish electricity works in the town. The company are to pay the Council £700 to cover the cost of obtaining and transferring the order, and are also to pay £100 annually as rent for the site of the works and £30 to cover cost of inspection. Electricity is to be supplied at prices not exceeding 7d. per unit for lighting and 3d. for power and heating. The Council is to have the option of purchase in 1913, 1918, 1925, 1933, or 1940, on payment of capital expended and 25 per cent. premium.

**Dundee.**—After hearing a discourse on car-top covers delivered by the tramways manager (Mr. P. Fisher) the Tramway committee decided to have a car equipped as an experiment at a cost of about £65 with a combination of the forms of roof covers used at Bolton and Glasgow.

The committee has authorised the preparation of specifications for an extension of the tramways.

The Board of Trade inspection of the electrical equipment of the

Dundee, Broughty & Monifieth line took place on Thursday last, and the permanent way was inspected on Tuesday.

At the meeting of the Electric committee on Monday the engineer (Mr. H. RICHARDSON) explained his estimates for the extension of the existing station and mains at a cost of £25,000, and also his alternative scheme for a new station at an outlay of £75,000. Mr. Richardson, who advises the adoption of the latter proposal, is also to report upon the desirability of erecting a refuse destructor with steam raising plant at the present works in the event of the scheme for a new station being adopted.

Mr. BROWNLEE (convener of the committee) referred to an offer made to Mr. Richardson of an appointment at £700 per annum by a leading engineering firm in England. Mr. Richardson stated that he had decided to decline the offer, feeling that he enjoyed the confidence of the committee.

Negotiations between the Council and Messrs. Gourlay Bros. & Co. for the supply of electric power to Camperdown Shipyard have fallen through, and the firm have decided to put down an independent plant for generating current for lighting and power. The Council proposed, it is stated, to supply three-phase current, and Messrs. Gourlay wished for continuous-current supply.

**East Ham.**—The engineer and manager of the electricity works (Mr. W. C. Ullman) is to report on the proposal for the supply by Woolwich Council electricity department of electricity in bulk for distribution in certain parts of East Ham.

An employe of the Council is to be allowed to trim and adjust private arc lamps, if desired by customers, at 2s. per lamp per quarter.

**Electrical Exhibition Memento.**—The smoking concert of the Electro-Harmonic Society on Friday evening last was of special excellence, and introduced members of the Society to some new artistes and to some new songs. The event of the evening was the presentation, previous to the interval, to each of the members of the Executive committee of the recent Electrical Exhibition at Olympia of a memento of that event subscribed to by a large proportion of the exhibitors, and presented as a slight mark of their appreciation of the labours of Mr. E. Cunliffe Owen, C.M.G., and his colleagues on the committee, whose good work contributed so considerably to the undoubted success of the Exhibition.

The memento took the form of a non-magnetisable open-faced gold chronograph, jewelled in 17 holes, manufactured by Messrs. S. Smith & Sons, of 9, Strand, London, W.C., suitably inscribed, for Mr. E. Cunliffe Owen, as chairman; a 15-carat gold combined matchbox and sovereign purse, suitably inscribed, for Mr. C. S. Northcote, as deputy-chairman; and a 15-carat London-made gold curved matchbox in case, suitably inscribed, to each of the following: Messrs. S. W. Baynes, H. Bevis, O. H. Bishop, H. W. Butler, Sydney T. Dobson, J. E. Edgcome, T. C. Elder, Frank Gill, J. E. Kingsbury, H. Oppenheimer, W. L. Pakenham, W. H. Patchell, Roland Portheim, W. R. Rawlings and Walter Davenport (secretary). The matchboxes were supplied by Messrs. J. J. Stockall & Son, of Clerkenwell-road, E.C. Between £67 and £68 was collected, the following each contributing 10s. 6d.:—

W. H. Allen, Son & Co.
Amalgamated Dry Batteries.
Arc Lamps (Ltd.).
Armorduct Mfg. Co.
Babcock & Wilcox.
Bat Electrical Co.
A. Blackmore.
D. H. Bonnella & Son.
Brockie-Pell Arc Lamp.
British Auto. Photo. Co.
British Elec. Plant Co.
British L. M. Ericsson Co.
British Prometheus Co.
Bruce Peebles & Co.
Brush Elec. Eng. Co.
N. Burt & Co.
Callender's Cable Co.
Charing Cross, West End & City Elec. Supply Co
City of London Electric Lighting Co.
Cons. Pneumatic Tool Co
Cory Bros. & Co.
Cowans (Ltd.) & Key Eng. Co.
Crompton & Co.
Davey, Paxman & Co.
D. P. Battery Co.
J. Defries & Sons.
Jas. Dickson.
Diesel Engine Co.
Dorman & Smith.
Dowsing Radiant Heat Co.
Drake & Gorham.
Edison & Swan Co.
Efandem Co.
Elec. & Ordnance Accessories Co.
Elec. Eng. (R.E.) Volunteers.
Electrical Press (Ltd.)
"Electrical Review."
"Electrical Times."
"The Electrician" Printing & Publishing Co.
"Electricity."
Elec. Power Storage Co.
Electromotors (Ltd.).
Electrophone (Ltd.).
Elliott Bros.
Escare & Denelle.
Everett, Edgcumbe & Co.
Falk, Stadelmann & Co.
Ferranti (Ltd.).
Foxcroft & Duncan.
I. Frankenburg & Sons.
Fricker & Miller.
Geipel & Lange.
General Electric Co.
W. T. Glover & Co.
E. Green & Son.
J. Halden & Co.
A. C. Hands.
Hart Accumulator Co.
W. T. Henley's Tel. Works Co.
Carl Hentschel (Ltd.).
High Speed Braiding Machine Co.
Howard Bros.
Hunter Elec. Candle Lamp Co.
Hunt & Hess.
International Electric Co.
Klein Enging. Co.
Jas. Keith & Blackman Co.
Lahmeyer Electrical Co.
Langdon-Davies Motor Co.
Le Carbone.
Linolite Co.
Lister Electric Mfg. Co
London Elec. Fittings Co.
Lucy and Co.
A. P. Lundberg.
W. McGeoch & Co.
Marryatt & Place.
Maple & Co.
McPhail & Simpson's Dry Steam Patents Co.
Metropolitan Elec. Supply Co.
Monte, Callow & Co.
Morgan Crucible Co.
Mountain and Gibson.
Nalder Bros. and Co.
Nalder Bros. & Thompson.
National Gas Engine Co.
New Brotherton Tube Co.
Oliver & Co.
Oliver, Clark & Co.
Ozonair (Ltd.).
Thos. Parker (Ltd.)
R. W. Paul.
Frank Pearn & Co.
Pope's Electric Lamp Co.
Pritchetts & Gold.
Rawlings Bros.
Reason Mfg. Co.
Regina Arc Lamp Mfg. Co.
A. Reyrolle & Co.
Robertson Elec. Lamps.
Rumney & Rumney.
D. Santoni & Co.
St. James' & Pall Mall Elec. Lighting Co.
Selig, Sonnenthal & Co.
Siemens Bros. & Co.
Simmonds Bros.
Simplex Steel Conduit Co.
Steel Core Concrete Co.
Steel, Peech & Tozer.
Sterling Telephone & Electric Co.
Stewarts & Lloyds.
J. J. Stockall & Sons.
Sturtevant Eng. Co.
J. E. Spagnoletti & Co.
Sunbeam Lamp Co.
Switchgear Co.
Temperley Transporter Co.
"Tramway & Railway World."
Dr. Heinr Traun & Sons.
J. H. Tucker & Co.
Tudor Accumulator Co.
Union Electric Co.
Vickers, Sons & Maxim.
Veritys Limited,
W. G. Walker & Co.
Wandsworth Elec. Mfg. Co.
Western Electric Co.
Westminster Elec. Supply Corpn.
A. P. Wright & Co.

Mr. JOHN GAVEY, C.B., President of the Institution of Electrical Engineers, distributed the souvenirs, amid the applause of a large gathering. Mr. Gavey referred to the all-round success of the recent exhibition. Not only had it been the means of displaying before a large public the possibilities and advantages of electricity in all directions, and in converting the most sceptical, but it had also been a decided financial success. Thus it had been possible to give back to the exhibitors 25 per cent. of what they had paid for space, to hand over £250 to the Benevolent Fund of the Institution of Electrical Engineers, and to contribute largely to the Benevolent Fund of the National Electrical Manufacturers' Association. The success of the venture was largely due to the skill and untiring energy of Mr Cunliffe Owen and his committee, and the exhibitors, under the auspices of the electrical journals, had felt impelled to express their gratitude to those gentlemen in the form of the souvenirs they were now receiving.

Mr. E. CUNLIFFE OWEN, in a few well-chosen words, replied on behalf of himself and his colleagues, and said that any good work his committee and he had accomplished had been a work of love. Not only had the exhibition been a success financially, but it had brought about much good feeling and even friendship between exhibitors to a degree which had not previously existed. He was a guest at the Electro-Harmonic Society's gathering that evening, but so genial and excellent had been the entertainment offered that he hoped to be present at many more gatherings, not as a stranger but as a member, and he believed many others had made the same resolution. He was speaking for all his colleagues when he thanked the conductors of the electrical journals who had organised the presentation and the contributors for their kindly recognition of the committee's services.

**Electrical Workers in Canada.**—Mr. F. A. Cambridge, city electrician, Winnipeg, Man., writes us as follows:—

I think it is about time that electrical workers were apprised of the fact that there is little chance of their obtaining employment in that line out in this section. Many cases have come to my notice within the past 12 months in which men had given up employment at home in order to, as they thought, better their positions out here, only to find that they had made a mistake. There is every chance for agricultural help out here, but electrical work in the Far West being somewhat limited it is impossible to find work for the numbers of men coming out.

**Electricity in Workshops.**—A spinning and weaving factory is to be established, it is stated, at Cerano, Italy, and the whole of the machinery is to be electrically driven.

**Erith.**—From March 31 the charges for electric current for power will be reduced to 2d. per unit for first 1,500 units per month, 1¾d. up to 3,000, and 1½d. beyond.

**French Submarine Telegraph Cable Enterprise.**—The French war cruiser "D'Entrecasteaux" sailed recently from Toulon to make the preliminary surveys, &c., for the French Tamatave-Réunion-Maurice telegraph cable.

**Guatemala.**—The Empresa Electrica de Guatemala, which owns the electricity supply service of the city, has recently added a considerable power load, 85 alternating-current motors (equal to 475 H.P.) being now connected. There are 280 arc lamps also on the company's supply and 1700 consumers, with a total connection of the equivalent of 30,000 8 c.p. lamps. The charge for current for power is 10s. 6d. per horse power per annum.

**Hamilton, N.B.**—In connection with the dispute between the Council and the Clyde Valley Electrical Power Co. as to the route to be taken through the burgh for laying the company's mains, the Board of Trade arbitrator (Major-Gen. Hutchinson) has issued his report. The route proposed by the company has been sanctioned.

The capital expenditure to date on the electricity works is £50,683. 19s. 10d. and the loans sanctioned amount to £55,000. The Electric Lighting committee had before them last week certificates by the engineers for the following payments to the contractors (Edmundson's Electricity Corpn.): Buildings £1,200, mains £500, free wiring £400, making total for free wiring £4,972. 14s. 2d. Regarding the last-mentioned item, the committee decided to have a conference with the resident engineer (Mr. Colson) as to the advisability of discontinuing free wiring.

**Hanley.**—The Council have fixed the rate for ordinary free wiring at 1s. 6d. per lamp per quarter for three years.

**Heywood-Rochdale Tramways.**—The Rochdale section of Heywood Corporation tramways was officially inspected on Wednesday. It is anticipated that a service of cars will be run between Heywood and Rochdale next week. The completion of the section opens out communication with Rochdale, Oldham and Manchester on one side, and Bury, Whitefield and Manchester on the other, and will establish through communication between Rochdale and Liverpool. The construction of a line in Todmorden will ultimately establish through communication between Halifax and Liverpool.

**Hipperholme.**—The Council are canvassing to ascertain the probable demand for electric current for lighting and power.

**Huddersfield-Halifax Tramways.**—Huddersfield Council on Wednesday conditionally approved the scheme of the National Electric Construction Co. to construct a tramway line via Rastrick and Brighouse, connecting Halifax tramways with Huddersfield. The company are to be allowed to run cars into the centre of Huddersfield.

**India.**—The Calcutta Electric Supply Corpn., which has given supply since 1899, has now 2,380 consumers connected to the mains, with an equivalent of 207,484 8 c.p. lamps connected. The population of the district served by the company is about 1,000,000.

**Islington (London).**—On Friday the Council considered the recommendation of the Lighting committee to substitute 245 arc lamps for 714 incandescent gas lamps and it was decided to refer the question to a special committee consisting of the Lighting and Finance committees for consideration and report.

**Italy.**—It is stated that the Italian Government Railways Department has approved a scheme for the establishment of an electric tramway system in Bergamo, and for the substitution of electric for horse lines on a portion of the existing tramways.

The Rome & Civita Castellana Tramways Co. has submitted a scheme for the construction of an electric railway between Civita, Castellana and Viterleo.

A company has been formed at Tranentola (Potenza) to utilise the waters of the River Caolo, estimated at 600 H.P., for the generation of electricity.

**Jamaica.**—The West India Electric Co., which supplies current for lighting and power at Kingston and St. Andrew, has bought out the Jamaica Electric Light & Power Co., and now controls the street tramcar service of these districts as well as the electric lighting. Water power is utilised from the river Rio Cobre.

**Japan.**—On April 12 last the Hanshin Electric Railway Co. inaugurated their electric railway service at Amagasaki. The line represents 20 miles of double track, on the overhead trolley system, the feeder cables being of Japanese make (by the Fajokura & Yokohama Wire Co.) The type of car used is double-truck single-deck for 52 passengers per car, the weight of the car being 24 tons. Air and hand brakes are employed.

The Kioto Electric Traction Co., which commenced running its service on Jan. 1 last, has established tramway connection between Kioto and Tushima. The length of this line is 30½ miles single and 1½ miles double track on the overhead trolley system. The feeder cables were made by the Tsuda Wire Works, and are run on wooden trolleys. Closed cars are used, 14 ft. and 16 ft. in length, with seating capacity for 22 and 28 passengers respectively. The Kioto Co. have also under contemplation the construction of a tramway from Kioto to Osaka, comprising 28 miles of double track. On this line 40 ft. closed bogie cars, with seating capacity for 60 passengers per car, will be used, each car weighing 22 tons.

**Johnstone.**—At a meeting on Tuesday the Town Council considered the proposal of the local Tramway Co. to construct a single line to the boundary of the burgh, and to pay the Council £250 in lieu of constructing a double line in the extended area. The Council decided to accept the proposal, but stipulated that if the company construct an extension to Kilbarchan they are either to double the proposed extension in the burgh to its boundary or pay over to the Town Council the cost that would have been incurred in causewaying the street for a double line.

**Lancaster.**—On Wednesday the Council considered a recommendation of the Electricity committee to supply the L. & N.W. Railway with electricity for lighting and power at their new works at Lancaster. Objection was taken that the charge proposed to be made was too low, and the recommendation was consequently taken back.

**Leyton.**—The Council have applied for sanction to a further loan of £21,100 for extensions of the electricity works.

**Light Railways.**—The Ryhope, Seaham, Murton and South Hetton Light Railways Order has been submitted to the Board of Trade for confirmation. Objections by Jan. 10.

The Light Railway Commissioners held an inquiry at York on Tuesday into an application for an order to transfer the powers of the Derwent Valley Light Railway order, 1902, from the District Councils of Estrick and Riccall to a company. The Commissioners decided in favour of granting the order.

The last section of the Colne and Trawden Light Railway was officially inspected on Wednesday.

Last week Staffordshire County Council approved an application to the Light Railway Commissioners to insert in the Leek, Caldon Low and Hartington Light Railways Amendment Order, 1905, provisions enabling the council to advance to the Leek & Manifold Valley Light Railway Co. £5,000 in addition to £10,000 already advanced by way of loan.

The Mansfield & Sutton-in-Ashfield Light Railway was opened for traffic on Tuesday.

The order issued by the Board of Trade amending the Blackpool & Garstang Light Railway Order, 1901, sanctions the altering of the name of the company to the Blackpool & Fylde Light Railway, and extends the time for the compulsory purchase of land and the completion of the railway.

**London Chamber of Commerce.**—The Council has approved the new rules and scale of fees in connection with the London Court of Arbitration.

**London County Council.**—At Tuesday's meeting a loan of £25,000 was made to Fulham for electric lighting.

In connection with this loan it will be remembered that the Finance committee expressed the opinion that, in view of the uncertainty as to the method of generating electrical energy in London in future, they would have preferred that large works of extension of generating plant should not be undertaken by the borough councils at the present time, but this loan, being for a continuation of the work now in progress, might be granted.

On the recommendation of the Highways committee Shoreditch Council is to be again asked to give consent to the construction of single lines of tramways along Curtain-road and Harwar-street for use alternately with the existing single lines in Old-street and Kingsland-road on the ground of public convenience.

*Tramways.*—The Highways committee recommended that £186,000 be expended upon the erection of the second portion of the Greenwich electricity generating station, and that the capital expenditure of £250,000 in respect of the provision of plant, machinery and other equipment be allowed. Further, that they be authorised to take the necessary steps, including the invitation for tenders for the execution of the necessary works.—Agreed.

It was also agreed that the British Westinghouse Co. be allowed to sublet the following portions of the work included in the company's contract for the supply of 34 tramcar trucks and electrical equipments: (i.) manufacture of trucks to Mountain & Gibson, and (ii.) to A. Reyrolle & Co. the manufacture of plugs for car ploughs.

**Lowestoft.**—For the current year the charge for electric energy supplied to the tramways has been fixed at 2¼d. per unit. For current supplied during the year ended Sept. 30 for traction the Electric Lighting committee have agreed to return ¼d. per unit.

**Luton.**—The charge for electric current for lighting has been reduced to 6d. and 2d. on the maximum demand and for power to 2d. per unit for the first 1,000 units per quarter, 1½d. for the second 1,000 and 1d. beyond.

**Madrid.**—The Eastern Tramways Co., of Madrid, have applied for a concession for the construction of two electric tramway routes in the city. Applications upon terms more favourable to the Government will be received by the Directorate-General of Public Works, Madrid, up to Jan. 14. The "Madrid Gazette" of Dec. 14 gives further particulars.

**Marylebone (London).**—The Electric Supply committee reported on Tuesday that extra batteries were urgently necessary at North-street and Rathbone-place in connection with the changeover in the Rathbone-place area.

The expenditure had (the report stated) always been foreseen, but the committee thought they would have had available for the purpose the £15,000 which the Council were receiving from the Metropolitan Electric Supply Co. for the nine motor generators at North-street. The Council's legal advisers stated, however, that this £15,000 must be applied to the purposes specified in the Council's 1901 Order, which do not include that of further capital expenditure. As it will thus be necessary to apply to the County Council for sanction to further capital expenditure, the committee considered it desirable at the same time to obtain sanction for all fresh capital expenditure required for the next year. The committee find that it will be necessary to order an extra turbine with the requisite boilers, bringing the estimated fresh capital expenditure up to £34,000, made up as follows: Storange battery at North-street £5,000, ditto at Rathbone-place £10,000, ninth turbine £10,000 and two boilers £9,000. The turbine would probably not be actually required for about a year, but it was advisable to put the order in hand at once. The Finance committee, in their report upon the proposed expenditure, state that, of the £433,800 sanctioned, £340,405 (the total amount sanctioned for 42 years) has now been advanced, and the Council has still borrowing powers for £48,545 for alterations of works and mains consequent upon change of pressure repayable in 38 years and £44,850 for meters or alterations to existing meters repayable in 10 years.

In another report presented by the Electric Supply committee it was stated that, in view of the large amount of medical and dental apparatus installed in the Middlesex Hospital it was advisable to continue to supply the building at the old voltage, and certain conditions had been provisionally agreed to in connection with this matter. The report adds that during the last six months the staff of the Council's electricity department had been working at very high pressure; holidays had to be foregone, and overtime, for which no payment had been made, was put in. The saving to the borough had amounted to some thousands of pounds, and the committee had decided to distribute amongst the staff of the department £485.

**Mexico.**—The Mexican Gas and Electric Light Co. has recently put down an extensive complete electric generating and distribution plant. The Necaxa Power Supply Co. has in progress of construction for Mexico City a large water-power plant and transmission of 40,000 kw. The lines of the Mexico City telephone service are being placed underground. A correspondent writes us that Mexico is becoming very wideawake to the advantages of electrical methods of lighting, tramways and transmission, mining, telegraphs, telephones, driving of works and factories, &c., and in each of these branches of electrical work much is being done, and there are openings throughout the country for British manufactures, which, however, have to come into keen competition with American, German, Swedish, and, in many cases, Mexican manufactures. Messrs. P. M. Bennett y Cia, of Mexico City, have done the whole of the recent work carried out for the Mexican Gas and Electric Light Co. (approximately 150 km. of mains laid), and are about to put down 30 km. of underground cable in the district occupied by the new American colony. The laying of the necessary underground system for the telephone installation is also being carried out by this firm.

**Municipal Telephony.**—The engineer and manager of the Brighton telephone department (Mr. D. J. Barnes) recently reported that the authorised capital of the department had been expended, and recommended that application be made for sanction to borrow £2,000 further for connecting new subscribers on to existing spare plant, pending settlement of negotiations now in progress with the Post Office. The Telephone committee endorsed Mr. Barnes' recommendation, which was, we are informed, adopted by the Council yesterday.

**Newcastle-on-Tyne.**—The lamp inspector (Mr. Geo. Lamb) presented to the Lighting committee on Tuesday his estimates for street lighting for the year ending March, 1907, and the estimated cost of electric lighting (650 arc lamps) is £4,583. 13s., against £4,490. 13s. for the current year.

**North Middlesex Tramways.**—The completion of the small section of track extending the Metropolitan Electric Tramways Co.'s Highgate-Whetstone system from Highgate Archway to the Archway Tavern, Holloway, has proceeded leisurely, but is now completed. The Board of Trade inspection took place on Wednesday, and it is expected that the cars will be running from the terminus of the North Metropolitan Co.'s horse system at Upper Holloway to the Hertfordshire border at Whetstone to-day (Friday).

**Paddington (London).**—The Council decided on Tuesday to call the attention of London County Council to the recent quinquennial assessments of the municipal electric undertakings of Bermondsey, Fulham, Hackney, Hammersmith, Hampstead, Islington, Poplar, St. Pancras, Shoreditch, Stepney and Woolwich, and to suggest that such assessments be raised to the real values of these undertakings.

**Palma (Balearic Isles).**—Attention is called by the French Consul to the necessity and practicability of an electric tramway service in Palma. There are two electricity generating stations in the town and the present single line horse tramway covers only a small portion of a busy and thickly-populated town and suburbs.

**Personal.**—Mr. G. H. Oswald Strick is leaving the Westinghouse Companies' publishing department to take up the position of publicity manager with Messrs. Davidson & Co. (Ltd.), Belfast.

**Plymouth.**—The Tramways Committee have discontinued the service on one of the tramway routes.

**Portsmouth.**—The Council are applying for sanction to a loan of £29,800 for additional electricity generating plant and for 16 double-deck tramcars.

**Presentations.**—On Friday, Mr. A. H. Seabrook, who was recently appointed borough electrical engineer at West Ham, was presented by the members and officials of Barking Council with a gold keyless English lever watch, and by the consumers of current with a silver-mounted spirit tantalus.

On leaving Swansea for Plymouth, Mr. John Law, chief district clerk to the National Telephone Co., has been presented by the technical staff with a bookcase, and by the clerical staff with a photographic group.

**Robbing Telephone Boxes.**—At the Central Criminal Court last week, before Commissioner Rentoul, K.C., Thomas Green pleaded guilty to stealing a cash box and 10s. belonging to the National Telephone Co. He also confessed to another robbery, and admitted having been found by night in possession of house-breaking implements. Mr. H. H. Lawless, for the company, said that robberies from the public call offices had become very common. No fewer than 170 robberies of that class had been reported this year, about one-half of them being committed at railway station call offices. A gentleman offered to find some work for prisoner on his release, and he was discharged on his own recognisances. The Commissioner stated, however, that the leniency shown in this case was entirely owing to exceptionally sad circumstances. The offence of robbing telephone offices was a serious one, and would be so regarded by the Court.

**St. Pancras (London).**—A feeder and mains are to be laid in Cumberland market to maintain the pressure of supply, at an estimated cost of £1,516. 10s. In future a charge is to be made for subsidising meters for registering current supplied for cooking, heating, &c. The rent is to be a minimum of 1s. per quarter varying with size of meter. Main extensions estimated to cost £514 have been authorised.

Seven occupiers of houses in Great College-street have commenced proceedings against the Council for damages for alleged nuisance caused by vibration, dust, noise, &c., and for an injunction.

At a special meeting last week the Council decided to proceed with their bill for further powers for electricity supply.

**Siam.**—The Siam Electricity Co. (Ltd.), a Danish concern, has absorbed the Bangkok Light Synd. and the Bangkok Tramways Co. The new company has a capital of £150,000. The population served by this enterprise numbers about 500,000, and at the end of July the total connections for lighting and power represented the equivalent of 60,000 8 c p. lamps, including 85 H.P. for motors. The company's tramways are 11 miles in length, and there are 56 cars running on the service.

In addition to the Danish Company there is a Siamese undertaking entitled the Siamese Tramways Co. (Ltd.), which has recently been formed.

**Simplon Tunnel.**—Work has been commenced for establishing telephonic communication between Milan and Lausanne via the Simplon Tunnel. The cable through the tunnel will have a length of 19 km., and will consist of 14 copper conductors.

**South Africa.**—Since 1898 Pietmaritzburg, Natal, has had electricity supply, and there is now connected to the Corporation's mains nearly 1,100 consumers, with the equivalent of over 40,000 8 c.p. lamps connected.

At Pilgrims' Rest (Transvaal) the Transvaal Gold Mining Assets (Ltd.) supplies current from three generating stations (turbines direct-coupled to generators) almost entirely for power to the mines in the district. The turbines are of the Escher-Wyss type, with Siemens-Halske generators. The different mining properties supplied vary in distance from the generating station up to 7 miles, and there are in all over 5 miles of electric railways supplied from these stations.

**Southampton.**—The Council have received sanction to a further loan of £6,291 for electricity supply.

**Southwark (London).**—Two patent "Clero" machines, which are to be worked electrically, are to be obtained for dealing with house refuse.

**Southwick.**—The Highways committee are considering the question of public lighting, and at the last Council meeting a recommendation was made to enter into an agreement with the County of Durham Electrical Power Distribution Co. for a supply of electricity for 30 Nernst lamps at £150 7s. 6d. per annum. After discussion the matter was referred back. Some of the members favoured an agreement with Sunderland Corporation.

**Swanage.**—The Council have approved the draft provisional order for this district which is being applied for by the Bournemouth & Poole Electricity Supply Co. Mr. H. B. Renwick, on behalf of the company, attended a meeting of the Council on Friday last to meet the expert appointed by the Council, and after a lengthy discussion a resolution was passed consenting to the company's application and approving the order submitted.

**Switzerland.**—The imports into Switzerland for 1904 included dynamo-electric machines to the value of £23,300, out of which the contribution of the United Kingdom amounted to £900. The new duty (on Jan. 1) on this class of machinery is from 4s. to 11s. 2d. per 100 kilos., compared with 3s. 2½d. under the previously-existing tariff. The value of electrical apparatus similarly imported in 1904 was £137,100, of which the U.K. contribution was £2,100, Germany £103,500. The duty on this apparatus will now range from 4s. 10d. to 16s., compared with 4s. 10d. formerly. Under the new tariff the duties on copper and brass goods are considerably increased, but the duties on porcelain and china goods remain unchanged.

**Telephone in Paris.**—Increased facilities are about to be given to the Parisian public for telegraphing and telephoning by the opening of a new office at the Paris Bourse. The office belongs to the French Telegraphic Administration. It may be mentioned that the Eastern and Direct Spanish Telegraph Companies are in direct telegraphic communication with the Paris Bourse by special wires between Marseilles and Paris.

**Tiverton.**—The Council are opposing the application of the National Provincial Electricity Supply Corpn. for a provisional order.

**Tonbridge.**—The Electric Lighting committee have reduced the charge for electric current for arc lighting to £20 per lamp per annum for the year ending March 31, 1907, to be further reduced to £18 for the year to March 31, 1908. The charge for ½-ampere Nernst lamps is to be reduced from £3. 15s. to £3. 12s. 6d. per annum and to £3. 10s. after March 31, 1907.

**Torquay.**—The Electric Lighting committee on Wednesday recommended the Corporation not to accept the National Electric Construction Co.'s offer to take a lease of the electric lighting undertaking, but that conditions be drawn up upon which the Council would consider tenders for the purchase of the works.

Ald. BEAVIS, in moving the adoption of the committee's recommendations, said the company's offer contained some difficult conditions as to what the company would require at the expiration of 25, 30 and 50 years respectively; and the committee thought, if they were to sell, they should draw up conditions and consider whether it was advisable to receive offers from companies or contractors who were willing to pay cash down for what they purchased. There was nothing in the committee's proposals that pledged the Council to sell if it was found that the amount offered was deemed to be insufficient or inadequate, and it would also enable the Council to invite competitive offers, so that it could be seen what those desirous of buying were prepared to give. In the first six and a-half years' existence of the undertaking there was a profit of £470, but, for the present year, the borough accountant estimated a profit of £1,244. Supposing they had a similar profit next year, they would have to deduct from this £1,244, interest and redemption on the new loan of over £8,000 for machinery. This would mean £780 out of £1,244. Then they had to face the reduction in price of electric current, which they were bound to give. As a set-off there was the profit they would derive from supplying the Dolter Co. with current. He thought at first that this profit would be something like £500 or £600 a year, but since then they had had the opinion of the L.G. Board inspector that there would be no profit at all. If that should be the case, all they would have left was a business with a profit of £210 a year. In their electricity undertaking they had invested £42,000, with the additional £8,000 of the new loan, or £50,000 in all. It might be said, if the business was no better than he represented it, how could they expect to find buyers and to receive a good offer? The explanation of that lay in the secret that a company properly managed, and which thoroughly understood its business, would make a profit where a Corporation made a loss. In saying that he did not intend anything derogatory to their electrical engineer. A company could make economies which were perfectly impossible for a Corporation to make. A company could also arrange salaries contingent upon paying a dividend.

An amendment, moved by Mr. Pike, that neither the offer of the company nor any other offer to purchase the undertaking be entertained, was adopted by 15 votes to 14.

**Tramway Returns.**—The annual return of the capital and traffic of tramways and light railways for the year 1904-5, which was issued by the Board of Trade yesterday, shows that since 1878 the length of lines open has increased from 269 to 2,117 miles (of which 1,780 miles are electrical), the capital expenditure from £4,207,350 to £52,675,152, the net receipts from £230,956 to £3,351,977, and passengers carried from 146 millions to 2,069 millions, or 48 times the population of the kingdom. There are in all 320 undertakings, including 174 municipal (an increase of 12 over last year), and 146 non-municipal (decrease 4). Local authorities have applied out of tramway receipts £209,881 in relief of rates. Last year the amount was £207,087. This year they have applied out of revenue to repayment of moneys borrowed for their tramways £572,725.

**Tunis.**—The Compagnie Electrique de Soussa has been formed for the supply of electricity for lighting and power. The company's power station will be erected at Soussa.

**Tunstall.**—Burslem Council are now supplying electric current in this district.

**Upholland (Lancs.)**—Wigan Corporation have decided that they have no powers to supply electric current in Upholland.

**West Ham.**—On the recommendation of the borough electrical engineer (Mr. A. Hugh Seabrook) it has been decided to order four more chain-grate stokers.

In future the rental of motors let on hire is to be 15 per cent. per annum on the cost, and in addition the consumer is to be charged for current used at ordinary rate. Hitherto consumers have had to pay a fixed rental, based on the H.P., and not on the price of the motor, plus a flat rate of 2d. per unit for all energy consumed.

**Will.**—The late Mr. C. Grey Mott, J.P., of Harrow Weald, pioneer of electric "tube" railways, who at the time of his death was chairman of the City & South London Railway, the Bala & Festiniog Railway, the Midland Uruguay Railway, the Scarborough, Bridlington & West Riding Junction Railways, deputy-chairman of the Princetown Railway and a director of the Great Western, the West London Extension Railway and the North-Western of Uruguay Railway, left estate of gross value £23,652, net £11,002.

**Workhouse Lighting.**—Consideration of a report from the visiting committee recommending the installation of electric lighting plant at Basford (Notts) Workhouse, at an estimated cost of £2,000, has been postponed for a month.

Windsor Guardians are considering an offer by the Windsor Electrical Installation Co. for supply of electric current for lighting the workhouse at 7d. and 3d. per unit. The estimated cost of lighting the building with 180 lamps is £154, against £160 for the present oil lamps.

**Yardley.**—The Council decided on Monday to proceed with their application for a provisional electric lighting order.

**Dinner.**—Mr. A. T. Cooper, managing director of the Whitchurch & Pangbourne Electric Supply Co. and engineer and manager of the Reading Electric Supply Co., who was recently appointed engineer and manager of the Bombay electricity works, was entertained to dinner at Pangbourne on the 12th inst.

The chairman of the Whitchurch & Pangbourne Co. (Mr. F. J. Ferguson) was in the chair, and among those present were Messrs. P. and J. Ferguson, Ald. Martin, J.P., Mr. P. O. Payze, Mr. C. T. Watson, Mr. G. W. Spencer Hawes (of R. Hammond & Son), Mr. E. Rowley Hill (the new consulting engineer, who is also taking Mr. Cooper's place at Reading) and Mr. D. H. Coombs (resident engineer).

Mr. Cooper replying to the toast of his health, said he was sorry to sever his connection with the little company, in the engineering of which he had taken such a keen interest. Lately the company had become a paying concern, which was the forerunner of being a dividend-paying one. He thanked Mr. Ferguson for his hospitality, and for the compliment which had been paid him.

**Dance.**—The Christmas dance organised by members of the Robertson Social Club will take place in the Brook Green Hall of Brook Green Works, Hammersmith, London, W., on Saturday evening, Dec. 30.

# TRADE NOTES AND NOTICES.

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## TENDERS INVITED.

*St. Pancras* (London) Council invite tenders for arc lamp columns and cradles and open type arc lamps. Specifications, &c., from the chief clerk (Mr. A. E. Pycraft), Electricity Department Offices, 57, Pratt-street, N.W. Tenders to the town clerk (Mr. C. H. F. Barrett), Town Hall, Pancras road, N.W., by noon, Jan. 9. See also an advertisement.

The Guardians of *Croydon* Union invite tenders for the installation of electric fire alarms at the Infirmary, Thornton Heath. Specifications, &c., of the architect (Mr. H. Berney), 105, George-street, Croydon. Tenders to the clerk (Mr. Harry List), Union Offices, Mayday-road, Thornton Heath, by 4 p.m. Jan. 8. See also an advertisement.

*Grimsby* Corporation invite tenders for a 500 kw. continuous-current direct-coupled high-speed double-acting engine, water-tube boiler and underfeed stokers, extension of switchboard, condensing plant (surface type), buildings, pipe-work, coal-conveying plant and lead-covered paper-insulated cables. Tenders by first post Jan. 5.

*Leyton* District Council want tenders by 7 p.m. Jan. 8 for the construction of about nine miles of double tramway track.

*Pontypridd* Council want tenders by Jan. 1 for 1,320 yds. of three-way $2\frac{1}{2}$ in. and 3,500 yds. of single $2\frac{1}{2}$ in. conduit.

*Manchester* Corporation require tenders by 10 a.m. Jan. 2 for laying underground telephone pipes with other appurtanant works.

*Oldham* Electricity committee want tenders by noon Dec. 26 for six or 12 months' supply of steam coal.

## TENDERS RECEIVED AND ACCEPTED.

London County Council have received the following tenders:—

*Supply, Delivery and Erection of Steelwork for Greenwich Station.*

| | | | |
|---|---|---|---|
| E. C. & J. Keay (*accepted*) | **£46,490** | Thames Ironworks Co. | £53,139 |
| J. Butler & Co.'s Trustees | 57,897 | Braithwait & Kirk | 50,275 |
| Head, Wrightson & Co. | 54,918 | J. Westwood & Co. | 49,461 |
| Redpath, Brown & Co. | 54,660 | Clayton, Son & Co. | 47,726 |

The architect's estimate comparable with the tenders was £48,180.

*Roadwork in Vauxhall Bridge-road.*

| | | | |
|---|---|---|---|
| J. Mowlem & Co. (*accepted*) | **£20,873** | Dick, Kerr & Co. | £21,448 |
| J. G. White & Co. | 21,809 | | |

Engineer's estimate, £19,070.

Marylebone (London) Council have received the following tenders:

*Storage Batteries.*

| | | | |
|---|---|---|---|
| Electrical Power Storage Co. (*provisionally accepted*) | **£14,918** | D.P. Battery Co. | £18,135 |
| Hart Accumulator Co. | 28,490 | Chloride Electrical Storage Co. | 16,988 |
| Accumulator Industries Co. | 25,400 | A.P.B. Accumulator Co. | 16,704 |
| Tudor Accumulator Co. | 22,446 | | |

*Three Motor Generators.*

| | | | |
|---|---|---|---|
| Electric Construction Co. (*provisionally accepted*) | **£769** | 0 | 0 |
| Siemens Bros. & Co. | 789 | 7 | 9 |

Glasgow Electricity committee recommend the following tenders for acceptance:—

| | | | |
|---|---|---|---|
| Willans & Robinson, three turbine-driven generators | £43,717 | 0 | 0 |
| British Westinghouse Co., seven sets of motor-generators and double balancing attachments | 17,850 | 0 | 0 |
| Ditto, high-tension switchboards and instruments | 867 | 11 | 0 |
| Bruce Peebles & Co., two sets of motor-generators and double balancing attachments | 5,000 | 0 | 0 |
| Ferranti Ltd., low-tension switchboards | 1,398 | 0 | 0 |
| Babcock and Wilcox, ten boilers for Port Dundas and St. Andrew's Cross stations | 16,716 | 0 | 0 |

The Underground Electric Railways Co. of London have placed an order with the American Car & Foundry Co. for about 200 cars for the Charing Cross, Euston Hampstead Railway. The cars will be all steel and similar to those which the same company are building for the Baker-street & Waterloo Railway.

Ashton-under-Lyne Council have accepted the tender of the Harris Patent Feed Water Filter (Ltd.) for a Harris-Anderson water purifier for the electricity works; and the tender of Mather & Platt for a tank.

Paddington (London) Council are recommended to accept the tender of the Metropolitan Electric Supply Co. for electric light fittings, &c., for the Town Hall at £636.

Southwark (London) Council have accepted the tender of Hammond & Harris for electric light fittings for stables at £57. 10s. There were 12 tenders, ranging from that accepted to £123. 11s. 5d.

St. Pancras (London) Council has accepted the tender of E. F. Moy (Ltd.) for two test panels at £38 each. J. Pitkin & Co. tendered at £56. 5s. 6d., and the Electrical Co. at £80. For three distributing boards the tender of the same company was accepted at £89. 5s. each. There were eight tenders, varying from that accepted to £175. For four liquid controlling resistances the tender of Dorman & Smith was accepted, at £8. 10s. each. There were four tenders, the highest being £50.

Croydon Council have accepted the tender of the British Thomson-Houston Co. for a motor generator at £1,450.

Larne (Ireland) District Council have accepted the tender of the Larne Electric Light Co. for the public lighting of the town.

Burslem Council have accepted the tender of E. M. Evans for wiring St. John's market at £104. 17s.

Isle of Wight Education committee have accepted the tender of the Isle of Wight Co. for wiring Ventnor Council schools.

City of London Guardians have placed an order with Wentworth & Co. for switches.

Belfast Improvements committee have accepted the tender of the British Electric Plant Co. for Electric pumping plant.

### BUSINESS NOTICES.

Geo. Hewer Scriven and Harold Chas. King (trading as the Consolidated Accessories Co.), electrical engineers, &c., Craven House, Kingsway, London, W.C., have dissolved partnership. Debts by Mr. King, who continues under old style.

The Private Wire & Telephone Installation Co. (Ltd.) has removed to 78, Queen-street, Cheapside, London, E.C., where extensive well-equipped showrooms are established. Electric fittings are displayed, and the company has facilities for charging and repairing accumulators. Motoring men who go to the City will find the company's premises handy. It is nearly 12 years since this company commenced operations.

### BANKRUPTCIES, LIQUIDATIONS, &c.

George Webber, formerly an ironmonger, of High-street, Putney (who was recently convicted with Leslie and Cheeseman of complicity in the electrical frauds, and sentenced to five years' penal servitude) was brought up for public examination in bankruptcy at Wandsworth (London).

Webber put his liabilities at £30,000, and attributed his insolvency to orders for goods which Leslie induced him to sign. Debtor said he did not know Cheeseman till he met her in the dock at the Guildhall. He had never received a penny from the Electric Accessories Co. On the contrary, they received money from him. The orders for flexible wires sounded ridiculous to him now, but he placed implicit confidence in Leslie. Leslie showed him letters purporting to have been written by Mr. Arthur, the lessee of Fulham Theatre, on that gentleman's notepaper, agreeing to the expenditure of a large sum of money at the theatre. Leslie at no time handed him more than £4,000 in money. It was not true that he received over £6,000 in banknotes, and had burnt them. There was also no truth in the statement that he had received even a portion of the notes. Examination adjourned.

John Richd. Charnock, electrical engineer, &c., Meanwood-road, Meanwood, Leeds, has been adjudicated bankrupt. The first meeting of creditors will take place on Dec. 29 at 22, Park-row, and the public examination on Jan. 9 at the County Court House, Leeds.

Harry Jones and Gwilt Lloyd Cathrall, electrical engineers, 19, Chester-street, Wrexham, were examined on Dec. 12. Liabilities £543 (including £531 to 33 trade creditors), assets £128. Debtors commenced business 13 years ago with £50. The stock was sold in October for rent. Examination adjourned for accounts to be filed.

Wm. Geo. Leather (trading as the Windus Electrical Co.), 25, Howard-street, Sheffield, has been adjudicated bankrupt.

A first and final dividend of 2s. 8¾d. is payable at Trinity House-lane, Hull, in the bankruptcy of Fred Shaw, electrical contractor, 259, North Boulevard, Hessle-road, and 258, Hessle-road, Hull.

Fuller, Macleod & Co. (Ltd.) is being wound up voluntarily. Messrs. Ehrenfest and T. V. Macleod are liquidators.

**Deed of Assignment.**—In the matter of a deed of assignment made by Ernest Smart and Joseph Bustin, electrical and general engineers, 54, Bridge-street, Banbury, claims must be sent to Mr. G. E. Cornfield, Balfour House, Finsbury-pavement, London, E C., by Jan. 2.

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**Agents Required.**—Agents are wanted for the sale of "Securitas" electrical safety door lock with alarm. Applications to Messrs. Harry & Wengen, Stuttgart, Germany.

**Award.**—The highest award (the only silver medal) for an exhibit of mechanical stokers and compressed-air furnaces at the recent exhibition of the Smoke Abatement Society at Westminster was awarded to Messrs. Ed. Bennis & Co., Little Hulton, Bolton, who also took a bronze medal for the new Bennis-Miller-Bennett chain grate. A fine model of this grate was shown.

**Increase in Prices.**—We are informed by the secretary of the National Electrical Manufacturers' Association that at a meeting of conduit tube manufacturers, held on the 18th inst., it was unanimously decided, owing to the rise in price of raw material, to increase prices 5 per cent. on the net, as from Dec. 20.

**Calendars and Diaries for 1906.**—The "Gloucester Diary" for 1906, published by the Gloucester Railway Carriage & Wagon Co., is to hand, and is, as usual, a useful and welcome addition to the hardy annuals which reach us at this season of the year. The "Gloucester Diary" has reached its 11th year of issue.

That always welcome table companion, the E.P.S. calendar, blotting pad and incut diary, is to hand for another year, and, besides all the usual merits of this useful "pad," contains an accident insurance policy for £500. As an advertising device the E.P.S. calendar is, we think, hard to beat.

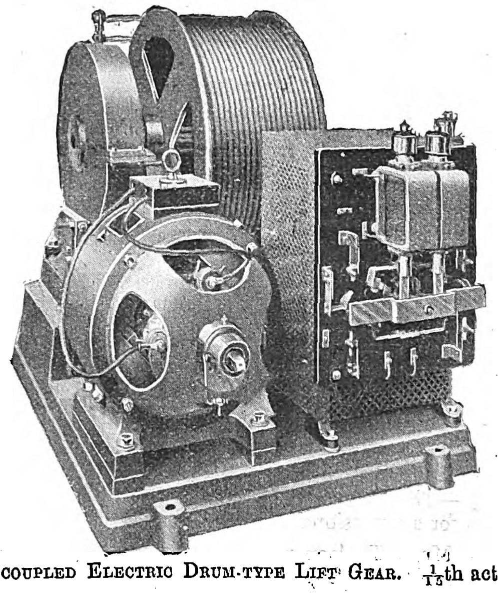
A neat pocket-book form of calendar and diary, with page mark and an acceptable accident assurance policy for £1,000 and other benefits, has been adopted by Messrs. Clarke, Chapman & Co., of Victoria Works, Gateshead-on-Tyne. Besides being neat and compact, this calendar contains a good deal of serviceable information.

Messrs. John Knox & Co., 210, Upper Thames-street, London, E.C., issue a hanging card tear-off pad calendar, which provides an attractive sheet of miscellaneous electrical and engineering tools, contractor's plant, &c., for which this firm possess an old-established reputation.

A new pocket calendar and diary, with information of considerable interest to those who use the British submarine cable service, has been issued by the Eastern and Associated Telegraph Companies. Provided with end pockets, with a good stock of memoranda paper and an excellent coloured map of the empires of the world and the entire cable system of the Eastern and Associated Companies, this is a compact and serviceable pocket companion.

**Catalogues, &c.**—A comprehensive catalogue of the manufactures of mechanical rubber and asbestos goods of the Titan Packing Co., 2 & 3, Tower Royal, Cannon-street, London, E.C., has reached us, and is an up-to-date publication containing some excellent illustrations of "Solvis" jointing material, which is a non-conductor, and is claimed to be practically indestructible; of "Standard" spiral piston packing, of which the thick part is made of the highest grade of cotton duck with insertion and the outer part of finest quality Para rubber, the whole saturated with a special lubricating compound just eliminating the element of friction; of "Calovis" tubular gasket, which can be cut off to any length and connected by a small metal rod to fit any size man-hole, plate or pipe flange; of "Titan" asbestos and metal steam packings for hydraulic and all high-pressure packings. A feature of this company's manufactures is a special type of packing for certain classes of work which are not to be satisfied by ordinary asbestos goods.

A new catalogue of electrical hoisting machinery has been issued by the Electromotor & Dynamo Co., of 15, Grays Inn-road, London, W.C. The accompanying illustration shows one of the company's direct-coupled electric drum-type of lift gear for passenger or goods lifts. It will be seen that all parts of the machine are easy of access and the controller, whether of the handrope, car switch or push-button type, can be arranged on the bed-plate alongside the motor, as shown in the illustration. This type of machine is made in seven sizes, that shown being No. 5, about one-fifteenth actual size.



DIRECT-COUPLED ELECTRIC DRUM-TYPE LIFT GEAR. $\frac{1}{15}$th actual size.

The reducing gear consists of a hardened and polished steel worm, turned out of a solid bar and working into a machine-cut phosphor-bronze wheel fitted in an oil-tight case. The thrust of the worm is taken by a specially-designed continuously-lubricated ball-thrust bearing, and leaves an ample margin of safety in all its parts to resist shocks or overloading. A powerful electro-magnetic brake is fitted to the coupling on the worm-shaft, and comes into operation immediately the current is switched off or fails from any cause whatever.

Messrs. Ferranti Limited have issued a new price list (No. 54) of double-pole double-throw quick-brake knife switches for from 25 to 1,400 amperes.

R. J. Nicholson & Co., 26, Cannon-street, Manchester, have ready a number of new price lists describing and illustrating the "Ideal" petrol engine. This company contract for the supply of "Ideal" electric lighting outfits for country house lighting and similar isolated plants. These outfits are sent out ready for erection.

Messrs. W. T. Glover & Co. have taken advantage of the festive season to provide their clients with an ornamental pipe cleaner, fitted with the necessary absorbent material, and prominently displaying the firm's trade mark.

A catalogue of artistic metal, wood and glass fittings for electrical purposes has been compiled by O. C. Hawkes (Ltd.), 69 and 70, Aldersgate street, London, E.C., and Bromsgrove-street, Birmingham. The list also illustrates and describes the XL patent induced-draught electric heating stoves and their fittings. A choice selection of special types of fittings is here listed in various art styles, and comprising brackets and pendants, electroliers, &c. There is a large section devoted to heating stoves, of which numerous open and closed examples are shown in all the leading art designs. It is claimed for these stoves that they fill a gap in electric heating, as the list comprises designs which can be placed in any artistically furnished room without outrage to the general harmony of the surroundings.

The London Electric Fittings Co. have issued a new list of electric radiators with both fixed and detachable reflectors.

The Power Plant Co., Temple Bar House, London, E.C., have ready a new list of machine-cut double helical wheels for electric traction working.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Dec. 13 to Dec. 19, with the ports of destination:—

*Africa.*—Alexandria, £63; Delagoa Bay, £1,281 (including £75 telegraph material); Durban, £3,251; Port Elizabeth, £69; Suez, £29 (telegraph material). *Argentina*—Buenos Ayres, £63; Rosario, £980. *Australasia*—Auckland, £192; Christchurch, £58; Fremantle, £174; Lyttelton, £21; Melbourne, £422; Otago, £306; Perth, £100; Port Pirie, £80; Sydney, £998 (including £151 telegraph material). *Belgium*—Antwerp, £292. *Borneo*—Labuan, £28. *Canada*—Toronto, £25. *Ceylon*—Colombo, £18. *Chili*—Valparaiso, £51 (telegraph material). *China*—Shanghai, £80 (telegraph material). *Denmark*—Copenhagen, £36. *France*—Bordeaux, £12. *Gibraltar*, £24. *Holland*—Amsterdam, £249 (including £112 telegraph material); Rotterdam, £29. *Hong Kong*, £423. *India*—Bombay, £6,110; Calcutta, £2,041 (including £355 telegraph material); Karachi, £57; Madras, £14. *Japan*—Kobe, £112; Nagasaki, £21; Yokohama, £4,988. *Malta*, £15. *Portugal*—Oporto, £70. *Russia*—Kureh, £300; Reval, £20; Riga, £150; St. Petersburg, £60. *Straits Settlements*—Singapore, £2,080 (including £29 telegraph material). *Sweden*—Gothenburg, £550 (telegraph cable); Stockholm, £123 (including £66 telegraph material). *Uruguay*—Monte Video, £50. *U.S.A.*—New York, £20. Total, £26,126, against £18,725 in the corresponding week last year (Dec. 14 to 20).

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

Note.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specification. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

November 3, 1905.

22,460 Yasuda. Electrodes. Date applied for, Jan. 21, 1905).*†
22,472 Bolton. Electric lighting.
22,505 Hawkes. Weatherproof electric light for vehicles.
22,531 Pansa. Transmission of telegraphic, telephonic and autographic messages by Hertzian waves. (Date applied for, Nov. 4, 1904.)*†
22,544 Kallmann. Self-acting load resistance for the comparison or standardisation of current, tension and effects.

November 4, 1905.

22,578 M'Laren. Trolley heads.
22,585 Electric Ignition Co. & Hall. Switches.*
22,616 Dineen. Circuit-closing device operated by depression of the rail on railways or tramways.
22,620 B.T.-H. Co. & Holden. Electricity meters.
22,622 Millington & Muller. Switches.

November 6, 1905.

22,631 Parker. Sliding contact pieces for Wheatstone bridges and potentiometers and in arrangement of wire for same.
22,635 Ellis. Glow lamps.
22,636 Neumann. Clock for automatically connecting and disconnecting electric current.
22,654 Wood & Lancashire Dynamo & Motor Co. Equalising output of main dynamo electric generators supplying energy to a fluctuating external load.
22,660 Fry. Producing electricity by steam.
22,673 Knight. Storage batteries. (Date applied for, Nov. 16, 1904).*†
22,675 Westinghouse. Turbines. (Date applied for, Nov. 17, 1904).*†
22,710 Bates & Schultz. Manufacture of cables.
22,721 Regnart. Electric candle lamp.
22,723 and 22,724. Kriéger & Cie. Parisienne des Voitures Électriques (Procédés Krieger). Regulating speed of electric motor cars. (Date applied for, Dec. 3, 1904.)*†
22,731 Granström & Lundbohm. Sorting and transporting magnetic mineral.*
22,733 Moy, Bastie & Ernest F. Moy, Ltd. Electric safety fuses.
22,740 Cowper-Coles. Electrolytic deposition of metals.
22,741 Harrison & Frazer. Indicators for ships' electric signal lamps.*

November 7, 1905.

22,763 Tierney & Malone. Moving electrically points on electric tramways and railways.
22,767 Hall. Electric wiring.
22,802 Smith. (Boulanger, France.) High-tension magneto ignition systems.
22,819 Hadfield. Communicating signals telegraphically.
22,820 Jacobs. Omnibus electrical signalling circuits, particularly for telephony.*
22,833 Kriéger & Cie. Parisienne Des Voitures Électriques (Procédés Krieger). Automobile vehicles. (Date applied for, Nov. 18, 1904.)*†
22,841 Cattori. Electric traction.*
22,856 B.T.-H. Co. (G.E. Co., U.S.) Electric switches.

November 8, 1905.

22,874 Kamm. Printing telegraphs.
22,889 Smith. Electrical contact breakers.
22,899 Kraft. Dynamo-electric machines.
22,919 Cambridge Scientific Instrument Co. & Burton. Apparatus for estimating and recording quality of gases.
22,931 Lentz. Steam turbines.*
22,939 Bacon. Electric control apparatus.*
22,943 Watts. Incandescent vapour lamps.
22,952 B.T.-H. Co. (G.E. Co., U.S.) Alternating electric currents and controlling same.
22,954 Reed. Contact breakers for electric ignition gear.

November 9, 1905.

22,970 Hildburgh. Dynamo-electric machinery.
22,971 Hildburgh. Current collectors for dynamo-electric machines.
23,005 Berry. Electric fusible cutouts.
23,016 Stewart. Magnets, magnetic drilling posts, or braces and the like.
23,035 Hess. Arc lamps.*

November 10, 1905.

23,058 Electric Ignition Co. and Hall. Magneto ignition systems.
23,075 Large. Electro-magnetic power hammer drop stamp or press.*
23,077 Lachman. Electric welding. (Date applied for, Nov. 17, 1904.)*†
23,083 Lawrence. Point mechanism for tramways and the like.*

### SPECIFICATIONS PUBLISHED, price 8d. each.

1904 Specifications.

22,443 Andersson. Combined telephone and sounding telegraph.
24,573 Batchelder. Dynamo-electric machines. (Date applied for, Nov. 12, 1903.)
24,618 Martin. X-ray obstructing material.
24,689 Roselle. Storage batteries. (Date applied for, Nov. 16, 1903.)
24,701 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control systems and apparatus.
24,769 Nalder Bros. & Thompson, Nalder & Cox. Commutators.
24,788 Whitney. Arc lamps. (Date applied for, Nov. 16, 1903)
25,010 Thompson. (Westdeutsche Thomasphosphat-Werke, G.m.b.H.) Producing nitric acid by electricity. (*Rights under Patents, &c., Act, 1901, not granted.*)
25,026 and 25,027 B.T.-H. Co. (G.E. Co., U.S.) Electric switch operating mechanism.
25,370 Lee & Bottone. Utilising live wires of an electric lighting and like circuit to convey signals by electric waves.
25,519 Dafforn. Incandescent candle lamps.
25,645 Stone. Space telegraphy. (Date applied for, Nov. 25, 1903.)
25,682 Andersson. Arc lighting lamps. (Date applied for, Nov. 30, 1903.)
25,764 B.T.-H. Co. (G.E. Co., U.S.) Electric motor controllers.
25,784 Leitner & Lucas. Regulating electric circuits.
26,169 B.T.-H. Co. (G.E. Co., U.S.) Fusible cutouts.
26,175 B.T.-H. Co. (G.E. Co, U.S.) Electric transformers.
26,295 B.T.-H. Co. (G.E. Co., U.S.) Electric control systems.
27,211 B.T.-H. Co. (G.E. Co., U.S.) Protecting electric distribution systems.
27,352 Otis Elevator Co., Ltd. (Otis Elevator Co.) Electric controlling apparatus.
27,354 Willis. (Strouse.) Mechanical stokers.
27,444 Eckstein & Krause. Switches.
27,869 Burnett & Richmond. Lock and electrical contact maker and breaker for lifts.
28,157 Unterberg. Actuating magneto-electric spark ignition apparatus.
28,336 Veritys Limited & Rogers. Brush-holders for dynamo-electric machines.
28,787 Stern & Greene. Switches.
28,840 Hirst & Brook. Self-acting motor starting rheostat.
29,015 Siemens Bros. & Co., & Ledger. Automatic control of electric circuits under overload.
29,107 Davis & Graham. Telephones for diving and like purposes.
29,337 Gaiffe. Protection of electrical apparatus branched on circuits traversed by currents of high frequency.
29,607 Bruce, Peebles, & Co. & Peebles. Liquid resistances for controlling current in electromotors.
29,627 Shore & Heap. Electrical fire alarm or other call apparatus.

### 1905 Specifications.

1,670 B.T.-H. Co. (G.E. Co., U.S.) Alternating-current motors.
2,015 Barker & Burleigh. Brush-holders for electric dynamos or motors.
2,310a Fairweather. (National Electric Co.) Electric control of brake apparatus, (Date applied for, Feb. 6, 1905.)
2,545 Chandler & Bonniksen. Electrical regulation of clocks.
2,586 B.T.-H. Co. (G.E. Co., U.S.) Safety cutout devices.
2,850 Wilson & Wilson. Electrostatic watt and-watt-hour meters.
3,171 Vickers, Sons & Maxim & Williamson. Dynamo-electric machines.
3,183 Dick. Automatic regulation of electrical installations with variable current consumption, worked by dynamos and accumulators.
3,604 Swan. Prepayment attachments for electricity meters.
4,097 Pape & Bender. Electro-magnetic devices.
4,127 Hollyer. Automatic electric warning signals for railways.
4,166a Bines. Induction coils. (Date applied for, Feb. 28, 1905.)
4,233 Millington & Miller. Electric ignition for internal combustion engines.
4,273 Fricker. Automatic electric advertising apparatus.
4,379 B.T.-H. Co. (G.E. Co., U.S.) Supply and regulation of the electric energy used in search-lights and like apparatus.
4,701 Brown & Crosta. Tramway rails, points and crossings.
4,715 Cushing. Insulators.
4,774 Coverstone. Standards for supporting electric lamps.
4,848 Justice (Phönix Elektrotechnische, G.m.b.H.) Arc lamps.
5,205 Bradley & Mason. Trolleys for electric tramcars and the like.
5,981 B.T.-H. Co. (G.E. Co., U.S.) Alternating-current motors.
6,337 Torrens. Magnetic sparking plugs for internal combustion engines.
6,596 Warwick Machinery Co. (G.E. Co., U.S.) Turbines.
7,008 Ottinger. Safety electric circuit closers.
7,591 Johnson. (Voigt & Haeffner, Akt.-Ges.) Alternating-current dynamo-electric machines for synchronising and connecting them with distributing conductors.
7,620 Gaiffe. Apparatus for the measurement of X and other rays.
7,698 Sandberg. Manufacture of steel for railway and tramway rails.
8,158 Horton. Electric motor starters. (Date applied for, Nov. 2, 1904.)
8,511 Hülsmeyer. "Tuning" Hertzian-wave receivers to particular transmitters.
8,652 Kirk & Coblett Electrical Engineering Co. Plug boxes for the connection of electric conductors to main supply cables.
9,344 Kruyswijk. Electric motor. (Date applied for, May 5, 1904.)
10,480 Bertalot (Bonino). Night sights with electric incandescent lamps.
10,978 Breuer & Isaac. Telautograph apparatus. (Date applied for, May 25, 1904).

## COMPANIES' MEETINGS AND REPORTS.

### India Rubber, Gutta Percha & Telegraph Works Co.

The forty-second general meeting was held on Tuesday. Major Leonard Darwin presided.

The SECRETARY (Mr. A. P. Crouch) read the notice convening the meeting and the auditors' certificate.

The CHAIRMAN then said: Gentlemen, in moving the adoption of the report and accounts, I must express the pleasure your directors experience in being able to lay before you a satisfactory statement of the results of last year's trading. A year ago Mr. Henderson and I ventured to express the hope that your board would be able to meet you on this occasion with a more favourable statement than was then submitted, and this hope has been in part realised by the result of the year's trading. One of the factors in this result has been that prices of raw material, although high, have undergone no very great fluctuations. This comparative steadiness has enabled us to adjust our selling prices to a certain extent to meet existing conditions. The high level of prices has an effect which I should not ignore in addressing you. It produces an apparent increase in our turnover—that is the handling of the same quantity of material causes a larger cash turnover to appear. It is, however, a satisfactory state of things when high prices do not, as they might do, reduce the quantity of goods handled. With an uncertain, disturbed market in raw material one is never quite certain how to deal with manufactures, and we can only wish that when the fall takes place, as take place it must, the lowering will be a gradual and not a violent one. The manufacture by the company of the Manilla–Shanghai cable is progressing in a perfectly satisfactory manner, 900 nautical miles having been manufactured. The "Buccaneer," which returned from her charter since the drawing up of the directors' report, left again last evening on a further short charter. In the report mention is made that considerable further expenditure must be incurred at the Persan works. This expenditure will be principally in the nature of extending our buildings and putting down more plant, as there are certain lines of goods which at present we cannot produce in sufficient quantity to meet the demand. I may be allowed again to take the opportunity of calling attention to the heavy burden of local taxation which industrial undertakings have to contend with in certain localities. At Silvertown we have to pay rates which exceed 10s. in the pound, whereas in Newcastle, for example, they are, I believe, at about 5s. 9d. On the assumption that properties are valued on the same basis in Newcastle and West Ham it has been estimated that the direct and indirect effect of this difference in the rating is to handicap us to the extent of about £25,000 a year as the result of our works being at Silvertown instead of at Newcastle. If this possible economy could be capitalised the sum thus created would be sufficient to erect new works in another district where the local burdens were less heavy. The action of Messrs. Yarrow, who are said to be leaving the banks of the Thames for the North, proves that in these districts this is not a mere imaginary possibility. Local authorities should remember, and the bankers who lend to them should also remember, that the closing of one large firm will generally throw an increased local burden on the other firms which remain; or, in other words, that the geese who lay the golden eggs will be tempted to take flight in a body if they are too much harassed. I now move that the report and accounts be adopted and that the distribution of a dividend of 15s. per share, tax free, be sanctioned.

Mr. GEORGE HENDERSON seconded the resolution.

Mr. FLINT referred to the forthcoming renewal of debentures and reminded the chairman of his remarks last year as to the equalisation of dividends, and asked if the question of the formation of a real reserve would be considered?

The CHAIRMAN said the question of the issue of debentures was before the directors. The issue would take place, he thought, next March. When the proper period arrived the board would take the subjects alluded to by Mr. Flint into consideration, although they did not anticipate the slightest difficulty with regard to those debentures. Any question as to the equalisation of dividends would be most carefully considered. It had been the policy of the board, and always would be, to make the dividends as equal as possible. He ventured to remind the shareholders of the dividends the company had distributed in the past, and he doubted whether they could find many companies which had paid more steady dividends. The dividend had been 10 per cent., with only one exception, for something like 20 years.

The motion was then carried unanimously.

The retiring directors, Major L. Darwin and Mr. G. Henderson, were then re-elected, as were the retiring auditors, Messrs. Turquand, Youngs & Co.

A cordial vote of thanks to the chairman and directors was carried unanimously, and the chairman having briefly replied, the proceedings terminated.

### British Westinghouse Electric & Mfg. Co. (Ltd.)

At the meeting on Monday the deputy chairman (Mr. Wm. I. Buchanan) presided, and moved the adoption of the report given in our last issue. Mr. Buchanan said the controlling factor which guided those who created their large industrial undertaking was not the immediate present but the future industrial development that must follow the constantly increasing uses to which electric power is being put. It would appear reasonable to suppose that if in the near future any strides are taken in this country in the electrification of railways proportionate to those that had taken place in America during the past eight months alone, there would then possibly be proof in sight that the optimistic views held by those who founded the company were not without foundation. He proceeded to analyse and explain the accounts, after which he said that if they began the manufacture of motor omnibuses, as seemed likely, during the next year, additional tools would be required for that special purpose. The increase in the item "shares in other companies" consisted of an addition of £50,000 in the Traction & Power Securities Co. and of £65,254 on shares of the Clyde Valley Electrical Power Co.; the remainder represented shares of electrical power undertakings which were large customers of the company. The two large power stations built by the company for the Clyde Valley Co. had begun to regularly furnish power service to consumers. The two stations were probably the most modern that had been built in connection with power undertakings in this country, and certainly reflected great credit on the company. In the matter of depreciation on their plant, in addition to £11,500 for depreciation on tools, &c., £25,012 was charged to general expenses during the year for repairs, renewals and improvement. £15,144 was equally charged to general expenses for repair and renewals of patterns, dies and small toools, and £19,040 for new patterns, the last item being exclusive of patterns charged directly to contract for which they were made. There was also charged to general expenses £6,536 expended during the year for maintenance of buildings and fixtures, while furniture and fixtures had been depreciated £1,277. The amount of work turned out by their plant at Trafford Park had materially increased, indicating progress in the use to which their works were being put. Further, there had been an increase of £360,000 in shipments during the year, and a striking decrease in "purchases resold" of £165,000. An especially encouraging feature had been a decrease of £10,000 in selling and administration expenses. The dispute with the Mersey Railway Co. as to the date when the line was to be considered as being completed had been referred to arbitration, but during the proceedings an amicable adjustment of the matters in dispute was reached. An item of importance in the accounts was the suspense account, which appeared for the first time, and against which the directors recommended that £25,000 should be written off. The items comprising that account were carefully and exhaustively considered by the management, with the result that the directors were convinced that the account was one which in their judgment should be opened and treated as they had recommended. Their reason was that it was unwise and unfair to charge against profits earned in one year the whole of the very large sum that had had to be expended during the period in connection with the development and building of important new types of apparatus during the year, notably steam turbines and gas engines, and for the experimental work which had been carried out in connection with the development of single-phase traction apparatus, as well as in several other fields of electrical and mechanical development in which it had been deemed by the management vital to their interests to try to place their company in a prominent place in relation to the wider use of such apparatus and machinery, which all indications pointed to as being practically certain in the near future. While no orders for the execution of large undertakings had fallen to their lot there had been a constant increase in the number of orders received and in the number of new customers who had opened accounts with them. The number of orders received during the year was nearly double that for the previous year, and three times that for 1903, while the total value had remained approximately that of the previous year. Another encouraging feature was the fact that the business being done by the company in the British colonies was increasing. The directors were making extra efforts to further increase that by opening branch offices and by vigorously entering into competition for all work offered. A further market was being looked for through an extension of the sales of other Westinghouse companies through utilising the great advantages their works had to offer in the production on a larger scale of many products for which the market might thus be extended. The competition they had to meet at home was still disadvantageously affected by Continental companies, and he saw little likelihood that any change in that vital matter was in sight. It was a factor that completely destroyed all plans that a British company could make who were trying to secure fair prices in competition on important contracts here. Many of them might have seen the statements in the Press regarding the experimental application of single-phase electrical traction to one of the prominent railway lines, the order for which was given to a Continental company. The British Westinghouse Co., among other British concerns, submitted tenders for that work—a new and important class of work, by the way—which their company was peculiarly fitted to carry out, both by reason of their plant and through the ability of their company to avail itself of the wide and valued experience attained in that special class of work by the American Westinghouse Co. His information was to the effect that the work in question was awarded the Continental company under terms hitherto unknown in large undertakings, and at an exceedingly low price. He was sure, however, that the increasing reputation being secured by their products, the growing increase in the number of orders received, showing a widening distribution of their products, a lessened factory cost, indicating a lower cost of production, a decreasing selling and administration expense, a decrease in the value of purchases resold, and a heavy increase in the value of the product of their factory, would be of aid and permanent advantage to their interests, and would enable them to quickly take advantage of every favouring condition that arose.

Mr. D. BROWNE regretted that there was nothing in the speech from the chair to give shareholders hope for the future. The accounts showed a deficit on the past year's working of over £15,000, and shareholders could see from the balance-sheet how extravagantly the company had been worked. The enormous sum of £794,867 had been paid for patents and goodwill. They had spent over £1,000,000 on the works at Trafford Park, and £928,811 in machinery, plant, tools, &c. He feared that the preference shareholders were in danger of being squeezed out by the American company. He moved that the report be not accepted.

The CHAIRMAN, replying to Mr. Browne, said it had been suggested that the American Westinghouse Co. had some ulterior object in view in connection with this company, but anyone who considered the facts of the case would see that that was hardly likely. The interest of the American Westinghouse Co. in this company had been constantly increasing. The number of patents taken out by the company during the year was approximately 120 or 130. The sums paid to the American company for goodwill and patents represented deferred shares, and the preference shareholders had to be satisfied before the deferred shareholders received anything.

Mr. BROWNE then withdrew his amendment, and the report and accounts were adopted.

**BLACKPOOL, ST. ANNE'S AND LYTHAM TRAMWAYS CO. (LTD.)**—The directors' report states that on the past year's working the profit was £4,909. Debenture interest outstanding from 1904 absorbed £1,356, debenture interest £7,500, law costs £1,392, debenture trustees' fees and bank charges £439, and £1,500 placed to sinking fund left an adverse balance of £6,956. 1½ per cent. on account of interest due to debenture holders is to be paid.

**COSTA RICA ELECTRIC LIGHT & TRACTION CO. (LTD.)**—For the year ended June 30 the net earnings in Costa Rica amounted to £10,159, against £9,155 in previous year. The lighting concession under which the company is working in San José was dated to expire on Dec. 31, but a new concession of 50 years from Jan. 1, 1906, both for lighting and tramways, has been granted subject to confirmation by the President of the Republic. The small plant at Cartago has been disposed of to a local enterprise. As practically all the power at present at the company's disposal has been taken up, and they were compelled to refuse new customers, it has become necessary to develop further water power and to install additional machinery, surveys have been made and estimates obtained showing that for £8,000 to £9,000 the lighting capacity on the Tiribi River can be increased from 15,000 to 36,000 8 c.p. lamps. The directors propose to make an early issue of debentures for this purpose.

**MANX ELECTRIC RAILWAY CO. (LTD.)**—For the year ended Sept. 30 the gross receipts were £32,638 and gross expenditure £15,349, leaving net earnings £17,289. After deducting interest (£9,054) and adding balance forward (£780) the credit balance was £9,015. After payment of preference dividend £2,205 has been carried forward. A considerable sum has been spent out of revenue in maintenance and renewals, and the whole line has been kept in good repair. The passengers carried during the year totalled 501,696, compared with 472,556 for the previous twelve months.

**PROVINCIAL TRAMWAYS CO. (LTD.)**—For the year ended September 30, the net revenue received from the local companies was £24,050. 3s. 1d., against £24,095. 0s. 6d. last year. The directors recommend a dividend on the ordinary shares of 4s. per share, making 7s. per share (tax free) for year. Through unforeseen difficulties in connection with the construction of the track and overhead work of the Gosport and Fareham Tramways, and also in consequence of delay in the completion of the power station plant, the opening of the lines has been delayed. The lines are, however, completed and the machinery has been running for a short time with satisfactory results.

## NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

### NEW COMPANIES.

**CORK CITY RAILWAYS & WORKS BILL PROMOTION CO. (LTD.)** (3,031)—Reg. in Dublin Dec. 11, capital £10,000 in £10 shares, to apply for, promote or procure the promotion of a bill in Parliament, authorising the incorporation of a company for constructing railways, tramways, sidings, &c., in the city of Cork. First directors, Right Hon. J. Barrett, J. Long, J. Pike, D.L., Sir E. Fitzgerald, S. French, D.L., R. Hall, jun., W. McDonald, J. Collins, J. Dinan, W. Phair, H. Shanahan, W. T. Green, J. Ogilvie, W. Donegan, J. Simcox, C. Desmond, E. McCarthy, D. McDonnell, M. Barry, J. S. Ashlin and J. Dillon. Reg. office, 60, South Mall, Cork.

**ELDON ELECTRIC CO. (LTD.)** (86,880.)—Reg. Dec. 16, capital £3,000 in £1 shares, to acquire and carry on business of electrical engineers, importers, manufacturers' agents and dealers in all kinds of electrical apparatus, appliances and accessories carried on by A. G. Robson and R. Burdis as the Eldon Electric Co. First directors, A. G. Robson (managing) and A. A. Goldstone (both permanent). Reg. office, 8, Eldon-square, Newcastle-on-Tyne.

**FOOTS CRAY ELECTRICITY SUPPLY CO. (LTD.)** (86,863).—Reg. Dec. 15, capital £20,000 in £1 shares, to carry on in Kent the business of suppliers of electricity, engineers, manufacturers of and dealers in wire ropes and cables, makers of all plant, appliances, and apparatus required or used in connection with the generation, accumulation, distribution, and supply of electrical energy, &c., to acquire undertaking authorised by Foots Cray Electric Lighting Order (1901), and to carry into effect an agreement. The subscribers are: G. H. Nisbett, engineer (3000 shares); E. K. Muspratt, J.P. (1000); J. S. Harmood Banner, M.P. (1000); J. Taylor, J.P. (1000); D. Sinclair, engineer (1000); Mordey and Dawbarn, consulting engineers (1000); J. C. Still, J.P. (500); A. E. Levin, engineer (500); D. Bates, engineer (500); A. P. Haslam, engineer (250); G. W. Peard, engineer (125); and W. Kerfoot (125). First directors, James Taylor, G. H. Nisbett and D. Sinclair. Registered office, Dacre House, Victoria-street, London, S.W.

**Q.C.E.D.A. SYND. (LTD.)** (86,794.)—Reg. Dec. 9, capital of £60 in £1 shares, to acquire any existing or new patents and inventions relating to quick changing and efficient charging of accumulators, and to carry on the business of manufacturers and sellers of accumulators, motors, motor cars, &c.

**RUBBER TRADE MUTUAL INSURANCE CO. (LTD.)** (86,822)—Reg. Dec. 12, capital £10,000 in 10s. shares, with objects as indicated by title. First directors, H. G. Tippet Cleeve, D. Moseley, G. C. Mandleberg, P. H. Lockhart and F. Pegler. Among the subscribers are the Liverpool Rubber Co., the Liverpool Electric Cable Co., Hooper's Telegraph & Indiarubber Works (Ltd.) and I. Frankenburg & Sons.

### STATUTORY RETURNS.

**AMAZON TELEGRAPH CO. (LTD.)**—According to return to Nov. 28 capital is £250,000 in 25,000 shares of £10 each, all of which have been taken up and paid for in full. Mortgages and charges, £255,600.

**COMPAGNIE DES MAGNETOS SIMMS-BOSCH (LTD.)**—Return to Aug. 11 gives capital as £15,000 in £1 shares, all of which have been taken up. £1,000 has been received, and £14,000 is considered as paid. Mortgages and charges, nil.

**EDISON & SWAN UNITED ELECTRIC LIGHT CO. (LTD.)** (18,984.)—In return to Oct. 26, capital is £941,090 in 150,000 "A" and 26,436 "B" shares of £5 each and 23,564 "B" shares of £2. 10s. each, of which 99,261 "A" (£3 paid), 17,139 "A" (£5 paid) and 23,564 "B" (£2. 10s.) shares have been taken up. £5 per share is considered as paid on 17,139 "A" and £2. 10s. per share on 23,564 "B," making £144,605 credited on shares issued as fully paid. £2. 10s. per share is considered as paid on 89,261 "A" (£3 paid) and £3 per share on 10,000 of same class, making £253,152. 10s. credited on shares issued as partly paid. £44,630. 10s. (10s. per share) has been paid in cash on above-mentioned 89,261 "A." Mortgages and charges, £399,576.

**ELECTROLYTIC ALKALI CO. (LTD.)**—In return to Nov. 21 capital is £500,000 in 300,000 ordinary and 200,000 preference shares of £1 each, of which 202,210 ordinary and 100,000 preference have been taken up. £1 per share has been called up on 227,210 shares, and 75,000 are considered as fully paid. Mortgages and charges, £20,850.

**ELECTRIC SUPPLY CO. OF VICTORIA (LTD.)**—Return to Oct. 25 gives capital as £300,000 in 150,000 preference and 150,000 ordinary shares of £1 each, of which 125,000 preference and 125,000 ordinary have been taken up. £7 has been received and £249,993 is considered as paid. Mortgages and charges, £160,000.

**FLATHER & CO. (LTD.)**—In return to Oct. 16 capital is £3,000 in £1 shares, of which 1,527 have been taken up. £27 has been received, and £1,500 is considered as paid. Mortgages and charges: £1,000.

**PACIFIC AND EUROPEAN TELEGRAPH CO. (LTD.)**—Return to Nov. 28 gives capital as £100,000 in 10,000 shares of £10 each, all of which have been taken up. £4 per share has been called up and £40,000 has been received. Mortgages and charges: £100,000.

### MORTGAGES AND CHARGES.

**ELECTROLYTIC ALKALI CO. (LTD.)**—Issue on Nov. 30 of £300 4½ per cent. first mortgage debentures, part of series created July 9, 1904, to secure £50,000, charged on company's undertaking and property, present and future, including uncalled capital. Trustees, Liverpool Mortgage Insurance Co. Previously issued of same series: £20,850.

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. No. of weeks. | Aggregate. Amount. | Aggregate. Inc. or Dec. (a) |
|---|---|---|---|---|---|---|
| | | £ | £ | | £ | £ |
| Aberdeen Corporation | Dec. 16 | 1,152 | + 54 | 29 | 41,178 | − 1,239 |
| Airdrie | ,, 8 | 240 | + 59 | 49 | 10,115 | + 230 |
| Anglo-Argentine | ,, 16 | 14,404 | + 433 | 49 | 675,296 | + 40,859 |
| Ayr Corporation | ,, 9 | 175 | + 10 | 31 | 10,834 | − 121 |
| | ,, 16 | 171 | + 1 | | | |
| Barcelona Trams Co. | ... | ... | ... | ... | ... | ... |
| Barcelona, Ensanche, Gracia | ... | ... | ... | ... | ... | ... |
| Barnsley | ,, 8 | 152 | − 1 | 49 | 7,874 | − 328 |
| Barrow | ,, 8 | 212 | + 32 | 49 | 11,765 | + 2,281 |
| Bath Electric Trams, Ltd. | ,, 13 | 611 | + 116 | 50 | 34,057 | + 2,365 |
| Birkenhead | ... | ... | ... | ... | ... | ... |
| Birmingham Corporation | ,, 16 | 590 | + 46 | 37 | 18,538 | + 1,689 |
| *Birmingham & Mid. | ,, 8 | 1,867 | − 185 | 49 | 77,059 | − 327 |
| Blackpool Corporation | ,, 14 | 270 | + 8 | 24 | 44,659 | + 1,800 |
| Blackpool and Fleetwood | ,, 16 | 144 | − 9 | 24 | 19,810 | − 1,106 |
| Bolton Corporation | ,, 17 | 1,804 | + 126 | 38 | 73,018 | + 9,045 |
| Bournemouth Corporation | ,, 13 | 1,264 | + 471 | †36 | 52,540 | + 10,834 |
| Bradford Corporation | ,, 16 | 4,084 | + 854 | 37 | 163,840 | − 5,096 |
| Brighton Corporation | ,, 17 | 718 | + 40 | 38 | 38,983 | + 454 |
| Bristol Trams & Carriage | ,, 15 | 4,510 | + 3 | 18 | 82,517 | + 1,207 |
| Buenos Ayres & Belgrano | ,, 17 | 3,667 | + 553 | 50 | 173,794 | + 9,901 |
| Buenos Ayres Elec. Trams | Nov. 18 | 1,324 | ... | 46 | 54,480 | ... |
| Burnley Corporation | Dec. 16 | 1,061 | + 74 | 37 | 51,898 | + 2,548 |
| Burton Corporation | ,, 17 | 249 | − 89 | §37 | 11,679 | − 1,438 |
| Bury Corporation | ,, 10 | 796 | ... | §36 | 26,979 | ... |
| Calcutta Tramways Co. | ,, 16 | R15,820 | + R4,112 | 24 | R1,086,624 | + R126,222 |
| Camborne-Redruth | ,, 16 | 103 | + 5 | 7 | 703 | − 30 |
| Cardiff Corporation | ,, 16 | 1,503 | − 78 | 37 | 76,584 | − 82 |
| Carlisle Tramways Co. | ,, 16 | 146 | − 25 | 50 | 9,100 | − 668 |
| Central London Railway | ,, 16 | 7,500 | + 318 | 24 | 152,789 | − 576 |
| Chatham & Dist. Lt. Rys. | ,, 14 | 543 | + 41 | 50 | 32,593 | + 3,513 |
| *City of Birm'gh'm Tram Co. | ,, 8 | 5,196 | + 140 | 49 | 262,498 | + 116 |
| City & South London Rly. | ,, 17 | 3,570 | + 310 | 24 | 63,380 | + 593 |
| Colchester Corporation | ,, 14 | 145 | − 15 | 20 | 5,207 | − 1,880 |
| Cork Electric Trams Co. | ,, 14 | 401 | + 25 | 50 | 23,960 | + 642 |
| Devonport & Dist. Trams | ,, 8 | 410 | − 27 | 49 | 22,414 | − 3,378 |
| Dover Corporation | ,, 16 | 167 | − 13 | 37 | 8,598 | − 43 |
| Dublin & Lucan Railway | ,, 15 | 98 | + 7 | 24 | 2,983 | − 32 |
| Dublin United | ,, 15 | 4,510 | + 106 | 24 | 121,834 | − 238 |
| Dudley—Stourbridge | ,, 8 | 758 | + 24 | 49 | 48,778 | + 1,684 |
| Dundee Corporation | ,, 13 | 921 | + 137 | §30 | 27,750 | + 1,742 |
| East Ham Council | ,, 16 | 729 | + 111 | 37 | 20,802 | + 3,656 |
| Gateshead & Dist. Trams | ,, 8 | 933 | + 61 | 49 | 45,237 | + 1,022 |
| Glasgow Corporation | ,, 16 | 15,835 | + 1,975 | 29 | 487,462 | + 24,940 |
| Glossop | ,, 9 | 126 | + 22 | 50 | 6,158 | + 579 |
| | ,, 16 | 122 | + 19 | | | |
| Gloucester Corporation | ,, 13 | 229 | + 21 | 37 | 11,120 | ... |
| Gravesend—Northfleet | ,, 8 | 197 | + 9 | 49 | 11,993 | − 856 |
| Gt. Northern & City Rly. | ,, 16 | 1,848 | + 222 | 24 | 37,792 | + 8,066 |
| Greenock & Port Glasgow | ,, 8 | 661 | + 136 | 49 | 31,550 | + 3,487 |
| Halifax Corporation | ,, 13 | 1,314 | + 231 | 37 | 59,226 | + 3,791 |
| Hartlepool Tramways | ,, 8 | 251 | + 9 | 49 | 13,059 | − 1,184 |
| Hastings Elec. Trams Co. | ,, 14 | 311 | ... | 19 | 10,052 | ... |
| Huddersfield | ,, 16 | 1,300 | + 179 | 37 | 50,840 | + 2,204 |
| Hull Corporation | ,, 16 | 2,156 | + 41 | 37 | 82,580 | + 860 |
| Ilford Dist. Coun. | ,, 16 | 870 | + 18 | 37 | 17,770 | + 495 |
| Ipswich Corporation | ,, 16 | 340 | − 30 | 37 | 16,403 | − 1,855 |
| Isle of Thanet Co. | ,, 16 | 210 | − 14 | 11 | 3,059 | − 450 |
| Kidderminster & District | ,, 8 | 91 | − 1 | 49 | 5,895 | − 334 |
| Kilmarnock Corporation | ... | ... | ... | ... | ... | ... |
| Kirkcaldy Corporation | ,, 13 | 191 | + 8 | 15 | 8,017 | − 91 |
| Lanarkshire Trams Co. | ,, 14 | 778 | + 183 | 50 | 37,611 | + 5,050 |
| Leamington | ,, 8 | 126 | + 45 | 21 | 3,889 | + 1,415 |
| Leeds Corporation | ,, 16 | 5,848 | + 437 | 37 | 225,049 | + 5,832 |
| Leicester Corporation | ,, 16 | 1,925 | + 224 | 50 | 108,800 | + 30,162 |
| Liverpool Corporation | ,, 9 | 10,410 | + 713 | 49 | 517,040 | + 10,156 |
| Liverpool Overhead Rly. | ,, 17 | 1,322 | − 110 | 24 | 37,452 | − 1,630 |
| *London County Council | ,, 9 | 13,880 | + 1,900 | 36 | 537,029 | + 74,155 |
| Lowestoft | ,, 16 | 122 | − 9 | 11 | 1,688 | − 44 |
| Maidstone Corporation | ,, 14 | 78 | − 7 | 37 | 4,716 | ... |
| Manchester Corporation | ,, 16 | 12,628 | + 851 | 37 | 479,706 | + 21,880 |
| Mersey Railway | ,, 16 | 1,689 | + 79 | 24 | 38,074 | + 2,281 |
| Merthyr | ,, 8 | 172 | − 7 | 49 | 9,258 | − 517 |
| *Metropolitan Elec. Trams | ,, 8 | 2,535 | + 658 | 49 | 130,888 | + 55,103 |
| Middleton | ,, 8 | 294 | + 89 | 49 | 16,524 | + 761 |
| Musselburgh | ,, 7 | 136 | ... | 51 | 11,050 | ... |
| Nelson Corporation | ,, 16 | 120 | + 17 | 33 | 5,000 | + 469 |
| Newcastle-on-Tyne Corp. | ,, 16 | 3,636 | + 79 | 37 | 141,259 | + 3,288 |
| Newport (Mon.) | ,, 16 | 511 | ... | 11 | 4,842 | + 878 |
| Northampton Corporation | ,, 15 | 842 | + 19 | 36 | 15,342 | + 4,872 |
| Oldham, Ashton & Hyde | ,, 8 | 516 | + 64 | 49 | 27,867 | + 777 |
| Oldham Corporation | ,, 17 | 1,512 | + 159 | 33 | 62,455 | + 15,673 |
| Perth (W. A.) Elec. Trams | ,, 15 | 1,583 | + 125 | 50 | 68,962 | + 4,038 |
| Peterborough | ,, 8 | 93 | − 8 | 49 | 6,570 | − 678 |
| Pontypridd Dist. Council | ,, 16 | 132 | ... | 37 | 6,016 | ... |
| Potteries | ,, 8 | 1,845 | + 182 | 49 | 84,045 | + 1,024 |
| Preston Corporation | ,, 13 | 567 | ... | 11 | 6,462 | ... |
| Reading Corporation | ,, 14 | 586 | − 26 | ... | ... | ... |
| Rotherham Corporation | ,, 14 | 429 | + 43 | 37 | 16,893 | − 526 |
| Rothesay | ,, 8 | 38 | + 5 | 49 | 9,542 | + 2,688 |
| Salford Corporation | ,, 18 | 4,093 | + 281 | 38 | 162,570 | + 9,094 |
| Sheerness | ,, 6 | 44 | − 8 | 49 | 8,390 | + 270 |
| Sheffield Corporation | ,, 17 | 4,835 | + 287 | 33 | 187,834 | + 9,868 |
| Southampton Corporation | ,, 18 | 843 | + 25 | 10 | 9,092 | − 311 |
| Southend Corporation | ,, 13 | 283 | + 28 | 37 | 14,717 | + 752 |
| Southport Tramways | ,, 8 | 226 | + 13 | 49 | 15,160 | − 543 |
| S. Staffordshire Trams | ,, 8 | 819 | + 179 | 49 | 36,896 | + 1,840 |
| Stockport Corporation | ,, 15 | 808 | + 410 | 41 | 28,814 | + 7,080 |
| Sunderland Corpn. | ,, 17 | 1,216 | + 100 | 37 | 49,083 | + 1,780 |
| Swansea Trams | ,, 8 | 713 | + 284 | 49 | 35,421 | + 9,166 |
| Swindon Corporation | ,, 6 | 158 | + 18 | 36 | 7,172 | ... |
| Taunton | ,, 8 | 42 | ... | 49 | 2,059 | − 226 |
| Tynemouth and District | ,, 8 | 184 | + 16 | 49 | 12,558 | − 1,590 |
| Tyneside Trams Co. | ,, 13 | 846 | + 89 | 50 | 20,444 | + 1,125 |
| Wallasey District Council | ,, 16 | 683 | + 7 | 37 | 24,806 | + 961 |
| Walsall | ,, 16 | 486 | + 41 | 50 | 24,540 | + 544 |
| Warrington Corporation | ,, 7 | 836 | + 89 | 37 | 12,622 | + 704 |
| | ,, 14 | 824 | + 26 | | | |
| West Ham Corporation | ,, 14 | 1,773 | + 759 | 37 | 66,709 | + 28,230 |
| Weston-super-Mare | ,, 6 | 25 | − 1 | 49 | 6,777 | + 526 |
| Wolverhampton Corpn. | ,, 13 | 746 | ... | 11 | 8,226 | ... |
| Wolverhampton District | ,, 8 | 892 | + 49 | 49 | 19,409 | + 383 |
| *Worcester | ,, 8 | 236 | − 16 | 49 | 14,718 | + 375 |
| Wrexham | ,, 8 | 89 | + 5 | 49 | 4,921 | − 359 |
| Yorkshire W.R. Trams | ,, 17 | 669 | + 158 | 50 | 35,772 | ... |
| Yorkshire Woollen District | ,, 8 | 845 | + 345 | 49 | 32,827 | + 4,524 |

(a) These comparisons are with the corresponding period last year. † Minus 3 days. § Plus 2 days. * Partly electrical.

**GUILDFORD ELECTRICITY SUPPLY CO. (LTD.)**—£25,000 debentures, created 21st and dated Nov. 30, 1905, have been registered. Property charged: company's undertaking and property, present and future, including uncalled capital. No trustees.

**WEBSTER ELECTRICAL ENGINEERING CO. (LTD.)**—Issue on Dec. 9 of £375 6 per cent. first mortgage debentures, part of series created Feb. 28, 1905, to secure £1,000, charged on company's undertaking and property, present and future, including uncalled and unpaid capital (if any). Holder, F. W. Taylor. No trustees. Previously issued of same series, £625.

## CITY NOTES.

**MEMORANDA** (Dec. 21).—Bank rate 4 per cent. (since Sept. 28, 1905) Price of silver 30¼d. per oz. Consols $89\frac{1}{16}$—$89\frac{3}{16}$ for money, $89\frac{3}{16}$—$89\frac{5}{16}$ for account; 2½ per cent. annuities 88—88¼. Consols Pay Day, Jan. 4 Stocks and Shares Continuation Day, Dec. 27; Ticket Day, Dec. 28; Pay Day, Dec. 29; Mining Share Carry-over Day, Dec. 22.

**POWER GAS CORPN. (LTD.)**—For the year ended Sept. 30 the profit, including £2,000 brought forward, was £3,965.

**SHANGHAI ELECTRIC CONSTRUCTION CO. (LTD.)**—During the week this company offered for subscription 312 shares of £1,000 each at par.

**WESTERN TELEGRAPH CO. (LTD.)**—The coupons of this company's second issue of 5 per cent. debentures due 31st inst. will be paid on and after Jan. 1 at Parr's Bank, Bartholomew-lane, London, E.C.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Dec. 20. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Dec. 20. Highest. | Business, Week to Dec. 20. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | £ s. d. | | | |
| 5 | 3/0 | Anglo-Argentine Ord. Shares | $8\frac{3}{8}$—$8\frac{5}{8}$ | 4 12 9 | Ap, Oct | $8\frac{11}{16}$ | $8\frac{7}{16}$ |
| 5 | 2/9 | Do. 5½% Cum. Pref. | $5\frac{7}{8}$—$6\frac{1}{8}$ | 4 9 8 | — | $6\frac{1}{16}$ | [illegible] |
| St. | 6% | Do. Permanent 6% Deb. Stock | 142 —146 | 4 2 8 | — | .. | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 105 —107 | 4 13 5 | — | 107 | $106\frac{1}{2}$ |
| 10 | 12/0 | Barcelona Tramways Ord. | $13\frac{3}{4}$—$14\frac{1}{4}$ | 4 4 0 | — | .. | .. |
| 10 | 5/0 | Do. 5% Cum. Pref. | $9\frac{1}{2}$—10 | 5 0 0 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock (red.) | 97 —102 | 4 8 3 | — | .. | .. |
| 100 | 5% | Do. 5 per Cent. Debs. | 93 —101 | 4 19 0 | — | .. | .. |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1 —$1\frac{1}{2}$ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 4 —$4\frac{1}{2}$ | 5 18 3 | — | $4\frac{1}{8}$ | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts | 95 —98 | 4 12 0 | — | $97\frac{1}{2}$ | .. |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. ex rights | 119 —122 | 4 18 4 | — | .. | .. |
| St. | 5% | Do. Pref. Ord. Stk ex rights | 109 —113 | 4 7 6 | — | $110\frac{1}{2}$ | $109\frac{1}{2}$ |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock. | 103 —109 | 4 11 8 | — | .. | — |
| 4 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs | 103%—105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 102 —105 | 4 5 9 | — | .. | .. |
| [illegible] | 2/6 | Buenos Ayres and Belgrano Ord. | $2\frac{3}{8}$—$2\frac{5}{8}$ | 5 3 0 | — | [illegible] | $1\frac{7}{8}$ |
| 5 | 3/0 | Do. 6 per Cent. "A" Cm. Pref | $5\frac{11}{16}$—$5\frac{15}{16}$ | 5 2 0 | — | [illegible] | .. |
| [illegible] | 3/0 | Do. "B" | 5 —$5\frac{1}{2}$ | 5 9 1 | — | $5\frac{1}{2}$ | $5\frac{5}{16}$ |
| St. | 5% | Do. 5 per Cent. Debs. | 107 —109 | 4 11 8 | — | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102 —105 | 4 16 8 | — | $104\frac{1}{2}$ | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 98 —100 | 5 0 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 101 —105 | 5 4 9 | .. | .. | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 100 —104 | 5 17 0 | .. | .. | .. |
| 5 | 8/6 | Calcutta Tramways (Nos. 1 to 105) | $8\frac{1}{4}$—$8\frac{3}{4}$ | 4 7 2 | — | .. | .. |
| 5 | [illegible]/3 | Do. Nos. 105,001 to 137,610 | $8\frac{1}{2}$—9 | .. | .. | $8\frac{1}{2}$ | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 107 —109 | 4 2 7 | .. | .. | .. |
| 1 | 0/6 | Cape Electric Tram Shares | $\frac{7}{8}$—$1\frac{1}{8}$ | 4 8 10 | — | .. | .. |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 101 —103 | 4 17 2 | — | $102\frac{1}{4}$ | 102 |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 97 —98% | .. | .. | $97\frac{5}{8}$ | 97 |
| 1 | .. | Lisbon Elec. Trams Ord. | $1\frac{3}{8}$ —$1\frac{5}{8}$ | .. | .. | $1\frac{5}{8}$ | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | $1\frac{1}{8}$—$1\frac{3}{8}$ | 4 7 4 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 101 —104 | 4 16 3 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 103 —105 | 4 15 3 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101 —104 | 4 16 2 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102 —104 | 4 6 7 | — | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 104 —107 | 4 13 5 | .. | .. | .. |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 141 —141 | 5 11 0 | .. | .. | .. |
| .. | 5% | Do. 5% 1st Mt. $500 Dbs. | 97%—99% | 5 1 0 | .. | $98\frac{1}{4}$ | $98\frac{3}{4}$ |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | — | Adelaide Elec. S'ply Co. 6% Cu.Pr. | 5 —$5\frac{1}{2}$ | — | .. | — | .. |
| 5 | 3/3 | Calcutta Elec. (1-50,000) | $8\frac{3}{4}$ $9\frac{1}{4}$ | 4 9 0 | — | $9\frac{1}{8}$ | .. |
| 10 | 5% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50 —52 | 4 16 1 | .. | 51 | $50\frac{3}{4}$ |
| .. | .. | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 96 —98 | .. | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | $2\frac{1}{2}$—3 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Debs. | 87 —9[illegible] | 5 8 8 | — | 92 | $91\frac{3}{4}$ |
| 10 | .. | Havana Electricity Co. Shares | 9 —10 | .. | — | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92 —94 | 5 6 8 | .. | — | .. |
| St. | .. | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. 50% pd. | 60 —62 | .. | .. | .. | .. |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | $\frac{7}{8}$—1 | 6 0 0 | — | [illegible] | — |
| 1 | 1/0 | Rand Electric | $1\frac{1}{4}$—$1\frac{3}{8}$ | .. | — | .. | — |
| 1 | .. | River Plate Electricity Co. Ord. | [illegible] | .. | .. | .. | .. |
| 1 | [illegible] | Do. 6% Non. Cum. Pref | [illegible] | .. | .. | .. | .. |
| St. | 5% | Do. 5% Deb. Stock | 103 —105 | 4 15 0 | .. | .. | .. |
| 5 | 5/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | $5\frac{1}{4}$—$5\frac{3}{4}$ | 5 4 4 | .. | .. | — |
| [illegible] | [illegible]3d | Do. (12,001-20,000) | 5 —$5\frac{1}{2}$ | 3 8 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100 —103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 10/9 | Shawinigan Water and Power 5% Bds., Scrip | 102 —103 | 4 17 0 | .. | 102 | .. |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Share. | Last Dividend | Name. | Price Wed., Dec. 20. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business, Week to Dec. 20. High-est. | Low-est. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| 1 | .. | Bath Elec. Trams Pref. Ord. | 15/16—1 | .. | .. | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16—1 1/16 | 4 14 9 | .. | 31/32 | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 103½—105½ | 4 5 0 | .. | 104¼ | .. |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 103 —105 | 4 5 9 | .. | 104 | .. |
| 10 | 9% | Bristol Tramways and Carriage Ord. | 17 —17½ | 5 2 11 | Feb, Aug | .. | .. |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10⅛—10⅝ | 3 18 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Debs. | 105 —107 | 3 14 10 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 7½—8½ | 7 1 0 | .. | 8⅜ | 7 9/16 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 10 —11 | 5 8 0 | Feb, Aug | 10 9/16 | 10⅛ |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 117 —119 | 4 4 0 | .. | 119 | 117 |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 97 —99 | 4 11 0 | .. | 98 | 97 |
| St. | 4% | Central London Ordinary Stock | 93 —95 | 4 4 0 | June, Dec | 94 | 93⅛ |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 101 —103 | 3 17 8 | .. | 102½ | 102¼ |
| St. | 4% | Do. Deferred Stock | 85 —88 | 4 11 0 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 111 —113 | 3 10 3 | .. | .. | .. |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 4⅞—5⅛ | 4 17 6 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 100 —103 | 3 17 8 | .. | .. | .. |
| St. | 2% | City and South London Rly. Con. Ord. | 44 —46 | 4 1 6 | Feb, Aug | 45⅛ | 44½ |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 119 —122 | 4 2 0 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 117 —120 | 4 3 4 | .. | 120½ | .. |
| St. | 5% | Do. (1901) | 114 —117 | 4 5 6 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 105 —108 | 3 14 1 | May, Nov | .. | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13½—14½ | 4 2 8 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½—15½ | 3 17 8 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5 —5½ | 7 5 6 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8 —9 | 4 8 11 | .. | .. | .. |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 101 —103 | 4 7 6 | .. | .. | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 17 —18 | 5 0 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 13¾—14¼ | 4 4 2 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 111 —113 | 3 19 8 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼—2¾ | 9 8 6 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 83 —88 | 4 10 11 | — | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8 1/16—8 3/16 | 3 13 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾—10¼ | 4 15 3 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99 —102 | 3 19 3 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9¾—10¼ | 4 17 6 | — | 10 1/16 | .. |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 100 —103 | 3 17 8 | — | 102½ | 102 |
| St. | .. | Mersey Con. Ord. Stock | 7 —9 | — | — | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8 —11 | — | — | .. | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32—9/32 | .. | — | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1 —1 1/16 | 4 14 1 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106 —108 | 4 3 3 | — | 106⅛ | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½—1½ | .. | May | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾—9¼ | 5 5 8 | .. | .. | .. |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9¾—10¼ | 4 17 6 | Feb, Aug | 10 3/16 | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103 —106 | 4 5 0 | — | 104 | .. |
| 100 | .. | Sunderland Dist. Elec. Trams. 5% 1st Mort. Debs. | 95 —99 | .. | .. | .. | .. |
| .. | 5% | Underground Elec. Rys. Co. of London | 96½—97½ | 5 2 6 | .. | .. | .. |
| St. | 3% | Waterloo and City Ord. | 94 —97 | 3 2 0 | June, Dec | .. | .. |
| St. | 12/11 | Yorkshire W.R. El. Trs. Co. 4% 1st Debs. | 96 —98 | 4 1 6 | .. | 97 | .. |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | * African Direct Tel. 4% Mrt. Deb. (red.) | 99 —102 | 3 13 5 | Jan, July | — | .. |
| 10 | — | Amazon Telegraph | 3¾—4¼ | .. | Jn, Dec | — | .. |
| 100 | .. | Do. 5% Debs. (red.) | 85 —90 | 5 11 0 | .. | .. | .. |
| St. | 15/0 | Anglo-American | 61 —63 | 4 15 0 | F, My, Ag, N | 61½ | — |
| St. | 30/0 | Do. Preferred | 109 —110 | 5 4 6 | F, My, Ag, N | 110 | 109 |
| St. | 2/0 | Do. Deferred | 16¾—17 | .. | F, My Ag, N | 17¼ | 16⅞ |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 96½—98½ | 4 1 2 | Jn Ap, Jy, O | 98⅞ | 96¾ |
| 10 | 5/0 | Cuba Submarine Ord. | 8½—9 | 5 11 0 | Feb, Aug | 8⅞ | 8¾ |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17 —18 | 5 11 2 | Feb, Aug | 17¾ | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜—3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 8¾—9¼ | 5 8 0 | April, Oct | .. | .. |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 100%—103% | 4 7 5 | Jan, July | .. | .. |
| 20 | 3/0 | Direct United States Cable. | 14 —15 | 4 6 6 | Ja, Ap, Jy, O | 14⅝ | 14 9/16 |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 101 —103 | 4 7 6 | Jn, Dec | .. | .. |
| St. | 25/0 | Eastern Ordinary | 144 —147 | 4 15 8 | Ja, Ap, Jy, O | 146½ | 145½ |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 90 —92 | 3 16 0 | Ja Ap, Jy, O | 91¾ | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 106 —108 | 3 14 1 | May, Nov | 106¼ | .. |
| 10 | 2/6 | Eastern Extension | 14½—15 | 4 18 4 | Ja, Ap, Jy, O | 14⅝ | 14 9/16 |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 106 —108 | 3 14 1 | Feb, Aug | .. | .. |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 100 —102 | 3 18 8 | Feb, Aug | 101⅜ | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 100%—102% | 3 18 8 | May, Nov | .. | .. |
| 10 | 5/0 | G. N. (of Copenhagen) | 37 —39 | 6 6 0 | Jan, July | 38½ | 38 |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 101 —103 | 4 7 6 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57 —59 | 5 10 0 | May, Nov | 58 | 57½ |
| 100 | $1 | Mackay Companies Common | 58 1/16 | 3 17 0 | Jan, July | — | .. |
| 100 | 4% | Do. Preference | 72 15/16 | 5 7 8 | Ja, Ap, Jy, O | .. | — |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1¼—1⅜ | .. | .. | .. | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 100 —103 | 3 17 8 | June, Dec | .. | .. |
| 10 | 4/0 | West African Telegraph Shares | 9½—10 | 5 0 0 | .. | .. | .. |
| 2½ | — | West Coast of America | 9/16—1⅛ | .. | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100½—102½ | 3 18 0 | Jan, July | .. | .. |
| 10 | — | West India and Panama | ¼—¾ | .. | May, Nov | .. | .. |
| 10 | 6/0 | Do. 6% 1st Pref. | 8¼—8¾ | 6 6 8 | May, Nov | 8½ | .. |
| 10 | — | Do. 6 per Cent. 2nd Pref. | 6½—7½ | .. | May, Nov | .. | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 101 —104 | 4 16 2 | Jan, July | .. | .. |
| 10 | 5/0 | † Western Telegraph | 13¾—14¼ | 4 18 0 | Mr, Jn, O, D | 14¼ | 14 |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 102 —104 | 4 16 0 | June, Dec | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 102½—105½ | 3 15 9 | .. | 103¾ | .. |
| | | **TELEPHONES.** | | | | | |
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 102 —104 | .. | .. | — | — |
| 6 | 5/0 | Chili Telephone (fully paid) | 7¾—8 | 5 0 0 | August | .. | .. |
| 1 | 0/9⅜ | Monte Video Telephone Ord. | ⅞—1 | 4 0 0 | — | ⅞ | .. |
| 1 | 1/0 | Do. 5% Pref. | ⅞—1 | 5 0 0 | .. | .. | .. |
| St. | 6% | National Co. Pref. Stock | 110½—111½ | 5 7 7 | — | 111½ | 110½ |
| St. | 5% | Do. Def. Stock | 108 —110 | 4 11 0 | .. | 109 | 108⅛ |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13 —15 | 4 0 0 | Feb, Aug | 14⅛ | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 11 —13 | 4 12 4 | Feb, Aug | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅝—5⅞ | 4 5 2 | Feb, Aug | .. | .. |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 98½—100½ | 3 9 6 | June, Dec | 99¼ | 99 |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 104 —106 | 3 15 6 | .. | 105 | .. |
| 1 | 0/7½ | Oriental | 1¼—1⅜ | 3 12 9 | April, Oct | .. | .. |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1¼—1⅜ | 4 7 0 | — | .. | .. |
| St. | .. | Do. 4% Red. Deb. Stock | 97 —99 | .. | .. | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 103 —106 | 4 4 9 | .. | .. | .. |
| 5 | 5/0 | United River Plate | 7½—8 | 5 0 0 | July | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5½—5¾ | 4 7 0 | June, Dec | .. | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 111 —113 | 4 8 6 | June, Dec | .. | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 5 —5½ | 5 9 0 | .. | .. | .. |
| 10 | 2/0 | Globe Telegraph and Trust | 10½—10¾ | 5 0 8 | Ja. Ap. Jy, O | 10 11/16 | 10⅝ |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14⅛—14⅝ | 4 3 0 | Ja. Ap, Jy, O | 14⅜ | 14⅛ |
| 10 | 6% | Submarine Cables Trust (Cert.) | 125 —128 | 4 13 9 | April, Oct | 125 | — |

| Share. | Last Dividend | Name | Price Wed., Dec. 20. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Week to Dec. 20. High-est. | Low-est. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12¼—12¾ | 5 9 10 | .. | .. | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10⅛—10⅝ | 4 4 9 | .. | 10½ | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11¼—11¾ | 4 18 0 | .. | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 107 —109 | 4 2 6 | .. | .. | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 102 —105 | 4 5 9 | .. | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 8¾—9¾ | 5 2 6 | .. | 9¼ | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 9 —9½ | 3 14 5 | Mar, Sept | .. | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 102 —105 | 3 16 3 | .. | .. | .. |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 5¾—6¾ | 4 16 0 | Feb, Aug | 6 1/16 | 6⅛ |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5½—5¾ | 3 18 3 | Feb, Aug | .. | .. |
| St. | 4% | † Do. 4% Deb. Stock (red.) | 101 —103 | 3 17 6 | .. | .. | .. |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4¾—5 | 4 10 0 | .. | .. | .. |
| 5 | 2/3 | Do. Do. (1903) | 4¾—5 | 4 10 0 | .. | .. | .. |
| 5 | 2/3 | Chelsea Electric Supply Ord. | 5 —6 | 5 0 0 | March | 5 11/16 | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 110 —112 | 4 0 4 | Jn, Dec | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 11 —12 | 5 0 0 | Feb, Aug | 11¼ | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13¾—14¼ | 4 4 2 | Jan, July | 13⅞ | 13 11/16 |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 124 —128 | 3 18 1 | Jn, Dec | .. | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 103 —105 | 4 5 8 | .. | .. | .. |
| 5 | .. | County of Durham Elec. P.D. Ord. £2 pd. | 2 3/16—2 7/32 | .. | April, Oct | .. | .. |
| 5 | 6¾d. | Do. Do. 5% non cum. pref. | 5⅝—5⅞ | .. | April, Oct | .. | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 8½—9½ | 4 6 6 | .. | 9 1/16 | 9 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅝—12⅞ | 4 13 2 | Mar, Sept | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 112 —115 | 3 18 3 | .. | .. | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 101 —103 | 4 7 6 | .. | .. | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼—5¾ | 4 15 8 | .. | 5 9/16 | 5½ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5 —5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101 —104 | 4 6 6 | .. | .. | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8¼—8¾ | 4 17 2 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100 —103 | 4 7 5 | .. | .. | .. |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 11¾—12¾ | 5 0 0 | .. | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½—7 | 4 5 9 | Jan, July | .. | .. |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98 —101 | 3 19 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101 —103 | 3 17 8 | .. | .. | .. |
| 3 | 1/9⅜ | London Electric Supply Ord. | 1¾—2¼ | 4 0 0 | .. | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 4¾—5¼ | 5 14 4 | .. | .. | .. |
| St. | 4% | † Do. 4 per Cent. 1st Mort. Deb. | 97 —100 | 4 0 0 | Mr, Jn, S, D | 98¼ | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 9 —10 | 5 0 0 | April, Oct | 9 9/16 | 9 5/16 |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5¼—5½ | 4 2 0 | Jan. July | 5 11/32 | 5 5/16 |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 109 —113 | 3 19 7 | Jn, Dec | 110 | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 97 —99 | 3 10 8 | .. | .. | .. |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 101 —103% | 4 7 5 | .. | .. | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 12⅛—12¼ | 5 11 6 | Feb, Aug | .. | .. |
| 100 | .. | Do. 4½% Deb. | 101 —102 | .. | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8 —8 1/16 | 4 19 5 | Feb, Aug | .. | .. |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6⅜—6½ | 3 16 11 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 100 —101 | 3 19 7 | Jan, July | .. | .. |
| 1 | 8% | Northern Counties Elec. Sup. 17/- paid | 13/16—27/32 | 3 1 1 | Mar, Aug | .. | .. |
| 100 | .. | Do. 4½% Deb. | 100½—101½ | .. | Jan, July | .. | .. |
| 10 | 6/0 | Notting Hill Electric Ord. | 13¾—14¾ | 4 15 0 | March | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98 —100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅜—6⅞ | 5 1 6 | March | 6¾ | .. |
| St. | 4% | Do. 4% Deb. Stock | 100 —102 | 3 18 5 | .. | .. | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 12¾—13¾ | 5 4 0 | Feb, Aug | 13⅛ | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 8 —9 | 3 17 9 | Feb, Aug | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 98 —100 | 3 10 0 | .. | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2 —2½ | 8 0 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76 —80 | 5 0 0 | .. | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 3 —3½ | 5 10 0 | .. | .. | .. |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | 1 3/16—1 5/16 | .. | .. | .. | .. |
| 1 | 0/8¾ | Do. 7% Cum. Pref. | 1 5/16—1 7/16 | 4 17 2 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105 —108 | 4 8 8 | .. | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4½—4¾ | 5 5 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5 —5¼ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 104 —106 | 4 4 10 | .. | 103 | .. |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 11½—12½ | 5 12 0 | Mar, Sept | 12 3/16 | 12 |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5¾—6¼ | 4 0 0 | .. | .. | .. |
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d | Alliance Elec. Co. 5% Cum. Pref. | ⅝—⅞ | 5 6 6 | .. | .. | .. |
| 1 | 10½d. | Aron El. Met. 6% Cm. Pf. ex on a/c of arrs. | ½—⅝ | .. | .. | .. | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3¾—4 | 5 0 0 | .. | .. | .. |
| 1 | 7½d. | Do. Pref | 1 7/16—1 9/16 | 3 16 10 | .. | .. | .. |
| 5 | 4/0 | British Insulated & Helsby Cables Ord. | 6½—7 | 5 14 0 | July, Feb | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾—6¼ | 4 16 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103 —106 | 4 4 11 | .. | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98 —100 | 4 10 0 | .. | 2¼ | 2 |
| 5 | .. | British Westinghouse 6% Pref. | 1⅝—2¼ | .. | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 80 —85 | 4 14 0 | .. | ½ | .. |
| 2 | .. | Brush Electrical Engineering | ¼—½ | .. | March | .. | .. |
| 2 | 2/4½ | Do. 6 per Cent. Pref. Non-Cum. | 1¼—1¾ | 6 17 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 96 —100 | 4 10 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 84 —86 | 5 4 6 | Jan, July | .. | .. |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11 —12 | 5 0 0 | Jan, July | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝—5⅞ | 4 5 2 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 109 —111 | 4 1 1 | Nov, May | 1⅛ | 1 1/16 |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1 —1⅛ | 5 7 0 | .. | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 97 —102 | 4 8 8 | .. | .. | .. |
| 1 | 9⅜d. | Chadburn's (Ship) Telegraph Ord. | 1 —1¼ | 8 0 0 | .. | .. | .. |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1 1/16—1 3/16 | 5 2 7 | .. | 2 1/16 | 2⅛ |
| 3 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 2 —2¼ | 3 9 0 | Jan, July | 2⅛ | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 97 —100 | 5 0 0 | Jan, July | .. | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8½—9 | 5 11 1 | Sept | 8⅝ | .. |
| 5 | 3/0 | Do. 6% Cum. Pref. | 5¾—6¼ | 4 18 0 | Sept | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106—108 | 4 4 1 | .. | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅜—1⅝ | .. | Feb, Aug | .. | .. |
| 5 | 2/6 | Do. (£5 paid) | 2¼—2¾ | .. | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 85 —90 | 4 8 11 | June, Dec | .. | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92 —97 | 5 8 1 | .. | .. | .. |
| 5 | 4/6 | Edmundson's Elec. Corp. Ord. | 5¼—5¾ | 6 1 9 | H'lf-yearly | 5 7/16 | 5 5/16 |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5¾—6 | 5 0 0 | .. | 6 | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 107 —109 | 4 2 6 | .. | 108¼ | 108 |
| 2 | 1/7½ | Electric Construction Co. | ½—¾ | 9 6 0 | July | .. | .. |
| 2 | 2/9¾ | Do. 7 per Cent. Cum. Pref | 1⅞—2⅜ | 5 18 8 | July | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 92 —95 | 4 4 2 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9¼—9¾ | 5 2 6 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96 —100 | 4 0 0 | .. | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 12½—13½ | 5 11 1 | Feb, Aug | 12⅞ | 12⅝ |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 6⅛—6⅜ | 4 3 9 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | — | 4 1 1 | Feb, Aug | .. | .. |
| 10 | 5/0 | India Rubber, Gutta Percha, &c., Wrks. | 18½—19½ | 2 11 3 | Feb, Aug | 19¼ | 19⅛ |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99 —102 | 3 18 5 | Mar, Sept | .. | .. |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¼—11¾ | 4 5 1 | Mar, Sept | .. | .. |
| 12 | 12/0 | Telegraph Construction & Mainten'ce. | 32 —34 | 5 5 10 | Mar, July | 34 | 33¾ |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 102 —104 | 3 16 11 | Jan, July | .. | .. |
| 5 | — | Willans and Robinson Ord. | 1¾—2¼ | — | Apr, Oct | .. | .. |
| 5 | — | Do. 6 per Cent. Cum. Pref. | ⅞—1½ | — | Apr, Oct | .. | .. |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 82 —87 | 4 12 0 | May Nov | .. | .. |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these

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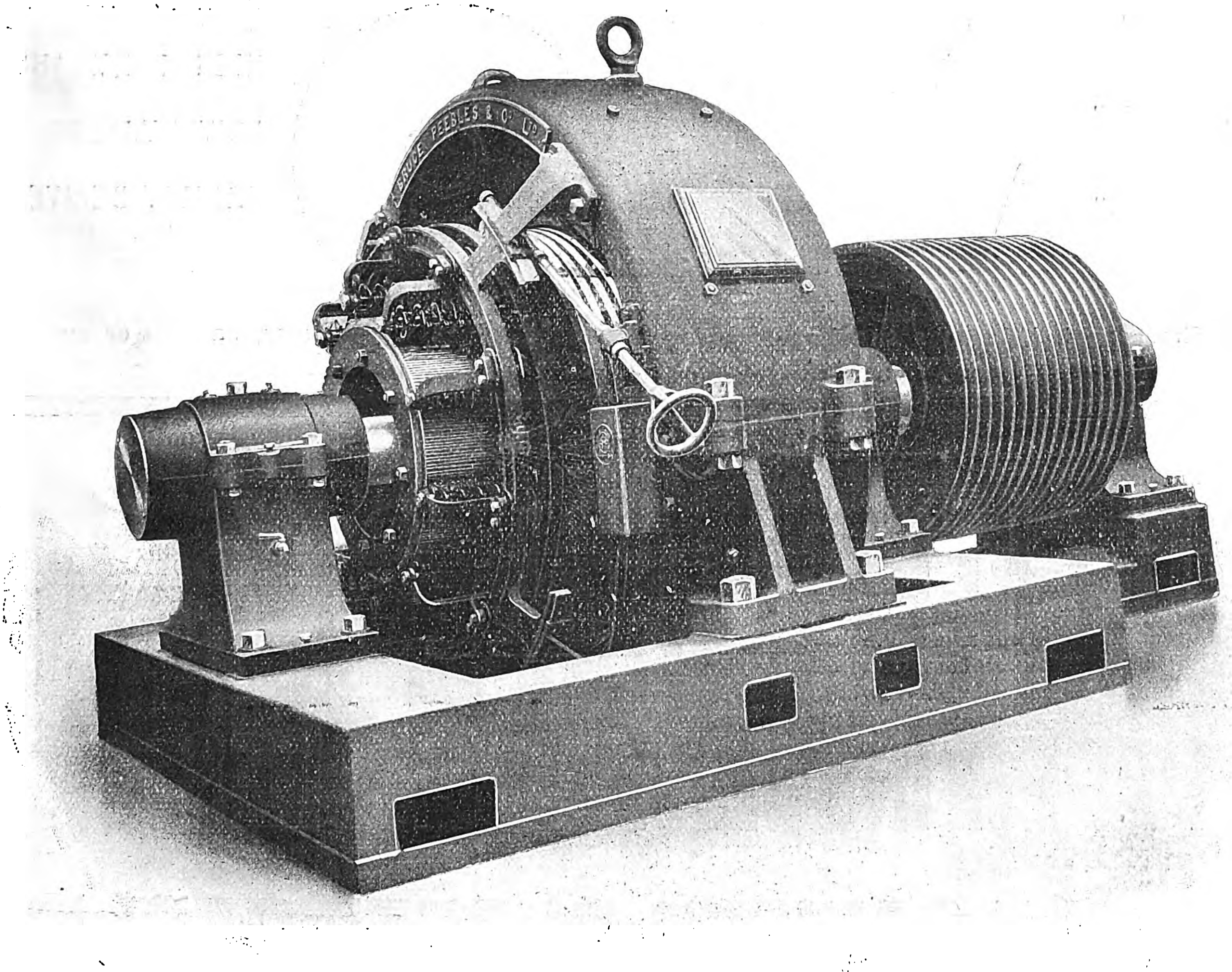

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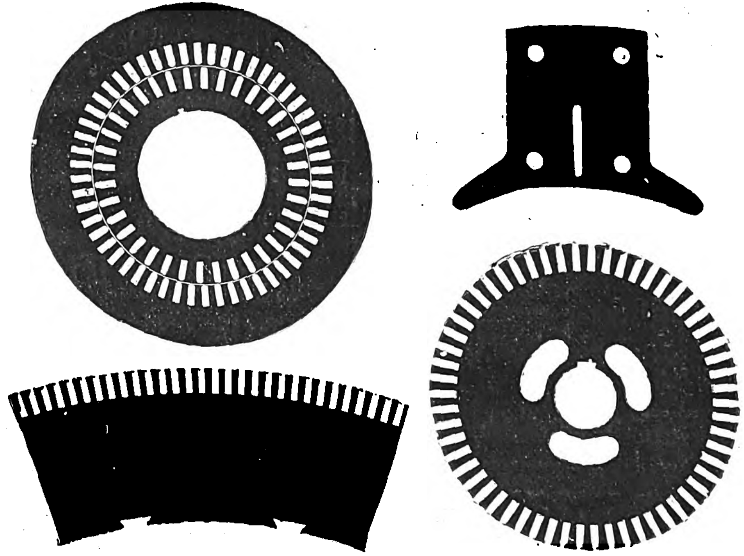

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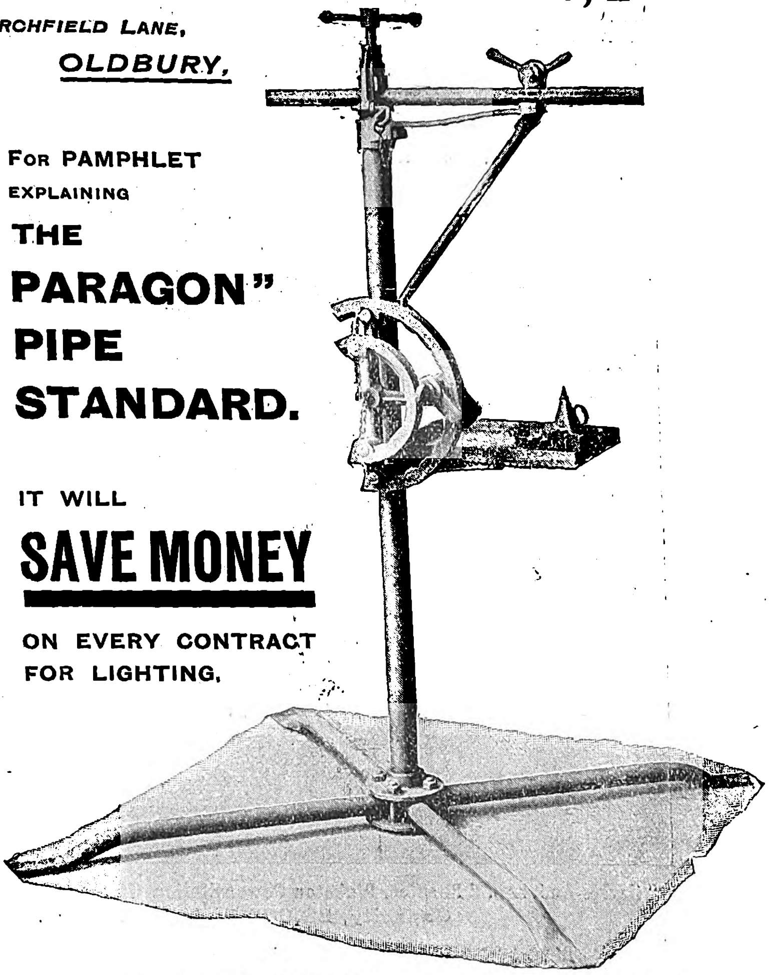

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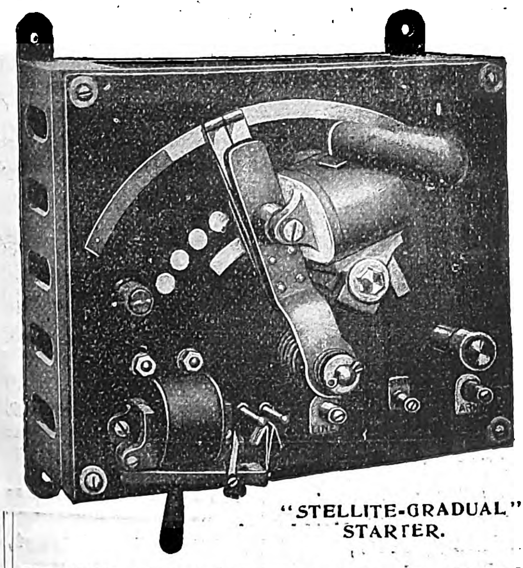

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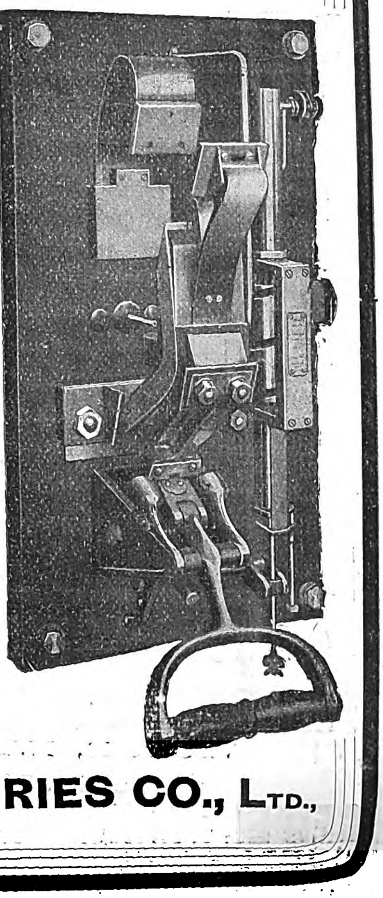

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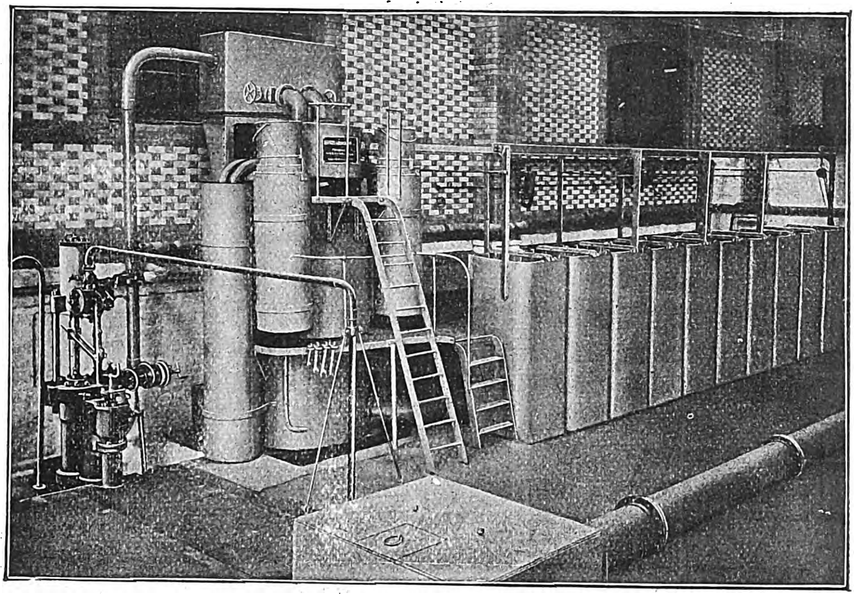

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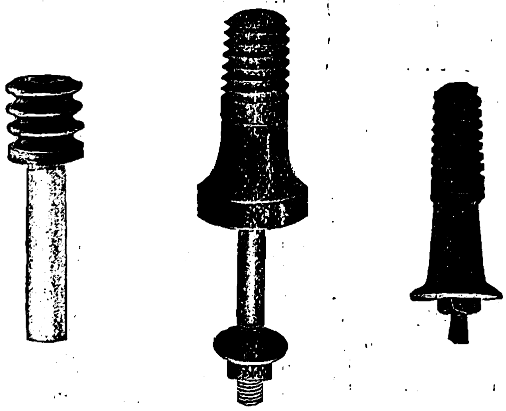

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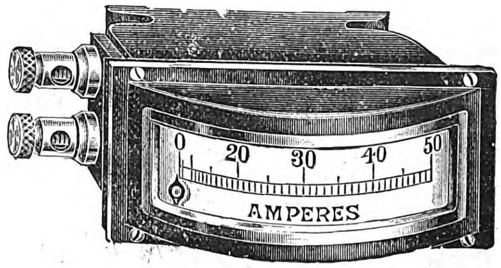

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# THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,441. [No. 11. Vol. LVI.] FRIDAY, DECEMBER 29, 1905. PRICE SIXPENCE (by post, 6½d.), *Abroad 9d., or 18 cents, or 90c., or 80pf.*

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## NOTES.

One of the many subjects dealt with in Sir Henry Campbell Bannerman's speech last week was the development of traffic on the inland waterways of this country, and the promise of a Royal Commission to inquire into the matter brings the question of the suitability of electric haulage or propulsion on canals strongly into prominence. The replacement of the horse on the towpath by the mechanical tractor, or the adoption of mechanically-propelled tugs or barges would undoubtedly result in a considerable gain in speed, but, whatever form of traction is adopted, a practical limit of speed is soon reached, as not only does the effect of wave action on the banks of a narrow canal become a serious matter at speeds above 3 to 4 miles an hour, but the power required increases far more than proportionally to the speed. A sufficient increase of speed could, however, doubtless be attained without unduly raising the cost of repairs, and with a decrease in the working expenses by the adoption of electric driving. The engineering difficulties are by no means insuperable. Experiments have been made and systems developed, both on the Continent and in America, which show that electrical haulage is not only feasible but economical. The main difficulty which is met with in the existing canals is the loss of time caused by the large number of locks, and considerable sums will have to be laid out in enlargements to the locks in order to render an accelerated service possible. The lack of prosperity of the canals is, of course, largely due to the effects of railway competition, and moreover, it is said that some 1,138 miles of canal are controlled in this country by railway companies. But we should like to see the canal companies availing themselves more freely of modern engineering methods, and making a better fight for their share in the traffic of the country, and we hope the promised Royal Commission will conduce to this result. Whatever course is adopted it is only by a very large expenditure of capital that any substantial increase in the earning capacity of our canals can be obtained, and we trust that the British electrical engineering firms will be ready with efficient systems when the time comes, so that the money may be spent on British labour for the electrical as well as the civil engineering work.

The Paper read by Mr. Aspinall Parr before the Leeds Local Section of the Institution of Electrical Engineers furnishes another welcome indication that the long-standing problem of the causes of the unreliability of storage batteries is still receiving close attention in several quarters. In theory storage batteries are not nowadays unreliable, and no doubt in the majority of cases this holds good in practice also. But a minority of exceptions are frequently occurring, sufficiently large to show that there is yet much to be learned before the depreciation and life of accumulators under normal conditions can be estimated with anything approaching to the degree of certainty that holds good for most other electrical machinery.

Like other recent investigators, Mr. Parr takes the view that impurities present in cells, in quantities so small as generally to be considered negligible, are the chief remaining cause of unsatisfactory working and premature deterioration; and the elaborate series of experiments upon which he has entered are designed to support this general statement with some definite and detailed results. Although the conclusions reached will probably be of a severely practical and empirical nature, they must almost certainly furnish some material towards a general theory of the action of impurities in cells—a subject upon which we are at present in almost total darkness so far as the permanent effects produced are concerned. A final clearing-up of this matter will most likely come from the workers in cells with alkaline electrolytes, for in this case impurities can occasion far more serious troubles than where an acid solution is used.

In the present stage of Mr. Parr's experiments, the fourteen cells to which he has added small quantities of the various commercial impurities do not afford any clear indication as to the ultimate conclusions that may be arrived at. Nitric acid, ammonia, copper, arsenic and so forth produce practically no divergence from each other or from the average behaviour; the one exception being a cell containing a mere trace of $SO_2$ which has lost half its capacity in five discharges. Considering the general character of sulphurous acid, and more especially the ease with which it is oxidised and destroyed, it seems almost impossible to believe that this is really a case of cause and effect, and the suspicion arises that the cell might have behaved just the same if there had been no $SO_2$ present at all. This possibility is indeed most difficult to guard against, as it cannot for a moment be assumed that any two cells, let alone fourteen, would have behaved alike because used under similar conditions, unless the facts were first demonstrated by putting them all through a long course of identical treatment before the addition of the impurities. Even then the liability to divergence later on is so great that most misleading conclusions will easily be formed unless rigorously checked by confirmatory experiments. However, Mr. Parr has no doubt taken all these things into account, and everyone interested in accumulators will look forward with much eagerness to further information when his work in this difficult field is concluded.

It has sometimes been said that we have too much experiment now, and that accumulating piles and piles of undigested facts does not help science much. But there are exceptions which are quite outside any carping criticism. Who would deny the utility of this formula: $\text{Log } N = \frac{1}{4}\{\cdot 233 + (3 \times \log \text{B.W.})\}$? It is hardly necessary to add that B.W. is the body weight of a white rat, and N is the total nitrogen in milligrammes per diem excreted by white rats differing in age and weight—and, perhaps, in religious opinions. All the information but the last item is in an abstract to be found in the November *Journal of the Chemical Society*, p. 740. We have not seen the original Paper; doubtless it will be out of print by this time. The compilers of technological pocket books will have swooped down upon it, and bought all the available copies.

A contribution to the interesting problem of the function of the earth in wireless telegraphy appears in short abstract on a page of this issue, this time from the laboratory of Prof. Drude. The experiments were on a tiny scale, unfortunately, and were carried out in a courtyard in front of a large building, so that the immediate application of the results to real wireless telegraphy is scarcely admissible. As it is, the experiments, so far as they are novel in method or conclusion, may provide for the advocates on the two sides of the earthing problem arguments in support of their respective contentions. For instance, the evidence that the earth behaves as a strong absorbing medium may please both sides; while the experiments showing that transmission is best when the sender is insulated will be particularly gratifying to the "insulaters." But the conclusion that the energy received varies inversely as the square of the distance cannot be said to have any bearing at all on wireless telegraphy, since the distances worked through were actually all smaller than a single wave-length.

At the present time, when prices are cut so fine, the application of labour-saving devices and methods amounts to a necessity. This principle has been thoroughly recognised and put into practice in most electrical workshops throughout the country, but it is surprising to note that the testing of the finished product is still often carried out by crude methods. Much time could often be saved by having, in the motor testing shop, a permanently rigged-up testing arrangement such as described by Mr. Thomas Carter elsewhere in this issue. There is not much to criticise in the author's arrangement which appears to have done satisfactory work for some time. In Mr. Carter's general remarks, which preceded the description of his testing set, there are one or two points, however, which cannot pass unchallenged. He makes the quite general statement, for instance, that a motor is most efficient when its brushes are in the neutral position. This, actually, is only true at no load. For every load there exists a definite brush position at which the motor works most efficiently. Of course, it is now considered to be impracticable to shift the brushes as the load fluctuates, and the compromise most usually made is to fix the brushes of a shunt motor in the position corresponding to the maximum efficiency (and perfect commutation) at half load. Another remark which is open to criticism refers to the statement that the secondary voltage of the small transformer employed for carrying out a breakdown test can be determined with sufficient accuracy by the brightness of a number of incandescent lamps connected in series in the secondary. It would surely be more satisfactory and accurate to measure the primary voltage with a voltmeter.

In this issue we conclude our report of the Conference on Smoke Abatement. The Papers dealing with Factory and Trade Smoke Abatement form a part of the Congress very closely connected with electrical engineering. The fact most clearly brought home was that it is only with the utmost care in stoking that anything approaching smokeless combustion can be attained. There was some difference of opinion on the question of mechanical stokers, some speakers condemning them entirely as making more smoke than steam. It appears, however, that some of the instances in which mechanical stokers were discarded were solely due to the want of intelligence of the men in charge of them. More will doubtless be heard on this subject at the next meeting of the Institution of Electrical Engineers. The closing day of the Conference was devoted to a consideration of the legal aspect of the smoke question and proposed legislative reforms. Elaborate details were discussed as to the means to be adopted for observing the nuisance and bringing offenders to judgment; but we cannot help extending our sympathy to some of these offenders, who are fined for offences which even the Conference itself has not satisfactorily told them how to avoid. One of the speakers in the discussion, it will be seen, informed the meeting that his company was prosecuted by the Coal Smoke Abatement Society, even while conducting experiments with a view to curing the nuisance.

MOST scientific men have a strong sense of humour, but they generally keep it out of their serious work. Usually this is a wise course, for not infrequently an unimportant passage treated humorously will attract to itself the lion's share of the reader's attention, so that the important part of the article, which may be comparatively dull reading, does not receive its due consideration. It is not every writer who has the happy knack possessed by Mr. SWINBURNE, for instance, of using his humour with discrimination. Prof. BOLTZMANN rather unexpectedly breaks through this rule in his "Populäre Schriften," recently published. He says in his preface that phonetic spelling is becoming the fashion in Germany, but he is too old to take it up; but he will at least write the preface in it. The preface is, therefore, in a sort of Josh Billings German, headed "forwort" and devoid of any capital letter from beginning to end, except in the date and his own name. But why does he write "shakespeare"?—we would suggest "schäkspier."

**Holborn to Strand Subway Tramway.**—Last week some trial trips were made on the shallow subway tramway under Kingsway between the Strand and Theobald's Road, and it is expected that the Board of Trade inspection will be made this week. Single deck cars run through the subway, and the conduit system is used, the construction of the conduit, however, being lighter than on the South London lines.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Tarifa—Tangier | Jan. 18, 1904 |
| Jamaica—Colon | Jan. 10, 1905 |
| Cadiz—Teneriffe | July 20, 1905 |
| Puerto Plata—Martinique | Dec. 15, 1905 |

**Municipal Accounts.**—In a speech at Battersea on Wednesday Mr. John Burns, the new President of the Local Government Board, said that he would do his best to relieve municipal activity from the conscious bias that had operated against it too long. Already he had drawn a reference and was now appointing a committee, "so that ratepayers and taxpayers should have their accounts presented in such a way that he who ran might read, and might have the knowledge which was not now always revealed as well as it should be."

**Accident at a Glasgow Sub-station.**—An unfortunate accident occurred at the new Stirling-road sub-station of the Glasgow Corporation electricity department. This sub-station is in an industrial quarter in the centre of the city, and receives current at 6,500 volts for distribution at 250 volts. An erector who was assisting the wiremen operated one of the high-tension section switches with his hands, under the impression that the high-pressure supply had been cut off. The unfortunate man received the full voltage and died from the effects.

**"The Central."**—The new number of "The Central" has now been issued. The editors apologise for its somewhat late appearance, which has been occasioned by the absence of one of them as a member of the official party of the British Association in South Africa, while the other editor is now permanently resident in Birmingham. As a frontispiece to the number there is an excellent portrait of Prof. Ayrton, apparently reproduced from a portrait taken a few years ago. It represents the professor as several of the older old students remember him. The magazine contains among other articles one on "The Electromagnetic Separation of Ores," by Mr. C. J. Guttmann, and also a review of the college session 1904-5.

**Wireless Telegraph Notes.**—A popular lecture on wireless telegraphy was recently given by Count Arco in Berlin, when experimental demonstration was made of calling up any one of six model stations. Reference was made to applications of wireless telegraphy in various parts of the world, and the lecturer concluded with the remark that there were more stations in existence on the "Telefunken" system than possessed by the Marconi Company and all the other wireless telegraph companies together.

It is proposed to establish wireless telegraphy at St. Abbs Head, in order to report the movements of passing ships entering and leaving the Firth of Forth.

**Mr. Yerkes' Health.**—The evening papers last night published a telegram from New York to the effect that one of Mr. Yerkes' physicians had abandoned all hope of his recovery. On enquiring at the offices of the Underground Electric Railways Co. of London we were told, on the other hand, that private despatches from America led them to think that the case was not so serious. During the last three days, we were informed, no change had been recorded, and although Mr. Yerkes' friends on this side realised the seriousness of a severe attack of kidney trouble at the age of 68 years, they assert that Mr. Yerkes has pulled through a similar illness whilst in this country, and they are not without strong hopes that he will do so again. Mr. Yerkes' recent trip to America was taken in the usual course of his yearly visits to the States for business purposes and his condition when he left England a few months ago was a considerable improvement upon what it had been during the summer.

**Municipalities and House Wiring.**—In the course of a letter on our recent leading article on the above subject, Messrs. Lea & Warren, of Kettering, write that in their opinion the continuance of the practice of municipalities carrying out wiring is the result of the mutual jealousy of the contractors, who will not support one another in fighting the cases where they occur. For example, in Leicester, not only do the Corporation carry out wiring and supply fittings, in spite of the fact that they were the losers in an action brought against them by an electrical contractor some years ago, but they also undertake private work and, our correspondents affirm, have lately wired a large asylum entirely outside their area of supply and for which separate plant was laid down. Messrs. Lea & Warren urged the other contractors to take up the matter at the time, but were unsuccessful in forming a strong enough combination to insist on the illegal nature of such procedure.

**Electric Motor Omnibus in New York.**—The motor omnibus on the petro-electric system described in our issue of 24th Nov. is now running on the Fifth-avenue route of the New York Transportation Co. It will be remembered that a 40-H.P. petrol engine drives a dynamo rated at 12 kw., but capable of 24 kw. for short periods, and two motors normally connected in parallel drive the car wheels through spur reduction and chains. The control is almost entirely effected by a pedal which acts simultaneously on the ignition and throttle of the engine, but the motors can be connected in series for very heavy grades. A small storage battery is carried for lighting the car, and this can also be used for starting the engine. The total weight of the vehicle is 15,500 lb., including body and all supplies, and a speed of 15 miles per hour can be maintained. We understand from the *Street Railway Journal* that the average petrol consumption is $\frac{6}{10}$ths of a gallon per car-mile.

**Heat Economy in Factories.**—At a meeting of the Institution of Civil Engineers on Tuesday, last week, the Paper read was "Heat-Economy in Factories," by H. A. Mavor :—

In an investigation undertaken in 1898 on the comparative costs of power in factories in the United Kingdom, the author found great difficulty in obtaining accurate data, owing in many cases to the fact that the fuel consumed was applied for heating as well as for power. This circumstance appeared to offer inducements for further examination of the question, and the Paper is an account of a method of inquiry which has resulted in a simplification of the problem and in the acquisition of useful results. The method consists in dealing with the heat-production and distribution by a system of double-entry accounts, in which the boilers are debited with the heat represented by the coal and credited with the heat represented by the steam. These credits are carried to the debit of accounts dealing with the various uses to which the steam is put in the factories. These accounts, again, are credited with the work performed, the balances being carried to a balancing account, which brings out the efficiency of the prime movers and separates out the useful work and the losses in such form that the losses can be divided into necessary and avoidable losses, the whole giving a comprehensive view of the conditions of efficiency in terms of British thermal units. Six specimen balance-sheets are given in the Paper, and the accounts are shown in detail, the cases chosen being: (*a*) A factory in which there is a small amount of heating and a number of steam engines. (*b*) A factory where the power is obtained from one large engine and the heating occupies a prominent place. (*c*) A similar factory where there are many engines and a scattered and complicated heating system. (*d*) A factory where there are a number of engines of various sizes and a considerable amount of heating and boiling. (*e*) A factory similar to *d*. (*f*) A blast-furnace plant. The balancing accounts in each case are discussed in detail, and indications are given of the methods of arriving at the results, showing the bearing which the ascertained efficiencies have upon existing methods of working and proposed modifications thereof.

**All-Steel Cars for the Great Northern, Piccadilly and Brompton Railway.**—The following table comparing the dimensions of the new steel cars which have recently been delivered for the above railway with the District Railway's wooden cars will be of interest. It will be noticed that the saving in weight per passenger seated is 261 lbs.

| Descriptive. | Metropolitan District Railway. | Great Northern, Piccadilly & Brompton Railway. Steel car. |
|---|---|---|
| | Ft. In. | Ft. In. |
| Length over body | 35 8 | 41 8½ |
| Length over platforms | 49 9½ | 49 9½ |
| Width over end posts | 8 9 | 8 8 |
| Extreme width | 8 10½ | 8 9 |
| Height from floor to roof | 8 5 | 7 6 |
| Height from rail to top | 12 3¼ | 9 5⅜ |
| Wheel base | 6 6 | 5 0 |
| Truck centres | 33 10½ | 33 0 |
| Diameter of wheels | Motor, 3 ft.<br>Trail, 2 ft. 6 in. | 2 6 |
| Seating capacity | 52 | 54 |
| Weight | 47,600 lb. | 35,550 lb. |
| Weight per passenger seated | 918 lb. | 657 lb. |

**Obituary.**—It is with great regret that we announce the death of Mr. C. R. Bellamy, the popular manager of the Liverpool Corporation tramways. The circumstances surrounding his decease, at the early age of fifty, are particularly sad. Mr. Bellamy, a couple of weeks ago, stumbled over some old rope in the basement of his house and badly sprained his ankle. He was attended to by a medical man, but serious consequences were totally unlooked for, although there was considerable swelling. He had practically returned to business, and as late as ten o'clock on Saturday evening, December 23rd, he was in communication with his chief assistant. During the day, however, the swelling had increased and rapidly developed later, and just before midnight, when about to retire, Mr. Bellamy suddenly collapsed. The doctors were immediately summoned, but their efforts were unavailing, death following from the clotting of an artery from the heart to the lungs. Mr. Bellamy was appointed to the general managership of the Liverpool Corporation tramways soon after their conversion to electric traction in 1898 and has also had charge of the street lighting. The results which he has achieved in these departments are too well known to need repetition. In addition to his success as a manager, credit is due to Mr. Bellamy for his reversed stairway, which has increased the public safety in ascending and descending tram-cars, and his application of the top cover to the trolley car. He has also brought out a patent hexagon indicator, and a salt distributing waggon for dispersing snow. The Liverpool tramway employés, too, have reason to bear grateful remembrance of Mr. Bellamy, for not only has he shown them sympathy and forbearance, but he has given practical demonstration of his feelings towards them by the inauguration of a friendly society and the proposition of a superannuation fund which is shortly to be put into operation. Mr. Bellamy was President of the Municipal Tramways Association in 1904, and was President-elect of the Tramways and Light Railways Association. It will be remembered that in his Presidential Address of 1904 Mr. Bellamy made an earnest appeal for the construction of real light railways intended primarily for the transport of agricultural produce, and as an extension of this idea he had lately been working out a scheme for the transport of merchandise from the Liverpool docks by tramway to a number of other towns in South Lancashire.

**The Measurement of High-Frequency Currents and Electric Waves.**—The series of Cantor lectures on the above subjects before the Society of Arts terminated on Monday, last week, when Prof. J. A. Fleming, F.R.S., explained the nature of stationary waves, the conditions under which they appear, and the methods employed for detecting and measuring them. Stationary air waves are met with in organ pipes, and the lecturer's reference to these greatly helped in making the corresponding electrical phenomenon clear. A mechanical model was also shown in operation illustrating the nature of stationary waves. The velocity of the electric wave along the conductor was equal to $1/\sqrt{CL}$, C being the capacity and L the inductance of the conductor. As an example of the values obtained in actual cases, the lecturer quoted the case of the old Ferranti H.T. cable between Deptford and London which had a resistance of $\frac{1}{3}$ ohm per mile, an inductance of $\frac{1}{3}$ millihenry per mile, a capacity of $\frac{1}{3}$ microfarad per mile, and an insulation resistance of 720 megohms per mile. It could be calculated from these figures that the stationary wave had a length of 940 miles and travelled at the speed of 77,700 miles per second. Stationary waves appeared if a certain ratio existed between the length of conductor and the wave-length. According to the conditions, we might have the fundamental wave or any harmonic. This was shown experimentally by exploring a long helix of 5,470 turns wound on an ebonite rod with a neon tube. The neon tube remained dark at the nodes of the wave, but brightened up at intermediate points, the brightness being a rough indication of the amplitude of the stationary wave at the particular point. When a certain frequency was applied at the end of the helix, the fundamental wave appeared in the helix. By altering successively the frequency of the impressed oscillation in a suitable manner the lecturer produced various harmonics in the helix. The velocity of the waves in the particular case was 1,100 miles per sec. Such a helix could be (and had been) used as a cymometer, and was then known as an "open circuit" cymometer. Prof. Slaby's wave-measurer was based on this principle. In this case the length of the helix was varied by gripping it with the hand at various points, and, when measuring the length of a wave, the observer slid his hand up and down the helix until a stationary wave was produced, this being indicated by the brightening-up of a piece of fluorescent paper fixed at the far end of the helix. A neon tube was a much more sensitive detector, however, and the "closed-circuit" cymometer, as described in the previous lectures, was a better instrument, since its action did not disturb the thing one was measuring in the same degree as an "open-circuit" cymometer. Waves could also be induced by induction, and an arrangement of this kind, embodying the principles of an ordinary transformer, were shown and experimented upon. From this laboratory arrangement to the actual antenna was only a step, and a number of lantern slides were thrown on the screen, showing the method of inductive coupling usually employed in practice. In conclusion, Prof. Fleming said that much had been done, but a good deal remained yet to be done. A sensitive detector which measured, not the R.M.S. of the train of waves, but the maximum amplitude of the waves, was greatly needed. At present also the spark was a necessary evil, and much room for desirable improvement lay in the direction of producing continued oscillations more efficiently.

## ARRANGEMENTS FOR THE WEEK.

**THURSDAY, January 4th.**

RUGBY ENGINEERING SOCIETY.

*8 p.m.* Meeting in the Benn Building, High-street, Rugby. Paper to be read: "The Conversion of Mechanical into Electric Energy," by F. R. Clough.

RÖNTGEN SOCIETY.

*8:15 p.m.* Meeting at 20, Hanover-square, London, W. Prof. F. Soddy, President, will deliver his Inaugural Address on "The Present Position of Radio-Activity."

## ELECTRICAL ENGINEERING SCHEMES IN PARLIAMENT, 1906.

We conclude below our résumé of the contents of the private bills of electrical interest which will come before Parliament next session. Last week we dealt with the electric power schemes. Some reference to important points of detail is made in our leading article.

### TRACTION BILLS.

#### LONDON.

*Baker Street & Waterloo Railway Bill* asks for power to undertake certain deviations of the route already authorised, to take some additional lands in the boroughs of Paddington and St. Marylebone and to abandon certain works.

*Hammersmith, City & North-East Railway Bill* again proposes the construction of a deep level twin tunnel railway from Hammersmith along Knightsbridge and Piccadilly to Fleet-street and thence through Stoke Newington and Tottenham to Southgate. The promoters named in the bill are Arnold F. Hills, David Urquhart and Charles Joseph Wills, who will also be the first directors. The capital of the company is £9,000,000 in £10 shares, and interest out of capital during construction to the extent of £70,000 is to be paid. The railway is to be completed within five years, or powers shall cease. Lands for generating stations have been scheduled at Hammersmith and Shoreditch. No goods will be carried, and the maximum fares are 3d. per mile first class and 1d. per mile third class. A clause in the bill binds the promoters to submit plans to the Board of Trade for approval on the following matters: (1) Platforms, stairs, lifts and other communications, permanent tunnels and junctions, (2) rolling stock, (3) lighting and (4) ventilation.

*London County Council (Tramways) Bill* seeks an extension of time for certain tramways authorised in 1904 and also proposes new tramways in many parts of London, north, south, east and west. The Victoria Embankment tramway is again revived and agreements with the City Corporation as to the widening of Blackfriars Bridge and the running of tramways over it are provided for. Powers to continue the Holborn to Strand subway on to the Embankment are taken in this connection. The tramways under the bill are to be completed in seven years. Borrowing powers to the extent of £1,370,000 are taken. An agreement is also scheduled to the bill providing for the acquisition by the London County Council of the tramway running along the boundary of Finsbury Park, one pair of rails of which hitherto has been purchasable by the Hornsey Borough Council.

*London Outer-Circle Railway Bill* proposes the construction of railways on the outskirts of London, making junctions or connections with all existing railways en route, and linking up the following districts, all north of the River Thames: Feltham, Southall–Norwood, High Wycombe, Greenford, Wembley, Hendon, Finchley, Wood Green, Southgate, Tottenham, Ilford, East Ham and West Ham. The capital of the new company will be £4,500,000 in £10 shares, and £1,500,000 in borrowing powers. Powers to work the railway electrically are taken, and lands for generating stations at Willesden, Isleworth and Tottenham are scheduled. Works to be completed in five years. Interest out of capital during construction at 3 per cent. per annum to the extent of £250,000 is to be paid. The promoters are Henry Kerr Rutherford, Hon. Arthur Cornwallis Ponsonby, Reginald Henry Cox, William Brodie Cownie and Cornelius Rozenraad, who are also named as first directors with the Right Hon. Hugh Earl Fortesque and Lord Montague of Beaulieu.

*London Southern Tramways Co.* seeks additional powers in regard to its existing tramways, which the London County Council could have purchased in 1903. It is now proposed to adapt the lines for electric traction, and to raise £180,000 additional capital, with £60,000 borrowing powers.

*London United Tramways Bill* provides for an extension of time in respect of lines authorised in 1900, 1901 and 1903. Powers for a considerable number of road widenings in Middlesex and Surrey are taken. Provision is also made that owners should only be required to sell portions of their property. Five years is the period suggested for the extension of time and for the construction of a few new lines, and in default a penalty of £50 per day will be inflicted, which shall be recoverable by anyone claiming to have sustained damage through the tramways not being in operation. Purchase of the lines under the bill to take place in 30 years at fair market value.

*Middlesex County Council Tramways Bill* authorises the Middlesex County Council to construct new tramways in Willesden and Hampstead and to widen roads. Powers are taken to lease the tramways and to enter into agreements with the North Metropolitan Electric Power Co. The lines are to be worked under the terms of the Light Railways Act, 1896. The borrowing powers are £80,248 for tramways and £295,652 for street widenings.

*North-East London Railway Co.* wishes to raise additional capital to the extent of £250,000, to pay interest out of capital during construction to the extent of £25,000 at 3 per cent. and to make certain subsidiary works.

*North Metropolitan Tramways Bill* provides for the winding up of the company and its dissolution, and the surrender of the company's lease to the London County Council. The agreement between the parties is scheduled to the bill.

*North-West London Railway Bill* seeks four years extension of time for the construction of the Marble Arch–Cricklewood tube railway, sanctioned in 1899, and also an extension of the line to Victoria. Certain other minor works are proposed. In order to carry out these works a restriction of the powers of the Metropolitan District Railway Co. to deviate is necessary, and this is sought for in the bill. Additional capital to the extent of £1,050,000, with borrowing powers of £350,000 is applied for.

#### PROVINCES.

*Bournemouth Corporation* seeks authority to use its generating station for the purposes of its Tramways Acts from 1900 to 1904, and to introduce penny stage fares upon its tramways.

*Cork City Railways Bill* proposes the incorporation of a new company to construct new railways in the neighbourhood of Cork, and authorises agreements with the Cork Electric Lighting & Tramways Co. for a supply of electrical energy in the event of electric traction being adopted.

*Dover Corporation* seeks an extension of time for the purchase of certain lands and the construction of tramways under an act of 1901.

*Folkestone, Sandgate & Hythe Tramways Bill* gives powers to the Sandgate & Hythe Electric Co. to acquire the existing tramways in this district and to construct new lines.

*Folkestone, Sandgate & Hythe Tramways Bill* proposes the incorporation of a new company for the reconstruction of existing tramways and the construction of new lines. Capital £250,000, borrowing powers £83,000.

*Huddersfield Corporation Bill* authorises the construction of some short lengths of additional tramways for which £5,340 will be borrowed repayable in 60 years, and £822 for electrical equipment repayable in 20 years.

*Macclesfield & District Tramways Bill* seeks the incorporation of a company, with a capital of £135,000 in £10 shares, to construct a network of tramways in and around Macclesfield. The promoters are W. L. Madgen and Alfred Christian Hobson. Works to be completed in five years. The carriage of goods and animals will be undertaken and 1d. stage fares arranged. Purchase is to take place in 42 years from date of Act at fair market value. General powers are taken for agreements with local authorities, as to the supply of electrical energy and with contiguous undertakers. Interest out of capital during construction to the extent of £15,000.

*Manchester Corporation* in a general powers bill asks for an extension of time regarding tramways sanctioned in 1901. Five years is the time specified in the bill. The bill also provides that certain other lines shall not be constructed until street widenings have been carried out.

*North & South Shields Electric Railway Bill* extends the time for the construction of a tube electric railway connecting North and South Shields authorised in 1902.

*Nottinghamshire & Derbyshire Tramways Bill* asks for an extension of time for the construction of works and acquisition of land authorised in 1903, and also provides for a re-arrangement of the capital of the company. Powers are also taken to sell certain tramways to the Mansfield & District Light Railways Co. and the Nottingham Corporation.

*Oldham & Saddleworth Tramways Bill* proposes the abandonment of tramways authorised in 1902 and 1904.

*Oxford Corporation Bill* provides for the acquisition of the existing horse tramways and their reconstruction for electric traction. Five years is specified as the period for the completion of the works. Powers are also taken to run motor omnibuses in connection with the tramways and to enter into working agreements. Land for a generating station is scheduled and the extraction of water from the River Thames for condensing purposes is proposed.

*Preston, Chorley & Horwich Tramways Bill* seeks an extension of time for the tramways authorised in 1903, the authorisation of certain new lines and the abandonment of others. Five years for the completion of works. The bill also provides for the acquisition of certain lines by the Wigan Corporation.

*South Lancashire Tramways Bill* asks for an extension of time for the construction of tramways authorised in 1900, 1901 and 1903.

*Southport & Lytham Tramways Bill* seeks an extension of time for ines authorised in 1899, &c.

*Watford & Edgware Railway Bill* seeks an extension of time for the acquisition of land and the construction of works under Act of 1903, and the transfer to the company of certain powers of the Edgware & Hampstead Railway Co.

*West Yorkshire Tramways Bill* provides for the incorporation of a new company to construct tramways in the West Riding of Yorkshire. The capital will be £120,000 in £1 shares and borrowing powers of £40,000. The promotors and first directors are L. B. Schlesinger, J. T. Jervis, B. Benham and W. B. Cownie. Interest out of capital during construction at 3 per cent. will be paid to the extent of £5,000. Running powers over the Huddersfield and Halifax Corporation lines are sought, and it is proposed to carry goods and animals. No purchase is to take place unless by agreement between all the local authorities concerned, and then only after 42 years.

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*Buenos Ayres Grand National Tramways Bill* provides for dealing with the arrears on the preference and second preference shares of the company and the accumulated balance to the credit of the revenue account, and for the increase and rearrangement of its capital.

### COMBINED LIGHTING AND TRACTION BILLS.

*Bury Corporation* in an omnibus bill proposes the construction of additional tramways and extensions to the municipal electricity works. Sanction is sought to borrow £54,000 for tramway purposes repayable in 50 years, £12,500 for electrical equipment, and £45,000 for extensions to the municipal electricity works both repayable in 30 years. Powers to supply electricity in neighbouring localities with the consent of the municipal authorities in each case, are also included in the bill.

*Haslingden Corporation* provides for the acquisition of the existing tramways, their reconstruction for electric traction and the construction of new lines. Penny stages are to be introduced, and motor 'buses are proposed as feeders to the tramways. The bill also seeks authority to enter into working agreements with the Accrington and Rawtenstall Corporations. The date of purchase of the existing lines is also re-arranged. The Corporation also takes powers to trade in electric fittings, lamps, &c. It is proposed to borrow £38,000 for the purchase and reconstruction of the existing tramways, repayable in 40 years; for the purchase of the tramway company in Rawtenstall £12,000, repayable in 40 years; £25,000 for new tramways, repayable in 40 years; electrical equipment of tramways £25,000, repayable in 20 years, and £3,000 for electric fittings, &c., repayable in five years.

*Hull Corporation* seeks powers, *inter alia*, for an extension of time for the construction of tramways authorised in 1900 and 1903, to build additional lines, to attach brackets to buildings, to lay temporary tramways where necessary and to run motor omnibuses as tramway feeders. Borrowing powers to the extent of £75,000, repayable in 30 years, are asked for in this section of the bill. It is also sought to supply electricity in adjoining districts, for all purposes, including traction, and also to deal in fittings, &c., but it is specifically provided that the latter work shall only be done through contractors. Brackets may also be attached to buildings for lighting purposes, and the stand-by clause is in the bill.

*Romford & District Tramways Bill* seeks to authorise the incorporation of the Romford & District Tramways Co., and to transfer to it existing electric tramway and lighting powers originally granted to the Corporation, but now held by the Empire Electric Light & Power Co. The tramways were authorised in 1903, and an electric lighting provisional order was granted in 1900. The promoters and first directors of the new company are Theodore Peterson, William Paxman and Alfred Slatter. The capital will be £90,000, and interest out of capital during construction may be paid to the extent of £2,000. The bill asks for an extension of time with regard to the powers to be transferred.

*Wallasey Corporation Bill* seeks powers to construct new tramways, to enter into working agreements with regard to tramways, to attach brackets to buildings and to run motor omnibuses in connection with the tramways. The supply of electricity in bulk to outside areas is also provided for. The stand-by clause is included.

*West Cumberland Tramways Bill* extends the time for carrying out the electric traction and lighting powers granted in 1901 and 1903. The bill exempts the generating stations of the company from liability for nuisance, and provides for agreements to supply in contiguous areas, and the supply of electrical energy to railways, tramways, &c., partly within and partly without. The name of the company is to be changed to the West Cumberland Electric Power & Tramways Co.

## ELECTRICITY SUPPLY BILLS.

*Ascot District Gas Co.* seeks powers, *inter alia*, to supply electricity within its gas area.

*Brixham Gas Co.* seeks among other things powers to supply electricity in Brixham. The Brixham Urban District Council is supporting the application.

*Crediton Lighting & Power Bill* seeks the incorporation of a new company to take over the existing gas company and also the Crediton electric lighting provisional order.

*Folkestone & District Electricity Supply Bill* confers further powers upon the Folkestone & District Electricity Supply Co., and seeks to legalise agreements with the Sandgate and Hythe Corporations as to electric supply. The bill also provides for the transfer of the provisional orders of the Sandgate and Hythe Corporations.

*Mid-Oxfordshire Gas Co.* seeks powers to apply for electric lighting provisional orders.

*St. Pancras Borough Council* seeks the exemption of its generating stations from liability for nuisance, and also provides for the acquisition of lands.

*Todmorden Corporation Bill* includes, *inter alia*, certain provisions in regard to the municipal electricity undertaking, such as the stand-by supply clause, refusal to supply person in arrears with payment, &c.

*Twickenham & Teddington Electric Supply Co.'s Bill* confirms agreements with the Hampton and Teddington Urban District Councils, and authorises the company to lay mains from its Twickenham power house to supply other districts. Powers are taken to supply energy in any adjoining areas. The stand-by clause is also part of this bill.

## MISCELLANEOUS.

*Bacup Corporation* is promoting an omnibus bill, which includes powers to attach brackets to buildings for lighting purposes, and also to trade in electrical wiring, fittings, &c. There is no stipulation that this latter work shall be carried out by a contractor.

*Corporation of London (Blackfriars and other Bridges) Bill* proposes the widening of Blackfriars Bridge for the purpose of accommodating a tramway, which shall run along Victoria Embankment. Certain conditions affecting the tramway, which will be laid by the London County Council if sanctioned by Parliament, are included in the bill.

*London County Council (General Powers) Bill*, Part VI., seeks to authorise London borough councils, who are electric lighting authorities, to borrow money under the Electric Lighting Acts for the purposes of electric wiring, fitting, &c. The adjustment of the expenditure and revenue in each year is provided for by the insertion of a similar clause to the original Bermondsey clause. There is also the power to enter into agreements in connection with such work.

*Metropolitan Pneumatic Despatch Bill* reintroduces the proposal rejected last session to incorporate a company for laying down a system of tubes in London through which carriers containing parcels will be propelled by pneumatic power, the necessary air compressors being driven by electricity. The capital of the company is to be £500,000, with the usual one-third borrowing powers. The local authorities are to have full voice in the matter of routes. Interest out of capital during construction at the rate of 3 per cent. per annum to the extent of £45,000 is to be paid.

*Newport (Mon.) Corporation*, in a general powers bill, makes further provision in connection with its electricity undertaking. Powers to supply fittings, &c., are sought, and clauses relating to stand-by supply and exemption of machinery and fittings from distress are inserted.

*Rathmines & Rathgar Urban District Council Bill* provides for the acquisition of the free wiring rights of the National Electric Construction Co. under an agreement dated May 17, 1899. When the undertaking is taken over by the Council the work is only to be carried on through contractors.

# THE CHARING CROSS COMPANY'S CITY OF LONDON WORKS.*

BY W. H. PATCHELL.

(*Concluded from page 384*).

### SUB-STATIONS.

There are four sub-stations in the City, each provided with a motor generator and battery plant. As the type of plant used in each is the same a description of the Fenchurch-street sub-station will suffice. Fig. 9 shows a plan of the basement and a sectional elevation of the building. It will be seen that it is arranged for machines and switchboards in the basement; the ground floor may subsequently be used as a battery room, but it is very convenient for cable stores, trucks and the other loose plant necessary for the street work of the mains department. The floors over are laid out for batteries. This building will take motor generator plant of 8,400 kw. capacity and battery plant of 1,600 kw. capacity on a four-hour rating.

*Switchboards.*—The E.H.T. mains are brought to the E.H.T. chamber underneath the switchboard platform, and are there connected through oil fuses to the ring 'bus bars. Each motor is connected to the 'bus bars through oil fuses and a Siemens & Halske chimney-type switch, which are also fixed in the E.H.T. chamber. The switches are controlled positively by levers from the machine operating panel on the switchboard platform above. Each motor generator has its own standard panel complete. Main switches, ammeters, voltmeters, also field switches and ammeters, are provided for both the motors and generators. A synchronising gear of voltmeter and lamps combined is provided for the synchronous motors, and the motor field switches are omitted on the panels for induction machines. The synchronous motors are all started up from the generator side, and the starting switch is used as the main switch for one pole of the generator, while the induction motors can be started alternately from the generator side or from the motor side, and are fitted accordingly.

*Motor Generators.*—Induction motors are preferred in some quarters because they can be started up more quickly, and it is believed that in the event of an accident they will maintain their load better than synchronous machines, which, however, are preferred by some engineers because of their better power factor. The regulation of the direct-current side can be managed equally well with either type of machine under normal conditions.

Rotary transformers have their strong advocates. For tram and railway work they are used largely of the fixed ratio type. Modifications of this type to give a variable pressure are more novel, but have been largely made by Messrs. the A.E.G. for the Berlin works. There are also other patents by Messrs. Lahmeyer and Mr. La Cour for variable ratio rotaries. The small size of a rotary transformer as compared with a motor generator is very striking and seems much in favour; but it must be remembered that the necessary transformers are, like the condensers for turbo-generators, generally out of sight in a large basement, and the mind, if not the eye, must grasp them both together. It is stated that rotaries will give a higher efficiency, but from any records that the author has been able to obtain of the practical working of the machines, the regulation, although good enough for a power load, is not usually sufficiently good for a high-class lighting load.

After investigating the types of rotaries then available, and considering the respective merits of synchronous and induction motors for the particular case, the choice fell upon synchronous motors for the majority of the machines with one or two induction motor sets in each substation. In all cases the motors are wound for the full pressure of 10,000 volts, with a uniform size of motor of 500 H.P. and a speed of 300 revs. per min. As so much, in fact everything, depended on the smooth running of these machines, the author did not feel justified in experimenting with light high-speed machines, and it will be very interesting to see whether the result of working some of the higher speed and lighter machines now being made is equally satisfactory.

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* Paper read before the Institution of Electrical Engineers, Dec. 7, Slightly abridged.

The motors in some cases drive 350 kw. generators wound for the full pressure, 400 to 440 volts, across the "outer" wires, and in some cases they drive two generators, each of 175 kw. capacity, which are wound for 200 to 220 volts, and are used as balancers on the three-wire system.

*Storage Batteries.*—The batteries at Fenchurch-street at present comprise 204 cells, each of 4,000 ampere hours' capacity at a four-hour rate, made by Messrs. The Tudor Accumulator Co. The overall dimensions of each cell are 24 in. × 48 in. × 45 in. high, and its weight in the working order 3,000 lb. In accordance with the author's standard custom for several years past, end cells are not used, their place being taken by reversible boosters. When he first used this system in the Short's-gardens sub-station, the motors were wound for the Lambeth pressure 1,000 volts direct current, to avoid double transformation losses. Had boosters with high voltage motors been used in the City, the size is so small that step-down transformers would have been necessary. It was, therefore, decided to use the ordinary pressure from the "outers" of the distributing network for running the motors. They are thus available at all times, no matter whether the E.H.T. plant is running or not.

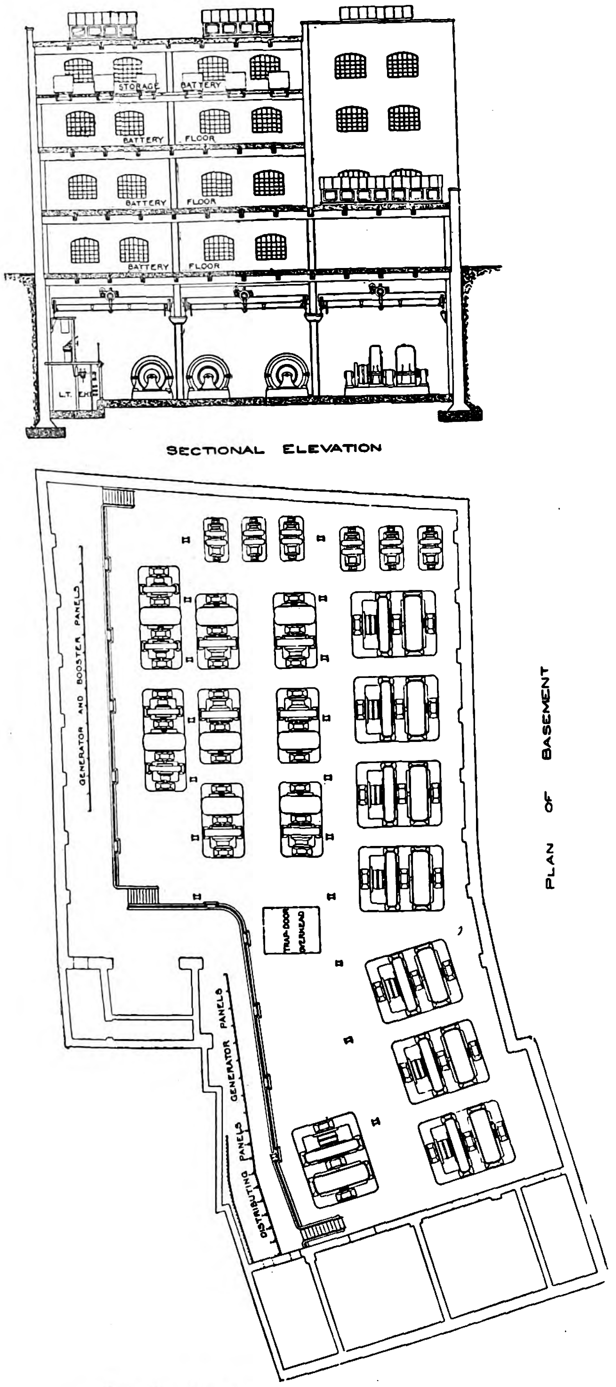

Fig. 9.—Fenchurch Street Sub-station.

As the author mentioned in the discussion on Mr. Highfield's Paper on "Reversible Boosters" at this Institution in 1901, hand regulation is used throughout. The conditions obtaining are better met by hand regulating than by automatic regulation, which, although excellent for tramway work as used by Mr. Highfield, would not be so convenient for the work now under discussion. [A drawing of one of the machines is given in Dr. S. P. Thompson's "Dynamo-Electric Machinery."]

Practically, no movement of the brushes is required from no load to full load of 1,200 amperes. The latest construction is even better, as in it the generator machines are provided with compensation poles, and can be run from full load in one direction to no load, and up to full load in the other direction, without moving the brushes or showing any signs of sparking.

Battery-room floors have frequently caused some anxiety. In the author's experience with small cells, where there is apt to be a good deal of acid splashed and dropped, blue-brick laid on cement, but grouted up with pitch instead of cement, has proved thoroughly satisfactory. He has also used asphalt, but found that this was not sufficiently hard; the cell bearers sink into it in course of time. In subsequent work, where the cells do not stand on lead-covered steel joists, they stand on concrete screeded over with a hard cement smoothed off and tarred with two coats of Stockholm tar. This has been found to withstand any acid dropped on to it in the ordinary course of working, and has proved a cheap and efficient floor.

### Supply.

The supply into the districts presents little novelty. The Ludgate area was first supplied from the western districts of the Charing Cross Company at 2 × 100 volts on the three-wire system by simply extending the existing network, and supplementing the supply from the old sub-stations with a temporary plant in Ludgate sub-station. Before Bow generating station was started there were more than 50,000 lamps supplied in this way; the pressure, therefore, was kept at 2 × 100 until this year, when a change to 2 × 200 volts began to be effected. The other three districts of the City, Fenchurch-street, Cannon-street and Beech-street, are all supplied at 2 × 200 volts.

The feeders and distributors are paper-insulated lead-covered cables laid on the solid system, with spare-ways into which further feeders can be drawn as required. Each feeder is provided with an automatic cut-out in the sub-station, and the distributing networks supplied by separate feeders are interconnected through enclosed type fuses.

### General Working Results.

The Bow plant began to run in May, 1902. Fig. 10, showing weekly output of B.T.U. generated and coal used, is interesting, as it indicates the value of the plant more truly than any other tests The units and coal are plotted on a 1 to 4 scale, and it will be noticed that almost throughout the coal used is less than 4lb. per unit. The coal used at first was large Welsh, but in the second half of 1904 small Welsh began to be used in gradually increasing quantities, and through the winter not much more large coal was used than was necessary for lighting the fires, and a little on the peak. During the year 1905 the quantity of large coal used has been infinitesimal.

### Experiments with Switches, Fuses and Spark Gaps.

As already mentioned, the chimney-type switches first installed have been replaced by oil switches in the generating station. Before the type of switch and fuse was decided upon in the year 1900 extensive test-room experiments were made, and under any conditions there obtainable the chimney-type switch and tubular fuses operated satisfactorily. Various fuses were experimented with. The type adopted consisted of two tubes in parallel. The main tube was of glass, about 1½ in. in diameter, and open at each end. It contained the main fuse wire. A second tube of ebonite, very small in diameter, containing a fine wire fuse, intended to break last and take the spark, was fitted in parallel with it. Experience, however, showed that laboratory tests are of little value as indicating the performance of switches and fuses which may have to open circuits under the working conditions which obtain in a large power plant. It was found that these fuses were apt to maintain the arc instead of breaking promptly when the 1,600 kw. machines were working. A further set of experiments were then made, first in the direction of filling the glass tubes with cable compound and also with oil, neither of which were satisfactory, as the heat in the fuse wire was conducted away by the surrounding compound, and it was therefore impossible to correctly calibrate a fuse; and further, the small explosions made in the oil or cable compound due to the fuse acting, distributed the medium in the immediate vicinity and so rendered this type of fuse impossible for switchboard work. As the experiments were continued a type was developed which has operated most satisfactorily.* The substitution of oil switches for the chimney-type switches in the generating station rendered the retention of fuses there unnecessary, but this type of oil fuse is now being used throughout the sub-stations.

Previous inquiry as to the procedure with three-phase underground lines, none of which were working at more than 6,000 volts, and also with overhead lines at higher pressures, showed generally that no particular care was taken in switching the cables in or out; but the author was not satisfied that the plant herein described, comprising large machines and long underground cables, could be worked at 10,000 volts without special precautions, he therefore arranged for a complete oscillograph investigation to be made by Mr. W. Duddell. In view of the great importance of the matter and the dearth of public information on the subject, the results of the investigation will be found in the Appendix.

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* The type in question is illustrated in the Paper, and is an application of the Lahmeyer fuse described in *The Electrician*, Vol. LIV., p. 398.

Preliminary switching tests were made at 5,000 volts, that is, half normal working pressure, when the maximum volts were found to be about twice the normal. The result of the experiments was to show that resonance was more likely to occur if the periodicity was varied, and that, therefore, it was dangerous to switch a cable in at a low frequency and then run up to normal speed on the cable, and that the safer procedure was to switch it on the normal frequency with low volts and then raise the pressure.

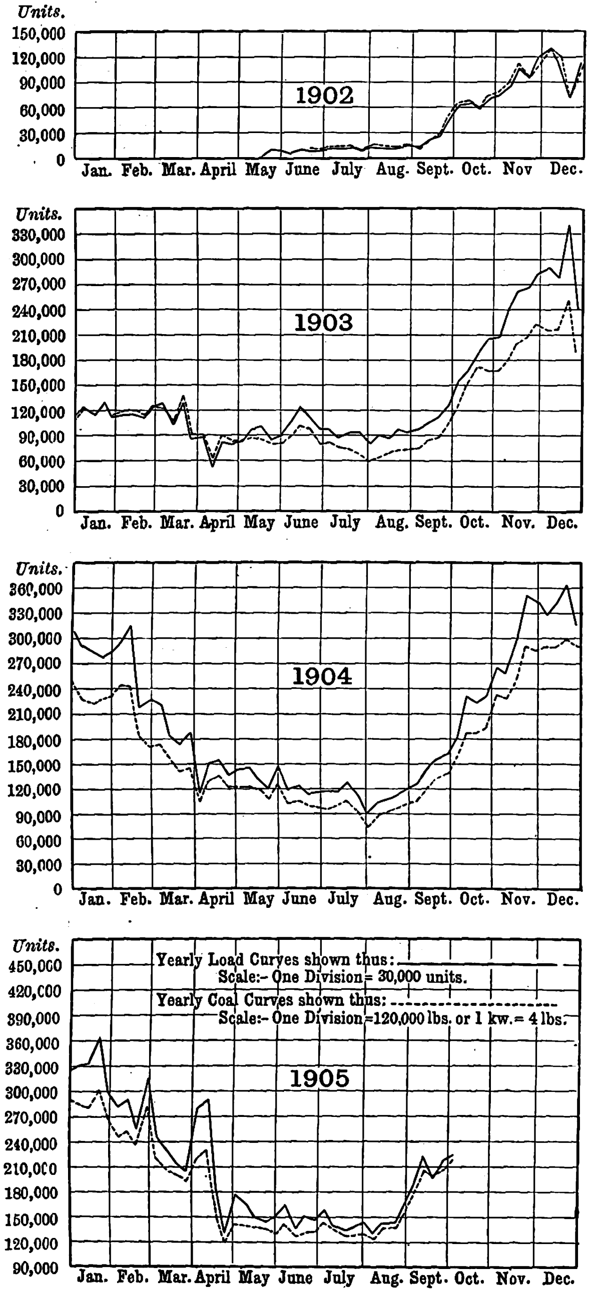


Fig. 10.—Output in Kw. and Coal Consumed.

It was then further shown that under working conditions, in the event of a circuit being opened through, for instance, the action of a fuse, a surge was likely to occur, and that it would be safer to provide spark-gaps. A spark-gap in itself, although a safety-valve for a surge, may start a rush of current which will cause further surges. The use of spark-gaps as a remedy may easily be worse than the disease, it is therefore very important to carefully consider the amount and form of resistance to be used in series with them. The common form of horn type spark-gap was experimented with and abandoned in favour of a spark-gap of the type shown in Fig. 11, which has carbon on the one side and copper on the other. The travelling of the spark up the parallel portions of the horns is increased by the chimney action of the glass enclosure, and the result of many tests has been to show that they may be calibrated and set with much greater accuracy than the ordinary bent wire horn type.

As regards resistances, a non-inductive type must, of course, be used, and after many experiments an extended trial was given in the form of liquid resistance, also shown in Fig. 11, which consists of earthenware vessels filled with a solution of glycerine and water. What at first appeared to be unaccountable changes took place in some of the resistances; investigations showed that they were due to the action of sodium or other salt in the air. Alternative solutions have also been tried with sodium in them which were found to be more constant. Further experiments have been made, and are still being made, in the direction of dry resistances, as, no matter how good it may be, a liquid resistance always has the disadvantage that it is liquid, and may leak. Attempts to obtain rods made of graphite mixture have not up to the present been successful, and forms of pressed graphite contained in cylinders, which, though satisfactory for low pressures, have not yet proved reliable for high pressures. In view of the amount of high-pressure plant now being made, the author hopes that manufacturers will give attention to this detail, and produce a high resistance of small bulk which can be relied on under working conditions.

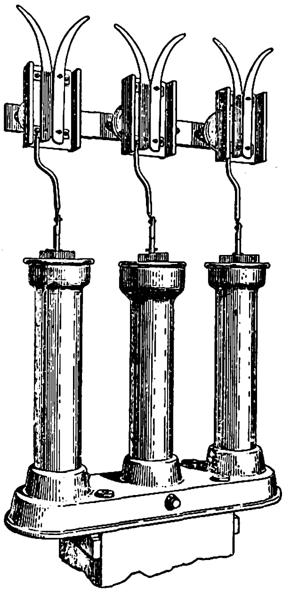


Fig. 11.—Spark-gap with Resistances.

The width of spark-gap employed is 4·5 mm. for 10,000 volts. working pressure—*i.e.*, 5,800 volts between each phase and earth with the centre of the star earthed. A spark will jump the gap at 12,000 volts when the horns are clean and the atmosphere normal. Occasional and irregular working of the spark-gaps soon attracted attention, and the author determined to try and find out the causes which resulted in these surges. For this purpose a detector was extemporised for experimental use and subsequently adopted in a more permanent form. Fig. 12 is a diagram of the connections. The apparatus consists of a small transformer with its primary inserted in the earth wire of the spark-gap resistance, without adding appreciable self-induction to the circuit, and a relay which is actuated by the secondary and rings a bell, or it could equally well mark a time recorder. When a discharge occurs the relay shutter falls, causes the bell to ring, and so calls the attention of the switchboard attendant, who notes on a report from the exact time, and whether any change in switching or alteration in the conditions of running was made. These reports are then collected and examined with the running logs of the other stations, when frequently the effect in one place can be directly traced to the cause in the same or another place. But again there are many occasions when no cause can be assigned.

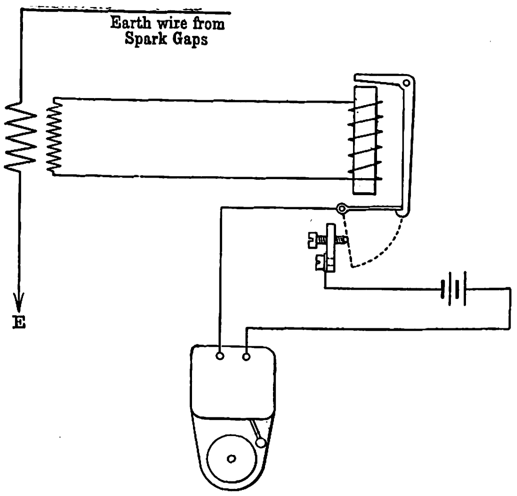


Fig. 12.—Diagram of Spark-gap Discharge Detector.

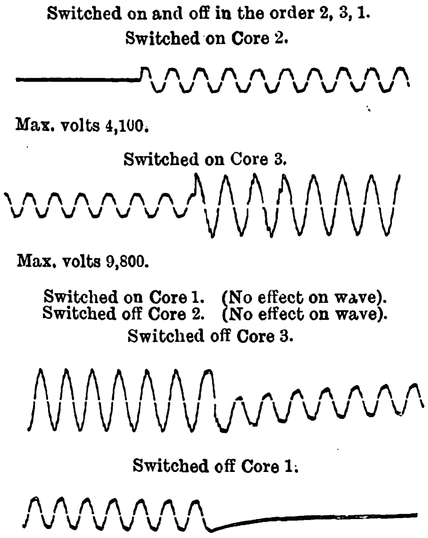
Irregularities when starting up machines, although not sufficient to affect easy synchronising or switching in, are prolific causes of spark discharges. On two occasions small measuring transformers have gone to earth, and their failure not only immediately followed discharges, but was preceded by discharges during the previous day. Faulty insulators have caused interruptions, and on nearly every occasion discharges have been reported, which emphasises the fact that sudden interruptions cause surges all over a system. Another curious fact is that after a failure the spark-gaps have acted for some time after all obvious indications of the trouble were over, from which it would appear that a system took some time to recover from a severe shock; in fact, it might almost be human in this respect. The author mentioned the effect of atmospheric changes to Prof. Epstein, who subsequently found that he could so set a spark-gap that it would, when protected from dust, give very reliable indications of the humidity of the atmosphere.

In conclusion the author takes the opportunity of thanking his assistants for their help in carrying out the scheme and in the preparation of the Paper; they are too numerous to name, but special thanks are due to Mr. H. W. Kingston, who took nearly the whole of the photographs shown.

### APPENDIX.

Wave-forms of both generators were taken to ascertain the effect of increasing the load from 0 upwards. As the wave-forms were very satisfactory in shape under all the conditions examined, it remains to consider the possibility of dangerous conditions arising due to different arrangements or to future extensions. With the 1,600 kw. machine there is a tendency to a resonance of the 13th harmonic with three City feeders, and to a resonance of the 11th harmonic with four City feeders; that is to say, with a capacity of three feeders the circuit formed by the generator and feeders has a free frequency of 650 ∿ per second, and for a capacity of four feeders 500 ∿ per second. Reducing this by Kelvin's law the free frequency would be 1,100 ∿ per second for one feeder.

The resonances which may be dangerous are those of the fundamental, the third (the third harmonic exists between one terminal and the neutral point) and fifth harmonic. In order to obtain a resonance of the fundamental, which would be very troublesome and dangerous, the product of the self-induction into the capacity would have to be 484 times as large as with one feeder and one 1,600 kw. machine. The self-induction of the 800 kw. sets is probably double that of the 1,600 kw., so that for a resonance of the fundamental with a 800 kw. set, about 240 times the capacity of a City feeder would be required; this is never likely to occur. The resonance of a third harmonic is also for the same reason unlikely. A resonance of the fifth harmonic would require 19·4 times the capacity of a City feeder with a 1,600 kw. set and 9·7 times with an 800 kw. set. This could, therefore, occur with the present plant, though it is not likely that nearly all the feeders will ever be connected to an 800 kw. set at times of light load. If at any time it is proposed to energise one or more of the feeders by means of any apparatus having a high self-induction, such as a very small alternator used with or without tranformer, it is necessary to take great care that the self-induction does not have such a value as to make it possible to have a dangerous resonance of the fundamental or one of the lower harmonics. It is to be noted that larger generators than at present installed will probably have *less* self-induction, and will therefore be, if anything, less liable to produce resonance; also several generators in parallel behave as if they had *less* self-induction than one machine. It appears, therefore, that as far as resonances are concerned the plant is very free from dangers.



Scale 1 mm.=2,000 volts.
FIG. 13.

### SWITCHING TESTS at 5,000 R.M.S. VOLTS.

An 800 kw. generator was switched on and off a Cannon-street feeder on open circuit, and the wave-form of P.D. between cores Nos. 2 and 3 was recorded:

Frequency 50 ∿ per second. The cores were switched on and off one at a time. Many curves were taken, and Fig. 13 is a typical set. As might be expected, the highest P.D.'s. are recorded when the oscillograph is connected between the first and second cores which are switched on. The highest instantaneous value of the P.D. recorded was 9,800 volts, or nearly twice the R.M.S. value (5,000), so that it should be just safe to switch on a feeder on open circuit at 10,000 R.M.S. volts; if the insulation will stand 20,000 R.M.S. volts, this would give a margin of safety of about 40 or 50 per cent. The oscillations which occurred between the self-induction of the generator and the capacity of the feeder are very high frequency, and die down so quickly that it is difficult to estimate their frequency with any accuracy. Measurements on the films make the frequency about 750 ∿ per second, and this is in accordance with the value one would expect deduced from the tendency to give resonances under steady running conditions which have already been noted.

An 800 kw. generator was also switched on and off a Cannon-street feeder on open circuit, and the wave-form of P.D. between core No. 2 and earth (lead) was recorded:

Switched on cores in the order 2, 3, 1. Switched off in the order 1, 3, 2. Any sudden change of voltage on the cable, or of current through the machine, will tend to set up oscillations whose amplitude will be the greater the less the losses in the system, so that any sudden changes in P.D. or current, especially when a cable is on open circuit, are dangerous. Thus it is dangerous to switch on an unloaded feeder or to switch off, or remove by a fuse, a very heavy load or short-circuit if by so doing any unloaded or lightly-loaded feeder is left connected to the generator. Added to the high P.D.'s produced by these oscillations, which do not seem to exceed three times the R.M.S. value, there are the much higher P.D.'s which can be set up when any unstable arcs or sparks occur in the circuit.

It is most important to avoid any arcs or sparks of any sort whatever occurring in the circuit, or they will probably produce sufficiently high voltages to break down the insulation. The breakdown of the insulation in a single place generally produces an arc or spark there, which in its turn aggravates the evil, producing still higher voltages and further damage. Thus a single tiny arc or spark may lead to the breakdown of a lot of valuable plant and cause an interruption of supply. As it is necessary to be able to switch in and out feeders without shutting down the station, charging gear was provided for the purpose.

## THE COMMERCIAL TESTING OF SMALL MOTORS UP TO 15 B.H.P.*

BY THOMAS CARTER.

A serious trouble as regards testing arises from the enormous number of different voltages used throughout the country. Those most commonly used for motors are 100, 105, 110, 115, 200, 205, 210, 215, 220, 225, 230, 240, 250, 260, 400, 410, 420, 430, 440, 450, 460, 480, 500, 520, 530 and 550; but even these are not all, for motors have been specified to run at a given speed on a circuit with a voltage of some such ridiculous value as 204·8. In designing a test shop at Messrs. J. H. Holmes & Co.'s works for motors up to 15 B.H.P. in quantities, this uncertainty of voltage was the first difficulty that met the writer, and it proved to be almost the only one of any magnitude.

Before describing the actual apparatus used, it may be well to speak of the tests generally made on motors, of the size dealt with here. The motors are built up from stock parts, of course, including as a rule armatures and field coils, and it is the writer's practice to have the two latter parts inspected by the test department before they leave the winding shop—the field coils simply having their resistance measured on a portable Wheatstone bridge, while the armatures are tested by measuring the drop in volts from segment to segment all round the commutator with a constant current sent through the winding from the nearest lamp-holder through a portable resistance of variable value. The insulation resistance is, of course, also measured. The taking of these tests by the test department is not a universal practice, as in some places the winding shop does its own testing of these parts after winding them: but it is found that the check on the winders by the department which will next deal with the parts, and will suffer from the delay if the errors are found only on beginning to run the motor, has resulted in much less time being wasted over putting on faulty motors for test than was formerly the case. A little may be said, in passing, about carbon brushes for motors. As a rule the writer uses, for all machines, from 1 B.H.P. right up to motors and generators of, say, 150 B.H.P. to 200 B.H.P. or kilowatts respectively, one of three sizes of brushes, 1 in. by $\frac{7}{16}$ in. $1\frac{1}{2}$ in. by $\frac{7}{16}$ in., $1\frac{1}{2}$ in. by $\frac{3}{4}$ in. respectively in contact area. There is a 1 in. by $\frac{3}{4}$ in. brush for low-voltage machines, and there are two other sizes, $1\frac{1}{4}$ in. by $\frac{7}{16}$ in. and $1\frac{1}{4}$ in. by $\frac{5}{8}$ in., necessitated by a peculiar design of brush gear on two sizes of machines only, but practically only the first three sizes have to be stocked in large quantities. The grade of carbon used is quite ordinary, and has been found to give quite as good results as more expensive grades and to run very quietly and smoothly. In cases where special brushes, generally of low specific resistance, are required, the writer used to use "graphitic" brushes, made by "Le Carbone," of the quality known as Z, which were good, but expensive, as all low-resistance brushes seem to be. Afterwards brushes were used in these cases made of a mixture of carbon and metal dust, which reduced the resistance, but gave poor results if the commutator tended to be hot at all, as in that case or if there was the least sparking, the metal particles appeared to fuse on to the copper of the commutator, making it very rough in a short time. Recently, however, the Morgan Crucible Co. have been making "Morganite" brushes†, which are of quite special construction, and are often found to be very good in the difficult cases which crop up from time to time, as they can be built up of copper and graphite, or of graphite of varying specific resistance, or in almost any way desired to suit special cases.

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* Abstract of a Paper read before the Newcastle Local Section of the Institution of Electrical Engineers on December 11th.

It is useful at the outset to find the "neutral point" on the commutator corresponding to the armature conductor in the centre of the gap between the pole-pieces. This is most easily done by finding experimentally the position of the brushes where the motor runs at the same speed in both directions of rotation. It is important to notice that the further the brushes are away from neutral, the less efficient is the motor. The writer recalls one case where there was too weak a field and too strong an armature, in which the light load current of the motor, which is a rough criterion of efficiency, varied from one ampere to 11 amperes when the brushes were moved from the neutral point to a place not abnormally far back from it.

The motor can now be set to its temperature run, after getting some readings of speed variation with varying loads, as well as seeing that any speed regulation by shunt resistance specified can be carried out, and attending to any other points needing special notice. For the current of the motor of full load during this run it is usually sufficient to assume an efficiency and calculate back from the required brake horse-power; it is unnecessary to take a break test of every motor, though this should be done as often as possible. When there is no specification as to the length of the temperature run, the writer is in the habit of taking as sufficient:—One hour for a normal 1 B.H.P. frame; two hours for normal 2 B.H.P. and 3 B.H.P. frame; three hours for normal 4 B.H.P. and 5 B.H.P. frames; four hours for normal 7½ B.H.P. and 10 B.H.P. frames; and five hours for normal 10 B.H.P. to 15 B.H.P. frames; especially if they are of standard winding and a considerable number of similar tests have been taken before. At the end of the extended run at full load or overload as may be specified (during which readings should be taken, at intervals of not longer than half an hour, of all instruments, speed, and behaviour at the brushes), the temperatures of various parts of the motor are taken. The writer knows of no measurement which is less satisfactory than that of temperature taken in the ordinary way by a thermometer, with the bulb covered up by a piece of waste, felt, or putty. Even if, as is sometimes done, the bulb of the thermometer is wrapped up in leadfoil, and covered with a felt pad of a standard size, it is almost impossible to repeat a set of temperatures, within 5 deg. or even more, on any small motor if another run be taken under exactly the same conditions as the first. For windings the method of calculation from increase of resistance is much more satisfactory, always provided that the same temperature is not specified to be obtained by this method as by using a thermometer, as the latter measures superficial rise of temperature only, which is always less, and may be much less, according to ventilation facilities in the motor, than the average rise of temperature as calculated from increase of resistance. Consulting engineers are beginning to specify this means of measurement, but in some cases, unfortunately, they are transferring the old 70 deg. rise into the new specification, which is absurd.

The insulation resistance should now be tested, both of the various parts of the motor and of the motor as a whole to its frame, which may be taken as "earth." This is most satisfactorily done by applying between the windings and the frame an alternating pressure of, say, twice the normal voltage of the machine with a minimum of 500 volts. To get this conveniently, a small transformer is used with a variable primary voltage and a variable secondary winding, and the secondary voltage can be estimated with sufficient accuracy by lighting up from it a set of incandescent lamps in series and observing the brightness of the filament. The writer considers an ohmmeter test of insulation resistance to be of little value compared with the other, as there may be cases in which a good result is got with the ohmmeter, while the insulation goes down altogether under the alternating voltage test. While the old-fashioned rope brake or one of its modifications is perhaps as accurate as any other, it takes some time to rig up, and needs a considerable amount of attention to get good results, and the writer has lately tried an air dynamometer consisting essentially of a calibrated fan fixed directly on the motor shaft, the blades being adjustable so as to give varying torque. The disadvantage of the arrangement has been found to lie in the fact that for a given arrangement of the blades the horse-power absorbed is proportional to the cube of the speed, and thus, unless the driving voltage is absolutely constant, the variations in speed cause temporary variations of the third power in the result, which largely increases the error due to necessary small inaccuracies in reading. Further, the distance of the blades from the floor, as well as the nature of the base on which the motor is standing seem to have some influence on the accuracy of the result. On the whole, however, such an apparatus as this is most convenient, and fairly accurate.

It may be of interest now to describe in some detail the arrangement of apparatus as used at the works of Messrs. J. H. Holmes & Co. After considering many alternative arrangements, it was finally decided to deal with each motor entirely through its own set of apparatus, and to have nothing common to all the motors being tested, except necessarily the supply from the power house, between which and the test shop only one pair of 19/14 cables is available. These cables are brought to a small distributing board, with four double-pole fuses branching out from one double-pole main switch, each feeding one switchboard and other apparatus complete in itself for testing one motor

Set out in a diagram, the apparatus for testing one motor is shown in Fig. 1. Referring to this, 1, 2 and 4 are three standard motor carcases of the size giving 10 B.H.P. at 1,000-1,100 revs. per min. The field of each is wound to go direct on 110 volts, and to have, with no resistance in series, the maximum possible number of ampere-turns for the particular size of field coil employed. The mains from the double-pole fuse, already mentioned as being connected to the power house on the distributing board, are brought to a double-pole switch on this testing board, and connected thus through an ammeter, A, to the centre pair of a row of five pairs of terminals, T, any pair of which can be connected up by short wires, with suitable sockets on the ends, to any other pair, top to top and bottom to bottom, or vice versa. There are also two sets of four small terminals, $T_1$, connected up to the large power-house terminal T, as shown, while a fifth terminal, $T_3$, is coupled on each side to the large terminal to the left of the power-house pair. The other small terminals, $T_2$, can be coupled directly by means of a short rod of copper to the terminals $T_1$ vertically opposite them, and it will be seen that the $T_2$ second from the right-hand end can be coupled either to this power-house $T_1$ row or to the $T_3$ joined to the large terminal next the power-hour pair.

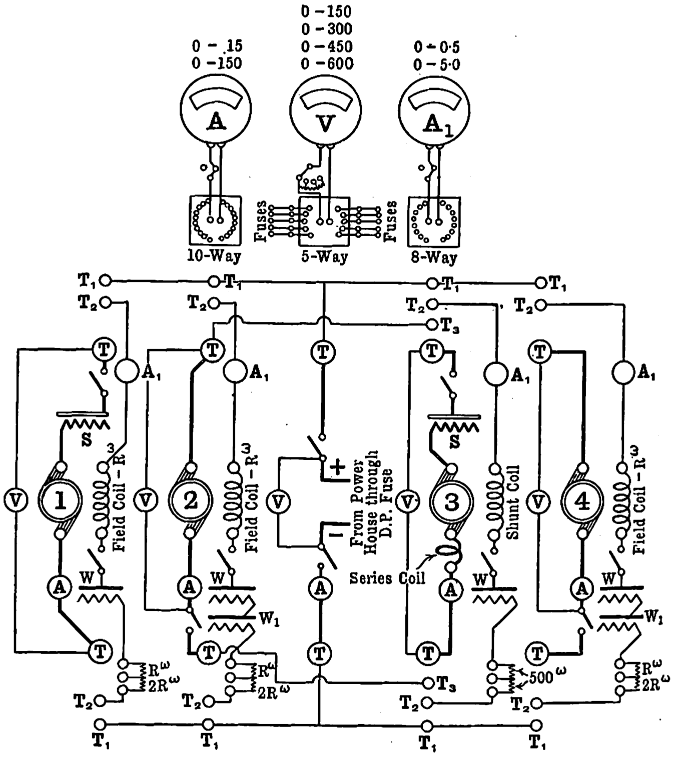

Fig. 1.

A=Armature Ammeter; $A_1$=Field Ammeter; S=Starting Switch and Resistance; T=Large Terminal; $T_2$=Field Terminal; $T_1$ and $T_3$=Exciting Terminal; V=Voltmeter; W=Resistance-24 Steps×$20^{\omega}$; $W_1$=Resistance-24 Steps×$1^{\omega}$.

The motor on test is that marked 3. It is shown as compound wound, but may, of course, be shunt or series as well. It will be seen that between each pair of large terminals, T, with the exception of the power-house pair, there is connected the armature of one of the machines 1, 2, 3, and 4 through a single-pole switch, a starting resistance, S, of about 50 ohms, suitably graded in about 12 steps, and an ammeter, A, in the case of 1 and 3, while in circuit with 2 and 4 there is no starting switch and resistance, but only a single-pole switch, on the opposite pole from that in series with 1 and 3, and an ammeter, A. There is also a voltmeter, V, on each pair of terminals, coupled up in each case to be most suitable for the conditions—as motor or generator, that is to say—under which each machine will run, as will be evident from what follows. Further, the terminals $T_2$ are connected to their respective shunt field windings through an ammeter, $A_1$, on one pole, and on the other pole a single-pole switch and a resistance, W, consisting of 24 steps of about 20 ohms each. This is the same for all four field circuits. In 2 and 4 there are, in addition, resistances of 24 steps of 1 ohm each, so that the whole of this resistance, $W_1$, is a little more than one step of W. These give fine regulation of the shunt current in 2 and 4, as by their means any whole number of ohms from 0 to 480 can be obtained. Further, in the field circuit of 3, the motor on test, there are two additional resistances of about 500 ohms each, connected to three terminals, as shown vertically above each other, this allowing one or both of the 500 ohm resistances to be put in circuit or cut out by being short-circuited by means of a copper rod sliding through the holes in all three terminals, and capable of being clamped in any position so as to put in circuit or short-circuit the desired resistance. Thus a total of about 1,500 can be got in the shunt circuit of the motor on test, rising in steps of about 20 ohms, which is found in practice to be sufficiently small. There is a similar arrangement in the case of 1, 2 and 4, but the values of the resistance are R and 2R ohms respectively, R ohms being the resistances of the 110 volt coils of 1, 2 and 4. These coils are always excited through $T_2$ coupled to $T_1$—that is, from the power-house voltage, whatever it may happen to be. It may happen that the testing part of the power-house plant is running at some voltage other than 110, for tests in other parts of the works, and in that case this motor test might have to be run from this voltage also. Hence it may be necessary to excite coils 1, 2 and 4 from a voltage of from 200 to 250, or of from 400 to 500. In the former case, by sliding the short-circuiting rod out from the top terminal connected to R, but leaving the other two still short-circuited, R is put in series with the field coils, also of R ohms resistance, and hence there are still only about the proper volts on the coil, the rest being absorbed in R. Similarly, if the power house is working at the highest volts, it is only necessary to remove the short-circuiting rod altogether to get 3R ohms in series with the R ohms of the coil, which will thus take only one-quarter of the total voltage, or again, about the right amount. It may also be necessary occasionally to use higher volts in the power house if there happened to be on test four motors at once all of 15 B.H.P. as then the 19/14 mains would not carry the requisite power at 110 volts. In that case, also, the resistances R and 2R would come into use. All the apparatus shown in the diagram, and described above, including the carcases and coils of 1, 2 and 4, is a permanent part of the works testing plant. The movable parts are only the motor on test, 3, and the armatures for 1, 2 and 4 which are in every case standard, and taken from stock as required.

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† See *The Electrician*, November 3rd, p. 96.

In cases where 3 is to work at the voltage available in the power house, 1 and 2 are not used. The shunt of 3 is then excited from $T_1$, and its armature circuit is coupled directly across to the power house terminals; this completes the necessary connections. Load is put on 3 by bolting it to 4, and having in 4 an armature which will generate the same voltage as 3 is working from. The terminals of 4 can then be coupled up directly to the power-house terminals, and when the voltage of 4 is adjusted by means of its shunt resistance, it can be switched in to run in parallel with the power-house generators. To vary the load in 3 is then simply a matter of adjusting the shunt current of 4, which is, of course, supplied from $T_1$. It is here that the use of the 1 ohm steps in $W_1$ is found for getting small variations in the load of 3.

As a rule, however, the power house does not give the exact voltage required for 3, and then 1 and 2 are also belted together to run as a motor-generator set. The armature of 1 is coupled to the power house, while 2 must have an armature which will generate the volts required for 3. Then 2 and 3 are electrically coupled together, and the shunt of 3 is in this case excited from $T_3$. The process of putting load on 3 is exactly as before: 3 and 4 are belted together, and 4 can be put in parallel either with 2 to assist it in driving 3, or with the power house as before, to assist it in driving 1, according to the voltage of the armature that happens to be in 4. During the temperature run all the resistance in the shunt circuit of 3 is, of course, cut out; it is only inserted when tests for speed regulation are being made. All adjustment of volts, &c., is made through the resistances in connection with 1, 2 and 4. Since the motor on test is always—except in a special case to be referred to afterwards—loaded by running 4 in parallel with another generator, no external resistances are required for taking up waste power, and, therefore, the apparatus, just as it has been described, complies perfectly with the requisite of flexibility at both ends, as it has been shown how, by a suitable arrangement of pulleys, stock armatures, and field strengths, practically any desired voltage for testing can be obtained from a source of power at the same or any other voltage.

In actual practice 1, 2, 3 and 4 are mounted on a wooden bench 11 ft. long, 2 ft. 6 in. wide, and 2 ft. 6 in. high. It has four legs on each side, 3 ft. apart lengthwise, so that one pair of legs comes under each machine; and the whole is fixed down to the floor—cement in this case—as firmly as possible. A row of slide rails is fixed along each long side of the top, and four pairs of cross-rails sliding on these, and capable of being bolted down to them carrying the four machines. All the switches, instruments and terminals already described are mounted on a switchboard which stands at the end of the bench. The terminals T and $T_2$ on the switchboard are connected for convenience to corresponding terminals mounted on the under side of the bench top to avoid having loose wires lying over the floor between the board and the bench. Thus, 1, 2 and 4 being for all practical purposes permanently coupled up, all that is necessary to get a motor running for test is to connect it to two pairs of terminals, armature and field respectively, which terminals are in practice all ready provided with wires for fixing at once to the motor terminals. The rest is all done at the switchboard. The overall size of the two slate bases, positive and negative, is in this case 2 ft. 10 in. wide by 4 ft. 11 in. high, and they are mounted on angle irons, so that the top is 6 ft. 6 in. from the floor. As the switchboards happen to be near a wall, all the starting and regulating resistances, as well as the ammeter shunts, are mounted on the wall, which leaves the back of the board quite clear. It is, perhaps, unnecessary to metion that there are not actually five voltmeters, five ammeters A and four ammeters $A_1$. There is one voltmeter only, reading 0–150 volts direct, with resistance to give 0–300, 0–450 and 0–600 volts, and a five-way double pole switch couples it up, through a fine double-pole fuse on each circuit, to any one of the five V points of Fig. 1. Similarly, the five points A are five separate shunts, connected, however, through a 10-way double-pole switch to the instrument, which has a small switch between the double-pole switch and its terminals, so that it can be cut out of circuit in changing over the double-pole switch in case of an excess of current. The reason for the 10 ways is that each point A is actually two shunts in series, one giving full deflection with 15 amperes, the other with 150 amperes, so that the ammeter has two ranges. Similarly, the four $A_1$ points are coupled through an eight-way switch to their instrument, and each $A_1$ has a 5-ampere and a 0·5 ampere shunt giving again two ranges on the ammeter according to the position of the double-pole selecting switch. These instruments are checked about once a month against a standard. It may be said here that the cost of one complete set of apparatus as above described will probably be from £60 to £90, including everything but the armatures for 1, 2 and 4.

In cases where the power-house voltage is only a few volts different from that of the motor to be tested it is convenient sometimes to generate from 2 only the difference in volts and put this in series with the power-house voltage, thus increasing or diminishing it by the necessary amount. The connection would be as in Fig. 2, which shows only the armatures. The shunt of 3 must be excited from $T_1$ on the positive side and $T_3$ on the negative side in this case, and 4 can run, as shown by the full and dotted lines on the negative side, in parallel either with the power house—that is, with 1—or with 3 as usual. This method saves transforming all the power required from one voltage to another, and is consequently a little more economical.

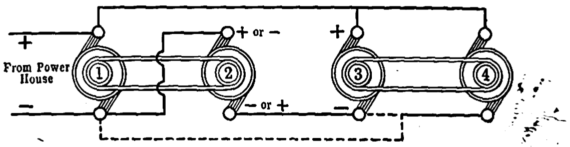

Fig. 2.

It is a very simple matter to measure armature and series resistances on these benches. It is only necessary to disconnect the shunt of 3 and prevent the armature from turning, and then to send a current through the armature and series, if any, of 3 from 2, running at a reduced voltage. The drop of volts recorded on a low-reading voltmeter at once allows the required resistance to be calculated, the current giving this drop of volts being read on the ammeter A in circuit with B.

For brake tests on the larger sizes of motors 1 is not capable of developing enough power to drive the combination, as there is no longer any opportunity of running in parallel when 3 is loaded by a brake instead of by being belted to 4. In such a case 1 and 2 on another bench must be used in addition, and the two 2 armatures put in parallel, unless it can be arranged to get the necessary voltage direct from the power house.

In testing series-wound motors, the only difficulty is in starting up, as sufficient torque must be kept on the motor all the time to prevent it running away. This is accomplished by keeping the volts of 2 very low at first, and by putting 4 in parallel with 2 at the very start, and continually adjusting the field while raising the speed by means of increasing the volts of 2 so as to keep enough current in 3 to avoid a dangerous speed. Otherwise the procedure is just the same.

In testing small dynamos, the simplest method is to bring 4 along to the place of 3 on the bench and run it as a motor, while the dynamo on test is coupled up to the mains of 4. This avoids all changing over of ammeter flexibles which would be necessary if the dynamo were put in place of 3, everything being coupled up to suit the testing of a motor normally. Load is put on the dynamo 4 by putting it in parallel with the motor 3, and then, keeping the speed right by adjusting the field of 3, the current from 4 is adjusted by altering its field in turn. Dynamos of very low voltage, such as milking boosters or plating dynamos, are most simply loaded by wasting the energy in a resistance. This is the only case in which an external heavy current resistance is necessary, except in a few special cases where it is desired to test a motor specially for starting under full torque. In this case the resistance is put across the terminals of 4, which is then loaded as soon as it begins to rotate, being separately excited, and consequently puts load on 3 at once, instead of, as usual, having to be run up to the correct volts for putting it in parallel with 1 or 3, which means that 3 would start light, as it does, of course, in all the usual tests.

These benches have not as yet been actually used for alternating-current motors, but it is proposed to do so by replacing 1 and 2 by an alternating-current transformer fed from mains which are quite independent of the continuous-current board.

### DISCUSSION.

Mr. WEST did not quite agree with the writer in measuring the resistance of the armature by the drop in voltage, because of the difficulty in getting good contact for the voltmeter leads on the commutator.

Mr. LAWS agreed with the author as to the unreliability of temperature tests with the ordinary thermometer. Many engineers specified that the temperature rise should be taken one minute after the shut-down of the test, but he had found that the temperature on the surface rose considerably for some time after a machine had been stopped.

Mr. CLATWORTHY asked whether the high-tension alternating-current test strained the insulation of a machine when the testing voltage was more than twice the normal voltage.

Mr. HUNT did not agree with high-flash tests, as these usually did more harm than good. The author had made no mention of the means employed for transporting the motors to and from the test house; he suggested runways as most suitable.

Mr. ASH said that a one-hour test for a 1 B.H.P. machine seemed too short, since small machines with fine windings were more apt to break down than larger ones.

Dr. THORNTON pointed out that the resistance method only gave the average temperature, whereas it was the maximum that was desired.

Mr. CARTER, in reply to the discussion, said that the test described was not the Hopkinson test. The latter was not suitable for small machines as the conditions were different for the motor and generator. If the tested speed was within 5 per cent. of the calculated speed, the usual method was to alter the pulley, or, if the speed was too slow, to insert the starting resistance in the shunt circuit after the motor had been started. High-flash tests undoubtedly strained the insulation and frequently impaired it. A useful method of detecting shorts in an armature was by passing a current through it and measuring the drop across each section. The mechanical handling of the motors was done by trucks and a runway. In reply to a remark by Mr. Ash, the time expended on testing small motors was entirely a question of cost.

## SECONDARY CELLS: THEIR DETERIORATION AND THE CAUSES.*

BY G. D. ASPINALL PARR, M.SC.

Comparatively little or no literature of a definite nature exists in connection with the effects on the E.M.F., capacity and life of such cells, of impurities, either in the plates themselves or the electrolyte in which they are immersed. That certain impurities are injurious to the action of the lead-sulphuric acid cell (which is the ordinary storage cell now so commonly used) is fully realised by every manufacturer of these cells. In fact, one and all agree that there must not be more than a given percentage of certain impurities, and no trace of others present, but the exact maximum amount of each admissible is indefinite and practically a matter of conjecture. Doubtless want of more exact data in this direction is due to the costly, lengthy, and extremely laborious nature of the research entailed by the quantitative determination necessary to elucidate this matter. That such should be a reason is surprising, in view of the occasional dismal failures of storage batteries which come to hand, as well as of the heavy capital sums at stake in connection with them.

Ten years ago the capital involved in this country in connection with the manufacture of storage cells was about £426,000, now it is about £987,000, while the proportion of turn-over to capital is much greater than it was.

It is, of course, common knowledge that the prime cost of a storage battery, having a given kilowatt output for a given time, is about the same as for a steam generator and boiler of the same output. The useful life of the battery will be less than that of the steam plant, while the energy efficiency of the former will range from 60 per cent. to 80 per cent., with an average, under commercial conditions, of about 70 per cent. Both the efficiency and capacity of secondary cells gradually diminish with the time of use, the falling off being due to (*a*) natural causes, (*b*) unnatural causes, which embrace the effects of *ill-treatment* and *impurities* respectively. Under heading (*a*) we have loss of active material and loss of porosity, and under (*b*) we have, firstly, the ill effects of excessive charge and discharge rates, short-circuits, and those due to allowing cells to rest in a discharged condition and never fully charging them up; secondly, the ill effects of impurities in the cell, which is the main subject of the present Paper.

Impurities may be introduced through the medium of the plates, or through the electrolyte, or by reason of the salts formed by corrosion of the cell connections dropping into the solution. Plates of the Planté, or non-pasted type, are given porosity in the course of manufacture by treatment in some oxidising or so-called pickling solution, containing nitrogen compounds—for example, nitric acid, ammonia, nitrates of sodium, potassium, ammonium and ammonium sulphate. Manufacturers of such plates, however, take precautions to eliminate all traces of these compounds before the plates leave the works, and this is not difficult to do. Assuming that this is done, it remains for us to consider the main source of trouble—namely, the impurities liable to be introduced through the medium of the electrolyte. These may be present in either the sulphuric acid (the same grade of which from the same maker, varying greatly in purity), or the water with which it is mixed. According to Dr. G. Lunge, the greatest living authority on sulphuric acid, the concentrated acid of commerce may contain:—

Sodium sulphate (135 parts in a million); potassium sulphate (more rarely); calcium sulphate (58 parts in a million); ferrous sulphate (291 parts in a million); lead sulphate (520 parts in impure and 172 parts per million in pure acid); aluminium sulphate; sulphate of ammonia (very largely); copper, zinc, and other metals (rarely); selenium; arsenic (500 to 1,420 parts per million); hydrochloric acid; hydrofluoric acid; sulphurous acid; antimony (80 parts per million); arsenious acid (1,420 parts in impure and 31 parts per million in pure acid); compounds of nitrogen (always present).

Ammonia has been found in acid to the extent of 6,700 parts per million, but it is often present in 3·6 parts per million, and is the most common impurity. Sulphuric acid is prepared either from sulphur by heating it in a current of air to form sulphur dioxide or from sulphide of iron (iron pyrites). The former method gives what is known commercially as "brimstone" acid, the latter method an acid which (unless very carefully purified) contains traces of iron, arsenic and other metals. It is, therefore, safest to use "brimstone" (which is usually free from arsenic) acid for storage battery purposes, unless careful analysis is resorted to. Both kinds of acid are liable to contain traces of nitrogen compounds.

According to Dr. R. A. Smith, in his standard work "Air and Rain," 1872, rain-water has been known to contain the following impurities to the maximum extents given—namely:—

Hydrochloric acid (chlorides) (560 parts per million), greatest at the sea coast; sulphates (1,226 in a million), greatest in large cities; ammonia (London—32 parts per million; Glasgow—9 per million); albumenoid ammonia (London—1·08 parts in a million; Liverpool—0·66 in a million); nitric acid (London—25 parts per million); nitrites. Other substances found in rain are organic substances, soda, potash, magnesia, alumina, carbonic acid, lime, oxide of iron and manganese.

Over 100 parts per million of foreign matter have been found in rain.

Water from town mains may contain sodium chloride, sulphuretted hydrogen, sulphates of ammonium and potassium, magnesium, calcium, which latter two make the water hard, but drinkable. Most impurities would be alternately oxidised and reduced with succeeding charges and discharges, and would thus help to discharge the cell irrespective of whether it is sending a current externally or not. It is well known that cells standing idle slowly discharge, the density of the acid becoming weaker; this loss of charge in a good cell amounts to from 1 to 2 per cent. of its total capacity per day, but may amount to from 40 to 50 per cent. if the cell contains impurities. Impurities in the form of metals which are more electro-negative than lead, are deposited on the latter, forming with it a short-circuited local element, which causes lead sulphate to form in the active material of the negative plate and hydrogen to be evolved. Metals that behave in this way are iron, silver, nickel, copper, &c., the loss of charge being due principally to (1) the chemical action of sulphuric acid on the spongy lead; (2) the increase in density of the electrolyte, the sulphating of the negative increasing rapidly with the density; (3) the electro-chemical action of the couple formed by the spongy lead of the active material of the negative and the lead of the support, especially when this contains impurities such as antimony (under 1 per cent.); iron, and copper from corroded connections.

This local action is about three times greater at a specific gravity of 1,300 than at 1,170 for a temperature of 15°C.

L. Jarnau finds that high density suits the positive much better than it does the negative plate, and therefore that the best result and highest capacity will be obtained by making the total area of the negative plates greater than that of the positives. On the other hand, the more electro-positive metals, such as tin, zinc, mercury, &c., can do no harm in the solution. Manganese salts, often met with as an impurity in litharge, are to be avoided, owing to the formation of permanganic acid at the positive plate, and to the consequent setting free of the oxygen of the active material of this plate.

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* Abstract of a Paper read before the Leeds Local Section of the Institution of Electrical Engineers, December 13th.

From the above remarks it would appear that considerable risk is run by the use of either rain water or town water, and hence the only other option is to use pure distilled water. This is unfortunate in one way on account of the cost of it, but when carefully considered it is trifling compared with the cost of a new battery, which the use of impure water might entail. The practice which some central station engineers adopt of using the condensed steam from the boilers is dangerous, because boiler water, in addition to its natural impurities, often contains some special alkaline softening fluid. Another equally dangerous custom with some engineers is to add from 1oz. to 2oz. of ammonium sulphate, sodium sulphate or sodium carbonate per gallon of the electrolyte, with the object of improving the condition of the cells. This practice, while giving a rich colour to the plates, in time acts detrimentally on them, diminishing both capacity and efficiency. Accepting the limitations put by battery makers on the amount of impurities allowable it would seem that the electrolyte should be free from arsenic, nitrogen compounds, sulphuretted hydrogen, sulphurous acid, and organic matter, and that it should contain only mere traces of hydrochloric acid and iron. Mr. R. W. Vicarey has recently found that from 10 to 0·1 per cent. of ammonia added to the solution, decreased the capacity immediately by some 20 to 31 per cent., thus showing the deleterious effect of nitrogen compounds. The ammonia has a strong affinity for water and turns to nitric acid on the passage of a current.

The author of this Paper has recently commenced a series of tests with a view to determining the maximum amount of any given impurity which may be present in a secondary cell, without seriously affecting its capacity and efficiency. The tests, which will continue for many months and are at the present time, therefore, obviously incomplete, are being operated on 14 exactly similar cells. Each cell has one positive and two negative plates, all of the Planté type, and 5in. × 5in. × ¼in. in size, contained in a glass box 6¾in. × 5½in. × 2in. inside. The normal charging rate is listed as 2 amperes and the discharge rate as 1·5 amperes for 10 hours (normal capacity 15 ampere-hours); 2 amperes for six hours and 3·5 amperes for three hours, with an electrolyte of specific gravity = 1205. The manufacturers were asked to make them all under the same conditions, and particularly to ensure the elimination of all nitrogen compounds, both of which requests were carefully attended to. The sulphuric acid and the distilled water were analysed and no impurities were found.

Eleven of the commonest impurities in sulphuric acid and in water have been chosen, and in amounts at least equal to the maximum which has ever been found in any ordinary water and ordinary purified *commercial* acid. One cell contained pure electrolyte and three others contained different percentages of sulphurous acid. The following table shows the impurities used and their proportion per million parts of the solution :—

| Cell No. | Impurity. | Parts per million. |
|---|---|---|
| 1 | Arsenic | 225·0 |
| 2 | Ammonia | 27·5 |
| 3 | Antimony | 33·0 |
| 4 | Copper | 40·0 |
| 5 | Zinc | 40·0 |
| 6 | Sodium | 45·0 |
| 7 | Iron | 115·0 |
| 8 | Sulphurous acid ($SO_2$) | 6·0 |
| 9 | Calcium | 83·0 |
| 10 | Nitric acid | 25·0 |
| 11 | Hydrochloric acid | 50·0 |
| 12 | None | .. |
| 13 | Sulphurous acid ($SO_2$) | 0·6 |
| 14 | Sulphurous acid ($SO_2$) | 2·0 |

Twenty-two charges, all at 2 amperes, and 22 discharges, also all at 2 amperes, have so far been taken in succession day and night. In the case of the charge curves sulphurous acid has in cells Nos. 8 and 13 greatly affected the rate of rise of terminal P.D., distorts the ordinary form of curve, and has diminished the capacity, but no very unusual results have been noticeable otherwise. The discharge curves of Nos. 1, 2, 4 and 13 showed a much better result than the others, the mean voltage and time of discharge being greater in these, but they are falling off with the number of discharges, in No. 8 the capacity of this cell being almost annihilated after five discharges. With the exception of No. 8 cell, the specific gravities of all the cells were about the same at corresponding points of the charge and discharge; that of No. 8 was, however, very low for both. Doubtless the effects will become more marked as the length of the tests proceed, and I much regret the incomplete nature of the results at this stage.

I now venture to give some curves showing the results of a lengthy series of tests which I made some time ago for a storage battery company on several large 9-plate storage cells having four Planté positives and five pasted negatives. The results are interesting and instructive as showing the effect of a variation in the charge and discharge rates on the capacity and efficiency of the cells, which I have given in the accompanying table :—

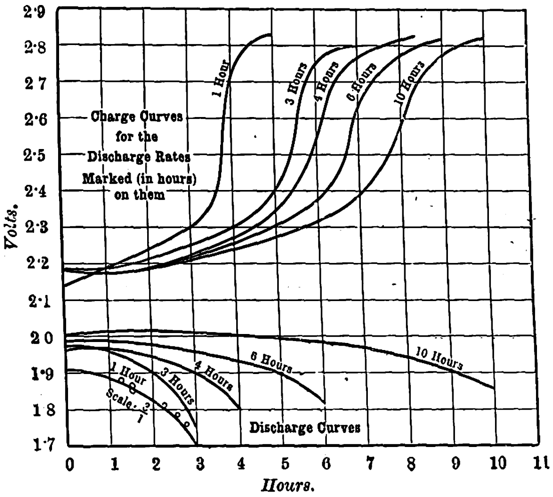

Fig. 1.

| Discharge. | | | Ampere-hours. | | Watt-hours. | | Efficiency. | |
|---|---|---|---|---|---|---|---|---|
| Rate in hours. | Limit in volts. | Current in amperes. | Input. | Output. | Input. | Output. | (Amp.-hour) quan. | (Watt-hour) energy |
| 10 | 1·85 | 29·0 | 318 | 290 | 764 | 574 | 91·2 | 75·1 |
| 6 | 1·80 | 42·5 | 288 | 255 | 730 | 494 | 88·5 | 67·7 |
| 4 | 1·80* | 50·0 | 224 | 200 | 517 | 385 | 89 3 | 74·5 |
| 3 | 1·75 | 70·0 | 256 | 220 | 630 | 402 | 85·9 | 63·8 |
| 1 | 1·70 | 134·0 | 168 | 134 | 414 | 247 | 80·0 | 59·7 |

* This should have been about 1·77 volts, and accounts for the efficiencies at this rate being disproportionate with the rest.

The normal charging current = 32 amperes, discharging current = 29 amperes at the 10-hour rate, and 134 amperes at the one hour rate. Fig. 1 shows very clearly that the higher the discharge rate is, the shorter the time of charging and the smaller the output. Fig. 2 shows that within the current limits taken the charging rate has but little or no effect on the output of the cell at the particular discharging rate taken. All the curves of Figs. 1 and 2 are the means of the last two or three out of some 10 charges and discharges at the particular rate shown. The cells had therefore arrived at a normal state for each rate.

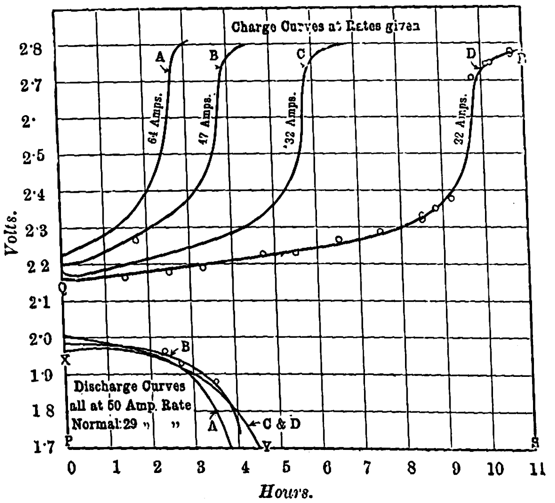

Fig. 2.

## INFLUENCE OF THE EARTH IN WIRELESS TELEGRAPHY.*

BY J. S SACHS.

After remarking that a comparison of over-land and over-sea transmission shows that the earth has an influence on the propagation of long electromagnetic waves, the author proceeds to describe a series of experiments he has made at the request of Prof. Drude. The sender was an electromagnetically coupled system designed on lines laid down in Papers by Prof. Drude two or three years ago. It consisted of a primary circuit containing a spark-gap and a condenser, and a secondary with its ends connected respectively to an air-wire and a balancing capacity. The primary was a single turn of thick wire interrupted by the spark-gap. Its condenser was made of lead foil fastened to a glass plate. The secondary was inside the primary and possessed 10 well-insulated wires wound in a single layer on an ebonite ring of 8·7 cm. diameter. The air-wire consisted of a brass tube 3 metres long and 1·4 cm. diameter, and the balancing capacity was a metal plate. The coils were designed to resonance, and the wave-length was computed, by Drude's formulæ, to be 31 metres.

An induction coil that gave 15 cm. sparks with 10 volts was used to energise the primary of the sender. The receiver differed from the sender only in having a constantan-iron thermo-couple in the position of the sender's spark-gap. The couple was made of wire 0·05 mm. diameter, and had a resistance of nearly 1·2 ohm. In order to be able to make allowance for the variableness of the energy radiated from the sender, a coil coiled the "standard" coil, not in resonance with the sender, was kept in a fixed position relative to the sender's winding, and was provided with a thermo-junction very similar to that in the receiver.

Most of the experiments were carried out in the open court at the front of the Physical Institute of Giessen. The distance between sender and receiver varied from 25 to 50 metres, the line joining the ends being parallel to the Institute and about 25 metres away from the building. The induction coil was fed from a battery of accumulators in the Institute, and the thermo-elements of the standard coil and of the receiver were connected by leads to galvanometers inside the Institute. The galvanometers were of the non-astatic Du Bois-Rubens type. Preliminary tests showed that the disturbances that might arise from the proximity of the standard coil to the sender, and from the various wires leading into the building, could safely be neglected.

The mode of experimenting was to pass a current through the induction coil for the same period in each observation of a set. This period was sometimes five, sometimes ten seconds. The deflections of the galvanometers connected with the two thermo-couples divided the one by the other gave the figures that are used in drawing conclusions. In this manner were investigated the effect of varying the relative positions of the various parts of the sending apparatus or receiving apparatus and the effect of asymmetry at the two ends. The results have but small interest. Another series of experiments, not given with much detail, however, were performed to contrast the behaviour of the receiver when sender and receiver were wholly insulated with its behaviour when the balancing plates at both ends of the 30 metres stretch were connected to a plate buried 1 metre in the ground. When insulated the balancing plates were 1 metre above the ground. It was found that the readings of the galvanometer were about twice as great when the whole apparatus was insulated as when the apparatus was earthed.

In order to examine the influence of the earth on the propagation of waves the author used the principle that this influence must alter with alteration of the height of the apparatus above the ground. Tables of results are given for a distance of 30 metres between sender and receiver. In dry frosty weather, with air-wires vertical and balancing plates horizontal, the maximum efficiency occurred when the apparatus was 3 metres above the ground. The effect at this height was more than four times the effect when the plates were only 10 cm. above the ground. On the other hand in wet cloudy weather the maximum occurred at about 1 metre elevation, the effect at this height being about two and a half times the effect at the height 10 cm. In both these cases, dry and wet weather, the maximum value was maintained, with but slight change, on further raising the apparatus to 4 or 5 metres above the ground.

Another series of experiments was conducted to show the effect of distance on transmission. Distances varying between 12 and 24 metres were worked with, and gave for the received energies numbers obeying the inverse square law. And other experiments on the effect of trees, &c., in screening the receiver were carried out with the apparatus.

The author's main conclusions may be stated thus :—

1. The earth's surface is for waves of 31 metres, a strong absorbing and weak reflecting medium.

2. The connecting to earth of sender or receiver is greatly prejudicial to transmission ; insulating it is decidedly favourable.

3. It is desirable to instal the apparatus as high above the earth as possible.

4. The integral effect at the receiver varies inversely with the square of the distance of transmission.

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* Abstract of an article in the *Annalen der Physik.*

## ELECTRIC MAINS FOR POWER TRANSMISSION WORK.*

BY PROF. JOHN T. MORRIS.

The Paper presents a brief account of some of the main theoretical and practical considerations which affect extra high-tension transmission, and refers to some transmissions of this description which are in actual operation.

Three-phase currents are employed in most cases, but there are a few examples of direct current, a few of single-phase, and a fair number of two-phase transmissions. In the Thury direct-current system a constant current is maintained in the circuit, and variations in the load are dealt with by adjusting the voltage to suit. It is only necessary to carry a single wire through each town or village on the route in which power is required, these all being linked upon a single circuit ; the circuit returns to the station by a different route. The following are the most notable examples of this system of transmission : La Chaud de Fonds (14,000 volts, 3,000 H.P., 32 miles) ; St. Maurice-Lausanne (23,000 volts, 4,600 H.P., 35 miles) ; Moutiers-Lyons in course of construction (60,000 volts, 6,000 H.P., 114 miles). Single-phase currents have been but little used for extra high-tension power transmission work, though it is quite possible that in the near future such currents may be employed, particularly at low frequencies. The two-phase system, owing to the necessity of using in it a greater weight of copper and insulation than is required for three-phase work, is not much favoured.

*Materials for the Overhead Conductor.*—Practically only two materials are employed : Hard-drawn copper and aluminium. American practice seems to show that up to 0·3 in. diameter, solid hard drawn copper wire is employed. Above 0·4 in. stranded copper wire is almost always used. With regard to intermediate sizes, practice varies. Aluminium wire is usually stranded for the work, and is stronger than copper for the same conductivity, but the wind pressure is greater with aluminium, owing to the greater surface for a given conductivity. Experiments conducted on a span 950 ft. in length, supported on poles 45 ft. high, give as a relation between velocity of wind and pressure on cable $P = 0{\cdot}0025\ V^2$ for a stranded cable, where P = pressure per square foot of projected cable area and V = actual velocity of wind in miles per hour. Apparently, 65 miles per hour may be taken as a reasonable maximum for wind velocity if such exceptional events as tornadoes are left out of account.

The following table gives some of the principal constants :—

*Properties of Aluminium and Copper.*

| | Aluminium. | Copper. |
|---|---|---|
| Elastic limit in lbs. per square in. .... | 14,000 | 40,000 |
| Coefficient of expansion per degree C... | 0·000023 | 0·0000173 |
| Modulus of elasticity ............... | 9,000,000 | 16,000,000 |
| Electrical conductivity .............. | 62 p.c. | 100 p.c. |
| Specific gravity ..................... | 2·68 | 8·9 |
| Melting points ...................... | 625°C. | 1,080°C. |

It will be observed that the expansion of aluminium is to that of copper in the proportion of four to three, which means that if copper and aluminium wires of equal span are erected, there will be a greater sag in the aluminium span for a given rise of temperature. This fact, though not important as regards short spans, shows that with a long span the height of the poles for aluminium circuits must be greater. To quote an example of one of the longest existing spans, there is an aluminium line on the west coast of America having a single span of 1,800 ft.—rather over a third of a mile. It may be mentioned that steel is not very far from competing with copper and aluminium for long span work, particularly on account of its smaller coefficient of expansion, and also its greater tenacity.

*Brush Discharge from Wires.*—The voltage at which this occurs is dependent on the diameter of the wire, as well as on the barometric pressure. The chief reason for the dependence of the brush discharge on the diameter is that the potential gradient—that is the drop in volts per millimetre—passing away from the wire at right angles to the axis, will be greater for the smaller wire if the same voltage is applied in the two cases, owing to its radius being smaller. A curve embodying results of tests by Signor Jona was shown to demonstrate the relation of the voltage at which brush discharge begins to occur to the diameter of the wire. Curves were also included in the Paper, based upon figures given by Prof. W. E.

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* Abstract of a Paper read before the Junior Institution of Engineers on Dec. 15

Ayrton at Johannesburg, to show that once a wire has begun discharging in the air a furthei increase of voltage will increase very largely the brush discharge distance.

*Pole Construction.*—It is practically essential for long spans to use the latter steel towers for the wires on account of their greater strength and durability. There is, however, a drawback that should an insulator break and the wire fall, the line will have at once to be shut down, while with wood construction several minutes will probably elapse before a blaze is started which will short-circuit the line. Indeed, a case is known of a 40,000 volt three-phase circuit, with grounded neutral, where the wire lay on a dry cross-arm for several hours before the circuit could be switched over, and even in this case the cross-arm was not badly charred. It may be of interest to note that an extremely rough rule for giving the distance between the wires is that the distance in inches is equal to 1½ times the number of kilovolts used.

*Loss in the Line.*—A reasonable loss in the line is about 5 per cent. of the energy transmitted per 50 miles, though a smaller loss than this may well be obtained.

*Insulators.*—Porcelain and glass are practically the only two materials used for insulators. In some of the earlier power transmissions in the States, until about the year 1897, the insulators employed for voltages up to about 15,000 were formed and pressed in iron moulds, but this method of manufacture was rather apt to produce an insulator with flaws. Now, American practice has reverted to making the insulators in pieces on the potter's wheel and separately glazing the parts, afterwards cementing them together, either with sulphur or litharge and glycerine, or with Portland cement. White porcelain insulators in America form too attractive a mark for unscrupulous rifle shots, and brown porcelain and glass are much more generally employed now. One advantage possessed by glass is that a flaw can be at once seen. Glass is apparently better than porcelain as a dielectric, but has the serious defect of mechanical weakness due to internal strains which occur during manufacture. These strains can, of course, be greatly reduced by good design, and also by subsequent annealing. Specimens of various insulators were exhibited, including one suitable for 60,000 volts, and weighing 26 lb.

*Distribution of Electrostatic Stress in and around an Insulator when at Work.*—Take, for example, one of the insulators used in the Shawinigan-Montreal transmission line, which works at 53,000 volts three-phase; and consider as an extreme case 50,000 volts between the line wire and pole arm when rain is falling. The whole of the upper side of the "umbrella" will be at the same potential as the wire. If the potential gradient is too steep at the surfaces of the insulator, then a brush discharge will start from the edges, and this means that the surrounding air is rendered partially conducting, or is ionized as it is called, which possibly will reduce the effective thickness of the dielectric, and this may cause a breakdown. It should be noticed that the voltage of the intermediate surfaces will depend partly on the relative capacities of what may be looked upon as condensers—electrically in series. It is obvious that these condensers are shunted by the surface leakage paths, but expert opinion in the States seems to incline to the belief that the surface leakage effect is in reality extremely small.* This is mainly due to the fact that at these extra high voltages surface leakage cannot permanently exist, since the conducting path will vanish, owing to the heat produced by the leakage current itself. As is well known, when conductors are connected in series, the voltage divides in the inverse ratio of their capacities.

*Burning of Pins.*—Pins are usually made either of locust, oak or eucalyptus wood, carefully treated so as to exclude moisture. Iron pins are also largely used. After a line has been in operation for some months, the pins carrying the insulators, if of wood, are sometimes found to have a charred appearance. This is caused by a discharge, which can be seen at night, and which produces an appreciable sound. This charring effect is practically absent below voltages of 20,000, but at 40,000 becomes a factor requiring serious attention. Opinions differ as to the cause of this burning of pins. Some authorities consider it to be due to surface leakage, whilst others attribute it to the effect of a brush discharge between the inner part of the insulator and the pin. Undoubtedly, however, this effect has to be reckoned with, as in some lines pins have had to be replaced two or three times in a year.

Iron pins are much better from a mechanical point of view, but the attachment of the insulator to them requires care. The iron pin may be enlarged at its upper end, and then fixed in the insulator by means of lead or cement. Or, the metal pin may have a wood sleeve having a thread on its outer side, and the insulator may be screwed on to this pin, as in the Locke insulators, specimens of which were shown.

*Underground Cables.*—Signor Jona gives the following data for dielectric strength and specific capacities as good working averages for materials used in cable manufacture:—

Dielectric strength of rubber in lengths on cable 12-15,000 volts per mm.
Dielectric strength of paper in lengths on cable 8-10,000 volts per mm.

*Specific Capacity of Various Materials.*

| | |
|---|---|
| Paper cables | 3—4 |
| Paper | about 2 |
| Resin | 2—3 |
| Mixtures used for impregnating | 3—4 or above |
| Pure vulcanised rubber | about 3 |

The addition of certain materials to rubber raises its specific capacity without appreciably altering its dielectric strength. The following table gives facts relating to some of these mixtures as compared with pure vulcanised rubber.

| | | | | Sp. capacity. |
|---|---|---|---|---|
| Pure vulcanised rubber | | | | about 3·0 |
| Per cent. | Per cent. | Per cent. | Per cent. | |
| 58 para | 2·0 sulphur | 26 talc | 14 zinc oxide | 4·0—4·2 |
| 40 ,, | 5·0 ,, | 55 carbonate of lime | — | 4.6 |
| 64 ,, | 8·0 ,, | 16 talc | 4 zinc oxide 8 per cent. minimum | 5·0 |
| 56 ,, | 22·0 ,, | 22 ,, | — | 6·1 |

Take the cases of a concentric cable in which $r$=the external radius of the inner conductor in mm. R=the internal radius of the external conductor in mm., $x$=the radius in mm. at some point $r$ and R, and V=volts between $r$ and R. Then it can be shown that the drop in volts per millimetre—*i.e.*, the potential gradient, is given at any point by the expression

$$\frac{0{\cdot}434\,V}{x\log_{10}\frac{R}{r}}$$

which means that in a concentric cable the electric stress each layer supports in inversely proportional to its radius, or the potential gradient is in the inverse proportion of the electric capacity of each layer. This implies that in this case the dielectric is not uniformly stressed, the inner layers being more highly stressed than the outer. In some cases the stress on the inner layer may be as much as four times that on the outer. A stranded wire as compared with a solid wire of the same section will always have a greater potential gradient very close to the surface of the conductor, owing to parts of the outlines of the section of the conductor having more sudden curves. It is for this reason that Signor Jona, in attempting to construct a single-core cable for an extraordinary high voltage, adopted the bold expedient of encasing the stranded wire with a thin lead sheath. This sheath is first covered with a layer of dielectric of specific capacity 6·1, then a layer of specific capacity 4·7, then one of specific capacity 4·2, and finally a layer of specific capacity of 4·0, over which the ordinary lead sheath is placed. This particular cable has successfully withstood a pressure of 150,000 volts for one hour. For further information on the principles underlying this grading of insulation members are referred to two standard Papers on this subject: "Insulation on Cables," by M. O'Gorman, "Insulating Materials in High-tension Cables," by E. Jona.

Within the last three or four years extra high-tension three-phase cables are given cores of a 120 deg. sector shape in place of the circular, the three corners being more or less rounded. This results in making the dielectric stress more uniform, owing to the fact that the dielectric is more uniform in thickness between the cores and also between each core and the sheath. In the recently introduced so-called "Laminæ" Henley cable, this idea is even more perfectly carried out.

Reference was then made to the author's article published in *The Electrician* of September 2, 1904, on losses by eddy currents in cable sheaths, and it was pointed out that these losses are unimportant compared with the total power transmitted.

*Surges.*—A Paper by Prof. F. G. Baum on "High Potential Long-Distance Transmission and Control" shows that the surge voltage for an average overhead transmission cannot be greater than 200 times the current in amperes, at the instant of breaking. Further, as a consequence, if E=R.M.S. voltage between line wires and neutral, and C=current the instant before interruption, then for a sine wave with instantaneous interruption the maximum strain in volts=1·4 (E+200 C). The surge voltage will be less than this by an amount dependent on the slowness of current interruption. He further points out that with still greater increase in the length of transmission lines, if some hundreds of miles are used, the surge voltage frequency may not be very far from the frequency of supply, which means that some factor in the circuit must be modified in order to avoid the possibility of the natural time of swing of the circuit coinciding with the working frequency. Needless to remark this case can hardly occur in our country. Actual experiments on a 100-mile line working at 40,000 volts have shown that, on suddenly removing a short-circuit, induced (or "kick-back") voltages are produced, varying from 2½ to six times the normal voltage, this pressure being measured by the length of air-gap broken down. Should a distributed load be used these effects will be greatly reduced.

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* Exceptions must be made in the case of lines close to the sea coast, where the salt in the air gets deposited on the insulators, also in the neighbourhood of chemical factories and under other special conditions.

*Lightning Arrester and Static Dischargers.*—It is probable that the most reliable arrester would be one having a capacity in parallel with an inductance in order to be able to absorb high or low-frequency effects, but so far no good arrangement of this sort has been devised. Up to a pressure of 25,000 volts or so, arresters of the non-arcing type—that is, with multiple gaps in series, used either with or without a resistance in series—appears to give reasonable security. Above this voltage a modified form of the Siemens' arrester has been found fairly successful for circuits up to 50,000 volts, when used with a suitable resistance in series between it and the ground. It is now considered good practice to fix static dischargers at each end of a transmission circuit of any length, both for overhead and underground circuits.

*Board of Trade Regulations.*—The position of the Board of Trade with regard to extra high-tension transmissions at the present time would appear very reasonable. No hard-and-fast rules have as yet been made, each individual case being considered on its own merits. Transmission lines, it is interesting to note, must not be taken alongside of roads, but must be carried across open country. It is understood that a definite set of regulations as to extra high-tension work is about to be issued by the Board of Trade, but it is not as yet published.*

### SOME DETAILS OF POWER TRANSMISSIONS.

*Shawinigan-Montreal.*—Length, 90 miles; horse-power transmitted, 15,000. Transmitting pressure, 53,000 volts. Mains, aluminium cables, each of seven strand No. 7 wire. Distance between line wires, 5 ft. Height of wire from cross-arm, 1 ft. 3½ in. Insulators: porcelain, made in three pieces. Wooden pins used.

*North-Eastern Railway Electrification.*—6,000 volts, 40 frequency. Mains: Dimension, 0·25 sq. in. section; thickness of dielectric, 250 mils.; thickness of lead sheathing, 150 mils.; finished diameter, 2·22 in.; copper strip inside lead sheath, 16 mils. thick. Method of laying: Underground cables laid in creosoted wooden troughs and filled in solid, troughs then covered with tiles 3 in. thick; above-ground cables lain in wrought-iron troughs, supported on cast-iron brackets. Connection maintained throughout over each joint of sheathing. At end of cable both lead and copper sheaths connected to earth plates.

*Lancashire Electric Power Co.*—The normal pole construction consists of A-shaped poles made by two sloping poles, meeting at the top, with a crown of spikes pointing downwards, placed half-way up the pole. The normal insulator is of glazed white porcelain, triple petticoated, and is made in two pieces, cemented firmly together, and has an iron pin. Where special strain has to be taken, a construction is used consisting of four poles, arranged in a square on the ground and meeting in a point at the top. The three-phase circuits are carried on cross-arms, as shown in diagram. Where the transmission line crosses roads the iron support shown is used to carry the guard wires. Where unusual strain has to be taken a special arrangement is used of three shackle insulators. The conductors are 0·1 of a square inch in section. The overhead mains are taken along three routes, each circuit has a duplicate, and each circuit is spiraled slowly along the line. There are at present about 4½ miles of overhead mains and 16 miles of underground mains in this transmission. The underground work is three-core paper-insulated lead-covered, and armoured cables, laid in earthenware troughs and filled in layer by layer, until solid, with bitumen and covered over with earthenware. For lightning protectors B.T.-H. Wirt arresters are used.

*North Wales Power & Traction Co.*—Messrs. Bruce Peebles state that they have under erection for the North Wales Power & Traction Co. about 130 miles of 10,000-volt overhead three-phase mains. Generating plant capacity being some 10,000 H.P.

## MERCURY-VAPOUR LIGHTNING ARRESTERS AND CIRCUIT-BREAKERS.

Five American patents were issued on September 12th to Mr. Peter Cooper Hewitt for apparatus using mercury vapour as a conductor of electric current. One of the patents relates to lightning arresters, while the others deal with circuit breakers.

Fig. 1 shows the circuits of the arresters, the operation of which depends upon the quality of mercury vapour of possessing a high initial electrical resistance which can be overcome by a sufficiently high potential. The apparatus is arranged to resist the normal potential of the line, but will permit current to pass when the potential reaches a certain higher voltage. Should an excessive potential be impressed upon the main conductors by a lightning charge, when it reaches the predetermined limit, it will traverse the vapour apparatus and will be dissipated through a discharge or a succession of discharges through the apparatus to earth. When used on alternating-current circuits, as soon as a lightning discharge shall have overcome the normal resistance of the apparatus, the current will be immediately cut off at the first alternation, since the negative electrode resistance immediately re-establishes itself unless the flow is continued in the original direction. Accordingly the line current will not follow the lightning discharge to earth and the circuit will not be grounded. When the apparatus is applied to direct-current circuits, the same effect of cutting off the flow of current will be brought about by the fact that the particular apparatus applied to the circuit is so designed as to develop too much heat under the influence of the normal current in the circuit to permit the current to flow.

One form of circuit-breaker is illustrated in Fig. 2. The vapour apparatus is here shown in shunt to a switch. The junction of the apparatus is to prevent excessive sparking or an injurious rise of voltage in the circuit when the switch is opened. The apparatus is provided with two starting bands, one near each electrode, which are connected to the secondary terminals of a transformer. By this arrangement of devices the vapour apparatus, which is short-circuited when the switch is closed, will, when the switch is opened, have impressed upon it not only the full voltage of the current at the electrodes, but also a secondary voltage at the starting bands. These combined effects are sufficient to start the vapour apparatus and permit a temporary flow of current through it, thus relieving the sparking at the terminal of the switch. Any tendency to maintain an alternate flow of current through the vapour device will, however, be defeated by the development of too great density of vapour in the apparatus, which is designed in this instant for suppressing the flow after the first passage of current has performed its function of relieving the hand switch. In a modified form of circuit breaker, the rupture of the circuit within the vapour apparatus takes place through the action of a magnet upon the current passing through the gas. The effect of the magnet is to deflect the current passing through the apparatus, which is so designed as to allow the deflection to be sufficiently great to interrupt the current. The circuits are indicated in Fig. 3, where two supplemental electrodes perform the function of starting bands.

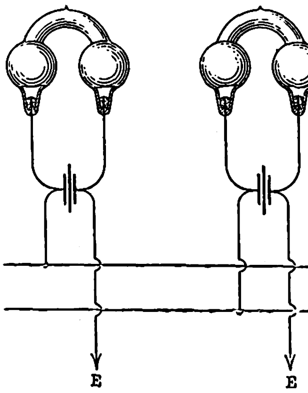

FIG. 1.—LIGHTNING ARRESTER.

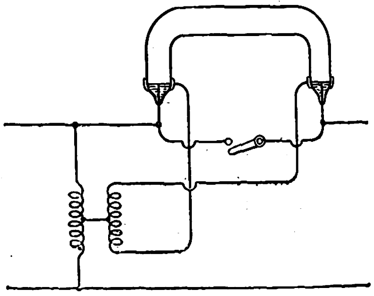

FIG. 2.—CIRCUIT BREAKER.

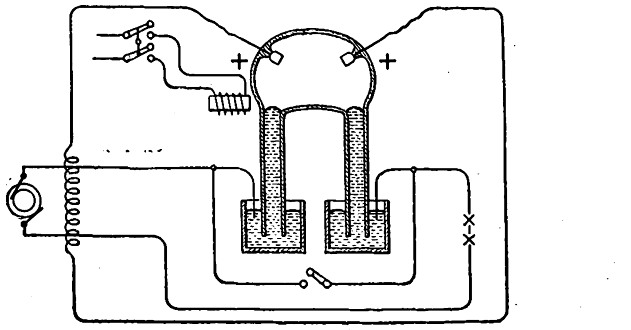

FIG. 3.—VAPOUR SWITCH WITH MAGNETIC BLOW-OUT.

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

Über die Oxydation des Stickstoffes in der Hochspannungsflamme. By Dr. Johannes Brode. (Halle-a-S.: Wilhelm Knapp.) 2.50m.

"Practical Dynamo and Motor Construction." By Alfred W. Marshall. (London: Percival Marshall & Co.) 1s. net.

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* [Prof. Morris is not quite accurate here. A "model" set of regulations will in all probability be available shortly, but we believe that the practice will still continue of issuing special regulations for each particular case, and that the model will be altered to suit each instance.—ED. *E.*]

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

*Electro-mechanics.*—E. Riecke summarises the attempts hitherto made to connect the electric conduction in metals with the transportation of ions and electrons in their interior. The most fruitful of fields for such speculations lies in the comparison of thermal and electric conductivity. Three theories including these values have been formulated, one by Drude, another by Lorentz and a third by the author. All these theories involve the same quantities. Their result for the ratio of thermal to electric conductivity only varies as regards a numerical factor, which is 3/2 in the author's theory, 4/3 in that of Drude, and 8/9 in Lorentz's more general theory. A matter in which theory is at present still somewhat at a loss concerns the four magnetic effects, but in bismuth, nickel and cobalt the order of magnitude of the quantities is at least accounted for. Planck's law of radiation is fully explained for long waves.

[E. Riecke, *Physikalische Zeitschrift*, November 9, 1905.]

*Rays due to Oxidation.*—Since visible radiation is produced by burning substances, it is not unreasonable to suppose that slow oxidation gives rise to some kind of radiation, and such a radiation has been discovered and studied by F. Streintz. He found that magnesium, and to a slighter extent aluminium, zinc, and cadium emit some form of radiation, possibly ultra-violet light, when in a gas containing oxygen; that this radiation ionises the gas, and that it produces certain chemical effects which can be exhibited by means of photographic plates or by paper soaked in a solution of potassium iodide. Half a minute's exposure suffices to produce an image of a magnesium ring laid on a piece of KI paper. When one edge of it is supported by a plate of mica 0·5 mm. thick, the image is blurred towards that side, showing that the rays cannot penetrate more than a few hundredths of a millimetre of air. A magnesium or aluminium condenser is discharged sooner in oxygen than in carbonic acid. If one plate of it is copper and the other magnesium, its discharge may be accelerated by charging the zinc negatively, or retarded by charging it positively. The author finds that these metals may be protected from oxidation by a positive charge, a fact which suggests important practical applications.

[F. Streintz, *Physikalische Zeitschrift*, November 9, 1905.]

*Electro-optic Properties of Carbon.*—The electromagnetic theory of light suggests that certain specimens of carbon, possessing a high electric conductivity, might possess a high reflective power for rays of great wave-length, provided the passage of electricity through them takes place in the same manner as in metals. E. Aschkinass has found, indeed, that certain carbons possess a reflective power of 100 per cent. for waves of the Hertzian order. But the influence of the good conductivity is already sufficiently apparent in the infra-red spectrum. In gas carbon, Siemens arc-lamp carbon and graphite, the curve of reflecting power rises immediately on leaving the visible spectrum, and continues to do so until the Hertzian waves are reached. Thus for polished gas-carbon the reflective power is 4·4 at 0·589$\mu$, and 56·5 at 51·2$\mu$. Anthracite also exhibits considerable reflective power in the infra-red, but this never goes beyond 14, even for Hertzian waves. This anomaly is to be expected in consideration of its comparatively low conductivity. It, therefore, also transmits some of the waves, and its refractive index for infinitely long waves, as calculated from the reflection, comes out as 2·2. The refractive index of diamond for yellow light is 2·4.

[E. Aschkinass, *Physikalische Zeitschrift*, November 9, 1905.]

*Projection of Cathode Particles.*—The manner in which electrons are projected from the cathode is open to some doubt on account of a discrepancy in the value of the ratio $e/m$ obtained by two different methods. The method of electrostatic deviation used by Thomson gives $0{\cdot}8 \times 10^7$, while the calculation of the potential made by Kaufmann and Simon gives double that value. In the latter case the difference of potential fallen through by the electron is assumed to be that between the cathode and the observation space. This again assumes that the electron is liberated at the cathode itself, which remains to be proved. J. Malassez has essayed such a proof by a method devised by Langevin. It consists in directly determining the difference of potential under which the rays are produced by observing the change of velocity imparted to them by a second magnetic field. If, after traversing a difference of potential V, and thus acquiring a velocity $v_1$ the cathode rays are made to work up against another difference of potential V′, the resultant velocity $v_1$ will be determined by the equation $\frac{1}{2}mv_1^2 = (V - V')e$. Now let the rays be deflected by a magnetic field, and acquire a radius of curvature $\rho$. With only one difference of potential to traverse we have $Hev = mv^2/\rho$. With the additional V′, let the magnetic field be so arranged that the curvature is the same as before. Then we have $mv_1^2/\rho = H_1 ev_1$ and $V'/V = (H^2 - H_1^2)/H^2 = (i^2 - i_1^2)/i^2$, where $ii_1$ are the magnetising currents. The ratio on the right-hand side is easily determined, and since V′ can be accurately fixed, V is known. If it is equal to the difference of potential between anode and cathode, it proves, then, the rays or electrons are projected from the cathode itself. The author finds that that is the case, and that the great velocity is acquired from the cathode itself.

[J. Malassez, *Comptes Rendus*, November 27, 1905.]

*Molecular Layers of Lead Superoxide.*—J. Koenigsberger and W. J. Mueller maintained last year that any molecular layer producing the passivity of iron must be less than one-tenth of the wave-length of the light in thickness. They now go much further, and maintain that such a layer does not exist at all, for, if it did, it would have to be at least one molecule in thickness, and layers of molecular thickness are easily discoverable by optical methods. The authors precipitated lead superoxide from a nearly neutral solution of acetate by a current of 62 micro-amperes acting for 10 seconds, the cathode being a plate of platinum-iridium alloy. By observing the interference colours with layers of greater thickness they made sure that Faraday's laws of electrolysis hold good for the thinnest layers, and so they are in a position to maintain that the quantity of $PbO_2$ deposited was $7{\cdot}8 \times 10^{-4}$ milligrammes. Moreover, the layer was continuous, as proved by observing the reflection by Toepler's method. The electrolytic forces were stronger than the forces of crystallisation. Since the density is 9·3, the layer had a thickness of 0·81 $\mu\mu$, or $\frac{1}{500}$th of the wave-length of blue light. On depositing more $PbO_2$, the reflecting power gradually fell from 61 per cent., that of the platinum-iridium to 15 per cent., that of the superoxide, which it reached at about $\frac{1}{20}$ mm. By measuring the E.M.F. of thin layers of $PbO_2$, the authors found that they do not acquire their full E.M.F. with thicknesses less than 4·2 $\mu\mu$, so that electrolytically active layers are easily perceived. The thickness 0·84 $\mu\mu$ is, according to the mean of the best calculations hitherto made, equal to the diameter of the molecule of $PbO_2$, or perhaps double that diameter. It agrees with Stefan's value deduced from diffusion by the kinetic theory of gases.

[Koenigsberger and Mueller, *Physikalische Zeitschrift*, Dec. 1, 1905.]

*Actino-electric Phenomena.*—H. Dufour has examined a number of different bodies with a view to discovering new photo-electric effects. They included amalgamated zinc, known for its great sensitiveness to ultra-violet light, an Auer incandescent mantle, and wire netting, either bare or blackened, so as to determine the effect of adhesive layers of gas. The ultra-violet light was derived from an arc lamp, while infra-red rays were obtained from a Nernst lamp, an electric furnace, or a red-hot cannon ball. The author endeavoured to discriminate between the "corpuscular" rays emitted by the body under the influence of illumination and the impact of ions proceeding from the radiating body. The latter is specially active in the case of the electric furnace or cannon ball when shining with a very faint light. It has the effect of retarding the discharge provoked by ultra-violet light or similar agents employed at the same time, just as it extinguishes the luminescence of a body. When the furnace gets more luminous it begins to acquire an action of its own, but only on negatively-charged bodies. This discharging action rapidly increases up to a bright red heat.

[H. Dufour, *Physikalische Zeitschrift*, December 1, 1905.]

A. Righi (*ibid*) announces that he is unable to discover any influence of Röntgen or radium rays on the conductivity of dielectrics, whether solid or liquid.

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## THE COMING PARLIAMENTARY SESSION.

We conclude in another part of this issue our extracts from the various Bills of electrical interest which have been deposited in Parliament, and will come up for consideration during the next session. Fortunately, the change in the political constitution of the Government has happened at a period of the year which will render unlikely any interference with the course of private Bill procedure. If, as we hope, there is no truth in the rumour that one of the first actions of the new Government will be to appoint a Royal Commission to go into the whole question of electric power supply in London, the session will undoubtedly be an "electric power" one. There are no less than ten Bills affecting the supply of electric power in London, and eleven others dealing with the provinces. The London Bills are more or less a repetition of those deposited last year, with some others thrown in, partly as the result of the experience gained from the exhaustive inquiry in connection with the Administrative County of London Company's Bill, and partly in consequence of the failure of the late Government, after the third attempt, to pass the very necessary reforms contained in the Supply of Electricity Bill, which would have had the effect of consolidating and systematising the numerous existing sources of supply. Under the existing state of the law, these are compelled to remain so many isolated systems, a condition of things which we have constantly urged should be remedied. In fact, the impression made upon us after a perusal of the Bills deposited this year is the very great need for a general revision of the whole of the law relating to electric supply, in order to avoid the constant and expensive applications to Parliament, which seem to multiply every year, for powers obviously of universal application. For instance, no less than six of the electric power Bills for London have been promoted with the object of obtaining relief from the onerous conditions imposed by the Electric Lighting Acts as to non-association with other undertakings, the removal of which would render possible an extensive development of the existing undertakings.

The Bills seeking a power area in and around London are four in number—viz., the Administrative County of London Company, the Additional Electric Supply Co., the London County Council and the Charing Cross, West End & City Electricity Supply Co. The latter Bill is not so comprehensive as the others, only scheduling a large area north of the Thames. It will thus be seen that any Committee considering these measures will have first of all two points of principle to dispose of: first, the advantage or otherwise of "districting" the London area and giving a portion to different companies, and, secondly, the equity of permitting the London County Council to trade widely outside the limits of the area in which its jurisdiction is exercised, and in some instances to compete with existing companies having similar powers for the supply of electricity in bulk. Having solved this part of the problem, the issue would then resolve itself into one of price. No price is scheduled in the London County Council Bill, possibly because of the inclusion of a clause compelling the Council to raise their tariff if no profit is shown after five years' working, but various scales of charges are given in the other Bills; particular attention may be directed to the extremely low tariff of the Additional Company. If they wish to avoid determined opposition from the Supply Companies, both the Administrative and the Additional Companies will have to modify their proposals in a similar manner to that finally adopted by the Administrative Company last year. The Administrative Company seeks power, as before, to supply power direct to the consumer under certain conditions in possible opposition to existing companies, and certain words of the Additional Company's Bill, quoted in our last issue, may indicate similar powers.

There remains the question of the probability of the appointment of a Royal Commission to deal with the whole matter, and it is one which must be viewed with somewhat mixed feelings at this period. Whilst the problems presented may, from some points of view, lend themselves more readily to treatment by this method, past history cannot be ignored, and we feel that the time when this procedure would have been useful has gone by. Commenting on the matter last June, when the Administrative Company's Bill had passed the House of Lords and was approaching the Committee stage in the Commons, we said:

> The solution of the question is a difficult one, and we would be inclined to approve Mr. Bryce's suggestion that it should be referred to a Royal Commission, were it not that a delay of at least two years would be necessary before the report could be received and due effect be given to it. As a first step, the Administrative County of London Power Bill should be rejected, and as a second step the long-delayed Supply of Electricity Bill, the general terms of which are approved by all concerned, should be passed. This will not entirely remove the difficulties in the way of cheap power supply in London, however, which are enhanced by the existence of several municipal electricity works, some of them of small size and supplying necessarily under uneconomical conditions. A general agreement between the companies is requisite, and this must be followed by a compromise with the local authorities, who must, however, first disabuse their minds of the idea that a function of a municipal electricity undertaking is to make a profit for the relief of the general rates.

This is practically the course that the existing companies are endeavouring to follow, although the situation is somewhat altered by the fact that the new power companies will probably be willing, with but little persuasion, this time to agree not to compete with the existing companies and to restrict their business to a wholesale one.

In connection with the power schemes relating to the provinces, an interesting proposal relates to the incorporation of a new company for the supply of electricity and power gas in Cumberland, whilst the Shropshire & Worcestershire Company asks for an extension of area. The County of Durham Company, the Kent Company, the Lancashire Company, the Newcastle-upon-Tyne Electric Supply Co. and the Derbyshire & Notts Company also seek additional facilities, including powers to erect overhead mains, with a removal of any local veto that may exist, subject to an appeal to the Board of Trade. There are also one or two applications for the exemption of generating stations from liability for nuisance, and the St. Pancras Borough Council is also to be numbered amongst them.

Coming to the municipal Bills, we are again reminded of the necessity for a revision and amplification of the general legislation relating to electric supply. Every year municipalities find the need for applying for powers, such as the exemption from distress of fittings and apparatus on consumers' premises, the application of what has become to be known as the "stand-by" clause—viz., that a consumer having separate generating plant and desiring a supplementary supply should be treated on a different basis to the ordinary customer; and the right to refuse supply in certain cases—for instance, where there are arrears of payment due. These powers are necessary for the proper management of an electrical undertaking, and invariably they are granted without opposition. It is true that they are usually dealt with in the form of one or two clauses in an "omnibus" Bill, but it would remove much inconvenience and waste of time and introduce some uniformity into these matters were such powers to be made universally applicable in a general Act.

Special attention may be drawn to the application by municipalities for powers to engage in the wiring and fitting business, upon which we expressed our views a fortnight ago. The London County Council has again introduced a Bill authorising the London borough councils to do this work, and for some reason a similar proposal is also included in the Bill deposited by the Hackney Borough Council. In both cases powers are taken to enter into agreements with contractors, but it is to be feared that this will hardly satisfy the Electrical Contractors' Association or the general body of ratepayers, as there is nothing binding in such a clause. A number of provincial corporations also make a like application, and similar remarks apply to these, with the exception of the Rathmines and Rathgar Council and the Hull Corporation, whose Bills expressly stipulate that the work shall be done through contractors and not by the councils themselves.

Of the remaining measures, the tramway Bills do not call for particular comment. The London County Council, in its tramway bill asking for borrowing powers to the extent of nearly $1\frac{1}{2}$ millions, this year comes to Parliament with the co-operation of the City Corporation in connection with its Thames Embankment scheme, and there are a number of ordinary tramway Bills of purely local interest. Tube railway schemes in London are few, and only one new line is promoted—viz., the Hammersmith, City & North-East London Railway. This will run from Hammersmith, via Knightsbridge and Piccadilly and the Strand, to Shoreditch and on to Tottenham and Palmer's Green; but this year the branch from Shoreditch to Walthamstow and Waltham is not included, no doubt in consequence of the passage of the North-East London Railway Bill last session. The North-West London Railway Co. asks for an extension of its route. The London Outer Circle Railway is an interesting proposal, but the Bill as it stands hardly reveals sufficient detail to enable us to discuss it at this stage. The Folkestone Electricity Supply Co. seeks the legalisation of certain agreements to supply in bulk in Sandgate and Hythe, although a supply is being already given in these towns; whilst another Bill, for which there was a precedent last session, is that of the Teddington and Twickenham Electric Supply Co., which has powers to supply in both districts under two distinct Provisional Orders, but has to secure Parliamentary sanction to supply both areas from one generating station. Similar powers were granted to the Weybridge Electric Supply Co. in respect of its Walton area last year.

The main interest will centre around London, however; but it is premature to express any opinion as to the result. If the suggested Royal Commission is not appointed much will depend on the constitution of the Committees in the two Houses, and it is useless to speculate on this before the General Election.

## REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign book.)

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**The Coal Fields of Great Britain.** By Prof. EDWARD HULL, LL.D., F.R.S. 5th Edition. (London: Hugh Rees, Ltd.) 14s.

The title of this excellent reference book barely does justice to its contents, for one finds not only a complete description of the various British coal fields, but also a useful summary of the coal formations in almost every other country. The author, himself one of the Royal Commissioners of 1871 and 1901, refers to the then searching investigations, and embodies much useful information from the reports. After a brief description in the early chapters of the plant and animal remains of the carboniferous period the author proceeds to illustrate the formation of the coal measures. The succeeding chapters, which contain the most important matter, deal very minutely with the various British coal basins, not only describing the physical geology of each district, accompanied by a useful map and geological section in each case, but also providing valuable reference tables of the various local coal seams and the commissioner's estimates of the remaining available coals of their respective kinds. One notes that in describing the coal field of Durham (Chap. XXI.) the author, while mentioning the Tyne and Tees, entirely omits any mention of the Wear, from which river much, if not most, of the coal is locally shipped. The statistical information given must prove of great value. One joins in the author's lament that the coal industry in Ireland has almost ceased, though there is much undeveloped fuel near to hand, even in the manufacturing province of Ulster; and his favourable opinion of the prospects of the Kentish coal field will be welcomed by many. The author's comments upon the coal fields of the Midland counties and their restricted extension under the surrounding mesozoic formations, represent a valuable summation of the most recent researches.

Chapter XXXIII. is reassuring and sums up the total supply of coal in these islands—though elsewhere the author sounds a note of warning as to the measurable extent of the store within the limits of practical depth. The next Chapters deal in a somewhat general way with the coal formations of India, the various Colonies, and foreign countries, and contain useful information about their palæontology and physical character, estimated available tonnage, and details of the seams worked.

Suggested substitutes for coal are referred to, but one cannot quite agree with him that water power "is everywhere present and unfailing wherever water in motion is available."

The average prices at the pit's mouth in various districts are given, and tables showing the tonnage of coal exported and used in home consumption. Part VII. deals with the physical limits of deep coal mining, and the results give little hope of gleaning the vast masses of coal which remain at depths exceeding 4,000 ft. The relations of temperature and increasing depths is fully dealt with, but the author does not appear to deal with such effects or barometric changes in dangerous mines.

The concluding chapters refer to the physical geology of this period, and the overlying strata, and one would have preferred to have seen them more naturally grouped with the opening geological chapters.

This book, as would be expected of such a distinguished geologist as Prof. Hull, is a most valuable text book of information about almost everything relating to coal, whether considered from the scientific view of geology or from the industrial view, as a mineral of such importance to our national welfare.

J. F. C. SNELL.

**Higher Mathematics for Students of Chemistry and Physics.** By J. W. MELLOR. (London: Longmans, Green & Co.) 15s. net. 2nd edition.

**Electrical Engineering.** By TYSON SEWELL. (London: Crosby Lockwood & Son.) 7s. 6d. net. 3rd edition.

**Elementary Manual of Magnetism and Electricity.** By ANDREW JAMIESON. (London: Chas. Griffin Co.) 3s. 6d. 6th edition.

**Elementary Electrical Engineering.** By J. H. ALEXANDER. (London: Crosby Lockwood & Son.) 3s. 6d. net.

**Elementary Electrical Calculations.** By W. H. N. JAMES and D. L. SANDS. (London: Longmans, Green & Co.) 3s. 6d. net.

**A Guide to the Electrical Examinations.** By F. H. TAYLOR. (London: Percival Marshall & Co.) 1s. net.

It will be seen from the above list that the deluge of elementary text-books for electrical engineering students continues with unabated vigour. Perhaps it is scarcely right, however, to include the book at the head of this list among so-called elementary text-books. As a matter of fact it is more of an encyclopædia of mathematical applications such as must be studied by candidates for university degrees in science. It is not a work that can be recommended to a first-year student of electrical engineering, but we can conceive of no better work of reference for the man who has advanced to his second or third year. No matter whether he be studying engineering, physics or chemistry, he will find in Dr. Mellor's book a veritable mine of information without which he will be placed at a great disadvantage. We do not wish to infer that the information cannot be obtained elsewhere, but Dr. Mellor has succeeded in picking out a large number of vital points, at the same time omitting material which may well be left to special text-books. Not only to students, but also to those who have passed the student stage and are engaged in highly technical work, we can strongly recommend this book.

Mr. Sewell's book differs very little from former editions. Certain of the illustrations have been improved and a considerable number of examples have been added to the appendix. These examples are of great value, both to students and teachers, and might be added to still further without occupying an undue amount of room. The appreciative remarks which we made concerning the first and second editions of the book apply equally well to the third.

Anything beyond a few words of acknowledgment of the sixth edition of a book might well be considered superfluous. Prof. Jamieson has made few alterations to his fifth edition, and he has used as a frontispiece a reproduction of Mr. Acland Hunt's picture of Dr. Gilbert showing his experiments to Queen Elizabeth. This picture, it will be remembered, was presented by the Institution of Electrical Engineers to the town of Colchester. The book has been written specially for and is undoubtedly suited to candidates for the Board of Education first stage examination.

Mr. Alexander's book is of a type that is becoming all too common nowadays. It is obviously a well-meaning attempt to provide a simple non-mathematical treatise principally for use by students of the kind usually found in evening classes. To write a successful book for this purpose is no easy task, and Mr. Alexander's labours have proved that the problem still remains to be solved. We can congratulate the author neither upon his illustrations nor upon his ability to express matters in a happy manner. When discussing the amperes the author states: "The symbol is A or C. It is $\frac{1}{10}$th part of a C.G S. unit, and is expressed as $10^{-1}$." The ambiguity would not be of great moment if only the author had previously defined the C.G.S. unit.

Messrs. James and Sands' book is a very useful little work, and the greatest fault we have to find with it is that it is not provided with an index. For teachers and students in applied classes it contains a large amount of matter put in a convenient form. As a laboratory handbook it cannot be considered desirable, and the authors apparently had no intention of recommending it for this purpose. The theory is reliable and the numerical examples possess the merit of accuracy.

The title of Mr. Taylor's book is self-explanatory. In addition to a large number of particulars relating to the electrical examinations of the City and Guilds of London Institute, and of the Board of Education, the author gives many examination questions followed by model answers. For students preparing for the examinations conducted by the above-mentioned bodies the book will prove of considerable service.

**Die Elektrolyse geschmolzener Salze.** By Von Richard Lorenz. Part I. Verbindungen und Elemente. Part II. Das Gesetz von Faraday. (Wilhelm Knapp Halle.) 1905. Part I. 8m. Part II. 8m.

These books complete the 20th and 21st volumes of "Monographien über Angewandte Electrochemie." No one is better qualified to deal with this very difficult branch of electrochemistry than Prof. Lorenz, who has himself done so much to simplify and elucidate the methods and to expand the theory of this subject.

Part I. deals with the preparation and actual electrolysis of the salts of the various metals which have been reduced by the electric current. Historical data is fully given and the properties of the different metals are also set out. The book commences with the electrolysis of fused salts of the alkali metals beginning with lithium. Twenty-five pages are devoted to sodium, commencing with the work of Faraday on the electrolysis of sodium chloride and going back on p. 18 to the experiments of Davy in 1808, when he first isolated sodium by the electrolysis of sodium hydroxide. Although the book deals largely with laboratory methods, manufacturing processes are also described, although not in the detail which the technical reader might desire.

But we venture to think that as the theory of the processes are so carefully detailed, manufacturers would do well to study this work carefully before taking up the technical processes. Much labour would often be saved if those who desire to work on a commercial scale would first of all thoroughly master the theoretical side of the question.

Very little work has been done upon the electrolysis of fused organic salts and what has been done will hardly have the effect of stimulating research, because most of the results have led into a cul-de-sac.

Part II. treats mainly of theory, and deals with the application of Faraday's laws to the electrolysis of fused salts and to the conductivity, &c. One of the great difficulties met with in the electrolysis of fused salts is the diffusion of the metal in a state of fine division throughout the electrolyte, forming what is called a "metal fog." In sec. 10 experiments are described which show that very considerable quantities of a metal actually dissolve in the fused electrolyte. Thus at a temperature of 580 deg. 0·0052 grammes of lead dissolves in 40 minutes in fused lead chlorate, but when the temperature is raised to 956 deg., the boiling point of lead chloride, 0·3212 grammes dissolved in 14 minutes. After reading this monograph one feels that not only is Prof. Lorenz a splended experimenter, but that he is full of ideas.

The monograph is by no means easy reading, but it well repays a careful study, and is therefore to be highly recommended. German writers as a rule delight in prolixity, but although this book consists of 257 pages it is difficult to lay one's finger upon any special part and say "this might have been left out."

It will probably be new to some students of electro-chemistry, that by electrolysis of a mixture of fused salts of different metals, separation of the metals can be obtained. For example, when a mixture of the fused chlorides of zinc and lead are electrolysed the lead is first deposited out and then the zinc. In a mixture of silver, lead and zinc chlorides, the silver is first deposited. Particulars of mixtures of fused salts will be found in sec. 16.

On looking through the index of the authors, both in this and in the preceding volume, we regret to see how comparatively little work has been published in this country upon the subject. And yet the first work was done by Davy; in fact, we were the pioneers. We hope that these two monographs will be read by electro-chemists in this country, and that they will interest themselves in the electrolysis of fused salts; the very difficulty of the subject should serve as an incentive.

**Annuaire pour l'An 1906, publié par le Bureau des Longitudes.** (Paris: Gauthier-Villars.) 1fr. 50c.

This fat little annual of nearly 900 pages comprises a calendar for 1906, extensive astronomical tables as in former years, and a large collection of valuable data and tables relating to many branches of science, including electrical science, physics, chemistry, thermo-dynamics, &c. A number of illustrated articles in connection with this year's eclipse of the sun are appended.

## ELECTRICITY METERS.*

BY C. H. W. GERHARDI.

*(Continued from page 380.)*

### METER TESTING (*continued*).

*Testing Motor Meters.*—A set of motor meters of the same size and make having been connected up in series on the test table and unclamped, the first thing to do is to examine all the counting trains to see that they are free, and that there is sufficient—but not too much—play between the worm and wormwheel. They should also be examined for constant—*i.e.*, that they have the correct train for their size. With meters having a uniform speed and constant, this becomes hardly more than a matter of inspection after a little practice, but a short dial run should also be made. The jewel should be quite smooth and possess a polished surface, which can be ascertained by feeling it with a sharp needle.

The brushes and commutators next require examining (in such meters as have them). Upon the state in which these are left depends to a very great extent the successful running of this class of meter. The tension with which they press on the commutator should be just enough to prevent sparking with slight vibration. The correct tension is felt by lifting one brush off the commutator. The second brush should leave the commutator when the one lifted is between $\frac{1}{16}$ in. and $\frac{1}{8}$ in. from the commutator. Each brush should bear quite flat and not on its edge; this is most important. The shunt current should not be left on while the brushes are being set.

It may save a lot of trouble if the compounding coil is tested to make sure that it is helping and not opposing. This is easily done by tapping the meter with the shunt current on, but no main current; the disc should then rotate slowly in the right direction. Meters having brake magnets should be carefully examined to see that no grit or particles of iron are between the poles and the brake disc, and that no hairs or stray threads are clinging to the armature.

Motor meters containing mercury are more difficult to examine owing to the armature, or moving part, being enclosed and not visible. If friction is apparent by bad or non-starting, the first thing to examine, as in other motor meters, is the wheel train, especially where it gears with the main spindle. To examine the jewel it is necessary to empty the mercury. Sometimes bad starting may be due to contact of the main spindle with the clamping gear or to bubbles in the mercury, or perhaps an iron filing in the mercury chamber, in which case the mercury must be emptied out in the hope that it may bring the obstruction with it, fresh clean mercury being used to refill the chamber.

After having ascertained that the friction is not above the normal and that the meter starts with the usual starting current, the full load may be switched on, and after running a short time the test at this load made. A test at a low load ($\frac{1}{10}$th or $\frac{1}{20}$th of full load) will then be sufficient for meters having a straight line law, but in those cases where the law is otherwise, tests at intermediate loads will be necessary.

Some meters are affected by a short-circuit, the usual effect being a weakening of the brake magnets caused by the intense momentary field set up by the rush of current through the main coils. It is, therefore, advisable to cause a short circuit through such meters by connecting them through a fuse of double the meter capacity to a supply at the correct pressure. It is not necessary to do this to every meter after it has been ascertained that no damage is caused. Many meters are provided with an iron plate between the coils and the magnets, which acts as a magnetic screen, and diverts the path of the field, causing it to pass through and above the screen instead of through the magnets. In some meters the magnets are placed so that their length is at right angles to the field of the coil, in which case they are little affected.

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* From a forthcoming book to be published by "The Electrician" Printing and Publishing Co. All rights are reserved.

Where tests have to be made by taking readings as in the case of the Aron and electrolytic meters it is necessary to make the run long enough to produce a reading sufficiently large to prevent an error of more than 0·5 to 1 per cent. in the reading at the most. This means that a reading of at least 20 B.T.U. must be obtained on such meters as the Bastian or Wright electrolytic, or 2 on the last dial but one of meters possessing dial trains. A larger reading, however, is recommended.

The current and volts require to be kept constant by regulating during the test. Electrolytic meters, such as the Bastian or the Wright, which necessarily require a long run may conveniently be tested by means of a good motor meter, such as an O.K. which can be standardised during the run.

In this way it is not necessary to regulate during the test, as the current variations ought to be felt both by the meters under test and the meter used as the auxiliary standard. Provision should be made for connecting up a number of such meters, as a quantity take very little longer to test than a few, the only difference being the extra time in taking the readings. It is desirable to test shunted meters at more than one load to ascertain if the curve is a straight line. If the cell circuit resistance is not properly compensated for temperature the errors will not be the same. The cell circuit may be tested for resistance at two temperatures differing by about, say 15°C., when practically no difference should be found in the resistance if the compensation is correct. When the necessary tests to ascertain the curves of the meters are completed, the shunt currents of watt-hour meters may be taken, as also the starting current, after which all current is switched off; the end of the shunt which had been disconnected from the main replaced, and the meters are ready for insulation test to case.

The quickest way to ascertain the insulation resistance is with an ohmmeter and generator. Prepayment meters require further testing to prove the accuracy of the prepayment gear, which is usually an attachment to the ordinary meter. These tests include: (1) Checking the ratio of the additional wheels and pinions of the prepayment attachment, which is a similar operation to the ascertaining of the watt-hours per revolution. (2) Tests of the slot with actual coins. For this purpose it is desirable to collect a few new, medium, and very thin coins, as any and all of these will probably be used in practice. The slot should also be tried with other coins than those for which the meter is designed; for instance, a meter to take sixpenny pieces should not allow of farthings being inserted; one designed to take shillings must not have a slot capable of admitting halfpennies, and so on. (3) Tests of the cut-off gear and switch: Several trials should be made to ascertain that the cut-off gear acts without fail and that the switch is not likely to stick in when it should come off. Equally important is it that it cannot, by shaking or otherwise, come off too soon.

The switch should be double break and quick break, its contacts being good. Switches in prepayment meters have up to the present not been particularly good, and the author has had trouble with these, more especially in the contacts, the switch acting, but not making good contact. This is a most important point in connection with prepayment meters, as nothing tends to put this system of charging so much into disfavour as the fact that a consumer is left in the dark after having put the coin in.

It would be a long operation to test the meter for cut-off by running it even at full speed in the usual way. Several types of prepayment meters can, however, be run down by hand in a few seconds, and consequently many tests can be made in a short time. The method differs with each meter. When testing the cut-off in this way, on nearly reaching the point at which cut off takes place the speed of running down should be reduced to the normal rate if possible and care taken that the cut-off does not occur prematurely due to shaking; it is not of great importance that the meter be within the 2½ per cent. limit of accuracy when running to the point of cut-off at each test; probably this accuracy would not be obtainable. Demand indicators are very easy to test. A number are connected up in series with the standard instrument in circuit. They are all set to zero and steady currents of different strengths are passed through them for the specified time (or perhaps a little longer at low loads). After each "run" a reading is taken. Those intended for motor loads should be tested with, say, 100 per cent. over load for a minute or two. If provided with two scales, which is usual, one being calibrated in amperes and the other in units to be consumed per quarter (or other period) before the reduced price is charged, the latter scale should in each case be checked by calculation at a low, high, and intermediate point. Sample meters, that is to say, meters of a new type not previously employed should be further tested for torque, effect of temperature and drop.

The full load torque of meters varies from about 30 gramme centimetres down to about 1 gramme centimetre, the torque of the majority being considerably under the higher figure mentioned. Apparatus for measuring the torques has already been described. From the supply undertaking's point of view—as also the consumers—the *permanence of the accuracy* is the important point, and this depends on the driving torque to a large extent. The friction may increase with time, but the higher the driving torque the less the curve of accuracy is affected by a given increase of friction. The increase in the friction in no way depends on the initial friction, but on mechanical details, such as quality of jewel, accurate cutting of wheels in train, dust, &c.

(*To be continued.*)

## STREET LIGHTING.

The following is an abstract of the discussion which took place at the Manchester Local Section of the Institution of Electrical Engineers on December 12th, in connection with Mr. Haydn T. Harrison's Paper on the above subject. The Paper itself was published in abstract in our last two issues, pp. 351 and 388:—

The CHAIRMAN (Mr. S. L. Pearce) thought that not the least interesting portion of the Paper was that dealing with the various methods of measuring illumination. Seeing that all tests are made largely for comparison, he thought it preferable to focus the light and measure the normal ray at various distances from the source of illumination. This method eliminates all reference to the angle of the screens, and also disposes of any consideration regarding height of lamps. Direct illumination, of course, meant making an adjustment every time a measurement was made at a different angle, but this added nothing appreciably to the length of time taken; every photometer maker took this point into consideration in the design of the instrument. With reference to the Manchester curves, the candle-power foot for the normal ray was measured at different distances from one source of illumination, and then the photometer was turned round and similar measurements taken from the second source. Two overlapping curves were thus obtained, and by summing these a third curve was arrived at, which gave the total maximum illumination sent to any point from the two sources of light. He cordially agreed with the author that the use of a few large units of light for street illumination did not give the best results, but was not prepared to go to the limit Mr. Harrison did in the other direction.

Prof. A. SCHWARTZ sympathised with the author's evident desire for simplicity, but he was afraid that in endeavouring to attain this simplicity the author had partly disregarded some matters of fundamental importance. The author, in common with most engineers, had almost totally disregarded questions of colour, steadiness and suitable intrinsic brilliancy, and the speaker urged the importance of their consideration. Recognising that the human eye had been developed under the influence of sunlight, they would agree that that artificial light which most closely approximated in composition to daylight would be the most suitable for seeing by. Daylight was only white about noon, and as the sun set more and more of the blue rays were filtered out by the atmosphere and the light became more yellowish in character. He favoured an artificial light with the same tendencies; some arc lamps that were bluish and Welsbach lamps, which were greenish, were not so visually useful, as they might be. Further, on examining the spectrum of daylight with a photometer, about 80 per cent. of the total luminosity would be found to reside in the yellow region. With regard to the question of intrinsic brilliancy, it should be a fundamental rule of proper illumination that all radiants of high intrinsic brilliancy should be kept out of the field of view as far as possible, unless protected with diffusing globes. He considered high-temperature filaments, such as in the Tantalum, Osmium and Nernst lamps, particularly when furnished with the author's reflecting device, too trying if not shaded and if mounted on short posts. The author had stated that the process for obtaining contour curves after the manner of Mr. Trotter was so laborious and intricate that he could not advise anyone to undertake it. Stimulated by this remark, he had, in conjuction with his colleague, Mr. C. F Smith, taken some of the interesting and valuable illumination curves obtained by Mr. Pearce for the Manchester streets and plotted the contours by a simple graphical process, shown in Fig. 1. Considering the illumination from two sources, A and B, the 1 candle-foot contour could be plotted from the intersection of circles of equal illumination, described about A and B as centres. Figs. 2 and 3 show contours obtained in the case of the Gilbert arcs in Albert-square and the intensified gas outside the School of Technology. He did not quite know what the author meant by the term diversity factor, but presumed it referred to the rate of change of the illumination, in which case it would not be sufficient to know only the maximum and mimimum values as the author claimed.

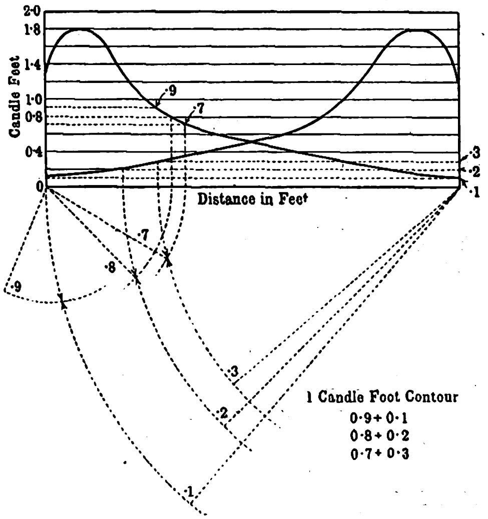


FIG. 1.

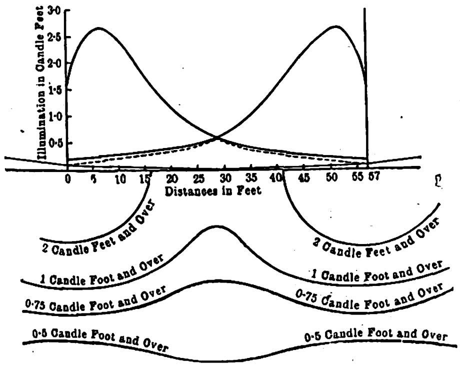


FIG. 2.—CURVES FOR GILBERT ARCS.

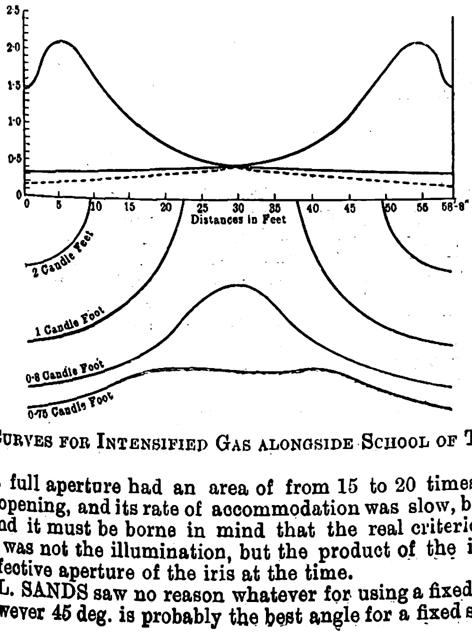


FIG. 3.—CURVES FOR INTENSIFIED GAS ALONGSIDE SCHOOL OF TECHNOLOGY.

The iris at full aperture had an area of from 15 to 20 times that of its minimum opening, and its rate of accommodation was slow, being several seconds, and it must be borne in mind that the real criterion of visual usefulness was not the illumination, but the product of the illumination and the effective aperture of the iris at the time.

Mr. D. L. SANDS saw no reason whatever for using a fixed photometer screen, however 45 deg. is probably the best angle for a fixed screen. The author answers this question by stating "that it requires another adjustment every time a measurement is made, thus not only complicating the design of the instrument, but also increasing the time occupied in making the tests." The speaker's experience was that with a direct-reading photometer the adjustment objected to by the author of the Paper can easily be made in five or six seconds, and that this adjustment, besides enabling the operator to obtain the direct illumination from the source of light, insures that the source is in strict alignment with the photometric axis. Fig. 4 illustrates these points. The disc on being turned from the sighting position A (normal to incident beam) to the testing position B (midway between lines A and C), presents the same angle of incidence to both light sources, then the value CP/$d^2$ is the direct illumination from the source under test—*i.e.*, illumination on a surface in position A, the value CP being the candle-power of the standard lamp employed. The illumination on a horizontal surface at this point can easily be obtained by multiplying the value CP/$d^2$ by the sine of the angle contained between lines A and C. A great advantage of this arrangement is that the further away from the light source the photometer is placed the more nearly normal does the disc become to the incident beam, whereas in the case of the screen fixed constantly at 45 deg. the incident beam is exactly normal to the disc at a point in the street which is as far distant from the lamp standard as the light source is above the photometer; but if the photometer is moved in either direction from this position the angle of incidence is increased, and consequently the sensitiveness of the instrument is depreciated, especially in the case of low-intensity street lamps.

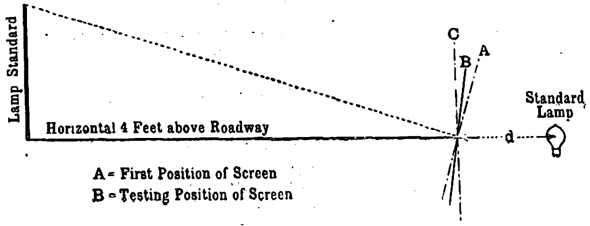

Lamp Standard
Horizontal 4 Feet above Roadway
C
B
A
d
Standard Lamp
A = First Position of Screen
B = Testing Position of Screen

FIG. 4.

Mr. J. G. NEWBIGGING, Chief Engineer Manchester Corporation Gas Department, defended the value of the opinion of "the man in the street," whose views on street lighting are quite unbiassed, although treated with contempt by Mr. Harrison. He did not know on what grounds Mr. Harrison claimed that electrical engineers have less antipathy to the actual measurement of street lighting than gas engineers have. The latter have everything to gain by such a method of comparison, because, on Mr. Harrison's own showing, a so-called 1,000 c.p. arc lamp only gives an actual light of 600 candles, or 40 per cent. less than the nominal power. If photometrical observations were taken of a nominal 1,000 c.p. gas light and a nominal 1,000 c.p. arc light at intervals of, say, 10 minutes over a period of several hours, it would be found that the gas light would give a greater percentage of efficiency than the arc light, and this is the only true basis of comparison on photometrical lines. It is, however, well known that the varying conditions existing in the streets, such as vibration and the state of the atmosphere, render the comparisons on photometrical lines alone not absolutely reliable. There is another point in making a comparison between electric arc lighting and incandescent gas lighting that must not be lost sight of, and that is, in the case of electric arc lighting the whole of the light is reflected downwards by the aid of reflectors, whereas in the case of incandescent gas lighting a portion of the light is allowed to travel upwards. This accounts for the increased illuminating power which has been obtained by the President and others when taking photometrical observations of the two systems of street lighting. It is a moot point whether the reflecting of all the light downwards is advisable, because the sharp line which divides the darkness above the reflector and the light below the reflector creates an oppressive effect on those walking in the street. It is, after all, largely on the general lighting effect by which different methods of street lighting will be judged, and the speaker maintained if this general effect in the one case is better than the other it is impossible to prove by photometry that the opposite is the case. After asserting that the comparative photometrical observations of gas and electric lighting which have been put forward from time to time by electricians are totally fallacious and misleading on account of the unequal conditions under which the lights have been compared, Mr. Newbigging quoted at some length the views of Mr. A. C. Morton, the chairman of the Streets committee of the City of London Court of Common Council on the question, in the course of which Mr. Morton had stated that since that replacement of some of the City lighting by incandescent gas they had been getting four times the light for the same money. In comparing the respective prices charged for gas and electricity the author of the Paper had stated that in taking the cost of gas at 2s. per 1,000 cubic ft. he had taken a price at which only 12 towns out of 223 were able to charge, all the others being higher, whereas 1½d. per Board of Trade unit was higher than was being charged by a large number of electrical undertakings. He would like Mr. Harrison to show him the electricity undertaking in existence that is able to make the same percentage of profit, or, in fact, any profit at all, on their capital outlay, by charging an average all-round price of 1½d. per unit, as the gas undertakings do who charge 2s. per 1,000 cubic ft. The argument brought forward by the electricians that as the street-lighting customer is a heavy-load customer they are able to supply him at a less cost applies equally to the gas undertaking. He expressed the opinion that the question of the respective values of gas and electricity for street lighting, both from the point of view of effectiveness and cost, could only be settled by each department in a town or city having allotted to them an equal area, say a street or square, and each undertaking the lighting on a basis to be agreed upon, the total cost in each case of capital outlay and maintenance carefully noted, and the consumption of gas and current properly registered, photometrical observations of the lights being taken on equal lines. Mr. Newbigging expressed his conviction that incandescent gas lighting has nothing to fear, and would in the future still more firmly establish itself as the best and cheapest method of lighting the streets.

In his reply, Mr. HARRISON maintained his opinion about the use of 45 deg. for the photometric tests against those methods advocated by the Chairman (Mr. S. L. Pearce), Prof. Schwartz and Mr. Sands, and pointed out that to add together candle-foot measurements obtained from various sources was misleading, as the result would not represent useful illumination, as only one side of the illuminated body could be seen at one time. In reply to Mr. Sands, the author concluded he referred to the "Simmance-Abady" flicker head. He had used this for two years, but objected to the extra adjustment for the angle, which could not be made without striking matches, whereas in the instrument exhibited, the angle shown by the light spot could be read at once. In reply to Mr. Newbigging, he said that he was misunderstood with regard to the opinion of "the man in the street," and if Mr. Newbigging would refer to the Paper he would find that he did not undervalue that opinion, but he considered that the "man in the street" who is called upon to judge on a subject he knows little about was often misled by appearances.

## CONFERENCE ON SMOKE ABATEMENT.

*(Concluded from p. 393.)*

*Thursday, December 14th.*

Sir William Preece, as chairman for the day, read an address of which the following is an abstract:—

After briefly mentioning the exceptional cleanliness of the Berlin atmosphere, where a patent fuel was burned in very large grates, quite enclosed, after the nature of a radiator, the Address pointed out that the presence of carbon particles in the air was a proof of the imperfect combustion of coal in domestic as well as in factory fires. To minimise fog, therefore, it was necessary to reduce the number of carbon particles in the air, and this must be done by improving the methods of combustion.

The proposals to establish a few large power houses on the river in London to supplant the 70 or 80 scattered electric generating stations now existing, had one great merit—they would abate the nuisance of smoke and introduce more perfect methods of fuel combustion and so reduce fog, for the cheapening the cost of production of electric energy means the adoption of every known means of economy.

Internal combustion engines where producer gas was sucked in and exploded was another promising field for the enthusiast. They produced no smoke and discharged no particles, but they were limited at present to small engines and are not yet applicable to the great power houses that were now increasing in all industrial areas.

There were many well-known smoke-consuming processes. Bituminuous coal could be burnt completely so as to emit no smoke. It was only necessary (1) to regulate and heat the air supply to the furnace, (2) to secure and maintain the proper temperature in the furnace, (3) to control the escaping gaseous products up the chimney. Such arrangements are undoubtedly economical. Crossfield & Sons, of Warrington, had saved 1,000 tons of coal per week by adopting scientific smoke abatement methods. Newness & Co. and the Cardiff Railway Co. asserted that they had saved 25 per cent. of their coal consumption. A firm of brewers in London had saved £3,500 per annum, and he could speak from his own experience that wherever such appliances had been used marked economies had followed. But it must be remembered that chimney, flue, furnace, mechanical stoking, air regulation, preparing, elevating and conveying fuel, and water heating, all lent their weight to the desired consummation—the complete conversion of the potential energy of coal to the kinetic energy of heat and the total elimination of smoke. The production of smoke was a wasteful and useless barbarism, and he hoped this Conference would drive that fact home.

The Smoke Abatement Society prided itself on the number of convictions it had obtained under the Public Health Act of 1891. It would be much more effective if they recorded the number of firms who had adopted scientific measures and shown their economical results. This would excite emulation—a very potent force in commerce and industry. Law was not so effective as simple common sense. Satisfy people that money could be saved and they would save money. Most people rejoice in doing what they were told they ought not to do; it was the cussedness of human nature.

Legislation was often obstructive, for it excited the love of resistance to enforced action against personal will and party proclivities. People would not adopt smoke-consuming systems if they could avoid it simply to comply with supposed parliamentary tyranny. It was different when their pockets were touched and when they were convinced that economy resulted. Then political objections disappeared, and common sense, or, in other words, science, reigned supreme. He thought legislation would be looked upon with more favour if "emitting black smoke" were regarded as an occasional, exceptional occurrence and treated as an ordinary nuisance, done with negligence, and which had been provided against by every reasonable precaution as determined by Lord Blackburn's judgment. Sudden fogs, sudden breakdowns, unexpected accidents, might cause the steam to lose pressure, and then, in electric generating stations, for instance, the engineer in charge had to decide between the loss of voltage and the presence of smoke. He should always support the maintenance of voltage, for the loss of voltage would affect a large district and a great number of innocent people, whilst the presence of smoke might affect one engineer only. However, there was no excuse for neglecting to take reasonable precautions.

"Factory and Trade Smoke Abatement" formed the subject for discussion, and eight Papers were submitted dealing with the matter from various points of view. We give below abstracts of some of them:—

### STOKING AND SMOKE ABATEMENT.

BY COMMANDER W. F. CAHORNE, C.B.

This Paper emphasied the importance of the employment of only trained men as stokers, stating that the efficiency of several forms of smoke consuming appliances was more or less dependent upon careful attention of the stokers. Speaking of mechanical stokers, the author expressed the opinion that it did not seem probable that they would supersede hand-firing to any extent owing to the drawback of wear and tear, and also what he considered "the obvious certainty that moving machinery exposed to the intense heat of furnaces is specially apt to get out of order."

### THE ABATEMENT OF SMOKE IN FACTORIES.

BY SAMUEL RIDEAL, D.SC., F.I.C.

This Paper contains an analysis of the replies which had been received to a circular letter issued by the Coal Smoke Abatement Society, and addressed to 63 firms, in respect of whose manufactories or chimneys no smoke nuisances had been observed for six months. Of the 42 firms which replied, 38 supplied information of whom 32 agreed to the publication of their methods. Three firms have substituted gas engines for steam plant, leaving for further analysis the information supplied by the remaining 35 firms. Thirteen firms mainly ascribe their success in preventing the emission of smoke to careful stoking.

Of mechanical devices for economising fuel, 18 firms supply information of the results of their experiments. The British fuel economiser, Martin's patent smoke-consuming door, Richard's patent forced-draught tubular fire bars, supplying heated air to back of bridge, and induced draught, are all described as economical; perforated furnace doors are fairly economical; a slight saving is reported with Johnson's economiser, one chain grate stoker was not successful, a steam blower is given as not economical, Meldrum's forced draught is described as very economical, also automatic air louvres; Venetian fire bars are stated to be effective, but extravagant of coal, and in one case a Venetian rocking furnace has saved 10 per cent. of fuel. Two firms which have tried various mechanical devices, emphatically disclaim any benefit derived from them, and support the evidence of other firms in favour of careful stoking. Two firms ascribe success to the height of the chimney shaft giving an excellent draught, and one of them, in addition, to the fact that their boilers have been "set" with large flues. One firm is abandoning their mechanical devices in connection with their boilers and steam engines, and is replacing them by electrical machinery, in the hope of effecting an economy. It will be seen from these replies that though not denying the efficacy of many mechanical devices, yet the general consensus of opinion favours skilled and careful stoking as of the first importance.

### THE ARTIFICIAL PRODUCTION OF PERSISTENT FOG.

BY THE HON. ROLLO RUSSELL, M.A., F.R. MET. SOC.

This Paper gave an able exposition of the meteorological phenomena connected with the formation of fog, pointing out in particular the more serious effect which smoke particles have on the precipitation of moisture in the atmosphere than fine dust of other kinds, owing to soot being one of the most effective radiators of heat.

### AIMS AND WORK OF THE HAMBURG SMOKE ABATEMENT SOCIETY.

BY JOHN B. C. KERSHAW, F.I.C.

This society is an entirely voluntary organisation of steam-users, and has now been in existence 3¼ years. The work of the society is controlled by a committee of six to nine members. The technical and scientific work is undertaken by the staff of experts retained by the society for this special work, consisting of a chief engineer, two assistant engineers, two instructors for firemen and one clerk, while for special steam-raising and other trials, three additional assistants had also been employed. The society is entirely self-supporting. In the two valuable reports which have been issued great stress is laid upon the improved efficiency obtained by the instruction of firemen in the proper performance of their duties. In this connection the engineer of the Hamburg Society wisely emphasises the fact that smoke abatement by untrained stokers, without scientific supervision, generally ends in failure; for their plan is simply to allow air in enormous excess to flow through the furnaces, which means great losses due to the heat passing away up the chimney and high fuel costs per pound of water evaporated. The highest tests in these reports show losses from this cause amounting to 27·4 per cent., or over one-fourth of the heat value of the fuel burnt.

The other branches of the society's work—namely, alteration in the design and methods of working of the plants under their charge—are also dealt with in these two reports, and shows the improvements obtained by the systematic and scientific control inaugurated by the society in place of the methods which had been formerly in use.

During the 14 months ending December 31, 1904, 32 installations were submitted to the first thorough examination and test, and 71 firemen received instruction in their duties at these plants for a period of 175 days. Seventy-four installations were visited for the second, third and fourth time, and in connection with these visits, 190 tests were made, as a check upon their continued good working. The total number of reports issued from the central office in connection with these and other tests was 226. As already pointed out, over 300 firemen have now received training in their duties at the hands of the expert staff of the society.

The practical lesson which we in this country might learn from the work of the Hamburg Society, was, he thought, that the smoke problem is to be solved, like many another problem, by application of the method of self help. Manufacturers and fuel-users generally in this country, must be taught that the emission of black smoke is largely preventable, and that the smokeless combustion of fuel promotes economy when carried out under proper supervision. What is wanted. however, is some society or organisation which will provide fuel-users with the technical advice and oversight required for obtaining the smokeless combustion of fuel in their own works. The Hamburg Society, in the author's opinion, is such an organisation, since it is showing manufacturers how to combine together to attack the evil at its source—namely, the boiler and heating installations in their own works. It would be well if similar societies were started in every large centre of manufacturing industry in this country.

## ON PRECAUTIONS NECESSARY FOR MAKING RELIABLE OBSERVATIONS ON SMOKE DENSITIES.

BY JOSEPH W. LOVIBOND.

The author of this Paper describes an instrument of his own design for measuring and recording the density of smoke as it issues from chimneys by the tontometer equivalent colour scales. The instrument consists of a rectangular tube 1½ in. by 1 in., section 4 in. long; one end is closed except a circular ⅛ in. opening used as an eyepiece. The purpose of the tube is to cut off disturbing side lights, which never equally affect two colours placed side by side, as when matched without this protection a change of position will certainly disturb it. In the middle of the tube is a diaphragm having two ⅛ in. square apertures ½ in. apart; one is intended to command the smoke to be measured, and the other is filled with a beam of diffused daylight for comparison. The object of the ⅛ in. open- ings is to limit the field of view to the area of smoke under observation. At the open end the base is prolonged 2 in., forming a stage to carry a reflector, which consists of a slip of Chance's matted white opal glass fixed at an angle of 15 deg. with the prolonged stage. The standards are slips of neutral tint glass sliding in grooves on one side of the instrument, intercepting the beam of diffused daylight and reducing its luminosity according to the absorptive value of the glasses themselves, which had previously been co-related to the equivalent scales; each glass and each combination is separately measured, and their values inscribed on top of the instrument in neutral tint units for ready reference.

A general discussion upon all the Papers followed :—

Mr. J. P. GIBSON, of the Public Health committee of Edinburgh, laid much of the trouble of the emission of black smoke to bad stoking. He had made a practice of sending one of his inspectors to superintend the stoking in works which offended in regard to the smoke trouble. He advocated the amplification of the present powers of local authorities, but at the same time thought much would be accomplished by paying greater attention to stoking.

Mr. W. H. PATCHELL welcomed the spirit of sweet reasonableness now manifested by the Coal Smoke Abatement Society. When prosecu- tion was turned into education, much more would be accomplished. He was about the first engineer to start induced draught in London on a large scale, and he put his company to a very large expense in doing it, but he was sorry to say that it was a huge failure so far as hot air went. With regard to mechanical stokers generally, he had had samples of nearly all types through his hands, but with most of them more smoke could be made than steam. He knew of a case in which a whole battery of mechanical stokers had been removed and hand firing resorted to. The load was so variable in most electricity works that it was impossible to use mechanical stokers exclusively.

Mr. J. GELDARD, of the Bradford Dyers' Association, referred to a case in which no less than 33⅓ per cent. of the coal bill had been saved by paying greater attention to the stoking. In his opinion machine stoking was absolutely smokeless when used with ordinary common sense. Hundreds of London firms used smoky north-country coal and mechanical stokers, and smokeless chimneys were the result.

Mr. R. S. RICHARDS said that he was convinced that the smoke nui- sance in London was not nearly so bad as in Edinburgh and Glasgow. He emphasised the necessity for greater education with stokers, and knew of instances in which mechanical stokers had had to be removed, solely owing to the want of intelligence on the part of the men operating them. He looked to the time when heating by electricity would be universal; he did not see why we should be bothered with what was always more or less a nuisance—viz., gas heating.

Dr. ORMANDY (Messrs. Crossfield, Warrington) said that the cause of the failure of mechanical stokers in many cases was that they were under the control of the engineering staff. His firm had mechanical stokers which at first caused so much smoke that their name became a by-word, so frequently were they fined. The chemical staff were then instructed to take charge of things. The consequence was that the stokers were made to work, and the economy was increased with very great rapidity. At Warrington his firm had saved £25,000 per annum by the improved methods that had been adopted, and the working of the various pieces of apparatus together with the record taking was managed by a few boys. The results were then handed over to the chemical staff to be dealt with. He recommended the training of a staff of such boys who could be hired out to small works by some organisation possessing the necessary chemical staff to subsequently deal with the records taken.

Mr. McAULAY (Liverpool) said that under steady loads mechanical stokers were the best possible things to have, but with varying loads hand firing was the best.

Mr. RHODES (Central London Railway Co.) entered a lengthy protest against the treatment which his company had received at the hands of the Coal Smoke Abatement Society. Even whilst experiments were being carried out to cure the nuisance they had been fined.

Bailie ANDERSON (Glasgow) said the method adopted in Glasgow was to have trained engineers as inspectors who, when smoke was seen, immediately went to the manufacturer and discussed ways and means of avoiding the trouble. In 90 cases out of every 100 the trouble was due to bad stoking; and most people paid a man 24s. a week and expected him to solve the problem which that conference was trying to solve.

*Friday, December 15th.*

The Papers and discussion on the final day of the Conference had reference to "Administration, Legislation and Necessary Reforms." The following Papers were read :—

## A PLEA FOR A SYSTEMATIC COMPARATIVE ANALYSIS OF THE AIR OF TOWNS AND A CONSOLIDATION OF THE LAW DEALING WITH SMOKE EMISSIONS.

BY SIR JOHN URE PRIMROSE, BART.

The Paper pointed out that, while there were standards for such things as noxious exhalations from works classed under the Alkali Acts, a suitable standard for city or town air did not exist. It had been calcu- lated that 6 tons of solid matter, consisting of soot and tarry hydro- carbons, are deposited every week on every quarter of a square mile in and about London.

A glance at the various acts of Parliament on the subject showed the disparity that exists between them. They nearly all appeared to give power to abate the smoke nuisance, and then, by the use of certain limiting expressions, permitted a loophole of escape.

The act in Glasgow made it compulsory upon a respondent to prove, not only that he has constructed his furnaces so as, as far as possible, to consume the smoke, and carefully attended to and managed them in a proper manner, but also "that he has used the best practicable means for preventing smoke," thus covering defects in chimney, flues, or any other part of his steam-raising or heating installation. Nothing was said as to the quality of the fuel, but, in his opinion, no person should be per- mitted to burn a low-class and smoky dross or slack in any furnace, no matter how perfectly constructed or how well fired, and escape the meshes of the law if the result is black smoke. Every town but Nottingham suffered more or less from qualifying words. There the stoker or fireman might be the convicted party and not the master or firm, as in the case of the Alkali Act, by which, if the issue of acid vapours be in excess of what is prescribed, the careless employee is made responsible, if, in the opinion of the inspector, the apparatus of the manufacturer is in perfect order.

He was informed by the Chief Sanitary Inspector of Glasgow that over 90 per cent. of the complaints of excessive smoke taken against manufac- turing firms there, were caused by careless firing on the part of the stokers.

The law, to his mind, was deficient as it stood at present. It needed amendment, and it also needed consolidating. The manufacturers in one town should in this respect be placed in an equal position with those in every other town; otherwise legislation against this evil would be partial, and would operate unfairly.

## THE PROPOSED AMENDMENT OF SEC. 24 (SUB-SEC. 6) OF THE PUBLIC HEALTH (LONDON) ACT, 1891.

BY JULIAN S. CORBETT,
Barrister-at-Law.

This sub-section reads as follows: (*b*) Any chimney (not being the chimney of a private dwelling house) sending forth black smoke in such quantity as to be a nuisance . . . ." The author pointed out that the difficulties were constantly occurring in proving that the smoke complained of was "black."

The Corporation of the City of Westminster had proposed to delete the word "black" from the section altogether. This would be merely to for- bid smoke that was a nuisance, and would involve the proving in every case that the smoke complained of was of such a character as to amount to a nuisance—always a difficult proceeding. The society therefore suggested that the words "black smoke" should be retained, and the words "or smoke" inserted immediately after them. On the whole, however, it would appear that we stood far ahead of the majority of foreign countries. In most of these no legislation existed at all. In France and Germany no general law had been adopted. The serious opposition to any extension of the law came from manufacturers who pleaded that any further restrictions in smoke production are incompatible with London remaining a manufacturing city.

American legislature attached importance to a time-period, that is, to having a minimum period during which the emission of objectionable smoke is permitted as unavoidable. No such period of grace had been enacted in this country, but in practice it was allowed.

## LOCAL AUTHORITIES AND SMOKE ABATEMENT.

BY LAWRENCE W. CHUBB,
Secretary, Coal Smoke Abatement Society.

With the object of ascertaining to what extent local authorities have grappled with the problem of smoke abatement, all corporations and urban district councils in the United Kingdom have been asked to furnish replies to a series of questions addressed to them on behalf of the Royal Sanitary Institute and the Coal Smoke Abatement Society.

It was further suggested that Parliament should be invited to fix a definite hourly time-limit for the emission of black smoke, proof of the limit having been exceeded to be sufficient to secure a conviction.

The returns disclose that while the black smoke evil is very generally felt and deplored, relatively few local authorities have in the past taken a decided stand in the matter, and that while this inactivity may sometimes be traced to apathy, it is more often due not to any inclination to evade responsibility, but to a feeling of hopelessness in view of the uncertainty of obtaining convictions. Little improvement or zeal could be looked for until the law was simplified and extended, and a more summary and effective method of procedure provided. It was, perhaps, not too much to hope that the Local Government Board, in view of the suggestions made by important corporations, may see its way to clothe local authorities in the immediate future with the further powers for which they asked.

## SMOKE ABATEMENT FROM THE SANITARY INSPECTOR'S POINT OF VIEW.

BY T. G. DEE,
Sanitary Inspector, City of Westminster.

The Public Health (London) Act (1891) definitely fixed on sanitary inspectors in the metropolis the duty of reporting to their several local authorities nuisances arising from the emission of smoke, and this Paper detailed the obvious difficulties experienced in giving a clear definition of the law as it at present stands, and supported the need pointed out in previous Papers for the appointment of expert inspectors, and greater education of the manufacturer in the matter of scientific stoking.

## SMOKE NUISANCE INSPECTORS AND THEIR DIFFICULTIES.

BY WM. NICHOLSON,
Smoke Inspector, Sheffield.

This Paper advocated the appointment of a board of experts to ascertain what is and what is not a statutory nuisance. These experts would test smoke-preventing appliances and processes suitable for boilers, furnaces and fireplaces, and find out what smoke was necessary under various conditions of working. If Government would not provide money for this necessary work to be done, then manufacturers and owners of appliances ought to.

The Paper also pointed out that a smoke inspector ought to be a mechanical engineer, who has had experience with various kinds of boilers, furnaces and fireplaces.

The discussion was opened by

Mr. A. J. MARTIN, who thought that if the restrictions of existing legislation were removed much good would accrue.

Mr. FREDERICK CLEAVES agreed that a more definite law was necessary. He pointed out that, in Berlin, a manufacturer causing black smoke to be emitted had his attention called to the matter, and was informed that if the nuisance was not abated within one month his works would be closed.

Councillor MUIRHEAD (Liverpool) regarded the Liverpool Act of 1854 as a very good one. In this the word "black" did not appear, and, in addition, all summonses under the act came before the stipendiary magistrates and not before a lay bench.

Dr. ORMANDY (Messrs. Crossfield, Warrington) asked for a consolidation of all the smoke abatement societies in the country. A duty of such an organisation would be the carrying out of local analyses of the atmosphere, all of which would be recorded at headquarters. It was only by systematic analyses that improved legislation could be arrived at.

Dr. SYDNEY DAVIES (Woolwich) thought it was time that the Government set an example in this matter. At Woolwich all the Government factories were exempt from prosecution, and consequently an enormous quantity of smoke was emitted.

Bailie ANDERSON (Glasgow) thought a great deal could be accomplished with the present law if it were applied intelligently. He advocated that the local sanitary officers and public health officials should be appointed smoke inspectors. He objected to any qualifying word such as "black," for under the present law a man could be summoned for emitting black smoke for three minutes, and left alone if he caused brown smoke to be emitted for 45 minutes.

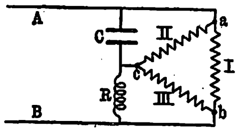
During the Conference, an exhibition of smoke abatement appliances was held, some of the leading exhibits being the following :—

The Westminster Electric Supply Corpn. (Ltd.) and the St. James' & Pall Mall Electric Light Co. showed (in conjunction with Messrs. Rashleigh Phipps & Co.) a collection of heating, cooking, domestic and other appliances on the "Prometheus" system for which a silver medal was awarded. Like awards were also made to the Power Gas Corpn. for a complete model of a Mond gas plant, and to Messrs. Edward Bennis & Co. for their well-known mechanical stoking appliances. Amongst the recipients of bronze medals were Messrs. Babcock & Wilcox, Messrs. Crosseley Bros., the Swartzkopff Dust Firing Synd., Mr. J. W. Lovibond and Messrs. Sanders, Rehders & Co. Other exhibitors were the Triumph Stoker (Ltd.), Messrs. Matthews & Yates, the British Fuel Economiser & Smoke Preventor Co., the Horsfall Destructor Co. (Ltd.), Messrs. Meldrum Bros. (Ltd.), and many well-known makers of gas appliances.

## THREE-PHASE MOTORS FED WITH SINGLE-PHASE CURRENT.

Herr J. Dalemont published in a recent issue of the *Elektrotechnische Zeitschrift* some interesting experiments on a 1 H.P. three-phase motor fed with single-phase currents, the connections being as indicated in Figs. 1 and 2. C represents a condenser and R a reactance coil. The normal motor speed was 1,500 revs. per min. Figs. 4, 3 and 5 represent the characteristic curves of the motor when fed with three-phase current, single-phase current according to Fig. 1 and single-phase current according to Fig. 2 respectively. The author thinks that motors of this kind might be of value in connection with electric traction. In the tests corresponding to Figs. 3 and 4, the impressed voltage was 70 volts, while in the case corresponding to Fig. 5 the voltage was 80 volts.

FIG. 1.



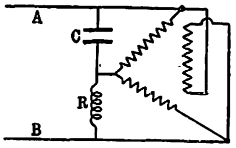


FIG. 2.

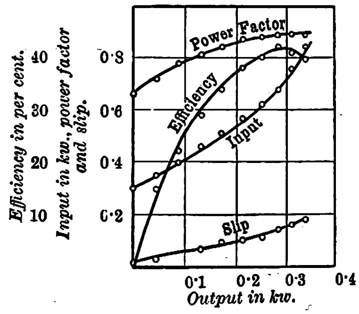


FIG. 3.—TEST OF THREE-PHASE MOTOR FED WITH SINGLE-PHASE CURRENT ACCORDING TO FIG. 1.

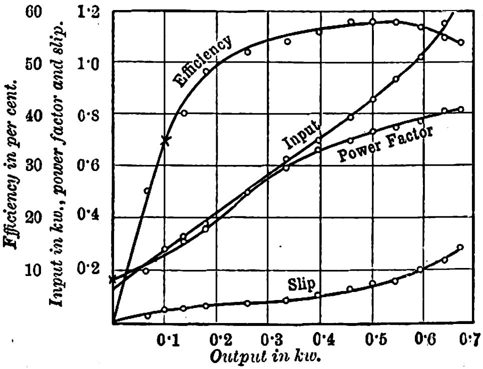


FIG. 4.—TEST OF MOTOR WHEN FED WITH THREE-PHASE CURRENT.

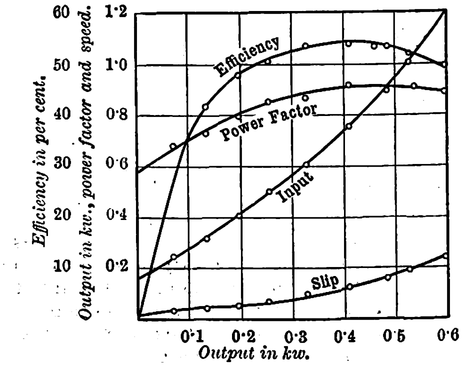


FIG. 5.—TEST OF THREE-PHASE MOTOR FED WITH SINGLE-PHASE CURRENT ACCORDING TO FIG. 2.

**Motor Ambulances.**—The London County Council have recently decided to spend £5,200 on an experimental scheme of motor ambulances. In view of the close competition between the advocates of petrol-driven and electrically-driven vehicles, it is interesting to note that, according to the *Daily News*, the experience of the St. John's Ambulance Association shows that the electric car is superior for the purpose on account of the comparatively greater absence of jerking and vibration.

## SOME POINTS RELATING TO STORAGE BATTERIES AND BOOSTERS.*

BY L. BROEKMAN.

The features, mechanical and electrical, which come under review for stationary work, lighting, power, or both, when judging the rival qualifications of cells from various makers are: (1) Weight of electrodes; (2) efficiency and permanence of contact between conducting frame and active mass; (3) how expansions and contraction of active material are provided for; (4) means adopted to equalise activity of plates in every part: (*a*) porosity and (*b*) open structure —*i.e.*, "linked surfaces" versus "separated surfaces," owing to central web; (5) conductivity of framework, constant or diminishing; (6) relative capacity and mean pressures at various rates of discharge; (7) emergency discharge permissible; (8) normal and maximum charging rates, mean and maximum pressures; (9) volume of electrolyte and maximum density; (10) method of mounting sections; (11) supervision required; (12) price.

When a discharge to the full extent is taken from the cells daily in from three to six hours, the active material will be in a soft state and less adhesive. Sediment, therefore, is thrown down more freely, and replating becomes necessary sooner than when, under a less exacting régime, the new formation is allowed to assume a crystalline texture. The battery, in effect, is too small for its work. Far the better plan, both from technical and pecuniary points of view, is to provide for a margin in capacity on the safe side, a share of which is almost invariably claimed by afterthoughts and extensions without corresponding facility for increasing the battery output. On the other hand, accumulators worked regularly under normal conditions will be in a healthier condition, and give longer full service, than others subjected to protracted periods of idleness. From the fact that most battery makers are prepared to enter into contracts for upkeep at rates varying between 5 and 10 per cent. per annum, according to size, service and locality, it can be accepted that the average life of a set of plates is not less than six years if the value of renewal sections throughout be taken roughly at one half the original cost of the storage plant, and running expenses for periodical inspections be borne in mind. These inspections are to the best interests of both user and manufacturer, and of much greater importance than is usually realised. For the sake of saving on carriage, users often obtain acid of doubtful quality from the nearest supplier, preliminary analysis being dispensed with, while water of any kind is considered suitable for making good evaporation. No battery maker would countenance such risks. Even the best soft well water undergoes changes periodically, and cannot be strictly relied upon; with rain-water everything depends on the district—where houses are in the vicinity of chemical works, or of the sea, the rain-water collected is decidedly unfit for use in a battery. Only pure distilled water (not condensed steam from boilers, hot-water pipes, &c.) is really safe for the purpose, and to grudge this relatively small expense is the worst possible economy in the long-run. All acid should invariably be ordered from the battery firm.

Limiting my remarks to the consideration of effects, produced or absent, according to the treatment of a battery by the user, one important point is to prevent the formation of white sulphate, $PbSO_5$, as distinct from the ordinary sulphate of lead, $PbSO_4$, which is the normal compound into which peroxide on the positives and finely divided lead on the negatives are converted during the discharge of a cell within the P.D. limits indicated by the makers. Below this safe point the action of the acid on the electrodes becomes greatly intensified, and continuing discharge habitually beyond it, or allowing plates in a discharged state to remain standing for any length of time in an attenuated solution, are the surest ways to produce white sulphate. When this forms between the metallic conductor and the active material, it practically insulates one from the other and lowers capacity. Being extremely difficult to reduce, and more bulky than the active material, it follows that enormous strains will be thrown on to the frames of the plates if there is insufficient free space to allow for the expansion of the active mass. If sulphating be taken in time, prolonged overcharging at half normal rate will improve matters, but on no account should such overcharges become an institution. Against doctoring the electrolyte by the addition of sulphate of potassium, sodium, or of caustic soda, users cannot be warned too strongly—this only leads to different and ineradicable trouble. Should any interruption occur in the course of the initial charge of a battery from a dry condition of the plates, notably during the first 20 hours—*i.e.*, before the specific gravity of the electrolyte has begun to rise again—the plates are particularly prone to become badly sulphated, and much trouble may result. Prof. Ayrton, in one of his tests, has found that when the peroxide on the positives had fallen to 31 per cent. the cell very rapidly lost its E.M.F., which he attributed partly to the layer of sulphate excluding the mass beneath from further participation in the discharge, and partly to the appearance of peroxide on the negatives. Herr Liebenow, on the other hand, has conclusively proved by very simple means that the rapid drop of pressure which determines the exhaustion pro tem. of a cell on discharge is almost entirely due to want of free acid. By continually urging acid through the pores of the negatives on to the positives, thereby reinforcing diffusion while maintaining level and density, he obtained nearly three times the normal capacity from the plates. During a rapid discharge, for instance, the $SO_4$ contained in the active material is used up at a much quicker rate than it can be replaced from the surrounding electrolyte. Hence the fall in pressure is sharp under continuous load; also, the recuperative effect is very marked when the current is interrupted, and the deficiency is made good by diffusion.

Coming now to the abnormal rise in P.D. towards the end of a full charge, and the fugitive high voltage given by cells immediately on breaking the charging circuit, commonly called "gas effect," this has been found to be due to the presence of unstable products, such as ozone and persulphuric acid, which only make their appearance to be decomposed at once. This high voltage, unfortunately is quite short-lived, and available only when a discharge is taken immediately on switching off the charging current. An instance when that effect can be taken advantage of to the best purpose occurs when a battery is operated through a reversible booster, say on a tramway system, which, as a rule, provides frequent and marked positive and negative fluctuations. Under such conditions the watt-hour efficiency of batteries has been proved as high as 80 per cent. With the constant-current method of charging the battery, as almost universally employed in this country, the best charging rate to adopt is at or near the normal indicated by the makers. The effect on the electrolyte, without being violent, is sufficient to promote a healthy action and uniform density, enabling reliable hydrometer and voltmeter readings to be taken, useless and harmful overcharging to be avoided. Overcharging frequently goes hand in hand with a low charging rate. Ten per cent. excess in ampere-hours over previous discharge, both operations metered for choice, is quite enough under ordinary circumstances, the charge being pushed on to a milky state of the acid, say, once every week or fortnight, and then continued for a length of time according to the depth of cells in use. Habitual overcharging is wasteful and decidedly detrimental, tending to cause excessive formation, to unduly increase sediment and thus to shorten the useful service of the plates, besides giving rise to violent spraying with its attendant evils if a high rate be maintained. When overcharging at a low rate is practised the case is perhaps worse, because no outward manifestation takes place; formation of spongy lead on the negative plates then becomes the immediate trouble, bringing complication in its train.

Prior to any prolonged period of disuse it is essential to give an abundant charge to the battery, so as to provide the conducting framework of the positives with an unbroken film of peroxide, thereby reducing local action to a minimum. This film ceases to be protective if even a short discharge be taken from the cells subsequently—it is, therefore, best under the circumstances to disconnect the leads at the battery terminals immediately the charge has been completed. To remove the acid from the cells, after due preparation of the plates, is unquestionably the safest plan of all to adopt in such cases, but this needs care and entails some trouble; moreover, the battery cannot then be made available on a surprise visit. Some of the following rough battery data may be found useful on occasions: Cells in glass boxes—weight in pounds, about one-half of ampere-hours at maximum capacity; space occupied—cells erected all on one level with narrow gangways, equals about 3 sq. ft. per kilowatt-hour at maximum capacity; price, £4 per kilowatt-hour at maximum capacity. When glass boxes are used, "bolted" connections between cells have the preference to "lead-burned" joints, as the heat of the soldering jet, unless very carefully applied, is liable to crack the glasses; besides nursing, repairs and cleaning are rendered much easier with the former. Bolts and nuts must, however, be encased in non-corrodible metal, so as to afford thorough protection against acid spray.

Immediate proximity of the accumulator house to stables or manure heaps has been shown to be detrimental to the life of cells on account of ammonia troubles. Vitrified brick laid on concrete and grouted with pitch makes a good battery-room floor, which should have a suitable slope for drainage. Protect the battery from direct sun rays, but give the attendant the benefit of good day and plenty of artificial light, especially portable hand lamps. Except in very much exposed localities, it is scarcely necessary to heat the battery room during our mild winters; low temperature merely limits the capacity for the time being, but does no harm whatever to the cells. Let the cells be arranged all on one level if possible, with gangways at least wide enough to admit passing a carboy basket along. With glass boxes double tiers are admissible, but expereince is altogether against placing cells beyond easy inspection and handling; also ample head room should be allowed above the cells. For battery pressure exceeding 250 volts the modern practice of double insulation—stands from earth and cells from stands—

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* Abstract of a Paper read before the Dublin Local Section of the Institution of Electrical Engineers on December 14th.

has effected a great reduction in the number of weak cells. Coming to accessories, trays filled with sawdust or sand are better for glass boxes than lead discs, as the latter do not evenly support the weight of the element. Hydrometers should read in single degrees on an open scale. It is best not to allow them to remain in the cells, where they are liable to become sticky and grimy after a short while, rendering them unfit for taking accurate readings. A neat and safe way of using a better class portable voltmeter with central zero, the needle swinging in a horizontal plane, is to attach the instrument to a short board, the lower side of which is provided with lead contact studs. By placing this board across the equalising bars of a cell, a slight pressure downwards will secure a reliable reading, which can be marked down at once on the note pad at the side.

When current to the lamps is invariably supplied from the battery alone, overcharging of end cells can be easily avoided. Not so when the dynamo is running part of the lights while charging the battery at the same time. Without adequate supervision some end cells then are liable to receive considerably more than their share of charge, while, if the outside load be heavy, the body of the battery may be kept short of current, possibly have to discharge occasionally. This destroys uniformity if it has not worse effects. Larger capacity cells for regulators are occasionally used to keep down the charging rate per positive plate, or paralleling several end cells on charge by means of a suitable switch to reduce their number, and the charging rate for the regulators is equally effective. Counter E.M.F. cells in one of the supply leads is another remedy, and a good one, yet rarely adopted. For any fair-sized installation, say of 500 lights and upwards, the additional cost of a semi-automatic reversible booster in place of a charging booster is not great, bearing in mind that the number of cells ordinarily required can then be reduced by approximately 14 per cent. Or, to put it in another way, 8 per cent. of the line voltage is about equal to the number of cells which can be dispensed with when the battery is discharged through a booster. As neither cell switches nor regulating leads are required then, further savings are made, which go towards cancelling the extra cost of the semi-automatic machine. The ease and delicacy of voltage regulation obtained with a booster is far ahead of the best that can be done by means of cell switches. If the pressure from a gas or oil-engine-driven dynamo varies considerably so that the pulsations are reproduced in the lights, floating a battery across the line has the desired steadying effect. To that end set the cell switch for the correct line pressure, running the dynamo to give about 2 per cent. higher voltage as a mean. Of course, the cells must not be switched in parallel until the generating plant has settled down to its work at that pressure; this is a convenient way of husbanding the capacity of a battery for long runs. To obviate the necessity for a large number of leads with cell switches for high-voltage batteries, some ingenious devices have been described. One means is to connect every fourth cell at the right-hand end of the battery to a main cell switch, and to use the first three cells at the left-hand end for connection consecutively to an auxiliary regulating switch, the two switches interlocked. The saving in leads is obvious. One difficulty, however, is to guard against charging certain cells in the reverse direction if the number of cells in the charge circuit happen to be less than that discharging at the time.

The practice of starting internal-combustion engines by running the dynamo as a motor off the battery should be discouraged. Without special gear this puts an exceedingly heavy strain on the cells at a time when they are least able to bear it—viz., as a rule, when they are low down in the morning after a night's run. Two smaller batteries in parallel versus one large single set—the drawbacks to parallel working far outweigh the almost solitary advantage of having one battery available for use while the other is being cleaned or under repairs. Two full-sized batteries by all means, operated turn and turn about; this promotes a good crystalline formation, and results in higher capacity and longer life, but no parallel working if it can be avoided. In modern cells, moreover, so much free space is provided for sediment that the necessity for its removal does not arise until the plates are worn out. The removal of sediment from older-form cells is best entrusted to the makers, as they keep a staff experienced in that work, and because much damage may be done by neglecting the necessary precautions. Great care is required during the removal of the plates from the electrolyte, as the negatives oxidise quickly, heat up and shrink when exposed to the atmosphere; it is important, therefore, to prevent their becoming dry. Failure to obviate this will not only entail a subsequent full deoxidising charge of about 40 hours before the cell will give capacity again, but in shrinking the active material is liable to lose contact with the conducting framework, and to impair seriously the capacity of the negatives. For the removal of a few defective plates only in several groups utilise the good plates of one or more of these, putting entirely new groups into the latter cells. Old and new plates mixed in the same group do not divide the work equally between themselves, and then discharge into one another after the circuit has been disconnected. Such groups invariably go to pieces in a comparatively short time. Sometimes one single cell alone gives trouble in a battery, and on renewal of the plate section the question arises how to give the long initial charge without greatly overcharging the entire set of cells in the absence of a milking booster. This difficulty is minimised by asking the makers to forward the new section fully formed and charged, the negative group being packed in wet sawdust. When put into circuit during charge subsequently this will only take from 10 to 12 hours altogether to come up with the other cells; until it does so it must, of course, be cut out during discharge.

Celluloid or kindred substances are undesirable materials to employ in connection with storage cells, whether in the form of containing boxes, separators, or envelopes. Their behaviour is uncertain; notably in proximity to the positive element the tendency of celluloid is towards decomposition, and the eventual formation of sulphate. At one time xylonite was much used for fork separators, being cheaper than ebonite, but, besides obstructing the view between the plates, forks are liable to twist and to defeat their object; hence they have been almost entirely superseded by glass tube or glass rod separators in stationary batteries. The introduction by the Chloride Company of board diaphragm separators, acting as a complete screen between plates of opposite polarity, marks, I consider, a most important step in the right direction. By rendering it impossible for any treeing to occur, scale or foreign substances to become lodged in the open spaces between plates, the liability of individual cells falling below par is practically excluded. No further need to peer into cells prospecting for possible shorts; the certainty that, by reason of the efficient protection of electrodes, excrescences, if any, cannot develop and do mischief renders supervision very easy. To keep the cells clean, acid level and density right is really all the attendant has to do in the battery room. An additional advantage of diaphragm separators is that by holding up the voltage, they raise the useful capacity of cells. This effect is readily verified by exchanging forks or glass tubes for board separators in any cell of low capacity the plates of which are, however, mechanically in good condition; after only a few weeks' regular use this cell will have redeemed its character completely—very likely will have become the strongest one in the whole set. Electrolyte liberal in volume and of 1,215 maximum density only is used, and as no attendant troubles from carbonisation of the wood or any other causes have been experienced in the course of close on five years' continuous employment under all conditions of work board separators have fairly passed the period of probation.

The operation of the carbon pillar machine, now introduced into this country, depends upon the reversal of the booster field by the variation of resistance in a circuit connected upon the Wheatstone bridge principle. By the difference in mechanical pressure effected on two sets of columns, each consisting of carbon discs, the resistance of the circuit and thereby the direction of the current are changed. The fields of exciter and booster correspond to the galvanometer circuit of the Wheatstone bridge. A bar for varying the pressure upon the carbon columns is pivoted at the centre, one end being pulled down by a solenoid in the main circuit, counterbalanced by the tension of a spring at the other end. To accelerate the speed of reversal, the exciting value can be made three times as great as is required. These machines are particularly suited to deal with very violent and rapid load variations, and by their use the generator output can be maintained constant to within 2½ per cent., provided the battery is proportioned to supply the peaks, and to absorb the average load as charge when the line demand is zero. This careful proportioning of the load between generator and battery is the crux of successful working. In the case of a railway load, for instance, it will be preferable to allow of a variation in the generator output 25 per cent. above and 25 per cent. below normal. By means of a regulator in the booster shunt coil the set may be given a discriminating value—*i.e.*, charging up to a certain amount only —and restricting discharge until the generator output has reached a predetermined maximum. As regards working methods, the directions given with Highfield machines are merely to the effect that the set is to be handled in the same way as a generator. To parallel an automatic set, the exciter is brought to the same pressure as the line when the booster is switched in. To increase load on generator, raise dynamo pressure and decrease exciter voltage. Reverse this process to obtain the opposite effect. The diverter is adjusted when the machine is installed, and will need no further regulation unless the mean load is very largely increased, or when further generating plant is added.

In many combined lighting and traction stations it will be an advantage to have the battery and booster available on the lighting 'bus bars. To that end, a double-pole throw-over switch provided transfers battery and booster on the lighting system as a two-wire unit. For cases of emergency—as, for instance, if the balancer breaks down—an additional single-pole switch is installed to connect neutral battery to neutral 'bus bar after the booster has been switched out. The factor of safety this arrangement gives amply justifies the small extra outlay for switch gear. That self-contained accumulator cars for tramway traction have not given better working results in the past is by no means due entirely, as alleged, to the excessive cost of upkeep, and to the weight of batteries constructed 10 and 15 years ago. There were numerous contributory causes. Given a good track, efficient motors and gearing, and present-day traction cells having an output of 9 watt-hours per pound at the five hours rate of discharge, and quite a different showing will be made. Line batteries at a distance from the power station are applied most successfully for maintaining the voltage at its average and for reducing the amount of copper necessary for transmission. The following comparison of actual working results will demonstrate this: Transmission distance about 7½ miles, 550 volts at power house, 400 volts minimum on line. Copper required without battery—350 amperes maximum transmitted; track drop 78 volts, line drop 72 volts; copper, 300,000 lb. Copper as actually installed with battery—167 ampere maximum transmitted; track drop 37 volts, line drop 113 volts; copper, 130,000 lb. Thus effecting a saving of over £4,000 in first cost and of £200 in annual charges all told except copper depreciation. Not only are fewer generating units required, but, through the relief from fluctuations, wear and tear thereof are materially reduced, and a reserve provided in case of breakdown.

The use of storage batteries on electric locomotives where an exposed conductor is inadmissible in mills, mines and for shunting purposes on railways is considerably on the increase. Particulars were forthcoming recently of two accumulator locomotives supplied for service on the Great Northern & Piccadilly Electric Railway in London: Total weight 65 tons, of which 31 tons battery; equipment two motors, each 20 H.P. normal, 85 H.P. maximum; 80 cells, 180 amperes normal, 800 amperes maximum; speed 7 to 9 miles per hour while hauling a load of 60 tons on the level. Figuring the power provided on the basis of 100 watt-hours per ton-mile, this will admit of 2 miles continuous haulage of full load with one complete charge of the battery.

The following is an abstract of the discussion which took place after the reading of the Paper:—

Mr. CUMMINS alluded to the extremely bad treatment which batteries in small private installations received, and desired to know what type of battery the author considered best able to stand such treatment.

Mr. M. C. OLSSON regarded the caution as to the use of pure water as most important, and wished to know what impurities were most harmful. He commented on the practical importance of the utilisation of the fugitive high voltage of charge in increasing the efficiency of a battery working with a reversible booster upon rapidly changing loads. He recalled the old-time attempts at battery working at the Chelsea station, and their failure through over-complexity. He desired information as to the proposed plan of preparing the plates of a defective cell for transmission to the makers. The author's condemnation of the practice of starting up a gas engine from the battery, using the dynamo as a motor, was correct according to his experience.

Mr. PORTE agreed with the lecturer as to the necessity for ample battery power—there were more failures from this than any other cause. He agreed as to the necessity for inspection by battery makers, and as to the necessity for pure water, and pointed out the importance of the continuity of the first charge. He considered that a battery should be used (*i.e*, discharged), and not merely kept charged as a stand-by. Wood diaphragms should increase the resistance and impede the circulation, and he would like to ask the author whether this had been found to be the case in practice.

Mr. C. H. EGAN thought the six years too short a life for a battery. Surely this was not the average?

Mr. W. J. U. SOWTER said that cells were in actual practice filled up with the nearest available water, and pointed out that the author recommended a water tap in the battery room. Was this meant to run "distilled water"?

Mr. EATON referred to his experience with the "Nodon" valve, but not on accumulator work.

Mr. W. TATLOW thought that both methods of charging referred to by the author—*i.e.*, (1) Constant current and (2) constant voltage—were wrong, and that the constant power method was preferable to either; he doubted the ill effects of not discharging a battery and adduced his experience with extreme end cells which had been very rarely discharged and were apparently in sound condition. The beneficial action of the wooden separator might be due to the interception of compounds which would otherwise be carried across.

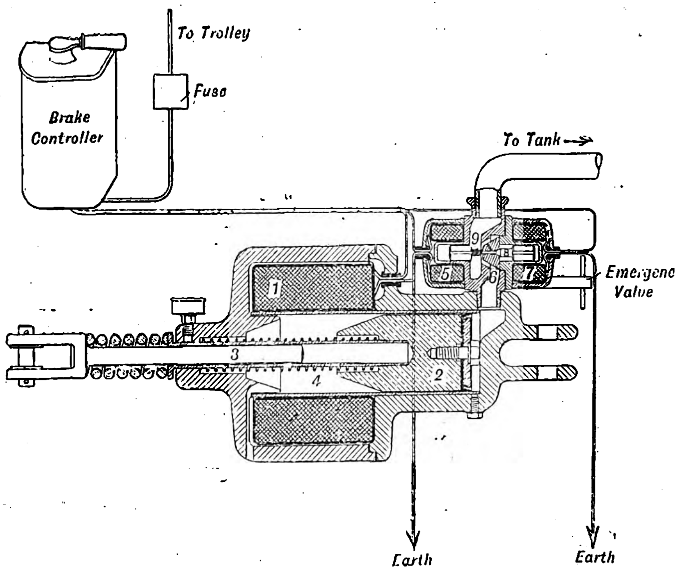
Mr. L. BROECKMAN, in reply, stated emphatically that every shilling spent in distilled water was worth a sovereign in the life of the battery; lime and ammonia were the elements most to be feared in water. He gave the following as the proper procedure to be adopted where the plates of a defective cell had to be returned to the maker: "Charge fully; discharge to 1·8 volts; syphon out the acid; fill with water; discharge on short circuit; remove the plate and allow to dry."

Mr. T. TOMLINSON, who had succeeded Mr. Sheardown in the chair after the reading of the Paper, then moved a vote of thanks to the author, which was seconded by Mr. Porte and carried.

**Tramways Over Thames Bridges.**—At Middlesex County Council meeting last week it was reported that a deadlock had occurred in the negotiations between the County Councils of Middlesex and Surrey and the London United Tramways (1901) Ltd. in regard to the terms on which consent would be given to the company to construct a line over King Edward VII. bridge.

## ELECTRIC TRAMWAY BRAKES WITH HYDRAULIC RELEASE.

We are informed that the tramway brake with hydraulic release, referred to in a note in our issue of Nov. 17, is made by the Allgemeine Elektricitäts-Gesellschaft, of Berlin, whose English agents are the Electrical Co. The accompanying illustration shows the brake electromagnet in section and indicates the connections generally. When the handle of the small brake controller is moved to the "on" position, current is enabled to flow through the main coil 1, and the plunger 2 and the rod 3 move to the left against the action of a helical spring, thus causing the brakes to be applied. As soon as the desired braking effect has been attained, the large valve 6 is caused to be closed by sending a current of short duration through the solenoid 5, the current through the main coil 1 being interrupted at the same time. The plunger piston 2 cannot return because the liquid, which was previously drawn into the cylinder past the valve 6, is now entirely enclosed. Hence the brakes remain "on" without loss of energy for any length of time. If it is desired to release the brake by degrees, current impulses are sent through the coil 7. This causes the small valve 8 to lift momentarily, and a small quantity of liquid is able to flow from the brake cylinder back into the tank. The brakes are thus released quite gently. In order to release the brakes rapidly, a current of longer duration is sent through coil 7, and the large valve 6 opens and lets the liquid escape quickly. The brake, it is stated, weighs only 260 lb., and the small controller has a weight of some 30 lb.



# CORRESPONDENCE.

## PERMUTATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In Dr. Charles V. Drysdale's article on Permutators, page 305 of your issue of December 8th, I read: "The first proposition of this kind appears to have been made in 1888 by Messrs. Zipernowski and Deri." In respect of this historical point my German patent No. 29,967 of 1882, which I send you under separate cover, may perhaps interest your readers.

You will see that my Fig. 5 is identical with Fig. 1, page 305 in Dr. Drysdale's article. The employment of two phases for the production of a constant continuous current is especially discussed in my patent, and illustrated in several figures, of which Fig. 8 is a concentric arrangement, but otherwise quite equivalent to the figure in your paper. The only difference in my machine is that the alternating magnetic flux is not generated by an alternating current from an external source, but is produced in the machine itself. That is certainly of practical importance, but in 1882 there was no reason for the conversion of alternating current into direct current, except for the production of the latter, because the distribution of alternating current with transformers was not yet invented at that time. However, this being taken into consideration, and without claiming anything of the particular construction of the "Permutator" or the "Panchahuteur," I may say, I think, that all essential arrangements of these modern machines for the conversion of alternating current into direct current are indicated in my patent of 1882. In this respect, and especially with reference to the means of reducing sparking described in Dr. Drysdale's article, Fig. 7, and commutating resistances, I beg to draw your attention to the gradual commutation of two phases described in my patent, p. 3. As I indicated there, the main point is "ein allmäliger Uebergang der einen Schaltung in die umgekehrte," that is, a gradual commutation is necessary between each reversal. The sub-division of the winding in a large number of parts connected with many commutator segments, is only a partial approximate solution of the question. A sudden change still remains in the transition of one phase to the other, because successive commutator segments are connected only to one phase, except at the point of reversal. Therefore, the defects of a two-part commutator are not avoided, only somewhat reduced in degree. But if between adjacent commutator segments are inserted parts of both phases, so that for successive segments more and more of one phase and gradually less of the other phase is included, as indicated in my patent, then we may obtain gradual differences of voltage around the commutator, but permanent upon the whole, that is independent of the phases of the electric induction. Therefore, between the positive and the negative commutator parts, there will be segments with no difference of voltage, where the brushes may be located to collect the current without sparks. This is real sparkless commutation, as in a well-designed dynamo with properly adjusted brushes, and is quite different from the commutation with such spark-reducing means as commutating resistances.

It is obvious that the arrangement Fig. 1. p. 305 is not really sparkless. Only once in each half revolution is there one real sparkless moment—that is, at the position of the left-hand circle. Except for that moment, there is on both commutators not a single pair of segments without difference of voltage; it is, therefore, absolutely impossible to set the brushes in a neutral non-sparking position.

Machines with my gradual two-phase commutation are in respect to sparkless commutation quite the same as the best ring or drum-wound armatures. At that time, when tunnel or slotted armatures were not yet invented, my continuous current machine of the alternator type had the advantage of a nearly closed magnetic circuit, the air gap being not more than necessary for clearance. I mention, also, my corresponding British patent, No. 184 of 1883, but the particular two-phase commutation above referred to is better explained in my former German patent. My British patent contains the same figures, and even a great deal more.—Yours, &c.,

The Hague, Holland, Dec. 16. C. L. R. E. MENGES.

[Herr C. L. R. E. Menges' communication is of much historical interest. We have perused the German patent specification to which he refers and can corroborate his remark as to the identity of Fig. 1 in Mr. Drysdale's article in *The Electrician* of December 8th, p. 305, with Fig. 5 in the German specification. This patent (No. 29,967 of December 20, 1882) claims a dynamo to produce an intermittent or continuous current, this result being obtained by causing one or more coils to rotate between field poles and varying the turns in series between the commutator brushes in a periodic and automatic manner. This is achieved by suitably sub-dividing each coil and connecting the junction points to the commutator segments in a certain manner. A number of possible ways of carrying out the connections are described and illustrated. Fig. 5, for instance, relates to the case in which a single coil rotates; Fig. 6 is also for a single coil, but one of the commutator segments is of greater peripheral length than the other segments; Fig. 7 relates to a double coil and one commutator, half of which is connected to one coil, the other half being connected to the other; Fig. 8 is an arrangement of two coils at right angles connected to two commutators; Fig. 9 is also for two coils at right angles but for only one commutator; and Fig. 10 shows the connections in the case where there are more than two poles. We reproduce above Figs. 5 and 9 of the German specification.—ED. *E.*]

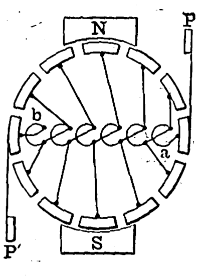


Fig. 5.

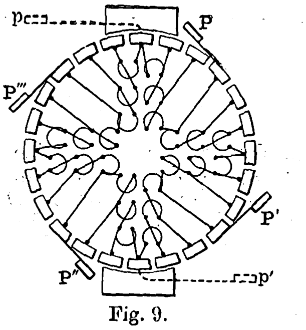


Fig. 9.

## DR. ERSKINE-MURRAY'S PAPER ON WIRELESS TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have been asked by Captain Jackson to state that the actual circumstances alluded to in the front part of my Paper [*The Electrician*, December 15th, p. 356] were as follows: Vernon receiving signals from Poldhu, 180 miles distant, on one mast, and sending to a ship 50 miles away by a separate aerial on another mast 200 ft. distant from the first. The former was unaffected by the latter. Captain Jackson had initiated and developed the apparatus, but was not actually present when this result was obtained.

I also mentioned Lodge's syntonic patent of 1897 as "one of the first." I should have said simply "the first," as I find that a patent of Tesla's, which is for a syntonic system of a somewhat different type, is of later date than I had supposed. Fig. 1 in your abstract is meant to represent the second Lodge-Muirhead receiver described, not Marconi's. It was taken from an account published in *The Electrician* some little time ago, but, as I am informed by Sir Oliver Lodge, the position of the syphon recorder is incorrect; it should obviously be in series with the coherer and source of current.

With your permission I should like to make a few remarks on your exceedingly fair and reasonable criticisms. Dr. W. H. Eccles has kindly pointed out to me that I did not, in my Paper, indicate with sufficient clearness that my formula for the computation of the maximum distance of transmission is of course entirely independent of the physical explanation given to account for it. The equation depends solely on the observations of Duddell and Marconi, and is applicable, like any other empirical formula, quite irrespectively of the truth or falseness of the physical theory proposed for its explanation. As a matter of fact, the formula was not deduced from the theory, but rather the theory from the formula.

As, however, the theory is also of interest, I must add some facts in its support. In regard to your first paragraph, suggesting a gradual dissipation of the wave as it rises through the atmosphere, I must point out that Prof. J. J. Thomson has shown ("Recent Researches in Electricity," §79), that there is a critical pressure for an electrodeless discharge in a gas above which pressure the gas is a nearly perfect insulator, and that the conductivity increases very rapidly when this critical point has been passed, soon reaching a surprisingly large value. Thus when rising through the atmosphere the electric wave front comes suddenly to a conductive layer at the moment the critical pressure is passed. Hence there need be very little dissipation before this occurs. Prof. Thomson has also proved (*loc. cit.*, §84) that the conductivity of rarified air for an electrodeless discharge is extraordinarily great, the maximum value being greater than that of a 25 per cent. solution of sulphuric acid.

The waves are thus bounded above by a layer whose conductivity is, at a certain height, very many times as great as that of the earth or sea which bounds them below. If we judge from Prof. Thomson's laboratory experiments, this critical pressure should apparently be reached at a height of about 30 miles, and the conductive layer should commence there; but the occurrence of auroræ as low as 6 miles above the earth's surface shows that in the atmosphere the limiting pressure must for some reason have a larger value corresponding to this lower elevation. In any case it seems certain that at a very moderate height there is a highly conductive layer which has a sharply defined lower boundary.

Your second paragraph is not, strictly speaking, a criticism of my theory, as I carefully avoided any mention of energy, confining myself to current received. The action of most receivers, since they are mainly of the relay type, depends on either the voltage or the current and not directly on the energy. In fact, the only responder depending directly on the energy which I know of is Fessenden's original barreter, now discarded in favour of an electrolytic device whose action appears to depend on voltage alone. However, since you have raised the question, I may say that the explanation you suggest occurred to me, but I rejected it, whether wisely or not, because it appears to contain at least one fallacy. The square of the current is proportional to activity, *i.e.*, time rate of change of energy, not to energy per unit volume. It is not clear that these quantities are equal. Even if they were, is it certain that a variation of the energy as the inverse square of the radius would represent the conditions in a hemispherical wave bounded by a plane conductor ? I think not.

The reasoning which led me to the cylindrical theory was somewhat as follows. The tubes of electric force between two parallel conducting plates, constituting a cylindrical wave, have their ends on annular strips on each plate. The surface density on a strip is inversely proportional to its distance from the origin. Hence the electromotive intensity, in the space between the plates varies inversely as the distance. The current seems to vary as the voltage, and should therefore also have its space variation inversely as the distance. Thus a cylindrical wave apparently satisfies Duddell's law.

I do not quarrel with your remark that my theory is not new, though the only previous theory I know of, which takes into account the conductive layer of the atmosphere, is one in which the radiation is supposed to pursue a zigzag course in straight lines like the repeated reflections of a beam of light in a thick plate of glass. This is, of course, quite different from my theory, which considers a cylindrical wave front propagated in a direction parallel to the earth's surface.—Yours, &c.,

Glasgow, Dec. 19. J. ERSKINE-MURRAY.

[Dr. Murray's point about the sharpness with which conductivity begins, makes the intermediate layers thinner but does not abolish them. J. J. Thomson's experiments on the electrodeless discharge gave the conductivity of *ionised* gas. In Hertzian telegraphy the waves as they ran along the "conducting layer" would have to do their own ionising—with dissipation, of course. Duddell and Taylor measured the heat produced in a resistance in series with the air-wire; their results show that the energy thus gathered from a train of waves varies with distance according to an inverse square law. But these results are possibly not antagonistic to Dr. Murray's hypothesis, seeing that the measurements were all made at distances smaller than those at which the cylindrical wave form could be established. As no long-distance measurements exist that support Dr. Murray, his formulæ are enormous extrapolations and not valid foundation for any theory. Dr. Murray will find his hypothesis of an upper conducting layer stated very clearly in Heaviside's article "Telegraphy" in the "Encyclopædia Britannica."—ED. *E.*]

## WAVE MEASURERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Professor Fleming, according to his remarks in *The Electrician*, No. 1,439, of Dec. 15, 1905, appears to regard the most important differences between his cymometer and the novelty of the same, as compared with our wave measurer, to consist in the possibility of being in a position to alter at the same time both the capacity and the self-induction.

This feature, among others, is, however, protected in our English and United States patents bearing the names of Dr. Franke and Dönitz, engineers connected with our company, and from the point of view of patent title, we would here remark that not only is the changing of the capacity or of the self-induction protected by us, but also the simultaneous changing of both in confirmation hereof; see, for instance, the specification of our United States Patent 363,164, from line 25, reading as follows:—

> Now, according to this invention, the apparatus is so arranged that one or both of these electric values (capacity and self-induction, line 24) may be altered immediately within limits.

With reference to the practical construction or carrying out of his invention, Professor Fleming claims that the employment of "Neon tubes" confers important advantages. These "Neon tubes," however, when used as indicators for resonance, are not superior in their sensitiveness to thermometers, current meters, &c., as at the present day, also thermo-instruments of extreme sensitiveness are manufactured, whilst the employment of these last-named instruments confers the important advantage that the whole of the resonance curve can be practically measured for the purpose of being in a position to carry out quantitative calculations of energy, which, however, cannot be done when using a "Neon tube."

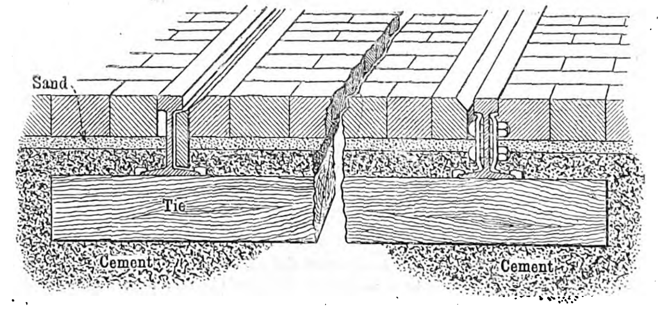
In conclusion, the accuracy of our wave measurer is greater than that of the cymometer, as the damping, on account of the great self-induction, upon which the bright parts of the capacity contact slide, is considerably larger than in our construction, with great capacity and small self-induction, consisting of several windings of thick wire. In consequence hereof, our wave measurer permits of a much looser coupling and of sharper tuning of the oscillatory circuit to be measured than can be obtained by a measuring system consisting of a self-induction coil with great self-induction and great capacity. For these reasons we maintain that the sensitiveness of our Dönitz wave measurer is greater than that of the cymometer.—Yours, &c.,

GESELLSCHAFT FÜR DRAHTLOSE TELEGRAPHIE.

Berlin, Dec. 21.

## VIGNOLES' RAILWAY CONSTRUCTION FOR TRAMWAYS.*

Battle Creek (U.S.A.) is one of the towns where the city engineer and other municipal officials believe that T-rail construction is in certain circumstances better than grooved girder-rail construction. As this track is laid in concrete, the company has had no trouble from low joints, and track laid in this same way two years ago does not show any perceptible wear. About two years ago, when the Jackson & Battle Creek Traction Co. entered Battle Creek, the Michigan Traction Co. laid double tracks from Postumville to Monument-square of 7 in. 70 lb. T-rail to facilitate the handling of the extra traffic along this route. During the same season it also double-tracked Lake Avenue to Goguac Lake, a very pretty lake resort two miles from the heart of Battle Creek. In May, this year, the same company began double-tracking all its lines in the central part of Battle Creek, and now has about four miles of double track.



CROSS-SECTION OF T-RAIL CONSTRUCTION.

The track is built entirely of T-rail, and the special work was furnished by the Lorain Steel Co. and the Paige Iron Works. That furnished by the Lorain Steel Co. was of the hard centre type and was used for the heaviest traffic. The rails were laid on 6 in. by 8 in. by 8 ft. white oak ties, placed at 2 ft. centres, well ballasted with gravel and filled to within 11 in. of the surface of the finished work, all joints being suspended. Under the two joint ties it was excavated to a depth of at least 8 in. and filled with concrete, as shown in the accompanying illustration. It was also excavated 8 in. under the ties at all special work, the space being filled with concrete. Repaving was accomplished by using 6 in. concrete, 1 in. cushion sand

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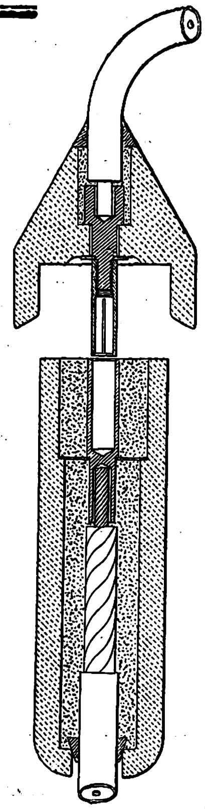
* From the *Street Railway Journal* of New York.

and Nelsonville paving block as a wearing surface. The groove or flangeway was formed by using the Nelsonville filler block and the Nelsonville stretcher block. On the whole, from the street railway standpoint as well as the horse traffic standpoint, this style of groove or flangeway is looked upon by all those who have seen this work as superior to the grooved girder rail. By drivers of horse drawn vehicles it is approved because such vehicles as get into the groove have an easy slope to get out, and thereby a great saving results in wheel wear. From the street railway standpoint it is preferred because it gives the bearing of the wheel squarely over the centre of the base, and forms a groove which is self-cleaning and does not wear the wheel flanges liked grooved girder rail.

## A DETACHABLE POT HEAD FOR HIGH-TENSION CIRCUITS.*

Where high-tension overhead circuits pass to underground cables there has been felt the need of a pot head which will not only protect the end of the cable insulation, but which will also make it possible to disconnect the overhead from the underground lines. It is also sometimes desirable in ordinary overhead distribution to have disconnecting devices for branch lines on poles. The detachable porcelain pot head shown in the figure has been developed on the circuits of the Commonwealth Electric Co., Chicago. The lead-covered cable enters a long porcelain sleeve. This sleeve is clamped to the cross arm. The conductor of the cable is soldered into a brass sleeve, one end of which forms a receptacle for a split plug by which a connection is made with the overhead line. The brass sleeve is held in a central position in the porcelain sleeve by a washer. When a cable has been slipped into the sleeve the space between the cable and sleeve is filled with "Mineralac," or other insulating compound. The overhead line wire terminates in a plug in a porcelain cap, the space between the wire and cap being filled in with compound in a similar manner. The split plug in the cap slides into the receptacle which forms the cable terminal. In the figure the plug has been withdrawn from the receptacle. The pot head is used on voltages of from 2,000 to 8,000.



DETACHABLE PORCELAIN POT HEAD.

**Electrical Towing on Canals.**—A Paper was read at the International Congress of Navigation at Milan by M. Leon Gérard and M. St. Johns Clarke on electric haulage on canals. In the earlier experiments in this direction it was found that the weight of the electric tractor could not economically be made great enough to afford sufficient tractive force to give the proper speed to the barges. A new type of tractor has been brought out during the past year, and has been experimented with on a special track at Schenectady, and is called the "proportional adherence tractor." The driving wheels, which are 12 in. in diameter, work on the top part of the guide girder. The main portion of the tractive effort at the moment of starting is supplied by wheels which run under the guide girder. These wheels are accurately fitted into place. The pressure exerted by them comes into play only when the traction strain is applied by the tow rope; a system of levers is provided which presses these wheels upward through springs. Although the apparatus weighs only 3 tons, it is stated in a contemporary that a pull of one ton is exerted at a speed of 4½ miles per hour, under which condition the overall efficiency is 86 per cent. The tractor is equipped with a 45-H.P. motor of the mine type, and forms a compact iron-clad and enclosed construction, the centre of gravity of which rests under the guide girder. The track consists of girders held in place by vertical posts of lattice construction to which they are fastened through brackets. With no load and at the greatest speed the apparatus does not exert on the track any pressure other than that due to its weight of 6,400 lb. At a speed of 8 miles per hour without load the tractor motor absorbs 7 kw.

## LEGAL INTELLIGENCE.

### Rating Appeal.

Last week the House of Lords (Lords Halsbury, Macnaghten and Robertson) delivered judgment in the appeal of Mr. T. Kirby against an assessment of Hunslet Union. Both the Divisional Court and the Court of Appeal affirmed the decision of the Recorder of Leeds. Mr. Kirby appealed against a rate made by the overseers upon the Standard Works, in respect of which he had been assessed at £67 gross estimated rental and £45 ratable value. Some part of the equipment of the works was fixed to the freehold, and formed part of the freehold by physical attachment. Other parts of the equipment consisted of machinery, also placed upon the premises for making them suitable for use as engineering works, much of which was of considerable bulk and fitted to the premises.

Before the Recorder APPELLANT unsuccessfully contended that, in arriving at the assessment of the premises, the value of the uses of the scheduled machinery to the tenant or occupier ought to be excluded from consideration, but the amount was reduced to £46 gross estimated rental and £31 ratable value. The case was stated by the Recorder as follows: Respondents contended that, in inquiring what was the gross estimated rental and the ratable value, the basis of the problem was to ascertain what was the rent which a hypothetical tenant would give for the premises equipped with the scheduled machines, and including the right to the use of such machines, and that, in ascertaining such rent, the value of the uses of the machines must be taken into account as enhancing the rental value of the freehold. It was upon this principle that the ratable value appealed against had been assessed.

Mr. BALFOUR BROWNE, K.C., for appellant, argued that in valuing the premises the value of the uses of the machinery, other than that which formed part of the freehold, ought not to be considered. The machinery ought only to be taken into account in so far as its presence afforded proof that the premises were fit for the purpose of the business, and would be likely to induce a tenant to give a higher rent for the premises than he would give if the machinery were not upon the premises. The effect of the order appealed against was to make the machinery ratable as if it were part of the freehold, notwithstanding the fact that the machinery was expressly found in the special case to form no part of the freehold. He contended that the Court of Appeal misinterpreted and mis-applied the decision in the Tyne Boiler case in holding that the machinery should be taken into account, by assuming it to be included in a demise to a hypothetical tenant.

Without calling upon counsel for the respondents Lord HALSBURY, in moving that the appeal be dismissed with costs, said that he was of opinion that the judgments below were perfectly right. Looking at the long series of decisions, he thought that it established the broad proposition that, although the machinery might not be part of the freehold, yet it was to be taken into account in assessing the amount of the rate which was to be exacted from the tenant. That was all he meant to decide in that case. Could they enhance the amount of assessment upon a building in which there was machinery adapted for manufacturing, although such machinery did not form part of the freehold? He was of opinion that they could do so under those circumstances.

Lord MACNAGHTEN and Lord ROBERTSON concurred, and the appeal was dismissed with costs.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT AND FILLED.

The Board of the Calcutta Electric Supply Corpn. (Ltd.) require a station superintendent (with previous experience in direct current central-station work) and a mains superintendent (with experience in laying and superintending laying of mains). Candidates should be prepared to enter into an engagement for three years. Salary 450, 500 and 550 rupees per month for each year respectively. Further particulars are given in an advertisement. Applications to the secretary (Mr. F. R. Reeves), Salisbury House, London Wall, E.C., by noon, Jan. 3.

The Council of Armstrong College, Newcastle-on-Tyne, invite applications for the position of lecturer in physics. Stipend commencing at £200, rising by annual increments of £10 to £250. Applications to the secretary (Mr. F. H. Pruen) by Jan. 13. See also an advertisement.

An improver is wanted to act as switchboard attendant at Coventry electricity works, with a view to becoming a shift engineer. Applications by first post Jan. 3, to the manager of the electricity works, Mr. Joseph A. Jeckell. See an advertisement.

An examination will shortly take place for appointments as second-class engineers in the Engineer-in-Chief's Department, G.P.O. Jan. 11 is the latest date for receiving applications. Forms from the Secretary, Civil Service Commission, Burlington-gardens, London, W. See an advertisement.

The governing body of the Northampton Institute require a junior technical assistant in the electrical engineering department. Applications by 10 a.m. Jan. 8 to the principal (Dr. R. Mullineux

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* From the *Electrical World* of New York.

Walmsley), Northampton Institute, St. John-street, London, E C. See also advertisement.

A lecturer in physics is required at Armstrong College, Newcastle-on-Tyne. Salary £200, rising by annual increments of £10 to £250. Applications as early as possible before Jan. 13. See an advertisement.

Aberdeen Town Council require a general manager for their tramways. Salary £300 per annum. Applications by Jan. 20.

An assistant lecturer in mechanical engineering is required at the Royal Technical Institute, Salford. Application by Jan. 10.

Brighton Corporation have made the following appointments of staff for operating the Southwick power house:—

Mr. Sharpe, who has acted as construction superintendent and clerk of works, to be superintendent at £5 per week; Mr. G. Claughton, who has been acting for the Westinghouse Co., to be assistant superintendent at £4. 10s. per week. Three high-tension switch gear operators are to be appointed as shift engineers at £2. 10s. each. The salary of R. Tonge, foreman fitter, has been raised from £2. 2s. 6d. to £2. 10s. per week; and F. W. Markwick has been appointed boiler house foreman at £2s. 10s. per week.

Mr. W. E. Milns, having secured an appointment with the Newcastle upon-Tyne Electric Supply Co., has resigned his position of engineer and manager of the Urban Electric Supply Co.'s Grantham and Stamford stations, being succeeded by Mr. J. E. Edmundson, of the Scarborough Tramways Co. Mr. W. E. Nicoll, hitherto secretary of the latter company, becomes manager of the company also.

Mr. John Barnard has been appointed assistant traffic manager of the Bolton tramways at £160 per annum.

Mr. A. W. Ashton, M.Sc., has been appointed assistant lecturer and demonstrator in electrical engineering at Leeds University.

## EDUCATIONAL NOTICES.

**Proposed Dundee Technical Institute.**—The chairman of the Dundee Technical Institute committee (Mr. Wm. Henderson) recently announced that over £18,000 had been promised towards the erection of a new technical institute. That sum would not warrant them proceeding with the new technical institute scheme, but they were not to allow it to drop altogether. The Education Department would be approached in regard to the £200,000 at their disposal for capital expenditure.

**Morley Memorial College.**—The opening soirée will take place on Saturday, Jan. 6. There are lectures on electricity and magnetism by Mr. H. Moore, B.Sc., on Tuesday and Friday evenings, and in practical electricity by Mr. J. J. Denton on Monday and Tuesday evenings. There are also classes in practical mathematics, chemistry, &c., and free popular lectures are given on Saturday evenings. Prospectuses may be obtained from the College, Waterloo-road, London, S.E.

**Association of Technical Institutions.**—Sir Wm. Anson, M.P. has accepted the position of president of this association for next year in succession to Sir Philip Magnus.

**Abercarn**—The Council resolved last week to apply for a provisional electric lighting order.

**Africa.**—Among the annual publications which have reached us one of the most important from a commercial point of view is certainly the "African World" annual for 1905-6. This is the third annual issue of a work which includes a review of the progress of the entire African Continent. No less than 50 special articles by well-known writers deal with a vast number of subjects of great commercial interest. Members of the electrical industry will find matter of interest in this annual, which is published at 2s., and can be obtained from the "African World" offices, Bourne House, Copthall-avenue, London, E.C.

**Argentina.**—The "Review of the River Plate" says: Rosario Municipality is calling for tenders (by April 16) for public lighting.

The new Post and Telegraph law prohibits telephone companies from receiving messages from or to persons who are not regular subscribers, as this is held to be an infringement of the Telegraph Department's monopoly. It is said that wireless messages are also to be prohibited.

Bahia Blanca Municipality have decided that the public and private electric lighting shall be immediately suspended, and that the electric lighting company shall be given eight days to decide whether they will comply with the Corporation's demand that the voltage of supply be changed to 500. In the meantime the public lighting will be effected by kerosene lamps.

**Australasia.**—Sydney (N.S.W.) Municipal Council, which has supplied current for lighting since July, 1904, had at Oct. 31, 1905, 466 consumers connected to the mains, taking energy equivalent to 67,940 8-c.p. lamps, including 1,216 H.P. for motors. The population of Sydney, including the suburbs, is 511,000. Gas is supplied in Sydney by a company at 4s. per 1,000.

There are now 1,100 consumers connected to the mains of the Kalgoorlie municipal electricity undertaking, with an equivalent of 20,000 8-c.p. lamps. This percentage of connections is large for a population of only 7,000.

Prahran (Victoria) municipality have applied for an Order-in-Council authorising the construction of an electric tramway. If the Order be granted Malvern Council will probably co operate.

**Bacup.**—The Council have made arrangements for taking a supply of electricity in bulk from the Lancashire Electric Power Co.

**Barking.**—The electrical engineer (Mr. Howard) advises that it is necessary to put in additional condensing plant and to adopt mechanical stoking at the electricity works.

**Bo'ness (N.B.)**—The differences between the Council and the National Electric Construction Co. as to the interpretation of an agreement regarding electricity supply are likely to be settled, the points in dispute having been referred to an independent engineer for report.

**Brighton.**—The Corporation have received a communication from the L.G. Board on the subject of the recent inquiry into the application for sanction to borrow £38,500 for electric lighting extensions and £5,909 for purchasing the Star Foundry site and erecting buildings in connection with the electricity undertaking. The Board are willing to sanction the latter sum, but the question of the larger amount is held over for the present.

On Thursday last week the Council appointed the staff for operating the Southwick works.

The electrical engineer (Mr. John Christie) reported that he had been unable to arrange with the L.B. & S.C. Railway Co. to supply them with electric current, and that one of the two new feeders for which application for sanction to a loan of £4,500 had been made would, therefore, not be required. The Town Clerk was instructed to withdraw the application in respect of this feeder.

**Burnley.**—The Council have adopted the report of the borough electrical engineer (Mr. James E. Starkie) to divide the lighting network by means of disconnecting fuse pillars into five areas, at an estimated cost of £450. The above will meet the requirements of the Board of Trade regulations and will reduce to a minimum the possibilities of a total failure in supply due to a fault on the mains.

**Cardiff.**—The borough electrical engineer and tramways manager (Mr. Arthur Ellis) attended the last meeting of the Finance committee to ask that in the electric lighting department actual and not estimated profits should be dealt with.

The Electric Lighting committee estimated that the profit of the year would amount to £5,000, and the Finance committee allocated £3,000 towards relief of rates. The Electric Lighting committee had had a rather bad year, and the profit only amounted to somewhat over £2,000, with the result that the city treasurer's accounts showed that there had been a loss on the working of the department. Mr. Ellis suggested that for one year nothing should be allocated from estimated profits towards rates and that subsequently the actual profits should be dealt with. The committee agreed to the suggestion.

**Chester.**—The Tramways Committee have been instructed to obtain information of the cost and upkeep of motor omnibuses, and of their efficiency and suitability for outlying districts of the city. A report is to be presented within 12 months.

**Chichester.**—A company has been formed with a capital of £30,000 to take over the Chichester electric lighting order and to establish electricity works.

**Cochin China.**—Saigon possesses an underground telephonic network owned by the State. The operators are chiefly women, and are preferentially selected from amongst the widows of Government officials.

Telegraphic communication exists almost all over the country, the chief instruments employed being of the Morse type, although Baudot and Hughes are also employed to some extent. Natives are employed by the Government as telegraphists.

Saigon is lighted electrically, the supply being in the hands of a private French company (the Société d'Electricité de Saigon), with headquarters in Paris. This company is subsidised by the Government. Bare overhead cables are used and, although there is a large water area available, steam is employed in the generation of energy.

A great effort has been made to establish Para rubber cultivation, and there are now about 15,000 five years' old trees standing, but their condition is causing the planters much anxiety, which may lead to the abandonment of the enterprise so far as Para rubber is concerned. Other kinds of seed have been tried, but have proved a failure, and attempts are now about to be made with Hamomea Speriosa, which it is thought will have a better chance on the damp soil of Saigon.

**Commercial and Trade Interests at the Forthcoming General Election.**—The Association of Trade Protection Societies of the United Kingdom, which represents 100 organisations, with an aggregate membership of about 50,000, has issued a manifesto calling attention to the reforms advocated by its members, so that when the new Parliament assembles the needs of the trading bodies of the country may receive adequate consideration. Among the reforms are the following:—

1. The establishment of a Ministry of Commerce and Industry.
2. The reform of our consular service.

3. The cheapening and extension of our postal, telegraph and telephone services.
4. The provision of cheap and rapid transit under fair conditions of goods and merchandise.
5. The public control and development of our canals and inland waterways.
6. The amendment of our patent, trade mark and copyright laws.
7. The amendment of our bankruptcy and company laws.
8. The prohibition by statute of illicit commissions in trade.
9. The compulsory registration of the real proprietors of trading firms.
10. The thorough reform of County Court procedure throughout the United Kingdom.
11. The compulsory adoption of the metric system of weights and measures.
12. The exemption of movable machinery from rating.
13. The amendment of the Revenue and Industrial and Provident Societies Acts so that co-operative societies shall be dealt with on the same basis as private firms.

**Dewsbury.**—The Town Council have decided to apply for a provisional order to extend the time for exercising the powers conferred by the Council's 1904 order.

**Dundee-Broughty Ferry Tramways.**—On Wednesday the line between Dundee and Monafieth was opened for traffic.

**Dunfermline.**—A long discussion on electricity supply took place at the last meeting of the Council.

Provost Macbeth held that the Council could not generate electricity themselves at less than double the price asked by the Fife Electric Power Co.—viz., $1\frac{3}{8}$d. per unit. Ultimately, the matter was remitted to the Electric Lighting committee to continue negotiations with the company and, in the meantime, to invite Messrs. Crossley Bros.' representative to meet the Council in committee to give particulars of a scheme involving the use of gas-driven plant outlined in a communication from Messrs. Crossley.

**Electrical Standardising, Testing and Training Institution.**—The standardising department of this Institution has issued a complete revised scale of testing fees. In introducing this revised scale it is pointed out that during the 15 years of the Institution's existence nearly every electrical engineering company and station engineer has, at one time or another, made use of its services. The large range of experience which this has provided has afforded the management opportunity to design an electrical testing laboratory especially suited to carrying out with rapidity and accuracy all kinds of measurements and tests required by electrical engineers, whether these be of the ordinary or of special character. The testing department is kept entirely separate from other branches of the Institution's work and employs a special staff. The situation now occupied by the laboratories and testing rooms at Faraday House, 62-70, Southampton-row, London, W.C., is very central.

**Exhibitions.**—It is proposed to celebrate the centenary of the birth of Argentina as a nation by holding an international exhibition at Buenos Ayres in 1910.

A prospectus is ready of the International Exhibition of Domestic Economy, which is to be held at Antwerp in April and May next. Electricity and its applications will form a conspicuous feature of the Exhibition.

**Football, &c., by Electric Light.**—The Winter Sports Club commenced operations on Saturday last at Olympia, London, and a football match on a huge green carpet was amongst the items. The game was rendered possible only by the adoption of electric lighting.

**Fraserburgh.**—Particulars of a scheme of electricity supply prepared by the Consolidated Pneumatic Tool Co. have been printed and circulated among members of the Council. Briefly, the scheme is for putting down additional plant at the company's works and supplying electricity to the Council for public and private lighting. The Council are to pay the company £4,000 for the additional plant, and the company to supply electrical energy at 2d. per unit for the first two years and at $1\frac{3}{4}$d. after that period. The cost of constructing the necessary underground cables, &c., will be £4,000. There are 81 street lamps for which the gas company is paid £65. 10s. per annum, and the estimated cost of 81 electric lamps is £88. 5s.

**Gosport-Fareham Tramway.**—This line, which was officially inspected on Friday, will be opened for traffic next week.

**Halifax.**—The official inspection of further tramway extensions took place on Thursday last and the lines are now open for traffic.

**Hydraulic Power.**—The experience of theatre managers in the West End of London on Tuesday evening of the trouble likely to ensue from the bursting of a hydraulic power main is hardly likely to extend the use of hydraulic power in theatres and similar establishments. Owing to the bursting of one of the London Hydraulic Power Co.'s mains the programme at the Hippodrome in Charing Cross-road had to be considerably modified and certain performances had to be abandoned. At this house and many others in the neighbourhood, if the fire-curtain had happened to be down, the evening performances at such houses would also have had to be abandoned. A number of the principal houses in London theatreland, however, have electrical or other means of operating these curtains and the general work of the stage, and were thus saved from inconvenience and loss. Much damage was done to the roadway where the burst occurred, and traffic was greatly interrupted.

**Ilford.**—An unopposed inquiry was held last week into the application of the Council for sanction to a loan of £5,000 for extending the electric lighting mains.

**Increase in Prices.**—It is announced that Austro-Hungarian manufacturers of electrical machinery and materials have decided to increase prices by 10 per cent. owing to the continued increase in the price of raw materials.

**India.**—The Bombay Electric Supply & Tramway Co. commenced their service of electricity supply on Sept. 11 last, and are extending the service rapidly. Already, we are informed, there is the equivalent of 13,000 8 c.p. lamps connected to the mains and about 100 consumers. The maximum demand system of charging is in operation, 8d. (8 annas) being charged for the first hour and 3d. after for lighting, and $1\frac{1}{2}$d. after for power.

**Italian Railway Electrification.**—A request has been forwarded to the Italian Government by the Chamber of Commerce at Lecco that the system of electric traction in force on the Valtelina line be extended to the Lecco-Milan, Lecco-Bergame and Ponte San Pietro-Usmate lines.

**Kingston-on-Thames.**—The charge for current for power and heating is to be reduced to 2d. per unit from March next.

**Lectures.**—Mr. S. E. Fedden (borough electrical engineer) delivered an interesting lecture at Sheffield recently on "The Uses of Electricity" before the Sheffield Society of Architects and Surveyors.

Mr. Fedden said it was only during recent years that much attention had been given to artificial illumination, particularly in dwellings. For interior lighting, except large halls, they were still restricted to some form of incandescent lamp. Fortunes had been sunk in developing it. Whether fortunes were now being made out of it he could not say, but, judging from the keen competition, he should doubt it. Over 50,000,000 incandescent electric lamps were used in the United Kingdom in a year, the majority being home made. One of the greatest difficulties electrical engineers had was in educating consumers to appreciate the advantage of good lamps. There was considerable saving in the account for energy when the better lamps were used. In regard to illumination there was frequently in the arrangement of electric light fittings an utter disregard of fitness and a complete ignorance of the first principles of illumination. There was room for specialists in that class of work, men who were able to suit the lighting, wiring and fittings to the decoration and general arrangement of a building. Of all the people engaged in competing with electric light, the vendors of gas and gas appliances had made most extravagant statements to support their claims. The comparisons made varied greatly, but stood for the most part self-condemned by their absurdity. Occasionally definite cases were cited where a saving had been effected by the substitution of some of the most recent forms of gas lighting, but it was generally found that the customer had contented himself with less light. In electric lighting great economies could be effected, and if those economies were adopted electric light accounts would go down. There were other great advantages. It was said that by introducing electric light Mr. William Whiteley, the "Universal Provider," saved £5,000 per year on painting and whitewashing and there was also the important question of health. In Sheffield, in nearly every case where electric light had been installed in a church or chapel, there had been a saving compared with gas. After dealing with meters, wiring buildings, the use of arc lamps, apparatus for electrical cooking, heating, &c., Mr. Fedden dealt with the subject of electric power, and contended that the day was past when it was necessary to demonstrate that electricity was equal to any other motive power. It was obviously superior in cleanliness, silence, safety, regularity and simplicity. The lecture was illustrated by lantern slides, and its interest was increased by specimens of heating, cooking and ventilating apparatus, electric lamps, &c. A hearty vote of thanks was accorded to the lecturer.

Recently Mr. Thos. Reed, head master of the Engineering Department of Birmingham Municipal Technical School, delivered an interesting lecture on his recent visit to the Continent with students to inspect foreign workshops.

The lecturer said that in Continental cities that were not nearly so large as Birmingham there were excellent industrial museums where students could gather information and gain assistance in their studies. Referring to the big tool-making works of L. Loewe & Co., Mr. Reed dwelt upon the perfect order observed in the workshops. The dominant note of the whole establishment was a place for everything and everything in its place; a place for every man and every man in his place; perfect discipline everywhere; not that discipline which was the result of constant supervision, but something infinitely better—the unconscious discipline resulting from thorough training and interest in the work. The visitors were struck with the superiority of the workmen. And there was no doubt that that superiority was due to the conditions under which they worked; for splendid provision was made for their comfort and social elevation. Another reason for the superiority of the German workman was the thoroughness of his apprenticeship. Mr. Read then showed pictures of A. Borsig & Co.'s engineering works and the Stettin shipbuilding works. Most of the works had attached to them technical schools and libraries. The staff at Messrs. Borsig's works made themselves conversant with English, so that they could in their library, read the English engineering journals. The general interest taken in apprentices was (Mr. Reed said) greater in Germany than here. One of the principle difficulties of the Birmingham Technical

School was that the apprentices, who should be attending school regularly, had to work overtime. In Germany all the men were encouraged to use their brains.

**Leeward Islands.**—Telephone extensions are being made in Dominica, the Windward and northern districts being now placed in connection with Roseau, and the Leeward coast lines being provided with a much-improved service. For the first time there was a small profit on the working of the telephone service in the Island of Antigua. Telephonic communication is established also at St. Kitts, the revenue from this source being almost equal to the expenditure (£408 against £456). Expenditure on the telephone service at Dominica reached £1,396.

**Light Railways.**—A deputation from Llandudno Council on Saturday waited upon Mr. Lloyd-George, M.P. (President of the Board of Trade), to urge him not to grant a further extension of time to Llandudno & Colwyn Bay Light Railway Co. for the completion of their line.

The Board of Trade has been asked to extend the period of the Walthamstow and District Light Railway Order, which expires in 1906.

**Malay Straits.**—The service of electricity supply at Kuala Lumpor (Selangor), which the Government of Selangor are constructing, is expected to be ready by July 1 next. The public lighting will consist of 60 Brockie-Pell open arcs, 60 ¼ ampere Nernsts and 500 incandescents.

**Marylebone (London).**—The reports of the Electric Supply and Finance committees, recommending application to the L.C.C. for further loans for electricity supply, &c., which were abstracted in our last issue, were approved by the Council on Thursday last.

**Municipal Honours.**—Mr. John Irwin, J.P., the very energetic chairman of the Dublin Electric Lighting committee, has been elected an alderman for the North City Ward, Dublin, by 507 votes to 460.

**Obituary.**—The death occurred on 15th inst. at Inverness of James Richard Craddock, A.M.I.E.E., formerly chief electrical engineer at the Raub Gold Mines, Straits Settlements. Mr. Craddock was only 35 years of age.

**Pontypridd.**—The Council have decided to construct a reservoir of a capacity of 1½ million gallons for condensing water for the electricity works at an estimated cost of £1,750.

**Provisional Order Transfer.**—Dorking Council give notice of intention to transfer to Edmundson's Electricity Corpn. their Electric Lighting Order, 1897, for 25 years. The Council reserve the right of purchase at 7, 10 or 14 years or any subsequent year.

**Rawtenstall.**—Sanction to a loan of £12,000 has been received by the Council for electricity supply.

**Sheffield.**—Some figures have been published showing the progress made by the electricity supply department.

When the undertaking was purchased by the Corporation nearly eight years ago there were only 688 consumers, at the end of 1904 there were 2,714, and by the end of this year there will be over 3,000, with the equivalent of about 380,000 8 c.p. lamps connected to the mains. There are 627 electric motors (against 509 in 1904) with an aggregate horse-power of 4,278 (against 3,341). The Neepsend generating station has been working over 12 months, and the demand for current has steadily increased, until now its machinery is fully loaded during the evening hours, and the works costs have been reduced to a figure which places it in the first rank for economy of operation. The advantage and economy of electric power is becoming daily more widely recognised, and many of the large Sheffield works are using electricity to drive their new machinery, and at the same time are gradually connecting the whole of their plant to the Corporation mains. In some cases contracts are being entered into between the Corporation and large power users for bulk supply for all purposes at low rates. The increase of electric light, not only in shops but in private houses, places of worship, &c., has also been very great. During the year the new University has been fitted with a complete installation for lighting, power, ventilation and experimental work. The use of electricity for heating, cooking and ventilating is also becoming more popular.

**Telephone in Mining.**—The Victorian Government Inspector of Mines (Mr. W. Abraham) considers that the telephone is of considerable utility in the workings of deep mines. It appears that the telephone has been in use for some time at Johnson's Reef, the South New Moon and the New Moon mines, Bendigo, and Mr. Abraham is of opinion that the system can be advantageously introduced into many other mines on the field. In the case of an accident at a depth, especially at a point below that at which crushing dirt is being hauled, much time would be saved, with the help of a telephone, in securing assistance and conveying the injured to the surface. The telephone would do away with the necessity of employing a powerful engine to lift for several thousand feet a "tally" board when the men below are in need of timber.

**Walthamstow.**—A writ has been issued against the Council for an injunction to restrain the commission of an alleged nuisance at the electricity works.

**Will.**—The late Sir Henry Charles Fischer, C.M.G., late Controller of the Postal Telegraph Department and a director of the Eastern Telegraph Co , Knight of the Order of the Royal Crown of Prussia and of the Danish Order of the Danebrog, who died on Nov. 30, left estate in the United Kingdom valued at £50,061.

## TRADE NOTES AND NOTICES.

### TENDERS INVITED.

The Electric Lighting committee of *Leyton* Urban District Council invite tenders for (1) 500 kw. dynamos and (2) overhead crane. Specifications, &c., from the electrical engineer (Mr. F. Harman Lewis), Electric Light and Power Works, Cathall-road, Leytonstone. Tenders will be opened at the meeting of the committee at the Town Hall, Leyton, on Jan. 18. See an advertisement.

*Aberdeen* Tramways committee invite tenders for supply and delivery of six tramcar top deck covers. Drawings and specifications from the city electrical and tramways engineer (Mr. J. Alex. Bell), Corporation Electricity Works, Millburn-street, Aberdeen, where tenders must be delivered by midday Jan. 6. See also an advertisement.

The Guardians of *Croydon* Union invite tenders for the installation of electric fire alarms at the Infirmary, Thornton Heath. Specifications, &c., of the architect (Mr. H. Berney), 105, George-street, Croydon. Tenders to the clerk (Mr. Harry List), Union Offices, Mayday-road, Thornton Heath, by 4 p.m. Jan. 8.

*Grimsby* Corporation invite tenders for a 500 kw. continuous-current direct-coupled high-speed double-acting engine, water-tube boiler and underfeed stokers, extension of switchboard, condensing plant (surface type), buildings, pipe-work, coal-conveying plant and lead-covered paper-insulated cables. Tenders by first post Jan. 5.

*St. Pancras* (London) Council invite tenders for arc lamp columns and cradles and open type arc lamps. Tenders to Mr. C. H. F. Barrett, Town Hall, Pancras road, N.W., by noon Jan. 9.

*Lochgelly* Iron & Coal Co. want tenders by Jan. 5 for 12 months supply of electrical goods, oils, &c.

*Southend* Corporation invite tenders for a 500 k.w. steam dynamo. Tenders to the Town Clerk by Jan. 25.

### TENDERS RECEIVED AND ACCEPTED.

Last week Glasgow Corporation were recommended to accept the tender of Babcock & Wilcox for 10 boilers for Dundas and St. Andrew's Cross stations at £16,716. An amendment was moved that nine of the boilers be given to Babcock & Wilcox and one to the Stirling Boiler Co.

Mr. WILLOCK, in moving the approval of the minutes of the Electricity committee, said the contract had been carefully looked into, and although it appeared at first sight that the difference between the two offers was £2,000, after taking into account the extra cost of erection and the extra cost necessary to equalise the amount of material offered in both cases, the difference only amounted to £629, which was really a very small item, per boiler. The department had already 20 Babcock & Wilcox boilers, and they had given every satisfaction. They were therefore naturally anxious to continue with these if the price was reasonable, so as to reap the full advantage of the various economies which arose from uniformity of plant. Their engineer had estimated that there would be a saving of something like £210 per annum in fuel and repairs on the extra capital expenditure of £629.

A further amendment was moved that the whole question be referred back. The first amendment was withdrawn, and the tenders were remitted to the committee for further consideration.

The Underground Electric Railway Co. of London have divided a contract for trucks for 210 steel passenger coaches for the Great Northern, Piccadilly & Brompton Railway between Les Ateliers de Construction du Nord and the Hungarian Railway Carriage & Machine Works. 72 of the cars will be trailers and the remainder motor coaches.

It is announced that the Brush Company has received an order from the L.B. & S.C. Railway Co. to build 21 all-steel cars for the London Bridge to Victoria section of the company's line. The cars will have cross seats and a central aisle, and side doors for each couple of seats, after the style of ordinary compartment carriages.

Leyton Council have accepted the following tenders:—

Stirling Boiler Co., two boilers with superheaters; Tudor Accumulator Co., storage battery; Brush Co., two engines (with Mirrlees-Watson condenser); Midland Engineering Co., water cooling tower; W. Boby, feed water heater and purifier; Lancashire Dynamo & Motor Co., reversible booster, &c.; Thermit Limited, welding and bonding tramway rails; Troup, Curtis & Co., wiring Lea Bridge branch library.

Southwark (London) Council received 12 tenders, varying from £57. 10s. to £123. 11s. 5d. for wiring the Greenmore wharf stables, and the lowest (that of Hammond & Champness) has been accepted.

Watford Council have accepted the tender of Davidson & Co. for an induced draught fan and damper at £98, and that of Edwin Freund for a variable speed single-phase motor at £250.

Dartford Council have accepted the tender of D. Santoni & Co. for supply of flame arc lamps and for switches, cable, &c., and that of J. G. White & Co. for drilling tramway poles for arc lamps.

Salford Education committee have accepted the tender of F. M. Burley for wiring the secondary school and pupil teachers' centre at £168. 17s. 6d.

St. Pancras (London) Council have accepted the tender of the Lahmeyer Electrical Co. for cables at £2,279. 18s. 7d.

Walthamstow Council have placed an order with Connolly Bros. (Blackley, Manchester) for wires and cables for the Council's schools.

Ilford Council have accepted the tender of Johnson & Phillips for feeder cables, joint boxes, &c., at £1,689. 9s.

## BUSINESS NOTICES.

Mr. F. E. Mackee, who has been with the British Insulated & Helsby Cables (Ltd.) for nearly 11 years, has left the company and started business with Mr. O. M. Robinson as electrical engineers. The style of the new firm is Frederick E. Mackee & Co., and the address is 22, Crane's-bldgs., Church-street, Liverpool.

Mr. D. G. Sutherland, who for the last five years has held the post of chief engineer of Messrs. Bruce Peebles & Co.'s contract department, resigns his position at the end of December to become partner in the firm of engineers, Messrs. Mitchell, Graham & Son, 46, Buccleuch-street, Edinburgh. Electrical and mechanical engineers are invited to forward lists and catalogues to Mr. Sutherland at that address.

## BANKRUPTCIES, LIQUIDATIONS, &c.

In the bankruptcy of W. Leslie, electrical engineer (now of H.M. Prison, Brixton, formerly 22, Bangalore-road and 1, Dryad-road, Putney, London, S.W.), the first meeting of creditors will take place on Jan. 2 at 132, York-road, London, S.E., and the public examination on Jan. 25 at the Court House, Wandsworth, S.W.

The discharge of Arthur Edgar Brooks, electrical engineer, 110, Cheapside, London, E.C. has been suspended for two years.

Claims against the Barcelona Tramways Co. (Ltd.) (in liquidation) to Mr. J. Barber Glenn, 845, Salisbury House, London Wall, London, E.C., by Jan. 31.

The Electrical Ore-Finding Co. (Ltd.) is to be wound up voluntarily. Mr. J. D. A. Norris, Suffolk House, Laurence Pountney-hill, London, E.C., is liquidator.

The Atmospheric Electrical Purification Co. (Ltd.) is being wound up voluntarily, Mr. E. E. Groome, 21, Spring-gardens, Manchester, is liquidator.

The Shanghai Electric Tramways (Ltd.) is being wound up voluntarily. Mr. G. G. Walker, 19, St. Swithin's-lane, London, E.C., is liquidator. Claims by Feb. 8.

At a meeting of shareholders of Graham, Morton & Co. (Ltd.) on Wednesday a resolution for the voluntary winding up of the company was passed.

**The "True Section-liner."**—A new drawing office instrument, intended to facilitate the drawing of parallel and equi-distant lines (for shading sections, &c.) is being put on the market by Messrs. Eyre & Spottiswoode, Great New-street, London, E.C. It consists of a small straight-edge and a set square, and a pin on the latter slides in a slot in the former. There are two stops on the straight-edge, one adjustable and the other fixed. By moving the set square and straight-edge alternately a series of parallel lines may be drawn.

**Catalogues, &c.**—From the British Electric Transformer Co., of Hayes, Middlesex, we have to acknowledge a handsomely-bound volume of the 1906 issue of Whitaker's famous Almanac. For several years past we have commended the company's excellent method of advertising their specialities, and at the same time providing their friends with an acceptable volume.

"Electric Train Lighting" forms the subject of a well got-up pamphlet just issued by Mather & Platt, Manchester. Some time back in *The Electrician* an article describing the Rosenberg train lighting system was published, and this article forms the concluding section of the pamphlet under notice. A very complete specification of the Mather & Platt system of electric train lighting (which embraces the Rosenberg patents) is given.

The Newcastle-on-Tyne Electric Supply Co. have sent us a seasonal pictorial representation of the Christmas fireside, in which the electric radiator usurps the place of the out-of-date coal fire. The "chimney corner" in the picture looks beautifully radiant, and the glow of Yuletide is upon all assembled within the family circle.

Third-rail insulators manufactured by the Reconstructed Granite Co., New York, are described in a pamphlet just to hand. The accompanying Fig. A shows the "Courtenay" type of insulator made in various sizes by this company, whose insulators have been employed on a number of lines in this country, including the Wolverhampton tramways (surface-contact system), Lancashire & Yorkshire Railway, North-Eastern Railway and Metropolitan District Railway. The bar type of insulator for signalling systems, travelling cranes, &c., and which can be placed either vertically or horizontally, is shown in Fig. B.

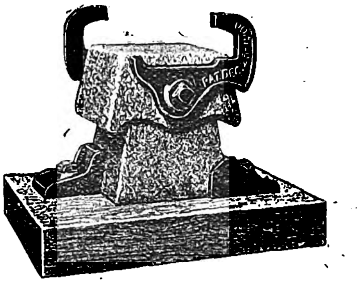

FIG. A.—RECONSTRUCTED GRANITE CO.'S "COURTENAY" THIRD-RAIL INSULATOR.

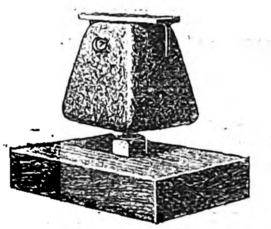

FIG. B.—THE SAME CO.'S T BAR-TYPE INSULATOR.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Dec. 20 to Dec. 22, with the ports of destination :—

*Africa.*—Alexandria, £72; Cape Town, £398; Delagoa Bay, £1,855; Durban, £5,826; East London, £67; Port Elizabeth, £403. *Argentina*—Buenos Ayres, £1,533 (including £380 telegraph material). *Australasia*—Adelaide, £107; Melbourne, £161; Otago, £72; Perth, £36; Sydney, £436; Wellington, £167. *Belgium*—Brussels, £10; Ostend, £7. *China*—Shanghai, £91. *Denmark*—Copenhagen, £17. *France*—Boulogne, £80; Le Treport, £30. *Germany*—Bremen, £370. *India*—Bombay, £635; Calcutta, £3,704; Madras, £248. *Italy*—Genoa, £17. *Japan*—Yokohama, £643. *North Atlantic*, £4,550. *Portugal*—Lisbon, £10. *Spain*—Malaga, £20. *Straits Settlements*—Penang, £130; Singapore, £98. *Turkey*—Constantinople, £37 (telegraph material). *West Indies*—Trinidad, £6. Total (for three days) £21,836, against £7,933 in the corresponding three days last year (Dec. 21 to 23).

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specification. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

November 10, 1905.

23,085 DEUTSCHE TELEPHONWERKE R. STOCK & CO. G.M.B.H. Systems of connections for telephone offices with separated plug-service and group calling. (Date applied for Nov. 10, 1904.)*†
23,097 SIEMENS & HALSKE A.-G. Incandescent bodies for electric light. (Date applied for, Nov. 15, 1904.)*†
23,098 SIEMENS & HALSKE, A.-G. Glow lamps, with incandescent bodies of tungsten molybdenum or similar metals. (Date applied for, Nov. 15, 1904.)*†
23,099 MILLS & HUMBY. Telephony and telegraphy without wires.
23,130 SMITH. Electrical cables.
23,132 SIMMS & BOSCH. Magneto-electric ignition for internal combustion engines.*
23,138 METALS CORPN. & COWPER-COLES. Electrolytic refining of copper.

November 11, 1905.

23,153 CHAPMAN. Electric current transformer.
23,172 PIEPER. Electro-mechanical propulsion of automobiles. (Date applied for, Sept. 29, 1905.)*†
23,197 SCHOFIELD. Control of distant levers and switches by electricity.*
23,211 THOMPSON. (Gesellschaft für drahtlose Telegraphie m.b.H., Germany.) Producing electric vibrations of different phase.*
23,221 GREETHAM. Electrical fog-signalling apparatus.

November 13, 1905.

23,241 BROOKING. Laying electric conductors.
23,261 LACEY. Folding platform step for tramcars.
23,267 POLE. Momentum engine and electrical self-generation dynamo and motors.
23,291 BELLISS & MORCOM & JUDE. Turbines for expansible fluids.
23,309 PECKHAM. Tramway, railway or like vehicles.
23,312 COWPER-COLES. Electrodeposition of copper and other metals.
23,313 COWPER-COLES. Removing electrodeposited cylinders from mandrels.
23,320 MILLINGTON & MILLER. Sockets for electric lamps, plugs, &c.

November 14, 1905.

23,328 Hoar. Electrical conduit tubing joints.
23,379 Smith. Pendants for electric lamps.
23,400 Belliss & Morcom & Jude. Turbines.*
23,402 Girod. Electric furnaces. (Date applied for, Dec. 24, 1904.)*†
23,416 Hill & Tollemache. Turbines.

November 15, 1905.

23,437 and 23,442 B.T.-H. Co. (G.E Co., U.S.) Incandescent lamps.
23,438 and 23,440 B.T.-H. Co. (G.E. Co., U.S.) Electric distribution systems.
23,439 B.T.-H. Co. (G.E. Co., U.S.) Heat radiators.
23,441 B.T.-H. Co. (G.E. Co, U.S.) Electric railways.
23,446 Dentith & Midgley. Divers' and miners' electrical lamp.
23,447 Dentith & Midgley. Electric lamp for photographing in the dark.
23,449 Swinburne. Electric working of mine shafts.
23,451 Taylor. Combined electric and automatic lock.
23,474 Roberts & Jaffray. Electrodeposition of metals.
23,526 Platschick. Electrical furnaces.

November 16, 1905.

23,547 Mills & Paine. Fixing grooved casing covers in electric wiring.
23,553 Veritys Limited & Horsch. Electric motors and similar dynamo-electric machines.
23,561 Hookham. Electricity motor-meters.
23,569 Bailey, Plews & Anderson. Accumulators.
23,582 McGeoch & Co. & Barber. Switches.
23,584 Howell & Richardson. Electric driving of machinery.
23,595 Paul. Road contact system of electric traction.
23,624 Felten & Guilleaume-Lahmeyer-werke A.-G. Electric circuit breakers. (Date applied for, Dec. 22, 1904.)*†

November 17, 1905.

23,656 Broadbent. Electric roller for electric stop-motion frames.
23,661 Arnold & La Cour. Regulating speed of compensated single-phase motors. (Date applied for, Nov. 21, 1904.)*†
23,662 Robinson. Expanding terminal connection for cables.
23,720 Zani. Transformers.*
23,722 Deutsche Telephonwerke R. Stock & Co., G.m.b.H. Connections for telephone offices with separated plug-service and means for signalling. (Date applied for, Nov. 17, 1904.)*†
23,728 Simmonds. Shade holders for incandescent lamps.
23,738 Mavor & Mavor & Coulson. Commutators.
23,751 Scott. Brush contacts for switches.
23,753 Rudd. Electrical apparatus for regulating clocks.

November 18, 1905.

23,756 Hill. Junction box for electric cables.*
23,803 Oppermann. Electrically-propelled vehicles.
23,838 B.T.-H. Co. (G.E. Co., U.S.) Apparatus for changing frequency of alternating currents.
23,839 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.

November 20, 1905.

23,863 Esser. Advertising device for electrical station indicators.*
23,878 Bastians. Locking device and electric coupling for arc lamps. (Date applied for, Jan. 6, 1905.)*†
23,889 Newton. (Klewe & Co., G.m.b.H., Germany.) Automatically cutting off current from electrically heated apparatus at any desired temperature.
23,894 B.T.-H. Co. & Wallace. Switches.
23,904 Felten & Guilleaume-Lahmeyerwerke A.G. Monophase electric motors. (Date applied for, Nov. 21, 1904.)*†
23,922 Chilton & Brush Electrical Engineering Co. Turbines.
23,934 Boult (Woodbridge, U.S.). Electrical distribution systems.*

November 21, 1905.

23,958 Elphinstone. Recording instruments.
23,976 Phoenix Dynamo Mfg. Co. & Pohl. Combined electric motors and air compressors.
23,997 Siemens Bros. & Co. & Grimston. Telegraphy.
24,024 B.T.-H. Co. (G.E. Co., U.S.) Controlling self-exciting generators.
24,025 B.T.-H. Co. (G.E. Co., U.S.) Vapour electric apparatus.

November 22, 1905.

24,058 Mountain, Gibson & Head. Elastic suspension devices for electric motors of tramcar and like trucks.
24,061 Bevis & Angold. Arc lamps.
24,063 Hilliard. Magnetic handles for steel instruments.
24,106 Braun. Operating rotating apparatus by single-phase commutator motors supplied for polyphase circuits.
24,115 Fougerat. Pirn carrying tubes of electric weft protectors.
24,139 Guillou. Magneto or dynamo-electric machines.
24,141 Parsons & Law. Dynamo-electric machines.

November 23, 1905.

24,158 Merritt. Prepayment mechanism and switch for prepaying rentals or instalments for hire purchase of electric apparatus or wiring.
24,162 Hudson. Obstruction removers applicable to electric tramcars.
24,183 Imeson. Controller finger contact for electrical work.
24,184 Newton. Automatic life-guard for overhead wires.
24,187 Large. Control of electromagnetic power hammers, &c.*
24,197 Stewart. Control of electric motors used with storage batteries.
24,200 Benard. Devices for electrically lighting inverted gas burners. (Date applied for, Nov. 26, 1904.)*†
24,205 Chilton & Brush Electrical Engineering Co. Turbines.
24,235 B.T.-H. Co. (G.E. Co., U.S.) Electric motor controlling devices.
24,236 B.T.-H. Co. (G.E. Co., U.S.) Improvements in and relating to electric switches.
24,240 Adams. Bracket for supporting electric lamps.

November 24, 1905.

24,249 Charles & Watson. Electrical contact breakers of explosion engines of motor vehicles.
24,265 de Macedo. Double-decked tramcars.
24,268 Peddie. Conduit for laying electric conductor for tramways.
24,280 Sykes, Hollins & Leake. Electric interlocking of railway signals.
24,281 Sykes, Hollins & Leake. Improvements in electrical block indicators for railway gate crossings.
24,293 Roos. Contact breaking devices for magneto-electric ignition.*
24,302 Tourtel. Automatically actuating switches for regulating supply of electricity at different rates.
24,303 Tourtel. Switch-releasing mechanism for coin-freed electricity meters.
24,316 Jevons. Electrical generators or motors.
24,323 Penniket. Mechanical and electrical register counting entries through turnstiles and recording them at a distance.
24,325 Boult (Knight, U.S.). Electric conductors.
24,339 Dawson & Pyne. Junction boxes for electric cables.

November 25, 1905.

24,383 Hirst & Brook. Switches.
24,403 British Westinghouse Electric & Mfg. Co. (Westinghouse Electric & Mfg. Co., U.S.) Controlling electric circuits.
24,421 Torda. Dynamo-electric machines.

November 27, 1905.

24,452 Harrison. Incandescent lamps.
24,461 Routledge. Electric conduits.
24,475 Anderson & Anderson. Carrying and suspending globes for inverted incandescent lamps.*
24,482 Skwirsky. Incandescent lamps.
24,494 Sykes, jun., Hollins & Leake. Electrically-driven mechanism clockwork.
24,502 Blondel. Arc lamps.*
24,507 Teichner. Electrolytically producing peroxide of hydrogen.*
24,518 Dahl. Self-generating steam or hot-air power electric machine.
24,538 Howorth. (Heirs of Carl Kellner, Germany.) Electrodes for electrolytic apparatus.
24,539 B.T.-H. Co. (G.E. Co., U.S.) Electric demand indicators.

November 28, 1905.

24,605 Kamm. Printing telegraphs.
24,611 Sykes, jun., Hollins & Leake. Twin rail contacts operated by railway vehicles for signalling, &c., on railways.
24,621 Gianoli. Electro-magnetic generators. (Date applied for 2/12/'04).*†
24,642 Daveluy. Ignition plugs. (Date applied for Dec. 5, 1904.)*†
24,644 Ullmann & Hardisty. Renewable head rail for tramways, &c.

## SPECIFICATIONS PUBLISHED, price 8d. each.

### 1904 Specifications.

25,647 Stone. Space telegraphy. (Date applied for, Nov. 25, 1903.)
26,174 B.T.-H. Co. (G.E. Co., U.S.) Transformers.
27,401 B.T.-H. Co. (G.E. Co, U.S.) Electric motor control systems.
28,175 Baynes. Electric tramways and railways.
28,827 Stone. Bolometers and space telegraphy. (Date applied for, Feb. 15, 1904.)

### 1905 Specifications.

617 Phillips. Splicing ear for trolley wires or the like.
1,391 Jackson. Controllers for apparatus operated by alternating currents. (Date applied for, June 6, 1904.)
2,194 Wenham. Inspection-boxes for electric-light leads and the like.
2,766 Major, Stevens & Stevens. Locks and switches for gates of electric lifts.
3,009 Fell & Rider. Electric tramway conduit systems.
3,125 Jones. Electric motor starters.
5,197 Byng & Coates. Switches.
5,295 Ibbetson. Electromagnetic pump.
7,240 Emmet. Governing mechanism for turbines. (Date applied for, April 5, 1904.)
8,000 Fox & Pearson. Automatic fire alarm system.
8,267 Russo & Feinstein. Electrically recording weights lifted.
8,789 Grisson. Safeguarding electric unipolar cells.
8,921 Campbell & Stephens. Contact boxes for surface-contact railways.
10,581 Joksch, Petrik, & Butta. Operating points on electric railways.
11,301 Cie. Thermo-Electrique (Systeme Hermite) Soc. Anon. Couples for sulphide of copper thermo-electric generators. (Date applied for, May 3, 1905).
11,336 Kingsbury. (Western Electric Co.) Supporting and enclosing telephone and other electrical apparatus.
11,337 Kingsbury. (Western Electric Co.) Safety apparatus for use with electrical apparatus.
11,441 Elektrizitäts-Akt.-Ges. vorm. W. Lahmeyer & Co. Limiting speed of compensated single-phase alternate-current motors. (Date applied for, July 30, 1904.)
13,062 Tweedy. Insulators of electric railways, &c.
13,327 Hancock. Responders for wireless telegraphy.
13,588 Siemens Bros. & Co., & Berry. Commutators.
13,589 Siemens Bros. & Co., & Berry. Cooling commutators of dynamos.
13,590 Siemens Bros. & Co. (Siemens Schuckertwerke, G.m.b.H.) Switches for coin-freed mechanisms.
13,707 B.T.-H. Co. (G.E. Co., U.S.) Fluid pressure brake systems.
13,708 B.T.-H. Co. (A.E.G.) Dynamo-electric machines.
13,953 Harrison. (Electric Railway Improvement Co.) Electrical recording devices.
13,964a Corkhill. Electric lighting installations. (Date applied for, July 6, 1905.)
14,211 Siemens-Schuckert-Werke G.m.b.H. Starting apparatus with controller drum for induction motors. (Date applied for, 3/8/1904.)

14,222 B.T.-H. Co. (G.E. Co., U.S.) Suspending electric motors of electric vehicles.

14,314 MAJORANA. Microphone apparatus for telephone and other circuits.

14,465 HARRISON (Electric Railway Improvement Co.) Controlling and recording apparatus for electrical indicating instruments.

14,569 WARWICK MACHINERY Co. (G.E. Co., U.S.) Buckets for turbines.

15,055 GANZ & CO., EISENGIESSEREI UND MASCHINEN-FABRIKS A.G. Extracting metals by electrolytics. (Date applied for, Aug. 26, 1904.)

15,257 GARDINER & STRINGFIELD. Storage battery electrodes.

15,290 JACOBSEN. Transportable telephone apparatus. (Date applied for, Dec. 16, 1904.)

15,298 and 15,299 JONES. Multiple telegraphy.

15,836 YORKE. Electric wiring.

16,024 LEAN. (Deutsche Telephonwerke R. Stock & Co. G.m.b.H.) Telephone office systems.

16,080 DAVIS. Interrupters for electric circuits.

16,518 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.

16,773 SIEMENS BROS. & Co. (Siemens Schuckertwerke G.m.b.H.) Revolving field magnets.

17,032 THOMPSON. (Firm Reiss & Klemm.) Electric fans.

17,079 SCHNEIDER. Receivers for electric waves.

17,084 SIEMENS SCHUCKERTWERKE G.M.B.H. Electric train lighting systems. (Date applied for, Aug. 25, 1904.)

17,223 HARRISON. Wireless telegraphy. (Date applied for, Aug. 26, 1904).

17,243 ARON. Electricity meters.

17,302 CUTMORE & TELAUPAD SYND. (LTD.) Telephone or like transmitters.

17,433 LAMBERT. Fittings and accessories for incandescent lamps.

17,873 BRIGGS. Signalling by electro-magnetic waves. (Secret document.)

17,974 SIEMENS BROS. & Co. & NEALE. Joints for cables.

18,401 SIEMENS BROS. & Co. (Siemens Schuckertwerke G.m.b.H.) Continuous-current dynamo-electric machines.

18,432 LEWY. Electric lighting apparatus for cycles.

19,116 ROLLAND. Electrically welding metal wires, cables, &c.

20,053 SIEMENS SCHUCKERT-WERKE G.M.B.H. Winding revolving field magnets. (Date applied for, Nov. 12, 1904.)

20,100 "POLYPHOS" ELECTRIZITÄTS G.M.B.H. Röntgen-ray tubes. (Date applied for, Oct. 5, 1904.)

20,898 RÜBER. Electrolytic apparatus. (Date applied for, Oct. 15, 1904.)

22,460 YASUDA. Electrodes. (Date applied for, Jan. 21, 1905.)

## NEW COMPANIES, STATUTORY RETURNS,

### NEW COMPANIES.

**W. BATH & SON (LTD.)** (86,938.)—Reg. Dec. 20, capital £50,000 in £1 shares (25,000 cumulative preference), to carry on the business of manufacturers, constructors, designers, users, buyers, sellers, letters to hire, and dealers in engines, motors, locomotives, carriages or vehicles of all kinds, engineers, machinists, boiler makers, &c. First directors are H. W. Sale, W. B. Bath and W. Savage. Reg. office, 25, Victoria-street, Westminster, S.W.

**BUENOS AYRES GRAND NATIONAL & LA CAPITAL TRAMWAYS JOINT COMMITTEE (LTD.)** (86,923.)—Reg. Dec. 20, capital £1,000 in £1 shares, to acquire lands, buildings and property in the Argentine Republic, to erect workshops, repairing and stabling sheds, buildings, plant and appurtenances, to adopt certain agreements, to acquire and carry out concessions for tramways, railways and other public works, to construct, equip and work tramways, to carry on the business of tramway, railway and omnibus proprietors, carriers, electrical engineers and contractors, constructors of power-houses, dynamos, engines, batteries, lamps, motors, converters, meters and other electrical plant, suppliers of electricity, &c. The subscribers are: J. Irving Courtenay, C. M. Rose, H. M. Cohen, W. A. Paine, T. F. Thomson (civil engineer), A. S. Jecks, F. Thursby and H. W. Johnson. The Buenos Ayres Grand National Tramways Co. and La Capital Tramways Co. may each appoint two directors, and the four directors so appointed may appoint a fifth.

**G. & A. J. CROSS (LTD.)** (86,950.)—Reg. Dec. 21, capital £1,000 in £1 shares, to acquire business carried on as G. & A. J. Cross, and to carry on the business of electricians, electrical, mechanical and motor engineers, suppliers of electricity, &c.

**T. HOOD & CO. ((LTD.)** (86,900.)—Reg. Dec. 18, capital £2,000 in £1 shares (800 6 per cent. cumulative preference), to acquire business carried on as Drewett & Hood, to act as factors and agents to manufacturing engineers, and to carry on the business of electricians, mechanical engineers, suppliers of electricity, manufacturers of and dealers in apparatus used in connection with generation, distribution, supply, accumulation and employment of electricity, &c. First directors are H. Drewett and T. Hood (both permanent). Reg. office, 26, Bath-street, Bristol.

**RANGOON ELECTRIC TRAMWAY & SUPPLY CO. (LTD.)** (86,932.)—Reg. Dec. 20, capital £500,000 (7,500,000 rupees) in 500,000 6 per cent. cumulative preference shares of £5 each (75 rupees) and 250,000 ordinary shares of £1 each (15 rupees), to acquire the existing Rangoon steam tramways, the Rangoon Tramways Order, 1905, the Rangoon Municipal electric and electric traction licences and the Rangoon Cantonment electric traction licence granted in 1905 by the Governments of India and Burma, to supply electricity, to electrically work the said tramways within the Municipality and Cantonment of Rangoon, and to act as electricians and tramway and railway proprietors generally. First directors, F. Tobin, S. Balthazar, J. Halliday, James Taylor, J. W. W. Danson and J. W. Darwood. Secretary (pro tem.) and reg. office, A. Goodlet, 16-18, Dale-street, Liverpool. Rangoon office, J. W. Darwood & Co., Lower Kemendine-road, Rangoon.

**SHARER & YOUNG (LTD.)** (6,038.)—Reg. in Edinburgh on Dec. 21, capital £20,000 in £1 shares, to manufacture, buy, sell and let out on hire gas and oil engines, electric generators and motors, to carry on the business of founders and metal workers, mechanical, electrical and consulting engineers, &c. First directors are A. Sharer and J. Young. Reg. office, 190, W. George-street, Glasgow.

### STATUTORY RETURN.

**DEWHURST'S ENGINEERING CO. (LTD.)**—Return to Oct. 20 gives capital as £10,000 in 2,000 preference and 8,000 ordinary shares of £1 each, of which 2,000 preference and 1,007 ordinary have been taken up. £1 per share has been called up and £3,007 has been received. Mortgages and charges, £9,400.

## CITY NOTES.

**MEMORANDA** (Dec. 28).—Bank rate 4 per cent. since (Sept. 28, 1905). Price of silver 30d. per oz. Consols $89\frac{1}{8}$—$89\frac{1}{4}$ for money, $89\frac{3}{16}$—$89\frac{5}{16}$ for account; $2\frac{1}{2}$ per cent. annuities $88\frac{1}{8}$—$88\frac{3}{8}$. Consols Pay Day, Jan. 4. Stocks and Shares Continuation Day, Jan. 9; Ticket Days, Jan. 10 and 24. Pay Days, Dec. 29 and Jan. 11; Mining Share Carry-over Day, Jan. 8.

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**ANGLO-ARGENTINE TRAMWAYS CO. (LTD.)**—Debenture interest warrants for the second half of 1905 will be posted to-day (Friday), and warrants for the preference dividend for the same period on 30th inst.

**BURMAH ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.)**—Mr. E. C. Morgan, at the meeting last week, in moving the adoption of the report for the year ended July 31 last, said the traffic receipts were £13,777, received from 2,807,287 passengers, the car miles run being 553,494. They had spent £11,329, leaving a surplus of £2,457. Fuel expenses were high (£2,075); they were obliged to keep their furnaces going with wood, which was the only fuel available. They were, however, informed that they might shortly expect to obtain good coal from fields which are being exploited on the Chindwin River, not far from Mandalay. The traffics were now showing appreciable increases. They were considering the question of constructing a line from the Zegyo Bazar, Northwood, to the municipal limit. If that scheme were carried out it would be necessary to raise money by debentures.

**DELAGOA BAY DEVELOPMENT CORPN. (LTD.)**—At the meeting last week Mr. J. C. A. Henderson said the tramways were at present the least satisfactory of the company's works. Expenses were being reduced and they hoped that before long receipts would exceed expenses. They had to contend with racial prejudices; whites would not ride with yellows or blacks, and those difficulties had to be overcome by running separate cars for each colour, which meant a tremendous increase in staff and working expenses. During the year ended June 30 they carried 721,078 passengers and 287,519 car-miles were run. The freight traffic was a promising feature, and would, he thought, steadily increase. They had called in the assistance of Messrs. Mordey & Dawbarn, consulting engineers, and within the past months these gentlemen had furnished a preliminary report. A member of the firm was at present in South Africa, and after the directors had received a further report from him they would determine the best course to follow.

**DIESEL ENGINE CO. (LTD.)**—The chairman (Mr. G. C. Ellis), at the meeting last week, stated that since the adjournment of the last general meeting they were fortunate in obtaining the services of Mr. T. Browett as manager, and since his appointment orders had increased very considerably; indeed, the orders which Mr. Browett had got for the company were somewhat phenomenal compared with those formerly received. They included orders from the Indian and Japanese Governments, and inquiries had come in from all directions which were certain to lead to good business. From March 31 to date they had received orders for 5,635 H.P., compared with 2,595 H.P. in the corresponding period of last year. In the past they had had trouble with some of the engines first delivered, but that was due to no fault of the company. Trials which had since been conducted by the makers, under the guidance of the company's engineer and manager, had proved very successful. The faults had all been overcome and adjusted. At present experiments were going on which they had every reason to believe would be successful, with a view to the introduction of a two-stroke engine, to cost considerably less per horse-power than the old types of engines. The space occupied by the new engine would be about the same, but its power would be doubled and there would be a saving of some 25 per cent. in weight. The patents for those two-stroke engines had either been obtained or applied for in Germany. Difficulty was sometimes experienced in selling the engines in this country owing to their being made in Germany and elsewhere. The Government, for instance, naturally preferred to have English engines; indeed, they insisted upon them. The directors had therefore been in negotiation with Messrs. Willans & Robinson, of Rugby, with the result that a contract had been entered into which the board considered would be a very profitable one for the company. No engines had as yet been made for the company by Messrs. Willans & Robinson, because considerable preparation was necessary.

**DOUGLAS SOUTHERN ELECTRIC TRAMWAYS (LTD.)**—At the meeting last week the directors reported that the total receipts for the season were £5,106, against £4,785 in 1904. The net profit was £1,744, against £1,681

**NEW BROTHERTON TUBE CO. (LTD.)**—There was a loss on the past year's trading of £405, and after deducting amounts written off for depreciation of plant, maintenance of buildings, &c., the debit is £2,477. From this has to be deducted the balance brought forward, and it is proposed to transfer £2,000 from reserve to meet the deficiency, leaving a credit of £12 after placing £500 to reserve.

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. | | |
|---|---|---|---|---|---|---|
| | | | | No. of weeks. | Amount. | Inc. or Dec. (a) |
| | | £ | £ | | £ | £ |
| Aberdeen Corporation | Dec. 23 | 1,236 | + 53 | 30 | 42,409 | − 1,186 |
| Airdrie | ,, 15 | 214 | + 41 | 50 | 10,329 | + 272 |
| Anglo-Argentine | ,, 23 | 15,656 | + 1,904 | 50 | 690,952 | + 42,763 |
| Ayr Corporation | ,, 23 | 187 | + 9 | 31 | 10,385 | − 121 |
| Barcelona Trams Co. | ... | ... | ... | ... | ... | ... |
| Barcelona, Ensanche, Gracia | ... | ... | ... | ... | ... | ... |
| Barnsley | ,, 15 | 154 | + 7 | 50 | 8,028 | − 321 |
| Barrow | ,, 15 | 200 | + 20 | 50 | 11,964 | + 2,252 |
| Bath Electric Trams, Ltd. | ,, 20 | 682 | + 65 | 51 | 34,689 | + 2,431 |
| Birkenhead | ... | ... | ... | ... | ... | ... |
| Birmingham Corporation | ... | ... | ... | ... | ... | ... |
| *Birmingham & Mid. | ,, 15 | 1,851 | − 206 | 50 | 78,410 | − 533 |
| Blackpool Corporation | ,, 21 | 288 | + 12 | 25 | 44,948 | + 1,801 |
| Blackpool and Fleetwood | ,, 23 | 187 | + 5 | 25 | 19,996 | − 1,103 |
| Bolton Corporation | ,, 24 | 1,875 | + 249 | 39 | 74,893 | + 3,294 |
| Bournemouth Corporation | ,, 20 | 1,223 | + 366 | †37 | 53,763 | + 11,200 |
| Bradford Corporation | ... | ... | ... | ... | ... | ... |
| Brighton Corporation | ,, 24 | 677 | + 25 | 39 | 39,861 | + 479 |
| Bristol Trams & Carriage | ,, 22 | 5,109 | + 33 | 19 | 57,626 | + 1,240 |
| Buenos Ayres & Belgrano | ,, 24 | 3,623 | + 307 | 51 | 177,417 | + 10,354 |
| Buenos Ayres Elec. Trams | Nov. 25 | 1,314 | ... | 47 | 55,794 | ... |
| Burnley Corporation | Dec. 23 | 1,121 | + 189 | 38 | 52,519 | + 2,687 |
| Burton Corporation | ,, 24 | 822 | + 60 | §38 | 12,000 | − 1,378 |
| Bury Corporation | ,, 17 | 724 | ... | §37 | 27,708 | ... |
| Calcutta Tramways Co. | ,, 23 | R47,324 | + R4,228 | 25 | R1,083,948 | + R180,450 |
| Camborne-Redruth | ... | ... | ... | ... | ... | ... |
| Cardiff Corporation | ... | ... | ... | ... | ... | ... |
| Carlisle Tramways Co. | ,, 23 | 180 | + 6 | 51 | 9,280 | − 661 |
| Central London Railway | ,, 23 | 7,398 | + 346 | 25 | 160,187 | − 922 |
| Chatham & Dist. Lt. Rys. | ,, 21 | 603 | + 107 | 51 | 33,196 | + 3,619 |
| City of Birm'gh'm Tram Co. | ,, 15 | 5,144 | − 337 | 50 | 267,642 | − 141 |
| City & South London Rly. | ,, 24 | 8,044 | − 723 | 25 | 66,424 | − 180 |
| Colchester Corporation | ,, 21 | 147 | − 21 | 21 | 5,375 | − 1,852 |
| Cork Electric Trams Co. | ,, 21 | 443 | − 8 | 51 | 21,403 | + 638 |
| Devonport & Dist. Trams | ,, 15 | 408 | − 39 | 50 | 22,822 | − 3,418 |
| Dover Corporation | ,, 23 | 209 | + 17 | 38 | 8,807 | − 27 |
| Dublin & Lucan Railway | ,, 22 | 108 | + 2 | 25 | 3,091 | − 29 |
| Dublin United | ,, 22 | 5,100 | + 117 | 25 | 126,434 | − 3 |
| Dudley—Stourbridge | ,, 15 | 760 | + 26 | 50 | 44,538 | + 1,609 |
| Dundee Corporation | ,, 20 | 939 | + 124 | §31 | 28,690 | + 1,866 |
| East Ham Council | ,, 23 | 858 | + 294 | 38 | 31,660 | + 8,951 |
| Gateshead & Dist. Trams | ,, 15 | 923 | + 65 | 50 | 46,159 | + 1,087 |
| Glasgow Corporation | ,, 23 | 15,837 | + 1,770 | 30 | 459,299 | + 26,711 |
| Glossop | ... | ... | ... | ... | ... | ... |
| Gloucester Corporation | ,, 20 | 225 | + 5 | 38 | 11,344 | ... |
| Gravesend—Northfleet | ,, 15 | 182 | + 5 | 50 | 11,474 | − 831 |
| Gt. Northern & City Rly. | ,, 23 | 1,899 | + 27 | 25 | 39,691 | + 8,118 |
| Greenock & Port Glasgow | ,, 15 | 537 | + 91 | 50 | 32,087 | + 3,578 |
| Halifax Corporation | ,, 20 | 1,372 | + 222 | 38 | 60,617 | + 4,031 |
| Hartlepool Tramways | ,, 15 | 240 | + 8 | 50 | 13,299 | − 1,176 |
| Hastings Elec. Trams Co. | ,, 21 | 355 | ... | 20 | 10,357 | ... |
| Huddersfield | ... | ... | ... | ... | ... | ... |
| Hull Corporation | ,, 23 | 2,408 | + 116 | 38 | 84,987 | + 976 |
| Ilford Dist. Coun. | ,, 23 | 455 | + 85 | 38 | 18,216 | + 581 |
| Ipswich Corporation | ,, 23 | 372 | + 26 | 38 | 16,780 | − 1,812 |
| Isle of Thanet Co. | ,, 23 | 247 | − 13 | 12 | 3,303 | − 463 |
| Kidderminster & District | ,, 15 | 88 | − 5 | 50 | 5,983 | − 339 |
| Kilmarnock Corporation | ... | ... | ... | ... | ... | ... |
| Kirkcaldy Corporation | ,, 20 | 200 | + 7 | 16 | 3,217 | − 84 |
| Lanarkshire Trams Co. | ,, 21 | 844 | + 247 | 51 | 36,455 | + 5,296 |
| Leamington | ,, 15 | 121 | + 44 | 22 | 4,010 | + 1,459 |
| Leeds Corporation | ,, 23 | 5,994 | + 709 | 38 | 231,043 | + 6,632 |
| Leicester Corporation | ,, 23 | 2,209 | + 427 | 51 | 105,509 | + 30,624 |
| Liverpool Corporation | ,, 16 | 10,237 | + 116 | 50 | 527,277 | + 10,662 |
| Liverpool Overhead Rly. | ,, 24 | 1,479 | − 16 | 25 | 38,931 | − 1,666 |
| *London County Council | ,, 16 | 12,809 | + 353 | 37 | 549,326 | + 74,507 |
| Lowestoft | ,, 23 | 161 | + 21 | 12 | 1,801 | − 17 |
| Maidstone Corporation | ,, 21 | 84 | − 8 | 33 | 4,800 | ... |
| Manchester Corporation | ,, 23 | 13,459 | + 2,436 | 38 | 493,145 | + 24,257 |
| Mersey Railway | ... | ... | ... | ... | ... | ... |
| Merthyr | ,, 15 | 170 | − 1 | 50 | 9,423 | − 518 |
| *Metropolitan Elec. Trams | ,, 15 | 2,513 | + 702 | 50 | 132,897 | + 35,805 |
| Middleton | ,, 15 | 278 | + 81 | 50 | 16,802 | + 795 |
| Musselburgh | ... | ... | ... | ... | ... | ... |
| Nelson Corporation | ,, 23 | 181 | + 28 | 39 | 5,118 | + 517 |
| Newcastle-on-Tyne Corp. | ,, 23 | 4,067 | + 330 | 38 | 145,327 | + 3,619 |
| Newport (Mon.) | ... | ... | ... | ... | ... | ... |
| Northampton Corporation | ,, 22 | 869 | + 82 | 37 | 15,712 | + 4,905 |
| Oldham, Ashton & Hyde | ,, 15 | 529 | + 45 | 50 | 27,816 | + 822 |
| Oldham Corporation | ,, 24 | 1,666 | + 408 | 39 | 64,121 | + 16,081 |
| Perth (W. A.) Elec. Trams. | ,, 22 | 1,093 | + 173 | 51 | 70,661 | + 4,206 |
| Peterborough | ,, 15 | 92 | − 11 | 50 | 6,062 | − 689 |
| Pontypridd Dist. Council | ... | ... | ... | ... | ... | ... |
| Potteries | ,, 15 | 1,779 | + 109 | 50 | 85,825 | + 1,134 |
| Preston Corporation | ,, 20 | 495 | ... | 12 | 6,957 | ... |
| Reading Corporation | ,, 21 | 597 | + 14 | ... | ... | ... |
| Rotherham Corporation | ... | ... | ... | ... | ... | ... |
| Rothesay | ,, 15 | 89 | + 10 | 50 | 9,581 | + 2,698 |
| Salford Corporation | ... | ... | ... | ... | ... | ... |
| Sheerness | ,, 13 | 46 | − 11 | 50 | 8,425 | + 259 |
| Sheffield Corporation | ,, 24 | 5,290 | + 825 | 39 | 192,624 | + 10,188 |
| Southampton Corporation | ,, 20 | 878 | − 22 | 11 | 9,965 | − 338 |
| Southend Corporation | ,, 20 | 245 | + 18 | 38 | 14,962 | + 770 |
| Southport Tramways | ,, 15 | 218 | − 6 | 50 | 15,373 | − 549 |
| S. Staffordshire Trams. | ,, 15 | 775 | + 150 | 50 | 37,171 | + 1,950 |
| Stockport Corporation | ... | ... | ... | ... | ... | ... |
| Sunderland Corpn. | ,, 24 | 1,328 | + 125 | 38 | 60,912 | + 1,605 |
| Swansea Trams | ,, 15 | 695 | + 226 | 50 | 36,116 | + 9,401 |
| Swindon Corporation | ,, 13 | 168 | + 26 | 38 | 7,504 | ... |
| | ,, 20 | 118 | + 13 | | | |
| Taunton | ,, 15 | 39 | − 1 | 50 | 2,097 | − 227 |
| Tynemouth and District | ,, 15 | 170 | + 1 | 50 | 12,728 | − 1,589 |
| Tyneside Trams Co. | ,, 20 | 840 | + 10 | 51 | 20,734 | + 1,135 |
| Wallasey District Council | ,, 23 | 767 | + 124 | 38 | 30,063 | + 1,085 |
| Walsall | ... | ... | ... | ... | ... | ... |
| Warrington Corporation | ... | ... | ... | ... | ... | ... |
| West Ham Corporation | ... | ... | ... | ... | ... | ... |
| Weston-super-Mare | ,, 13 | 26 | + 1 | 50 | 6,803 | + 596 |
| Wolverhampton Corpn. | ,, 20 | 760 | ... | 12 | 8,985 | ... |
| Wolverhampton District | ,, 15 | 881 | + 47 | 50 | 19,790 | + 430 |
| *Worcester | ,, 15 | 228 | − 18 | 50 | 14,966 | + 357 |
| Wrexham | ,, 15 | 90 | + 2 | 50 | 5,015 | − 357 |
| Yorkshire W.R. Trams | ,, 24 | 788 | + 359 | 51 | 86,559 | ... |
| Yorkshire Woollen District | ,, 15 | 794 | + 306 | 50 | 83,621 | + 4,880 |

(a) These comparisons are with the corresponding period last year. † Minus 8 days. § Plus 2 days. * Partly electrical.

**POWER GAS CORPN. (LTD.)**—Mr. A. Mond presided at the shareholders' meeting on Tuesday, when it was announced that the late chairman (Sir H. Fowler, M.P.), owing to his having joined the new Cabinet, had resigned. The chairman said that, owing to shortage of turnover at their engineering works, the trading of Ashmore, Benson Pease & Co. resulted in a loss instead of a profit. The South Staffordshire Mond Gas Co.'s station had now been working for some months, and had fulfilled anticipations from an engineering point of view. There were a number of difficulties which had had to be overcome after the plant was started, but they were trifling compared with the magnitude of the scheme. The number of customers was on the increase, and, therefore, he saw no reason why the company should not fulfil the expectations with which it was started. In regard to the power-gas branch, they were doing a large amount of pioneer work, and they were issuing a large number of estimates and doing a large amount of work for which there was no apparent return at present, but for which a return might come at any moment. They were carrying on important negotiations with influential firms for installations to a very large amount. Firms like John Brown & Co., Cammell, Laird & Co., and other firms of similar importance were putting in installations to run their huge shipbuilding yards with gas engines driven by Mond gas. The gas engine had disappointed them, but he only heard that morning that in Germany one firm has no less than eight 4,000 H.P. engines building, and when units of that kind were being built and run it would very greatly facilitate their business in inducing electricity generating station engineers to adopt their system, which was admitted to be the most economical power-producing system in the world for large generating stations.

**ST. HELENS CABLE CO. (LTD.)**—The St. Helens Cable Co. (Ltd.) is being wound up voluntary for the purpose of transferring the entire undertaking to a new company which has been formed to carry on the business. Mr. A. Wenham, 10, Walbrook, London, E.C., is liquidator of the old company

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Dec. 27. | Rate per Cent. Yielded. | | | Dividend Due. | Business, Week to Dec. 27. | |
|---|---|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | £ | s. | d. | | Highest. | Lowest. |
| 5 | 8/0 | Anglo-Argentine Ord. Shares | 8⅜–8⅝ | 4 | 12 | 9 | Ap, Oct | 8 11/32 | .. |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞–6⅛ | 4 | 9 | 8 | – | 5 31/32 | .. |
| St. | 6% | Do. Permanent 6% Deb. Stock | 142–145 | 4 | 2 | 8 | – | .. | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 105–107 | 4 | 13 | 5 | – | .. | .. |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1–1¼ | .. | | | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 4–4¼ | 5 | 18 | 3 | – | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 95–98 | 4 | 12 | 0 | – | .. | .. |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. ....ex rights | 119–122 | 4 | 18 | 4 | – | .. | .. |
| St. | 5% | Do. Pref. Ord. Stk ....ex rights | 107–111 | 4 | 10 | 0 | – | .. | .. |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock | 103–109 | 4 | 11 | 8 | – | .. | .. |
| 40 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs | 103%–105% | 4 | 5 | 9 | – | .. | – |
| 100 | 4½% | Do. Vancouver Power Debs. | 102–105 | 4 | 5 | 9 | – | .. | – |
| 1 | 2/6 | Buenos Ayres and Belgrano Ord. | 8⅞–9⅛ | 5 | 3 | 0 | – | 9½ | 8⅞ |
| 1 | 3/0 | Do. 6 per Cent. "A" Cm. Pref | 5 11/16–5 15/16 | 5 | 2 | 0 | – | .. | .. |
| 1 | 8/0 | Do. "B" | 6–6½ | 5 | 9 | 1 | – | .. | .. |
| St. | 5% | Do. 5 per Cent. Debs. | 107–109 | 4 | 11 | 8 | – | 109 | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102–105 | 4 | 15 | 3 | – | 104½ | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 98–100 | 5 | 0 | 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 101–105 | 5 | 4 | 9 | .. | .. | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 100–104 | 5 | 17 | 0 | .. | .. | .. |
| 5 | 8/6 | Calcutta Tramways (Nos. 1 to 105) | 9¼–9¾ | 4 | 7 | 2 | – | .. | .. |
| 5 | 6/3 | Do. Nos. 105,001 to 137,610 | 8½–9 | .. | | | .. | .. | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 107–109 | 4 | 2 | 7 | – | .. | .. |
| 1 | 0/6 | Cape Electric Tram Shares | ⅞–1⅛ | 4 | 8 | 10 | – | .. | .. |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 102–104 | 4 | 16 | 0 | – | 103 | .. |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 97–99% | .. | | | .. | .. | .. |
| 1 | .. | Lisbon Elec. Trams Ord. | 1 | .. | | | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛–1⅜ | 4 | 7 | 4 | .. | .. | .. |
| 100 | % | Do. 5% Reg. Mort. Debs. | 101–104 | 4 | 16 | 3 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 103–105 | 4 | 15 | 3 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101–104 | 4 | 16 | 2 | – | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102–104 | 4 | 6 | 7 | – | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 104–107 | 4 | 18 | 5 | .. | .. | .. |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 141–144 | 5 | 11 | 0 | .. | 142 | .. |
| .. | 5% | Do. 5% 1st Mt. $500 Dbs. | 97%–99% | 5 | 1 | 0 | .. | 98½ | .. |
| | | **ELECTRICITY SUPPLY.** | | | | | | | |
| 1 | – | Adelaide Elec. S'ply Co. 6% Cu.Pr. | 5–5½ | – | | | .. | – | .. |
| 5 | 3/3 | Calcutta Elec. (1–60,000) | 8¾–9¼ | 4 | 9 | 0 | – | .. | .. |
| 10 | 1% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbr. | 50–52 | 4 | 16 | 1 | .. | .. | .. |
| .. | .. | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 96–98 | .. | | | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½–3 | .. | | | .. | .. | .. |
| St. | 5% | Do. 5% Debs. | 87–92 | 5 | 8 | 8 | .. | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | 9–10 | – | | | – | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92–94 | 5 | 6 | 8 | – | .. | .. |
| St. | .. | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. 50% pd. | 60–62 | .. | | | .. | – | .. |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞–1 | 6 | 0 | 0 | .. | .. | .. |
| 1 | 1/0 | Rand Electric | 1¼–1⅜ | .. | | | – | .. | – |
| 1 | .. | River Plate Electricity Co. Ord. | [illegible] | .. | | | – | – | – |
| 1 | 1/2⅔ | Do. 6% Non. Cum. Pref | 1 3/16–1 5/16 | .. | | | .. | .. | .. |
| St. | 5% | Do. 5% Deb. Stock | 103–105 | 4 | 15 | 0 | .. | .. | .. |
| 5 | 3/0 | Rosario Elec. Co. 6% Pref. (1–12,000) | 5¼–5¾ | 5 | 4 | 4 | .. | .. | – |
| 5 | 9·43d | Do. (12,001–20,000) | 5–5½ | 3 | 8 | 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100–103 | 4 | 7 | 5 | Ap, Oct | .. | ... |
| .. | 10/0 | Shawinigan Water and Power 5% Bds., Scrip | 102–103 | 4 | 17 | 0 | .. | .. | .. |

* In calculating the yield, allowance has been made for accrued interest but not for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Share. | Last Dividend | Name. | Price Wed. Dec. 27. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business, Week to Dec. 27. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| 1 | .. | Bath Elec. Trams Pref. Ord. | 15/16–1 | .. | .. | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1 1/16–1⅛ | 4 14 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 103½–105½ | 4 5 0 | .. | .. | .. |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 103–105 | 4 5 9 | .. | 105¼ | .. |
| 10 | 9% | Bristol Tramways and Carriage Ord. | 17–17½ | 5 2 11 | Feb, Aug | .. | .. |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10⅛–10⅝ | 3 18 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Debs. | 106–107 | 3 14 10 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 7½–8½ | 7 1 0 | – | 8½ | 8 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 10–11 | 5 8 0 | Feb, Aug | 10½ | 10⅜ |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 117–119 | 4 4 0 | .. | 118 | .. |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 97–99 | 4 11 0 | .. | .. | .. |
| St. | 4% | Central London Ordinary Stock | 93–95 | 4 4 0 | June, Dec | 93⅞ | 92⅛ |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 101–103 | 3 17 8 | .. | .. | – |
| St. | 4% | Do. Deferred Stock | 85–88 | 4 11 0 | .. | 86½ | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 111–113 | 3 10 3 | .. | – | .. |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 4⅞–5⅛ | 4 17 6 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 100–103 | 3 17 8 | .. | .. | .. |
| St. | 2% | City and South London Rly. Con. Ord. | 44–46 | 4 1 6 | Feb, Aug | 44½ | .. |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 119–122 | 4 2 0 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 117–120 | 4 3 4 | .. | .. | .. |
| St. | 5% | Do. (1901) | 114–117 | 4 5 6 | – | .. | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 105–108 | 3 14 1 | May, Nov | .. | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13½–14½ | 4 2 8 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½–15½ | 3 17 3 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5–5½ | 7 5 6 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8–9 | 4 8 11 | .. | 8⅝ | 8¹⁄₁₆ |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 101–103 | 4 7 6 | .. | .. | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 17–18 | 5 0 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 13¾–14¼ | 4 4 2 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 112–114 | 3 19 0 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼–2¾ | 9 8 6 | – | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 83–88 | 4 10 11 | – | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8⅛–8⅜ | 3 13 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾–10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99–102 | 3 19 3 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9¾–10¼ | 4 17 6 | – | 10⅛ | .. |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 100–103 | 3 17 8 | – | 101¾ | 100½ |
| St. | .. | Mersey Con. Ord. Stock | 7–9 | – | – | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8–11 | – | – | .. | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32–9/32 | .. | – | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1–1⅛ | 4 14 1 | – | 1¹⁄₁₆ | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106–108 | 4 3 3 | – | .. | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum. Pref. | ½–1½ | .. | May | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾–9¼ | 5 5 8 | .. | .. | .. |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9¾–10¼ | 4 17 6 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103–106 | 4 5 0 | – | .. | .. |
| 100 | .. | Sunderland Dist. Elec. Trams. 5% 1st Mort. Debs. | 95–99 | .. | .. | .. | .. |
| .. | 5% | Underground Elec. Rys. Co. of London | 96½–97½ | 5 2 6 | .. | .. | .. |
| St. | 3% | Waterloo and City Ord. | 94–97 | 3 2 0 | June, Dec | 94 | .. |
| St. | 12/11 | Yorkshire W.R. El. Tr. Co. 4% 1st Debs. | 96–98 | 4 1 6 | .. | .. | .. |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | * African Direct Tel. 4% Mrt. Deb. (red.) | 99–102 | 3 13 5 | Jan, July | – | .. |
| 10 | – | Amazon Telegraph | 3¾–4¼ | .. | Jn, Dec | .. | .. |
| 100 | .. | Do. 5% Debs. (red.) | 85–90 | 5 11 0 | .. | .. | .. |
| St. | 35/0 | Anglo-American | 62–64 | 4 14 0 | F,My,Ag,N | .. | .. |
| St. | 30/0 | Do. Preferred | 109–110 | 5 4 6 | F,My,Ag,N | 110 | 109¾ |
| St. | 2/0 | Do. Deferred | 17⅛–17⅜ | .. | F,My,Ag,N | 17⁵⁄₁₆ | 17¹⁄₁₆ |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 96½–98½ | 4 1 2 | Jn,Ap,Jy,O | 97¾ | .. |
| 10 | 5/0 | Cuba Submarine Ord. | 8½–9 | 5 11 0 | Feb, Aug | .. | .. |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17–18 | 5 11 2 | Feb, Aug | .. | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜–3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 8¾–9¼ | 5 8 0 | April, Oct | .. | .. |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 100%–103% | 4 7 5 | Jan, July | .. | .. |
| 20 | 8/0 | Direct United States Cable. | 14–15 | 4 6 6 | Ja,Ap,Jy,O | 14⅝ | 14½ |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 101–103 | 4 7 6 | Jn, Dec | .. | .. |
| St. | 25/0 | Eastern Ordinary | 144–147 | 4 15 8 | Ja,Ap,Jy,O | 146¾ | 145½ |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 90–92 | 3 16 0 | Ja,Ap,Jy,O | 91¾ | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 106–108 | 3 14 1 | May, Nov | .. | .. |
| 10 | 2/6 | Eastern Extension | 14½–15 | 4 18 4 | Ja,Ap,Jy,O | 14½ | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 106–108 | 3 14 1 | Feb, Aug | 106¾ | .. |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 100–102 | 3 18 8 | Feb, Aug | .. | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 100%–102% | 3 18 8 | May, Nov | .. | .. |
| 10 | 5/0 | G. N. (of Copenhagen) | 36½–38½ | 6 5 0 | Jan, July | 33 | .. |
| 100 | 4½% | Halifax & Bermudas 4½% 1st Mt. Db. (red.) | 101–103 | 4 7 6 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57–59 | 5 10 0 | May, Nov | 57 | .. |
| 100 | $1 | Mackay Companies Common | 60¹⁄₁₆ | 3 17 0 | Jan, July | – | .. |
| 100 | 4% | Do. Preference | 75 | 5 6 6 | Ja,Ap,Jy,O | .. | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1¼–1⅜ | .. | .. | .. | .. |
| 100 | 4% | Pacific & European Tel. 4% Guar. Dbs. (rd.) | 100–103 | 3 17 8 | June, Dec | .. | .. |
| 10 | 4/0 | West African Telegraph Shares | 9½–10 | 5 0 0 | .. | .. | .. |
| 2½ | .. | West Coast of America | ⅞–1⅛ | .. | – | – | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100½–102½ | 3 18 0 | Jan, July | .. | .. |
| 10 | – | West India and Panama | ½–¾ | .. | May, Nov | .. | .. |
| 10 | 6/0 | Do. 6% 1st Pref. | 8¼–8¾ | 6 6 8 | May, Nov | 8½ | 8⅜ |
| 10 | – | Do. 6 per Cent. 2nd Pref. | 6½–7½ | .. | May, Nov | .. | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 101–104 | 4 16 2 | Jan, July | .. | .. |
| 10 | 3/0 | † Western Telegraph | 13¾–14¼ | 4 18 0 | Mr,Jn,O,D | 13⅞ | .. |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 102–104 | 4 16 0 | June, Dec | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 103½–105½ | 3 15 9 | .. | 105 | .. |
| | | **TELEPHONES.** | | | | | |
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 102–104 | .. | .. | – | – |
| 6 | 5/0 | Chili Telephone (fully paid) | 7¾–8 | 5 0 0 | August | .. | .. |
| 1 | 0/9⅜ | Monte Video Telephone Ord. | ⅞–1 | 4 0 0 | – | .. | .. |
| 1 | 1/0 | Do. 6% Pref. | ⅞–1 | 5 0 0 | .. | .. | .. |
| St. | 6% | National Co. Pref. Stock | 110½–111½ | 5 7 7 | – | 111½ | 110½ |
| St. | 5% | Do. Def. Stock | 108–110 | 4 11 0 | .. | 108½ | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13–15 | 4 0 0 | Feb, Aug | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 11–13 | 4 12 4 | Feb, Aug | 12½ | .. |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅝–5⅞ | 4 5 2 | Feb, Aug | .. | .. |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 98½–100½ | 3 9 6 | June, Dec | 100 | 99¾ |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 104–106 | 3 15 6 | .. | .. | .. |
| 1 | 0/7½ | Oriental | 1¼–1⅜ | 3 12 9 | April, Oct | .. | .. |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1¼–1⅜ | 4 7 0 | – | .. | .. |
| St. | .. | Do. 4% Red. Deb. Stock | 97–99 | .. | .. | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 103–106 | 4 4 9 | .. | .. | .. |
| 5 | 5/0 | United River Plate | 7½–8 | 5 0 0 | July | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5½–5¾ | 4 7 0 | June, Dec | .. | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 111–113 | 4 8 6 | June, Dec | .. | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 5–5½ | 5 9 0 | .. | .. | .. |
| 10 | 2/0 | Globe Telegraph and Trust | 10½–10¾ | 5 0 8 | Ja,Ap,Jy,O | 10¾ | 10⁹⁄₁₆ |
| 10 | 2/0 | Do. 6 per Cent. Pref | 14⅛–14⅜ | 4 8 0 | Ja,Ap,Jy,O | .. | – |
| 10 | 6% | Submarine Cables Trust (Cert.) | 125–128 | 4 13 9 | April, Oct | .. | – |

| Share. | Last Dividend | Name | Price Wed. Dec. 27. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Week to Dec. 27. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12¼–12¾ | 5 9 10 | .. | .. | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10⅛–10⅝ | 4 4 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11¾–12¼ | 4 18 0 | .. | .. | – |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 107–109 | 4 2 6 | .. | .. | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼–5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 102–105 | 4 5 9 | – | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 8¾–9¼ | 5 2 6 | .. | .. | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 9–9½ | 3 14 5 | Mar, Sept | – | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 102–105 | 3 16 3 | – | .. | .. |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 5¾–6¾ | 4 16 0 | Feb, Aug | .. | .. |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼–5¾ | 3 18 8 | Feb, Aug | 5⅛ | .. |
| St. | 4% | † Do. 4% Deb. Stock (red.) | 101–103 | 3 17 6 | – | .. | .. |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4¾–5 | 4 10 0 | – | 4²¹⁄₃₂ | .. |
| 5 | 2/3 | Do. Do. (1903) | 4¾–5 | 4 10 0 | .. | 4¾ | .. |
| 5 | 2/3 | Chelsea Electric Supply Ord. | 5–6 | 6 0 0 | March | .. | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 110–112 | 4 0 4 | Jn, Dec | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 11–12 | 5 0 0 | Feb, Aug | 11¼ | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13½–14½ | 4 4 2 | Jan, July | .. | – |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 124–128 | 3 18 1 | Jn, Dec | .. | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 103–105 | 4 5 8 | .. | .. | .. |
| 5 | .. | County of Durham Elec. P.D. Ord. £2 pd. | 2³⁄₃₂–2⁷⁄₃₂ | .. | April, Oct | .. | .. |
| 5 | [illegible] | Do. Do. 5% non cum. pref. | 5⅛–5⅜ | .. | April, Oct | .. | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 8½–9½ | 4 6 6 | – | [illegible] | 8¾ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅝–12⅞ | 4 13 2 | Mar, Sept | 12⁹⁄₁₆ | .. |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 112–115 | 3 18 8 | .. | 114½ | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 101–103 | 4 7 6 | .. | .. | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5½–5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5–5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101–104 | 4 6 6 | – | – | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8¼–8¾ | 4 17 2 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100–103 | 4 7 5 | – | .. | – |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | [illegible] | 5 0 0 | .. | – | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½–7 | 4 5 9 | Jan, July | – | – |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98–101 | 3 19 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101–103 | 3 17 8 | .. | .. | .. |
| 8 | 1/6 | London Electric Supply Ord. | 1¾–2¼ | 4 0 0 | .. | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 4¾–5¼ | 5 14 4 | .. | .. | .. |
| St. | 4% | † Do. 4 per Cent. 1st Mort. Deb. | 97–100 | 4 0 0 | Mr,Jn,S,D | .. | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 9½–10¼ | 4 17 6 | April, Oct | 9¹⁵⁄₁₆ | 9⅝ |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5¼–5½ | 4 2 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 109–113 | 3 19 7 | Jn, Dec | .. | – |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 97–99 | 3 10 8 | – | .. | .. |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 101–103% | 4 7 5 | – | 102¾ | 101¼ |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 12⅛–12¼ | 5 11 6 | Feb, Aug | .. | .. |
| 100 | .. | Do. 4½% Deb. | 101–102 | .. | Jan, July | – | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8–8⅛ | 4 19 5 | Feb, Aug | .. | .. |
| 5 | 6% | Do. 6 per Cent. Non. Cum. Pref. | 6⅜–6½ | 3 16 11 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 100–101 | 3 19 7 | Jan, July | .. | .. |
| 1 | 8% | Northern Counties Elec. Sup. 17/- paid | ¹³⁄₁₆–⅞ | 3 1 1 | Mar, Aug | – | .. |
| 100 | .. | Do. 4½% Deb. | 100½–101½ | .. | Jan, July | – | – |
| 10 | 6/0 | Notting Hill Electric Ord. | 13¾–14¾ | 4 15 0 | March | .. | – |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98–100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅜–6⅞ | 5 1 6 | March | .. | .. |
| St. | 4% | Do. 4% Deb. Stock | 100–102 | 3 18 5 | – | .. | .. |
| 5 | 6/0 | St. James' & Pall Mall Elec. Ord. | 11¾–12¼ | 5 4 0 | Feb, Aug | .. | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 8–9 | 3 17 9 | Feb, Aug | – | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 98–100 | 3 10 0 | – | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2–2½ | 8 0 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76–80 | 5 0 0 | – | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 3–3½ | 5 10 0 | .. | .. | .. |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | ⅞–1⅛ | .. | .. | .. | – |
| 1 | 0/8⅖ | Do. 7% Cum. Pref. | 1⁵⁄₁₆–1⁷⁄₁₆ | 4 17 2 | .. | .. | – |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105–108 | 4 3 8 | – | .. | – |
| 5 | 2/6 | Urban Electric Supply Ord. | 4½–4¾ | 5 5 8 | – | .. | – |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5–5¼ | 4 15 8 | – | – | – |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 104–106 | 4 4 10 | .. | .. | .. |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 11½–12½ | 5 12 0 | Mar, Sept | 12¹⁄₁₆ | 11⅞ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5¾–6¼ | 4 0 0 | .. | .. | .. |
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝–⅞ | 5 6 6 | – | .. | .. |
| 1 | 10½d. | Aron El. Met. 6% Cm. Pf ex on a/c of arrs. | ½–⅝ | .. | .. | .. | – |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3¾–4 | 5 0 0 | .. | .. | .. |
| 1 | 7½d. | Do. Pref | 1⁷⁄₁₆–1⁹⁄₁₆ | 3 16 10 | .. | .. | .. |
| 5 | 6/0 | British Insulated & Helsby Cables Ord. | 6½–7 | 5 14 0 | July, Feb | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾–6¼ | 4 18 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103–106 | 4 4 11 | .. | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98–100 | 4 10 0 | .. | .. | .. |
| 5 | .. | British Westinghouse 6% Pref. | 1⅞–2¼ | .. | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 80–85 | 4 14 0 | .. | 80 | .. |
| 2 | .. | Brush Electrical Engineering | ¼–½ | .. | March | .. | .. |
| 2 | 2/4⅘ | Do. 6 per Cent. Pref. Non-Cum. | 1¼–1⅜ | 6 17 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 96–100 | 4 10 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 84–86 | 5 4 6 | Jan, July | .. | .. |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11–12 | 5 0 0 | Jan, July | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝–5⅞ | 4 5 2 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 109–111 | 4 1 1 | Nov, May | .. | .. |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1–1⅛ | 5 7 0 | .. | 1⅛ | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 97–102 | 4 8 8 | – | 99¾ | [illegible] |
| 1 | 3⅜d. | Chadburn's (Ship) Telegraph Ord. | 1¹⁄₁₆–1³⁄₁₆ | 3 11 0 | .. | .. | .. |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1⅛–1⅜ | 5 2 7 | .. | .. | .. |
| 8 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 2¹⁄₁₆–2⁵⁄₁₆ | 3 7 0 | Jan, July | 2⁷⁄₃₂ | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 97–100 | 5 0 0 | Jan, July | .. | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8½–9 | 5 11 1 | Sept | .. | .. |
| 5 | 3/0 | Do. 6% Cum. Pref. | 5¾–6¼ | 4 18 0 | Sept | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 106–108 | 4 4 1 | .. | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅜–1⅝ | – | Feb, Aug | 1¹⁵⁄₃₂ | .. |
| 5 | 2/6 | Do. (£5 paid) | 2¼–2¾ | .. | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 85–90 | 4 8 11 | June, Dec | – | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92–97 | 5 8 1 | .. | .. | .. |
| 5 | 4/6 | Edmundson's Elec. Corp. Ord. | 5¼–5¾ | 6 1 9 | H'lf-yearly | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5¾–6 | 5 0 0 | .. | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 107–109 | 4 2 6 | .. | .. | .. |
| 2 | 1/7½ | Electric Construction Co. | ¼–⅜ | 9 6 0 | July | .. | .. |
| 2 | 2/9⅗ | Do. 7 per Cent. Cum. Pref | 1⅞–2⅜ | 5 18 8 | July | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 92–95 | 4 4 2 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 4¼–4¾ | 5 2 6 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96–100 | 4 0 0 | .. | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 12¼–12¾ | 5 11 1 | Feb, Aug | 12¼ | .. |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5⅛–5⅜ | 4 3 9 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | – | 4 1 1 | Feb, Aug | .. | .. |
| 10 | 5/0 | India Rubber, Gutta Percha, &c., Wrks. | 18½–19½ | 2 11 3 | Feb, Aug | 18¼ | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99–102 | 3 18 5 | Mar, Sept | .. | .. |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¼–11¾ | 4 5 1 | Mar, Sept | .. | .. |
| 12 | 12/0 | Telegraph Construction & Mainten'ce. | 32–34 | 5 5 10 | Mar, July | 33¾ | .. |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 102–104 | 3 16 11 | Jan, July | .. | .. |
| 5 | – | Willans and Robinson Ord. | 1¾–2¼ | – | Apr, Oct | .. | .. |
| 5 | – | Do. 6 per Cent. Cum. Pref. | 3¼–3¾ | – | Apr, Oct | .. | .. |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 82–87 | 4 12 0 | May Nov | .. | .. |

* In calculating the yields, allowance has been made for accrued interest but not for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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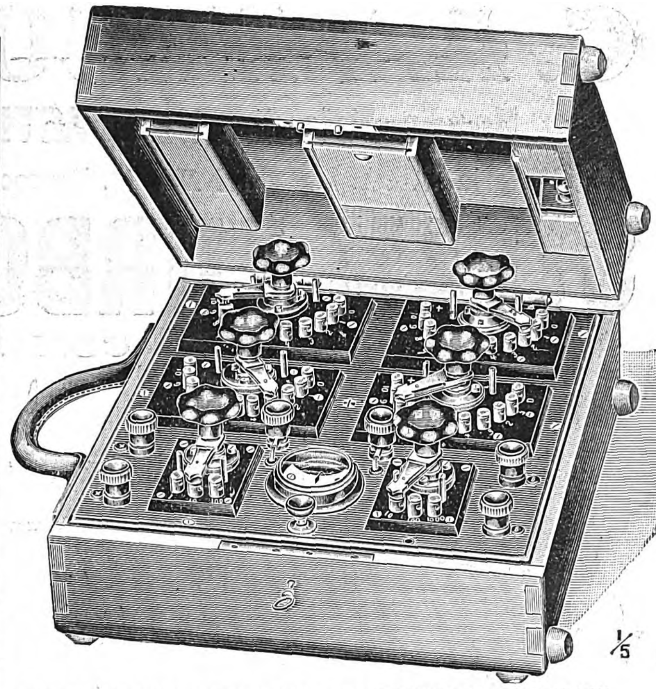

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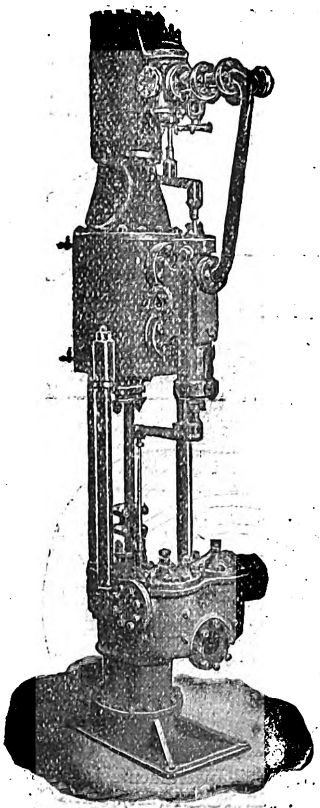
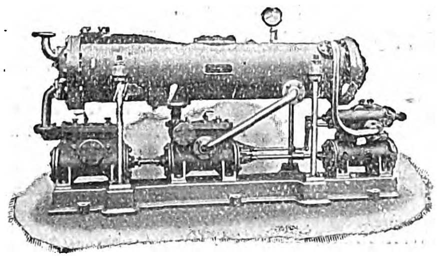


Tandem Compound Type.



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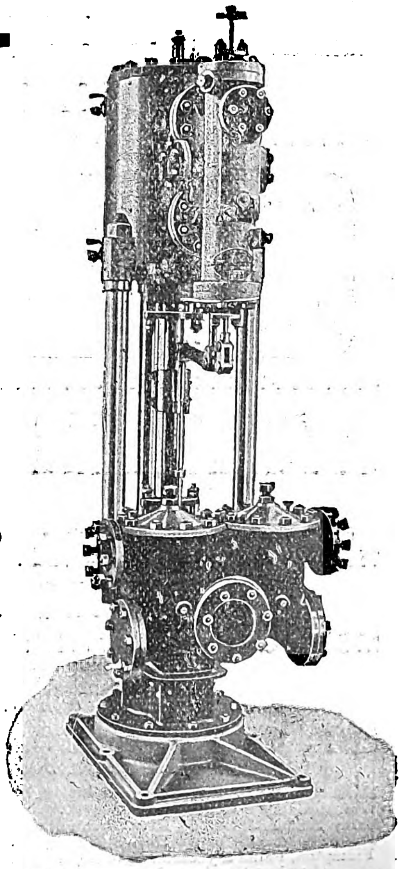

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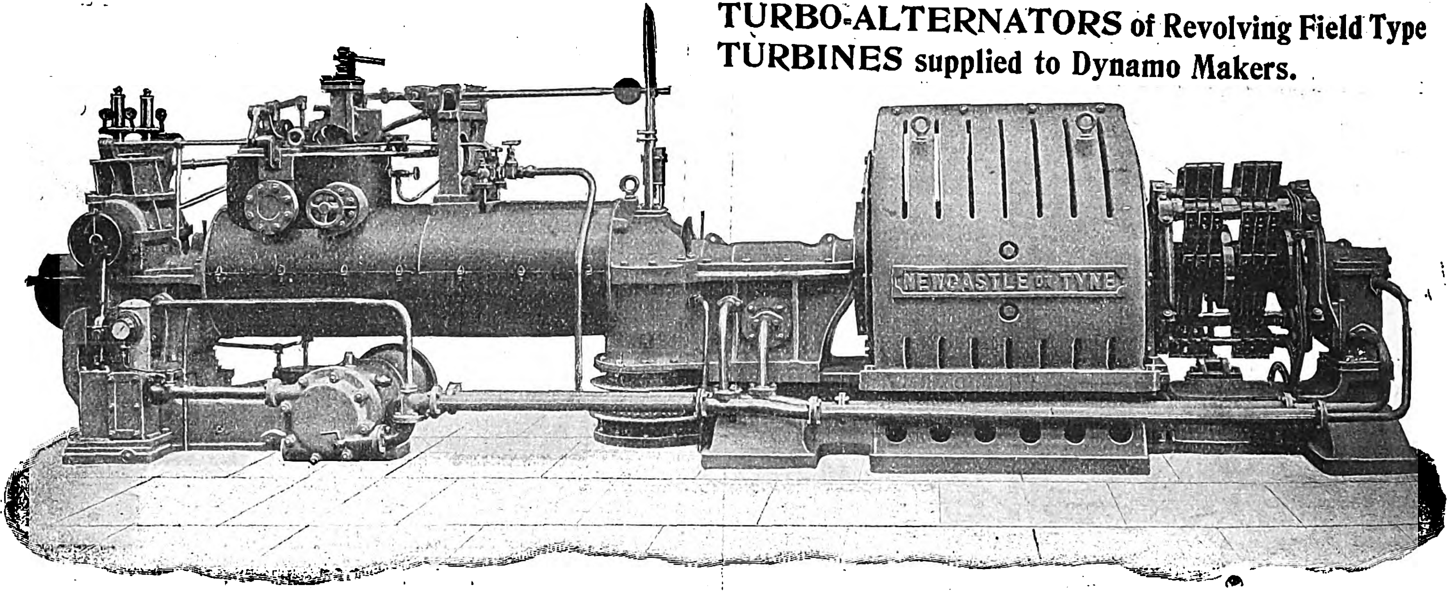

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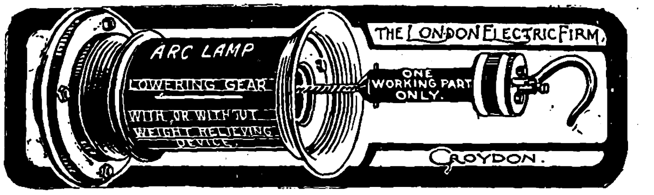

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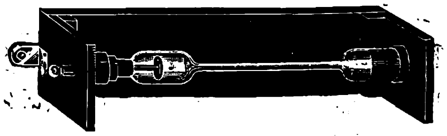

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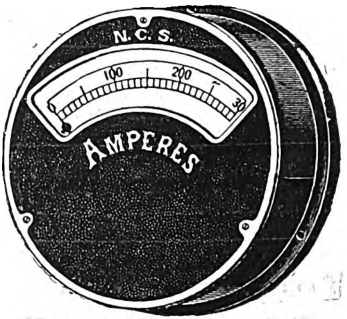

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The Committee do not bind themselves to accept the highest or any of the Tenders sent in.

R. E. FOX, Town Clerk.

Leeds, January 1st. 1906.

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SITUATIONS VACANT, &c., continued on page xvi.

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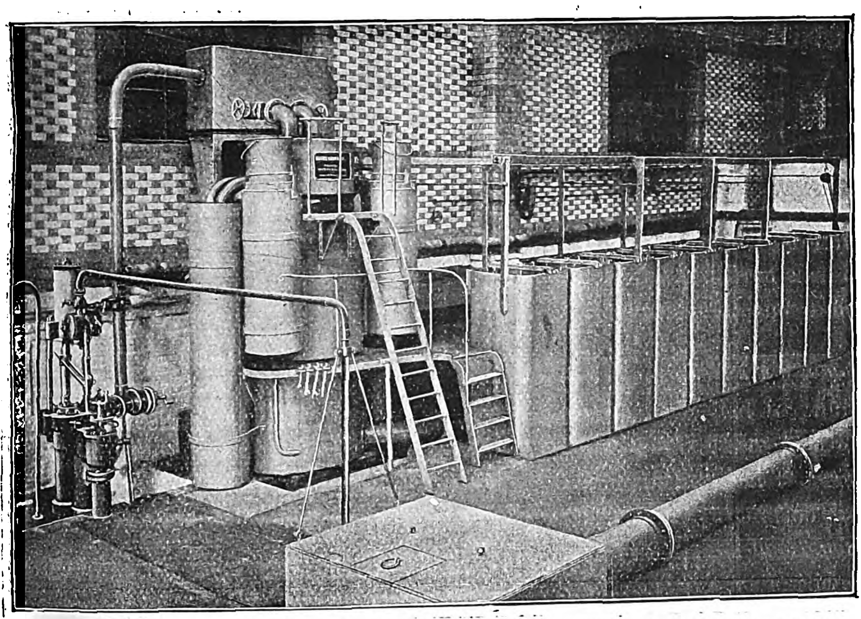

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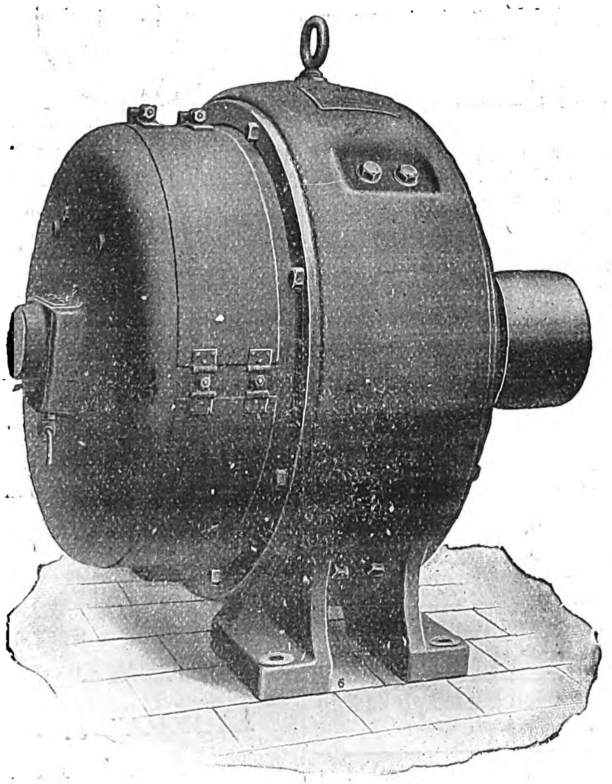

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THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,442. [No. 12. Vol. LVI.] FRIDAY, JANUARY 5, 1906. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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# NOTES.

IN another column we give an abstract of a report by Mr. J. F. SIMMANCE on the public lighting of Edinburgh. It forms a valuable and impartial compilation of data relating to both gas and electric lighting. The writer of the report gives high praise to the manner in which the electric street lighting is carried out, but a careful examination of the photometric figures seems to emphasize a feature of open type arc lamps which is often lost sight of—namely, that unless lamps are correctly adjusted and are used with a high quality of carbon, the candle-power given is far from that generally claimed. For instance, the average maximum candle-power of the 10-ampere arcs tested (considerations of space only permit us to publish one or two of the tables of tests) comes out at 336, and ranges from 213 to 572. There may be local conditions in Edinburgh accounting for this, but we think that more attention could advantageously be paid to the point by supply-station engineers generally, with the result that the industry would be able to obtain contracts for electric lighting of the streets with far more ease than is possible at present.

◆

A GLANCE at our table of patents expiring this year, which is published on another page, will show that the patents of interest to the electrical community are quite as numerous as formerly, but do not compare in point of importance with the lists of some previous years. Among the more noteworthy patents taken out in 1892 is No. 13,765, granted to MM. HUTIN and LEBLANC, and covering the familiar short-circuited damping coil or "amortisseur," which has been extensively used for restricting the hunting of paralleled alternators and rotary converters. Every electrician must be familiar with the Lundell spherical continuous-current motor, whose peculiarly shaped and arranged poles are excited by a common (circular) coil. The patent (No. 9,365) for this design is one of those which expire this year. Another expiring Lundell patent (No. 20,611) claims the method of varying the speed of an electric motor by providing two armature and two field windings, and connecting all these in a number of different ways. Still another patent from America (No. 22,187) which terminates its allotted span is that relating to the employment of "non-arcing" metals in lightning arresters. Mr. KAPP'S patent, No. 6,707, is a proof that the importance of improving the load-factor of electricity works and of fostering the demand for current during slack hours by reducing the charge was well recognised fourteen years ago, for the specification contains descriptions of a number of alternative designs of a double-tariff electricity meter actuated by clockwork. Details of arc-lamp regulating mechanisms are dealt with in patent No. 18,116, granted to Mr. W. MATHIESEN. Two patents taken out by Messrs. FELTEN and GUILLEAUME (Nos. 7,029 and 11,526) relate to this firm's particular form of paper-insulated telephone tables, and an interlocking armouring; and the patents for the Buckingham type-printing telegraph are also on the list. Electrochemistry is represented by a number of patents, including two granted to Mr. T. L. WILLSON and referring to the electric smelting of refractory ores.

◆

OF the patents of general engineering interest, there is one (No. 4,863) issued to C. G. P. DE LAVAL, describing his well-known means of ensuring the stable action of rapidly rotating bodies—more especially turbine wheels—by employing a flexible shaft. Another patent of some general interest is that granted to Mr. W. SCHMIDT for his improved superheater, which has found considerable favour on the Continent. No. 15,677 is the Hon. C. A. PARSONS' patent for governing steam turbines by admitting steam in puffs, the duration of which is regulated by the governor. Not the least important patent to expire is No. 7,241, which was granted to Mr. R. DIESEL for the internal combustion engine known by his name. It will be interesting to see whether there will be an application to the Judicial Committee of the Privy Council for a prolongation of this patent, for the various difficulties which have retarded the construction of the engine are being surmounted, and it is stated that a successful two-stroke engine, effecting a considerable saving in weight, has now been developed. Another interesting gas-engine patent of 1892 is No. 14,317, covering the well-known "Oechselhäuser" two-stroke gas-engine, in which two mechanically-connected pistons, moving towards and from each other in a common cylinder, open and close the inlet and exhaust ports, thus doing away with the usual valves.

◆

WE are glad to publish this week a letter from Mr. L. G. TATE, hon. sec. to the Electrical Contractors' Association, announcing that the Association is taking action against the Sheffield Corporation in order to stop the objectionable trading in fittings and house wiring carried on by this Local Authority without express Parliamentary sanction. Contractors in other towns who suffer damage from similar rate-aided competition are invited to communicate with Mr. TATE, who will look into their grievances.

◆

IT is hopeless nowadays to expect a discontinuance of the expression direct current with its convenient abbreviation D.C. and a general retention of the more accurate term continuous current. Still the use of the word "direct" in this connection often leads to many absurdities. For instance, Mr. RIDER in the discussion on Mr. PATCHELL'S Paper at the Institution, reported on another page, said: "Mr. PATCHELL'S distribution is by direct current, which *means* that all the energy goes through rotary transformers of one kind or another," while, on the other hand, Mr. HIGHFIELD spoke of "direct" generation at 10,000 volts (alternating).

◆

MANY interesting matters have been raised in the discussion, which was happily much more of a technical character than has been customary of late at the London meetings of the Institution of Electrical Engineers. The various questions as to boiler house practice are particularly interesting and we trust that there will be more debate still upon these. Peculiarly enough, the respective advantages of steam turbines and reciprocating engines have not yet been touched upon, but the subject was certainly well threshed out in the discussions on the Papers by MERZ and MCLELLAN and PARSONS, STONEY and MARTIN two years ago. Mr. PATCHELL has decided to defer his reply to the points raised in Mr. EBORALL'S letter in our columns until he replies generally to the discussion at the Institution, and we think that he has done wisely. Mr. HIGHFIELD'S article in *The Electrician* last January has given rise to an interesting controversy, and we are glad to hear the experience of others on this question of deterioration of alternator armature coils. It is rather disappointing that Mr. MORDEY, who should have had some experience in this matter, contributed so little to the discussion on this point. He has, of course, good reason for pointing to the necessity of good mechanical construction of the coils and their insulation, but we do not think that his theory of a hammering action due to electrostatic attraction and repulsion will receive endorsement.

◆

ALTHOUGH a Paper has been set down for reading at the next meeting but one of the Institution, there should be a certain elasticity about the dates, and we hope that the discussion on Mr. PATCHELL'S Paper will not be curtailed and that he will be able to make a full reply. Replies in the Institution journal only escape the attention they deserve.

◆

CORRESPONDENCE has been published in the *Dundee Advertiser* which shows what may frequently happen when the electricity department of a Local Authority is the only public supplier of electricity in a district in which there is an opening for electrical power distribution. Messrs. Gourlay Bros. & Co., shipbuilders, near Dundee, accepted, after prolonged negotiations, an offer by the Dundee Corporation to supply electric power for their works. Soon after this, it appears, there was a change in the constitution of the Electricity committee, and the firm received the following note from the electrical engineer:—

> Dear Sirs,—The new Committee of Dundee are to go carefully into the whole question of power generation for Dundee, and such a system to be adopted will seriously affect your supply. We would urgently recommend your delaying electrification, if to be supplied from the town mains, until the new system of distribution is settled. Therefore, your offer for supply will not be accepted nor an agreement signed until the result of their inquiry is known.

As a consequence, Messrs. Gourlay Bros. & Co. have decided to erect their own electric generating plant.

◆

WE have frequently alluded to the pernicious effect of the much-abused Parliamentary Standing Order, No. 22, which makes it necessary for the promoters of a tramway Bill to obtain the consent of the Local Authority before the Bill can be proceeded with. An example of the abuse of this practice has arisen in connection with a proposed tramway between Folkestone and Hythe. Two companies seek powers for building a tramway on this route. One has offered to pay the Hythe Corporation £1,500 for street widenings if their Bill is passed; and in reply to this offer the other set of promoters offer £1,500 for the same purpose as a price of the Corporation's consent, whether the Bill is passed or not! Mr. STEPHEN SELLON, in making this offer, quoted the opinion of the Hon. J. D. FITZGERALD, K.C., to the effect that the Council can legally accept this offer, although apparently the Council would have no legal remedy if the promoters were to refuse to make this payment on the Bill having failed to pass. Mr. SELLON also cited a case in which £750 had been paid towards a Technical Institute to obtain the consent of a Local Authority to a tramway, and another in which the Croydon Rural District Council had been paid £2,000 for their consent, the money to be applied "for any purpose which they thought fit."

**Macassar-Balikpapan Cable.**—According to the *Elektrotechnische Zeitschrift* the above cable has now been laid. It is 600 miles long, and was laid in three days by the North German Seekabelwerke to the order of the Dutch Government.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Tarifa—Tangier | Jan. 18, 1904 |
| Jamaica—Colon | Jan. 10, 1905 |
| Cadiz—Teneriffe | July 20, 1905 |
| Puerto Plata—Martinique | Dec. 15, 1905 |
| St. Thomas—St. Kitts | Dec. 29, 1905 |
| Manila—Iloilo | Dec. 29, 1905 |

**Kingsway Underground Tramway.**—The Board of Trade inspection of the subway tramway, constructed by the London County Council under Kingsway, between the Strand and Theobald's-road, took place on Thursday last week, and we understand that everything went off satisfactorily. The actual date of the opening of the line to the public is not now far distant.

**The Electrical Chess Club.**—The membership of the Electrical Chess Club is increasing satisfactorily. A number of matches and tournaments have been arranged, and the club should have a successful season. Meetings are held on Thursday evenings at Carr's Restaurant, Strand. It is to be regretted that the same night should have been chosen as that upon which the Institution of Electrical Engineers meets. The club is open to all connected with the electrical industry. Applications for membership should be addressed to the Hon. Secretary, Donington House, Norfolk-street, Strand, W.C. Subscription 5s. per annum.

**Government and Municipal Telephone Systems.**—In the discussion on telephone matters in Brighton, briefly referred to in our issue of December 22nd, it was stated in the course of the discussion on the Brighton Telephone Committee's report that the Post Office was approached by the Corporation on the question of the purchase of the municipal telephone system in October last. In November the Post Office engineers visited Brighton and inspected the plant. The municipal system at Portsmouth and Swansea, it was also stated, have been inspected on behalf of the Post Office, and that similar inspections were to be made at Glasgow and Hull. It was not expected that any decision would be come to with regard to Brighton until the Postmaster-General had come to a decision as to how he could deal with all the municipal telephone systems in the Kingdom, and probably several months would elapse before anything definite was made known.

**New Books and New Editions.**—"The Electrician" Printing and Publishing Co. announce the issue of a new edition of the late E. Tremlett Carter's "Motive Power and Gearing for Electrical Machinery," revised by Mr. G. Thomas-Davies, price 12s. 6d. net; a new edition of the "Steam Engine Indicator and Indicator Diagrams," by Mr. W. W. Beaumont, revised and enlarged, price 6s. net. The same company have in the press a new work by Mr. C. H. W. Gerhardi, entitled "Electricity Meters: Their Construction and Management," which will be ready in March. The 1906 (24th annual) issue of the same Company's Big Blue Book—"The Electrician" Electrical Trades Directory and Handbook"—is now in active preparation, and will be published within a few days of the end of January, 1906, up to which date the book is corrected and extended. Some new features will be included in the 1906 Edition.

**Extension of Electric Signalling on the District Railway.**—A description of the automatic signalling system installed on the District Railway Co.'s line between Hanger-lane Junction and South Harrow, a distance of about 5 miles, appeared in *The Electrician*, Vol. LIV., p. 616. Last Monday an announcement was made by the District Company to the effect that the system had been largely extended and that extensions were to be inaugurated in sections in the very near future, having already been inspected by the Board of Trade officials. We understand that the system, as far as the Mansion House, is to come into operation by about the middle of this month. This new signalling system is expected to facilitate traffic greatly, and the number of trains per hour is to be raised considerably. A two-minute headway has been promised in the near future, and a 1½ min. headway is even being spoken of.

**Wireless Telegraph Notes.**—According to *Elektrotechnischer Anzeiger*, the Hamburg-American line, which has already equipped its liners "Deutschland," "America," "Blücher," "Moltke" and "Hamburg" with a Marconi wireless telegraph installation is also having its new liner, the "Kaiserin Auguste Victoria," fitted with this system. Each installation consists of two parts, one of which is to serve the general telegraphic traffic, while the other part is to receive the daily news which is transmitted, at certain hours, from the two large Marconi stations at Poldhu and Cape Cod respectively. The installation for the general telegraphic traffic has an active radius of 125 miles, and communication with the shore, it is stated, is frequently possible by way of the other liners on the high seas between Europe and America.

The *Western Daily Press* states that the Aberdeen (Rennie) liner "Inkosi," which arrived in London from Natal and East Africa on Saturday last, has completed her first voyage since she was fitted with the Marconi apparatus. She reports having spoken with her sister ship, "Inanda," and various men-of-war during the voyage, and received messages from the great Marconi station at Poldhu, Cornwall, as far south as 24 deg. 36 min. N., a distance of 1,620 miles.

**The Post Office Power Station.**—There is some misconception with regard to the statements which have been published recently as to the new power house which the Post Office is erecting in order to supply power to its various offices. The Post Office has obtained a site for such a station on the south side of the river near Blackfriars Bridge, but although the building work has been started, the tenders for the generating plant and other equipment of the station have not yet been let. It is intended not only to supply power for the lighting of the various offices, but also for working the telegraph circuits, the secondary batteries for which are now charged by independent plant, and it is not improbable that such a station will contain several units of 500 kw. capacity. When the time comes, cables will be laid to the various offices by alternative routes as far as possible to avoid any disturbance through accident, although it may be necessary for the cables to cross the same bridge, one set on either side. Some system of duplicate or linked up mains will be necessary, so that there can be no cessation of the telegraph traffic in the event of a breakdown. The statements which have been published to the effect that the engineering department of the Post Office is not satisfied with the methods of laying mains proposed by the power companies, has, however, absolutely no foundation in fact.

**Fires and Searchlights.**—The recent collapse of part of the roof of Charing Cross railway station and the valuable help rendered by the Electrical Engineers' Volunteer Corps, which, by the use of their searchlights enabled the work of rescue and clearing to be carried on night and day without intermission, has brought the question of the general use of searchlights upon such occasions into prominence. A suggestion has been made that the London County Council should equip its fire engines with portable searchlights and electric lamps, and the idea appears to be meeting with favour, whilst the further suggestion that the fire pumps would be more effectively operated by electric motors is one that should be supported by the various electric supply companies, especially in the crowded parts of London and other big cities, where a supply of electrical energy is available in practically every street. Mr. E. Wilmot Seale, the secretary of the Charing Cross, City & West End Electric Supply Co., is taking an active part in this movement, as a result of his company having been called upon to provide the supply to the searchlights used on the occasion of the Charing Cross disaster. The idea of equipping fire engines with portable lamps, however, is by no means a new one. In *The Electrician* for September 16, 1904, was published an illustration of a fire engine constructed for the Manchester Corporation by Messrs. Merryweather & Sons, of London, in connection with which the firemen were equipped with telephones, and protected portable hand lamps supplied through cables wound round drums beneath the fire manual. The lamps, when not in use, are hung upon a rack. Anything that would facilitate such work is to be commended, and electricity lends itself as the most flexible agent in this connection.

**Leitner-Lucas Train-lighting System.**—In order to demonstrate the capabilities of the Leitner-Lucas train-lighting system (a description of which appeared in *The Electrician*, Vol. LV., p. 454), Mr. Henry Leitner, managing director of Accumulator Industries (Ltd.), agreed to seal up for 12 weeks the dynamos, accumulators and automatic cut-outs of the three carriages of the Great Western Railway equipped with the system and running regularly between London and Penzance. This endurance test came to an end last Saturday, nothing in the way of adjustments, filling-up, &c., having been done to the lighting equipment since the start. One of the carriages, it is stated, has covered 25,200 miles during the 12 weeks, while the two remaining coaches, which were withdrawn temporarily from service for reasons not connected with the lighting, are said to have run 23,800 and 16,000 miles respectively. Last Monday we were invited to inspect the three coaches, but the seals were not broken. The coach which has run the longest distance consists of first and third-class compartments, and is provided with twelve 10 c.p., ten 12 c.p. and some eight 8 c.p lamps. There are four 10 c.p. (osmium) lamps in a cluster in each first-class compartment, and two 12 c.p. 3½-watt carbon filament lamps in every third-class compartment. The storage battery under each coach has a capacity of 180 ampere-hours, and the voltage is about 23. We are informed that on Tuesday last the seals were taken off in the presence of officials from the railway traffic department and the engineering works at Swindon, and as the equipment was found to be in perfect condition, the carriages were ordered to go immediately into traffic again. We understand that enough oil was left in the oil wells of the dynamos to last for several more months of running, that the commutator and automatic cut-out were in good condition, and that the brushes had worn very slightly and evenly. At the commencement of the test the specific gravity of the battery, when fully charged, was about 1·205, and it had increased during the 12 weeks to 1·220. The battery, it is believed, could have run safely for another four months without being filled up with water.

**Obituary.**—After a considerable period of ill-health and suffering, Mr. C. T. Yerkes died on Friday at the Waldorf Astoria Hotel, New York, from what is understood to be Bright's disease. Mr. Yerkes' name first became familiar to Londoners in 1900, when he interested himself in the chaotic condition of affairs upon the London underground railways. He originally approached the problem independently, but for some reason he at first abandoned any ideas he may have entertained regarding the application of electric traction to the steam-driven underground lines. Mr. R. W. Perks, M.P., who was on the board of the District Railway Company urged Mr. Yerkes to apply himself once more to the task, and in 1901 the Metropolitan District Electric Traction Co. was registered, with a capital of £1,000,000 to carry into effect agreements with the Metropolitan District Railway Co. and the Brompton & Piccadilly Circus Railway Co. for the working of their lines. Before this company had got to work, however, Mr. Yerkes directed his attention to the other tube railways in London which were not being proceeded with mainly owing to the difficulty in securing financial assistance. These lines were the Baker Street & Waterloo, the Great Northern & Strand and the Charing Cross, Euston & Hampstead Railways, and consequently in April, 1902, the Underground Electric Railways Co. of London was brought into being with a capital of £5,000,000 for the purpose of converting the District Railway to electric traction and to build the tube lines above mentioned. In the course of time the Great Northern & Strand and the Brompton & Piccadilly Railways were amalgamated, under the title of the Great Northern, Piccadilly & Brompton Railway Co., in order to give a through connection between the north and west and south-west of London. All these lines are now well towards completion. The Underground Electric Railways Co. of London took over all the liabilities of the Metropolitan District Electric Traction Co., which went into voluntary liquidation. Agreements between the various companies were entered into, and the huge generating station at Lot's-road was constructed, the capital for which was found in certain proportions by each, current being purchased at cost price. Other lines in which Mr. Yerkes was very largely interested were the Hampstead-Edgware and Edgware-Watford Railways, which are intended to be electric railways on the surface, running as extensions of the Charing Cross, Euston & Hampstead tube railway. Mr. Yerkes' early life in America was largely connected with Stock Exchange matters, although at the early age of 23 he interested himself in railway matters when he secured a controlling interest in one of the street railway companies of Philadelphia; but his outstanding achievement in the United States, from the electric traction point of view, has probably been the conversion of some 300 miles of street railways and tramways in Chicago and district, including the Union Elevated Road in that city. For a financier, Mr. Yerkes had an unusual grasp of the engineering side of the projects undertaken by him, and his advent into the realm of "traffics" in London undoubtedly expedited that improvement in the conditions upon the Inner Circle which had been so sorely needed for many years. It is not too much to say also that indirectly Mr. Yerkes was responsible for the appointment of the Royal Commission on London Traffic, for in certain quarters his American influence in London was viewed with great apprehension a few years ago and this set the agitation in favour of the Royal Commission on the move.

**Mr. Yerkes' Successor.**—It is officially announced that Sir George Gibb, general manager of the North-Eastern Railway Co., has been offered, and has accepted, the managing directorship (deputy chairman) of the Underground Electric Railways Co. of London, in which post he will take over the managing responsibilities of the late Mr. C. T. Yerkes. Sir George Gibb will also become chairman and managing director of the Metropolitan District Railway Co.

Sir George received the honour of knighthood in July, 1904, and has been general manager of the North-Eastern Railway Co. since 1891. It is well known that this company was the pioneer on the introduction of electric traction on "heavy" railways in this country; some 40 miles of steam lines in the Newcastle district have now been converted to electrical working with considerable financial success. As a member of the Royal Commission on London Traffic, Sir (then Mr.) George Gibb was extremely painstaking, and his questioning of the most important witnesses was of the keenest description. He was one of the sub-committee of the Royal Commission which visited America.

Mr. Edgar Speyer, of the firm of Messrs. Speyer Bros., succeeds to the chairmanship of the Underground Electric Railways Co. of London.

Messrs. Speyer Bros. have been responsible for the capital of the Underground Company, and the successful progress of the works in connection with the District Railway and the various "tubes" is, in a large measure, due to their co-operation with Mr. Yerkes.

## ARRANGEMENTS FOR THE WEEK.

**SATURDAY**, **January 6th.**

Association of Engineers-in-Charge.

*2:45 p.m.* Visit to the electric lighting plant at the Royal Courts of Justice, Strand. Meet at foot of steps leading from the Strand to Carey-street.

**MONDAY, January 8th.**

Tramways and Light Railways Association.

*2:30 p.m.* Visit to L.C.C. subway, Kingsway. Meet at Aldwych station.

**TUESDAY, January 9th.**

Institution of Electrical Engineers: Glasgow Local Section.

*8 p.m.* Meeting at 28, Bath-street, Glasgow.

**WEDNESDAY, January 10th.**

Tramways and Light Railways Association.

*8 p.m.* Meeting at the Institution of Civil Engineers, 25, Great George-street, Westminster. Paper to be read: "On Brakes," by A. L. C. Fell, Chief Officer, L.C.C. Tramways.

Association of Engineers-in-Charge.

*8 p.m.* Meeting at St. Bride's Institute, Bride-lane, Fleet-street. Paper to be read: "Storage Batteries and their Application to Public Institutions," by Frank Crawter.

**THURSDAY, January 11th.**

Institution of Electrical Engineers.

*8 p.m.* Ordinary General Meeting, when the discussion on Mr. W. H. Patchell's Paper, "The Charing Cross Company's City of London Works," will be concluded.

**FRIDAY, January 12th.**

Manchester Students' Section, Institution of Electrical Engineers.

*7:30 p.m.* Meeting at the Municipal School of Technology, Sackville-street, Manchester.

Institution of Civil Engineers: Students' Meeting.

*8 p.m.* Lecture by Prof. J. D. Cormack on "The Theory of Machines."

# THE CHARING CROSS COMPANY'S CITY OF LONDON WORKS.

The following is an abstract of the discussion which took place at the Institution of Electrical Engineers on December 7th and 14th in connection with Mr. W. H. Patchell's Paper on the above subject. The Paper, slightly abridged, was published in our last three issues, pp. 341, 382 and 420. Mr. John Gavey, C.B., occupied the chair on both evenings of the discussion.

*Thursday, December 7th.*

Mr. CARL SULZER, who was called upon to open the discussion, said that Mr. Patchell had dealt with his task in such an able manner that very little remained to be said, but should anyone wish to ask any questions relating to the engines he would be glad to answer them.

Mr. C. P. SPARKS, chief engineer to the County of London Electric Supply Co., in correcting a statement in the original Paper, said that generation at the Deptford power house, where direct generation at 10,000 volts had been adopted, was not only the first in England, but the first in the world, to use such pressures with transmission by underground cables. He had been connected with Mr. Ferranti in this enterprise at the time the Deptford machines were projected in 1888, and they actually worked on the supply in London in 1890. With regard to the machine at Bow, Mr. Highfield had drawn attention last year to the formation of nitric acid in the alternator coils of some of the machines at his works, and he believed that Mr. Patchell's explanation of this was the correct one. His own view was that the proper way to build these coils was to impregnate the insulating material at a very early stage of manufacture. The insulated wire should be treated by some vacuum process, and the insulating material impregnated. The whole coil when wound, if it was not a slot-wound machine, should be put into an impregnator, the moisture extracted and all interstices filled. He thought that the safety of extra high-pressure cables had been overlooked. It was the exception to get a fault on alternating-current cables, but the difficulties with direct current were very great, due to electrolysis. When extra high-pressure cables were carefully manufactured and laid the deterioration was very small. So long as the lead or sheathing was kept impervious to moisture, there should be no depreciation at all. He did not think that the cables in this instance should have been laid solid. In such a city as London it was a mistake owing to the value of the road space and the immense expense of reinstatement. The conduit system was the right system, so that any repairs could be carried out without inconvenience to the public. His next point was as to the site. Not many of them had had the opportunity that Mr. Patchell had had, and as he was obliged to go several miles outside his area why was not the site put even further away, where not only would the advantage of rail-borne coal have been obtained, but also water for condensing purposes in large quantities. There was one feature in the general lay-out of the Bow station in connection with which he had always envied Mr. Patchell —viz., the chimneys to the boiler house. Owing to the regulations of the London County Council a steel chimney was not allowed to be erected within London, because it was thought to be a danger to the public. At the present moment, he was afraid to make any comment on the boilers themselves. The large boiler appeared to be of very great interest, but without comparative figures as to what had been done elsewhere he was unable to criticise. He would also like more information with regard to the load factor and the actual coal consumption. With the very highest class of steam reciprocating machinery, with the latest type of boiler and with all modern improvements at this station, which had been running some 2½ years, he should have looked for a lower figure with Welsh coal than "something under 4 lb." He hardly liked to go into figures as to the stations with which he was connected, because the stations were very old and the units were very small, but with North-country slack coal, the cost of which was very much less than that of Welsh small coal delivered in London, he used only 4½ lb. per unit. With reference to the concluding part of the Paper Mr. Duddell had carried out some very valuable tests for the County of London Co. in 1902-3, about the same time that he carried out the tests for Mr. Patchell's company. They had derived very great benefit from his advice and experiments. Mr. Duddell had demonstrated to the County of London Co. that the oil-break switch and the oil-break fuse were the only reliable and safe form to use. He agreed entirely with Mr. Patchell that at the engine house there should be oil-break switches controlled by automatics.

*Thursday, December 14th.*

Mr. SPARKS, continuing his remarks and referring again to the large boilers at Bow, said the first point to consider was the limitation with regard to boiler practice. The limitation was really the size of the furnace, and it would appear that Mr. Patchell, by putting in a boiler whose fire grate was practically the area on which the boiler stood, had really reached the limit of boiler performance. The heating surface of this boiler was given as 10,850 sq. ft., whereas the biggest boiler he had used had a heating surface of 6,182 ft.

Mr. PATCHELL: That is half the boiler; two of them are set as one unit.

Mr. SPARKS: So are mine. Then the figures are really 21,700 and 12,364.

Mr. PATCHELL: In my case there is one common furnace to two boilers.

Mr. SPARKS replied that this made the point clear. He noticed, however, that the normal evaporation of the upright boiler was given as 33,000 lb. per hour, and the heating surface as 10,850 sq. ft. Was this half a unit or a whole unit? In the case of his own boilers the heating surface was 6,182 sq. ft. with one boiler, which was half a unit, and which was 12,364 sq. ft. for the complete unit. If they compared the normal evaporation of these boilers, which was 33,000 lb. against that of his own boilers which was 20,000 lb., the evaporation per square foot of heating surface in Mr. Patchell's case was 3·04 lb., and in his case 3¼ lb. The ratio of the heating surface to the square feet occupied by the boiler in Mr. Patchell's case was 21, and in his case it was 18·4. The principal difference, however, appeared to be the very large overload capacity which Mr. Patchell's boiler appeared to possess, as he had been able to run it up to 100,000 lb., which was 50 per cent. over the normal. The author's boilers were hand-fired, but his were stoked with mechanical stokers. He maintained that with mechanical stokers of the chain-grate type such as he used, it was possible to evaporate the full normal output of the boiler continuously, whereas with hand-fired boilers, although they possessed great capacity of running on continuous loads for very long periods, one was bound to deduct a very considerable proportion of their output in consequence of the necessity for repeated cleaning. In his opinion a boiler house with hand-fired boilers required to have 25 per cent. greater capacity than if it were fired by means of mechanical stokers. Mr. Patchell's boiler was also referred to as being able to deal with the smoke question. However, he knew of other types of water-tube boiler, set with large combustion chambers, and run with chain-grate stokers, which also solved the smoke difficulty, and at the same time permitted the use of a very much lower-priced fuel. Fog loads were a great difficulty in London, but he could say from his own experience that they could be adequately dealt with by mechanical stokers of the chain-grate type. In conclusion he would like to know what were the losses in the various parts of Mr. Patchell's system in connection with Bow, so as to show what was the coal cost per unit delivered at the sub-station, &c.

Mr. J. S. HIGHFIELD entirely agreed with Mr. Sparks on the question of boilers and mechanical stokers. He next dealt with the question of pressures. At Deptford there was 11,000 volts single-phase and at the Willesden station of the Metropolitan Electric Supply Co. 11,000 volts two-phase on a four-conductor system, the latter with two concentric cables with the outer conductors earthed at the station. In the case of Bow the plant was three-phase, the generators were star-wound, and the centre point of the star was earthed, so that the pressure to earth was only 6,400 volts, the pressure between the phases being, of course, 11,000 volts. On the two-phase system, on the other hand, the pressure to earth was the full 11,000 volts, and the pressure between phases 15,000 volts, so that the difficulties of handling two-phase current on a four-wire system with one pole of each phase earthed were practically double those in connection with three-phase current. Indirectly, too, this made clear the great advantage of three-phase current for transmitting power over long distances. He had very little to say concerning the switchgear at Bow, except with regard to the cable charging. Two years ago he was convinced that some sort of cable-charging system was a necessity. Quite recently his company had installed a new lot of switchgear with oil switches, and by accident 7 miles of 0·25 sq. in. concentric main cable at the full working pressure were switched off. They then switched it in again purposely to see what would happen, but no accident occurred, and it was clear that this could be done, and the insulation made strong enough to stand the great strain. It seemed to him that it was a great advantage to do away with the whole of the cable-charging gear, and simply to switch the cables straight in. His only precaution was to keep small transformers, for working the voltmeters, &c., connected at various points along the cable. The next point he wished to touch upon was that of nitric acid and generators. Mr. Patchell's opinion was that the acid was probably present due to impurities in the insulating materials, which promoted the destruction of the pure material by ozone. In his (Mr. Highfield's) little article in *The Electrician*, Vol. LIV., p. 573, he had particularly stated that the materials were of the best possible quality and workmanship as far as he could see, and all he could imagine was, of course, that Mr. Patchell had not gone very carefully into the article in question. At Willesden he had two 3,000 kw. machines generating directly at 11,000 volts, and one of them ran for about a year without trouble. Then it broke down and the coils that had failed were taken out and it was found that the whole of the cotton braiding had vanished and its place was taken by a green material. On running a hand down the copper little projections were encounted (a sort of roughness). He had the green substance analysed, and nitrate of copper and sulphate of copper were discovered. Separate analyses were made by Prof. Wilson, of King's College, for the Metropolitan Electric Supply Co., and by Prof. Gütell for the makers of the machines, and the result was to show the presence of a large amount of sulphuric acid, a certain amount of nitric acid, and a lot of other things which did not concern the question. In the insulation itself no nitrates were found and no nitric acid, but only gypsum. This made the thing quite clear. The production of nitric acid by silent discharge was discovered 100 years ago by Cavendish. The presence of sulphuric acid, of course, was due to the nitric acid combined with the gypsum, and liberating sulphuric acid, and it appeared at once that his explanation of the damage to the coils was quite proved. The rate of action was determined by the presence of moisture. With a perfectly dry coil there was very little damage, whilst with a damp coil a great deal of damage happened, so that although machines might be built to work perfectly well in a dry climate they might not work for any length of time in a damp climate. He had stripped one winding entirely, and it was exceedingly interesting to find that the action began at the point of the winding representing about 2,000 volts and increased rapidly, so that at 8,000 volts the coil was destroyed. Some coils were much worse than others, although at lower pressure, due, no doubt, to the presence of moisture. In order to reproduce the occurrence, he had taken one of the tubes and had placed in it some copper gauze wound round with filter paper. The gauze was connected to the 10,000 volt 'bus bars, and the outside of the tube was covered with tinfoil, which was earthed. In three days the paper was cut away, and the copper gauze was green. This seemed to him to prove that the formation of nitric acid accounted for the whole of the trouble he had had. The only way to prevent this, he thought, was to exclude the air entirely from the micanite tubes containing the coils. But he thought that 10,000 volts above earth—about 18,000 volts between phases with three-phase—was getting towards the maximum pressure at which direct generation could be carried on in this climate.

Mr. W. H. BOOTH complained that very little had been given in the Paper about the details of output or temperatures so far as the steam plant was concerned, and he could, therefore, only take the general principles. To judge from the drawings in the Paper, the boiler furnaces were not very well designed for burning ordinary coal. It was not always possible to get Welsh coal, and it seemed to him that there would be a lot of smoke if, for any reason, ordinary coal had to be used. The secondary furnaces were a very good idea if the doors were made thoroughly air-tight, and were not merely ordinary doors, plain and faced, because they would soon warp through differences of temperature. There should be a ring of asbestos or something of that elastic nature. He could scarcely believe that the back sections of the boilers acted as economisers as the author pointed out, because, so far as he could make out, they would be as hot as the front sections, about 370 deg., so that the waste gases must go away with a temperature of something like 600 deg. The only feed heating appeared to be by means of a coil or surface condenser placed in the path of the exhaust steam. If the vacuum was at all reasonable, the temperature of the condenser must be rather low, and the exhaust steam from the cylinder must be nearly as cold as the condenser, so that a comparatively small amount of heat would be given to the water on its way to the boiler. The position of the superheater should give exceedingly good results so far as dry steam was concerned, but it was too far from the furnace to give superheat, whilst, on the other hand, if it were nearer, presumably it would be exposed to the risk of burning. It seemed to him that this station was devoid of the modern principle of stage heating, which should be present in every modern station. To give an idea of what could be done in the matter of stage heating, he had had some figures prepared from a recently erected plant. The water was taken at its ordinary natural temperature and heated up by exhaust steam to 100°F., which was the temperature at which it entered the economiser. It left the economiser at 230°F. and entered the controller pipes of the superheater at 225°F., having lost 5 deg. in passing from the economiser to the superheater. The water left the superheater for the boiler at 350°F.—*i.e.*, the boiler working at 120 lb. per square inch was at the same temperature as the feed water which entered it, and in that way the boiler was made to act strictly as an evaporator, and not as a feed heater. The steam left the superheater at 495°F., it lost 30 deg. in passing to the high-pressure cylinder, and left the latter at 258°F. The engine was an ordinary factory engine. Between the low and high pressure cylinders a reheater was fitted which was fed by superheated steam, and the whole of the steam passing through this went into the boiler, so that the only heat that the water lost, apart from radiation losses, was just the amount of heat it put into the steam entering the low-pressure cylinder. As the result of this system it was found that the indicated horse-power, which was formerly 367, had been reduced for doing the same duty and output to 348. He presumed that this was due to the decreased resistances within the cylinders of the engine, and during nine months in 1904 and 1905 there was a reduction in the coal of 200 tons on a total consumption of 730 tons. These figures showed that such a system of steam raising in a small factory plant gave better results than did a large plant with the ordinary system of steam raising—*i.e.*, with jumps instead of a steady progression of temperature.

Mr. J. H. RIDER thought the author's reply would contain more information than the Paper, judging from the number of questions that were being put to him. He himself also had several. He could not understand why, having selected 10,000 volts for his pressure, Mr. Patchell had not taken full advantage of it to place his station where he could get condensing water and avoid the use of cooling towers, and also get his coal delivered by ocean steamers. He sympathised with Mr. Patchell in going outside the London county boundary in order to avoid the London Building Acts, but why did he not go still further, say to the neighbourhood of Beckton, which would have been within the economical limits of transmission at 10,000 volts, but which would also have secured many other advantages which he did not get now. Mr. Patchell's distribution was by direct current, which meant that all the energy went through rotary transformers of one kind or another. This being so, he could not understand why 25 cycles per second had not been chosen in preference to 50. In passing, he might mention that it would have enabled some of the bulk supply schemes to supply direct to Mr. Patchell without the necessity of rotary transformers. Under the heading, "system" (*The Electrician* December 15th, p. 341) the author said: "In considering the question of pressure the author decided to take the highest pressure that could be directly generated by the machines and used by the motors, as he was anxious to eliminate the complication of static transformers and to save the extra space and switch gear necessitated by them." But he failed to see what extra switch gear would be required, because so far as he knew it was not the custom to put switch gear between the static transformer and the motor-generators. There was merely the high-tension switch gear on the primary side of the static transformer and the low-tension switch gear on the direct-current side of the motor-generator. He considered the Bow boiler house the most interesting part of the system, but he would like to hear, in Mr. Patchell's reply, why he had gone in for hand firing and why he had not adopted any form of mechanical stoking. It appeared that the system of coaling was that the coal was deposited in heaps upon the boiler-house floor, which, although very convenient for the stoker to get at, did not conduce to a clean boiler house or a proper up-to-date plant. The system of double grates was a very good idea indeed, particularly for those stations which were liable to be called upon for sudden emergency loads. He was also glad that Mr. Patchell's experience showed that the vertical tube Hornsby boiler worked practically without smoke, for this was a corroboration of what they had been led to believe. The great advantage of a vertical water tube boiler was that its larger combustion chamber was much more likely to give smokeless combustion than any horizontal boiler where the water tubes were practically on top of the fire. In reference to the statement in the Paper that one of the pairs of boilers had been worked up to 100,000 lb. per hour, and the figures given in Table I, where the normal evaporation per hour was given at 33,000 lb., he would like to know whether this latter figure referred to half of the power, or whether the boiler normally working at 33,000 lb. per hour could on emergency be run up to 100,000 lb. per hour. He did not think this could be the case. He thought too much complication had been gone in for in the matter of the feed supply. He did not know why the water was not pumped up directly to the boilers from the tanks in the basement, through the water heater. Apparently also he was depending on two 13 in. artesian wells for his supply, which each gave 20,000 gallons per hour. He calculated that the amount of water required for a 20,000 kw. plant was 40,000 gallons per hour, and already there were 18,000 kw. in the station. Had Mr. Patchell no stand-by supply? In connection with these wells, he had had one sunk at Greenwich as make-up, but the water was exceedingly hard and water-softening plant was necessary. Was this the case at Bow in respect of the whole of the supply? He was sorry to see that the generating plant and switch gear had been made on the Continent. Did Mr. Patchell go abroad on the question of cost or efficiency, or both, because although he was not a believer in putting a fence around your town or your country, yet it was a pity to go abroad for plant which he happened to know could have been obtained at home. He entirely agreed with Mr. Highfield in his inclination to think that cable charging gear could be done away with. He had had some charging gear put in for his high-tension feeders, but for the past 12 months it had not been used, and he was entirely of the opinion that if only the right kind of cable were put in this was not necessary, and for simplicity sake they were better without it. He did not agree with Mr. Patchell's charging device—viz., a motor-generator, because such a system meant that the cable was being practically run up through all the periodicities from 0 to 50, and they were liable to get high pressures at certain low frequencies, which would not be obtained if the cables were charged directly. This method also gave all the trouble of synchronising the cable before it was put upon the 'bus bars, just as if it were a generator. The trunk mains from Bow to the City were mostly laid on the solid system, but in view of the great cost of laying mains in London—a cost, by the way, which some people had altogether failed to realise—he thought Mr. Patchell would have been wiser had he adopted the draw-in system. Neither did it appear that anything like an adequate number of spare ducts had been put in. He had originally adopted a method of making high tension joints similar to that shown in Fig. 14 (Fig. 8 *The Electrician*, December 22nd, p. 384), but after some experience he had given them up entirely, and was now making joints with linen tape, well boiled in resin oil, wrapped around the joints with mica between the layers. He would like to hear if Mr. Patchell had had any trouble with the porcelain insulators which he used in the joints. Everything in the distribution system, again, was of foreign make, but they were exceedingly good machines. He disagreed with Mr. Patchell in his choice of synchronous machines, and apparently he had deliberately gone to these after experience with induction machines, whereas he (Mr. Rider) had gone the other way. Induction machines had their faults, but they were simpler in many ways, and he was a strong believer, in power house and distribution systems, in the use of the simplest possible plants. Throughout the Paper there was not a single figure about cost, and he did hope that Mr. Patchell in his reply would give what they were all longing for—viz., some figures of the cost of the power house and the cost of operation. He had given 4 lb. of coal per unit, but what did the coal cost per ton? Would Mr. Patchell tell them—and if not, would he tell the speaker privately—what was the capital cost per kilowatt, what his coal cost per ton delivered into the bunkers, whether he brought it by rail or steamer, what it cost to barge, what the load factor at the power house was, and what the works costs were?

Mr. A. VENNING said that the plant was either "over-boilered" or else the engines were not very economical as regards steam consumption. Excluding the two 300 kw. auxiliary sets, 16,000 kw. of main engine capacity remained, for which boilers equivalent to 528,000 lb. of steam per hour had been installed, both being reckoned on a normal basis. This gave 33 lb. of steam per kilowatt, or, including the auxiliaries, 31·8 lb. per kilowatt, or on a basis of heating surface about 11 sq. ft. per kilowatt. He himself had found, when using ordinary Corliss engines, in conjunction with water-tube boilers and burning a cheap grade of coal, that 10 sq. ft. of heating surface had been sufficient to deal with all loads. In designing large plants he had gone as low as 8 sq. ft. per kilowatt, and had found it ample, even when working with saturated steam. The clearance of 36 ft. 6 in. under the traveller hook might have been increased with advantage. The distance between the top of runway girders and the tie rod of the roof truss was between 17 ft. and 18 ft., whereas 10 ft. would have been ample with this type of crane, and by placing it so much higher the danger of a swinging piston coming in contact with the top part of valve gear and possibly damaging it would have been avoided. The Hornsby horizontal boiler was, in boiler phraseology, a "three-decker," but it would have been more efficient and more economical if it had been arranged in two decks, with the same aggregate number of tubes. If the baffles had been arranged in a different manner from that shown on the section the evaporative capacity would have been increased, and a better degree of superheat obtained, for, as now arranged, he thought only 40°F. or 50°F. of superheat was possible. The Hornsby upright boiler was a combination of the Stirling, Cahall and another type, each having upright tubes. One point did not commend itself, and that was the number of tubes of varying lengths, and, being of great length, presumably 18 ft., they required a clear vertical space of at least 23 ft. or more for removal and renewal. This necessitated great height in the boiler room in order to have clear space without interfering with coal bunkers, tanks, &c. A comparison between the Hornsby upright boiler as described and the Stirling boiler about to be installed at the Carville station of the Newcastle Electric Supply Co. might be of interest, as both happened to have a normal evaporation of 33,000 lb. per hour.

| —— | Hornsby. | Stirling. |
|---|---|---|
| Normal evaporation per hour, lb. | 33,000 | 33,000 |
| Heating surface, sq. ft. | 10,850 | 6,380 |
| Grate surface, sq. ft. | 168 | 110 |
| Ratio H.S. to G.S. | 64·5 : 1 | 58 : 1 |
| Floor space or ground space occupied in sq. ft. | 506 | 286 |
| Normal evaporation per sq. ft. of H.S. per hour in lbs. | 3·04 | 5·17 |
| Normal evap. per hour per sq. ft. of ground space | 65 | 115 |
| Draft in inches of water | .. | 0·6 |
| Efficiency of boiler | .. | 75% |

Another boiler with upright tubes, and one which was now being placed on the market, attracted a great deal of attention from engineers at the recent electrical exhibition at Olympia—viz., the "Davies Water-tube Boiler," which, with a heating surface of 1,028 sq. ft., had evaporated 6¼ lb. to 7¼ lb. of water per square foot, or about 85 lb. to 100 lb. per square foot of ground space. Its efficiency was about 80 per cent. Regarding the pumping arrangement, he would like to know the number of pounds of steam used per pump horse-power with the compound pumps described in the Paper, because he recently saw a large boiler feed pump with triple-expansion cylinders which worked with 35 lb. of steam per pump horse-power, whilst a compound pump used 47 lb., and he had heard of a Manchester make of pump using only 42 lb. per pump horse-power. The feed-water temperatures on the various stages of working would also be interesting. He quite agreed with Mr. Patchell's arrangement of a primary heater, but thought an enclosed heater placed between the feed pumps and boilers, working in conjunction with exhaust steam from the pumps, would have been preferable to heating the water in the tank, as a higher temperature would have been obtained.

Mr. H. C. ANSTEY, of Messrs. Hornsby, said the normal evaporation of the boilers was 66,000 lb., and not 33,000 lb. per hour. The question of evaporation and heating surface was one that had not received the attention that it deserved. Many people no doubt remembered the almost classical experiments by M. Niclausse, who measured with his boilers the amount of steam which was evaporated by each section of the tubes. He found that the first two rows of tubes accounted for about 37 per cent. of the total evaporation of the boiler. Although the upright boiler differed very essentially from that of M. Niclausse, they had been able to take some measurements, which showed that the conclusions M. Niclausse had arrived at applied to these also. When the upright boiler was evaporating 100,000 lb. its heating surface directly exposed to the fire in the first two rows, would account for 25,000 lb., and the rate of evaporation per square foot of heating surface in these tubes was 8·3 lb. The mean evaporation over the whole heating surface at this rate was 4½ lb. Assuming that the horizontal boiler was able to steam at the same rate per square foot of heating surface as the upright, it would give 37,500 lb. In this case it would be giving 4½ lb. per square foot of heating surface, and the evaporation over the tubes near the fire would be 14·7 lb., or 77 per cent. greater than the corresponding tubes in the upright boiler. This was an important point. It was quite possible to design a boiler in which, while the rate of evaporation over the whole of the heating surface was comparatively low, the rate in the tubes over the fire would be dangerously high. The question of the heating surface in the tubes near the fire had a most important bearing upon the durability of those tubes. As emphasising this, he mentioned that at Bow the first rows of tubes after 15 months work were as straight as when put in. On the question of mechanical stoking, he would leave Mr. Patchell to reply, but he would just mention that if Mr. Patchell had considered it advantageous to fit mechanical stokers this could easily be done. The upright boiler had a very large combustion space. It was no less than 6,000 cubic ft., and those who had had experience of burning liquid fuel would know that the rate of combustion per cubic foot of space was the one that determined whether smoke was made or not. The same thing applied, though probably in a less degree, when burning coal. When the upright boiler was burning at the rate of 30 lb. per square foot of grate area it was only burning at the rate of 1·6 lb. per cubic foot of combustion space. The horizontal boiler had only 570 ft. of combustion space, and when burning at 30 lb. per square foot of grate, the amount burned per cubic foot of combustion space was 6·5 lb., or four times the amount in the upright boiler. On the question of floor space, the previous speaker had taken the normal evaporation when comparing the Hornsby boiler with the Stirling boiler, but he should have taken the maximum evaporation which Mr. Patchell had given, which was almost the normal figure, as the boiler did this performance so easily. In fact, experience showed that if by any means the grate area or draught could be increased, it would be quite safe to run these boilers up to 120,000 lb. or 130,000 lb. per hour. Further, the amount of evaporation per square foot of floor space actually occupied by the boiler was 200 lb. per square foot for the upright against 115 lb. for the horizontal tube boiler, so that Mr. Patchell had doubled his evaporation for the same floor space. Cleanliness had not been touched upon very much in the Paper, but there were many aspects of this question. One was the loss of efficiency, because the tubes got dirty, either internally or externally, or both. Horizontal tubes got covered with a coating of dust, and the upper part of the surface was practically useless. With vertical tubes the dirt fell away and collected at the bottom of the furnace. The circulation in the upright boiler was such that the feed entered the back sections and deposited the mud in them, the front sections nearest the fire remaining practically free from scale after long periods of working. In the upright boiler at Messrs. Hornsby's own works they ran regularly for three months without cleaning.

Prof. J. EPSTEIN, referring to Mr. Highfield's remarks, said that the film due to the action of nitric acid was noticed in his laboratory three years ago, and some extraordinary tests were made upon the dielectric strength of mica tubes. He had tested tubes by various manufacturers and he had hoped to overcome the difficulty in one of two ways: either in filling up the tube with some material which would absorb the bad gases, or by giving to the coil inside the tube a sort of metal covering which would take the blow of the discharges and absorb the bad gases. But when testing for long periods this had not been successful, and he quite agreed with Mr. Highfield's opinion on the matter. He disagreed with the view expressed that 25 cycles would have been better than 50 cycles, as the latter allowed more space between the different tubes containing the coils.

Mr. W. M. MORDEY agreed with Prof. Epstein regarding the choice of 50 cycles. With regard to the deterioration of insulating materials under alternating high pressures, he suggested that the action might be mechanical and not chemical or electrical. On the coil shown by Mr. Highfield there was a little more than ⅛ in. insulation and 10,000 volts. Some time ago he had gone into the question of trying to account mechanically for the heating that occurred in insulated wires subject to alternating high pressure, and had come to the conclusion that there was one possible explanation, but he was not enough of a physicist to say whether it was correct or not. This was that the actual hammering on the insulating material due to the static attraction between the two conductors was a very serious quantity indeed. He forgot the exact figures, but he believed they worked out that with $\frac{1}{10}$ in. thickness of insulation and 10,000 volts at 50 cycles, the static attraction was something like 1 lb. per square foot. Imagine a blow between two insulated conductors of 1 lb. per square foot applied 100 times per second to the insulating material!

Mr. H. M. SAYERS said he had had more than one experience of trouble due to silent discharge, which went to confirm Mr. Highfield's view that it was a chemical action and not a mechanical one. In a good many cases he had had troublesome faults on the inners of concentric cables working at 2,000 volts with the outers earthed. They were india-rubber cables, and every time the rubber was within a small fraction of an inch of earthed metal. It seemed to him that the silent discharge produced nitric acid, or some other oxide of nitrogen, which damaged the rubber, and eventually broke it down. But it was peculiar that this effect could be entirely prevented by covering the rubber with a close sheathing of lead or some other conducting material, or else keeping it at such a distance from all earthed metal that no silent discharge could take place. The boilers at Bow had been so much discussed that he would only say that it seemed to him that mechanical stokers of the correct type would enable Mr. Patchell to burn bituminous coal quite as smokelessly as he now burned Welsh coal hand fired. About three years ago he made some tests with an underfeed stoker, using washed peas and a very fair bituminous coal. This gave an evaporation from and at 212 deg. of 10·46 lbs. of water per pound of dry coal. This was considerably better than he had been able to get on the same boilers with hand-firing. This was with superheated steam to about 120 deg. and an economiser which heated about 171 deg. The boiler furnace could, with a ¼ in. of water pressure, to burn over 31 lb. of the same coal per sq. ft. of grate surface, and he imagined that small bituminous coal would be delivered at considerably less price than small Welsh. One point had not been touched upon by any speaker, but it was a rather interesting one. Mr. Patchell had discarded the use of surface condensers because of the difficulties he had found in other cases with dirty tubes. He had had some difficulty in this direction by the scaling of the tubes, but the cause was pretty obvious. It very rarely happened with what might be termed a natural condensing water, although he knew of a very bad case where canal water was used. In his own case he had to take out the tubes about every three months and treat them to a bath of dilute hydrochloric acid. But nearly every time that this trouble had occurred it had been when cooling towers had been used. Obviously, if cooling towers were used and the circulating water was passed through the condenser over and over again, the evaporation that went on led to a concentration of salts in the water, and eventually something approaching a concentrated solution was arrived at. If this was a concentrated solution of carbonate of lime, the condenser tubes would scale. The remedy was to soften the make-up water in the proper way, according to the amount of its impurity, and if the circulating water was kept at from 10 deg. to 12 deg. of hardness scaling would not take place. There was another contributory cause. Concrete reservoirs were often used under the cooling tower. All the water dropping from the cooling tower, and coming into contact with large quantities of air absorbed carbonic acid, which, coming into contact with the concrete of the tank, dissolved into powdered lime and hardened itself. Resonance troubles were mentioned in the appendix to the Paper. He had had some resonance troubles once. He was in charge of 100 miles or more of high-tension conductors, which used to fail in dozens of places at once, but he noticed that the failures always took place at light load. They were obliged at light load to run two sets, because the magnetising current was a little too much for one. The power factor was very low, and to economise as far as possible the sets were run at a very low speed, the normal frequency was 83 and he used to run at 65. Some rough calculations showed that there was great probability of getting resonance at about 60 to 65 cycles, and he therefore took care that during the day time and during hours of light load they ran at 70 or 75. From that time the wholesale cable troubles ceased. Mr. Patchell's little trouble with the spark-gaps he thought was due to the water dissolving the glaze of the earthenware in small quantities and forming sodium. He believed that a substance could be obtained which would not yield anything of the sort, but a better plan was to use a weak but definite solution of some salts.

The discussion was adjourned until Thursday next, January 11.

## ELECTRICITY METERS.*

BY C. H. W. GERHARDI.

(*Continued from page 436.*)

### THE TESTING OF METERS IN SITU.

In a large electric light undertaking a number of accounts will be disputed each quarter, and to settle these it is necessary to make a test of the meters in situ. Apart from the tests made for the above reason, it will be found economical to test meters in situ at intervals in order to ascertain how they are working.

The meter may preferably be loaded with the consumers' lamps, or a portable resistance composed of a bank of lamps may be used. If possible it is better to use the consumers' lamps, as the average evening load can then be asked for, and the test made at this load. A second test can be made afterwards at a lower load.

The easiest and quickest way to make a test in situ of a motor meter is by counting the revolutions of the disc and comparing the watts by meter with the watts as indicated by the portable wattmeter, or the current by meter with the current by ammeter in the case of ampere-hour meters. The author has had considerable trouble with shunted instruments for this work. It is unfortunate that instruments of this class are unsatisfactory for testing in situ, as a set of shunts for one instrument enables such good readings to be obtained at widely different loads. It has been found, however, in practice that in time the constant connecting up and disconnecting, together with the coiling up of the flexible leads provided with these shunted instruments, causes a few strands of the flexible lead to break. These broken ends may make contact intermittently, causing variable readings to be obtained. The resistance of the shunted circuit being small, very little alteration in the resistance of the leads makes considerable difference in the reading of the instrument. Owing to this defect, it is preferable to use instruments which carry the whole main current, whether they be ammeters or wattmeters.

When non-inductive wattmeters are used two readings should be taken with the current in both coils reversed in order to eliminate any effect due to stray fields. It is convenient, therefore, to include a portable switch in the outfit, which will enable the change-over to be made quickly and conveniently.

Each tester should be provided with a table of the testing constants (or watt seconds per revolution) of all the sizes and types he is likely to come across on his rounds. This simplifies his calculations considerably, his formula being $Wm = BR/T$, where $Wm$ = watts by meter, $B$ = watt seconds per revolution, $R$ = revolutions counted, $T$ = time in seconds for $R$ revolutions. Or the constant $K$ (which is the multiplier for the watts by meter to make the meter correct) is obtained at one operation: $K = W/Wm = WT/BR$, where $W$ = the true watts as indicated by the portable instrument (using a correction if necessary). The same formula holds in the case of ampere-hour meters, but $W$ is arrived at by multiplying the true amperes by the declared pressure.

Meters other than motor meters cannot be tested in situ in the manner just described. The only way to obtain a test on these is by connecting another meter in series, and leaving it up for a week or more, until readings are obtained large enough to be compared accurately.

*Connections.*—With ampere-hour meters the connections are simple. The portable ammeter is inserted preferably between one of the meter terminals and the lead which is taken out of this terminal. Watt-hour meters and the portable wattmeter must be connected up, as in Figs. 162 and 163; the shunt circuit of the wattmeter is isolated from the main coil, and the latter is inserted on the "house" side of the meter under test. The leads from the wattmeter shunt terminals are connected to the supply main terminal and shunt terminal of the meter respectively. If a lamp box is used the connections would be as in Fig. 163. The house lead A is removed from the house terminal of the meter as before, and if connected to the station terminal by a lead B, the test can be made without interrupting the supply. It will be noticed that with the connections shown the current passing through the portable lamps passes through the shunt tee. For large loads this would not be safe, but up to 10 amperes no harm can be done to this lead for the short time during which the current is kept on.

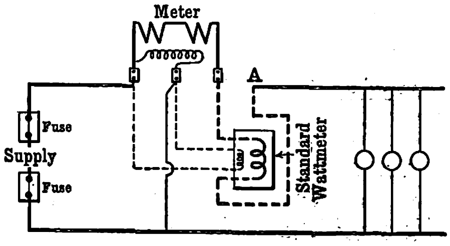

Fig. 162.—Correct Connections for Test of a Watt-hour Meter in situ, using Consumer's Lamps as Load. The Dotted Lines indicate the Temporary Connections.

Testing in situ, if done properly, also becomes a check on the wiring of the house. It is very often difficult to trace wiring (especially additions), and it sometimes occurs that a lamp or lamps may be connected on the station side of the meter. The tester should therefore always be on the look out for such unmetered circuits, which are easily found out by leaving the end A out of the meter and trying to turn on suspected lamps, which, of course, would only glow if connected to the wrong side of the meter.

Three-wire circuit meters are not easily tested in situ; it is therefore preferable to change them and test them in the test room. Unless a specially-designed wattmeter is obtained, having its main coil divided into two halves, well insulated from one another (to be capable of withstanding the pressure between the outers of the three-wire system without breakdown), it becomes necessary to use two wattmeters, as it is practically impossible to be sure that the load on each arm is the same.

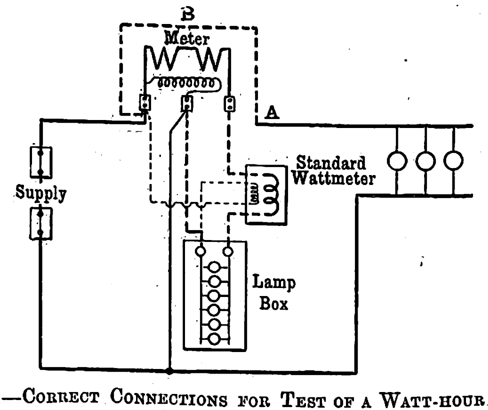

Fig. 163.—Correct Connections for Test of a Watt-hour Meter in situ using Portable Lamp Box as Resistance Consumer's Supply being uninterrupted. The Dotted Lines indicate the Temporary Connections.

The main coils of these instruments are inserted in the two outers on the "house" side of the meter, and their shunt circuits connected up to the station terminals of the meter and a point on the neutral. It might be more convenient to connect both shunts of the wattmeters, including the necessary added resistances, in parallel across the two outers, in which case they would be under the same conditions as the meter—*i.e.*, the wattmeters would take no account of any slight difference in the pressure which might exist on the two arms due to unequal loading. Neglecting this difference—which would be small—if the shunt currents of the wattmeters were normal, a constant of 0·5 would have to be used, as the instruments would indicate twice the actual watts passing. The connections for this test are seen in Fig. 164. Three-wire meters are usually of large capacity, and apart from the difficulties of properly measuring the power by means of standard instruments when testing in situ, there arise others, such as the insertion into the circuit of these instruments where the mains are heavy and end in special sockets, and the practical impossibility of keeping the load steady during the test, owing to the probable switching off of lamps. Portable lamp banks would be too cumbersome in large sizes.

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In the case of meters provided with dials, indicating tenths and hundredths of a B.T.U., tests in situ may be made by means of a standard meter, also having dials showing fractions of a unit. The standard meter would be connected temporarily in the circuit and both meters read. The connections in this case are the same as if the indicating wattmeter were used as shown in Fig. 162, so that the shunt watts of neither the standard nor the meter to be tested are registered. A load is switched on for a short time and the consumption by each meter ascertained. This method is perhaps more simple than that in which a stop watch and standard wattmeter are used, but where meters have no dial lower than the "units per division" one, such a test would take too long. Were it not for the fact that comparatively few meters are provided with the fractional dials, this method of testing in situ would be preferable to any other.

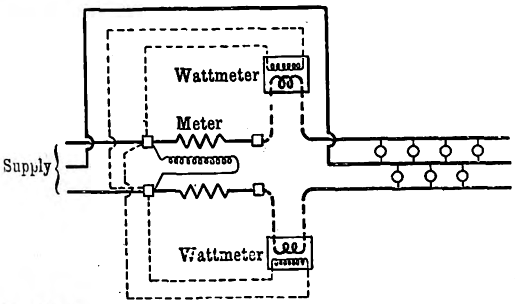

Fig. 164.—Connections for Test of a Three-wire Watt-hour Meter in situ using Two Wattmeters (applying a Constant of 0·5 to obtain the True Power if their Shunt Currents are Normal).

(*To be continued.*)

## WAVE SHAPES IN THREE-PHASE TRANSFORMERS.

BY R. C. CLINKER.

In a former article* the writer gave curves traced by the Hospitalier ondograph showing the effect of a star connection in excluding triple harmonics from the magnetising currents of transformers. In the case of the delta connection, as has already been pointed out, the triple harmonics circulate within the closed delta, and may be regarded as induced currents set up by a slight triple-frequency flux in the cores.

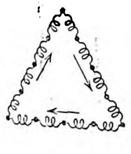

Fig. 1.

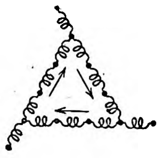

Fig. 2.

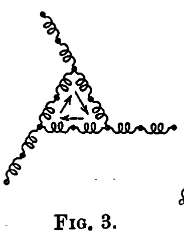

Fig. 3.

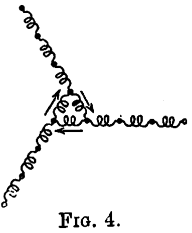

Fig. 4.

The system of connection shown in Figs. 1 to 4 is sometimes used and presents very interesting properties with regard to the triple-frequency components. The figures show three successive steps in passing from a simple delta to a simple star connection. Starting with Fig. 1, we have a certain triple frequency component flowing round in the delta, whose value may be looked upon as proportional to the induced E.M.F. in the delta and inversely proportional to the impedance of the windings. In changing to Fig. 2, however, we have reduced the E.M.F. in proportion to the reduction of turns included in the delta. But the impedance has been reduced nearly proportionally to the *square* of the turns (as the resistance is small compared with the reactance), and hence the circulating current has increased. In this way it may be seen that by continuously reducing the number of turns included in the delta, while keeping the voltage per winding the same, the triple harmonics will be continuously increased. When the delta becomes very small, the resistance component becomes large enough to prevent the current from exceeding a limiting value. This value may, however, be many times that of the normal magnetising current, and will distort the wave shape of the latter considerably.

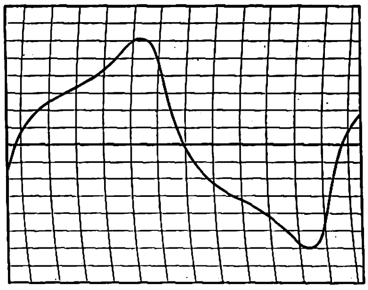

Fig. 5.

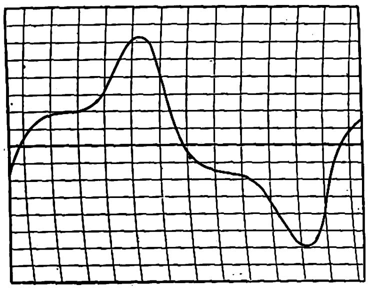

Fig. 6.

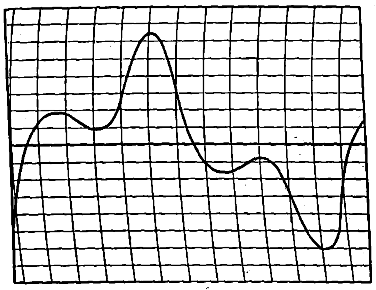

Fig. 7.

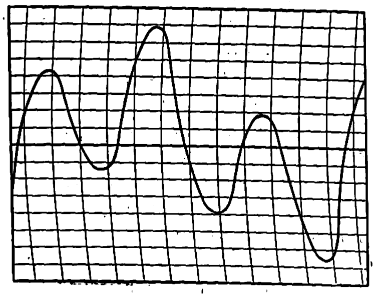

Fig. 8.

The curves in Figs. 5 to 8 show the magnetising current as obtained by the ondograph in four such successive steps. The transformers were single-phase, each having four coils which were connected in series for the test, the corners of the delta being located in each case at the junctions between coils. A low resistance providing sufficient drop to work the ondograph was placed in the delta part of one transformer. Fig. 5 shows the current wave in the full delta. It contains the usual triple term. Fig. 6 shows the wave with a three-quarter delta connection, the triple term having increased. Fig. 7 shows the next step, the harmonic being yet more pronounced, while Fig. 8 shows the current wave in the smallest delta obtainable. This last wave is so distorted that it is hardly recognisable as being developed from that in Fig. 5, but it will be seen that this distortion is produced solely by the increase in the triple term. An analysis of these four waves by Wedmore's method shows the magnitudes of the triple terms in the four cases to be in the proportion of the numbers 1, 1·35, 1·8 and 3·25. The reciprocals of the numbers of turns in the four cases are in the proportion of 1, 1·33, 2, 4. The current increased at a slower rate than the reciprocal of the turns, a fact probably due to the resistance, as shown above. The resistance necessary to work the ondograph also increased this effect.

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* See *The Electrician*, for November 10th, page 135.

The magnitude of the flux harmonic may be deduced from the known current and resistances. The analysis of the curve in Fig. 5 showed that the triple component amounted to about 0·16 ampere. The resistance of the delta was about 0·4 ohm, giving an induced E.M.F. of 0·064 volt. The fundamental voltage was 450, so that the flux harmonic did not in this case exceed about 1½ hundredths of 1 per cent. of the fundamental term. The effect shown by these curves may also be explained in another way when we consider that a certain M.M.F. of triple frequency must be supplied to maintain a sine-shaped flux wave, and that, therefore, a reduction of turns must be accompanied by an increase in current.

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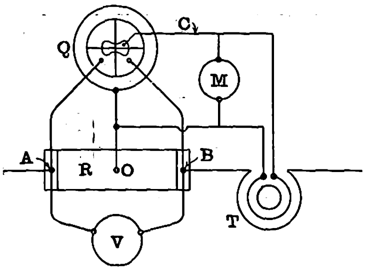
## A METHOD FOR THE MEASUREMENT OF SELF-INDUCTION.

BY ERNEST WILSON AND W. H. WILSON.

The method of measuring self-induction herein described has been found convenient in practice and we believe it to be valuable. The diagram of connections is given in the figure.



R is the resistance whose self-induction it is required to find, shown as a straight shunt. Q is a Kelvin Quadrant electrometer, whose quadrants respectively are connected to the terminals AB of the resistance R, and whose "case" is connected to a point, O, midway between AB when the best accuracy is desired, but which can be connected to either A or B with accurate results when the P.D. between A and B is small compared with the P.D. between the "needle" and "case" of the electrometer Q. T is an air transformer whose primary coil can consist of a single turn of stout copper wire when large currents have to be dealt with. In the experiments six turns were employed for large currents and 246 turns for small currents. The secondary of this transformer consisted of 40,000 turns of copper wire having 5,000 ohms resistance, and is the secondary of an induction coil. One end of the secondary circuit is connected to the "case" of the electrometer and the other to the "needle." M is a multi-cellular voltmeter connected between the "needle" and "case" of the electrometer. V is a hot-wire meter which can be used to measure the current in the circuit when the resistance R is a suitable shunt; but, if more convenient, an ampere-meter can be placed in the circuit. It is necessary that the electrometer should obey Maxwell's law under the conditions of the test. The instrument used obeys Maxwell's law at higher voltages than were impressed upon it in the tests.

Adopting Maxwell's symbols, C is the P.D. between the "needle" and "case." A − B is the P.D. between the quadrants. The P.D. C is supplied by the secondary circuit of the air transformer, and is in quadrature with the current in its primary circuit. If $x$ be the current in the circuit, then the P.D. R$x$ will produce no movement of the "needle" if the electrometer is a true wattmeter, since it is in quadrature with C. If L be the co-efficient of self-induction of the resistance R, and $f$ the frequency, then for a simple harmonic current $2\pi f LxC$ will be measurable on the instrument if it has sufficient sensibility, and is equal to $\theta k$ where $\theta$ is the deflection and $k$ a constant. The constant $k$ is found by impressing known voltages between the needle and case and between the quadrants, and noting the deflection $\theta'$, in which case $k$ will be equal to the product of the voltages divided by $\theta'$. If alternating voltages are employed, the power factor as between them must be unity, or direct current voltages can be used with convenience. In order to find L it is necessary to determine the frequency $f$, the amperes $x$, and the volts C. Root mean-square values can be used.

Experiments 1 and 2 (see table) were made to test the accuracy of the method when large coefficients of self-induction are to be found. The coils used were rectangular in shape and wound with insulated copper wire. Their coefficients of self-induction were measured by a bridge method and found to be 0·027 and 5·64 henries respectively. It will be seen that the agreement is close.

Experiments 3 and 4 were made with a piece of Eureka wire 1·64 mm. diameter, approximately 8·6 metres long, bent on itself, one half being insulated with tape. When closed on itself, Maxwell's formula for self-induction would indicate a coefficient of 0·000019 henries. The agreement is as good as one could expect. The wire was then opened and the insulated portion coiled up a few times, and this gave rise to a considerable increase in L, as shown by experiment 4.

Experiment 5 deals with the self-induction of a straight shunt used with a hot-wire ampere-meter. It is made of corrugated manganin.

Experiments 6 and 7 were made with a shunt composed of 240 strands of single silk-covered Eureka wire 25 L.S.G. in parallel bent once on itself. It was constructed as follows: Eight wires were stranded on to a hemp cord. Six such stranded conductors were re-stranded on to a larger hemp core, and five such stranded conductors were re-stranded on to a still larger hemp core. It will be seen that the self-induction of this conductor per ohm compares unfavourably with the resistance used in experiment 5. Eddy currents are practically eliminated, but the self-induction has been increased.

Experiment 8 was made with a manganin strip described in *Proc.* Roy. Soc., Vol. LXII., p. 368, and supported on six insulators, in a zig-zag manner.

In carrying out the test, it is well to have the higher of the two available P.D.s on the needle. In experiment 2, for instance, the "needle" and "case" were placed across R, and the quadrants across the secondary of T. In this case it must be remembered that the product of $2\pi f Lx$ and the P.D. between the quadrants (A − B) must be taken. With discretion a suitable electro-magnetic instrument might be employed. If when calibrating the electrometer exactly the same readings on M and V be reproduced, the test of low-resistance shunts requires the measurement of the frequency $f$ and the ohmic resistance R.

The results of these tests show that low-resistance shunts capable of carrying large currents have to be used with discretion in connection with alternate currents, more especially alternate-current wattmeters.

| Experiment. | Frequency $f$. | R.M.S. amperes $x$. | R.M.S. volts C. | R.M.S. volts A − B. | Electrometer deflection $\theta$. | Resistance R in ohms. | Coefficient of self-induction L in henries. |
|---|---|---|---|---|---|---|---|
| 1 | 88·8 | 0·503 | 76·5 | 7·6 | 289·0 | 33·0 | 0·027 |
| 2 | 88·8 | 0·029 | 93·5 | 4·18 | 191·0 | 377·0 | 5·7 |
| 3 | 88·0 | 3·91 | 570·0 | 3·91 | 8·6 | 1·0 | 0·000014 |
| 4 | 89·0 | 3·91 | 564·0 | 3·91 | 15·5 | 1·0 | 0·000025 |
| 5 | 88·0 | 176·0 | 596·0 | 0·79 | 3·2 | 0·0045 | 0·00000016 |
| 6 | 88·5 | 128·0 | 423·0 | 1·07 | 6·0 | 0·0084 | 0·00000048 |
| 7 | 100·0 | 128·0 | 480·0 | 1·07 | 7·6 | 0·0084 | 0·00000050 |
| 8 | 88·4 | 21·9 | 81·0 | 10·1 | 10·0 | 0·46 | 0·000021 |

## PATENTS EXPIRING IN 1906.

The following is a list of the patents of interest to electrical engineers which (unless specially extended by recommendation of the Judicial Committee of the Privy Council) will expire during the present year. The list includes only those patents of 1892 which have been kept in force up to date by payment of the renewal fees:—

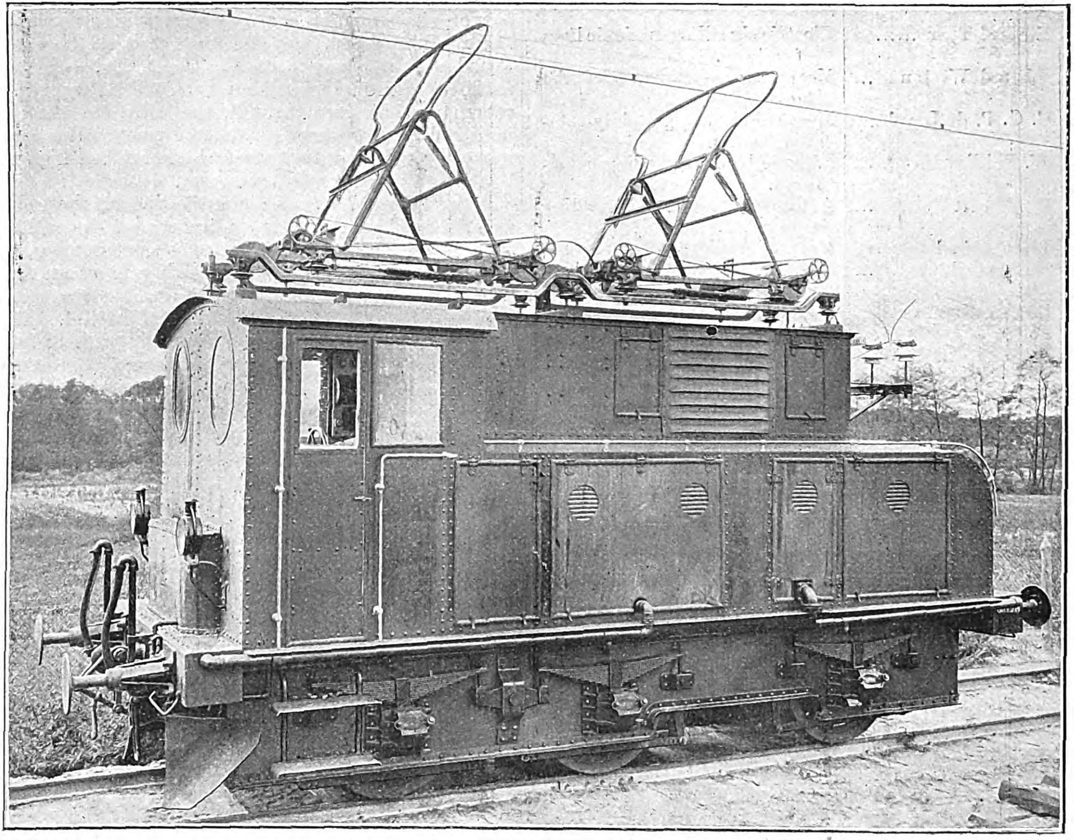
| Date (1892). | No. | Name of patentee. | Subject of patent. |
|---|---|---|---|
| Jan. 7 | 363 | Druitt Halpin ......... | Improved means of generating steam and purifying the water employed. |
| Jan. 9 | 491 | Carl A. W. Hultman | Underground conduits. |
| Jan. 22 | 1,312 | Max Mannesmann ... | Fire and water tubes for boilers. |
| Feb. 8 | 2,353 | J. J. Meldrum & T. F. Meldrum | Furnace grates and fire bars. |
| Feb. 12 | 2,798 | Edward Tyer ....... .. | Electric signalling on single lines of railway. |
| Mar. 1 | 4,017 | Edward Weston .. ... | Measuring instruments of the hot-wire type. |
| Mar. 11 | 4,863 | C. G. P. de Laval ... | Means of balancing rapidly-rotating bodies. |
| Mar. 15 | 5,086 | W. Phillips Hall ...... | Electric block signalling apparatus. |
| Mar. 22 | 5,609 | W. Robert Sykes ... | Automatic railway signalling apparatus. |
| Mar. 31 | 6,253 | Lord Alfred Spencer Churchill ............ | Method of picking up current applicable to electric tramways and railways. |
| Apr. 7 | 6,707 | Gisbert Kapp ......... | Double tariff electricity meter. |
| Apr. 12 | 7,029 | Felten & Guilleaume | Electric cables. |
| Apr. 14 | 7,241 | Rudolf Diesel .. ...... | Diesel engine. |
| May 17 | 9,347 | Carl Kellner ......... | Process for the separation of the alkali obtained by electrolytical decomposition. |
| May 17 | 9,365 | R. Lundell & H. Johnson ...................... | Improvements in electric motors and dynamos. |
| May 20 | 9,631 | Emile Andreoli ...... | Improvements in connection with ozonisers. |
| June 1 | 10,430 | Robert Wood ......... | Electrical insulating sheet. |
| June 2 | 10,524 | A. H. S. Dyer ......... | Electrical insulating sheet. |
| June 7 | 10,818 | C. W. Jefferson ...... | Electrical insulating conduit. |
| June 20 | 11,526 | Felten & Guilleaume | Electric cables. |
| June 23 | 11,721 | Wilhelm Schmidt ... | Superheaters. |
| July 16 | 13,083 | Hugo Junkers......... | Calorimeters. |
| July 21 | 13,380 | F. Le Breton Bedwell | Means of protecting telegraph cables connected with lightships and floating stations. |
| July 28 | 13,765 | M. Hutin & M. Leblanc | Damping coils on alternating-current machines. |
| July 30 | 13,920 | W. H. Knight and W. B. Potter | Improvements in series parallel control. |
| Aug. 8 | 14,317 | W. von Oechelhäuser and Hugo Junkers | Gas engines. |
| Aug. 22 | 15,120 | H. W. Headland .... | Accumulators. |
| Sept. 1 | 15,677 | C. A. Parsons ...... .. | Governing of steam turbines. |
| Sept. 7 | 16,046 | H. Young Castner ... | Electrolytic decomposition of alkaline salts. |
| Sept. 16 | 16,588 | Pompeo Garuti ..... | Production of oxygen and hydrogen by electrolysis of water. |
| Sept. 24 | 17,093 | W. E. Ayrton and T. Mather | Electrostatic measuring instruments. |
| Sept. 26 | 17,160 | J. E. Kingsbury ...... | Telephone switchboards. |
| Sept. 26 | 17,169 | Charles Kellner ...... | Electrolytical decomposition of metallic salts. |
| Oct. 6 | 17,826 | M. Hutin & M. Leblanc | A method of transforming alternating current to continuous current, and vice versa. |
| Oct. 8 | 17,982 | Louis Boudreaux...... | Dynamo brushes. |
| Oct. 10 | 18,039 | J. Hargreaves & T. Bird | Electrolytic cells & diaphragms. |
| Oct. 11 | 18,116 | W. Mathiesen ......... | Arc lamps. |
| Oct. 15 | 18,516 | E. N. A. Picard and J. A. Tanière | Electro-deposition of metals. |
| Oct. 22 | 18,994 | J. A. Timmis ......... | Electromagnets. |
| Nov. 15 | 20,611 | Robert Lundell ...... | Improvements in governing electric motors. |
| Nov. 28 | 21,696 | T. L. Willson ......... | Electric smelting of refractory ores. |
| Nov. 28 | 21,701 | T. L Willson ......... | The treatment of refractory metallic compounds by electric smelting. |
| Nov. 29 | 21,794 | Emile Andreoli ...... | Electrodes for ozonisers. |
| Dec. 3 | 22,187 | Westinghouse Co. ... | Lightning arresters. |
| Dec. 13 | 22,914 | C. L. Buckingham ... | Printing telegraphs. |
| Dec. 13 | 22,915 | C. L. Buckingham ... | Printing telegraphs. |
| Dec. 13 | 23,931 | C. L. Buckingham ... | Printing and multiple synchronous telegraphs. |
| Dec. 14 | 22,987 | W. Woodnut Griscom | Accumulator plates. |
| Dec. 27 | 23,892 | M. Hutin & M. Leblanc | Multiple telephony. |
| Dec. 31 | 24,127 | Frank King ............ | Secondary batteries. |

## 20,000-VOLT SINGLE-PHASE LOCOMOTIVE FOR SWEDEN.

It will be remembered from previous notes in *The Electrician*, that the Swedish railway authorities have been conducting tests with single-phase traction on the Tomteboda-Värtan line for some time. A brief description of the power station used in connection with these tests was given in Vol. LIII., p. 780. Of the experimental track only 6 km., about 3¾ miles, are ready at present, but 5 km. more are under construction, and later more additions will be made. The trolley wire is a round 8 mm. (0·315 in.) hard-drawn copper wire, and is suspended at a height over the rails of 4·7 m. to 5·7 m. (15 ft. to 18 ft.). Since one object of the experiments is to determine the most suitable method of wire suspension, many different kinds of suspension have been used on different parts of the track. In all cases the insulation is double, there being one insulator between the pole and the span and cross bar, and one insulator for the message wires. At some places, especially curves, rigid members are necessary in order to hold the wires in the right position, and for this purpose bicycle tubes are used. Wooden poles are used on the whole line, with the exception of six made of armoured concrete situated at curves. Of course, the return current goes through the rails, but these are not provided with rail bonds, except on a small part of the line. This arrangement is made in order to test whether at the high voltages used rail bonds will prove necessary or not.

A telephone line runs along the line on the trolley poles. Some experiments regarding the influence of the railway current have shown that the static influence is considerable, the voltage of the telephone line to ground amounting to about 4,000 volts in some cases. In order to correct this two discharging coils were connected between the two telephone wires and ground. These removed the static charge, but the telephones are provided with high-tension insulation. At present, experiments are being carried out with two locomotives and two motor cars. One of the locomotives was obtained from the British Westinghouse Co. (for a description see *The Electrician*, Vol. LV., p. 206), while the other locomotive was supplied by the Siemens-Schuckert Co. (see the adjoining illustration). It weighs 36 tons, and is primarily intended to haul goods trains at speeds up to 40 miles per hour. The locomotive has three driving axles, the distances between centres being 5½ ft. and 7½ ft. respectively, and wheels 43 in. in diameter. The frame of the locomotive consists of side plates braced together by strong cross stays and rolled-iron end plates. It is supported on the axles by laminated springs 1,200 mm. (47¼ in.) long hung on equalising levers. The axles are made from the best nickel steel, and are 150 mm. (5⅞ in.) in diameter, turned down to 110 mm. (4⅜ in.) diameter at the journals. Standard coupling gear and buffers are provided at each end of the locomotive, and there are two ploughs at the forward end. Each axle is driven through a 1 to 5 gearing by a 110 H.P., 25 ∼, 320 volt compensated single-phase series motor, as used on the Murnau-Oberammergau line (*The Electrician*, Vol. LV., pp. 757-808). All three motors together are able to exert a maximum draw-bar pull of 13,300 lb. The car body is of sheet metal and is 21 ft. long, 8½ ft. wide and 11½ ft. high. The driver's cab, to which access is gained by two side doors, is situated in front in an elevated position. Behind it is a compartment, 4 ft. high, containing the transformers, all switch and control gear and the two auxiliary motors. On top of this there is another (but narrower) compartment for the H.T. cables. Two current collectors of the bow type are provided, which change their position automatically when the locomotive reverses its direction of travel. Spring-action is depended on for pressing the aluminium bow against the overhead wire, and, in order to ensure a more or less constant pressure with varying heights of the trolley wire, the springs exert their pressure through the medium of suitably curved discs, so that the leverage is small when the bow is depressed and the springs under a high tension, and vice versa. The H.T. conductors in the special compartment referred to are bare, being supported by ordinary insulators. A lightning arrester of the horn type is connected between the H.T. supply and earth, in series with a high resistance. The transformer is of the oil type and has a normal capacity of 300 kw. In order to be able to experiment with various voltages between 5,000 and 20,000 volts, the primary winding of the transformer is divided into eight equal sections. The secondary winding can be tapped at a number of points, and the voltage to the motors can be varied from 160 to 320 volts. Current at 120 and 240 volts for lighting and heating the locomotive and for driving the auxiliaries is also obtained from the secondary. The controller has 10 main positions. In the first position (for a very slow speed) a resistance is connected in series with the motors. Blow-out magnets are provided. Although the motors are liberally designed and show only a small temperature rise under existing conditions, provision is made for them to be artificially cooled by an air blast, in view of their employment, later on, for continuous long-distance traffic. To this end a fan is provided capable of delivering some 1,400 cubic ft. of air per minute at a pressure of 3 in. of water when driven at 1,725 revs. per min. It is driven, together with some other machinery mentioned below, by a 7 H.P. motor. The fan itself is stated to absorb 1·8 H.P. Air for cooling purposes is drawn from the upper compartment, which is provided with half-open shutters. After passing through a number of fine sieves for removing dust, the air is fed to the interior of the motors through a number of sheet-iron tubes connected together by flexible leather joints, and finally escapes through openings in the motor carcase. The same auxiliary motor serves to circulate the transformer oil through the cooling pipes (which are laid around the locomotive), and also drives a small air compressor for actuating the whistle. The vacuum brake is applied and released by a single lever, which, when placed in its first position, causes the motor driving the vacuum pump to run at full speed, when shifted to the second position it reduces the pump motor speed, and when moved to the third and last position stops the motor and establishes communication between the brake cylinder and the atmosphere. At starting, the lever is moved to the first position, but when the vacuum has been established it is shifted to position two, where it remains as long as the train is running. A hand brake is also provided.

The motor cars were built by the Nya Aktiebolaget Atlas, Stockholm, and their electical apparatus supplied and installed by the Allgemeine Elektricitäts-Gesellschaft, of Berlin. The motor truck of each car has two single-phase Eichberg motors, each motor having a rated capacity of 120 H.P. The wheel diameter is 1 m. (3 ft. 3⅜ in.), and the two gearing sets have a ratio of 1 : 4·26 and 1 : 2·96 respectively. The maximum speed of the motors is 1,000 revs. per min., and thus the highest attainable speed of the car is 45 km. and 65 km. (28 and 40 miles) per hour. Each car is provided with two contact arms of a special design. It is further provided with a regulating transformer, controlling apparatus and relays for speed regulation. All high-tension apparatus is placed in a special chamber, which is accessible only when the contact arms are pulled down. In each end of the car there is a motorman's cabin. The controlling apparatus is on the multiple-unit system. The auxiliary current for the controlling apparatus is not, however, direct current from a small storage battery, as in the case of the Westinghouse system, but is taken from the mains by means of a transformer. Current for heating purposes is taken from the regulating transformer, so that the heating current is heaviest when the motors take no current, while at full load the heating current almost ceases entirely.



SIEMENS-SCHUCKERT 20,000-VOLT LOCOMOTIVE FOR SWEDEN.

## THE PUBLIC LIGHTING OF EDINBURGH.

A report giving the results of an exhaustive series of tests on the electric and gas lighting of Edinburgh, carried out by Mr. J. F. Simmance, has recently been issued. The scope of the investigations is briefly outlined as follows :—

(1) What is the illuminating power of the gas supplied to the city of Edinburgh, and what loss, if any, of such illuminating power is incurred in the distribution from the Granton works? (2) At what pressure is such gas delivered to different parts of the city, and what is the voltage of the electric current? (3) What are the illuminating powers of the street lights—(*a*) the electric arc lamps, and (*b*) the gas lamps of the types usually adopted? (*c*) What is the general lighting effect between lamps of each kind at their usual distance apart?

Three testing stations were established, where an extensive series of tests were made of the quality of gas supplied to various parts of the town, which were found to show great variations, especially in districts where, owing to the increase in electric street lighting, the use of gas practically ceases each night after the house lights are extinguished and gas remains inert for some hours in the pipes. A long series of records of the variation of gas pressure was also made at a number of different parts of the city. Many diagrams were taken, and all secured in the same district are remarkably alike, evidencing careful governing and regulation of the pressure.

Similar tests were made of the variation of the voltage of the electric supply. As the mere statement of voltage is of little use to the consumer, except in relation to its effect upon his lighting, careful photometric tests were made upon an aged lamp running upon the ascertained voltages, and diagrams prepared which record both voltage and illuminating power. The figures require very little comment. At the Synod Hall, representing the centre of the city, no possible fault could be found with the electric supply, which was excellent. As a matter of interest, it is mentioned that the switching on of every light in the hall (some hundreds) caused a drop of 2 volts at the main terminals. Complaints from Portobello as to low voltage are stated to be unfounded. What occurred was a fluctuation in voltage; and fluctuations in light were caused by the changes from a high voltage to something approaching normal, and the deteriorating effect of this voltage upon 230 volt glow lamps, Mr. Simmance points out, must be very considerable. The variation in candle-power of the lamp during test was very great—nearly 100 per cent.; and this must have occurred on every lamp in use in the district working on the same voltage.

Figs. 1 and 2 show typical curves for gas pressure and voltage respectively.

The photometric tests of street lighting were made by a street photometer with pentane standard and Simmance-Abady "Flicker" head, mounted on a four-wheeled carriage. The following explanations and comparisons are given to make clear the course pursued and the results obtained: A foot-candle is the light thrown by the flame of a standard spermaceti candle (of six to the pound) upon a surface placed normally at 1 ft. from the flame. The moon, three days past the first quarter, 12 deg. above the horizon, at 11:30 p.m. on July 12, gave a light equal to a standard candle held at a distance of 12·6 ft. The daylight from the zenith, in Cambridge-street-lane, at 9 p.m. on July 4, equalled a standard candle at 1 ft. 1 in., the sky being absolutely clear of cloud. The expression "foot-candles" is, to some extent, a misleading one, because it would appear at first glance that if 1 foot-candle is the light 1 ft. from a candle, then ½ foot-candle is the light 2 ft. from a candle. This, however, is not so, as will be seen from the appended explanation of the formulæ used. In order, therefore, to make the results quite clear, each expression of foot-candles has have converted into a statement of the distance in feet at which a candle must be held to give a light equal to that of the lamp under consideration.

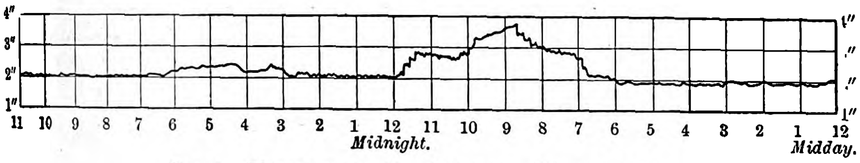


Fig. 1.—Variation of Gas Pressure (Portobello).

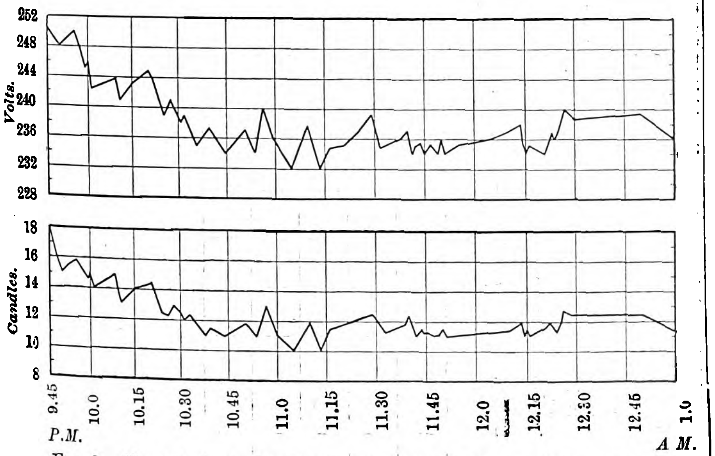


Fig. 2.—Variation of Voltage and Candle Power (Portobello).

The report continues: It should be noted, in looking at the results, that the power is in inverse ratio to the distance at which a candle is held. Thus the light equal to a candle held at 2 ft. is very much greater than that equal to a candle held at 57·7 ft. It will also be obvious that as no lamp emits the same amount of light in all directions, the light varies according to the angle at which it is observed; and the theoretically perfect lamp would be that whose light at any point on the ground is equal to a candle held at the same distance in every case. In Fig. 3, A is a source of light, A C is the length of the lamp-column, C D is the ground line, B C is the height of the photometer, E is the point at which the reading of the illuminating power was taken, B A E is an angle of 60 deg., B E A is therefore an angle of 30 deg. In order to find the illuminating power of the source of light—*i.e.*, the lamp under test—it is necessary to find the length of A E in feet, to observe on the photometer the distance in feet ($x$) at which a candle must be held at E in order to equal the light given by the lamp at this angle; and the illuminating power is then found from the following formula: $(x/\mathrm{AE})^2 = \mathrm{I}$ = the illuminating power.

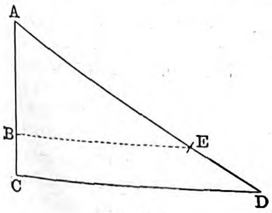


Fig. 3.

In order to find the illuminating effect in foot-candles thrown by the light A at the angle B E A upon the ground, it is necessary to extend A E to D; and the illuminating effect is then found from the following formulæ:—

(*a*) $\mathrm{I}/\mathrm{AD}^2 = \mathrm{F}$ = the illuminating effect at D, but on a line at right angles to the line A D.

(*b*) $\mathrm{F} \times \cos 90 - \mathrm{B\,E\,A} = \mathrm{G}$ = foot-candles at D on the ground surface or pavement.

Now, G represents foot-candles—a term of expression used in light tests which conveys little to the lay mind. In order to make this clearly understood, I have converted each expression of foot-candles into a statement as to the distance in feet at which one candle must be held to give an equivalent light. This conversion from G is arrived at as follows: Distance at which a candle must be held $= \sqrt{\mathrm{I}/\mathrm{G}}$.

The same angles of illumination have been tested in each case; the only deviations from this rule being occasioned by the necessities of the varying levels of the ground line. For comparative purposes, they may be taken as relatively the same angle.

We give below some typical results of these observations:—

ELECTRIC LAMPS.

*15-Ampere Arc Lamp in Princes-street, opposite No. 120.*

| θ ± | Candle-power. | Light on ground in foot candles. | Equal to candle held at | Distance from column. |
|---|---|---|---|---|
| 71·0 | 147·37 | 0·24435 | 2·02 ft. | 7·9 ft. |
| 57·0 | 410·87 | 0·465 | 1·46 ft. | 14·9 ft. |
| 42·30 | 617·52 | 0·363 | 1·65 ft. | 25·0 ft. |
| 28·0 | 841·0 | 0·116 | 2·93 ft. | 43·0 ft. |
| 15·0 | 744·19 | 0·02 | 6·4 ft. | 85·0 ft. |
| 6·0 | 656·89 | 0·0013 | 27·7 ft. | 218·0 ft. |

*Four 15-Ampere Lamps selected at random in Princes-street, and tested at one angle only for comparative purposes.*

| | | | | |
|---|---|---|---|---|
| 35·5 | 844·48 | 0·1600 | 2·5 ft. | 32·2 ft. |
| 35·0 | 786·80 | 0·1525 | 2·56 ft. | 32·8 ft. |
| 35·0 | 773·96 | 0·1506 | 2·57 ft. | 32·8 ft |
| 35·9 | 816·24 | 0·1508 | 2·574 ft. | 31·8 ft. |

*15-Ampere Lamp, Sea Front, Portobello, corner of Melville-street.*

| | | | | |
|---|---|---|---|---|
| 75 | 84·78 | 0·09 | 3·31 ft. | 6·1 ft. |
| 60 | 112·99 | 0·17 | 2·42 ft. | 13·2 ft. |
| 45 | 119·02 | 0·06 | 4·0 ft. | 23·0 ft. |
| 30 | 222·60 | 0·04 | 5·0 ft. | 39·79 ft. |
| 15 | 213·16 | 0·005 | 14·1 ft. | 85·1 ft. |
| 5 | 291·72 | 0·0003 | 57·8 ft. | 262·2 ft. |

*10-Ampere Arc Lamp, junction of Grindlay-street and Lothian-road.*

| | | | | |
|---|---|---|---|---|
| 61 | 132·94 | 0·168 | 2·43 ft. | 12·7 ft. |
| 45 | 357·58 | 0·231 | 2·07 ft. | 23·0 ft. |
| 25 | 572·16 | 0·79 | 1·12 ft. | 49·2 ft. |
| 13 | 291·72 | 0·0066 | 12·28 ft. | 98·9 ft. |
| 5 | 453·69 | 0·0005 | 44·7 ft. | 262·2 ft. |

GAS LAMPS.

*4 ft. Crescent Lamp. Two 2 ft. Flat-Flame Governor Burners, Gillespie Crescent.*

| | | | | |
|---|---|---|---|---|
| 75 | 4·38 | 0·036 | 5·24 ft. | 2·7 ft. |
| 60 | 10·12 | 0·056 | 4·18 ft. | 5·98 ft. |
| 45 | 9·15 | 0·035 | 5·33 ft. | 10·5 ft. |
| 30 | 11·71 | 0·012 | 9·1 ft. | 25·5 ft. |
| 15 | 7·06 | 0·001 | 31·6 ft. | 38·8 ft. |
| 5 | 11·51 | 0·00009 | .. | 119·7 ft. |

*3 ft Incandescent Gas-Lamp, Moray-place, opposite No. 3.*

| | | | | |
|---|---|---|---|---|
| 75 | 19·23 | 0·121 | 2 8 ft. | 2·7 ft. |
| 60 | 43·4 | 0·201 | 2·22 ft. | 5·98 ft. |
| 45 | 68·6 | 0·167 | 2·44 ft. | 10·5 ft. |
| 30 | 69·5 | 0·066 | 3·8 ft. | 25·5 ft. |
| 15 | 69·18 | 0·012 | 9·1 ft. | 38·8 ft. |
| 5 | 68·59 | 0·0005 | 44·7 ft. | 119·7 ft. |

*4 ft. Gas-Lamp, Incandescent, Middle Meadow-walk.*

| | | | | |
|---|---|---|---|---|
| 75 | 33·91 | 0·272 | 1·91 ft. | 2·7 ft. |
| 60 | 36·79 | 0·228 | 2·09 ft. | 5·98 ft. |
| 45 | 49·67 | 0·182 | 2·34 ft. | 10·5 ft. |
| 30 | 59·13 | 0·074 | 3·69 ft. | 25·5 ft. |
| 15 | 98·60 | 0·017 | 7·6 ft. | 38·8 ft. |
| 5 | 115·77 | 0·0008 | 35·35 ft. | 119·7 ft. |

*9 ft. Gas-Lamp, Incandescent, Melville-drive.*

| | | | | |
|---|---|---|---|---|
| 75 | 20·38 | 0·087 | 3·43 ft. | 2·7 ft. |
| 60 | 43·17 | 0·134 | 2·73 ft. | 5·98 ft. |
| 45 | 72·30 | 0·126 | 2·81 ft. | 10·5 ft. |
| 30 | 109·41 | 0·069 | 3·76 ft. | 25·5 ft. |
| 15 | 179·02 | 0·015 | 8·1 ft. | 38·8 ft. |
| 5 | 265·69 | 0·0005 | 44·7 ft. | 119·7 ft. |

The following comments on the electric lighting are made in the report. The lamps tested were selected, not with reference to their condition or appearance, but wholly by reason of their individual situation. A lamp with a non-reflecting background, with a sufficiently long run of space in front to permit of the movement of the photometer over the necessary 200 odd feet, was in each case selected. As it is impossible to obtain a perfectly steady burning arc, and as in every case some fluctuations are observable, the readings on the photometer were continued over some little space of time, and these readings were averaged. I must express my admiration for the design and selection of the type of arc lamp used in Edinburgh. The steadiness of light is very satisfactory; and the light at the angles approaching the horizontal is far greater than in many types of lamps. It must be observed that the value of a lamp for street lighting is not measurable by its mean hemispherical intensity. The bare arc invariably gives its greatest results at angles from 40 to 50 deg., but at 5 deg. and horizontal the light is very small. With a gas incandescent lamp, the greatest light is, of course, horizontal to the mantle and the depressed degrees from it; and this affords an advantage over arc lighting in most cases. But the arc lamps used in Edinburgh afford a very considerable light at the longer distances, and thus must be looked upon as eminently satisfactory. In fact, the electric lighting of the city can be spoken of in terms of highest praise. The judgment shown in the placing of the lamps, and the efficient manner in which they are supplied with current are specially noticeable.

With regard to the incandescent gas lamps, Mr. Simmance says: The fact that most of these are fixed on the columns originally placed for the flat-flame lamps would lead one to expect that the lighting would be most brilliant. Such, however, was not the case. They are a great improvement, naturally, on the old flat flames; but in most cases nothing but disapproval can be expressed of them as specimens of incandescent gas lighting. The types of lanterns are good, and no fault can be found with the burner and mantle used. The fixing of the lantern and inefficient maintenance are, in my opinion, to blame for the fact—which I state definitely—that at least 40 per cent. of the gas expended in these lamps is wasted. Referring again to the table of lamp tests, it was ascertained by measurement that angle-ray 15 deg. strikes the ground in every case at a distance overlapping the similar angle from the next lamp, and thus this is the most important angle to be considered in point of general diffusive effect. The varying widths of the streets render it impossible to give any useful data as to the general effect between lamps, as such light is in every case greater than that attributed to any one lamp. The figures given, however, enable the lighting effect to be estimated with great practical accuracy for any street.

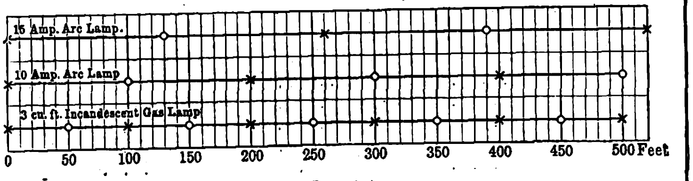


FIG. 4.

Print can be read with the light of a candle held at a distance of 10 ft. This is equal to 0·01 foot-candle; and as in every case of a normally-burning lamp with a mantle in comparatively fair condition the ray reaching half way to the next lamp is invariably more than double this. The comparative effects of the electric and gas lamps, taking good specimens of each, are shown in Fig. 4, X representing the lamp and O the point where the light equals 0·01 foot-candle. The vertical divisions equal 10 ft. of distance. Thus, three 15 ampere lamps equal six incandescent; and three 10 ampere lamps equal five incandescent—approximately.

It must be borne in mind, however, that the greater height of the electric lamps gives the rays forming the more acute angles with the ground a further reaching effect, and thus the more distant lamps afford more useful aggregate distance light than the shorter gas-columns can do; and I therefore should have no hesitation in stating that the 10 ampere lamps could do the work of three times the number of 3 ft. incandescent gas lamps in fairly straight streets where the height of the electric columns gives that system the advantage I mention.

The report proceeds to give some figures of the calorific power and specific gravity of the gas, and concludes with a short summary of the results obtained.

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Science Abstracts." December, 1905. Section A—Physics. Section B—Electrical Engineering. (London: E. & F. N. Spon.) 1s. 6d. each.

Proceedings of the Royal Society of Edinburgh. Session 1904-5. No. 12. Vol. XXV. (London: Williams & Norgate.) 5s.

"Lexikon der Elektrizität und Elektrotechnik." Edited by Fritz Hoppe. In 20 parts. Part I. A to Anzünder. (Leipzig: A. Hartleben.) 50pf.

"Krane: Ein Handbuch für Bureau, Betrieb und Studium." By Anton Böttscher. With a separate volume of diagrams and drawings. (Berlin: R. Oldenbourg.) 25m.

## ALUMINIUM FUSES.

BY ALFRED SCHWARTZ AND W. H. N. JAMES.

Entending the recent investigation of zinc fuses* to those composed of strip aluminium, a series of experiments was made with the fuse in a horizontal position with the axis of breadth parallel to the ground. On plotting fusing current and breadth for a constant thickness a straight line was obtained, and the law connecting these two quantities is of the character $c \propto (b+b_1)$. $c$=normal fusing current, $b$=breadth, $b_1$=a constant.

On plotting fusing current and thickness for a constant breadth a curve is obtained which approximates to a straight line with a slight tendency to become concave towards the axis of thickness; on drawing the mean straight line, however, the deviation of the extreme points will be found not to be large and, consequently, we may take it that $c \propto (t+t_1)$ in which $t$=thickness; $t_1$=a constant.

On experimenting with strip of various lengths and in different positions it was found possible to assume $b_1$ and $t_1$ constant for all cases; consequently for aluminium strip—

$$C=K\,(b+b_1)\,(t+t_1),$$

in which C=normal fusing current; $b_1=0{\cdot}035$ in inch measure=0·09 in cm. measure; $t_1=0{\cdot}0024$ in inch measure = 0·006 in c.m. measure; K = a constant.

This law holds between the following limits:—Breadth, 0·15 in. to 0·8 in. (probably more); thickness, 0·003 in. to 0·035 in.; current per strip, 25 to 600 amperes. The value of the constant K depends upon the position and environment of the strip, and its length between terminals, and also on the mass and character of the terminals used. The curve in Fig. 1 gives the connection between the value of the constant K in inch measure (K in inch measure = K in centimetre measure × 6·45), and the clear length of the fuse between terminals with the fuse horizontal, the axis of breadth parallel to the ground and terminals weighing 870 grammes each.

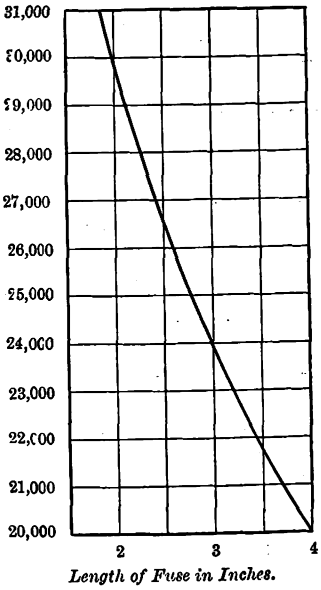


FIG. 1.—CURVE INDICATING THE VALUES OF THE CONSTANT "K" FOR VARYING CLEAR LENGTHS OF ALUMINIUM FUSES (HORIZONTAL) BETWEEN TERMINALS. THE TERMINALS WEIGH 870 GRAMMES EACH.

If the strip is placed horizontally, but with its axis of breadth vertical, the fusing current will be higher than that indicated by the above law due to the greater facility for cooling. The exact amount of this increase is difficult to ascertain, as it depends upon the breadth and thickness of the strip employed. As an average value we may take the increase in the fusing current to be about 6 per cent. If the axis of length of the strip is vertical and that of breadth horizontal, the fusing current is approximately the same as when horizontal and edgewise; and thus is about 6 per cent. higher than with the strip horizontal and broadways on. In this respect aluminium differs from copper and zinc, for which the reverse holds good.

Aluminium attains a dull red heat just before fusion, and a strip which will carry 200 or 300 amperes will, if blown on a low-pressure circuit of 10 or 20 volts, throw off burning globules of metal a distance of 2 ft. or 3 ft. An examination of the fuse after rupture discloses traces of a thin oxide film, but with the exception of strip of small dimensions this does not seem to have a prejudicial effect as regards the constancy of the fusing current. The short-circuit tests on aluminium strip were carried out on a 100 kw. generator with about 12 yds. of cable of 1 sq. in. cross-sectional area in circuit. Strip with a normal fusing current of 100 amperes when short-circuited produced heavy fumes and threw off numerous burning globules of metal to a distance of 15 ft. or 20 ft.

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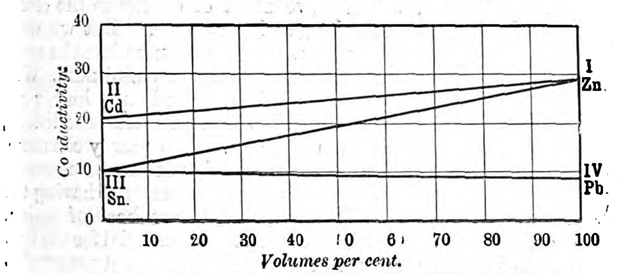
* *The Electrician*, Nov. 17, p. 184.

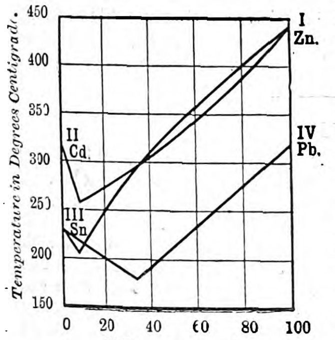
With large fuses, in which the breadth has been cut down for a couple of inches at the centre, the portion disrupted was almost entirely limited to this length, but the cutting down has to be carried to a much greater extent than with zinc; this is due probably to the much higher temperature attained by aluminium before fusion and to the smaller volume of metal required for a given service.



I,—II. Zinc-Cadmium. I.—III. Zinc-Tin. III.—IV. Tin-Lead.

FIG. 2.—DIAGRAM SHOWING THE CONDUCTIVITIES OF CADMIUM-ZINC, TIN-ZINC AND TIN-LEAD ALLOYS.

Unfortunately, aluminium, zinc and cadmium are highly electro-positive to copper or brass, and in the presence of moisture this contact difference of potential is likely to give rise to corrosion of the contacts, with consequent increase of contact resistance and impairment of the fuse. There are, no doubt, situations in which these metals may be employed with advantage, but for damp situations, such as network boxes and section pillars, they require careful inspection and attention. Aluminium is particularly difficult to deal with in this respect, as, although in normal salt solution or normal solution of sulphuric acid it is not so electro-positive to copper as zinc is, yet, unlike the latter, it cannot be soldered to contact pieces or electro-plated. A good plan to adopt to overcome this difficulty would appear to be to coat the contact clips of the fuse blocks with tin, and so reduce the contact difference of potential between the fuse strip and the clips. Prof. W. W. Haldane Gee has been kind enough to determine a number of these contact differences of potential, and his results are embodied in the following table:



I.—II. Zinc-Cadmium. I.—III. Zinc-Tin. III.—IV. Tin-Lead.

FIG. 3.—DIAGRAM SHOWING THE SMELTING POINTS OF CADMIUM-ZINC, TIN-ZINC AND TIN-LEAD ALLOYS.

*Average E.M.F., in Volts, Against Sheet Aluminium at 15° C. of Commercial Samples of Metals.*

| — | Normal solution of common salt. | Electrolyte: normal solution of sulphuric acid. | Normal solution of caustic soda. |
|---|---|---|---|
| Copper | – 0·54 | – 0·49 | – 1·23 |
| Zinc | + 0·31 | + 0·47 | – 0·29 |
| Tin | – 0·35 | + 0·08 | – 0·44 |
| Iron | – 0·33 | – 0·11 | – 0·90 |
| Nickel | – 0·50 | – 0·35 | – 0·94 |
| Carbon | – 0 80 | – 0·63 | – 1·15 |
| Brass | – 0·43 | – 0·50 | – 1·18 |
| Silver | – 0·57 | – 0·47 | – 1·16 |
| Cadmium | – 0·32 | + 0·41 | – 0 57 |

It may not be without interest at this juncture to contrast the conductivity of various alloys of the metals under consideration and also their melting points. Fig. 2 shows graphically the results obtained by Mathiessen* for the conductivity of alloys of cadmium-zinc, tin-zinc and tin-lead of varying proportions by volume. Fig. 3 shows the melting points of these alloys in degrees centigrade plotted from Gautiers† determinations. Some of the zinc aluminium alloys are already in use for fuses.

The above experiments were carried out in the electrical laboratories of the Municipal School of Technology, Manchester, and the writers wish to express their indebtedness to Mr. H. Gill for assistance in the experimental work.

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* *Phil. Trans.*, Royal Society, 1860.

† *Bull* de la Soc d'Enc. Vol. I, 1896.

## NOTES ON HEAVY ELECTRIC SWITCH GEAR.*

BY J. WHITCHER.

If we consider the various items which are called for in electricity supply, we find that the item of switch gear occupies a by no means insignificant place. Before coming to the general details of the subject, a plea for simplicity of purpose, of design, of construction and of operation is desirable.

The first consideration is the switch, the practical forms of which come into the following classes: (1) the plug type, (2) the lever type (3) the bridge type. The plug switch has been largely used, chiefly in the form of a screwed plug, for effecting multiple change-over operations. The usual arrangement consists of a number of circuit bars arranged in vertical lines on the front of the switchboard, with a number of 'bus bars arranged in horizontal lines immediately on the back of the board. Where these bars cross are provided through holes for the plugs, which are made to screw accurately into the 'bus bars at the back and have a head or cone fitting to make good contact with the front bar. The above form of the plug type of switch has had a wide sphere of activity in the low-tension direct-current stations of this country. In such stations it was advantageous to have a series of 'bus bars with small differences of voltage between them, so that a long or fully-loaded feeder can be connected to a high-voltage 'bus, while a short or lightly loaded feeder is kept on a low-voltage 'bus. Expanding plugs have been largely used on high-tension switchboards to isolate panels on circuits from the 'bus bars. Sliding contact plugs have also been used for similar purposes, and in America they are very extensively employed to control series arc lighting circuits.

The second or lever type of switch is the one which has swept the field, and is the simplest device that can be employed for actual circuit breaking as distinct from disconnecting. The plain lever switch consists of a flat straight blade of copper, pivoted at one end between flat flexible clips secured in one terminal contact block. The other contact block carries similar clips, slotted to give them greater resilence, and the blade closes down between them. The whole is of copper and capable of carrying current. The contact density should not exceed 50 amperes per square inch, while the "solid" density—*i.e.*, in the solid metal, may run up to 1,000 amperes per square inch. It is capable of development into a full range of sizes up to 5,000 amperes or more: but as wider blades than 3 in. cannot profitably be employed, owing to the imperfect fitting of such wide flat surfaces, sizes larger than 1,000 amperes should be obtained by using two or more of the 1,000 ampere blades in parallel. However, these multi-blade switches become heavy to operate owing to the friction of the large contact surfaces. This disability gives an opening in these very large switches for the preferential adoption of brush contact surface, as has been employed by many designers for quite small-size switches without the same reasonable excuse. In these the switch-blade is replaced by a lever carrying laminated hard copper brushes, which slide into or on to solid contact blocks. Well made laminated contact surface of this nature may be run at current densities of 400 or 500 amperes per square inch, so that the friction is very much less than in the corresponding size of multi-blade lever switch. On high-tension work the plain lever switch, used either as an isolating or selector switch, is generally superior to the plug type, as it can be operated at a distance, and when overhead, by a crook on a long wooden handle. As regards its circuit-breaking capacity, the plain lever switch does good service on circuits below 250 volts and of moderate ampere capacity. The single blade switches can be opened with sufficient rapidity to break the arc before it does much damage to the contact edges; but the limiting feature is the dangerous proximity of the hand to the arc. It has been persistently advocated in Great Britain that all switches must have a double break, and must not carry current through the hinge. These conditions may be very good in theory, but they are absurd in practice. As applied to the lever switch, the second break is almost useless, or certainly its value is not anywhere near a balance for the complication. And it passes one's understanding to discover why material used for the electrical function of current-carrying may not at the same time be used for the mechanical function of a hinge.

The great sphere of activity of the bridge-type switch is as the switching mechanism of the automatic circuit breaker. The bridge is generally devised so that it does not bind by friction into the contacts, being held thereon by a catch or toggle mechanism. Almost invariably (for switches and circuit-breakers other than oil) the bridge is a brush of laminated copper, pressed down upon flat contact surfaces in the direction normal thereto. Very good contact is secured thereby, as each leaf of the brush will bed independently upon the contact, if the brush be properly made. Considerable force is requisite to make all the leaves bed thus, and this is generally obtained by a toggle-jointed mechanism. It is the light release that makes the face contact bridge the sine qua non for automatic circuit breakers. The same feature gives it a dominating advantage for large and heavy switches; furthermore, the small part of the movement over which the heavy force of closing has to exerted, enables the immense leverage of the toggle to be employed. With reference now to the circuit-breaking function of switches in general. When a flux of power is broken by the opening of an electric circuit an arc follows across the widening gap. The volume of this arc, and the length to which it will be drawn out, depend upon the power broken, the voltage across the gap, the inductive character of the circuit, and the speed of opening; also, in some degree, upon the materials from which the arc springs and whose vapours feed the arc. The last two are the only conditions that can be influenced by the design of the switch. A prolonged arc will, of course, do damage to the contacts, and possibly to the surroundings. Rapid separation of the contacts is the simplest and most effectual method of subduing the arc, and for this reason the simplicity of the plain switch has for many purposes to be sacrificed to the exigencies of a quick break. The addition of this feature does not at all improve the mechanical design of the switch; and, if for this reason alone, quick-break switches ought not to be used indiscriminately, as is the prevailing humour in this country. The best quick-break switch should be the lever switch with the simple addition of a light follower blade, held by a spring to the edge of the main blade. The friction of the contact clips retains the follower until the spring is fully extended; and it will finally leave the contact, at high speed, with a long free arc of motion giving it the most favourable chance of clearing itself.

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* Abstract of a Paper read before the Rugby Engineering Society.

In the bridge type switch we cannot easily get so quick and long a break. The follower principle is difficult to carry out here, and it is metamorphosed into a system of auxiliary breaks. The whole of the bridge is usually subject to the spring off mechanism, but the auxiliary contacts are attached to the main bridge by spring arms, which, being under flexure, when the switch is closed, do not leave contact until the main contacts have opened and accelerated somewhat.

This opens up the question of arcing tips and carbon break attachments to switches and circuit breakers, and it is interesting to inquire into the reasons for the undoubted superiority of the carbon break over the metallic break. First of them is that the carbon does not scatter hot fused or solid particles. Another factor is that the products of the carbon arc absorb more of the energy to be dissipated than the products of the metallic arc. The energy that *must* be dissipated at the gap must be the same in each case; and in the one it is absorbed in the combustion of carbon, which forms a product which remains gaseous: whereas in the other case the product is a dust of solid metallic oxide, so that the latent heat of evaporisation here appears again as sensible heat. When laminated brush contact surface is employed, it is absolutely essential that it be protected against sparking. The resistance of the carbon, added to the inductive resistance of the spring arm carrying it, is sufficient to maintain appreciable voltage on the main gap causing it to arc. For this reason it is now usual in circuit breakers to add intermediate breaks taking place on copper contacts situated between the main and the carbon contacts. The position of the final carbon break, on which the main arcing occurs, should certainly be above the whole apparatus in a space clear overhead, and as much so as possible below, so that full advantage will be taken of air convection in drawing out the arc. It must be noted that the arc as it curves upwards becomes subject to a magnetic influence tending to expand it further, in the clean way in which an arc is run out off the horns of the well-known horn type arresters. The present tendency is to drop the magnetic blow-out. It appears to have reached its limits in the severe duty that is demanded of it on modern railway schemes, where the iron third-rail conductor seems to give a highly inductive character to the circuit, so that the heavy current rushes that can occur on systems of such large power capacity store up more energy in the circuit than the blow-out can dissipate in its characteristically sharp explosive snap. Irrespective of induction in the line, there will always exist a limit for the magnetic blow-out circuit breaker in the circumstance that the secondary contact must have considerable inductive resistance, because the coil magnetising the blow-out field must be connected in series with it. Therefore when the plant capacity is large enough to cause very rapid current rises on heavy short circuits, the blow-out coil reactance volts become sufficient to cause arcing across the main gap. The third element of the circuit breaker is the tripping mechanism. Most usually this is to operate on overloads, and consists of a nearly closed magnetic circuit of iron magnetised by a turn or more of the main circuit and pulling on a plunger or a hinged armature. With well designed mechanism an excitation of about 800 ampere turns is sufficient for a decisive action of the trip. It often happens that it is simpler to use electrical or mechanical relays operating by closing an auxiliary tripping coil circuit.

In practice a direct-current circuit breaker often has a plain switch in series with it, as it is advisable to close the breaker first and the switch afterward. Loose handles on circuit breakers are, however, being strongly advocated, to avoid the necessity of switches in series. The method gains little in simplicity, as the extra complication in the mechanism of the breaker about balances the omission of the switch.

There is one thing the ideal automatic circuit breaker needs, and that is a simple, effective and adjustable time limit device to check the well-nigh instantaneous action that distinguishes it as it stands now. No very promising solution of this problem offers itself, although many more or less indifferent methods are available. There is a very simple overload circuit breaker which has a time limit, and that is the fusible cut out. Touching the general theory of the fusible cut-out, the amount of energy dissipated in the fusion of the link and the consequent arc will depend much upon the duration of the operation. The inductive store of energy in the circuit must and will be dissipated at the gap in any case. But we want to reduce the feeding of energy from the main source into the arc as far as is possible, and cut the duration of the arc to a minimum. With a long link the arc will endure until it has melted out a longer gap than it can bridge against the convective and magnetic conditions, that may be active to bend it from the gap. The energy consumption is that required for the fusion of the metal, and the maintenance of the arc during that period. It follows that a material having the least specific resistance, specific heat, and latent heat of fusion, or the best compromise thereof, will be the best material for the fuse link. This will be silver, copper or zinc. If we are not prepared to locate the fuse where the energy dissipated can do no harm, we must introduce means of breaking the arc other than the simple method of fusion and air convection. We may use a strong magnetic field properly combined with a suitable chute to blow the arc from the gap, or we may employ the expansion of confined air or of compressed gases for the same purpose. All of these methods are in use, but they have disabilities of a more or less serious kind. The latest modification is an innovation now being introduced by the British Thomson-Houston Co. It is a combination of fusible cut-out with carbon break. A short copper foil link is stretched between a fixed terminal block and a movable arm, which springs outward when released by the fusion of the link. The arm carries a carbon contact block which bears on a fixed carbon contact and thus normally shunts the fuse strip. The carbon resistance is however too great to shunt more than 2 or 3 per cent. of the current. The circuit is broken finally on the carbon contacts and thus the action is similar to that of the carbon break circuit breaker.

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## DISCUSSION.

Mr. **WEDMORE** was in general agreement with Mr. Whitcher. He had referred to the practice of calling for double break in switches. The British Thomson-Houston Co. had always stood up against that. One had only to go to the Electrical Exhibition, then open, to see the effect. Where four or five years ago every maker was willing to supply a double-break switch, it would now be hard to find a double-break switch in the Exhibition. Undoubtedly many of the complications that were called for in switchgear were due to a lack of appreciation on the part of the customer of the real requirements of the case, leading to his calling for many devices which he afterwards finds he does not need.

Mr. **LARKE** wished to ask Mr. Whitcher whether he could tell if the fusing capacity of any fuse could be predetermined with any accuracy within 20 or 25 per cent.

Mr. **G. M. BROWN** said he did not quite agree with Mr. Whitcher's remarks about the effect of the time which elapses before the arc is broken. He thought that the amount of energy stored in the circuit did not depend upon the time spent in breaking it, and Mr. Whitcher did not make it very clear as to how this energy is actually dissipated, more especially in his remarks concerning the oil switch and the oil fuse.

Mr. **E. R. BRIGGS** (chairman), in calling upon Mr. Whitcher to reply to the discussion, said he would like to ask a question or two. Reference had been made to a form of switch in which the current passed through the hinge, and he would like to know what current capacity Mr. Whitcher considered necessary through the hinge. The other question he should like to ask was: What were the relative merits of slate and marble for switchboard panels?

Mr. **WHITCHER**, in reply, said that Mr. Wedmore quite confirmed him in asking for simplicity in switchgear.

In reply to Mr. Larke he quite agreed that it was difficult to predetermine the fusing point of a fuse, and would like to ask if it was necessary to be so close on that point? It did not much matter in practice whether it was 20 or 15 per cent. (Mr. Larke here said it would matter if it was about 20 per cent. too low.) Mr. Whitcher then agreed that it would matter very much if it happened to be too low; but he suggested that that was a fault very soon discovered in the overload test of the plant. We could certainly predetermine the fusing point within 20 per cent., and probably much closer than that. It depended much upon the position of the fuse.

In reply to Mr. Brown he did not intend to say that the amount of energy stored in the circuit depended on the duration of the arc. Of course, the energy stored in the circuit depended on the inductance of the circuit. What he wished to say was that the amount of sensible heat at the break depended on the duration of the arc, and the destructive effects are naturally dependent on the development of sensible heat. Mr. Briggs had asked about the current density in the hinge of the lever switch. So long as the contact density kept about 50 amperes per square inch, as at the other contact, it would be right. Mr. Briggs had also asked about the relative merits of slate and marble for switchboard panels. Practically they were much on a par. Marble was the better insulator, but slate the better mechanically.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. FOURNIER D'ALBE.]

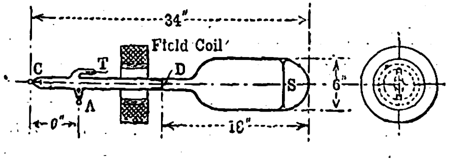
*Distillation of Copper.*—H. Moissan points out that the electric furnace has disposed of the assumption that there are any truly refractory bodies, and has proved that all solid bodies are capable of assuming the liquid and the gaseous states. Some bodies are decomposed before they liquefy, but on the other hand new compounds are also formed, like the newly-discovered carbides, borides and silicides. The author has lately studied the boiling point of copper and the best manner of distilling it at atmospheric pressure. He placed 300 grammes of pure copper cut into small cylinders into the crucible and conducted a copper tube cooled by a rapid current of water through the furnace to condense the copper volatilised by the electric current. An alternate current of 300 amperes at 110 volts was employed, and was applied for 8 minutes, after which it was found that 233 grammes of the metal had been volatilised. Boiling commences in about 3 minutes. The condensed copper is found on the copper tube in the shape of a felt consisting of copper filaments. Each filament has minute iridescent branches which make the mass look like velvet. The felt consists of pure copper. But at the boiling point copper dissolves some carbon, yielding it up again on solidifying in the form of graphite.

[H. MOISSAN, *Comptes Rendus*, November 27, 1905.]

*Cuprosilicium.*—In 1896, Vigouroux, by melting together copper and silicium in a Moissan electric furnace, obtained a body to which he assigned the formula $SiCu_2$. The same body was obtained about the same time by Chalmot, who heated a mixture of sand and carbon in the presence of copper in the electric furnace. But shortly afterwards he found that the body was really a mixture of copper silicide and free silicium. Again, in 1901, Vigouroux obtained a compound by passing vapour of silicium chloride over copper heated to 1200 deg., but could not make it contain more than 10 per cent. of silicium. Now P. Lebeau has analysed a sample of a commercial silicide of copper. It is slate-coloured, and its fracture possesses the lustre and colour of silicium. Microscopical examination shows large crystals of silicium embedded in a silicide, the crystals of the latter again containing minute crystals of silicium. When powdered and treated with a 10 per cent. solution of caustic soda, the silicium dissolves and leaves the pale yellow copper silicide. The latter, on being dissolved with nitric acid, leaves some very minute steel-coloured crystals, which the author found to be a silicide of iron, $Si_2Fe$, forming 3·5 per cent. of the total mass. The copper silicide has the composition $SiCu_4$, and is probably the highest silicide possessing any stability.

[P. LEBEAU, *Comptes Rendus*, November 27, 1905.]

*Cathode-Ray Oscillograph.*—R. Rankin has improved the Braun-Ryan oscillograph by placing a fairly low number of ampere-turns close to the anode, so as to produce a magnetic field along the path of the cathode rays. The apparatus is shown in the diagram, where C is the cathode, a flat aluminium disc and A the anode, a more or less irregular lump of the same metal. D is an aluminium diaphragm closely fitting the cylindrical wall of the tube and having at its centre a tiny hole through which the rays may pass on their way to the screen S. The latter is of transparent mica treated with a calcium sulphide coating which fluoresces powerfully when struck by the rays, thus showing a clearly-defined spot upon its surface. Since the cathode rays are deflected by a magnetic field without measurable inertia, it is only necessary to mount a set of coils carrying alternating current at a point just beyond D in order to obtain on the screen a graphical representation of the wave form. The advantages are claimed to be: To secure the well-defined spot of a rare medium without the troublesome flickering due to high voltages; to secure a more intense spot of light by the direction of more rays through the aperture in the diaphragm; and to obtain a means of varying between limits the velocity of the ray and therefore the sensitiveness of the oscillograph.



[R. RANKIN, *Physical Review*, December, 1905.]

*Luminosity of Lightning Tracks.*—B. Walter publishes some photographs to prove that the luminosity of tracks after the lightning has passed is not due to a phosphorescence of the air, but to a real subsidiary flow of electricity along the heated track. The photographs, taken with a moving camera, show a series of fringes representing a score of feeble subsidiary discharges, separated from the main discharge by a dark interval. The gap after the main discharge is due to the momentary exhaustion of the E.M.F., and disposes of the phosphoresence theory, for any phosphorescence would begin immediately on the passage of the main discharge.

[B. WALTER, *Annalen der Physik*, No. 14, 1905.]

## PUBLIC COMPANIES WOUND UP, DISSOLVED, &c., IN 1905.

The following are the principal electrical and engineering limited liability companies which have been wound up (either voluntarily or compulsorily) during the past year. An asterisk (*) denotes that the company was wound up by order or under the supervision of the court, and (†) that the company has been struck off the register of joint-stock companies :—

Anti-Collision Alarm Telegraph Co.
Atmospheric Elec. Purification Co.
*Automobile Corpn.
Barcelona Tramways Co.
†Benfleet Electric Light & Eng. Co.
Benham & Froud.
British Autovolt Co.
British Columbia Telephones.
*British Electric Calibrated Fuse Co.
British Electric Separating Co.
British Electric Signs Co.
British Microphone Co.
British Miller Signal Synd.
British Pioneer Electric Light & Power Co.
British Prism Globe Electrical Co.
†British Thermophor Synd.
†British United Tramways.
Bryan, Donkin & Clench.
†Cable Members Club Co.
†Canadian, British Columbian & Dawson City Telegraph Co.
Carl Oppermann Elec. Carriage Co.
†Clayton Engineering & Elec. Co.
Delafon Batteries Synd.
†Edison Telephone Co. of London.
Edmundson & Purdom.
Edmundson's Elec. Meter Synd.
Engineering Contract Corpn.
Elec. Turbine, Gas Retort, Charging & Discharging Machine Co.
†Electric & Magnetic Co.
†Electric Fur Machining Co.
†Electric Traction Insurance Association.
†Electric Tramcar Synd.
Electric Tramways Construction & Maintenance Co.
†Electrical Automatic Loom Synd.
†Electrical Instruments Syndicate.
Electrical Investments Synd.
Electrical Ore-Finding Co.
†Electrical Thawing Synd.
Electrical Treatment Association.
†Electrical Wonder Co.
Electro Smelting (Zinnoxyd).
†European Electric Railways & Public Works Construction Co.
"Every-day Electricity" Publg. Co.
†Farrall Incandescent Electric Light Synd.
French Electric Lighting Boards
Fuller, Macleod & Co.
†Garcin Renault Electric Cars and Accumulators.
General Water Power.
Graham, Morton & Co.
Holophane.
Hughes' Atlas Works.
Imperial Electric Lamp & Battery Synd.
Improved Electric Glow Lamp Co. (For reconstruction.)
Kamm's Zerograph Synd. (for reconstruction).
Light Cure & Electro-Therapeutic Synd.
Light Railways Development Co.
Lodge Electric Light & Power Co.
†London & N.-W. Elec. Tramways.
†Metal Electro-Amalgamating Synd.
†Metropolitan Electric Tubes Synd.
National Electric Traction Co.
Nernst Electric Light.
†New British Incandescent Electric Lamp Co.
New Zealand Electric Light & Traction Co.
North-West London Elec. Supply Co
†Nottinghamshire Elec. Tramways.
†O'Brien-Lennard Electrical Installation Co.
Otto Electric Mfg. Co. (1905).
†Peter Pilkington.
Poole & District Elec. Traction Co.
†Reno Electric Stairways & Conveyors (1902).
Rhodes' Electrical (Parent) Syndicate.
Rooper & Harris.
St. Helens Cable Co. (for reconstruction).
Shanghai Electric Tramways.
†South-West Wireless Telegraph Ship Co.
Stanley Electric Carriage Co.
†Tramways Construction Co.
Universal Microphone Co.
Wear Electrical Engineering Co.
Wm. Aug's Gibson.
†Weymouth Elec. Light & Power Co.
Wimshurst, Hollick & Co.
Yorkshire Electric Tramways Construction Synd.

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# 1905.

The year 1904 was a black year for British electrical industry: business was bad, capital was "shy," and the political situation had created a feeling of unrest in the whole commercial community from which our home industries were the first to suffer. This condition of affairs has had its effect on the records of the year that has just concluded, and it became apparent that two or three of the large electrical and allied manufacturing firms had suffered sorely by the trade depression of the previous year. These may be passed by as after-effects of 1904, however, and on the whole we are able to chronicle a somewhat greater activity in the electrical industry generally during 1905 both at home and in the colonies. Our own methods of manufacture have improved, and although this has been accompanied by the usual cutting of prices, competition from abroad has been less serious. Prices for electrical machinery now range generally higher on the Continent than in this country, for the Continental firms are busy, and are careful not to make the same mistake they made a few years ago of extending their works at a greater rate than the demand really justified. On the lighter branches of electrical manufacture, the Electrical Exhibition held in London last September has acted beneficially, and the extension of electric lighting, heating and power supply which has followed the appreciation of the Exhibition by the general public will, of course, in its turn have an influence on the manufacturers of generating plant and its accessories. Electrical power supply has also received still greater attention than in previous years, for the Power Bills before Parliament have emphasised the low price at which electrical power can be distributed if the demand is on a sufficiently large scale, while the starting of the works of a number of electric power companies in various parts of the country has demonstrated that the electrical engineer's schemes exist not merely on paper, but have developed already into actual working concerns. Collieries, shipyards, engine builders, textile mills, and, in fact, factories and works of all classes are obtaining considerable benefit from the economies arising out of electric driving. The works of the Yorkshire, Clyde Valley, Fife and Lancashire Power Companies, which we described in detail when each commenced operations this year, have afforded conclusive and practical testimony of the prevailing acceptance of electric power as a necessary adjunct to modern industrial methods, while, as an example of one of the largest, if not quite the largest self-contained electric power distribution scheme in this country, we may refer our readers to the account of Messrs. Harland and Wolff's shipbuilding works, which appeared in our columns during March and April.

The cheaper supply of electric power is being accelerated by the use of extremely large generating sets in the power house, and of turbo-generators working with highly-superheated steam and high condenser vacua, while the large gas engine has not yet fulfilled the anticipations of its advocates. Overhead wires are also being employed on certain parts of the Lancashire Power system, and on a wider scale on the North Wales Power scheme which will shortly be put into operation. These are at present the only examples of extra-high-tension overhead wires in this country. While the three-phase system is employed more than any other in all countries, the high-tension continuous current system is still being adopted in particular cases on the Continent, and its use has been contemplated for the transmission of power in South Africa from the Victoria Falls to the Rand. Three-phase transmission is proposed in connection with all the new power schemes for London which are to come before Parliament next session, including the proposal to transmit electric energy from St. Neots to the metropolis at a pressure of 20,000 volts and using overhead lines for the greater part of the distance. In addition to the power supply by the electric power companies and by independent plants, the motor load on electricity works erected primarily for lighting has greatly increased during the year, as will be shown by the tables we shall publish in our next two issues, and there has also been a large addition to the number of small towns buying their electrical energy "in bulk." One effect of the London Power Bills last year has been that a considerable reduction has been made by the existing electricity works in the price charged for electrical energy for power purposes, and, especially in provincial undertakings of medium size, this has occurred concurrently with a wider adoption of the "time-switch" system of charging than heretofore. A reduction has also been made in London in the tariff for electric heating and cooking; this has been largely due to the efforts of the organisers of the Exhibition, who encouraged manufacturers to bring these applications prominently before the public. One penny per unit is now a common price for electrical energy used for heating, cooking and power purposes.

In electric lighting there is a prospect of considerable advance also. Lamps with tantalum and osmium filaments are now on the market, and it will doubtless not be long before their superior efficiency to that of the carbon filament lamp will cease to be discounted by their high cost and other disadvantages inseparable from a new piece of apparatus. So far, the use of the tantalum lamp is restricted to continuous current and to pressures not exceeding 110 volts, while the osmium lamp is only made for still lower pressures. A process of making carbon filaments, said to produce a new allotropic form of carbon which can be run at a higher temperature than the present form, also gives promise of better efficiencies than in the incandescent lamp which has been standard for many years. In connection with incandescent lamps we may also refer to an article by Mr. Maurice Solomon which appeared in our columns recently, in the course of which the author definitely destroyed the tradition that a frosted globe absorbs 30 per cent. of the light. The use of the Nernst lamp has greatly extended, but there is still room for improvement in its manufacture, and the same applies to the mercury vapour lamp, which, in spite of its high efficiency, can still only be employed in particular cases, owing to the unpleasant colour of its light. In arc lamps great progress can be recorded. Several British firms have taken up the manufacture of the "flame" type of lamp for street lighting, and there has also been considerable development in the lamps of this class sent from Germany, the country in which it originated. On the other hand, little has been heard of the magnetite arc lamp this year; although several are in use in the United States, none, we believe, have made their appearance on the supply mains in this country. Much dissatisfaction has been expressed at the experiment which is being made with incandescent gas lighting in some streets of the City of London, and, although this competitor of electric lighting has made great strides, it has been proved conclusively that better and more economical results can be obtained with modern arc lamps. In the City of Westminster electric lighting has largely displaced gas for street lighting after exhaustive trials and tests, and the same has occurred in other parts of the country, although the action of the City of London authorities has deterred one or two other towns from adopting or extending electric street lighting.

We have already referred to the "heavier" electrical manufacturing industry in the first part of this article. The improvements have been rather of a general character, and there has been no great discovery or invention which we can particularise. In continuous-current machinery the employment of auxiliary poles has become almost a fashion, extending in some cases even to machines in which no apparent advantage is to be gained by their adoption, although in others it constitutes a distinct improvement in design. Useful investigations have been made at the National Physical Laboratory and elsewhere in connection with the rise in temperature in field coils and the dielectric strength of insulating materials. The work in the former connection was carried out on behalf of the Engineering Standards Committee, and this Committee has also issued standard specifications for telegraph material and trolley grooves, wire, and rail templates. The Committee is at present engaged in considering the question of standardising glow lamps. A strike of workers in the electrical factories in Berlin threatened to assume serious dimensions, but was quickly quelled by the firm attitude of the employers. Mention may also be made of the announcement that steps are being taken by the Institution of Electrical Engineers, in combination with other representative societies in Europe and America to arrive at an international agreement as to units, standards, nomenclature and the rating of electrical machinery. Less attention has been devoted to the compensated alternator this year than last, but the single-phase motor is making steady improvement. The "permutator" has been put on the market by a French firm as an alternative proposition to the rotary converters.

In electric traction, the single-phase system is now employed on several lines, in the United States, Germany and Austria, and it is to be adopted on one of the suburban routes of the London, Brighton & South Coast Railway, the contract for the electrical equipment of which has been let. The Metropolitan and Metropolitan District Railways have now completed their "electrification," and the monster power house at Chelsea as well as the smaller one at Neasden are in operation. Work on the Great Western suburban route which runs in connection with these lines is making rapid progress, and the electrically-equipped portions of the Lancashire & Yorkshire and the North-Eastern Railways opened last year are running regularly. No new tube lines have been opened during the year, but the Waterloo–Baker Street and the Great Northern, Piccadilly and Brompton tubes should be ready before many months have elapsed, and doubtless the work on the North-East London Railway, for which Parliamentary sanction was obtained last session, will shortly be commenced. This was the only tube railway Bill passed last year, others were delayed for the issue of the report of the Royal Commission on London Traffic. This report, which was issued in July, recommended large additions to the traffic facilities of London. The Government proposed to bring in a Bill for the establishment of a Traffic Board, in conformity with the recommendations of the Commission, and it is to be hoped that the new Government will adopt this plan.

The London County Council tramways have added to the number of their electrically equipped routes during the year, and are to take over and equip the North London lines.

The shallow subway tramway under Kingsway from the Strand to Holborn is just completed. A new surface contact system (the "G. B.") has been put into operation in Lincoln, and in Torquay a surface contact tramway on the Dolter system is being built. "Regenerative control" has been vigorously pushed by its supporters, but has not been welcomed by the large body of tramway men. Radial trucks, grooved trolley wire, mechanical ears, and other recent novelties in detail are finding many supporters, while the steel tyre has gained greatly in favour. Tramway engineers are busy investigating the cause of the troublesome "corrugation" of rails, and devising means for its prevention. An interesting controversy as to the comparative efficiency of motor 'buses and tramways was started by the *Daily Mail* in some sensational articles in February, and figures comparing the two systems will be found in our issues of Feb. 10 and 17. Electric motor carriages are still only town vehicles, and have not yet become tourist cars. There are a large number running in London, and charging stations have been provided in various parts. A mercury vapour rectifier has just been put on the market, particularly designed for use at such stations. Before leaving the subject of traction, attention may be called to the increased use during the year of electrical signalling systems on railways, in the development of which there have been great improvements, and to two new systems of train lighting.

Electrochemistry and electrometallurgy are still much neglected in this country. The Faraday Society still flourishes, it is true, but the Papers before it are too often of a purely theoretical or purely chemical nature. A notable exception was one on the electric smelting of iron and steel, a *Nachklang* of the report of the Canadian Commission—we do not hesitate to use a German word, for every electrochemist worthy of the name is a master of that language. Abroad the "fixation of nitrogen" industry is assuming large proportions; in this country there is only one solitary record of the application of this process, and, unfortunately, this was in an alternator armature, where the nitric acid was an uninvited guest.

In Telegraphy there has been alteration in the design of underground cables and an improvement in the speed of working on them. Some long-distance trials on ordinary landlines have been made in Australia, and an interesting account of direct Wheatstone working between London and Teheran was published in our columns early in the year. The application of telephone exchange methods to telegraph switching has been extended, and trials of new type-printing and writing telegraphs have been continued by the Post Office engineers. Two cable ships have been built, the Telegraph Construction & Maintenance Co.'s "Cambria," and the "Grossherzog v. Oldenburg" of the Deutsche Seekabelwerke. The working of the Pacific cable has shown a loss almost as great as last year, but no fault in the cable itself has developed. A Conference of representatives of the Governments contributing to the cable was held in London, and their report was open to considerable criticism.

In Wireless Telegraphy the Marconi Company is still on the point of inaugurating a commercial service between England and America, as it has been for years past. A number of licences have been issued by the Post Office authorising persons and companies to carry on wireless telegraphy, under the new Act that had been passed in the previous year, and some interesting independent experiments and cross-Channel installations have been carried out. Among the latter we may mention one from Heysham Harbour to the Midland Railway Co.'s steamers, and a "line" from Tobago to Trinidad, upon which we hope to publish an article in an early issue. Some excellent experimental work formed the subject of an Institution Paper by Messrs. Duddell and Taylor in the summer, and the Duddell thermo-galvanometer now enables proper quantitative tests to be carried out. An interesting controversy has been going on as to the effect of earthing the lower capacity surface of a wireless station; it appears that, for land wireless telegraphy, its insulation from earth may be of advantage. Systematic investigation, both by theory and experiment, will be of value. The patent situation remains where it was; in the United States an action has been fought with regard to the claims in the Marconi master-patent, and both sides claimed victory.

In Telephony the chief incident to record is the ratification of an agreement as to the details of the transfer of the National Telephone Co's. system to the Post Office in 1911; the proper growth of the service until that date, and the continuity of the service is thereby assured. Incidental to this was the statement by the Postmaster-General that no new municipal telephone licences would be issued, and that he was prepared to enter into negotiations with municipal telephone authorities for the transfer of their undertakings to the State. Mr. Gavey, in his Presidential Address to the Institution of Electrical Engineers, gave an account of the important results which had been obtained from the application of the investigations of Heaviside, Pupin and Campbell with regard to telephone lines, in addition to the information as to underground telegraph lines to which we have already alluded. The Post Office exchange system in London has obtained so many new subscribers that a large extension to its Central exchange has become necessary, and this will be working early in the year. An interesting feature of this addition is the discontinuance of the subscribers' multiple on the answering sections of the board. Three serious fires in telephone exchanges of the National Telephone Co. have had to be recorded. In only one of these could the cause be traced—viz., in the case of the fires occurring simultaneously in the test room of the Bank exchange and the junction-line test room in Oxford-court, when a cable of junction lines had been allowed to come into contact with the live rail during the "electrification" work in the District Railway tunnels.

In "pure" Electrical Science, Dr. Barkla's Royal Society Paper on the polarisation of Röntgen rays was undoubtedly one of the most valuable of the year. The transmutation of radio-active elements has been still more firmly established by the work both of Rutherford and Soddy, a valuable résumé of which is contained in Prof. Soddy's Presidential Address to the Röntgen Society, reported in another column. Research into the nature of the non-magnetic alloys of magnetic metals (discovered in 1903) is being continued. Langevin has published an ingenious new theory of magnetisation; and N-rays have fallen still further into disrepute. The British Association made an enjoyable visit to South Africa. A discussion on Units and Standards at the Institution of Electrical Engineers was divided into the usual two branches: suggestions for improvement of our "absolute" standards and for the demolition of the 4π "irruption." A new ampere standard on the lines of the Viriamu Jones standard is being built at the National Physical Laboratory. This laboratory has done good work during the year, but it has been severely censured in some quarters for its desire to embark in commercial work which is already well looked after by private enterprise.

The country has been mindful of the steps that must be taken to maintain and improve the higher grades of technical education. Additions have been made to the Treasury Grants to University Colleges, to which colleges also several private donations and bequests have been made. The project for establishing a well-organised college for the higher technical and scientific education of those destined to be leaders in the engineering professions has moved forward a step. A new electrical engineering laboratory has been opened at Liverpool University, and progress has been made with the extension of the electrical engineering department at Birmingham.

There have been a few legal decisions of importance during the year. The master patents held by the Jandus Company for enclosed arc lamps have been upheld, but there have been no other patent actions of wide general interest. The Willesden decision, imposing limitations on the holders of Provisional Orders, has been affirmed on appeal, as has also a case in which an electricity undertaker was held liable for the damage caused by "burning out" a fault on the mains. A customary clause in Tramway Acts has been held to give the tramway company powers to lay mains to the tramways from any generating station supplying power to them. An electricity works has been declared not to be a factory or works which is entitled under an old Act to make use of the water of a canal for condensing purposes free of charge. Finally, a decision has been given in the ridiculous case in which a Local Authority, having contracted with an electricity supply station for the destruction of its refuse, obtained an injunction against the company for nuisance caused by the destructor and then sued them for not destroying the refuse in accordance with the contract.

The Obituary list of the year included, we regret to say, many telegraph pioneers, among others W. E. Langdon, Sir Henry C. Fischer, C. A. Gerhardi, S. W. Silver, and C. Cuttriss; some other names of those we have lost in the electrical industry are John Verity, Alfred Morcom, J. H. Meidinger, C. G. Mott, G. A. Grindle, C. R. Bellamy and C. T. Yerkes.

The Parliamentary record of the year was mainly a negative one: The Administrative County of London Electric Power Bill, after drastic amendment which satisfied a large section of its opponents, failed to come up for its final third reading in time at the end of the session. The Supply of Electricity Bill passed through a few stages and was then forgotten by the Government, as in previous years. No amendment has been made in the law relating to electric tramways. The London County Council was again unsuccessful in its attempt to obtain sanction for tramways over bridges and on the Embankment, and its proposal that the Metropolitan Borough Councils should have power to do house wiring was also rejected. The North-East London Railway Bill has already been mentioned. For a summary of the other measures that were passed, our readers may refer to our issue of August 18; the Private Bills to be laid before Parliament this year were summarised and commented on in our last two issues. An unusually large number of those Electric Lighting Orders which were still in an undeveloped condition, although granted some years ago, have been revoked by the Board of Trade.

This concludes our summary of the year's progress. The prospects for the New Year point to a fair degree of prosperity in the electrical industry, but nothing phenomenal. There is much to be done, not only at home, but also in the colonies, and we have works well equipped to carry it out.

## REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign book.)

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**Telegraphy: A Detailed Exposition of the Telegraph System of the British Post Office.** By T. E. Herbert. (London: Whittaker & Co.) 6s. 6d. net.

This book differs from Preece & Sivewright's standard work in not being a text-book of telegraphy for the general student so much as a manual of Post Office practice, designed for the benefit of that department and dealing exhaustively with the construction and maintenance of their system. We confess to finding the perusal of the latest edition of the earlier work much the easier of the two, and to a feeling of pity for the Postal Telegraph officer who has to master Mr. Herbert's 868 pages and 509 illustrations for information which might have been compressed into much smaller compass with decided advantage. However, it will doubtless be of service to the department to possess for purposes of reference such a voluminous account of their methods, comprising, as it appears to do, practically all the official technical regulations. The general reader may gather from these pages the admirable thoroughness which pervades the system administered by the Post Office engineers, covering detailed provision against all sorts of possible contingencies, such as damage from fire, water, and power circuits, besides all inductive interferences. It will also be seen that our State telegraph department is keeping well abreast of others in the adoption of improvements, as was evident from Mr. Gavey's recent presidential address to the Institution of Electrical Engineers.

The distribution of subject matter renders precise information on some points somewhat uncertain. For example, quadruplex working on the London-Birmingham underground circuit is stated, on p. 276, to be impracticable, whereas, from p. 823, Appendix C, it is clearly implied to be in operation, with, moreover, a duplex earthed circuit superimposed on it; whilst on p. 853, Appendix E, a yet further addition is made to the earlier arrangements. The statement respecting the speed of paper cables, on p. 517, is most ambiguous, and does not agree with that on p. 652 as to their absorption. A similar confusion occurs in connection with absorption on p. 651, where we read "it is practically certain that the true insulation resistance does improve, and that the minute leakage current passing through the percha is constant." Some of the explanations of the action of signalling condensers are incorrect (*e.g.*, p. 397). The amount of space devoted to many subjects is excessive, and out of proportion to their importance. The account of the Eden morning test, for example, is a perfectly ponderous piece of elaboration, which surely might have been condensed with advantage, though the author had handicapped himself by renouncing the assistance of algebraic symbols. For this self-denial, which Mr. Herbert says his teaching experience recommended, it is to be hoped some departmental candidates will feel grateful. A little elementary algebra would, however, be a light matter compared with the severe tax imposed on them by some of the complicated considerations of connections which they have to follow out and memorise. It seems a pity that duplex working should not be explained by simply saying that, inasmuch as the sender's connections balance the effect of his battery on his own receiving instrument, the distant station's signals may be regarded as operating the receiver precisely as though they acted alone, superimposing themselves on those sent in the opposite direction, especially now that superimposed signals in the same direction are, as Appendix C shows, a familiar feature of modern telegraphy. His more complex mode of viewing the matter, in fact, finally lands the author in an admitted false conclusion on p. 341. Some of the passing references to ocean-cable working are inaccurate, and would have been better omitted from a work of this kind, especially as the author announces in his preface that he proposes to deal neither with submarine nor with wireless telegraphy.

The effects of inductance and the features of the magnetic circuit are dealt with clearly, and the actual values in henrys of various relays, as well as of some magnetic shunts, are mentioned. The information as to the latest types of construction of both overhead and underground lines is full and valuable, and the description of mechanical details of apparatus is only too comprehensive. There is a copious index and a good table of contents, which the arrangement of subjects renders very desirable. On the whole, in spite of the faults referred to, the book is one worthy of the department for whose use it is chiefly designed, whilst it forms an important contribution to the literature of telegraph engineering.

**Die Messtechnik.** (Part I.) By C. Heinke and J. Kollert. Being Vol. II. of the "Handbuch der Elektrotechnik." (Leipzig: S Herzel.) 20m.

The present volume, consisting of 464 pages with 408 illustrations, covers direct-current measurements and photometry, with three preliminary chapters dealing in a somewhat abstract fashion with measurements in general. The alternating-current and magnetic tests are reserved for Part II., which is to follow at a later date. The book may be described as thoroughly German in its painstaking comprehensiveness, but it is, perhaps, a little unfortunate that both its authors should be professors, since, while in the earlier chapters, dealing chiefly with what might be described as laboratory measurements, they are thoroughly at home with their subject, throughout the later portions a tendency is shown to include innumerable methods culled from various sources without much attempt being made to point out their particular uses and limitations. To some instruments, also, of purely academic interest, almost too much space seems to have been devoted; for example, 13 pages are assigned to tangent galvanometers.

The volume is essentially a German treatise on German methods, employing German apparatus, and the reader will look almost in vain for any references to either English, French or American publications or methods. In one or two instances, in fact, the omission seems almost more than accidental. The chapter on Dynamo Testing (37 pages) is very complete, and the methods of separating out the various losses are clearly given. Mention may particularly be made of the "slowing-up" method, which deserves more attention than it receives. The chapter on Mains Testing and Fault Localising is also excellent, though here again the various tests are given without much indication as to which method is best suited to any particular case.

Incidentally, it is interesting to notice the eliminating process which has been going on during the last 15 years, whereby the less satisfactory devices have been gradually weeded out. For example, the authors only find it necssary to describe two forms of standard cell, the Clark and the Weston cadmium type, which latter can be so constructed that its temperature coefficient is absolutely negligible. Again, the really satisfactory high resistance metals are only two in number—konstantan and manganin. Each has a perfectly negligible temperature coefficient (less than ·0003 per cent. per deg. C.) but while konstantan suffers from a relatively thermo E.M.F. with copper or brass, manganin is very readily oxidised in the air, and therefore needs protection. Both have been shown to be practically constant as regards resistance. Manganin is, as a matter of fact, considerably more difficult to solder although this point is not mentioned.

The last 50 pages in the book are devoted to a very detailed description of various photometers, preceded by a short dissertation on the physiological effects of light. Various forms of "Flicker" photometer are described without, however, any attempt being made to solve the important question as to what is actually being measured with these instruments. Is it equality of illumination or is it something totally different? The authors content themselves with the remark that "the phenomena taking place in the Flicker photometer are more complicated than was at first thought and in particular, the comparison of lights differing much in colour is, in this case also, a very difficult one." No mention is made of the "distinctness" or "discriminating" photometer which would appear to afford a promising field for further investigation. The photometric methods given (as distinct from photometers themselves) are in many instances somewhat crude; for example, when testing a glow lamp the suggestion is made with all seriousness that a benzine lamp should be used as a sub-standard, and it is moreover always assumed that the photometer head should be moved rather than either of the lamps.

Taken as a whole, the book can be thoroughly recommended to anyone wishing to keep abreast of the more recent advances in electrical testing and measurement, and the forthcoming volume on alternating currents will certainly be awaited with interest.

KENELM EDGCUMBE.

**Baku, an Eventful History.** By J. D. HENRY. (London: Archibald Constable & Co., Ltd.) 12s. 6d. net.

After an opening chapter on the interesting town of Baku and its population, composed of a mixture of no less than 44 nationalities, the writer, who is the editor of our contemporary, the *Petroleum World*, gives us a well-arranged account of the development of the oil industries of the Caucasus. This forms an interesting example of the gradual replacement by modern engineering processes of the old-time methods of hand labour. Electric power is as yet apparently unknown in the Russian oil fields, but we cannot help thinking that with the further consolidation of the interests a large scope for the centralisation and distribution of power will be found. The later chapters are stirring reading, and contain a graphic account of the recent risings and inter-tribal strife in the Caucasus. The book is well illustrated, and is prefaced by an introductory note by Sir Boverton Redwood.

**Engineering Mathematics Simply Explained.** By H. H. HARRISON (London: Percival Marshall & Co.) 1s. 6d.

The author of this book is certainly ambitious, for he attempts the almost superhuman task of compressing into about 160 small pages of by no means closely-printed type the whole of the more elementary portions of arithmetic, algebra (including determinants), trigonometry, mensuration, logarithms and differential calculus, and a chapter modestly headed "utility of squared paper," which is in reality an introduction to analytical conics. We are informed in the preface that the book is designed for the use of the young engineering apprentice, and will also be found useful by the artisan. We are inclined to think, however, that the apprentice or the artisan who near the outset of his studies has to be told that "a fraction is a symbol which is used to represent a given portion of a thing" will hardly be enabled, by the course of study through which this little work conducts him, to grapple successfully, without independent assistance, with the integrals to which he is introduced at the end. To learn to apply mathematical methods requires a longer and more gradual course of study than this little book provides. The formation of proper habits of mind and modes of thought cannot be effected by firing off the facts at frequent intervals at the student. The book is clever in its conciseness, but it is left to the student to make up examples for his own use.

**Lehrbuch der Praktischen Physik.** By FRIEDRICH KOHLRAUSCH. 10th edition. (Leipsig: Teubner.) 9s.

Kohlrausch's *Leitfaden*, now developed into a *Lehrbuch*, has become a standard work, in which the author, while conscientiously including all the best modern methods, liberally dispenses his own great store of practical experience. The present edition contains a considerable amount of new matter, necessitated by the rapid rise of physics since 1901, the date of the last edition, a rise which, as the author remarks, is characterised by somewhat less of deliberation than heretofore, and therefore prescribes an increased amount of caution to the compilers of text-books. The additions include chapters on the specific heat of gases, on diffusion constants, on ionisation, on polyphase current magnetometers and electric wave-meters, together with a good account of the optical pyrometer, whose development is largely indebted to the Reichsanstalt work. The practical receipts are excellent, but it should be pointed out that the Julius anti-vibration suspension as sketched and described on p. 48 would not fulfil its purpose except by accident. In the present state of electrical science practical text-books have an air of finality still painfully lacking in more theoretical works, and the book before us may be perused with almost unalloyed satisfaction.

## THE PRESENT POSITION OF RADIO-ACTIVITY.*

BY FREDERICK SODDY, M.A.

The address commenced with the consideration of three fundamental conceptions. The first and oldest is the *atom*, the unit or smallest particle capable of separate existence, of the simplest forms of matter or chemical elements. The essential feature of Dalton's conception was that the atoms of the same element are all exactly alike in mass and every other property, but are recognisably different from the atoms of any other kind of element. The statement will be found in text-books of chemistry written long before the recent discoveries were foreshadowed, that *if* it is ever found possible to transmute any one kind of atom, that is any one kind of elementary matter, into any other kind, there is little doubt that the same means would be sufficient to transmute or decompose the other elements.

The second conception is the *electron*, and this, although by origin an electrical conception, is in reality a material conception no less than the atom of matter. The electron could be defined as the smallest existence known capable of isolation and of free movement through space. It is a definite amount of "charge" of negative electricity, being the smallest possible amount known to exist for electricity, no less than matter, has been shown to consist of discrete particles or units, and not to occupy space continuously. Unlike the atoms of matter, only one kind of electron is known, consisting of the same amount or charge of negative electricity with identical properties in all its various manifestations.

It is certain that each atom of matter contains in the normal condition at least one electron, which it is capable of losing, and conversely may unite with at least one electron more than it normally possesses without deep-seated material change. An atom with one or more electron less than it possesses in the normal state is positively charged and is often called a *positive ion*. Similarly an atom with one or more electron in excess is a *negative ion*.

The third conception is the universal *ether*, in the sense of a medium of definite properties extending continuously between the discrete or separated particles of matter. Our definite knowledge of the properties of the ether dates from the determination of the velocity of light through intra-stellar space. The medium is capable of transmitting disturbances at a definite speed namely, $3 \times 10^{10}$ centimetres per second. Recent advances all show that the ether is only capable of transmitting disturbances at this one speed and in one way, and that all the effects which travel through the ether—light, X-rays and Hertz waves are various manifestations of essentially the same type of disturbance in the ether.

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* Presidential Address to the Röntgen Society, yesterday. Abstract.

Let us now consider the case of an electron moving through the ether unimpeded by matter. This is very nearly realised in the Crookes tube. When matter is negatively electrified in vacuo to a very high degree, as in the case of the cathode of an X-ray tube, the electrons may be regarded as accumulating in the cathode until their mutual repulsion is so great that some escape. The moment the electron is free to move outside the cathode it experiences a very great repulsion from the electrons remaining in the cathode, and consequently it moves away along the line of the repelling force. Its velocity continues to be positively accelerated until it has passed without the sphere of influence of the repelling cathode, and then it travels at uniform velocity through the empty tube until it meets the anti-cathode placed as an obstacle in its path. On striking this its velocity is destroyed, and the electron is brought to rest. The electron at rest constitutes a simple charge or electrostatic phenomenon, but the electron in motion is in every sense a current of electricity or electro-magnetic phenomenon. A current of electricity cannot flow without endowing the medium through which it flows with magnetic properties, and this medium then possesses magnetic *energy*. Thus the medium through which it moves at first possesses no magnetic energy, then it acquires magnetic energy, and then it loses its energy. So that we see at once that an electron cannot move from rest without receiving some definite amount of energy, and it cannot stop without again giving up the same amount. So that even an electron, disembodied from matter, and consisting of an electric charge only, must possess the fundamental property possessed by matter, of resistance to change of motion, or *inertia*.

The various disturbances, light, X-rays and Hertz waves, are now known to all to have a common origin in the acceleration or variation of the velocity of electrons, and all to travel at the same speed. If an electron moves at constant speed in a closed curve within an atom it will give rise to the regular periodic or rhythmatical disturbance we call light.

At the anti-cathode of a Crookes tube we have an irregular shower of free-flying independent electrons. X-rays thus partake of the character of irregular pulses, having a relation to light very analogous to that between a noise and a musical note in acoustics. But the suddenness with which they are stopped causes the thickness of the pulse, which corresponds to the wave-length of a light-wave, to be extremely small, and this probably accounts for their great penetrating power.

The Hertz waves of wireless telegraphy are a type of the opposite extreme. The electrons here oscillate along paths of perhaps several metres in length, and in consequence the wave-length, instead of being measured in millionths of a millimetre, as in the case of light where the orbits are of atomic dimensions, attain to dimensions appropriately measured in metres.

Turning to the phenomena connected with the radio-elements, the speaker remarked that the discovery of the natural radioactivity of matter by M. Henri Becquerel would celebrate its decenary this year.

Two out of the three types of rays emitted by the radio-active elements, known as the $\beta$- and $\gamma$-rays are substantially of the same nature as those emitted by a Crookes tube. Thus the $\beta$ ray is the familiar electron in motion and corresponds with the cathode-ray, while the $\gamma$-rays result from the $\beta$-rays in much the same way as the X-rays result from the cathode-rays. The difference is that the X-ray bulb acts under the action of a constant supply of external energy and ceases to work the moment the supply fails, whereas the radio-elements are entirely independent of external stimulus or supplies of energy. In the resemblance between the $\beta$- and $\gamma$-rays and the cathode-rays and X-rays of the Crookes tube there is an important difference. The electron which constitutes the cathode-ray travels ordinarily at a speed about one-tenth that of light, whereas the $\beta$-rays of uranium travel with a speed about seven times greater. Like the cathode-rays, the $\beta$-rays are deviated by a magnet, but with much greater difficulty. Some of the $\beta$-rays of radium have been shown by Kaufmann to have a velocity 95 per cent. of that of light. It was rightly considered a great experimental feat, so easily are the cathode-rays absorbed, even by the thinnest screen of matter, when Lenard for the first time succeeded in obtaining the cathode-rays outside the Crookes tube by inserting a tiny aluminium window just thick enough to stand the pressure of the atmosphere, and thin enough to allow a small fraction of the cathode-rays to pass through unabsorbed. Rutherford has given the thickness of aluminium necessary to absorb one-half of the $\beta$-rays of average penetration power as 0·5mm. So, too, with the $\gamma$-rays; these, although strictly speaking X-rays, are so penetrating that in passing through the hand, for example, there is so little absorption that the bones cast practically no shadow. The $\beta$-rays are not penetrating enough, while the $\gamma$-rays are too penetrating for radiography. 8 cm. thickness of aluminium are necessary to absorb half the $\gamma$-rays, while Rutherford has shown the effect on an electroscope of the $\gamma$-rays from 30 milligrams of radium bromide after passing through a foot thickness of iron.

An instructive difference exists between the $\gamma$-rays and the X-rays. In the Crookes tube the electrons are gradually started and suddenly stopped, and although theoretically X-rays should accompany both start and stop, the latter only are penetrating enough to get outside the glass tube. In the radio-elements the $\beta$-ray electron is suddenly started, and we have seen that it is so penetrating that even the densest matter cannot suddenly stop it. But the acceleration experienced by the $\beta$-ray electron expelled in the disruption of the radio-atom is the most sudden known, and in consequence the $\gamma$-rays are by far the most penetrating type of X-ray known. The $\beta$- and $\gamma$-rays invariably accompany one another, but together constitute only a small and comparatively insignificant fraction of the total energy emitted in the form of rays by the radio-elements. Rutherford recognised very early that there exists in the radiation another type, which he called the $\alpha$-ray, and this type comprises all but a few per cent. of the total energy radiated. The $\alpha$-ray is scarcely able to penetrate the thinnest sheet of paper, mica or aluminium, and is completely absorbed in 7 cm. of air. After prolonged study he succeeded in deviating it very slightly by the action of a magnetic field, and showed that the deviation was in the opposite sense, and only about one-thousandth as great as that which would be experienced by a cathode-ray under similar circumstances. He concluded that the $\alpha$-ray was a radiant *atom*, minus an electron, or positively charged, and that it travels with a speed about one-tenth of light. The most recent results point unmistakably to the conclusion that the particle is, in fact, an atom of the element helium. Now, the energy possessed by a radiant atom of helium is more than 1,000 times that possessed by a cathode-ray electron travelling at similar speed. But it is far more easily stopped by matter. Indeed, the surprising thing is that the $\alpha$-particle should penetrate at all. Some very recent most interesting results of Prof. Bragg, of Adelaide University, have shown clearly the nature of the process when a radiant atom strikes a stationary one "head on." The radiant atom passes on its way *through* the other none the worse for the encounter, much as two solar systems travelling at high speed in opposite directions might pass through each other.

The $\alpha$-rays are the cause of the scintillations of the sphinthariscope, each individual $\alpha$-particle producing a flash of light on impact with the zinc blende crystal. The $\alpha$-rays also cause by far the main part of the ionisation of gases, and therefore of the discharging action of the rays on a gold-leaf electroscope. The photographic and fluorescent action of the rays are mainly due to the $\beta$-rays, while the feeble $\gamma$-rays are most readily observed by their fluorescent action. Polonium is unique among the radio-elements in giving only $\alpha$-rays.

These facts began to be generally appreciated after the separation of radium from pitchblende by M. and Mme. Curie.

The recognition that the expulsion of the $\alpha$-, $\beta$- and $\gamma$-rays is the mere outward and visible sign of a deep-seated material change continuously occurring within the atoms of the radio-elements began with the clear elucidation of two other phenomena exhibited by certain of the radio-elements—namely, their power of producing a radio-active emanation, and the power of the latter to impart radioactivity to surrounding objects. These powers are shown by thorium, radium and actinium, but not by uranium or polonium. In addition to their radiations, each of the elements first named continuously produces what has now been clearly shown to be new radio-active gases generally called "emanations." The thorium emanation was first discovered by Rutherford, and the recognition of the other two quickly followed. The production of this emanation from the radio-element has been proved to be produced in the same constant amount under all circumstances. Under some circumstances the production is more obvious than in others, for certain of the solid compounds possess the power of retaining and storing up the gaseous emanation and so preventing its escape into the air. This does not occur with a solution. These emanations have all the same essential features, but differ among themselves greatly in detail. The radio-activity of the emanation continuously decays with time after its production from the radio-element according to a regular geometrical law. The activity of the emanation from actinium decays to one-half of its initial value after the lapse of only four seconds. The same occurs in the case of the thorium emanation in about a minute and for the radium emanation in four days.

All three emanations possess the extraordinary power of imparting to inactive solid objects in the neighbourhood a new and distinct type of temporary activity. This "imparted activity" decays also according to regular laws, which are characteristic and distinctive in each case for the different elements from which they are derived. This process has been elucidated and shown to be due to a change occurring in the gaseous emanation. Gradually and continuously it turns into a new type of radio-active matter, non-volatile and so depositing itself as a film upon any solid object available. The films are invisible and unweighable, and are only known by their activity. Nevertheless, if such a surface rendered active by exposure to the emanation is scrubbed with sand-paper, the film is removed and the activity is then found on the sand-paper.

In consequence mainly of these and allied phenomena the view was put forward in 1902 by Prof. Rutherford and Prof. Soddy that the radio-elements were in a state of continuous and spontaneous change, capable of an exact quantitative expression, and that the emanations and allied bodies were the products of these changes.

We have seen that radio-activity is a property intrinsic to the element, and, therefore, to the atom or smallest part of the element. The radio-elements possess the heaviest known atoms. If the lightest, hydrogen, is taken as unity, uranium is 238, thorium 232 and radium 225, while the next heaviest known are the inactive elements bismuth 208, and lead 207. The element helium is the second lightest known, and its atomic weight is 4. Now, if the α-particle is an atom of helium, the expulsion of one α-particle from an atom of radium will reduce its atomic weight from about 225 to 221. This must, therefore, be a new atom and represent an unknown element, for we have seen the nearest known element has the atomic weight 208. Now, you are aware that the chemical elements run in families. Radium, for example, is the missing "big brother" of the alkaline-earth family of elements, which consists of three elements, calcium 40, strontium 87, and barium 137, and chemically radium is an almost exact copy of its nearest relation, barium. Helium, in turn, is the lightest member of a family of gaseous elements, exactly similar in chemical nature. The family forms the well-known group discovered by the joint labours of Lord Rayleigh and Sir William Ramsay. The series runs, helium 4, neon 20, argon 40, krypton 82 and xenon 128. It happens that the heavy residue of the radium atom possessing an atomic weight of about 221, left behind after the expulsion of the light helium atom, turns out to be one of the missing big brothers of helium itself, being nearly twice as heavy as the heaviest (xenon) previously known. It is new, and a gas of the same chemical nature as the others, and is produced at a steady rate from radium, one atom for every α-particle expelled. It is, in fact, the radium emanation.

A quantity of radium, although it is sending forth its shower of α-particles continuously from year to year, does not grow appreciably less. The most sensitive balance has not yet succeeded in showing any change of weight. Hence it is obvious that although the actual number of α-particles and of new atoms of emanation may be, indeed must be, enormous, they only represent an unrecognisably small fraction of a minute amount of radium. The radium atom turns into a new atom, the atom of the emanation, by expelling an atom of helium. If the emanation expels another helium atom another new residue atom of weight 217 will be left. This is the solid form of matter which is deposited as a film from the emanation and is the cause of the phenomenon of the imparted activity. It is called by Rutherford *radium A*, and it also is recognised solely on account of the α-particles it expels. So the residue from radium A is another new atom of weight 213; it is called radium B. Rutherford, as the result of a series of observations elucidated with consummate skill, has recently arrived as far as radium F, in the analysis of the later slow changes of radium. But an α-particle is not expelled in each case; sometimes it is the β-ray or electron only, as in the case of the change of radium E into radium F; sometimes no radiant particle is expelled at all, and we have a *rayless* change, as for example when radium B turns into radium C, but then the next change, that of radium C into radium D, makes up by expelling both α- and β-particles. Reverting to radium F we find it also gives an α-particle and so must change into a radium G. Now radium F, the seventh successive product of the disintegration of radium, has been shown to be the polonium of Mme. Curie, found by her as a constant companion of radium in the uranium mineral pitchblende. Polonium gives α-rays, but no detectable other product. We have at length reached the apparent end of the process. Radium G does not expel either α- or β-particles, and so we have only a theoretical reason for believing it to exist. We can, however, make a good guess as to what radium G is. Counting the total number of helium atoms expelled in the series, we find they amount to five. or a loss of the atomic weight of 20 units, which leaves a residue about 205. Now remembering that the atomic weight of radium is uncertain to at least a unit, and that, if anything, the atomic weight of helium is likely to be less than four, you will see that lead (207) might well be radium G. This is as much as can be said for the moment.

Not only have the chemical and physical characteristics of these intermediate forms of matter produced in the successive break-up of the radio-elements been determined (and they exhibit a strange diversity), but also the period of average life of the atom in each case. This latter is the most characteristic constant by which the numerous forms may be distinguished. It was thus that polonium was shown to be radium G. The average life is got from the rate of decay of the radio-activity. A definite proportion of the total number of atoms present undergoes disintegration per second, and in consequence the number present diminishes after removal from the parent element, and the activity correspondingly decays. Thus, in the case of the thorium emanation, it can be readily calculated that about one eighty-seventh part of the total number of atoms expel α-particles and change per second, so that the period of average life of the atom of the thorium emanation is 87 seconds. Similarly, for the radium emanation atom only one five-hundred-thousandth disintegrates per second, so that the period of average life is 500,000 seconds, or 5·3 days.

The older methods of physics and chemistry are useless, except for those forms which exist in quantity. But the newer methods of radio-activity we have seen will succeed in detecting indirectly, on account of its energy-outburst, a single atom.

The second difference between the stable forms of matter dealt with by chemical methods and the unstable forms dealt with in radio-activity is that although there is no limit to the amount of any of the stable elements that can be accumulated and worked with, there is a very important limitation to the amount of an unstable or radio-active element that can be accumulated. For example, the real reason why polonium has never yet been obtained in weighable quantities, although enormous amounts of pitchblende have been worked up for it, is that, unlike radium, the period of its average life is only a few months. Not only, therefore, is there much less polonium in pitchblende than radium, but since the process of separation takes time, it tends to disappear as fast as it can be accumulated.

In any disintegration series where the products steadily accumulate with the parent element, the time will come when the number of each of the intermediate atoms formed equals the number which disintegrate, and then the quantity accumulating does *not* further alter. The longer-lived forms will accumulate to a greater extent than the shorter-lived forms, but more time will be required in the former case for the equilibrium state to be reached.

Thus, if solutions of radium and thorium are contained in closed bottles, the amount of emanation accumulating in the bottle containing the thorium will reach its maximum in a few minutes, and after that, however long the bottle is kept closed, no more emanation can accumulate, for as much disintegrates per second as is formed per second. But in the case of the radium solution the quantity accumulating will go on increasing daily, and the maximum or equilibrium amount will not be reached until some weeks after the bottle is closed up.

When, however, the end of the disintegration series is reached, since the ultimate product is not changing, the quantity accumulates without limit, and, provided that you are able to wait sufficient time, you will ultimately obtain enough to detect by ordinary chemical analysis. But in most cases centuries would have to elapse for this to occur. Fortunately there is an indirect method of obtaining evidence of the nature of the ultimate products. These processes have been going on continuously during past ages in the earth, so that if we track the disintegrating element to its natural source, the mineral in which it occurs, we shall expect to find there the ultimate products of ages of past accumulation. The short-lived, the long-lived intermediate forms and the final stable products will all exist in recognisable quantity in the natural mineral, as the invariable companions of the radio-element. Thus, long before the production of helium from the radio-elements was established experimentally, helium was clearly indicated as one of the ultimate products of radio-active change, because it is always found in the minerals which contain the radio-elements, and only in those minerals. We recognise radium, polonium and lead also as constant companions of uranium. We have seen that the average life of the radium atom is of the order of 1,000 years, and of the polonium atom about seven months. If we suppose that radium and polonium are two long lived intermediate forms in the disintegration series of uranium, the difficulties already raised in connection with the continued existence of these elements at the present time disappear. This view has now been experimentally proved. The growth of radium in solutions of uranium completely freed from it has been observed. In addition it has been established for all the uranium minerals that the ratio between the proportion of uranium and radium is constant. We have seen that radium disintegrates approximately a million times faster than uranium. So that after the lapse of only a few thousand years the radium present in a uranium mineral will attain the equilibrium ratio. As much will disintegrate as is produced from the uranium in its disintegration. As the latter process occurs about a million times more slowly than the former, the equilibrium ratio will be about one part of radium to a million of uranium. The exact amount experimentally found is 0·72 gramme of radium per ton of uranium. The identity of radium G and lead still remains unproved. In addition, the existence of several intermediate forms of long life between uranium (238) and radium (225) has been indicated and are now being sought for.

The discovery that the proportion of radium in the naturally occurring uranium minerals is a fixed constant, so that if the percentage of uranium is known, the quantity of radium can be calculated, has opened out a vista of new possibilities. A few thousand years hence, the small quantity of radium here to night will have had its day and cease to be. But if it were then possible to examine the uranium from which it was originally separated, it would be found that a new quantity no less in amount had grown in the interval, exactly as a closed bottle containing radium grows a new crop of the emanation again, however many times the emanation is removed.

The question now arises how far are these principles confined in their application to the radio-active elements, and how far are we justified in extending similar ideas to explain analogous phenomena in the case of the inactive elements.

But this much at least is clear. In the first place it is by no means necessary that the disintegration of an element should be accompanied by an energy-outburst of the kind known to constitute radioactivity. It is because the helium atom is so light compared with the residue atom that it carries with it the greater part of the energy of the explosion, and constitutes itself a penetrating and therefore detectable type of radiation. The most recent work has all gone to prove that it is rather a fortunate chance, so to speak, that the effect we know as radio-activity exists at all. The results of Rutherford have shown clearly that if the radiant particles expelled during the disintegration of the atom were ejected with but slightly less energy than is actually the case, they would neither ionise the air nor affect a photographic plate, nor cause fluorescence, and in fact there would be absolutely no effect capable of detection by our instruments. It is certain that atomic disintegration might be proceeding everywhere around us among the commonest elements at rates comparable with that occurring in uranium, and yet be beyond our utmost powers of detection. Bragg's work clearly shows that the hope of detecting such a change by a gain of charge of the matter is fallacious. Rutherford has also established that changes unaccompanied by detectable radiation ("rayless changes") occur in several cases. These can be recognised if, and only if, they are preceded and followed by changes in which detectable rays are expelled.

Then there is the chemical argument which has been alluded to. Barium is so extremely like radium that it is impossible to believe that they are not similar structures. Radium being the heavier atom has a greater store of internal energy in consequence, but not altogether disproportionately greater. The internal energy of the atoms is merely manifested when the structure breaks up. It is impossible for chemical reasons to suppose that only the radioactive atoms possess this enormous store of energy. The stability of all the atoms to external forces of all kinds, demonstrated by the fact that even now any artificial transmutation is impossible, shows that the energy associated with the internal structure of all atoms must be of a higher order of magnitude than that associated with the molecule.

There is one interesting deduction that can be made at the present stage. Although we cannot yet transmute one metal into another, we know very well why that has never been accomplished. Radium evolves for every gramme weight 100 calories of heat per hour, and since in a year only one-thousandth part changes, it follows that the total energy in the complete disintegration of a gramme of radium must be enormous. It is roughly about a million times that given out by a similar weight of coal burning. If the 30 milligrammes of radium exhibited were all to disintegrate suddenly, the effect produced would equal the explosion of about a hundredweight of dynamite. Uranium in its complete disintegration produces radium, and hence the amount of energy evolved must be as much greater than in the case of radium, as the whole is greater than the part. If we could artificially accelerate the rate at which radium or uranium disintegrates, we should, on the one hand, have achieved transmutation of a heavier element into lighter ones, and, on the other, have rendered available for use a new supply of energy a million times more powerful than any source at present known. If we succeeded in artificially transmuting uranium there is little doubt that the same means would be applicable to the other elements. Hence the supply of energy would be inexhaustible. But let us see what the old attempt of the alchemist involved. When he was concerned with building up a heavy element like gold from a lighter like silver, he was attempting a most profitless task. The energy absorbed would cost far more than the value of the gold produced. The energy of some hundreds of tons of coal would have to be put into the silver to turn it into gold. But where he was attempting to produce gold out of a heavier element like lead, not only would he have got the gold from the lead, but also a store of energy would have been released in the change of far more intrinsic and commercial value than the gold.

Leaving for a few moments the realm of experimental fact, the speaker made an interesting digression, taking an example from the field of economics and comparing the give-and-take laws governing the question of gold mining, currency and reserves with the broad principles of storage and interchange of energy underlying the phenomena dealt with in the earlier part of the address, and pointed out how great the influence of the field opened up by the disintegration theory was bound to be on the modern thought. It was not necessary that we should ever approach any nearer than we are at present to the application of these new powers and stores of energy to every-day use. The mere future possibility of doing so cannot fail to leave its mark. This was the answer to the question as to whether radium is ever likely to be of use. It might, or it might not, light our lamps or drive our motors. The assured certainty was that if it is ever made to do either of these things, man as we know him would quickly follow his steam engine and dynamo into the museum. At present we had not found how to control the gigantic forces, or affect the tremendous processes we have so lately discovered, and we never may. The important point is that by these discoveries the relations of mankind to Nature have undergone a certain change, and he has caught a glimpse of some latent possibilities within his legitimate destiny which cannot be effaced. Energy is the life of the physical universe. You cannot multiply the existing store by a million and leave things as they were. But the recognition of the internal energy of matter has done this within the progress of the century which has just begun. There is nothing now physically *impossible* in the engineering feats, which to-day are the marvel of the world, to-morrow being carried out on the million-fold higher scale. A journey to the moon to-morrow *may* rank with the halfpenny car ride of to-day, or the warming of a house with the thawing of an Arctic continent. To-day, so far as any use of the new knowledge is concerned, the one is as impossible as the other, but none would venture to deny to the future the possibility.

## ELECTRIC POWER FOR THE RAND MINES.

The scheme outlined by Mr. Robert Hammond, in his recent British Association Paper, for the erection of a large electric power works on the Rand is being developed as rapidly as circumstances will permit, and a syndicate has been registered in London for the purpose of obtaining the necessary powers from the Government of the Transvaal. The syndicate is to have a capital of £5,000, and it is estimated that £3,000 to £4,000 should suffice to pay the incidental expense.

Mr. Hammond went to South Africa last year mainly in connection with his consulting work for the Bloemfontein and Port Elizabeth electricity works. He also made use of the opportunity to investigate the possibility of building an electric railway from Johannesburg to Pretoria, a distance of 35 miles. The existing steam railway does not run directly, and a long time is taken for the journey. Mr. Hammond offered to build the railway and to lease it to the Government on a 4 per cent. basis with option to purchase at any time by the addition of 10 per cent. on the capital cost, but the consideration of the question has been postponed for the present, as the Government would probably prefer to build the line itself if it approves of the idea and can vote the necessary sum.

The advantage of an improved system of power distribution on modern lines had already engaged the attention of some of the mining engineers on the Rand, and Mr. Hammond was approached by one of them, who explained to him that the suggestion of a definite power scheme coming from an outside source would receive a more favourable reception than one emanating from any one of the mining groups. He, therefore, arranged with the Local Committee of the British Association to read his British Association Paper, but he informs us that no negotiations for the working-out in practice of the scheme put before the British Association had preceded this Paper. As a result of it, however, capital was immediately offered him, but he preferred to deal with the matter in London, and on the advice of his solicitors the formation of the above-mentioned syndicate was decided on. Of the 5,000 £1 shares, 1,000 are reserved for subscription in Johannesburg, and 1,000 will be allotted to Messrs. Robert Hammond & Co. to cover their engineering services up to the date of obtaining Parliamentary powers.

After reading the Paper, Mr. Hammond paid a visit to Vereeniging, where he found a suitable site for a power station, at which a plentiful supply of water from the Vaal River would be available for condensing purposes. There coal will probably be available at 5s. or 6s. per ton instead of the 10s. 6d. quoted in the British Association Paper for coal at a more central place on the Rand. Thus, Mr. Hammond is confident that the selling price of electrical energy at 0·7d. per unit will be quite feasible, and a number of mines would be ready to take power from the works at this price.

The following tests of Vereeniging coal have been made by Messrs. Lewis and Marks on the spot:—

| Type of boiler. | Water tube. | Fire tube. |
|---|---|---|
| Duration of test, hours | 16 | 16 |
| Number of observations | 34 | 33 |
| *Coal Analysis.* | | |
| Moisture, per cent. | 4·99 | 5·58 |
| Volatile matter, per cent. | 25·31 | 24·50 |
| Fixed carbon | 53·18 | 54·07 |
| Ash | 16·52 | 15·85 |
| Lbs. of coal fired per hour | 606·5 | 570·96 |
| Lb. of coal fired per hour per sq. ft. of grate | 12·008 | 16·31 |
| Lbs. of combustible fired per hour | 449·56 | 417 56 |
| Lb. of combustible per sq. ft. of grate p. hour | 8·96 | 11 93 |
| Lbs. of water evaporated per lb. of coal from and at 212° F. | 5·897 | 6·691 |
| Lbs. of water evaporated per lb. of combustible actual | 7·0789 | 7·762 |
| Lb. of water evaporated per lb. of combustible from and at 212° F. | 7·953 | 9·149 |
| Calorific value of coal | 10,547 | 10,494 |
| Efficiency of boiler used, in combustible | 59·187 | 68·53 |

Vereeniging is about 35 miles distant from a point on the Rand which would serve as a distribution centre. A pressure of 60,000 volts three-phase at 25~ frequency would probably be adopted for the transmission line to this centre, and the pressure would be reduced there to 30,000 volts. From this point, lines would radiate out to a maximum distance of about 25 miles, and at other transforming stations the pressure would be further reduced to 6,600 volts, at which it would be supplied to the consumers. All the lines would be overhead, probably of aluminium, and they would be erected on steel towers about 500 ft. apart. Two sets of three-phase lines would be erected initially, probably each on a separate pole-line, and these, it is proposed, shou'd be ultimately increased to four.

The telegram from Johannesburg in Wednesday's London papers with regard to the formation of a power scheme on the Rand probably refers to this one, as works at Vereeniging are mentioned in it, as well as 100,000 H.P., which is to be the ultimate capacity of the scheme to which this article relates. Representatives were sent to the spot a few weeks ago to collect further detailed information and to take the necessary preliminary steps for obtaining the sanction of the Transvaal Government, and it is probable their arrival which has inspired the telegram in question.

## THE "KAISERWERKE" ELECTRICITY WORKS IN THE TYROL.

A description by Herr H. Manasse, of the "Kaiserwerke" electricity works, near Kufstein, appears in a recent issue of the *Elektrotechnische Zeitschrift*. This works, built in 1904-1905, was designed to supply electric energy for all purposes in and around Kufstein. It is a water-power station, water being obtained from a small lake, the "Hintersteiner-See," some 2,900 ft. above the Adriatic. In former times the water from this lake flowed away to the east, but this outlet was stopped by a dam, its place being taken by an artificial outlet tunnelled through a mountain range at the west side of the lake. At the same time the level of the lake was raised by 30 cm. (1 ft.), its capacity being increased thereby to 150,000,000 litres (5,280,000 cubic ft.). During a recent dry winter the quantity of water flowing from the lake was measured, and the minimum amount was found to be 400 litres (14·1 cubic ft.) per sec. The head of water is 321 m. (1,050 ft.); hence the minimum power available is about 1,280 H.P. But as the lake can be used as an equalising reservoir it is calculated that at least 3,000 H.P. are available during a working week of six days of 11 working hours each.

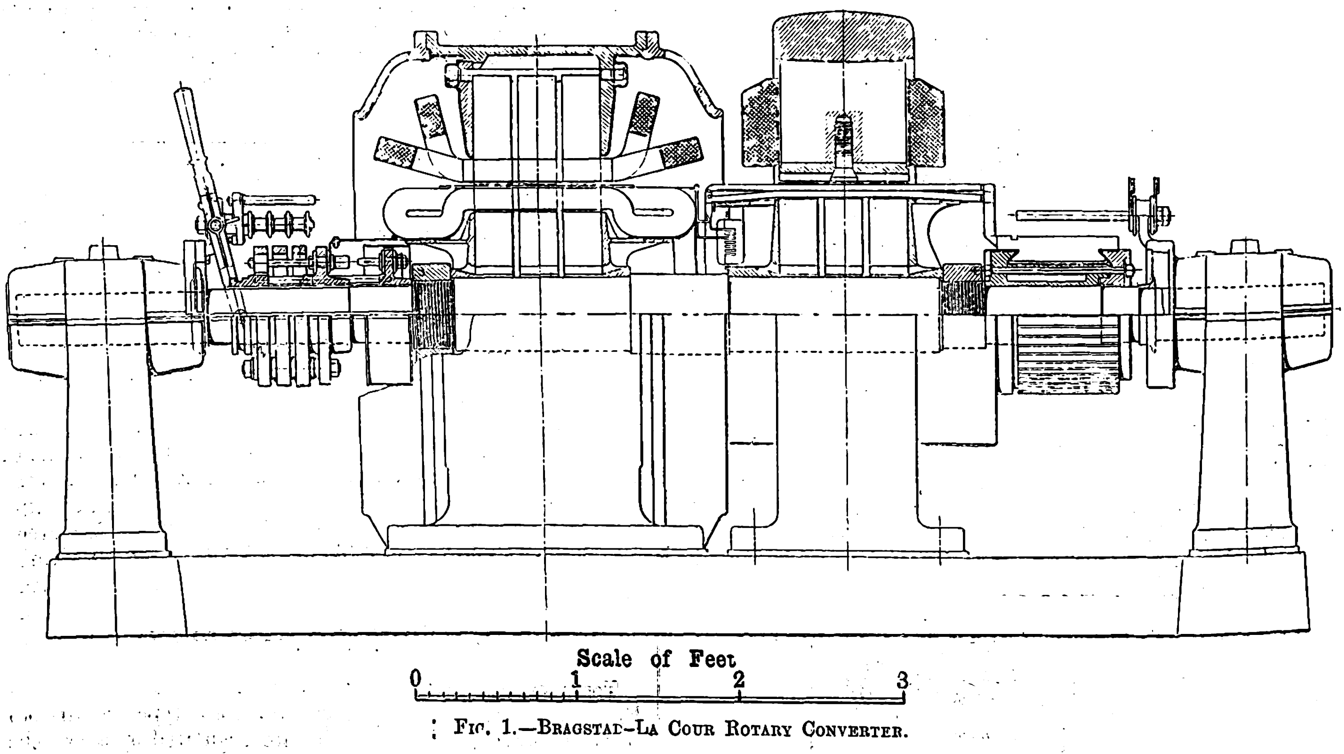


Fig. 1.—Bragstad–La Cour Rotary Converter.

So far, the generating plant in the power house comprises two 1,200 H.P. sets, each consisting of a water wheel of the "Pelton" type, running at 480 revs. per min., and coupled direct to a 1,000 kw. 10,500 volt 40~ 10 pole star-connected three-phase alternator of the rotating field type. The armature stampings are 0·45 mm. (0·0177 in.) thick, and there are four slots per pole per phase. Six ventilating ducts in the stator ensure a good ventilation. The following are some of the principal data of the alternators: Resistance of field winding, 0·139 ohms; resistance of one phase, 1·052 ohms; efficiency at full load and half load, at unity power factor, 96·2 and 94·2 per cent. respectively; the corresponding efficiencies at a power-factor of 0·75 are 94·2 and 92·6 per cent.; energyr equired for excitation (at unity power-factor), 16 kw.; the short-circuit current is not more than three times the normal current. There are also two 45 kw. 80-volt exciter sets. Each of these comprises a 60 H.P. "Pelton" water wheel, running at about 800 revs. per min., and a four-pole continuous-current dynamo with two armature windings and two commutators. Only one exciter set is used at a time, the other being a standby. All H.T. switches are of the oil type. No less than four different devices are used for protecting the plant against lightning—viz., lightning arresters of the "horn," "Gola," "high-resistance," and "water-jet" type. The latter type, which appears to be gaining in favour on the Continent, consists essentially of a fine jet of water (from the ordinary supply mains), which is maintained between the H.T. conductor and an earth. This jet has a high resistance, but allows a lightning discharge to pass.

At present there are two transmission lines. They are carried on the same poles as far as the Perlmooser cement works (4·3 miles distant from the power house) where one of the lines terminates. Insulators of the triple petticoated type are used, weighing 3⅓ lb. each, and tested to 30,000 volts. The H.T. transmission wires are arranged at the corners of an equilateral triangle with sides 800 mm. (31½ in.) long, and telephone wires are carried below them on the same posts. In three places the line wires are enclosed in by metallic guard networks.

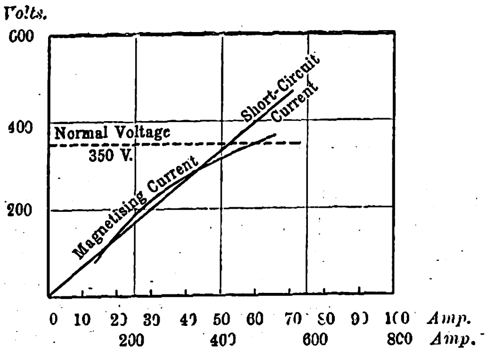


FIG. 2.—SHORT-CIRCUIT AND MAGNETISING CHARACTERISTIC OF THE BRAGSTAD-LA COUR ROTARY CONVERTER.

At the Perlmooser cement works the voltage is reduced from 10,000 to 2,000 volts by two 350 kw. three-phase transformers. An extra transformer is also kept as a reserve. The stampings of the transformers are 0·4 mm. (0·0157 in.) thick. The transformers are of the oil-cooled type, the oil itself being kept cool by means of a suitable system of piping through which cold water is constantly flowing. At full load the efficiency of the transformers is said to be 97·6 per cent. Three-pole oil switches are used both in the 10,000 and 2,000 volt circuits.

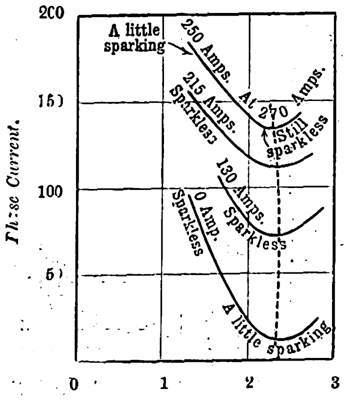


FIG. 3.—V-CURVES AT CONSTANT STATOR VOLTAGE.

The second transmission line proceeds to the Wörgl sub-station, about 7½ miles from the power house. This sub-station was built to supplement the regular Wörgl electricity works, which supply continuous current on the three-wire 2 × 150 volt system. The incoming H.T. current is stepped down to 300 volts in a 80 kw. transformer, and is then fed to a converter of the Bragstad-La Cour type (see *The Electrician*, Vol. LIV., p. 433), of the design shown in Fig. 1. Some characteristic curves are given in Figs. 2 to 6.

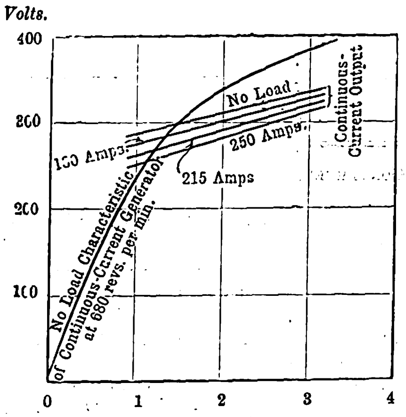


FIG. 4.—NO-LOAD CHARACTERISTIC OF THE ROTARY CONVERTER.

The sets consist each of an ordinary induction motor, the secondary (rotor) winding of which is connected to the armature winding of the continuous-current generator. Converters of this type may be readily started from the alternating-current side. The efficiency of the set was found to be 85 per cent. at full load, and increases in temperature in the various parts of the set after a six-hours test at full load were as follows: In the stator iron 40·5°C., stator copper 15°C., rotor copper 20°C., bearing (motor side) 29°C., field coils of continuous current generator 20°C., armature 33·5°C., commutator 26°C. and bearing (generator side) about 36°C. There are 72 slots in the rotor, each slot containing nine conductors. Each conductor itself consists of two wires (of a diameter ranging from 0·13 in. to 0·15 in.) in parallel. The rotor is wound with four poles and nine phases. The stator is also provided with 72 slots, each slot containing three conductors each consisting of two wires of a diameter ranging from 0·216 in. to 0·24 in in parallel. With regard to the continuous-current generator it may be remarked that it is of the four-pole type (each field coil consisting of 2,600 turns of wire ranging in diameter from 0·256 in. to 0·272 in.), and that 84 out of the 86 armature slots contain four conductors (0·1 × 0·353 in.) each, while the two remaining slots contain only two conductors of the same section.

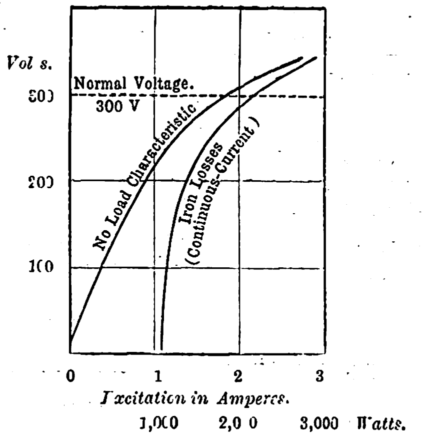


FIG. 5.—CONTINUOUS-CURRENT NO-LOAD CHARACTERISTICS OF THE ROTARY CONVERTER.

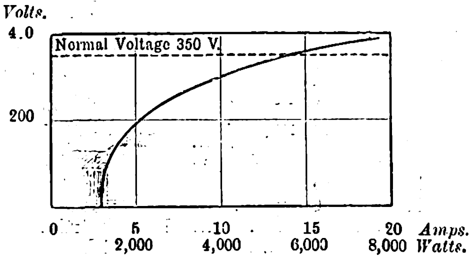


FIG. 6.—NO-LOAD LOSSES OF THE CONVERTER (SYNCHRONOUS MOTOR).

Electrical energy in form of alternating currents is distributed at various points along the transmission line between the power station and the Wörgl sub-station, a number of step-down transformers being provided for this purpose.

**Tests on Electric Drills.**—According to the *Railway and Engineering Review* of Chicago, the new type of air-cooled Duntley portable electric drills are regulated by a switch at the base of the handle and operated by thumb pressure. The drills are made both reversible and non-reversible. Single motor drills of the larger sizes are provided with a friction clutch which is set to slip when the load exceeds a certain value. A single motor breast drill weighing 30 lb., making 250 revs. per min., and using 2½ amperes at 110 volts drilled in a recent test a hole ½ in. by 1½ in. deep in cast iron in 42 seconds. The same drill made a hole ⅝ in. diameter and ½ in. deep in steel plate in 40 seconds, requiring 4½ to 5 amperes. A single motor drill weighing 32 lb. making 150 revs. per min., using 5 amperes at 110 volts, drilled a hole 1 in. diameter by 1½ in. deep in cast iron in two minutes. A three-motor drill weighing 52 lb., running 100 revs. per min. consuming 8½ amperes at 110 volts, drilled a hole 2 in. × 2in. in cast iron in 2½ minutes. In this test the amount of metal removed per minute was 0·635 lb.

## ELECTRIC LIGHTING PROVISIONAL ORDERS.

In October and November we gave particulars of the notices of intention to apply for Parliamentary powers for electricity supply, electric tramways and railways in the 1906 Session. Further particulars of the electricity supply and traction bills have appeared in the last two issues of *The Electrician*, and we now give a list of the applications for Electric Lighting Provisional Orders deposited with the Board of Trade by December 21st. Of the 55 applications (compared with 62 in 1905 and 74 in 1904) 31 are by companies or firms, and 24 by local authorities, against 33 by the latter and 29 by the former in 1905:—

| *Title of Order and Area.* | *Promoters.* |
|---|---|
| Abercarn | Urban District Council. |
| Aylesbury | Mutual Electricity Supply Co. |
| Barry (Amendment Order) | Urban District Council. |
| Barton-upon-Irwell | Rural District Council. |
| Bellshill (lighting district of Bellshill) | Lanark County Council. |
| Bettws-y-Coed | Urban District Council. |
| Blantyre (lighting district of Blantyre) | Lanark County Council. |
| Blaydon (Transfer of Powers) | Urban District Council. |
| Boston | National Provincial Elec. Corpn. |
| Bothwell (lighting district of Bothwell) | Lanark County Council. |
| Bude (Stratton and Bude, Parishes of Poughill and Marhamchurch and portion of Parish of Poundstock) | Christy Bros. & Middleton. |
| Calverley (Amendment) | Urban District Council. |
| Camberley and District (Frimley and Parishes of Sandhurst and Crowthorne in Easthampstead Rural Dist.). | Camberley Electric Supply Co. |
| Castle Ward, Weetslade & Cramlington | Newcastle-on-Tyne Elec. Sup. Co. |
| Cheshunt | North Metropolitan Electrical Power Distribution Co. |
| Dorchester (Amendment of 1901 Order) | Corporation. |
| Dunfermline and District (Royal Burgh of Dunfermline and portion of Fife). | Corporation. |
| Dunoon | Corporation. |
| East Barnet Valley | North Metropolitan Electrical Power Distribution Co. |
| Eastwood and Cathcart (Portions of Parishes of Eastwood and Cathcart) | Strathclyde Electricity Supply Co. (Limited). |
| Exeter (Extension to Heavitree) | Corporation. |
| Farsley | Urban District Council. |
| Fochabers (portion of parish of Bellie, Elgin, including Town of Fochabers). | The Duke of Richmond, Gordon and Lennox. |
| Foots Cray (Amendment) | Urban District Council. |
| Frome (Amendment of 1901 Order) | Urban District Council. |
| Gelligaer & Rhigos (parish of Gelligaer) | Rural District Council. |
| Godalming (Extension to portions of Godalming Rural and Compton. | Urban Electric Supply Co. |
| Gomersal | Elec. Distribution of Yorkshire. |
| Henley-on-Thames | Mutual Electricity Supply Co. |
| Hexham (Extension to portion of Rural District of Hexham). | Hexham & District Electric Supply Co. |
| Higham Ferrers, Rushden & Wellingborough (Rural District). | County of Northampton Electric Power & Traction Co. |
| Horsforth (Amendment of 1903 Order) | Urban District Council. |
| Inveresk (so much of parish of Inveresk not in Burgh of Musselburgh). | National Electric Construction Co. |
| Kilpatrick (portions of parishes of Old and New Kilpatrick and Renfrew) | Strathclyde Electricity Supply Co. |
| Market Harborough | Urban District Council. |
| Maryport | Brush Electrical Engineering Co. |
| Mid-Durham (Urban Districts of Crook, Willington & Brandon-and-Byshottles, & Parish or Township of Brancepeth). | County of Durham Electrical Power Distribution Co. |
| Pinner, Stanmore, Harrow Weald and Edgware (Rural District of Hendon). | Northwood Electric Light & Power Co. |
| Ryton | County of Durham Electrical Power Distribution Co. |
| Seaham Harbour | S.M.H. Tramways Syndicate. |
| Shellston and Tollcross | Lanark County Council. |
| Slough (Extensions to parishes of Burnham, Farnham Royal, Horton, Langley Marish, Stoke Poges & Wexham, and portion of Iver). | Slough & Datchet Electric Supply Co. |
| Stourport and Kidderminster | Kidderminster & District Electric Lighting & Traction Co. |
| Sunningdale and District (Staines, Egham, Parishes of Sunningdale and Sunninghill, Windlesham and Chobham). | Foote & Milne. |
| Swanage | Bournemouth & Poole Electricity Supply Co. |
| Uddingston | Lanark County Council. |
| Uxbridge and District (Extension to Hanwell and Beaconsfield, parishes of Iver, Hedgerley and Hedgerley Dean, Seer Green and Penn, and Rickmansworth Rural and Chorleywood). | Uxbridge & District Electric Supply Co. |
| Wantage and District (Wantage and parishes of Ardington, E. & W. Lockinge, E. & W. Challow, Charlton, Grove, and Letcombe Regis). | Wantage Engineering Co. |
| Waterford | National Provincial Elec. Corpn. |
| Wealdstone | N. Metrop. Elec. Power Disn. Co. |
| Wembley Electric Lighting (No. 1) | N. Metrop. Elec. Power Disn. Co. |
| Wembley | Urban District Council. |
| Wisbech (Amendment of 1901 Order). | Corporation. |
| Workington | Brush Electrical Engineering Co. |
| Yardley (Amendment of 1904 Order) | Rural District Council. |

## ELECTRICAL JOINT STOCK COMPANIES OF 1905.

The following are the more important limited liability companies connected with the electrical and allied industries registered during the past year, with their capital:—

| | |
|---|---|
| Accessories Mfg. Co. | £10,000 |
| Adelaide Elec. Supply Co. | 300,000 |
| Auto-Claw Co. | 15,000 |
| Automatic Electric Block Signalling Co. | 1,000 |
| Auxiliary Electric Co. | 70,000 |
| Barbados Light Railway | 20,000 |
| W. Bath & Son | 50,000 |
| Bohm Lens Lamp Co. | 4,000 |
| Bombay Electric Supply & Tramways Co. | 1,200,000 |
| Bombay Hydro-Elec Synd. | 15,000 |
| British Automobile Development Co. | 100,000 |
| British & Colonial Zoelly Turbine Syndicate | 20,000 |
| British Electric Car Co. | 1,000 |
| British Electric Co. | 2,000 |
| British, Foreign & Colonial Automatic Light Controlling Co. | 100,000 |
| British Hele-Shaw Patent Clutch Co. | 12,000 |
| British Hosiery & Electrolytic Bleaching Co. | 60,000 |
| British United Eng. Co. | 10,000 |
| E. Brook | 5,000 |
| Brune-Turchi Teleg. Co. | 30,000 |
| Buenos Ayres Grand National & La Capital Tramways Joint Committee. | 1,000 |
| Buenos Ayres Port and City Tramways | 200,000 |
| Burgess Hill & District Electric Supply Co. | 5,000 |
| Caracas Electric Trams | 25,000 |
| City of Ely Lt. & Power Co | 5,000 |
| Clift Mfg. Co. | 10,000 |
| Commercial Cars | 20,000 |
| Consolidated Supply Co. | 50,000 |
| Cordoba Central Buenos Ayres Exten. Railway. | 700,000 |
| Cork City Railways & Wrks. Bill Promotion Co. | 10,000 |
| Crawford Elec Lamp Synd. | 30,000 |
| Cremorne Motors | 30,000 |
| Cumberland Power Synd. | 5,000 |
| De Forest Wireless Telegraph Syndicate | 120,000 |
| Dewsbury Elec. Mfg. Co. | 5,000 |
| Diamond Elec. Lamp Co. | 20,000 |
| Durham Collieries Electric Power Co. | 125,000 |
| Edinburgh Suburban Electric Tramways Synd. | 10,000 |
| Eldon Electric Co. | 3,000 |
| Electric Accumulator Co. | 60,000 |
| Electric Flash Lights | 25 000 |
| Electric Ignition Co. | 10,000 |
| Electric Power Development Co. | 50,000 |
| Electric Railway & Tramway Carriage Works | 1,000 |
| Electrical Distribution of Yorkshire | 10,000 |
| Elec. Instrument Mfrs. | 5,000 |
| Elec. Safety Appliances Co. | 2,000 |
| Electro-Medical Supply Co. | 6,000 |
| Electromobile Hiring Co. | 8,000 |
| Engineering Contract Corp. | 15,000 |
| Everett, Edgcumbe & Co. | 20,000 |
| Ferranti | 130,000 |
| Folkestone Distric Electric Light & Power Co. | £50,000 |
| Foot's Cray Elec. Supply Co | 20,000 |
| Foreign Electrical Bleaching Patents | 15,000 |
| Forster & Sons | 16,000 |
| General Electric de France | 10,000 |
| A. J. Harris & Co. | 2,000 |
| Hayward-Tyler & Co. | 100,000 |
| Hexham & District Electric Supply Co. | 30,000 |
| Hopper & Co. | 8,000 |
| Houghton-le-Spring & District Elec. Lighting Co. | 15,000 |
| Illuminated Signs | 3,000 |
| Improved Elec. Supplies | 15,000 |
| Indian Electric Supply & Traction Co. | 600,000 |
| International Dowsing Elec. Heating & Appliances Co. | 20,000 |
| International Elec. Rlys. & Water Power Synd. | 120,000 |
| Johnson and Phillips | 175,000 |
| Johnson Secret Wireless Teleg. & Telephone Synd. | 15,000 |
| Kamm's Zerograph Synd. (1905) | 24,000 |
| Kerry Electric Supply Co. | 2,000 |
| Kuettner, Macdonnell & Cookson | 10,000 |
| Langdon-Davies Motor Co. | 5,000 |
| Lens Lamp Co. | 60,000 |
| Light Electric Motor Co. | 6,500 |
| Light Rlys. Co. of Sicily | 12,000 |
| London, Deptford & Greenwich Tramways Co. | 170,000 |
| London & Dist. Motor'Bus Co. | 405,00 |
| London & General Power Supply Co. | 60,000 |
| London Outer Circle Railway Synd. | 20,125 |
| Lowden Elec. Lamp Co. | 3,000 |
| Macclesfield Tram. Synd. | 5,000 |
| Mann, Egerton & Co. | 30,000 |
| Mansfield & Sons | 20,000 |
| Sir Hiram Maxim Elec. Co. | 50,000 |
| Richard Melhuish | 100,000 |
| Mexborough & Rawmarsh Construction Synd. | 175,000 |
| Mexican Power Development Synd. | 5,025 |
| George F. Milnes & Co. | 1,000 |
| Mountain & Gibson | 60,000 |
| Municipal Founding & Engineering Co. | 5,000 |
| Musselburgh & Dist. Elec. Light & Traction Co. | 120,000 |
| Newquay Electric Light & Bower Co. | 14,000 |
| North Melbourne Electric Tramways & Lighting Co. | 200,000 |
| "Otto" Elec. Mfg. Co (1905) | 75,000 |
| Joseph Overend & Sons | 10,000 |
| Ozonair | 5,000 |
| P. M. Electric Mfg. Co. | 2,000 |
| Para Electric Railways & Lighting Co. | 700,000 |
| Patent Conveyor Co. | 2,000 |
| Patent Elec. Carbonising Co. | 2,000 |
| A. W. Penrose & Co. | 40,000 |
| Philp's Heat Distributors | 1,500 |
| Portable Accumulators | 25,000 |

| | | | |
|---|---|---|---|
| Thomas Potter & Sons ... | £2,000 | Stratford-on-Avon Electricity Co. .............. | £15,000 |
| Rangoon Electric Tramway & Supply Co. ...... | 500,000 | Strathclyde Electricity Supply Co. ............... | 1,000 |
| Raymond-Phillips Elec. Rly & Tramway Equip't Co. | 10,000 | Switchgear Co. .. ......... | 10,000 |
| Richardson Electric Co.... | 2,500 | Torquay Tramways Construction Synd. .. ...... | 140,000 |
| S.M.H. Tramway Synd.... | 1,000 | Traction Unification ...... | 10,000 |
| Saxby & Farmer (India) | 50,000 | United Elec. Con. Synd.... | 10,000 |
| Security Elevator Safety Co. | 10,000 | Venezuela Central Rly.... | 200,000 |
| Shanghai Electric Construction Co. ............ | 320,000 | Webster Elec. Eng. Co. ... | 10,000 |
| Shanghai Elec. Tramways | 400,000 | Wemyss & Dist. Trams. Co. | 55,000 |
| Sharer & Young .. ......... | 20,000 | Wright, Methuen & Co.... | 2,000 |
| Singapore Elec. Tramways | 10,000 | Yates & Thom ........... | 240,000 |
| Sol Mfg. Co. ............... | 1,500 | Yorkshire (West Riding) Elec. Tramways Co. ... | 600,000 |
| S. American Traction Co. | 10,000 | Zea Arc Lamp Co. ......... | 1,000 |
| Stanley Elec. Carriage Co. | 10,000 | | |

# CORRESPONDENCE.

## MUNICIPALITIES AND HOUSE WIRING.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: My attention has been called to an article in your issue of December 15th on "Municipalities and House Wiring," and I have pleasure in informing you that this Association has applied for an injunction in the High Court of Chancery to stop the Sheffield Corporation carrying on their electric fittings and wiring departments. As you rightly suggest, this Association tries to the utmost of its power to stop all such cases of unfair trading, and we have been successful in a large number of cases, amongst which Bath, Todmorden and Huddersfield are the latest examples. I should esteem it a favour if you would, therefore, through your paper, give publicity to this work carried on by my Association, so that should any contractors find their business damaged through Corporation trading they may communicate with me, and I will immediately look into the matter with them.—Yours, &c.,

Leonard G. Tate, Hon. Sec.,
The Electrical Contractors' Association (Incorporated),
20, Bucklersbury, London, E.C., Jan. 1.

## INDUCTIVE BALANCE DEVICES FOR THE PROTECTION OF ALTERNATING-CURRENT CIRCUITS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Dr. Garrard, in his letter on the above subject which appeared in your issue of the 22nd ultimo, refers to what, at first sight, appeared to be a somewhat difficult problem which was set to electrical manufacturers in a recent specification. I would point out, however, that the difficulties are greatly reduced if, instead of depending upon the magnetising current only to operate the discriminating devices, this effect is supplemented by the current supplied to the working load, as is done in the devices Messrs. Cowans Limited have recently made for the Great Western Railway transformers. Dr. Garrard suggests that it may be required to switch out one of the transformers at a time when no load is being supplied by the two transformers. These conditions are, however, not likely to arise in practice, and no attempt is being made to make the devices work under such conditions. As Dr. Garrard rightly points out, if they were so delicate as would be required for this it would be impossible to run the system with them in operation.—Yours, &c.,

London, E.C., Jan. 2. Leonard Andrews.

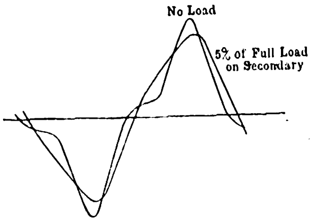
## WAVE-SHAPES AND THREE-PHASE TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Owing to absence from England I did not see Mr. Clinker's letter of the 16th ultimo until two days ago, and I must, therefore, apologise for the lateness of this letter. The experiments to which I referred were designedly carried out as far as possible under commercial conditions, and the three-leg transformer was therefore made in the usual way with three legs side by side, since this form is more common than the "shamrock" pattern. It was for this reason that, as stated in my last letter, "it was carefully arranged so that the two end cores should be symmetrical in all respects with regard to the centre core." This, of course, indicates that there were three cores side by side.

Mr. Clinker is quite right in his objection to my statement about the four-core transformer and the avoidance of distortion. The whole point of using the four-cores is to allow any *legitimate* triple-frequency flux to flow—not the forced triple-frequency flux dealt with in Mr. Clinker's original Paper—and the only means of applying a triple-frequency E.M.F. to the transformer is by connecting up the neutral wire from the generator. No other connection, star or mesh, can give any triple-frequency components. As it often happens, this was so clear to my mind that I accidentally omitted to mention that I assumed such a connection. If it be adopted there can be no distortion difficulties.

Whilst on the subject of the forced triple-frequency flux in a set of three-wire star connected transformers (neutral insulated), the enclosed oscillogram may be of interest, as it shows that the voltage distortion is only of importance at very light loads. Sine-shaped E.M.F. waves were applied to a set of three 2 kw. Parsons transformers, and the curves show the form of secondary P.D. wave from each at no load and at 5 per cent. of full load on each secondary respectively; even with this small load the wave is rapidly approaching the sine-shape, since the distortion in the magnetizing current wave is rendered comparatively small by the increase of the primary and secondary load currents; at about 10 per cent. of full load the distortion in the P.D. wave is inappreciable.—Yours, &c.,



F. J. Dykes.

Royal Naval Barracks, Portsmouth, Jan. 1.

## WAVE MEASURERS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The Gesellschaft für Drahtlose Telegraphie miss the point of my letter to you of December 15th last entirely. I did not say that the novelty of the cymometer consisted in being able to vary at the same time the inductance and capacity, but that a characteristic feature of the instrument for which broad patent claims had been granted to me by the United States Patent Office, after examination of the Dönitz patent, consisted in one movement of a handle *varying simultaneously and in the same proportion* the capacity and inductance of the instrument so that the scale reading oscillation constants is equidivisional. The quotation they give from their own specification involves no mention of the above quality, and hence has no bearing on the point at issue. Their further criticisms show that they have no practical experience of my instrument. In it the inductance consists of a spiral of copper wire of low resistance, and, therefore, the damping is quite small. The coupling with the circuit under test can be extremely weak, as I showed experimentally in my recent Cantor lectures. The use of the instrument for delineating resonance curves was practically demonstrated in these lectures and at the late exhibition of instruments by the Physical Society. With respect to accuracy, I have had before me lately an official certificate (the origin of which I do not disclose for obvious reasons) stating that my cymometers had been tested against a Dönitz wave meter, and found to give the same readings. The claim they make for the superior accuracy of their own appliance is not, therefore, borne out by independent tests, and in any case they themselves are not unbiassed judges in the matter; but it must be left to those who use these different types of wave-measurer to decide which they prefer.—Yours, &c., J. A. Fleming.

University College, London, Jan. 2.

[This correspondence is now closed.—Ed. *E.*]

**Telegraph Extension in Persia.**—The construction of the Indian extension of the Central Persian telegraph line to Panjgur, via Bela, which will be 300 miles in length, and will eventually connect with the Indo-European Telegraph Co.'s system at Persia, has been commenced.

# MUNICIPAL, FOREIGN & GENERAL NOTES.

## APPOINTMENTS VACANT AND FILLED.

A shift engineer, with central station experience, is wanted at St. Helen's Corporation electricity works. Applications by Jan 11 to the electrical engineer (Mr. E. M. Hollingsworth), Electric Power Station, St. Helen's. See an advertisement.

A draughtsman, used to design and arrangement of machinery, and a motor inspector for motors on hire, are wanted for Bristol Corporation Electricity Works. Applications to city electrical engineer (Mr. H. Faraday Proctor), Temple Back, Bristol. See an advertisement.

A draughtsman, accustomed to high and low-tension switch gear, is required by Ferranti Limited, Hollinwood, Lancs. See an advertisement.

The Council of Armstrong College, Newcastle-on-Tyne, invite applications for the position of lecturer in physics. Stipend commencing at £200, rising by annual increments of £10 to £250. Applications to the secretary (Mr. F. H. Pruen) by Jan. 15. See also an advertisement.

The governing body of the Northampton Institute require a junior technical assistant in the electrical engineering department. Applications by 10 a.m. Jan. 8 to the principal (Dr. R. Mullineux Walmsley), Northampton Institute, St. John-street, London, E C. See also an advertisement.

The London, Brighton & South Coast Railway Co. require a signal superintendent. Salary £300. Applications by 10 a.m. 19th inst.

An examination will shortly take place for appointments as second-class engineers in the Engineer-in-Chief's Department, G.P.O. Jan. 11 is the latest date for receiving applications. Forms from the Secretary, Civil Service Commission, Burlington-gardens, London, W.

Mr. Walter H. Tittensor, M.I.E.E., engineer and manager of Preston Corporation tramways, has declined the offer of the Council to extend his engagement until May 1, having accepted the position of Scottish manager for Messrs. J. H. Holmes & Co., with headquarters at 19, Waterloo-street, Glasgow, where he will take up his new duties on Feb. 1.

Preston Council have unanimously appointed Mr. J. F. Simpson, who has acted as chief assistant, to succeed Mr. Tittensor as borough electrical engineer and tramways manager at a salary of £300 per annum.

Mr. C. H. Thomas, clerk in the rating department of Islington Council, has been promoted to the collectorship of electricity accounts.

## EDUCATIONAL NOTICES.

**Carnegie Research Scholarships.**—The Council of the Iron and Steel Institute will shortly proceed to award research scholarships founded by Mr. Andrew Carnegie. Candidates, who must be under 35, must apply before Feb. 28 to the Secretary of the Institute (Mr. Bennett H. Brough), 28, Victoria-street, London, S.W. See also an advertisement.

**Educational Bequests.**—The will of the late Mr. Alex. Wm. Mills, of Bowdon, contains a number of bequests to Manchester institutions, amongst which Owen's College is to receive £4,000, to be invested to form a permanent endowment for the college under the title of the Alexander Mills Endowment Fund. A further £3,000 is bequeathed to the Manchester Grammar School, to found scholarships tenable at either Oxford or Cambridge by students who three years before their matriculation at the selected university shall have been educated at Manchester Grammar School.

**Glasgow & W. of Scotland Technical College.**—Glasgow Corporation have decided to contribute £10,000 out of the Common good, in four annual instalments of £2,500 to this college.

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**Aston.**—The Public Works Committee have complimented the contractor (Mr. Geo. Trentham) for the Birchfield-road and Witton-road tramway track, upon the celerity with which the work has been completed.

**Asylum Lighting, &c.**—The new York City Asylum at Naburn is to be lighted throughout by electricity. There are also to be complete fire alarm and telephone installations.

**Belfast.**—At the Corporation meeting on Monday a statement was made as to the cost of the Municipal electric tramways.

The total cost of the undertaking was a little over £1,000,000. The surveyor's estimate was £827,000, and the actual expenditure was £1,052,714 less salvage £40,405, leaving a net cost of £1,012,309. Only £900,000 has been borrowed, and there is an ultimate balance to be provided of £148,156.

The Corporation have voted the following bonuses for extra work in connection with the conversion of the tramways to electric traction:—

To Mr. H. A. Cutler, city surveyor, £300; to Mr. V. A. H. M'Cowen, electrical engineer, £200; to Mr. Andrew Nance, general manager, £200; to Mr. James Mance, assistant surveyor, £100; to Mr. E. S. Pinkerton, assistant engineer, £100; to Mr. Lewis, clerk of works, £20.

**Bethnal Green (London).**—The Council agree to Hackney Council supplying electric current to two sets of premises in Bethnal Green, subject to an agreement being entered into that the customers discontinue supply when current can be furnished by Bethnal Green Council.

**Boston.**—The Council have withheld consent to the National Provincial Electricity Corpn.'s application for an electric lighting order.

**Cable Makers' Association.**—A supplement to the current issue of *The Electrician* directs attention to matters of interest to users of electric cables and wires.

**Cheltenham.**—The Lighting committee have decided to alter the present charge of 5½d. per unit to 8d. per unit for the first 60 hours' maximum demand per quarter, and 3d. after.

**Chile.**—The Compañia Generale de Electricidad Industrial has obtained a concession for supplying electric current for lighting, heat and power to the city of Linares, to Los Angeles and to Providencia, in each case for a term of 10 years.

**Cleckheaton.**—It was reported to the Council on Tuesday that a sub-committee had discussed with the manager of the British Electric Traction Co. the suggested tramway extension to Oakenshaw. The local tramway company, it was reported, were using a number of cars with regenerative control upon the lines supplied with energy by the Council, and the committee had instructed the clerk to inform the company that the Council regarded the running of such cars as a breach of the agreement for the supply of current between them and the company, and requesting their immediate discontinuance. The Council have informed the company that they will hold the company responsible for damage to any instruments, meters or other apparatus which may occur as a consequence of those cars being used.

**Coventry.**—At Tuesday's Council meeting Mr. Errington moved that a return be prepared relating to electric motors let on hire by the Corporation and giving financial particulars and the respective numbers of motors in use in various trades and also a return of the annual income from public and private electric lighting.

Mr. Errington said he was led to move the resolution because the Council recently sanctioned the borrowing of a further £5,000 for the purchase of motors, and because of the unsatisfactory way in which the statement as to what had been done with the £7,000 previously expended had been prepared for the members of the Electric Light committee.

The motion was carried.

**Customs Decisions.**—The New Zealand customs authorities have recently classed air brakes for electric cars as tramway plant to bear a 20 per cent. ad. val. duty.

**Derby.**—On Wednesday the Council authorised the expenditure of £1,903 for doubling a portion of the tramways.

**Dockyard Power and Lighting.**—The Admiralty have resumed work in connection with the electric power and lighting installation at Sheerness Dockyard.

**Electric Driving of Paper Mills.**—Messrs. Owen, owners of the Ely Paper Mills, Cardiff, have decided to put down independent plant for the supply of electricity for power and lighting at the mills. The question of obtaining a supply of energy from Cardiff Corporation or from the South Wales Electrical Power Distribution Co. has been under consideration, and the latter company offered to supply energy at ⅝d. per unit, but the firm think they can generate their energy even more cheaply. They have entered into a contract with the Lancashire Dynamo & Motor Co. for generating plant of about 600 H.P., as well as for 26 electric motors of various sizes up to 60 H P. The consulting electrical engineers are Messrs. Herbert Lewis & Fletcher, of Cardiff.

**Electric Power in Lancashire.**—The Lancashire Electric Power Co. are making steady progress with their scheme for the supply of electricity for power in their area of supply.

During the past year the first part of their scheme has been completed, and at present the cables of the company have reached Edenfield, and will thence be conveyed across the moors in the direction of Whitworth, down that valley through Heywood, and home to the station at Outwood; but there will be divergencies to Haslingden, Rawtenstall, Waterfoot, Stacksteads and Bacup. From Ramsbottom the mains are being carried across the Holcombe moors to Turton, and through Little Lever they reach Little Hulton and Westhoughton; thence southward as far as Newton-in-Makerfield, returning by Leigh, Tyldesley, Worsley, Swinton and Pendlebury, where the first English chimneyless mill is taking both power and light from the company, and several other firms are tapping their mains

**Exhibition.**—An electrical exhibition, organised by the electricity department of Newport (Mon.) Corporation, was opened yesterday (Thursday). There is a large number of exhibitors of electric light fittings, arc and incandescent lamps, electric motors, cooking and heating apparatus, &c In connection with the exhibition the secretary of the tramways department (Mr. J. G. Ellis) has compiled an interesting pamphlet on the progress and development of the Corporation electricity department, which points out in lucid terms the advantages of electricity for lighting, power, heating, cooking, &c. There are many good and apposite illustrations of lighting and power installations and domestic apparatus.

**Horsham**.—There is now connected to the Council's electricity mains the equivalent of about 10,000 8 c.p. lamps. The public gas lighting is being gradually replaced by electric lighting.

**Hull.**—The contract for the supply of electric power by the Corporation electricity department to Earle's Shipbuilding and Engineering Co. has been renewed for three years. The Electric Lighting committee report that negotiations are proceeding for supply of current to G. & T. Earle's Wilmington cement works and the American Radiator Co.'s projected works at Chanterlands-avenue.

**Jamaica.**—At Kingston the West India Electric Co. have recently reorganised the equipment of the supply station, which has been increased from an aggregate of 300 kw. to 100 kw. On the lighting mains there are 370 consumers, taking the equivalent of about 6,000 8 c.p. lamps.

**Japan.**—The Imperial Government own the telephone service in Japan, which has been in operation since December, 1890. There are altogether 48 telephone districts. The female operating staff numbers 1,605, and the male staff for telephones and telegraphs combined numbers 2,799. There were in all 35,605 subscribers at March 31 last, and 196,460 miles of overhead and underground telephone wires. The telegraph department of the State owns 83,308 miles of telegraph lines, of which 755 miles are underground or subaqueous.

At Tokyo, with a population of 1,500,000, there are now 15,181 consumers, with an equivalent of 170,714 8 c.p. lamps, exclusive of motors, connected to the mains of the Tokyo Electric Light Co. There will be put into work during the present month additional steam plant of 4,000 kw. capacity, and some time in 1907 a water-power plant of 15,000 kw. capacity.

**Kirkcaldy.**—Mr. S. Sellon, engineer for the Kirkcaldy-Leven tramways, has declined to comply with the District committee's request to lay concrete instead of Whinstone setts in roads where there is no causeway, and the question has been referred to the Board of Trade.

**Mitteilungen der Berliner Elektricitatswerke**.—The union of electricity works in Berlin, known collectively as the "Berliner Elektricitätswerke," and closely allied with the Allgemeine Elektricitäts Gesellschaft, started at the beginning of last year to popularise and promote the use of electricity in all its applications by issuing a chatty illustrated monthly. We have received the 12 issues of 1905, neatly bound, and find that it forms one of the most artistic and persuading publications of its kind we have ever seen.

Descriptions of electric machines and appliances, and of electricity works and installations of all kinds alternate pleasantly with biographical sketches of great electricians, with brief accounts of the visits of distinguished guests to the electricity works, with semi-scientific lectures on the hygienic and æsthetic advantages of electric power, light and heat, and so forth. Many of the numerous illustrations are beautifully coloured, and a map of the Berlin districts served by the company is included. In the November issue we notice the following interesting table, showing the distribution of the electric power supplied by the Berliner Elektricitätswerke on June 30, 1905 :—

| | No. of motors. | H.P. |
|---|---|---|
| Ventilators | 1,868 | 601 |
| Printing presses | 1,730 | 5,005 |
| Metal-working machinery | 1,775 | 7,551 |
| Lifts | 1,698 | 9,704 |
| Wood-working machinery | 1,241 | 4,751 |
| Butchers | 678 | 2,394 |
| Grinding and polishing machinery | 376 | 1,390 |
| Paper industry | 369 | 1,149 |
| Pumps | 252 | 906 |
| Sewing machines | 229 | 201 |
| Tailors and cutters | 194 | 140 |
| Washing and laundry | 230 | 672 |
| Spinning | 96 | 274 |
| Leather industries | 111 | 417 |
| Electro-plating | 75 | 239 |
| For driving dynamos | 76 | 809 |
| For grinding and roasting coffee | 78 | 153 |
| Hatters | 27 | 74 |
| Miscellaneous | 1,446 | 3,491 |
| | 12,549 | 39,921 |

Compared with the figures for 1904, the increase in motors was 1,937, and in capacity 6,132 H.P.

**Manchester.**—There are now 6,220 consumers connected to the Corporation mains, compared with 5,620 at the end of 1904.

**Leeds.**—By 30 votes to eight, the City Council on Wednesday rejected the following resolution :—

"Believing in the desirability of the municipality being in a position to supply coal direct to consumers, be it hereby resolved that when next application is made to Parliament by this Council, it shall include an application for powers to so extend the municipal service of the city as to include an effective sale of coal service department."

**Liverpool.**—At the Corporation meeting on Wednesday the chairman of the Tramways committee (Sir Chas. Petrie) alluded in feeling terms to the death of Mr. Bellamy, the late manager of the tramways.

Mr. Bellamy (said Sir Charles) was one of their best and most valued officials, and he could not help thinking that hard work had contributed to Mr. Bellamy's death. He was sure the Council would deeply mourn his loss, and express sympathy with the widow and family in their irreparable loss.

**New York Street Railways.**—It is stated that a scheme is in hand for the purchase of all the street railways in New York by one company at a total cost of about $200,000,000.

**Obituary.**—Messrs. Ransomes, Sims & Jefferies (Ltd.), of Orwell Works, Ipswich, have suffered the loss of an esteemed colleague by the death of Mr. John Dillwyn Sims, who died on the 30th ult., and was interred at Ipswich on Tuesday. A great concourse of mourners and friends followed the deceased gentleman's remains to their last resting place.

**Outward and Homeward Mails.**—A supplement was issued with the "London and China Telegraph" for Jan. 1, giving a complete list of the outward and homeward mails for the Far East for the year 1906. This sheet (which contains other information) should prove very useful in business houses.

**Personal.**—Mr. W. E. Halton, chief superintendent of telegraphs and telephones at Manchester, retired on New Year's Eve. Mr. Halton joined the Electric & International Telegraph Co. at Penrith in February, 1860, and passed into the Government service when the telegraphs were taken over.

**Peru.**—The Empresa Electrica de Sta. Rosa, whose station is at Lima, has the equivalent of over 50,000 8 c.p. lamps connected to their lighting mains, including 2,000 H.P. in motors. The station has a capacity of 5,000 kw. and serves a population of about 175,000. The horse car tramway service at Lima is being converted to electric traction by the Ferro-Carril Electrico Lima y Colao, which purchases power from the Empresa Co., and 16 motor cars are already in service. The Empresa Co. has already 4,000 H.P. water-power developed out of an estimated 10,000 H.P. owned by the company in the Chosica district. The remaining 6,000 H.P. is now being developed and will soon be in operation. Mr. A. L. Kenyon is chief engineer to all these undertakings.

**Pontypridd.**—It has been decided to supply electric current to places of worship at 4½d. per unit. A motion to make the charge 3d. per unit was rejected by the Council.

**Presentations.**—Mr. W. R. Watson, chief draughtsman, and Mr. E. J. Allisstone, of the accountant's department at the B T.-H. works Rugby, were recently (on the occasion of their leaving the works) recipients of presents from their comrades. The former was presented with a microscope in case and an address on silk and the latter with a marble clock.

The staff and employes of Kidderminster & District Electric Lighting & Traction Co. have presented the retiring managing engineer (Mr. G. Charlton), who is proceeding to Merthyr, with a smoker's cabinet and acessories. Mr. Charlton is succeeded by Mr. Arthur Charlton, late of Leicester electricity works.

**Royal Warrants.**—The "London Gazette" announces that the following hold warrants of appointment :—

City & Suburban Electric Carriage Co., London, electric carriages; Edison & Swan Co., London, electric lamps; Electrical Power Storage Co., London, secondary cells ; T. J. Gawthorp, London, art metal work ; R. C. Murray, London, scientific apparatus.

**Siam.**—Bangkok is the centre of the Siamese Government telephone system. There are five exchanges on this service, and the number of subscribers has reached 320. Mr. H. W. Wilder is chief engineer to the Government telephone service.

**South Africa.**—Aliwal North Municipal Council commenced electricity supply in August last, and under the advice and supervision of Messrs Burstall & Monkhouse, the consulting engineers, and Mr. D. Gerrard (of Johannesburg) have installed a water-power plant aggregating 90 kw., the station equipment including a battery of Hart accumulators of 250 ampere hours capacity. The plant is driven by two 45 in. Achilles low-fall turbines, operated by the Orange River, the head of water being obtained by constructing a concrete weir across the river on a natural foundation. During the day the turbines work the power plant for the town water supply. For the distribution system Helsby paper insulated and lead-covered cables laid direct in ground are employed. Mr. A. H. Pashby, who is resident engineer for the Council's undertaking, has already 107 consumers on the books and total connections equivalent to 4,300 8 c.p. lamps.

At *Claremont*, where Mr. C. M. Read has succeeded Mr. J. Murray, plant is installed aggregating 450 kw., plus a battery of Accumulatoren Fabrik (Berlin) cells of 486 ampere hours capacity. The plant at this station has recently been increased.

**Street Lighting Experiments.**—The business manager of Ealing Electricity Supply department (Mr. Lewis) has reported upon the result of tests which have been carried out with "Osmi" and "Tantalum" lamps for street lighting:—

The "Tantalum" lamps (says the report) gave an excellent light, but the lamps tested had too short a life to allow them to be used for street lighting. Extended tests would, however, be made with the lamp, and a further report prepared. Current for two 25 c.p. "Osmi" lamps could be supplied for £3 per annum, renewals 24s., total £4. 4s. The cost of supply to two 16 c.p. lamps was £5. 8s. 8d., and renewals 5s. 4d., total £5. 14s., so that a saving of £1. 10s. per post per annum would be effected by adopting "Osmi" lamps, with an increase of 18 c.p. in light. The cost of shadowless lanterns, as fitted experimentally in one thoroughfare, was 38s. The Electric Lighting committee viewed the "Osmi" trial lamps and recommended the Council to purchase lanterns of that type for "Osmi" lamps to replace the 17 standards now fitted with two 16 c.p. lamps each, and this recommendation was adopted.

**Turbine Extensions.**—Glasgow Corporation have decided to instal three further turbo-generators of 3,000 kw. each, and the complete contract, including turbines, alternators (two of which are of Dick, Kerr & Co.'s make and the third of the Westinghouse Co.'s make) and condensing plant, has been placed with Messrs. Willans & Robinson, Rugby, who will themselves manufacture the turbines and condensers. Two of these turbine sets are intended for installing in the St. Andrews Cross station and the third at Port Dundas station.

**Wednesbury.**—The electric lighting cables are to be extended to the West Bromwich boundary. It was decided on Monday to borrow £17,500 for the purchase of the tramway undertaking within the borough from the South Staffordshire Tramways Co. Of the whole amount required (£29,000), £17,500 was for track, the balance for the depot at King's Hill, which is to be purchased and sold to the lessee company within 60 days.

**West Australia.**—A 500 ampere-hour D.P. battery and Crompton hand-reversible booster, with switchboard and accessories, have recently been shipped to Bunbury, W. Australia, to the order of Mr. Frank Broadbent, consulting engineer, acting on behalf of Splatt, Wall & Co., Perth, W. Australia. The booster, which was designed for 100 amperes, charging current at 60 volts and 200 amperes, discharging at 30 volts, was put through a severe test before despatch, the motor withstanding temporarily double it rated load.

**Willesden.**—The Council have received sanction to a loan of £20,000 for electricity supply, including £13,678 for mains, £1,382 services; £3,500 plant and lamps; £1,440 meters and indicators.

The Electricity committee reported at the last Council meeting that with respect to the 50 additional arc lamps to be erected, they were advised by the resident engineer (Mr. J. G. Bruce) that by using "flame" type 66 lamps would use only the same amount of energy as would be required for 50 of the existing type, and the committee therefore proposed adopting the flame lamp. The report and recommendations were adopted.

**Worcester.**—On Tuesday the City Council decided to apply for sanction for a loan of £950 for laying electric lighting mains to the Bromwich sewage works.

**Workhouse Lighting.**—South Stonehouse (Devon) guardians having been advised that a 300-light electrical installation can be maintained at £249. 6s. 9d. per annum (the initial cost being put at £1,450) compared with the present annual cost of gas, £225, the matter is to be considered shortly.

**Yarmouth.**—The Council will open showrooms for the display of electric fittings, heating and cooking appliances, &c

**York.**—At the Council meeting on Monday the chairman of the Electricity committee (Councillor Lambert), replying to questions as to the extent of the damage caused by the recent breakdown at the electricity works, said the city electrical engineer (Mr. C. A. Midgley) would return in about a fortnight from his month's leave of absence. It would be unwise at present to enter into the matter. An expert had examined the machinery on behalf of the contractors, and until his report could be placed before the committee it would be unwise to discuss the question. They had asked the Board of Trade for an inquiry into the whole matter, and at present, therefore, they were unable to discuss it. The Lord Mayor said Mr. Midgley came back when the accident took place, and it was on the advice of the Chairman of the committee and the Engineer that the Board of Trade had been communicated with.

# TRADE NOTES AND NOTICES.

## TENDERS INVITED.

Messrs. Preece & Cardew are instructed by *Shanghai* Municipal Council to invite tenders for single-phase alternating-current energy meters. Specifications, &c., from Messrs. Preece & Cardew, 8, Queen Anne's-gate, Westminster, S.W., to whom tenders are to be delivered by noon, Jan. 12. See also an advertisement.

The Guardians of *Croydon* Union invite tenders for the installation of electric fire alarms at the Infirmary, Thornton Heath. Tenders to Mr. Harry List, Union Offices, Mayday-road, Thornton Heath, by 4 p.m. Jan. 8.

*St. Pancras* (London) Council invite tenders for arc lamp columns and cradles and open type arc lamps. Tenders to Mr. C. H. F. Barrett, Town Hall, Pancras road, N.W., by noon Jan. 9.

*London* County Council want tenders by 10 a.m. 23rd inst. for roadwork and platelaying in connection with the construction of electric tramways in South London.

The Electric Lighting committee of *Leyton* District Council invite tenders for (1) 500 kw. dynamos and (2) overhead crane. Tenders will be opened on Jan. 18.

*Plymouth* Corporation invite tenders for 12 months' supply of lubricating oils, &c., engine waste, wipers, &c. Tenders to the borough electrical engineer by 24th inst.

*Hackney* (London) Council invite tenders for 12 months' supply of arc-lamp carbons and coal. Tenders by noon Jan. 25.

*Aberdeen* Tramways committee invite tenders for supply and delivery of six tramcar top deck covers. Tenders by midday Jan. 6.

*Camberwell* (London) Council want tenders by 5:30 p.m. 29th inst. for 12 months' supply of electric lamps, maintenance of private telephones and electric bells, &c.

*Pontypridd* Council want tenders by 15th inst. for eight 30 ft. double-deck tramcars.

Tenders are being invited by the Companhia Camis de Ferro Porto Alegrense for the erection and equipment of an electric power station for the tramways at *Porto Alegre* (Brazil) by March 1.

## TENDERS RECEIVED AND ACCEPTED.

The Lancashire Dynamo & Motor Co., Trafford Park, Manchester, have recently obtained the following contracts:—

One 350 kw. generator for direct coupling to Howden engine for Llandrindod Wells Electric Light & Power Co.; one automatic reversible motor-driven booster (Turnbull & McLeod Patent) and switchboard for Southport Corporation; one automatic reversible booster (three-wire for traction and lighting) for Pontypridd Council (per Tudor Accumulator Co.).

Heckmondwike Council have accepted the tender of the Paterson Engineering Co. for water-purifying apparatus. Tenders were also submitted by Howard Wright & Co., Arthur Koppel (Ltd.), Bell Bros., Lassen & Hjort, the Kennicott Water Softening Co. and the Haste Pump Co.

Wimbledon have accepted the following tenders:—

Johnson & Phillips, telephone cables and pilot wires, £586. 6s.; Herbert Morris & Bastert, 2-ton overhead crane, £42. 12s.; Brush Co., electrically-driven plant for Raynes Park pumping station, £407.

Leeds Corporation have accepted the tender of Babcock & Wilcox for two boilers at £2,300, and that of E. Green & Son for an economiser at £1,016. 10s.

Messrs. Babcock & Wilcox have received an order from Kosmoid Limited for 28 boilers for their works at Dumbarton, and for three boilers from David Colville & Sons.

The tender of the General Electric Co., at £1,315, has been accepted by Bridlington Corporation for extensions of plant at the electricity works.

Horsham Council have accepted the tender of the Horsham Engineering Works for wiring the depot buildings.

## BUSINESS NOTICES.

Mr. C. S. Vesey Brown is, we are informed, retiring from the position of engineer and general manager of the Northern Counties Electricity Supply Co. as from Jan. 1, and is starting in practice as a consulting electrical engineer at Millburn House, Newcastle-on-Tyne. Mr. Vesey Brown was with the London Electric Supply Corpn., both at the old Grosvenor Gallery station and at Deptford, and erected the first municipal electricity works on the alternating-current system in the North at Sunderland, subsequently going to Lincoln and afterwards to Stockton. In 1900, along with Mr. Fairweather, he started the scheme of the Northern Counties Co., and has, we understand, had in his charge practically all the engineering works which the company have erected. Mr. Vesey Brown will devote himself particularly to bulk supply undertakings, in view of this special experience.

Mr. Marshall H. Bennett, A.M.I.M.E., A.M.I.E.E., has resigned his position with the British Thomson-Houston Co., and will enter into partnership with Thomas L. Scott & Co., contracting engineers, 3, London Wall-buildings, London, E.C. It will be remembered that Mr. T. Laidlaw Scott was until recently engineering director of Macartney, McElroy & Co. (Ltd.).

Messrs. A. J. Boult, H. Wade, W. J. Tennant, and B. E. Dunbar Kilburn, chartered patent agents, 111 and 112, Hatton-garden, E.C., have dissolved partnership. The three first-named will continue to practice in partnership at the same address under the style of Boult, Wade and Tennant. Mr. Kilburn will practice in his own name at Chancery lane Station Chambers, High Holborn, London, W.C.

Messrs. Pritchetts & Gold have taken offices at 20, Victoria-street, London, S.W. (Telegrams "Acidulated London," Telephone 762 Victoria), and on and after Jan. 8 all communications respecting prices and quotations and all orders should be addressed to London, while correspondence regarding the dispatch of goods and execution of orders should be addressed to Feltham as usual.

## BANKRUPTCIES, LIQUIDATIONS, &c.

Creditors of the Perfecta Seamless Steel Tube Co. (Ltd.) (in voluntary liquidation) must send particulars of claims to Mr. R. A. Felton, 131, Edmund street, Birmingham, by Feb. 10.

Claims against Edmondson & Purdom (Ltd.) to Mr. W. M. Gray, District Bank-chambers, Booth-street, Bradford, by Jan. 31.

The trustee in the failure of Chas. Aubrey Smith, electrician, 23, King-street, Regent-street, London, W., has been released.

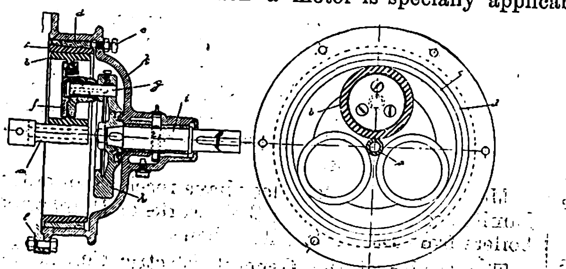
A meeting will be held on Feb. 8 at 61½, Fore-street, London, E.C., to receive an account of the winding up of the Electro-Sulphur & Light Synd. (Ltd.).

**Deed of Assignment.**—A deed of assignment has been executed by Walter Webb Gillard and Chas. Wm. Gatrell (lately trading as Gillard & Co., electrical engineers, 4, Terrell's-place, Islington, London, N.). Claims by Jan. 12 to Mr. Eric Cronk, 43, Lombard-street, London, E.C.

Claims against the St. Helen's Cable Co. (Ltd.), in voluntary liquidation for the purpose of reconstruction, are to be sent to Mr. Arthur Wenham, 10, Walbrook, London, E.C., by Feb. 13.

**Sale by Tender.**—Leeds Electricity committee invite tenders for purchase of electric generating plant (about to be replaced by plant of larger capacity), comprising two 500 I.H.P. vertical compound six-cylinder three-crank Belliss engines and two 300 kw. single-phase Ferranti alternating-current dynamos, with exciters. Further particulars are given in an advertisement. Specifications, &c., from the manager of the electric lighting department (Mr. H. Dickinson), 1, Whitehall-road, Leeds. Tenders to the town clerk (Mr. R. E. Fox) by Jan. 31.

**Centrator Motors.**—The Lahmeyer Electrical Co., 109-111, New Oxford-street, London, W.C., has issued a price list of new "Centrator" motors, shown in section in the accompanying illustration. The special feature of this motor is the reduction of speed which is obtained by means of rolling friction only. There are many instances where such a motor is specially applicable, especially with textile machines, printing presses and other machinery of a like nature where space is a consideration. The absence of gearing also increases the factor of safety in the factory, and the cost of the Centrator motor is less than for motors fitted with back gear or spur gearing. Probably the most unique feature is that the slow-speed shaft runs in line with, although not directly connected to, the high-speed motor shaft. The Centrator motor can be installed on three-phase or continuous-current circuits with equal facility.



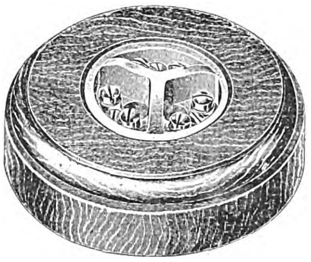
SECTION OF CENTRATOR MOTOR.

The fast-running main shaft of the motor is fitted at its extremity with a bearing bush, *a*. Around this a regrouped three or four rings, *b* (according to size of motor and ratio of gear). The pressure on the surface of the rings that is necessary for the transmission of power at the circumference is obtained by means of the clamping ring *c*, which is slit open at an angle, and by means of the cast-iron pressing ring *d*. The contact surface of these rings is conical. Therefore, by means of the tightening screws *e* equally distributed around the circumference, the pressure of the clamping ring *c* on the bearing rings *b* may be regulated. The guide rings *f* prevent slipping of the system in one or the other direction. It is now evident from the drawing how rotation at a reduced speed is transmitted by means of the bolts *g* and the disc *h*. The whole system is carried and enclosed by the case *k*, making it a compact dust and waterproof bearing. Lubrication is effected by means of centrifugal force, the oil being taken from the main bearing.

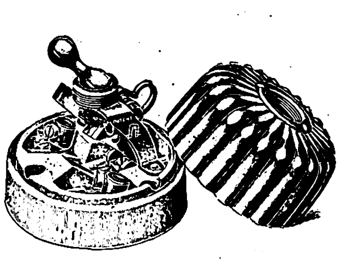
An illustration of an example of direct driving of textile machinery by a Centrator motor is given in the list.

**Catalogues, &c.**—A new catalogue has been issued by the General Electric Co., of 71, Queen Victoria-street, London, E.C., containing full technical particulars of this firm's single, two and three-phase "Witton" alternators for all the usual voltages and frequencies. Useful information is also given concerning the requisite exciters. The stator of the alternator consists of a laminated charcoal iron ring, built up of segments, and compressed tightly in a heavy cast-iron frame. Ample space for the circulation of air is provided between the frame and the punchings, as well as through the core itself. The width of these air spaces is kept the same in all machines—*i.e.*, ½ in., and the distance between two ventilating ducts in the core is 2 in. to 3 in. according to the size of the machine. After passing through the core, the air can escape directly from large circular holes in the cast-iron frame, thus ensuring perfectly cool running. Open stator slots are adopted in order to make it possible to replace any defective coil without difficulty. The top of the slot is closed by means of a wooden wedge. The coils are all wound on formers and carefully insulated before being dropped into the slots. Spare coils can, therefore, be supplied whenever needed, and repairs do not require specially skilled men. All windings and micanite insulating tubes are tested with more than twice the working pressure. The spools carrying the field winding are of metal and fitted with heavy gun metal end plates. Care is taken to keep the winding of the poles as free as possible from vibration or shaking. The alternators are fitted with one or two bearings as required of ample size, of the pedestal pattern with split bushes. The bearings are fitted for automatic continuous lubrication, and the pedestal of the bearing is shaped to form an oil reservoir. Each bearing is fitted with suitable oil gauges and glasses. The terminals for the high-tension mains are placed at the side, on the foot of the machine, being protected with a strong cast-iron cover. Any other position preferred can, we are informed, be arranged without difficulty

In the December "Progress Sheet" of the General Electric Co. will be found several items of particular interest, in the form of new designs of switches, fitting blocks, shade fixtures, &c. Our illustration, Fig. A, shows a two-circuit "New Era" fitting block for use for brackets and electroliers. The arrangement overcomes the old objection to "hand-made joints." Six fittings can be attached to the "New Era" in the same time that would be taken to fix one fitting to the ordinary block with hand-made joint, and the use of these blocks enables fittings to be removed without cutting wire or in any way damaging decorations. Fig B is a new pattern of the well-known "Quadrant" branch switch, 20 amp. type, and is supplied in either single or double pole styles. Fig. C is a new type of shade-fixer called the "Suregrip."

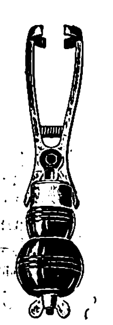


A.—"NEW ERA" FITTING BLOCK, for Pendants and Electroliers.



B.—NEW PATTERN "QUADRANT" BRANCH SWITCH.

The elevator department of Gibbons Bros., Dibdale Works, Dudley, has issued a useful new list of band conveyors, guide rollers and accessories, in which the prices for these goods have all been carefully revised, and new illustrations, showing some good views of the company's conveyors, have been added. The illustrations include some excellent views of this system of transport in actual use for a large variety of industrial purposes.



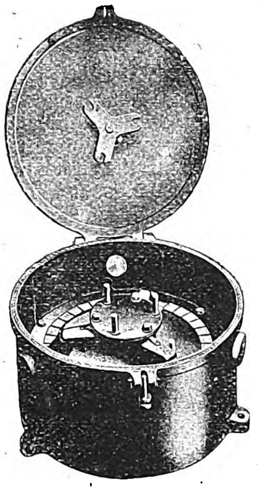
C.—"SUREGRIP" SHADE FIXER.

A new list (No. 55) of triple-pole, double-throw quick-break knife switches, for 25 to 1,000 amperes, is issued by Ferranti Limited, Hollinwood, Lancs.

The British Thomson-Houston Co. have issued pamphlets 189 and 190, dealing with the B.T.-H. Meridian lamp and the Mercury arc rectifier respectively. There are some good illustrations of "Meridian" lamp fittings by Messrs. Best & Lloyd in the first-named pamphlet, and of the Mercury arc rectifier in the second.

Thos. Piggott & Co., Birmingham, are issuing a circular relating to their welded pipes for steam, water, &c.

A representative catalogue of lubricating oils and greases for all kinds of engineering work, including steam turbine and dynamo oils, is being sent out by W. H. Willcox & Co., 23, Southwark-street, London, S.E., who are specialists in this and all other kinds of engineers' stores and general supplies.


"Emsea" Full Load Motor Starter. (Enclosed Pattern.)

A new list of "Emsea" specialities supplied by Monté-Callow & Co., Ludgate-broadway, London, is now ready, and copies can be obtained on application. Our illustration shows a three-phase full-load motor starter of the completely enclosed pattern.

Cryselco (Ltd.), Kempton, Bedford, have ready a new price list of the special makes of incandescent lamps sent out by the company. Some effective illustrations of these lamps are given.

Mr. J. Richardson Craig, jun., 145, Bath-street, Glasgow, forwards a pamphlet relating to a special class of ozone generators which he is supplying. These have received high approval from a number of users, and have been favourably reported upon by public health officers. In addition to Craig ozone generators, the list contains particulars of switchgear, cutouts and other electrical appliances. Copies of the pamphlet can be obtained on request.

The development of the motor bicycle is indicated by the class of literature sent out by the manufacturers of these machines. A very well got up catalogue of "Roc" motors, manufactured by A. W. Wall (Ltd.), Guildford, is to hand.

**Calendars, Diaries, &c.**—One of the latest advertising devices in aluminium is sent out by Stegmann & Co., of Clapham Junction, London, S.W., in the form of a neatly-framed and glazed calendar for 1906, the frame being of art design in aluminium. Messrs. Stegmann's calendar will readily find a prominent place wherever it is received.

A very effective desk and table calendar has been issued by the Electric Construction Co., of Dashwood House, New Broad-street, London, E.C., and Wolverhampton. This design of calendar makes an excellent advertisement without being aggressive.

The New Year reminder of the Hart Accumulator Co., Marshgate-lane, London, E., taking the form of a useful blotting pad, is always welcome, and serves to keep the company's name and class of manufactures before users.

Fearfully and wonderfully made, but all the same very compact and useful, is an appointment pad issued by the publication department of the General Electric Co., Queen Victoria-street, London, E.C. Like so much that the General Electric Co. sends out, it bears evidence of careful thought and a grasp of the needs of the busy professional man.

From the County of Durham Electrical Power Distribution Co. we have to acknowledge the receipt of a neat midget pocket diary for 1906, with a number of engineering tables arranged by Mr. W. Geipel. In this case, again, an accident insurance coupon for £1,000 is included. This company have also issued, with a £1,000 coupon, a desk blotting pad and diary. The diary is interleaved printed blotting effectively setting out the advantages of electricity supply.

A hanging sheet date remembrancer for 1906 is issued by W. H. Willcox & Co., of 23, Southwark-street, London, S.E. A large portion of the space on the 12 sheets of which the remembrancer consists comprises neat illustrations of a large variety of engineers' stores, pumps, packings, lubricants and lubricators, tools, &c., for which Messrs. Willcox have an ever-increasing demand.

Mr. R. Morgan, 65, Westow-street, Norwood, London, S.E., has sent us a copy of the "B.A.W." card calendar, which shows the day of the week of every day of the month for 25 years, new and full moons, &c. This will be found a useful calendar in business houses. It can be readily put into a slip frame for hanging. The price is 1½d. post free, on rollers 6d.

A handsome hanging calendar comes from the Brush Company. A prominent feature is a view of the company's fine works at Loughborough. There are also illustrated an example of the All-Steel Brush car being manufactured at Loughborough for the Great Northern, Piccadilly & Brompton tube railway, an ordinary steam railway main-line coach, &c. The tear-off pad bears a set of proverbs which the user of the calendar may commit to memory with considerable advantage to himself.

We have received from Messrs. Eason & Son, the well-known printers, publishers and wholesale stationers, of Dublin and Belfast, a set of useful diaries, the cheapest and best value we have yet found. These range from the foolscap size called the "Cabinet Scribbling Diary," published at 2s., and the "Every Hour" diary, published at 1s. 6d., to the 3d. "Swift" diary for the waistcoat pocket. Even this is outdone in the neat little 1d. diary, which contains all the indexed matter that many people will require. The "Every Hour" diary is a particularly useful one, and, fitted with a capacious pocket at one end and a blotting pad at the other, is a marvel of cheapness. This form of diary is supplied with additional features and bound up in handsome covers for presentation purposes, for which it is admirably adapted.

We have again to welcome the useful pocket diary with indexed foredge sent out by the Simplex Steel Conduit Co. This price list and diary is accompanied by an accident insurance policy for £1,000, and is an additionally valuable pocket companion for this reason.

Messrs. Dorman & Smith combine the useful with the ornamental in presenting their clients with a pocket calendar which serves to illustrate and describe a large number of their special class of manufactures in switches, wall connectors, fuses, distribution boxes, &c., besides giving a mass of information which the electrical engineer and contractor will find of service.

The Birmingham Engineering Co., Hooper-street, Spring Hill, who have recently increased their facilities for production, have issued a showy calendar for 1906.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Dec. 23 to Dec. 30, with the ports of destination:—

*Africa.*—Alexandria, £100; Delagoa Bay, £190 (telegraph material); Durban, £1,066 (including £193 telegraph material); East London, £120 (including £12 telegraph material); Mossel Bay, £17; Port Elizabeth, £500. *Argentina*—Buenos Ayres, £124 (telegraph material). *Australasia*—Adelaide, £18; Brisbane, £251; Christchurch, £31; Fremantle, £32; Lyttelton, £40; Melbourne, £1,301 (including £1,266 telegraph material); Sydney, £1,280 (including £51 telegraph material); Wellington, £191. *Belgium*—Brussels, £100; Ghent, £62. *Brazil*—Rio Janeiro, £656 (telegraph material); Bahia, £6,256 (submarine cable). *Ceylon*—Colombo, £153. *Channel Islands*, £87. *Chili*—Iquique, £44; Valparaiso, £836 (including £699 telegraph material). *China*—Shanghai, £128. *France*—Marseilles, £25; Boulogne, £87. *Germany*—Hamburg, £100. *Gibraltar*, £59. *Holland*—Amsterdam, £312 (including £187 telegraph material); Flushing, £135; Rotterdam, £1,000. *Hong Kong*, £316. *India*—Bombay, £3,492 (including £21 telegraph material); Calcutta, £2,233 (including £42 telegraph material); Karachi, £55. *Japan*—Hiogo, £245; Kobe, £396; Nagasiki, £29; Tokio, £4,300; Yokohama, £2,456 (telephone cable). *Malta*, £18. *Mauritius*, £398. *Portugal*—Lisbon, £59. *Russia*—Kurch, £4,503; St. Petersburg, £23 (telegraph material). *Spain*—Bilbao, £349 (telegraph material). *Straits Settlements*—Singapore, £59. *Turkey*—Constantinople, £89 (telegraph material). *U.S.A.*—New York, £9,085 (telegraph cable). *West Indies*—Dominica, £12. Total (for eight days) £43,451, against £21,873 for 11 days last year (Dec. 24 to Jan. 3).

# PATENT RECORD.

## APPLICATIONS FOR PATENTS.

Note.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specification. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

November 29, 1905.

24,718 Lori. Wireless telegraphy. (Date applied for Nov. 30, 1904.)*†
24,721 Rogers. Insulators.
24,724 Clark. (Darmstadter, Germany.) Electrolytic manufacture of metal tubes.
24,729 Atkinson. Electric controllers.
24,747 Dinin & Espagnent. Electric automobiles. (Date applied for Dec. 9, 1904.)*†

November 30, 1905.

24,761 Electric & Ordnance Accessories Co., Hall, & Booker. Enclosed type switches.
24,777 Neill. Electric clocks.
24,785 Mitkevitch. Production of the electric arc.*
24,794 Wilson. Brush holders.
24,809 Parravano. Syntonic system of radio telegraphy.*
24,810 Raworth & Raworth. Electrical control and propulsion of vehicles.
24,811 Rushton. Fixing electric bell to alarm clock.
24,835 Piggott. Electric bell pushes.
24,850 Cockburn. Switches or controllers for electric motors for ship's steering gear, hoists, &c.
24,853 B.T.-H. Co. (G.E. Co., U.S.) Switches.
24,854 Warwick Machinery Co. (G.E. Co., U.S.) Packings for rotating shafts.
24,855 B.T.-H. Co. (G.E. Co., U.S.) Electric resistances.

24,856 B.T.-H. Co. (G.E. Co., U.S.) Vapour electric apparatus.
24,858 Hawthorn. Electric fire alarm systems and apparatus.
24,867 Justice. (Industrial Development Co., U.S.) Ignition device internal combustion apparatus.
24,877 Hills, Urquhart & Honey. Dynamo electric machines.
24,882 Hegner. Arc lamps burning mineralised carbons.

### December 1, 1905.

6,790a Potthoff. Electro-plating. (Date applied for, March 30, 1905.)*†
24,902 Doulton & Morris. Insulating supports for conductor-rails of electric railways.
24,904 Chappel. Tram-line point controller.
24,931 Venner & Griesbach. Electrical time-switches.
24,943 De Malval. Telephonic and other electrical apparatus.
24,962 Mitchell & Dolter Electric Traction. Electric traction systems.
24,972 Warwick Machinery Co. (G.E. Co., U.S.) Turbines.

### December 2, 1905.

24,995 Carr. Control of any bank of electric lamps.
24,996 Codd. Electric arc lamps.
24,998 Hindley. Trolley boom apparatus.
25,007 Walls. Trolley poles.
25,023 Jacoby. Electric lifts.
25,032 Hawkes. Electric stoves.
25,047 Sir O. J. Lodge, Muirhead & Robinson. Vapour electric apparatus.*
25,058 Land-und Seekabelwerke Akt.-Ges. Insulation of electric cables. (Date applied for, Dec. 2, 1904.)*†

### December 4, 1905.

25,080 Atkinson. Sparking plugs for internal-combustion engines.
25,084 Kenworthy. Sand gear for electric tramcars.
25,085 Fielding. Safety electric car step.
25,114 Scrimshaw. Electric lock.
25,131 Mills. (Vitous & Hammond, U.S.) Switchboards.*
25,147 Lahmeyer & Co. Regulation of alternating-current motors. (Date applied for, Dec. 2, 1904.)*†
25,152 Fell. (Blanchard, U.S.) Street railway switches.*
25,153 Soc. Industrielle des Telephones, Constructions Electriques, Caoutchouc Cables. Protecting electric apparatus against currents of excessive strength or voltage. (Date applied for, Dec. 13, 1904.)*†
25,169 Kriéger. Controlling switch of electric vehicles. (Date applied for, March 9, 1905.)*†
25,170 Kriéger. Self-propelled vehicles. (Date applied for, Dec. 10, 1904.)*†
25,171 Kriéger. Control of electric motor. (Date applied for, 24/5/05.)*†
25,172 Kriéger. Electric vehicles. (Date applied for, May 24, 1905.)*†
25,173 Kriéger. Electric vehicles. (Date applied for, May 30, 1905.)*†
25,174 Soc. Anon. Electrometallurgique (Procédés Paul Girod). Electric furnaces. (Date applied for, Jan. 4, 1905.)*†

### December 5, 1905.

25,193 Crosta & Bidder. Tramway points.
25,224 Everett & Edgcumbe. Cases for electrical measuring instruments.
25,236 Allgemeine Elektricitäts-Ges. Nernst lamps. (Date applied for, Dec. 5, 1904.)*†
25,241 Cloud. Brakes for railway and other vehicles.
25,257 Janecek. Arc lamps.*
25,271 Arathoon. Operating the points and switches of tramways.
25,283 Dolter & Mertens. Electromagnetic band brakes for vehicles. (Date applied for, Dec. 5, 1904.)*†
25,287 Petersson. Apparatus for striking electric arcs between electrodes.*
25,288 Street. Electric signalling apparatus.*
25,295 Chinnery. Coin-actuated electrical advertising device.

### December 6, 1905.

25,347 Brooking & Claremont. Cut-outs.*
25,353 Taylor. Generating electricity on motor cars or motor boats.
25,356 Trilke. Electrical winding device for combined clock and wheel trains.*
25,361 Day & Wiesengrund. Electrically-driven hydraulic pumps.
25,365 Forwood. Trolleys for electrically-driven vehicles.
25,383 Schneider. Operating submarine and land mines by electric waves. (Date applied for, Jan. 23, 1905.)*†
25,393 Lahmeyer & Co. Limiting speed of series alternating-current motors. (Date applied for, Dec. 27, 1904.)*†
25,405 B.T.-H. Co. (G.E. Co., U.S.) Systems of electrical distribution.

### December 7, 1905.

25,412 Bowie & Phelps. Vacuum tube for producing X and other rays.
25,415 Henshaw & Swindells. Controlling the trolley poles of electric cars.
25,464 Mantle. Mouthpieces for telephones.
25,471 Gibbons. Switches.
25,490 Sir O. J. Lodge & Muirhead. Wireless telegraphy.
25,502 Dresdner Gasmotorenfab. vorm. Moritz Hille. Magneto-electric ignition of internal-combustion engines. (Date applied for, May 22, 1905.)*†
25,512 and 25,513 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control systems.

### December 8, 1905.

25,521 Hansard & Watson. Electric switches.
25,522 Williams. Connecting split or inspection fittings used in the erection of tubing for electric or other work.
25,525 Rathborne & Fielding. Electrical automatic signalling apparatus for tramways.
25,550 Large. Electromagnetic power hammer, drop stamp, or press.*
25,561 Von Ammon. Methods of cooling and ventilating electric machines.
25,570 Andrews. Circuit-breakers for alternating-current circuits.
25,581 Harrison. Electric lighting apparatus.
25,600 Munro. Ignition devices for explosion engines. (Date applied for, Dec. 8, 1904.)*†
25,612 Fairweather. (Müller, Germany.) Röntgen ray apparatus.*
25,614 Callender's Cable & Construction Co. & Ward. Fuse and switch mechanism.

### December 9, 1905.

25,615 Davis. Arc lamps.
25,636 Sims. Preventing broken "live" wires from falling.*
25,641 Andrews. Electrical distributing systems.
25,669 Knight & Nagel. Conduits or casings for electric conductors.
25,670 N. S. Electric Storage Co. & Niblett. Storage batteries.
25,676 McCollum & Forster. Electric controlling devices for cars.

### December 11, 1905.

14,889a Coridori. Insulating electric wires. (Dated applied for, 19/7/'05)*†
25,684 Strode & Richens. Electrical conduit fittings.
25,687 Harradine, Biddle & Crosta. Conduits for electric conductors.
25,702 Holmes. Electrical resistances.*
25,713 Pexton. Machine for cleaning grooves in tramway rails.
25,729 Thomson & Pinkerton. Automatic earthing device and cutout for the overhead conductors of electric railways.
25,748 Simpkin & Ballantine. Magnetic separator.
25,749 von Recklinghausen. Automatic starters for vapour apparatus. (Date applied for, Dec. 13, 1904).*†
25,754 Boult. (Lori & Marquis Luigi Solari, Italy.) Wave telegraphy.
25,759 De Kando. Protective devices for stators.*
25,768 Coridori. Insulating electric wires or cables.
25,771 Frick. Transformer furnaces.

### December 12, 1905.

25,802 Murphy. An improved electrical terminal attachment device.
25,811 Aldworth, Crosta & Boot. Improvements applicable to trolley standards for electric cars.
25,826 Peticky, Cizek & Suchanek. Automatically connecting up telephone subscribers.*
25,840 Blaschke. Means for conducting electric currents.
25,855 Betts & Improved Electric Supplies Co. Radiators.
25,858 Lake. (American Steel & Wire Co., U.S.) Rail bonds.*
25,866 Raymond-Barker. Telegraphy.*
25,880 Lester & Rochdale Electric Co. Electricity meters for alternating currents.

### December 13, 1905.

1,482a Noble. Contact makers or distributors. (Date applied for, Jan. 25, 1905.)
25,893 Skwirsky. Mercury or other vapour electric lamps.
25,944 Tollerton. Electric arc lamps.
25,952 Rabbidge. Dynamo-electric generator.*
25,971 Jones & Jones. (Patterson & Co.) Miners' electric safety lamps.

### December, 14, 1905.

26,032 Sturmey. (Duryea, U.S.) Electric ignition systems for internal combustion engines.*
26,046 Hubert. Electric clocks.*
26,052 Baron. Storing and paying out lengths of conductors connected to electric apparatus.*
26,065 Tourtel. Coin-freed electricity meters.
26,072 Siemens & Halske A.G. Telegraphs for transmitting orders. (Date applied for, Dec. 14, 1904.)*†
26,081 Bryant & Forster. Tremblers for induction coils.
26,086 Körting. Arc lamps.*
26,089, 26,090, 26,092 and 26,093 B.T.-H. Co. (G.E. Co., U.S.) Alternating-current dynamo-electric machines.
26,094 Allgemeine Elektricitäts Ges. Alternating-current dynamo-electric machines. (Date applied for, Dec. 15, 1904.)*†

### December 15, 1905.

26,097 Spark. Centralised control of switches connected to alternating-current distributing networks.
26,109 Thomas & Phillips. Conductors for miners' electric safety lamps.
26,122 Fowler. Incandescent and other electric lamps.
26,144 Richards. Fuses for electrical circuits.*
26,149 Palmer. System of electrical distribution. (Date applied for, Dec. 22, 1904.)*†
26,162 Fairbrother. (Thomas, U.S.A.) Couplings for electrical wires.
26,182 Klitz. Intercommunication by telephones or other electric signalling apparatus over lines used as feeder cables, pilot wires, &c.
26,187 Stone & Co. & Darker. Electric lighting of railway carriages.

## SPECIFICATIONS PUBLISHED.

### 1904 Specifications.

26,680 Siemens Bros. & Co. & Grimston. Telegraphs.
26,748 Marconi's Wireless Telegraph Co. & Priddle. Controlling telegraphic recorders.
27,168 Tilney. Automatically regulating the voltage in electric light and power circuits with varying loads.
27,400 B.T.-H. Co. (G.E. Co., U.S.) Systems of electric motor control.
27,437 Zingel, Wolf & Reiner. Arc lamps.
27,844 Jacoby. Controlling electric lifts, elevators or similar contrivance.
27,859 Electricitäts-Akt.-Ges. Westfalia & Kupferschlag. Automatic cell switches.
28,468 Gati. Electric distribution and conductors therefor.
28,687 Carr & Birch. Automatically controlling alternating motors.
28,858 Hirst & Brook. Switch and circuit-breaker.

1905 SPECIFICATIONS.

80 B.T.-H. Co. (G.E. Co., U.S.) Arc lamps.
522 B.T.-H. Co. (G.E. Co., U.S.) Oil switches.
571 McLELLAN & MERZ. Indicating or checking efficiency of electric train.
1,638 STOCKS. "Party line" system of telephones.
2,401 HEATH. Starting and control of direct-current motors.
3,289 B.T.-H. Co. (G.E. Co., U.S.) Electric heaters.
3,327 HOOKHAM & HOLDEN. Electrolytic meters.
3,814 LEITNER. Structure of accumulator cells.
3,857 FAIRWEATHER. (Diehl Mfg. Co.) Controlling devices for motors.
4,020 TORDA & BORNAND. Photometers using a selenium cell.
4,456 DEVONSHIRE. Conduits for conductors or cables.
4,513 CHANDLER & BONNIKSEN. Electric clocks.
4,731 WANSBROUGH. Pushes or switches for bells, telephones, &c.
4,780 LAKE (Jacobsen). Appliances for testing electric batteries.
5,865 HEPWORTH-COLLINS. Conduits for electric cables and wires.
5,980 B.T.-H. Co. (G.E. Co., U.S.) Alternating-current machines.
6,400 SIMPSON. Hangers or ears for overhead wires.
6,822 TUCKER. Switches.
8,704 ST. JOHN. Supporting telephone receivers.
8,890 SHOEMAKER. Detector for use in wireless telegraphy.
8,890B SHOEMAKER. Wireless telegraph receiving apparatus. (Date applied for, April 27, 1905.)
10,794 WOODWORTH. Electrical signalling apparatus in mines.
12,062 FLETCHER. Regulating rheostats and motor starters.
12,536 POPE. Electric candle fittings.
12,875 B.T.-H. Co. (G.E. Co., U.S.) Arc lamps.
13,706 A.E.G. Electric motors. (Date applied for, July 4, 1904.)
14,441 WHITAKER & WASS. Suspending electric lamps. (Date applied for, July 14, 1904.)
15,289 MEYER. Telephone call registers.
15,594 GANZ & Co. Conveying currents to electrodes in insulated tubes. (Date applied for, Aug. 26, 1904.)
16,542 WESTINGHOUSE. Turbines. (Date applied for, Aug. 23, 1904.)
16,945 CAPT-LECOULTRE. Automatically lighting and extinguishing electric lamps at certain hours varying with the seasons. (Date applied for, Sept. 3, 1904.)
17,181 B.T.-H. Co. (G.E. Co., U.S.) Thermo-electric couples.
19,138 A.E.G. Dynamo-electric machines. (Date applied for, Sept. 22, 1904.)
19,201 BÖHM. Constant current distributing system for variable sources of power.
20,769 MITKEVITCH. Application of alternating current to welding.

## NEW COMPANIES, MORTGAGES AND CHARGES.

### NEW COMPANIES.

**ANGLO-JAPANESE & ORIENTAL CORPORATION (LTD.)** (86,966.)—Reg. Dec. 22, capital £100,000 in £1 shares, to adopt an agreement with Guaranteed Investments, and to carry on in the United Kingdom, Japan, Korea, Manchuria, Formosa, the Far East, and elsewhere, the business of financiers, concessionaires, merchants, owners of mining, electrical, railway, gas, and trading rights, contractors, &c. First directors Sir Wm. F. Haynes Smith, K.C.M.G., Sir Ralph D. R. Moor, K.C.M.G., Shizuo Kondo, and Commander Tatzuzo Kosugi. The options being negotiated for include an option to purchase the Kobe Steel Works, to extend an electric tramway system and an electric power, traction, and light system in Japan, to acquire a water-power concession (over 8,000 H.P.) in Japan, to erect electric power, traction, and lighting plants in a large city in Southern Manchuria, &c. Registered office, 53, Billiter-buildings, 22, Billiter-street, London, E.C.

**BRIDLINGTON ELECTRICAL ENGINEERING CO. (LTD.)** (86,995.)—Reg. Dec. 23, capital £500 in £1 shares, to carry on the business of electricians, electrical engineers, &c., to take over undertaking of a company of same name and to adopt an agreement. Reg. Office, Princess House, Princess-street, Bridlington, Yorks.

**BRITANNIA ELECTRIC LAMP WORKS (1905) (LTD.)** (86,967.)—Reg. Dec. 22, capital £25,000 in £1 shares (10,000 6 per cent. cumulative preference), to adopt an agreement with the Britannia Electric Lamp Works (Ltd.) and to carry on the business of lamp manufacturers, &c. First directors: C. N. Radcliffe, R. N. Molesworth, W. T. Smythe and S. Horvath (all permanent).

**CHICHESTER ELECTRIC LIGHT & POWER CO. (LTD.)** (86,998.)—Reg. Dec. 23, capital £20,000 in £1 shares, to carry on at Chichester, Sussex, and elsewhere, the business of electrical engineers, electricians and contractors, manufacturers of and dealers in electrical apparatus, mechanical and chemical engineers, producers and suppliers of light, heat, sound and power by electricity, &c.

**LANCASHIRE UNITED TRAMWAYS (LTD.)** (87,044.)—Reg. Dec. 29, capital £200,000 in £1 shares, to adopt an agreement with the Hon. Arthur Stanley to take over all or part of assets of the Lancashire Electric Traction & Power Co. (Ltd.), to acquire, lease or construct and own tramways and railways, to equip, maintain and work same by electricity or other power, to generate, accumulate, distribute and supply electricity, to contract with other producers for supply of electrical energy to be used for purposes of the company, &c.

**RAND ELECTRIC SYND. (LTD.)** (87,046.)—Reg. Dec. 29, capital £5,000 in £1 shares, of which 4,000 are to be issued at par, payable in full on application. The syndicate has been registered to promote a power company to supply the Rand with electric energy on the lines indicated in the paper read by Mr. Robert Hammond before the Engineering Section of the British Association at Johannesburg last August, and to obtain the necessary powers from the Transvaal Government. The scheme contemplates the erection of a generating station alongside the Vaal River at a point about 35 miles distant from Johannesburg and transmission of energy thence by electric lines to a central transforming station on the Rand, as explained in Mr. Hammond's Paper. Application will be made at once for the necessary Parliamentary powers, and it is estimated that £3,000 to £4,000 should suffice to pay the incidental expenses. Mr. Hammond's firm will act as consulting engineers to this Syndicate, and 1,000 shares will be allotted to them as fully-paid to cover all engineering services up to the date of obtaining the Parliamentary powers, except out-of-pocket expenses. It is intended to reserve 1,000 shares for subscription in Johannesburg. The directors will be selected from amongst the subscribers. The temporary offices are c/o Annan Kirby, Dexter & Co., 21, Ironmonger-lane, London, E.C.

**TASKER'S ENGINEERING CO. (LTD.)** (87,052.)—Reg. Dec. 29, capital £25,000 in £1 shares, to acquire business of a manufacturing, mechanical, electrical and general engineer, engineers' factor, &c., carried on at Sheffield as Tasker's Engineering Co. First directors: J. H. R. Tasker (permanent), J. Snow and P. G. Pilling.

**TOPHAM, JONES & RAILTON (D)** (87,032.)—Reg. Dec. 28, capita £500,000 in £10 shares (40,000 6 per cent. cumulative preference), to acquire business carried on as Topham, Jones & Railton, and to carry on the business of constructors, owners and workers of railways, tramways, roads, electric or other lighting works, telephones, telegraphs, submarine cables, hydraulic, electric and other power supply works, mechanical engineers, manufacturers of iron, steel and wire, manufacturers of cables for telephonic, telegraphic, electric lighting and other purposes, builders of engines, waggons and rolling stock, producers and suppliers of electricity, &c. First directors, W. H. Topham, E. D. Jones and J. Railton. Reg. office, 2, Great George-street, Westminster.

### MORTGAGES AND CHARGES.

**BRITISH HOSIERY & ELECTROLYTIC BLEACHING CO. (LTD.)**—Particulars of £8,750 debentures, created by resolution of Nov. 15, 1905, charged on company's assets, including uncalled capital, have been filed.

**CUTTING BROS. (LTD.)**—Issue on Dec. 16 of £850 6 per cent. debentures, part of series created June 20, 1904, to secure £4,000, charged on company's property, present and future, including uncalled capital. Holders, Janetta W. French, Mrs. A. Priest and Mrs. H. Northwood. No trustees. Previously issued of same series, £2,800.

**GENERAL INTERNATIONAL WIRELESS TELEGRAPH & TELEPHONE CO. (LTD.)**—A charge on company's patents and extensions thereof, dated Nov. 28, 1905, to secure £550, has been registered. Holder, F. W. Corby.

**KUETTNER, MACDONNELL & COOKSON (LTD.)**—A debenture dated Dec. 22, 1905, to secure £1,000, charged on company's undertaking and property, present and future, including uncalled capital, subject to debenture dated March 28, 1905, securing £750, has been registered. Holder, B. Cookson.

**LIONEL ROBINSON & CO. (LTD.)**—Particulars of £4,000 debentures, created by resolution of Dec. 21, 1905, charged on company's undertaking and property, present and future, including uncalled capital, have been filed. No trustees.

**MANN, EGERTON & CO. (LTD.)**—Issue on Dec. 21 of £5,000 debentures, part of series created April 1, 1905, to secure £10,000, charged on various freehold and leasehold properties in Norwich and Ipswich, and company's undertaking and property, present and future, including uncalled capital. Trustees, G. F. Buxton and J. J. D. Paul. Previously issued of same series, £4,100.

**PROVINCIAL TRAMWAYS CO. (LTD.)**—Issue on Dec. 21 of £15,000 4 per cent. debentures, part of series created May 27, 1904, to secure £125,000. Property charged, Company's undertaking and property, present and future. No trustees. Previously issued of same series, £71,000.

**ST. AUSTELL & DISTRICT ELECTRIC LIGHTING & POWER CO. (LTD.)**—Issue on Dec. 22 of £150 5 per cent. debentures, part of series created June 1, 1904, to secure £2,000, charged on company's undertaking and property, present and future, including uncalled capital. No trustrees. Previously issued of series, £500.

**UXBRIDGE & DISTRICT ELECTRIC SUPPLY CO. (LTD.)**—Issue on Dec. 21 of £4,000 debentures, part of series created July 14, 1904, to secure £35,000, charged on company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series, £29,000.

## CITY NOTES.

**MEMORANDA** (Jan. 4).—Bank rate 4 per cent. since (Sept. 28, 1905). Price of silver 29¾d. per oz. Consols $89\frac{1}{16}$—$89\frac{3}{16}$ for money, $89\frac{5}{16}$—$89\frac{7}{16}$ for account; 2½ per cent. annuities 89¼—89½. Consols Pay Day, Feb. 1. Stocks and Shares Continuation Day, Jan. 9; Ticket Days, Jan. 10 and 24. Pay Day, Jan. 11; Mining Share Carry-over Day, Jan. 8.

**BUENOS AYRES GRAND NATIONAL TRAMWAYS CO. (LTD.)**—Interest warrants for half-year ended Dec. 31, on the 5½ per cent. preference debentures have been posted. The coupons on bearer bonds will be paid (less tax) at the Commercial Bank of Scotland, 62, Lombard-street, E.C.

**DOLTER ELECTRIC TRACTION CO. (LTD.)**—At the meeting last week Mr. H. N. Lubbock congratulated the shareholders upon the progress

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. No. of weeks. | Aggregate. Amount. | Aggregate. Inc. or Dec. (a) |
|---|---|---|---|---|---|---|
| | | £ | £ | | £ | £ |
| Aberdeen Corporation | Dec. 30 | 1,316 | + 20 | 31 | 43,755 | − 1,167 |
| Airdrie | ,, 22 | 214 | + 25 | 51 | 10,544 | + 297 |
| Anglo-Argentine | ,, 31 | 17,955 | + 934 | 51 | 708,807 | + 48,697 |
| Ayr Corporation | ,, 30 | 191 | + 12 | 33 | 10,712 | − 100 |
| Barnsley | ,, 22 | 154 | + 8 | 51 | 8,182 | − 818 |
| Barrow | ,, 22 | 214 | + 18 | 51 | 12,178 | + 2,270 |
| Bath Electric Trams. Ltd. | ,, 27 | 942 | + 215 | 52 | 35,681 | + 2,615 |
| Birkenhead Corporation | ,, 31 | 988 | − 39 | ... | ... | ... |
| Birmingham Corporation | ,, 30 | 445 | + 66 | 39 | 14,440 | + 1,826 |
| *Birmingham & Mid. | ,, 22 | 1,448 | − 188 | 51 | 79,858 | − 721 |
| Blackpool Corporation | ,, 28 | 408 | + 71 | 26 | 45,356 | + 1,890 |
| Blackpool and Fleetwood | ,, 30 | 283 | + 9 | 26 | 10,230 | − 1,092 |
| Bolton Corporation | ,, 31 | 1,870 | + 57 | 40 | 76,764 | + 8,351 |
| Bournemouth Corporation | ,, 27 | 1,805 | + 774 | †38 | 55,568 | + 11,974 |
| Bradford Corporation | ,, 23 | 4,215 | + 751 | 39 | 172,601 | − 4,096 |
| | ,, 30 | 4,515 | + 308 | | | |
| Brighton Corporation | ,, 31 | 905 | + 1 | 40 | 40,767 | + 480 |
| Bristol Trams & Carriage | ,, 29 | 5,472 | − 74 | 10 | 68,098 | + 1,166 |
| Buenos Ayres & Belgrano | ,, 31 | 8,889 | + 480 | 52 | 181,276 | + 10,831 |
| Buenos Ayres Elec. Trams | ,, 2 | 1,301 | ... | 48 | 57,095 | ... |
| Burnley Corporation | ,, 30 | 1,214 | + 125 | 39 | 58,783 | + 2,812 |
| Burton Corporation | ,, 31 | 274 | − 70 | §39 | 12,275 | − 1,449 |
| Bury Corporation | ,, 24 | 802 | ... | §38 | 28,504 | ... |
| Calcutta Tramways Co. | ,, 30 | R56,858 | + R12,890 | 26 | R1,840,801 | + R142,840 |
| Camborne-Redruth | ,, 23 | 131 | − 26 | 9 | 982 | − 53 |
| | ,, 30 | 148 | + 33 | | | |
| Carlisle Tramways Co. | ,, 30 | 188 | + 1 | 52 | 9,463 | − 662 |
| Central London Railway | ,, 30 | 5,781 | − 514 | 26 | 165,968 | − 1,436 |
| Chatham & Dist. Lt. Rys. | ,, 28 | 713 | + 12 | 52 | 33,908 | + 3,630 |
| *City of Birm'gh'm Tram Co. | ,, 22 | 5,501 | − 50 | 51 | 273,143 | − 191 |
| City & South London Rly. | ,, 31 | 2,939 | − 282 | 26 | 69,363 | − 412 |
| Colchester Corporation | ,, 28 | 217 | − 51 | 22 | 4,240 | − 1,402 |
| Cork Electric Trams Co. | ,, 28 | 512 | + 8 | 52 | 21,269 | + 646 |
| Devonport & Dist. Trams | ,, 22 | 436 | − 65 | 51 | 23,258 | − 3,483 |
| Dover Corporation | ,, 30 | 199 | − 15 | ‡39 | 9,007 | − 41 |
| Dublin & Lucan Railway | ,, 31 | 177 | + 16 | §26 | 3,268 | − 15 |
| Dublin United | ,, 29 | 5,149 | + 241 | 26 | 131,583 | + 101 |
| Dudley—Stourbridge | ,, 22 | 780 | + 145 | 51 | 45,328 | + 1,725 |
| Dundee Corporation | ,, 27 | 1,010 | + 155 | §32 | 29,700 | + 2,021 |
| East Ham Council | ,, 30 | 886 | + 205 | 39 | 32,546 | + 4,116 |
| Gateshead & Dist. Trams | ,, 22 | 972 | + 74 | 51 | 47,131 | + 1,112 |
| Glasgow Corporation | ,, 30 | 15,670 | + 1,561 | 31 | 468,968 | + 26,272 |
| Gloucester Corporation | ,, 27 | 296 | + 16 | 30 | 11,640 | ... |
| Gravesend—Northfleet | ,, 22 | 220 | + 44 | 51 | 11,694 | − 687 |
| Gt. Northern & City Rly. | ,, 30 | 1,759 | + 49 | 26 | 41,450 | + 8,162 |
| Greenock & Port Glasgow | ,, 22 | 693 | + 179 | 51 | 32,780 | + 3,757 |
| Halifax Corporation | ,, 27 | 1,596 | + 252 | 39 | 62,223 | + 4,291 |
| Hartlepool Tramways | ,, 22 | 254 | + 11 | 51 | 13,553 | − 1,164 |
| Hastings Elec. Trams Co. | ,, 28 | 597 | ... | 21 | 10,954 | ... |
| Huddersfield | ,, 30 | 1,309 | + 58 | 39 | 53,576 | + 2,590 |
| Hull Corporation | ,, 30 | 2,374 | + 71 | 39 | 87,263 | + 1,148 |
| Ilford Dist. Coun. | ,, 30 | 459 | + 54 | 39 | 18,685 | + 634 |
| Ipswich Corporation | ,, 30 | 402 | − 39 | 39 | 17,188 | − 1,872 |
| Isle of Thanet Co. | ,, 30 | 280 | − 24 | 13 | 8,596 | − 487 |
| Kidderminster & District | ,, 22 | 96 | − 6 | 51 | 6,078 | − 345 |
| Kirkcaldy Corporation | ,, 27 | 509 | + 8 | 17 | 8,426 | − 76 |
| Lanarkshire Trams Co. | ,, 28 | 809 | + 226 | 52 | 39,750 | + 5,725 |
| Leamington | ,, 22 | 183 | + 54 | 23 | 4,149 | + 1,513 |
| Leeds Corporation | ,, 30 | 6,180 | + 442 | 39 | 287,238 | + 6,778 |
| Leicester Corporation | ,, 30 | 2,320 | + 187 | 52 | 107,829 | + 30,727 |
| Liverpool Overhead Rly. | ,, 31 | 1,248 | − 185 | 26 | 38,959 | − 1,964 |
| *London County Council | ,, 23 | 16,130 | + 8,486 | 38 | 564,917 | + 77,994 |
| Lowestoft | ,, 30 | 146 | − 21 | 13 | 1,969 | − 26 |
| Maidstone Corporation | ,, 28 | 128 | − 17 | 39 | 4,929 | ... |
| Manchester Corporation | ,, 30 | 12,493 | + 461 | 39 | 505,578 | + 24,536 |
| Mersey Railway | ,, 23 | 1,992 | − 153 | 26 | 41,795 | + 2,114 |
| | ,, 30 | 1,729 | − 14 | | | |
| Merthyr | ,, 22 | 178 | + 4 | 51 | 9,001 | − 518 |
| *Metropolitan Elec. Trams | ,, 22 | 2,801 | + 1,022 | 51 | 125,628 | + 16,827 |
| Middleton | ,, 22 | 286 | + 62 | 51 | 17,088 | + 857 |
| Musselburgh | ,, 14 | 157 | ... | 53 | 11,319 | ... |
| | ,, 21 | 152 | | | | |
| Nelson Corporation | ,, 30 | 140 | + 22 | 40 | 5,571 | + 540 |
| Newcastle-on-Tyne Corp. | ,, 30 | 3,963 | + 242 | 39 | 149,289 | + 3,924 |
| Newport (Mon.) | ,, 30 | 651 | + 32 | 13 | 7,111 | + 412 |
| Northampton Corporation | ,, 29 | 491 | + 8 | 28 | 16,208 | + 4,912 |
| Oldham, Ashton & Hyde | ,, 22 | 533 | + 120 | 51 | 28,428 | + 943 |
| Oldham Corporation | ,, 31 | 1,603 | + 150 | 40 | 65,724 | + 16,181 |
| Perth (W. A.) Elec. Trams | ,, 29 | 2,037 | + 157 | 52 | 72,688 | + 4,243 |
| Peterborough | ,, 22 | 106 | + 2 | 51 | 6,767 | − 687 |
| Pontypridd Dist. Council | ,, 23 | 162 | ... | 39 | 6,872 | ... |
| | ,, 30 | 192 | ... | | | |
| Portsmouth Corporation | ,, 23 | 1,597 | + 8 | 39 | 78,060 | + 1,328 |
| | ,, 30 | 1,4[illegible] | + 4 | | | |
| Potteries | ,, 22 | 1,813 | + 192 | 51 | 87,628 | + 1,326 |
| Preston Corporation | ,, 27 | 814 | ... | 13 | 7,771 | ... |
| Reading Corporation | ,, 28 | 681 | − 58 | ... | ... | ... |
| Rotherham Corporation | ,, 28 | 629 | + 60 | 38 | 17,957 | − 438 |
| Rothesay | ,, 22 | 89 | + 9 | 51 | 9,619 | + 2,707 |
| Salford Corporation | ,, 25 | 4,760 | + 560 | 40 | 171,270 | + 9,996 |
| | Jan. 1 | 4,570 | + 242 | | | |
| Sheerness | Dec. 30 | 60 | − 9 | 51 | 8,484 | + 251 |
| Sheffield Corporation | ,, 31 | 5,591 | + 401 | 51 | 198,215 | + 10,689 |
| Southampton Corporation | ,, 27 | 931 | + 25 | 12 | 10,819 | − 108 |
| Southend Corporation | ,, 27 | 264 | + 41 | 39 | 15,226 | + 810 |
| Southport Tramways | ,, 22 | 222 | + 15 | 51 | 15,595 | − 184 |
| S. Staffordshire Trams. | ,, 22 | 865 | + 185 | 51 | 37,116 | + 2,174 |
| Stockport Corporation | ,, 29 | 884 | + 379 | 29 | 29,781 | + 7,661 |
| Sunderland Corpn. | ... | ... | ... | ... | ... | ... |
| Swansea Trams | ,, 22 | 796 | + 846 | 51 | 36,913 | + 9,748 |
| Swindon Corporation | ,, 27 | 225 | + 5 | 39 | 7,730 | ... |
| Taunton | ,, 22 | 44 | + 2 | 51 | 9,142 | − 225 |
| Tynemouth and District | ,, 22 | 175 | + 6 | 51 | 12,604 | − 1,588 |
| Tyneside Trams Co. | ,, 27 | 414 | + 47 | 52 | 21,118 | + 1,182 |
| Wallasey District Council | ,, 30 | 616 | + 15 | 39 | 30,759 | + 1,100 |
| Walsall | ,, 30 | 672 | + 12 | 52 | 25,665 | + 686 |
| Warrington Corporation | ,, 21 | 811 | + 29 | 38 | 12,968 | + 731 |
| West Ham Corporation | ,, 21 | 2,087 | + 1,075 | 39 | 71,091 | + 50,359 |
| | ,, 28 | 2,295 | + 1,084 | | | |
| Weston-super-Mare | ,, 30 | 26 | + 1 | 51 | [illegible] | + 597 |
| Wolverhampton District | ,, 22 | 891 | + 60 | 51 | 20,181 | + 490 |
| *Worcester | ,, 22 | 251 | − 11 | 51 | 15,267 | + 846 |
| Wrexham | ,, 22 | 97 | + 5 | 51 | 5,112 | − 852 |
| Yorkshire W.R. Trams | ,, 31 | 951 | + 281 | 52 | 37,510 | ... |
| Yorkshire Woollen District | ,, 22 | 807 | + 847 | 51 | 34,428 | + 5,177 |

(a) These comparisons are with the corresponding period last year. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days. * Partly electrical.

their system of electric traction was making. During the past year the Dolter system of traction had been adopted at Mexborough, where some 6 miles of track had already been equipped out of a total length between Mexborough and Swinton of 10 miles. The system was also in operation in Paris, Dresden and other places on the Continent, and was found capable of withstanding a very heavy traffic.

**EDMUNDSONS' ELECTRICITY CORPN. (LTD.)**—The directors have declared an interim dividend at the rate of 5 per cent. per annum on the ordinary shares (payable Jan. 15) for half-year ended Sept. 30.

**ELECTRIC SUPPLY CO. OF VICTORIA (LTD.)**—Warrants for debenture interest to Dec. 31 have been posted.

**MANX ELECTRIC RAILWAY CO. (LTD.)**—At the meeting on Wednesday Mr. A. Griffith-Boscawen, M.P., said that the receipts for the year ended Sept. 30 were £1,820 more and expenditure was £1,931 less than in 1904. The ratio of working expenses to receipts was 47 per cent., compared with 56 per cent. They had entered into negotiations with Douglas Corporation for electrifying the horse tramway along the Promenade.

**MIDLAND ELECTRIC CORPN. FOR POWER DISTRIBUTION (LTD.)**—Warrants for debenture interest to Dec. 31 have been posted.

**STOCK EXCHANGE NOTICE.**—The Stock Exchange committee have been asked to appoint a special settling day in 90,000 £5 fully paid ordinary shares of the *National Telephone Co. (Ltd.)*

**UNDERGROUND ELECTRIC RAILWAYS CO. OF LONDON (LTD.)**—At a board meeting on Wednesday the directors unanimously elected Mr. Edgar Speyer chairman in the place of the late Mr. C. T. Yerkes. Sir George Gibb, general manager of the North-Eastern Railway, was unanimously elected deputy chairman and managing director of the company, as well as chairman and managing director of the Metropolitan District Railway Co., R. W. Perks, M.P., continuing as deputy-chairman of that company.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend. | Name. | Price Wed., Jan. 3. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business, Week to Jan. 3. Highest. | Business, Week to Jan. 3. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | | | | |
| 5 | 3/0 | Anglo-Argentine Ord. Shares | 8⅜–8⅝ | 4 12 9 | Ap, Oct | 8⅝ | .. |
| 5 | 2/9 | † Do. 5½% Cum. Pref. | 5¾–6 | 4 10 0 | – | 6 | 5⅞ |
| St. | 6% | † Do. Permanent 6% Deb. Stock | 140 –143 | 4 3 6 | – | 141⅛ | 141 |
| St. | 5% | † Auckland Elec. Trams 5% Deb. (red.) | 103 –105 | 4 15 0 | – | 105 | 104½ |
| 5 | .. | Brisbane Electric Trams. Invest Ord. | 1 –1½ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 4 – 4½ | 5 18 3 | – | .. | .. |
| St. | 4½% | † Do. 4½ per Cent. Db. Prov. Cts | 93 –96 | 4 13 9 | – | 95 | .. |
| St. | 6% | British Columbia Elec. Rlwy Def. Ord. | 120 –123 | 4 17 6 | – | 122 | .. |
| St. | 5% | Do. Pref. Ord. Stk | 107 –111 | 4 10 0 | – | 109¼ | .. |
| 100 | 5% | Do. 5% Cum. Perp. Pref. Stock | 103 –109 | 4 11 8 | – | 109½ | – |
| 100 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%–105% | 4 5 9 | – | 103¾ | – |
| 100 | 4½% | Do. Vancouver Power Debs. | 102 –105 | 4 5 9 | – | .. | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | 4⅝–4⅞ | 5 3 0 | – | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. "A" Cm. Pref | 5¾ - 6 | 5 0 0 | – | .. | .. |
| 5 | 3/0 | Do. "B" | 5 –5½ | 5 9 1 | – | .. | .. |
| St. | 5% | † Do. 5 per Cent. Debs. | 105 –107 | 4 13 6 | – | .. | .. |
| St. | 5% | † Do. 5% 2nd Deb. (red.) | 100 –103 | 4 17 0 | – | 104½ | .. |
| St. | 5% | †Buenos Ayres Elec. Trams (1901) Ltd. | 96 - 98 | 5 2 0 | .. | .. | .. |
| 100 | 5½% | †Buenos Ayres Grand National 5½% Pref. Debs. | 100 –104 | 5 5 9 | .. | .. | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 100 –101 | 5 17 0 | .. | .. | .. |
| 5 | 2/6 | Calcutta Tramways (Nos. 1 to 105) | [illegible] | 4 7 2 | – | .. | .. |
| 5 | 2/6 | † Do. Nos. 105,001 to 137,610 | 8½–9 | .. | .. | .. | .. |
| 100 | 4½% | † Do. 4½% 1st Deb. Stock (red.) | 105 –107 | 4 4 0 | – | .. | .. |
| 1 | 0/6 | Cape Electric Tram Shares | ⅞–1⅛ | 4 8 10 | – | .. | – |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt Deb. (red) | 102 –104 | 4 16 0 | – | .. | .. |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Corp. Bds. | 97 –98% | .. | .. | 9⅜ | .. |
| 1 | .. | Lisbon Elec. Trams Ord. | 1 1/16– 1⅛ | .. | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛–1⅜ | 4 7 4 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 100 –103 | 4 17 0 | .. | .. | .. |
| St. | 5% | †Madras Elec. Trams 5% Deb. Stk. | 101 – 103 | 4 17 0 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101 –104 | 4 16 2 | – | 9½ | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102 –104 | 4 6 7 | – | 103 | .. |
| St. | 5% | †Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 102 –105 | 4 16 0 | .. | 104 | .. |
| .. | $2 | †Sao Paulo Tramway, Light and Power Co. $100 Stock | 139 – 142 | 5 11 0 | .. | .. | .. |
| .. | 5% | Do. 5% 1st Mt. $100 Dbs. | 97%–98% | 5 1 0 | .. | 98¼ | .. |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | – | Adelaide Elec. S'ply Co. 6% Cu. Pr. | 4¾–5¼ | – | .. | .. | .. |
| 5 | 8/8 | Calcutta Elec. (1-50,000) | 8¾–9¼ | 4 9 0 | – | 9⅛ | .. |
| 100 | 5% | †City of Wellington Elec. Lt and Power 5% Reg. 1st Dbs. | 99 –101 | 4 18 0 | .. | 100½ | 100¼ |
| .. | 5% | †Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 94 –96 | 5 4 0 | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½– 3 | .. | .. | .. | .. |
| St. | 5% | † Do. 5% Debs. | 95 –100 | 5 0 0 | – | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | 9 –10 | – | – | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92 –94 | 5 6 8 | .. | .. | .. |
| St. | 26/2 | †Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. | 108 – 110 | 5 0 0 | .. | .. | .. |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞ - 1 | 6 0 0 | – | .. | – |
| 1 | 1/0 | Rand Electric | 1¼ - 1⅜ | .. | – | .. | – |
| 1 | .. | River Plate Electricity Co. Ord. | [illegible] | .. | .. | .. | .. |
| 1 | 1/2⅖ | Do. 6% Non. Cum. Pref | [illegible] | .. | .. | .. | .. |
| St. | 5% | † Do. 5% Deb. Stock | 101 – 103 | 4 17 0 | .. | .. | .. |
| 5 | 3/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5½–5¾ | 5 4 4 | .. | .. | – |
| 5 | 3·3d | Do. (12,001-20,000) | 5 –5½ | 3 8 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100 –103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 5% | †Shawinigan Water and Power 5% Bds., Scrip | 100 –101 | 4 19 0 | .. | 101 | .. |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Share. | Last Dividend | Name. | Price Wed., Jan. 3. | Rate per Cent. Yielded. | Dividend Due | Business, Week to Jan. 3. Highest. | Business, Week to Jan. 3. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | £ s. d. | | | |
| 1 | .. | Bath Elec. Trams Pref. Ord. | 15/16—1 | .. | .. | .. | .. |
| 1 | 0/6 | † Do. 5% Cum. Pref. | 15/16—1 1/16 | 4 14 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 103½—105½ | 4 5 0 | .. | .. | .. |
| St. | 4½% | † B'ham & Midland Trams 4½ 1st Db. Stk. | 101—103 | 4 7 9 | .. | 102 | .. |
| 10 | 9% | Bristol Tramways and Carriage Ord. | 17—17½ | 5 2 11 | Feb, Aug | .. | .. |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10⅝—10⅞ | 3 18 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Debs. | 106—107 | 3 14 10 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 8¼—8¾ | 6 17 0 | .. | 8½ | 8¼ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 10½—11 | 5 8 0 | Feb, Aug | 10¾ | 10⅝ |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 118—120 | 4 8 4 | .. | 118¼ | 118 |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 98—100 | 4 10 0 | .. | 98¾ | .. |
| St. | 4% | Central London Ordinary Stock | 94—96 | 4 3 6 | June, Dec | 95½ | 94 |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 101—103 | 3 17 8 | .. | 102¾ | — |
| St. | 4% | Do. Deferred Stock | 85—88 | 4 11 0 | .. | — | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 111—113 | 3 10 3 | .. | — | .. |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 4⅞—5⅛ | 4 17 6 | .. | — | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 101—104 | 3 17 0 | .. | .. | .. |
| St. | 2% | City and South London Rly. Con. Ord. | 44—46 | 4 1 6 | Feb, Aug | 45¾ | .. |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 119—122 | 4 2 0 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 117—120 | 4 3 4 | .. | .. | .. |
| St. | 5% | Do. (1901) | 115—118 | 4 4 8 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 105—108 | 3 14 1 | May, Nov | .. | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13½—14½ | 4 2 8 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½—15½ | 3 17 3 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5—5½ | 7 5 6 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8—9 | 4 8 11 | .. | .. | .. |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 101—103 | 4 7 6 | .. | .. | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 17—18 | 5 0 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 13¾—14¼ | 4 4 2 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 112—114 | 3 19 0 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2½—2¾ | 9 8 6 | — | .. | .. |
| St. | 4% | † Do. 4 per Cent. Deb. Stock | 82—87 | 4 12 0 | — | — | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8⅛—8⅜ | 3 13 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾—10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99—102 | 3 19 3 | Jan, July | .. | .. |
| 10 | 5/0 | † London United Trams. 5% Cum. Pref. | 9½—10 | 5 0 0 | — | 9⅞ | 9 13/16 |
| St. | 4% | † Do. 4% 1st Mort. Deb. Stock | 98—101 | 3 19 6 | — | 98¾ | .. |
| St. | .. | Mersey Con. Ord. Stock | 7—9 | — | — | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8—11 | — | — | .. | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32—9/32 | .. | — | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1—1 1/16 | 4 14 1 | — | .. | .. |
| St. | 4½% | † Do. 4½% Deb. Stock | 104—106 | 4 5 0 | — | .. | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½—1½ | .. | May | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾—9¼ | 5 5 8 | .. | .. | .. |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9¾—10¼ | 4 17 6 | Feb, Aug | 9¾ | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103—106 | 4 5 0 | — | .. | .. |
| 100 | 5% | † Sunderland Dist. Elec. Trams. 5% 1st Mort. Debs. | 92—97 | 5 3 0 | .. | 96 | .. |
| .. | 5% | Underground Elec. Rys. Co. of London | 96½—97½ | 5 2 6 | .. | 98 | .. |
| St. | 3% | Waterloo and City Ord. | 94—97 | 3 2 0 | June, Dec | .. | .. |
| St. | 12/11 | Yorkshire W.R. El. Trs. Co. 4% 1st Debs. | 96—98 | 4 1 6 | .. | 96¼ | .. |
| | .. | **TELEGRAPHS.** | | | | | |
| 100 | 4% | * † African Direct Tel. 4% Mrt. Deb. (red.) | 98—101 | 3 19 0 | Jan, July | — | .. |
| 10 | — | Amazon Telegraph | 3¾—4¼ | .. | Jn, Dec .. | .. | .. |
| 100 | 5% | † Do. 5% Debs. (red.) | 88—98 | 5 12 0 | .. | 94 | .. |
| St. | 15/0 | Anglo-American | 62½—64½ | 4 13 0 | F,My,Ag,N | .. | .. |
| St. | 30/0 | Do. Preferred | 109½—110½ | 5 4 0 | F,My,Ag,N | 110⅜ | 109½ |
| St. | 2/0 | Do. Deferred | 16⅞—17⅛ | .. | F,My Ag,N | 17⅛ | 17 1/16 |
| St. | 4% | † Commercial Cable 4 per Cent. Deb. Stk | 96—98 | 4 1 6 | Jn Ap,Jy,O | 98½ | 98 |
| 10 | 5/0 | Cuba Submarine Ord. | 8½—9 | 5 11 0 | Feb, Aug | 8 11/16 | .. |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17—18 | 5 11 2 | Feb, Aug | .. | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜—3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 8½—9 | 5 11 0 | April Oct | .. | .. |
| 50 | 4½% | † Do. 4½ per Cent. Deb. | 98%—101% | 4 9 0 | Jan, July | .. | .. |
| 20 | 8/0 | Direct United States Cable | 14—15 | 4 6 6 | Ja,Ap,Jy,O | 14 13/16 | 14½ |
| 100 | 4½% | † Direct West India Cable 4½% Rg. Db. (rd.) | 99—101 | 4 9 0 | Jn, Dec .. | .. | .. |
| St. | 25/0 | Eastern Ordinary | 145—148 | 4 16 0 | Ja,Ap,Jy,O | 147¼ | 146½ |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 90—92 | 3 16 0 | Ja Ap,Jy,O | 91 | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 106—108 | 3 14 1 | May, Nov | 107¼ | 106¼ |
| 10 | 2/6 | Eastern Extension | 14½—14¾ | 4 15 3 | Ja,Ap,Jy,O | 14⅝ | 14⅜ |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 106—108 | 3 14 1 | Feb, Aug | .. | .. |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 100½—102½ | 3 18 0 | Feb, Aug | .. | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 100½%—102½% | 3 18 0 | May, Nov | .. | .. |
| 10 | 5/0 | G. N. (of Copenhagen) ex coupon 64 | 36—38 | 6 6 6 | Jan, July | 37½ | .. |
| 100 | 4½% | † Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 99—101 | 4 7 6 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57—59 | 5 10 0 | May, Nov | [illegible] | 57 1/16 |
| 100 | $1 | Mackay Companies Common | 60 1/16 | 3 17 0 | Jan, July | — | .. |
| 100 | 4% | Do. Preference | 75 | 5 6 6 | Ja,Ap,Jy,O | .. | — |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1¼—1⅜ | .. | .. | .. | .. |
| 100 | 4% | † Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 98—101 | 3 19 3 | June, Dec | .. | .. |
| 10 | 4/0 | West African Telegraph Shares | 9½—10 | 5 0 0 | .. | .. | .. |
| 2½ | — | West Coast of America | 9/16—11/16 | .. | — | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 99—101 | 3 19 3 | Jan, July | .. | .. |
| 10 | — | West India and Panama | ½—¾ | .. | May, Nov | .. | .. |
| 10 | 6/0 | Do. 6% 1st Pref. | 8¼—8¾ | 6 6 3 | May, Nov | .. | .. |
| 10 | — | Do. 6 per Cent. 2nd Pref. | 6½—7½ | .. | May, Nov | .. | .. |
| 100 | 5% | * † Do. 5 per Cent. Debs. | 99—102 | 4 18 0 | Jan, July | .. | .. |
| 10 | 3/0 | † Western Telegraph | 13¾—14¼ | 4 18 0 | Mr,Jn,O,D | 14 3/16 | 14 |
| 100 | 5% | * † Do. 5% Debs. (2nd Series, 1906) | 100—102 | 4 18 0 | June, Dec | .. | .. |
| St. | 4% | † Do. 4% Deb. Stock (red.) | 101½—103½ | 3 17 3 | .. | .. | .. |
| | .. | **TELEPHONES.** | | | | | |
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 102—104 | .. | .. | — | — |
| 6 | 5/0 | Chili Telephone (fully paid) | 7⅞—8⅛ | 4 18 6 | August .. | 8 | .. |
| 1 | 0/9⅞ | Monte Video Telephone Ord. | ⅞—1 | 4 0 0 | — | .. | .. |
| 1 | 1/0 | Do. 6% Pref. | ⅞—1 | 5 0 0 | .. | .. | .. |
| St. | 6% | National Co. Pref. Stock | 110½—111½ | 5 7 7 | — | 111¼ | 110¾ |
| St. | 5% | Do. Def. Stock | 108—110 | 4 11 0 | .. | 109½ | 108¼ |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13—15 | 4 0 0 | Feb, Aug | 14⅛ | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 11—13 | 4 12 4 | Feb, Aug | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅝—5⅞ | 4 5 2 | Feb, Aug | 5¾ | 5 11/16 |
| St. | 3½% | * † Do. Deb. Stock 3½ per Cent. (red.) | 98—100 | 3 10 0 | June, Dec | 99¾ | .. |
| St. | 4% | † Do. 4 per Cent. Deb. Stock (red.) | 102½—104½ | 3 16 6 | .. | 102⅝ | .. |
| 1 | 0/7½ | Oriental | 1¼—1⅜ | 4 14 6 | April, Oct | .. | .. |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1¼—1⅜ | 4 7 0 | — | .. | .. |
| St. | 21/7½ | † Do. 4% Red. Deb. Stock | 95—97 | 4 2 6 | .. | 96 | .. |
| St. | 4½% | † Telephone Co. of Egypt 4½% Db. Stk. Rd. | 101—104 | 4 6 6 | .. | .. | .. |
| 5 | 5/0 | † United River Plate | 7⅝—7⅞ | 5 4 9 | July | .. | .. |
| 5 | 2/6 | † Do. 5 per Cent. Cum. Pref. | 5⅜—5⅝ | 4 9 0 | June, Dec | .. | .. |
| St. | 5% | * † Do. 5 per Cent. Deb. Stock (red.) | 109—111 | 4 10 0 | June, Dec | .. | .. |
| | .. | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | † Elec. & Gen. Investment 6% Cum. Pref. | 4¾—5¼ | 5 14 0 | .. | .. | .. |
| 10 | 2/0 | Globe Telegraph and Trust | 10¾—11 | 5 0 0 | Ja, Ap, Jy, O | 10 13/16 | 10⅝ |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14¼—14½ | 4 2 6 | Ja, Ap, Jy, O | 14 7/16 | 14 5/16 |
| 10 | 6% | Submarine Cables Trust (Cert.) | 125—128 | 4 13 9 | April, Oct | .. | — |

| Share. | Last Dividend | Name | Price Wed., Jan. 3. | Rate per Cent. Yielded. | Dividend Due. | Business Week to Jan. 3. Highest. | Business Week to Jan. 3. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | £ s. d. | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12⅝—12⅞ | 5 11 0 | .. | 12¾ | 12⅝ |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10¼—10¾ | 4 3 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11¼—12¼ | 4 18 0 | .. | 11 15/16 | — |
| St. | 4½% | † Do. 4½ per Cent. Deb. Stock (red.) | 105—107 | 4 4 0 | .. | .. | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 102—105 | 4 5 9 | — | 103½ | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 8½—9½ | 5 5 0 | .. | 9⅛ | 8 15/16 |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 9—9½ | 3 14 5 | Mar, Sept | — | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 102—105 | 3 16 3 | — | .. | .. |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 5¾—6¾ | 4 16 0 | Feb, Aug | 6⅛ | .. |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼—5¾ | 3 18 3 | Feb, Aug | 5½ | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 101—103 | 3 17 6 | — | 103 | .. |
| 5 | 2/3 | † Do. City Undertaking 4½% Cm. Pref. | 4⅝—4⅞ | 4 12 6 | — | .. | .. |
| 5 | 2/3 | † Do. Do. (1903) | 4⅝—4⅞ | 4 12 6 | .. | 4⅝ | .. |
| 5 | 2/3 | Chelsea Electric Supply Ord. | 5—6 | 5 0 0 | March .. | 5¾ | .. |
| St. | 4½% | * † Do. 4½ per Cent. Deb. Stock (red.) | 108—110 | 4 1 6 | Jn, Dec .. | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 11—12 | 5 0 0 | Feb, Aug | 11 | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 14¼—14½ | 4 4 2 | Jan, July | — | .. |
| St. | 5% | * † Do. 5 per Cent. Deb. Stock (red.) | 125—128 | 3 19 4 | Jn, Dec .. | .. | .. |
| St. | 4½% | † Do. 4½% 2nd Deb. Stock (red.) | 101—103 | 4 7 6 | .. | .. | .. |
| 5 | .. | County of Durham Elec. P.D. Ord. £2 pd. | 2⅛—2 3/16 | .. | April, Oct | .. | .. |
| 5 | 5% | Do. Do. 5% non cum. pref. | 5⅜—5½ | 4 12 7 | April, Oct | 5 7/16 | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 8½—9½ | 4 6 6 | — | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅝—12⅞ | 4 13 2 | Mar, Sept | 12 11/16 | .. |
| St. | 4½% | † Do. 4½% Deb. Stock (all paid) (red.) | 110—113 | 3 19 6 | .. | .. | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 101—103 | 4 7 6 | .. | 102½ | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5—5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101—104 | 4 6 6 | — | — | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8¼—8¾ | 4 17 2 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100—103 | 4 7 5 | — | .. | .. |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 10¾—11¾ | 5 0 0 | .. | 11 1/16 | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½—7 | 4 5 9 | Jan, July | — | — |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98—101 | 3 19 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101—103 | 3 17 8 | .. | .. | .. |
| 8 | 1/6⅜ | London Electric Supply Ord. | 1¾—2¼ | 4 0 0 | .. | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5—5½ | 5 9 0 | .. | 5⅛ | 5¼ |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 97—100 | 4 0 0 | Mr,Jn,S,D | .. | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 9½—10½ | 4 15 0 | April, Oct | 10¼ | .. |
| 5 | 2/3 | † Do. 4½ per Cent. Cum. Pref. | 5 3/16—5 7/16 | 4 2 2 | Jan. July | 5 11/32 | 5 9/32 |
| St. | 4½% | † Do. 4½ per Cent. Deb. Stock 1st Mort. | 107—111 | 4 1 0 | Jn, Dec .. | .. | .. |
| St. | 3½% | † Do. 3½ per Cent. Mrt. Db. Stock (red.) | 96—98 | 3 10 3 | — | .. | .. |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 99—101% | 4 9 0 | — | .. | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 12—12½ | 5 11 1 | Feb, Aug | .. | .. |
| 100 | .. | Do. 4½% Deb. | 103—106 | .. | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8—8½ | 4 19 5 | Feb, Aug | 8 1/16 | .. |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6⅜—6½ | 3 16 11 | Feb, Aug | 6 7/16 | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 98—99 | 4 0 10 | Jan, July | .. | .. |
| 1 | 3% | Northern Counties Elec. Sup. | 31/32 | 3 1 6 | Mar. Aug | — | .. |
| 100 | 4½% | † Do. 4½% Deb. | 102—103 | 4 7 6 | Jan, July | — | — |
| 10 | 6/0 | Notting Hill Electric Ord. | 13¾—14¾ | 4 15 0 | March | .. | — |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98—100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅜—6⅞ | 5 1 6 | March .. | .. | .. |
| St. | 4% | Do. 4% Deb. Stock | 100—102 | 3 18 5 | — | [illegible] | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 12½—13½ | 5 11 0 | Feb, Aug | 13⅛ | 13 |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 7½—8½ | 4 2 6 | Feb, Aug | — | .. |
| St. | 3½% | † Do. 3½ per Cent. Deb. Stock (red.) | 97—99 | 3 10 9 | — | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2—2½ | 8 0 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76—80 | 5 0 0 | — | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 3—3½ | 5 10 0 | .. | .. | .. |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | 13/16—15/16 | .. | .. | .. | — |
| 1 | 0/8⅞ | Do. 7% Cum. Pref. | 1 5/16—1 7/16 | 4 17 2 | .. | 1 11/32 | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105—108 | 4 3 8 | — | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4½—4¾ | 5 5 8 | — | .. | .. |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5—5¼ | 4 15 8 | — | 5⅛ | .. |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 105—107 | 4 4 0 | .. | 106 | .. |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 11½—12½ | 5 12 0 | Mar, Sept | 12 3/16 | 12⅛ |
| 5 | 2/6 | † Do. 5 per Cent. Cum. Pref. | 5⅞—6⅛ | 4 1 8 | .. | .. | .. |
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d | Alliance Elec. Co. 5% Cum. Pref. | ⅝—⅞ | 5 6 6 | — | .. | .. |
| 1 | 10½d. | Aron El. Met. 6% Cm. Pf. | ½—⅝ | .. | .. | .. | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3¾—4 | 5 0 0 | .. | 3⅞ | [illegible] |
| 1 | 7½d. | Do. Pref | 1 7/16—1 9/16 | 3 16 10 | .. | .. | .. |
| 5 | 6/0 | British Insulated & Helsby Cables Ord. | 6½—7 | 5 14 0 | July, Feb | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾—6¼ | 4 16 0 | Jan, July | .. | .. |
| St. | 4½% | † Do. 4½% 1st Mort. Deb. (red.) | 103—106 | 4 4 11 | .. | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98—100 | 4 10 0 | .. | .. | .. |
| 5 | .. | British Westinghouse 6% Pref. | 1⅞—2¼ | .. | .. | 2 7/32 | [illegible] |
| St. | 4% | † Do. 4 per Cent. Mort. Deb. Stock | 78—83 | 4 16 6 | .. | — | .. |
| 2 | .. | Brush Electrical Engineering | ¼—½ | .. | March | 15/32 | .. |
| 2 | 2/4½ | Do. 6 per Cent. Pref. Non-Cum. | 1¼—1¾ | 6 17 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 96—100 | 4 10 0 | Mar, Sept | .. | .. |
| St. | 4½% | † Do. Perpetual 2nd Deb. Stock | 82—84 | 5 7 4 | Jan, July | 83 | .. |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11—12 | 5 0 0 | Jan, July | .. | .. |
| 5 | 2/6 | † Do. 5 per Cent. Cum. Pref. | 5½—5¾ | 4 5 6 | Jan, July | 5¾ | .. |
| St. | 4½% | † Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 107—109 | 4 2 6 | Nov, May | 107¾ | 107 |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1 1/16—1 3/16 | 5 1 0 | .. | 1 9/32 | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 97—102 | 4 8 8 | — | .. | .. |
| 1 | 8⅛d. | Chadburn's (Ship) Telegraph Ord. | 1—1¼ | 3 0 0 | .. | .. | .. |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1 1/16—1 3/16 | 5 2 7 | .. | .. | .. |
| 8 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 2—2¼ | 3 7 6 | Jan, July | .. | .. |
| 100 | 5% | * † Do. 5 per Cent. 1st Mort. Debs. (red.) | 95—98 | 5 2 0 | Jan, July | .. | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8½—9 | 5 11 1 | Sept | .. | .. |
| 5 | 3/0 | Do. 6% Cum. Pref. | 6¼—6½ | 4 18 0 | Sept | 6⅜ | .. |
| St. | 4½% | † Do. 4½% Deb. Stock | 104—106 | 4 5 0 | .. | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅜—1⅝ | — | Feb, Aug | 1 7/16 | .. |
| 5 | 2/6 | Do. (£5 paid) | 2¼—2¾ | — | Feb, Aug | — | .. |
| St. | 4% | † Do. 4 per Cent. Mort. Deb. Stock (rd.) | 86—88 | 4 11 0 | June, Dec | .. | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92—97 | 5 3 1 | .. | .. | .. |
| 5 | 4/6 | Edmundson's Elec. Corp. Ord. | 5½—5¾ | 6 1 9 | H'lf-yearly | 5 7/16 | 5⅜ |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5½—6 | 5 0 0 | .. | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 107—109 | 4 2 6 | .. | 107½ | 107¼ |
| 2 | 1/7½ | Electric Construction Co. | ½—¾ | 9 6 0 | July | .. | .. |
| 2 | 2/2⅛ | Do. 7 per Cent. Cum. Pref | 1⅞—2⅜ | 5 18 8 | July | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 92—95 | 4 4 2 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 6% Cum. Pref. | 9—9½ | 5 5 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96—100 | 4 0 0 | .. | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 12½—13½ | 5 11 1 | Feb, Aug | 13¼ | 13 |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5⅛—5⅜ | 4 3 9 | Feb, Aug | 5 3/16 | 5⅛ |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | — | 4 1 1 | Feb, Aug | .. | .. |
| 10 | 15/0 | † India Rubber, Gutta Percha, &c., Wks. | 18—19 | 2 12 6 | Feb, Aug | 18⅝ | 18⅜ |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99—102 | 3 18 5 | Mar, Sept | .. | — |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¼—11¾ | 4 5 1 | Mar, Sept | .. | .. |
| 10 | 12/0 | Telegraph Construction & Mainten'ce. | 32½—34½ | 5 5 0 | Mar, July | 32¼ | .. |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 100—102 | 3 13 6 | Jan, July | .. | .. |
| 5 | — | Willans and Robinson Ord. | 1¾—2¼ | — | Apr, Oct | 2 | .. |
| 5 | — | Do. 6 per Cent. Cum. Pref. | 3½—4 | — | Apr, Oct | 3⅞ | 3¾ |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 82—87 | 4 12 0 | May Nov | 84 | [illegible] |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

# WHEATLEY KIRK, PRICE & CO.

*(Established 1850.)*

ELECTRICAL AND MECHANICAL VALUERS, ARBITRATORS AND AUCTIONEERS.

**TRAMWAY & ELECTRICITY SUPPLY VALUATIONS.**

Periodical Valuations, Stock-takings and Reports for DEPRECIATION, RENEWALS, &c., in conformity with the Acts.

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## SALE BY AUCTION.

MESSRS. HORNE & CO., 8, Delahay-street, Storey's Gate, Westminster, S.W., will SELL by PUBLIC AUCTION at the Royal Arsenal, Woolwich, on WEDNESDAY, 24th. January, 1906, by order of the Secretary of State for War, at 11 o'clock in the forenoon precisely, the following **UNSERVICEABLE** and **OBSOLETE STORES**, viz.:—8½ tons Ashes (Lead and Founders' Skimmings); 415 tons Iron, Cast, Wrought and Steel; 50 tons Brass (C.M.G.); 1¾ tons Copper; 4 tons Gunmetal; 4 tons Mixed Metal; Phosphor Bronze; Cupro Nickel; 10 tons Lead; Zinc; 10 ozs. troy Platinum; two Lathes; 21 incomplete Field Forges; 80 Anchors; 1,000 Cast-iron Fenders; 120 Drag Shoes; 1,000 Iron Drums; 38 cwt. Files; Tinplate; three Guns, R.M.L. 7 pr.; Electric Cable; 25 Bullion Bags; Electrical Stores; Telephones; Telescopes; Telegraph Instruments; Levels; Tackles and Chains; Blocks Differential; 133 Blocks with Metal Sheaves; Lamps and Lanterns; 5,000 Glass Measures; 10 Diving Helmets; Animal Charcoal; Rope; Canvas; Silk Cloth; Shalloon and Felt Cuttings; Resin; Paper; Waterproof Material and Sheeting; Leather (from Harness Cuttings and Miscellaneous); Hosepipes; Bed Straps; Squad Bags; one Sling Wagon and Limber, 12-ton; 10 Horse Drugs; one Truck Railway B.G.; 45 Pairs Shafts; 106 Wheels; Cart; Raves; Boxes; Cases; Chests; Casks; Barrels; Wood, &c., &c., &c. The Lots may be viewed at the Royal Arsenal, Woolwich, from 10 to 1 o'clock and from 2 to 4:30 o'clock on the Monday and Tuesday previous to and on the morning of the Sale. Catalogues may be obtained at the War Office, Pall Mall; at the Ordnance Office, Tower; and at the Ordnance Office, Royal Arsenal, Woolwich.

## MISCELLANEOUS PLANT, &c., WANTED.

WANTED, an ALTERNATOR to give about 200 kw. at moderate voltage.—Apply, giving full particulars, price, and where it can be inspected, C. S. O., *Electrician* Office, Salisbury-court, Fleet-street, London.

STEAM DYNAMO SET. 300 kw., in good condition, WANTED at once.—Apply, with full particulars, price, and where to be seen, to C. S. S., *Electrician* Office, Salisbury-court, Fleet-street, London.

WANTED, LAMP TOPS, with Platinum, Scrap Platinum, &c.—EDEY & Co., 29, Ludgate-hill, London, E.C.

## MISCELLANEOUS PLANT, &c., FOR SALE.

ELECTRIC LIGHTING PLANT for SALE.—Two Dynamos, 110 volts, 380 amperes, each belt driven by separate vertical steam engine, 60 lb. steam pressure. All in first-class working order.—Full particulars given on addressing 5994, *Electrician* Office, Salisbury-court, Fleet-street, London.

ELECTRIC MOTOR and STARTING GEAR, by Taunton Engineering Company; 20 B.H.P; direct current; 210 volts; view at Oldham; offers.—R. ACKRILL, Printer, Harrogate.

FOR SALE or HIRE, high-class Dynamos, Motors, Alternators, Cable and Electrical Apparatus.—PERCY HUDDLESTON & Co., 72, Finsbury Pavement, London, E.C.

WATCHES, Non-magnetic. Each Watch warranted, unaffected by the strongest current. Oxydised cases, 5s. 6d. post free.—SWITHENBANK, Coral-street, Saltburn.

Telegrams: Turnstile London.

# STANLEY

GOLD MEDAL St. Louis, 1904

**SURVEYING & DRAWING INSTRUMENTS.**

*NOTICE OF REMOVAL OF THE RETAIL DEPARTMENT*
from GREAT TURNSTILE to
**286, HIGH HOLBORN, LONDON, W.C.** Price List post free.

## TENDERS INVITED.

### METROPOLITAN BOROUGH OF FULHAM.

ELECTRICITY DEPARTMENT.

CONTRACT "S."

The Council is prepared to receive TENDERS for the SUPPLY and ERECTION of:—

**A—STEAM PIPING.**
**B—WATER AND EXHAUST PIPING.**

Specifications and Forms of Tender may be obtained from the Borough Electrical and Consulting Engineer, Mr. Arthur J. Fuller, after the 13th instant, on payment of a deposit of One Guinea, which will be returned on receipt of a bona-fide Tender.

Tenders made out on the Form supplied, addressed to the Town Clerk, Town Hall, Fulham, and endorsed "Tender for Contract S," to be delivered at the Town Hall, not later than 12 noon on WEDNESDAY, the 31st January, 1906.

Contractors will be required to abide by the Council's Standing Orders as to hours of labour and rates of pay.

The lowest or any Tender not necessarily accepted.

By order,
R. M. PRESCOTT, Town Clerk.

Town Hall, Fulham, S.W., 9th January, 1906.

CITY OF ABERDEEN.—ELECTRICITY DEPARTMENT.

The Electricity Committee are prepared to receive TENDERS for the Supply and Delivery of **ONE CAST-IRON DISC FLYWHEEL** for fitting to an engine of Willans & Robinson's make—approximate weight 22 tons.

Specification and Form of Tender may be obtained from the undersigned upon payment of a deposit of £1, which will be returned on receipt of a bona fide Tender.

Tenders, endorsed "Flywheel," to be delivered at the Electricity Works not later than noon on MONDAY, 22nd January.

J. ALEX BELL, City Electrical Engineer.

Corporation Electricity Works,
Millburn-street, Aberdeen.

THE ELECTRICAL COMMITTEE of the CORPORATION of BRISTOL will be glad to receive alternative TENDERS for a **2,000 and 3,000 kw. SINGLE-PHASE TURBO ALTERNATOR** (2,000 volts, 93 periods) together with **CONDENSING PLANT.** For full particulars apply, on or after 16th JANUARY, to

H. FARADAY PROCTOR, City Electrical Engineer.

Temple Back, Bristol.

## FOR DISPOSAL.

ELECTRICAL ENGINEERING WORKS, fully equipped with modern plant and machinery, to be SOLD. The property is situate at Fambridge, Essex, having an extensive frontage to the river Crouch, and an area of about 35½ acres. The buildings are all ground floor only, of substantial construction, exceptionally well lighted, and conveniently arranged.—For full particulars and terms apply to FULLER, HORSEY & Co., 11, Billiter-square, London, E.C.

ELECTRICAL JOBBING and CONTRACTING BUSINESS, Bradford; established 8 years; profits £150 per annum; easly increased; low rent; £400 work in hand; sound opening; £600.—FIRTH & Co., Business Brokers, 7, Cookridge-street, Leeds.

# GAMBRELL BROS.

Durham House, North Side,
Clapham Common, London, S.W.

MANUFACTURERS of
**ELECTRICAL TESTING INSTRUMENTS.**

CATALOGUE ON APPLICATION.

# DOULTON TROUGHING

AND BRIDGE-INSULATORS

**For SOLID SYSTEM CABLES.**

**This troughing is made of strong, hard-burnt glazed stoneware, with socket joints, in a variety of sizes, to take one or several cables.**

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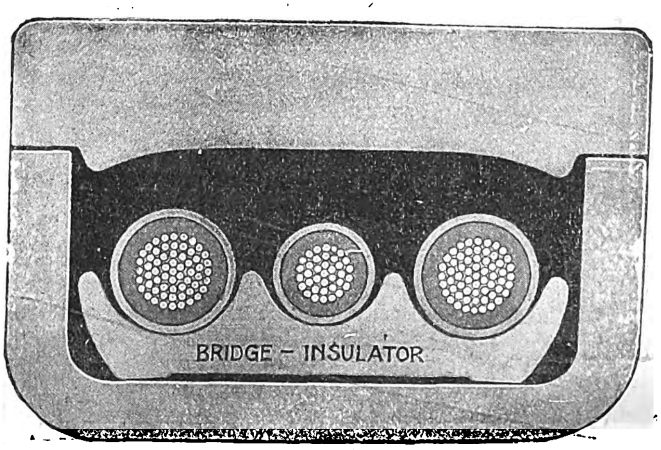

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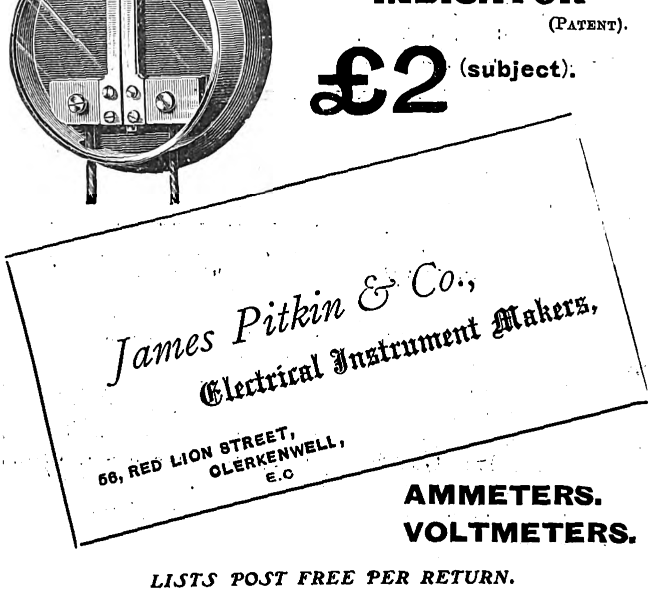

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ROME: Loescher & Co.

MILAN: U. Hoepli.
MADRID: Romo-y-Fussel.
SYDNEY (N.S.W.): Wm. Dymock.
ADELAIDE: W. C. Rigby.
TOKYO (JAPAN): Z. P. Maruya & Co.

LIVERPOOL CABLES

Our attention has been drawn to a circular issued by the Cable Makers' Association to which we wish to draw the careful attention of cable users to its suggestion that only Cables and Wires manufactured by the members of the Cable Makers' Association should be recommended by Consulting and Engineers in general. The inference is that manufacturers outside the Association are not reliable. Our Mr. TAYLOR and Mr. HARTFORD have had experience of above 25 years in the manufacture of V.I.R. Cables, Mr. TAYLOR introduced and for over 10 years (during which time the Cable Makers' Association was formed) had complete control of the manufacture of this class of Wires and Cables of one of the largest manufacturing members of the Cable Makers' Association. From this it will be seen that we are not wanting in experience.

Our Wires and Cables of the Three Standard Qualites, viz. :—300, 600 and 2,500 Megohm Grades, are equal as regards the quality of all material used, thickness of insulation, and care in manufacture in every respect to the products of the firms who compose the Cable Makers' Association. We also give the same guarantees.

The above are known as our "First Quality" or Standard Cables. Owing to the Cable Makers' Association taking what we consider a retrograde step by putting on the market an inferior quality of V.I.R. Cable, we were compelled, in self defence, to manufacture a similar "Second Quality" insulated with a good, but cheaper rubber than the standard "First Quality." In other respects all the materials used are equal to those used in the "First Quality" Cables.

These two qualities are distinctly marked in our Catalogue as follows :—

"Cables equal to Associated."
"Second Quality Cables Equal to Non-Associated."

The particulars of the latter are printed in our Catalogue on paper quite distinct from the other classes, the paper being red, so that there can be no mistake when ordering. The labels used on the coils are also of different colours—"First Quality" being White, "Second Quality" being Yellow with the words "Second Quality" printed on in large type.

As a proof of the high quality of our manufactures, we are continually receiving orders from the various Departments of H.M. Government, including the Post Office, War Office, &c., and many large Municipal bodies.

From this it will be seen that Consulting and Municipal Engineers may with perfect confidence use and recommend the use of our Cables, which are known as "LIVERPOOL CABLES," and they need not necessarily go to Members of the Cable Makers' Association in order to obtain a high quality.

For THE LIVERPOOL ELECTRIC CABLE CO., LTD.,
SAMUEL HARTFORD,
*Secretary and Manager.*

LIVERPOOL, *January 9th*, 1906.

LIVERPOOL CABLES

**CONNOLLY BROS., Ltd.,**
Vale Mills, BLACKLEY,
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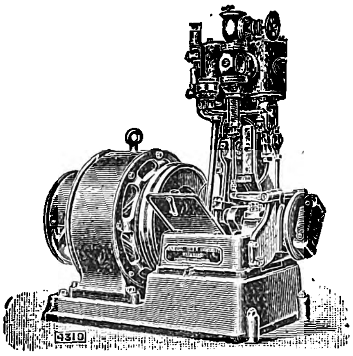

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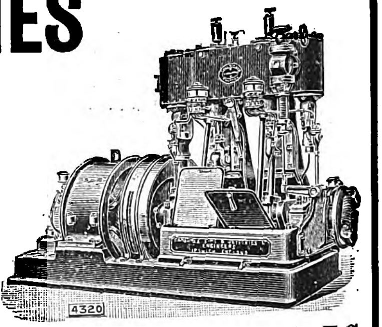

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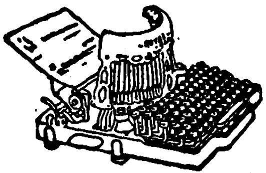

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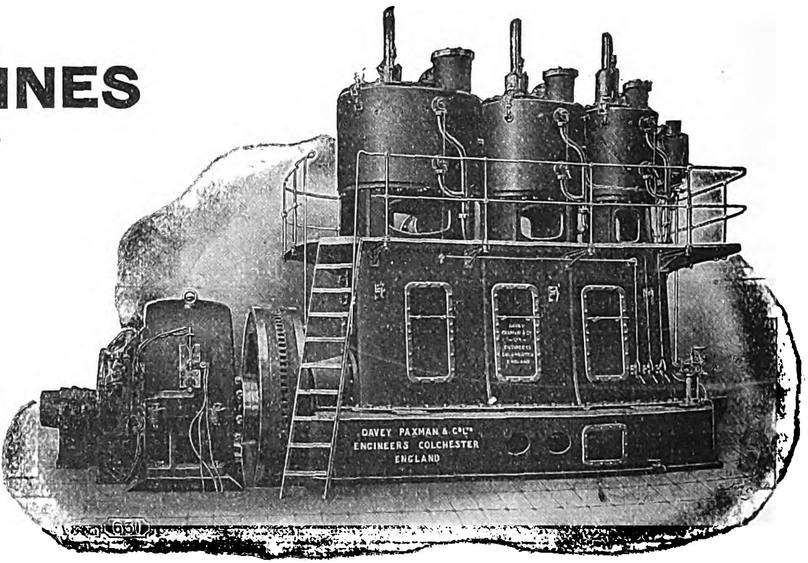

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# THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF
ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.
ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,443. [No. 13. Vol. LVI.] FRIDAY, JANUARY 12, 1906. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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## NOTES.

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A CONSIDERABLE amount of information, supplemented by detail drawings, is available concerning steam turbines, but very little exact data as to the construction of the electric machines driven by them has yet been published. It is, therefore, with much pleasure that we publish, on p. 498 of this issue, an article from the pen of Mr. H. S. MEYER, giving complete technical data of the 2,000 kw. turbo-alternators recently built by the British Thomson-Houston Co. for the Yorkshire & Lancashire Power Cos. Designers will appreciate the author's remarks concerning iron losses, ventilation, windage, centrifugal action and the other numerous points which are of much more moment in turbo-alternators than in slow-speed machines. The calculated efficiencies, which do not fall far short of 96 per cent., are very high, and it would have been interesting if the author could have confirmed his computations in this respect by an actual test; but those who know the difficulties attending a full-load test of such powerful generators will not quarrel with Mr. MEYER on this account.

IN another column will be found a description of the first public tramway to be equipped with the surface-contact system associated with the names of Messrs. GRIFFITHS and BEDELL. We described the system a short time ago, when it was in the experimental stage, and it is satisfactory to see it now in actual and, so far as we can tell at present, successful operation. The quaint old town of Lincoln, with its picturesque archways and its wealth of architectural detail, is one where the overhead trolley system would scarcely seem in keeping, but we cannot but admire the pluck and boldness of the Chairman of the Electricity Committee in recommending the Corporation to adopt an entirely new and practically untried system of surface-contact traction. No less do we admire the sporting qualities exhibited by the contractors, who, by the far-reaching nature of the guarantees they have undertaken, show that they are prepared to let their reputation stand or fall by the success of the first fifteen months' working. The technical journalists who travelled to Lincoln on Tuesday were given ample opportunity of appreciating the smooth and quiet running of the cars, though the final verdict of success or failure must be deferred until the results of running during a long period of varied conditions of weather are known.

◆

MR. MONCKTON'S note on the Trinidad–Tobago wireless telegraph stations is especially interesting as the first fairly exhaustive account of the working of the insulated Lodge-Muirhead sender. It is unfortunate, though, that this is not a normal instance of the application of that system, but rather one of exceptional difficulty. High mountains, and perhaps insufficient power, entered as serious handicaps. It is interesting to observe, however, that sufficient radiation bent over the hills to affect a receiver ten miles out at sea. We could wish that the author had tried what the primitive air-wire could accomplish in these circumstances; the comparison might have been instructive. The writer's remarks about the vigour of the atmospheric disturbances shows that this annoyance is not escaped even by the insulated receiver; but the insulation does not appear to have been nearly as perfect as is aimed at in the newest type of apparatus. This defect besides was responsible, probably, for some other of the engineer's difficulties. For if any variability in the perfection of insulation exists, tuning must become very difficult. This is especially the case in the Lodge-Muirhead radiator, since to yield the best effects its spark-gap must be at the electrical centre of the whole radiator, and variations in the capacity of the lower area, or variations in the contact with the earth, make this centre undeterminable.

THE short-circuiting of a tramway conduit by falling overhead wires appears to be a most improbable contingency, but it happened on Saturday morning last. A pair of telephone wires of about 16 gauge, which cross the roadway at Streatham-hill on a very long slant, fell, and for a length of over 100 yards the two wires mostly disappeared into one of the conduit slots of the London County Council Tramways. Coiling up inside, they crossed the conductor tees in so many places that they could not be cleared by burning out, and the tramway traffic on the up-road from Streatham-hill station was stopped for about 20 minutes whilst the short-circuiting pieces were raked out in detail. We will not suggest the provision of guard-wires, but it should be someone's business to prevent the erection of spans of fine wire about 200 yards in length over the carriage-way of an important thoroughfare.

SOME time ago a commission was appointed in Paris to examine the legal questions arising from the medical use of Röntgen rays. According to a Reuter telegram, this commission has now issued its report, with which the French Academy of Medicine has notified its agreement, and the Academy recommends that the employment of Röntgen rays for medical purposes other than by medical men should be adjudged an offence against the laws dealing with the illegal practice of medicine. This recommendation is a somewhat drastic one, and will be noted with interest by medical men in this country.

WE publish this week a short abstract of a thoroughly practical Paper by Mr. G. L. BLACK on the maintenance of underground mains. The practice in the mains department at Glasgow, now in charge of Mr. BLACK and formerly under Mr. J. C. A. WARD, is based on sound lines, and the reader will derive many useful hints from a perusal of the Paper. His testimonial to cable manufacturers—viz., that during his ten years' experience he has only come across two cases of faults in manufacture—is certainly a fine one, and we trust that cable makers will long continue to work up to so high a standard of efficiency. Ten years ago "manufacturers' faults" were by no means a negligible quantity, and doubtless the good record is largely due to the fact that in most cases the manufacturer contracted to lay the cable as well as to supply it, and that many defects which may have escaped attention in the testing room of the cable works have shown themselves immediately after the cable was laid. Faults still occur, due to external causes, however, and we notice that Mr. BLACK places main reliance on the loop test for localising them, a test which is certainly the most dependable when carried out in a proper manner. In fall of potential tests, such as the one he describes, there is always a danger that the resistance of the fault itself may be partly included in the main circuit, and that inaccurate results are obtained. This can often be avoided by using a pilot wire back from the end of the cable in cases in which an undamaged return conductor of sufficiently large section to complete the loop cannot be obtained. The arrangement described for indicating the presence of water in manholes is a luxury which will be appreciated when the expense of putting it in is warranted. There is, however, a cheaper alternative, used in Berlin, in which the ordinary low-tension pilot wires have done the duty of the multiple signalling cable in addition to fulfilling their usual function.

WE print in another column of this issue the text of a circular which has been issued to the shareholders of the Notting Hill Electric Lighting Co., and has aroused considerable comment in the City columns of the daily papers. The circular is for the purpose of calling a statutory meeting to affirm the introduction into Parliament next Session of the joint Bill promoted by the Westminster Electric Supply Corpn., St. James & Pall Mall Electric Lighting Co., Kensington & Knightsbridge Electric Lighting Co., Notting Hill Electric Lighting Co., Metropolitan Electric Supply Co., Chelsea Electricity Supply Co., Brompton & Kensington Electricity Supply Co., Central Electric Supply Co. and the Hampstead, St. Pancras, Hammersmith and Fulham Borough Councils. This Bill is called the West-End Electric Undertakers' Association Bill; and we summarised its objects in our issue for December 22nd, p. 398. Briefly it seeks to secure the authorities named from the operation of the "non-association" clause of the Electric Lighting Acts, an object which has our full sympathy.

WE commence in this issue the publication of Prof. J. A. FLEMING'S recent Cantor Lectures on "The Measurement of High-frequency Currents and Electric Waves," before the Society of Arts. These well-attended lectures were briefly reported in our "Notes" column from week to week, but we need not apologise for now reproducing the lectures in full, for they not only form the natural supplement of the author's Cantor Lectures on the same subject in 1900 and 1903, but they give an exceptionally clear and readable account of the advances made in the direction of quantitative measurements, which is the most important direction of all in any application of science which is to be developed into an engineering industry.

**Thunderstorm.**—A short, but severe thunderstorm, unusual at this time of the year, broke over London and neighbouring districts last Tuesday afternoon. Fortunately very few cases are reported of buildings being struck by lightning.

**Aron Motor Meter.**—The *London Gazette* of Tuesday contains an official announcement of the approval of the Board of Trade of the Aron Motor Meter, and further, of the means provided for fixing meters of this description, and for connecting them with the service lines.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Tarifa—Tangier | Jan. 18, 1904 |
| Jamaica—Colon | Jan. 10, 1905 |
| Cadiz—Teneriffe | July 20, 1905 |
| Puerto Plata—Martinique | Dec. 15, 1905 |
| St. Thomas—St. Kitts | Dec. 29, 1905 |
| Manila—Iloilo | Dec. 29, 1905 |

**The Patent Office Library.**—According to an interesting table in the *Illustrated Official Journal* (Patents) for December 30th of last year, the annual number of readers at the Patent Office library has increased from 4,643 in 1856 to 142,447 in 1905. In 1904 the number of readers was 137,171. Since its inauguration, in 1855, the reading room has been made use of by 2,681,599 persons, an average of some 52,500 per annum.

**Wireless Telegraph Notes.**—According to a New York telegram to the *Daily Telegraph*, the Weather Bureau at Washington has now established the system of communication by wireless telegraphy with Atlantic liners for meteorological purposes which was outlined in a note in *The Electrician*, Vol. LV., p. 248. It is also proposed to send weather forecasts, storm warnings, communications as to fog, icebergs, &c., from the shore to ships at sea.

**Obituary.**—We regret to announce the death, at the early age of 36, of Mr. Henry John Young, jun., eldest son of Mr. H. Young, of Messrs. H. Young & Co., Nine Elms, on whose staff he has been occupied in the design and execution of constructional engineering work. To perpetuate his memory a fund has been opened with the object of placing a bronze medallion portrait in the reading room of the Junior Institution of Engineers, of which he was a past chairman.

**Society of Arts.**—The following are among the lecture arrangements at the Society of Arts during January and February: On Thursdays, January 16th, 25th and February 1st, at 8 p.m., Prof. Silvanus P. Thompson will deliver his three Howard lectures on "High-speed Electric Machinery, with special reference to Steam Turbine Machines"; on Wednesday, February 7th, at 8 p.m., there will be a Paper by Mr. Leon Gaster on "Progress in Electric Lighting"; on Wednesday, February 14th, at 8 p.m., Mr. Claude Johnson will read a Paper on "The Horseless Carriage, 1895-1905"; on Wednesday, February 28th, Capt. G. S. C. Swinton (L.C.C.) will read a Paper on "London Traffic."

**Electric Power on the Rand.**—The *Yorkshire Observer* states that latest mail advices from the Rand state that the Anglo-French Exploration Co. propose to erect an enormous power station upon the New Kleinfontein group of mines. The intention is to erect the electric plant upon the Apex Farm to supply current to the whole Farrar group of companies in that district, including the New Kleinfontein, Kleinfontein Deep, Apex, Van Ryn Deep, the Chimes West, Benoni, and Klipfontein mines. This is the third electric power scheme that has been put forward. The first is the proposal to transmit power from the Victoria Falls, and the second is that of Mr. Robert Hammond's syndicate referred to in our last issue.

**Carnegie Research Scholarship.**—Applications to the Iron and Steel Institute for a Carnegie Research Scholarship must be made to the Secretary of the Institute, on special forms, before the end of February. Full particulars will be sent by Mr. Bennet H. Brough, the secretary, at 28, Victoria-street, Westminster; but we may point out two years ago Mr. Andrew Carnegie presented to the Iron and Steel Institute 89 $1,000 5 per cent. debenture bonds for the annual award of scholarships to enable students who have passed through a college curriculum or have been trained in industrial establishments to conduct researches in the metallurgy of iron and steel and allied subjects, with the view of aiding its advance or its application to industry.

**An Electric Accelerometer.**—A combined accelerometer and speed indicator is described by Prof. R. B. Owens in a recent Paper before the Canadian Society of Civil Engineers. A small continuous-current dynamo, constantly excited by a permanent magnet or otherwise, is driven by the shaft whose velocity and acceleration is to be measured. Instead of this being simply connected to a voltmeter as in the case with the ordinary electrical speed indicator, leads are taken to a circuit containing an ammeter, a resistance and the primary of a small transformer. The object of the latter is to enable the rate of change of the current in the primary circuit to be read on a voltmeter connected to the secondary. As the current in the primary circuit will be proportional to the speed of the generator and the rate of change of current to the acceleration, it will be possible to read these two quantities direct on the ammeter and voltmeter by a suitable calibration. The generator must be designed to have a negligible armature reaction, and the transformer a straight line saturation curve and a large transformation ratio. With recording instruments, the apparatus, an account of which is given in the *Canadian Electrical News*, should prove useful in studying tractive resistance problems in railway and automobile work.

**The Production of Nitrogen from the Atmosphere.**—At the inauguration of the new chemical institute of the Technische Hochschule in Berlin, Prof. O. R. Witt gave some interesting information regarding recent developments in connection with the production of nitrogen from the air by electrical means. According to the *Elektrotechnischer Anzeiger*, the professor said that the greatest progress had been made in Norway, where Prof. Birkeland, assisted by Herr S. Eyde, had developed a commercial method of producing nitrogen, using an arc elongated by a magnetic field and a voltage of 5,000 volts. Experiments were first started with a 20 H.P. plant in 1903. After experimenting with plants of increasing size, the inventors built their first factory at Notodden in May, 1905. The equipment here consists of three furnaces, each consuming 700 H.P., and all three combined deal with 75,000 litres (2,650 cubic ft.) of air per minute. Before entering the furnace, the air is mixed with nitric oxide which gives it an intense brown colour. After passing through the furnaces, the gases are led to stone towers (having a capacity of 8,800 gallons each) where nitric acid is formed. Copper tubes are used as electrodes, being cooled by a water circulation. It is stated that plants of less than 5,000 H.P. are not commercial; in fact, it would seem that installations of less than 20,000 H.P. are also doubtful in this respect, even if the power be very cheap.

**Visit to Kingsway Subway.**—A large number of members of the Tramways and Light Railways Association assembled at the Aldwych station of the Kingsway Subway last Monday afternoon, and were met by Mr. A. L. C. Fell, chief officer of the London County Council's tramways, and other officials. The subway is now practically finished, and the service of electric tramways between Aldwych and Theobald's-road, somewhat less than one mile, is to be inaugurated before the end of this month. At present the portion of the line between Aldwych and the north side of the Strand is to be used as a car depot pending the consent of Parliament to a continuation of the subway to the Embankment. In this temporary depot the cars are to be supplied with current from an overhead trolley wire, but the remainder of the subway is equipped on the conduit system. The tunnels are lined with glazed brick and look smart and bright. Incandescent lamps and small arc lamps are used to illuminate the subway stations, and supplement the day light, which is admitted through the entrance and exit. After inspecting the prolongation of the subway towards the Strand, the party boarded a car (which is of the all-steel type and single-deck), and were conveyed at a good speed to the Theobald's-road end of the subway, this being reached after dipping to a considerable depth under some sewers along Holborn, and climbing the stiff incline which leads to the surface system at Theobald's-road. The visitors returned to the starting point through one of the two small side tunnels used for accommodating water mains, gas pipes, electric power, telegraph and telephone cables, &c.

**High-tension Continuous-current Traction in Vienna.**—Herr Franz Krizik, who is carrying out tests with high-tension continuous-current traction on the Vienna railway system, read a Paper on this subject before the Austrian Society of Engineers and Architects a short time ago. Much of the information given coincides with that published in *The Electrician* of October 20th, p. 2, and the following contains some additional particulars abstracted from Herr Krizik's Paper. The railway system is to be worked with electric locomotives fed with current on the three-wire overhead system, the voltage between the outers being 3,000 volts. The locomotives have two axles, each being driven by two 200 H.P. motors, whose pinions engage with a common gear wheel keyed to the axle. In order to obtain satisfactory commutation, the flux-density in the armature has been kept high, a large number of commutator segments has been adopted and one turn per segment is employed. The air-gap is 5 mm. ($\frac{3}{16}$ in.). At starting, all the four motors of the locomotive are connected in series across one side of the three-wire supply; as soon as the counter E.M.F. of the motors reaches 375 volts they are connected in series across the outers of the three-wire system, and when the counter E.M.F. of the motors attains the value of 750 volts, the speed is further increased by weakening the motor fields. A 160 ton train is accelerated by a locomotive at the rate of

0·42 metres per second per second (1·38 ft. per second per second), and the energy consumed to accelerate the train up to 24·8, 28, 31 and 34·2 miles per hour is 4·271, 5·461, 7·13 and 9·37 kw.-hours respectively. The average distance between stations is about 0·59 miles, and the average energy consumption per ton-mile is computed to be 75·6 watt-hours.

**Motors for H.P. Centrifugal Pumps.**—Motors for driving high-pressure centrifugal pumps are often of unusual dimensions, and the figures reproduced below, from *Elektrische Bahnen & Betriebe*, relating to motors supplied by the Felten & Guilleaume-Lahmeyer works to a number of mines are not without interest:—

| | —— | Rhein-preussen mine, Homberg. | Char-lotte pit, Czernitz. | Friedlicher Nachbar mine. |
|---|---|---|---|---|
| | Cu. m. of water raised by pump per min. | 5·5 | 3·5 | 5 |
| | Head of water ..................... m. | 450 | 262 | 620 |
| | Capacity of motor ................ H.P. | 650 | 260 | 2, each 250 |
| | Revolutions per minute .............. | 60 | 175 | 1,500 |
| | Voltage ........................... | 2,000 | 750 | 5,000 |
| | Frequency ................ ∾ per sec. | 25 | 15 | 50 |
| | Number of poles .................... | 48 | 10 | 4 |
| Stator | Outside diameter ............... mm. | 5,000 | 1,800 | 1,000 |
| | Length (including vent. ducts) ...... | 450 | 450 | 800 |
| | Inside diameter.................... | 4,700 | 1,500 | 680 |
| | Number of slots.................... | 432 | 120 | 60 |
| | Dimensions of conductor........ mm. | 5·4 × 6·5 | 5·4 × 6·4 | 5·0 × 5·9 |
| | Resistance per phase .......... ohms | 0·15 | 0·068 | 0·69 |
| | Power factor ....................... | 0·75 | 0·93 | 0·94 |
| Rotor | Outside diameter .............. mm. | 4,693 | 1,496 | 674 |
| | Inside „ .............. mm. | 4,500 | 1,300 | 450 |
| | Number of phases.................. | 11 | 3 | 3 |
| | „ „ slots.................... | 528 | 150 | 84 |
| | Dimensions of conductor........ mm. | 16 × 18 | 15 × 10 | 9 × 11 |
| | Resistance per phase .......... ohms | 0·0053 | 0·0167 | 0·0192 |
| | Slip ............................ % | 3 | 2·75 | 1·25 |
| | Efficiency ...................... % | 91 | 91·4 | 95·1 |

**Turbine Worked with Exhaust Steam.**—According to the *Street Railway Journal* the Philadelphia Rapid Transit Co. has just installed at its power station at Thirteenth and Mt. Vernon-streets an 800 kw. Curtis low-pressure turbine, which takes steam from the engine exhaust. This station is equipped with four Wetherill-Corliss engines of 1,500 nominal H.P. and one Wetherill-Corliss engine of 2,200 nominal H.P., and have always been run without condensers. An Alberger condenser and cooling tower with 8,000 square ft. have recently been erected, however, for the use of the low-pressure turbine. The average vacuum attained in the condenser is 28 in., although a maximum of 29½ in. has been reached. The turbine takes steam from the exhaust main at a pressure of, say, 1 lb. above the atmosphere, and is provided with four wheels, each with a single row of buckets. Exhaust steam from one engine when developing 2,500 H.P. is sufficient to secure an output from the turbine of 1,300 amperes at 575 volts, with no increase in the back pressure on the engines. As about 150 amperes are required to operate the auxiliaries, the gain from the use of the turbine is from 1,000 to 1,200 amperes, or approximately 66⅔ per cent. of the output of the original generating unit, instead of the 25 per cent. usually expected from the introduction of a condenser. The turbo-generator has six poles and runs at from 1,100 revs. per min. to 1,200 revs. per min. When the turbine is receiving steam at atmospheric pressure without moisure and there is 2 in. absolute back pressure in the condenser, the guarantees provide that the steam consumption shall not exceed 36 lb. per kw.-hour at full load and 40 lb. at half load. At 4 in. absolute back pressure, these figures are respectively 45 lb. and 50 lb.

**H.T. Power Transmission in Germany.**—What is claimed to be the largest artificial lake in Europe has recently been completed in Germany. It was formed, according to the *Zeitschrift für Elektrotechnik*, by building a dam across the Urft valley near Gemünd (Germany), the dam being 740 ft. long, 190 ft. high and 166 ft. thick at the base. Some 210,000 cubic yds. of brickwork were used in its construction, and the reservoir is said to contain no less than 10,000 million gallons of water. The power station is at Hembach, and the water with a head of from 230 ft. to 360 ft., is fed here to six horizontal 2,000 H.P. turbines, by Escher, Wyss & Co., running at 500 revs. per min. Each turbine is directly coupled to a three-phase 5,000 volt alternator by the Felten & Guilleaume-Lahmeyer Co. The voltage is stepped-up to 35,000 volts by eight transformers. This pressure is the highest voltage used so far in Germany for transmission purposes, and it is necessitated by the large area of distribution from 200 to 250 miles in perimeter. Since the average annual quantity of water flowing into the reservoir is calculated to be 35,200 million gallons, it is expected that 4,800 H.P. will be available during 7,200 working hours, or proportionally more if the number of working hours is reduced. Current for the excitation is generated by one of two 200 H.P. turbo-generator sets. The overhead transmission wires are erected on poles 23 ft. high, and the lines are to be inspected by men on motor cycles. Taking all the losses into account, about 22 million kw.-hours will be available per annum at the consumers' premises, and we understand that 18 million units have already been applied for at prices varying from 0·72d. to 3d. per unit. Most of the energy will be consumed in Aachen and vicinity. The proposed single-phase railway from Call to Hellenthal is also to be supplied with electric power from the new station.

**Direct-connected Motors in Textile Work.**—In an article by Mr. H. S. Knowlton on the above subject in a recent issue of the *American Electrician* it is stated that the production rate of looms has been shown by actual test to be increased from 5 to 7 per cent. when the individual drive is employed in lieu of group-driving by belts. In a certain mill which manufactures cotton duck, the weave room was originally equipped with a 65 H.P. induction motor and shafting, from which the looms were driven by belts. The first cost of the motor was $985; the belts and shafting cost $1,970, making the total investment $2,955. Not long since the individual drive was substituted in the form of ten 1 H.P. and 64 ½ H.P. Westinghouse induction motors. The 10 large motors cost $760 and the smaller ones $4,150, making a total of $4,910. The difference in the investment was, therefore, $1,955 in favour of the group drive. However, tests showed with the individual drive a saving of 15 H.P. otherwise lost in belt and shafting friction, which would cost $375 per year at the moderate steam plant production cost of $24 per horse-power per annum. The interest on the excess cost at 5 per cent. came to $98 per year, leaving a saving of $277 per year in favour of the individual drive. In another recent case the first equipment of a spinning room was a 65 H.P. motor costing $985. The belts and shafting came to $798, making $1,779 for the installation. This was replaced by 18 motors rated at 3 H.P. each, representing an investment of $1,830. The annual saving in friction loss was 7 H.P., or $175 at $25 per H.P.-year. In this instance the cost of replacing the old equipment with direct-connected motors was so slightly in excess of the original investment that even if there had been no saving in friction losses it paid to make the change on account of the general advantages of the direct drive.

**Rateau's Regenerative Heat Accumulator.**—It is stated by Herr Martiny in a recent issue of the *Elektrotechnischer Anzeiger* that a Rateau regenerative heat accumulator (of a type similar to that illustrated and described in *The Electrician*, Vol. LIII., p. 350) has been employed since the beginning of May of this year at a certain steel and iron works in Düsseldorf. The accumulator receives the exhaust steam from the different steam engines working intermittently in the iron works, the average amount of steam thus received amounting to about 25,500 lb. per hour. Of course, the back pressure of the accumulator fluctuates somewhat, but the fluctuations are usually unimportant. If the pressure in the accumulator exceeds 1·20 atmospheres (17·6 lb. per square inch absolute) or thereabouts, a safety valve opens which permits the excess steam to escape into the air. If, on the other hand, the pressure in the accumulator drops to 1·05 atmospheres (15·4 lb. per square inch absolute), live steam is automatically admitted to the accumulator. It appears that the latter contingency does not often arise. From the accumulator the steam flows in a steady stream to the Rateau turbine, which is directly coupled to two 200 kw. 220 to 250 volt continuous-current generators for the works' electric supply. The following table contains some test figures. It was not possible to determine the steam consumption of the turbine per kilowatt-hour, but it is believed that this consumption does not exceed 46½ lb., the initial pressure being 14·7 lb. per square inch absolute and the pressure in the condenser being 2·06 lb. per square inch absolute. It may be remarked that provision is made for exhausting from the reciprocating engines directly into the condenser. But the gain in steam consumed, it is computed, would only be 15 per cent., while the saving with the new arrangements amounts to 51 per cent.

| Turbo-generator. | | | Lbs. per sq. in. in Rateau accumulator. | Turbine. | |
|---|---|---|---|---|---|
| Revs. per min. | Volts. | Kw. | | Init. pres. of steam (lbs. per sq. in. abs.). | Back-pressure (lbs. per sq. in. abs.). |
| 1,340 | 235 | 206·0 | 16·53 | 7·36 | 1·77 |
| 1,350 | 240 | 120·0 | 17·06 | 6·18 | 1·91 |
| 1,340 | 500 | 307·5 | 16·49 | 10·9 | 1·91 |
| 1,360 | 490 | 455·0 | 16·18 | 13·7 | 1·91 |

**New York Central and Hudson River Railroad.**—The two power stations at Yonkers and Port Morris which are under construction for the electrical operation of the suburban district traffic of this railway contain fine examples of compactly arranged generating plants. They are similar in general design and consist in each case of a main building, 167 ft. wide 237 ft. in length and 105 ft. high, containing the boiler and generating plant with separate switch houses about 40 ft. away. It is interesting to note that the cubical contents of the station buildings is 102 cubic ft. per kilowatt capacity and the floor space 1·49 sq. ft. per kilowatt. Coal is fed to the boilers from large overhead bunkers, to which it is supplied by a coal conveying plant of a capacity of 80 tons per hour. The battery of 24 Babcock & Willcox water-tube boilers rated at 625 H.P. each will be situated all on one floor. Each power station is designed to contain six 5,000 kw. turbo-generators. The turbines are of the Curtis five-stage vertical type, and each is provided with its own complete condensing plant. Directly coupled to each turbine is a three-phase generator wound for 11,000 volts 25 cycles. The armatures are star-connected, and the neutral points are earthed through cast-iron grid resistances to limit the current in case of a short-circuit in either branch to an amount sufficient to operate the line overload relays. Independent exciting plant is provided, consisting of two turbine-driven 150 kw. sets, and one 150 kw. induction motor-generator; in addition to these, a battery of 70 cells with a capacity of 1,200 amperes for one hour is provided, which also operates a portion of the station lighting and auxiliary motors. A noteworthy feature of the arrangement of the switch gear is the location of all the low-tension switching equipment in a separate building apart from the main building, only the control boards and the exciter and auxiliary low-tension boards being in the engine-room galleries. Provision is, however, made in the switch houses, so that the main operating control board can be put out of service for cleaning or repairs, and the station can be operated from the switch house in cases of emergency. The oil switches are all motor-driven. Overload time-limit relays are installed in both the generator and feeder circuits; the former are, however, set to operate only under extreme conditions. Reverse-current relays are also to be installed; they will not be used to trip the oil switches, however, but will only be connected to indicator lamps. The arrangement of oil switches and connections is such that the apparatus belonging to one generator and three feeders form a unit which is entirely separated from the others by fireproof walls in the basement. In each station a "load despatcher's" office is provided for the control of the distribution of power over the system, and in order to give quick relief in case of accident or trouble, only one of these offices will be in service at a time. Each load despatcher's office will be equipped with a record board, indicating by means of lights and plugs which generator lines or rotaries are in or out of service and which switches are open or closed. The current from these generating stations is converted to direct current at 666 volts at eight sub-stations. Two of these will contain eight rotary converters for 1,500 kw. each, one six machines of the same size, and the remainder eight units each, at 1,000 kw. capacity, although at first only three converters will be put down at each sub-station. The rotaries are fed by groups of single-phase transformers, which are provided with extra taps for varying the meltage according to the drop in the transmission lines, or according to the distribution of load among the sub-stations. Motor operated switches, similar to those in the main stations, are installed, and all control is effected from operating boards in the centre of each sub-station. A spare panel with auxiliary bus bars is provided, to which any feeder or machine may be connected during repairs to its own panel. Starting up can be done from either the alternating or continuous current side of the converters, the power being carried out by a series of taps on the secondaries of the transformers. Each sub-station is provided with a large battery controlled by reversible boosters governed by automatic carbon regulators. These batteries are of sufficient size to work the entire system for a period of one hour in event of a temporary stoppage of the generating plant. Five of them have a capacity of 2,250 ampere hours at a one-hour rating, and the others 3,000, 3,750 and 4,020 amperes at the same discharge rate.

## ARRANGEMENTS FOR THE WEEK.

**To-day (FRIDAY), January 12th.**

NORTHAMPTON INSTITUTE ENGINEERING SOCIETY.

*5:45 p.m.* Meeting at the Institute, St. John-street, Clerkenwell, London. Paper to be read: "Electricity Applied to Mining," by T. Y. Porter.

MANCHESTER STUDENTS' SECTION: INSTITUTION OF ELECTRICAL ENGINEERS.

*7:30 p.m.* Meeting at the Municipal School of Technology, Sackville-street, Manchester.

INSTITUTION OF CIVIL ENGINEERS: STUDENTS' MEETING.

*8 p.m.* Lecture by Prof. J. D. Cormack on "The Theory of Machines."

**SATURDAY, January 13th.**

BIRMINGHAM AND DISTRICT ELECTRIC CLUB.

*7:30 p.m.* Meeting at the Colonnade Hotel, New-street, Birmingham. Presidential Address, by J. A. Jeckell.

**MONDAY, January 15th.**

INSTITUTION OF ELECTRICAL ENGINEERS: NEWCASTLE LOCAL SECTION.

*8 p.m.* Meeting at the Armstrong College, Newcastle-on-Tyne. Paper to be read: "A Reversible Booster and its Running," by C. Turnbull.

**TUESDAY, January 16th.**

UNIVERSITY OF LIVERPOOL ENGINEERING SOCIETY.

*5:30 p.m.* Meeting in the University. Presidential Address, by H. G. Williams.

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER LOCAL SECTION.

*7:30 p.m.* Meeting in the University. Paper to be read: "Electric Winding as Applied to Main Shafts, considered Practically and Commercially," by W. C. Mountain.

ELECTRICAL CONTRACTORS' ASSOCIATION: LONDON SECTION.

*8 p.m.* Meeting at Frascati's Restaurant, Oxford-street, London. Paper to be read: "Secondary Batteries," by F. W. Crawter.

**WEDNESDAY, January 17th.**

INSTITUTION OF ELECTRICAL ENGINEERS: BIRMINGHAM LOCAL SECTION.

*7:30 p.m.* Meeting in the University. Paper to be read: "A New System of Automatic Boosting," by Max J. E. Tilney.

INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.

*7:30 p.m.* Meeting at 92, Victoria-street, Westminster, London, S.W. Paper to be read: "The Uses of Electricity on Automobiles," by R. A. Frank.

**THURSDAY, January 18th.**

INSTITUTION OF ELECTRICAL ENGINEERS: LEEDS LOCAL SECTION.

*7:15 p.m.* Ordinary General Meeting at the University. Paper to be read: "The Rectification of Alternating Currents," by P. Rosling.

SOCIETY OF ARTS.

*8 p.m.* "Howard" Lecture I., by Prof. Silvanus P. Thompson, F.R.S., on "High Speed Electric Machinery with Special Reference to Steam Turbine Machines."

INSTITUTION OF ELECTRICAL ENGINEERS: DUBLIN LOCAL SECTION.

*8 p.m.* Meeting at the Royal College of Science, Dublin. Paper to be read: "Electric Cranes," by John Ritchie.

RUGBY ENGINEERING SOCIETY.

*8 p.m.* Meeting at the Benn Building, High-street, Rugby. Paper to be read: "The Design of a Large Shop for Electric Manufacturing," by F. J. Sharr.

**FRIDAY, January 19th.**

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse by Prof. J. J. Thomson, F.R.S., on "Some Applications of the Theory of Electric Discharge to Spectroscopy."

**SATURDAY, January 20th.**

INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.

*10 a.m.* Visit to the Works of the India Rubber, Gutta Percha & Telegraph Works (Ltd.) at Silvertown.

# DESIGN OF TURBO-ALTERNATORS.

BY H. S. MEYER.

## INTRODUCTION.

The perfection of the steam turbine has forced electrical designers to extend considerably their limits of "good practice." This can best be seen when comparing some of the leading features in the design of engine-driven alternators with those of turbo-alternators. In the former, the output per pole for 25 cycles was usually limited to about 150 kw., and for 50 cycles to about 75 kw. With the latter, the output per pole for 25 cycles may go up to 1,000 kw., and for 50 cycles to 500 kw. In the same manner the peripheral speed had to be increased from a maximum of about 8,000 ft. per minute to a maximum of about 16,000 ft. per minute. This large extension of the working range involved many new and difficult problems, both in regard to the mechanical and the electrical design. It is proposed to show in the following, on an example, how the main points in the design and the construction of such high-speed alternators are worked out in practice; the writer having been responsible for the design of the generators connected to the Curtis turbines, built by the British Thomson-Houston Co. in Rugby, will deal with a 1,500 kw. to 2,000 kw. unit of this type, as supplied to the Yorkshire & Lancashire Power Cos.

### GENERAL SPECIFICATIONS.

*Output.*—1,500 k.w. at 85 per cent.; power factor, 11,000 volts 50 cycles.

*Overload.*—50 per cent. for two hours.

*Regulation.*—8 per cent. full non-inductive load; 20 per cent. at 85 per cent. power factor.

*Heating.*—Not more than 40°C. after continuous run at rated load.

*Excitation Voltage.*—200 to 220 volts.

*High-potential Test.*—22,000 volts for one minute when hot.

Since the Curtis turbine for this output is designed for a speed of 1,000 revs. per min., the alternator requires 6 poles, and, in view of the vertical arrangement of the steam end, it is laid out to work with a vertical shaft on top of the turbine. The general arrangement of this set was shown in *The Electrician*, Vol. LV., p. 162, and Vol. LII., p. 160.*

## I.—ELECTRICAL DESIGN.

*Rotor Diameter.*—For electrical reasons this should be as large as possible, but mechanical reasons limit it in this particular construction to about 48 in., with a resultant peripheral speed of about 12,500 ft. per min.

*Length.*—In view of the large output per pole, the length in these machines becomes considerable, and therefore ample provision has to be made for ventilation. In the machine under discussion there are seven internal air ducts of $\frac{1}{2}$ in. each, giving a total effective radiating surface of about 50,500 sq. in., with a total length of iron = 23 in. Considering that the insulation between core plates takes up about 10 per cent. of the actual iron length, we obtain an effective length of iron = 17·5 in.

*Armature Reaction.*—To obtain a short machine, the armature reaction should be high, but the required voltage regulation limits the designer in this direction. The theoretical ampere turns per pole in a three-phase machine are equal to $\sqrt{2} \times 1{\cdot}5 \times$ amperes per phase × turns per pole and phase; and, as found from experience with three slots per pole and phase in the stator, a correction factor of 1·15 – 1·2 has to be added for obtaining the actual armature reaction. The specified regulation calls for a ratio of

$$\frac{\text{no-load field ampere turns}}{\text{full-load armature ampere turns}} = \text{about } 2,$$

and since the maximum space available for field copper can be obtained from the preliminary lay out of the magnetic circuit, the armature reaction has to be chosen accordingly. In the present case there is room for about 16,000 field ampere turns per pole, with a current-density of about 1,500 amperes per square inch. Allowing now about 30 per cent. of these ampere turns as increase in excitation for counteracting the armature reaction at rated load, the available no-load ampere turns are 11,000 and the corresponding armature reaction about 5,500. With a current per phase = 79, this means about 27 turns per pole and phase or 162 turns in series per phase.

*Stator Winding.*—54 slots being selected for the stator as most suitable, one obtains 18 conductors per slot grouped, for instance, as shown in Fig. 1. The insulation of such high voltage windings takes up a considerable amount of room, the space factor in the slots—*i.e.*, the ratio $\frac{\text{area of copper}}{\text{area of iron}}$ in this case being only about 0·25. The method of winding and insulating these coils will be dealt with later; here it is sufficient to refer to the resultant dimensions of the slot as given in Fig. 1. The conductors consist of stranded cable giving a current density at full load of from 1,500 to 1,800 amperes per square inch, according to the character of the load.

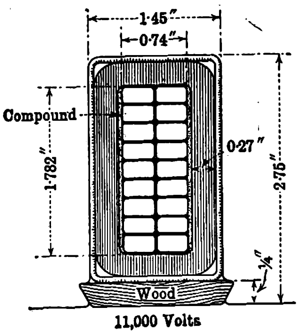

FIG. 1.

*Magnetic Data.*—From the selected number of turns in series per phase the flux per pole is obtained by the well-known formula:

$$\text{flux} = \frac{\text{Voltage per phase} \times 10^8}{4{\cdot}4 \times \text{frequency} \times \text{turns}},$$

or, in this case, about *18 megalines.* This value, together with the experimentally determined leakage flux of about 3 megalines, gives by referring to Fig. 2 the following magnetic densities:—

Armature core = 50,000 lines per square inch.
Armature teeth = 106,000 " "
Air-gap = 52,000 " "
Magnet core = 102,000 " "
Magnet yoke = 80,000 " "

From the length of the magnetic path, and by choosing the proper length of air-gap, the resultant no-load ampere turns at 11,000 volts are made to be 11,000 as required. After calculating the no-load saturation curve, the field excitation for various loads, using an armature reaction of 5,200 ampere-turns, is obtained by the well-known graphical method* as follows:—

Full load, 100 per cent. P.F. = 12,100 ampere turns.
Full load, 85 per cent. P.F. = 16,800 " "
50 per cent. overload, 100 per cent. P.F. = 14,600 " "

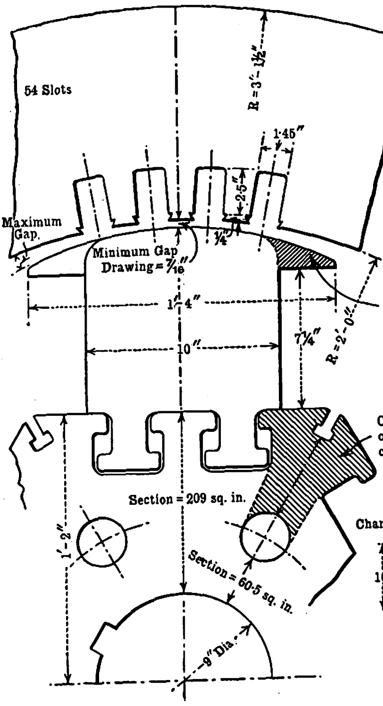
54 Slots
R = 3′-1½″
1·45″
2·5″
⅞″ Maximum Gap.
Minimum Gap Drawing = $\frac{7}{16}$″
¼″
1′-4″
10″
7¼″
R = 2′-0″
Core length of shaded part only 16″ each side
Core length of shaded part only 15″ and on two of the corners only 14″
Section = 209 sq. in.
1′-2″
Section = 60·5 sq. in.
9″ Dia.

FIG. 2.

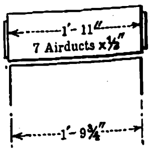

FIG. 3.

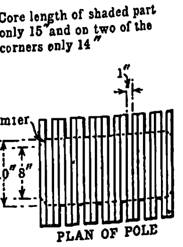

FIG. 4.

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* The first-mentioned of these two articles (*The Electrician*, Vol. LV., p. 162) indicated the general lines on which these turbo-alternators are built, and the present article may be taken as giving the necessary supplementary detail of the design of such machines.—ED. *E.*

* See "Voltage Regulation in Alternating-current Systems," Paper by the author before the Liverpool Engineering Society, 1901, *The Electrician*, Vol. LII., pp. 701, 743, 772.

The corresponding values for the voltage regulation expressed as rise in volts from full load to no load with full-load excitation, are :—

Full load 100 per cent. P.F. = 7·5 per cent.
Full load 85 „ „ P.F. = 18·0 „ „

or both well within the specification.

*Field Winding.*—In view of the high excitation voltage, it was found necessary to resort to a double field spool, such as illustrated in Figs. 3, 4 and 5. It will be seen that ventilating spaces are provided between the two spools, as well as between the inside spool and the iron core, thus facilitating the dissipation of heat produced in the field winding. There are 300 turns in series per pole, each consisting of copper strip wound on edge 0·035 × 1 in. The resistance of the winding at 60°C. is 2·93 ohms, this giving the following values for the excitation.

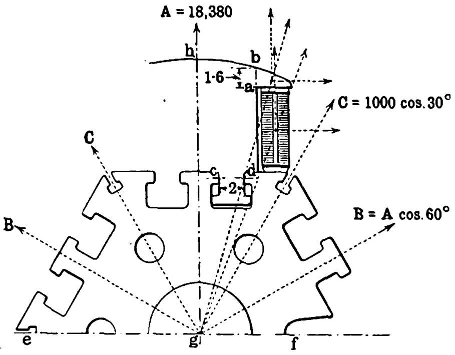

Fig. 5.

| | Current. | Voltage. | Kw. |
|---|---|---|---|
| No load, 11,000 volts ................ | 37 | 109 | 4,000 |
| Full load, 11,000 volts 100 per cent. P.F. | 42·7 | 125 | 5,330 |
| Full load, 11,000 volts 85 per cent. P.F. | 53·7 | 158 | 8,460 |

The difference in the voltage is taken up in the field rheostat.

### LOSSES AND EFFICIENCY.

*Core Loss.*—One of the most marked features of turbo-alternators is the predominating influence of the iron losses on the efficiency. While in moderate speed alternators the iron losses are about equal in value with the total copper losses, in the former type the iron losses may be as much as three times the copper losses, particularly if the insulation of the core plates is not made with the greatest care. It is exceedingly difficult to predetermine exactly the iron losses, and most designers multiply the theoretical loss by an empirical constant lying between 1·5 and 2·5. In view of the importance of this point, a detailed calculation of the core loss is given.

The theoretical loss is obtained by the method given in Steinmetz' "Alternating Current Phenomena," p. 133. The laminations are assumed to be perfectly insulated from one another—the thickness is 0·5 mm., and the specific conductivity K is the average value of that measured in the works laboratory—*i.e.*, has a value of $0·77 \times 10^5$ or 1·3 microhms per centimetre. The hysteresis loss is based on Steinmetz' coefficient, $\eta = 1·7 \times 10^{-10}$, which is equivalent to 3,000 ergs. per $cm^3$ per cycle, with a maximum induction of 8,000 lines per square centimetre, as given in the tests of the iron used.

*Eddy Current Losses.*—$P = 1·645 V d^2 \gamma N^2 B^2 \times 10^{-16}$.

$\gamma$ from laboratory tests $= 0·77 \times 10^5$.

$\therefore P = 1·27 V d^2 N^2 B^2 \times 10^{-11}$; $d = 0·05$ cm. $N = 50$. V = Volume of iron. $B = 7,900$.

(*a*) Core. P = 3,000 watts.
(*b*) Teeth. P = 1,600 watts.

*Hysteresis Losses.*—$P = \eta \times N \times B^{1·6} \times V$.

(*a*) Core. P = 7,450 watts.
(*b*) Teeth. P = 3,500 watts.
Total loss 3,000 + 1,600 + 7,450 + 3,500 = 15·550 kw.

This theoretical value should in the present case be multiplied by 2, so as to take care of the loss between plates due to imperfect insulation, and also of the loss in the pole faces. Both these losses being eddy losses, they will vary with the square of the thickness of the plates, so that any contact between plates would very quickly increase this loss. From experiments made in this direction, it has been fully borne out that the iron loss consists chiefly of eddy losses, since it varies almost with the square of the frequency.

Further, it is probable that the actual hysteresis loss will be close to the calculated value, since the total flux and cross section of the iron can be accurately determined, and experiments have shown that even if the distribution across the section of iron varies very considerably, this only has a very small effect on the loss. The other factor—*i.e.*, the effect of higher harmonics—will also affect the hysteresis loss very slightly, as the amplitude of these harmonics is not large enough to cause an actual reversal of magnetism, and only cause the magnetic cycles to be described slower at some instants and faster at others. This, of course, does not affect the area of the hysteresis loop.

*$C^2R$, Stator.*—This loss, taking a mean length of turn of about 135 in. and 60°C, amounts for full load at 100 per cent. power factor to 6,500 watts ; and for full load with 85 per cent. power factor to 9,000 watts.

*Friction and Windage.*—This loss is considerable in high speed structures if good ventilation is aimed at. In the present case it is assumed to be about 20 kw., and actual tests have shown that this figure is rather under than over estimated.

*Efficiency.*—When the above-given losses are added we obtain the following efficiencies :—

| — | $C^2R$. | $C^2R$ Armature. | Core Loss. | Fric. and Windage. | Total. | Efficiency. |
|---|---|---|---|---|---|---|
| Full 100% P.F. | 5,330 | 6,500 | 31,100 | 20,000 | 62,930 | 95·9 |
| „ 85% P.F. | 8,460 | 9,000 | 31,100 | 20,000 | 68,540 | 95·6 |

*Heating.*—Taking the core loss *plus* about one-third the $C^2R$ armature loss as representing the loss taking place in the iron, the watts per square inch of radiating surface are $\frac{35,000}{50,500} = ·69$, which, in view of the forced ventilation produced by the rotor, can be accepted as a guarantee that the rise in temperature will keep below the 40°C specified.

## II.—MECHANICAL DESIGN AND CONSTRUCTION.

*Stator Frame.*—The stator is built up of annealed and japanned punchings, which are held in a cast-iron frame by dove-tailed keys and clamping flanges. These end flanges press on strong fingers supporting each tooth, thus preventing vibration with consequent noise.*

*Winding.*—The windings consist of single coils per slot, shaped as shown in Figs. 6, 7, and 8. They are made in such a manner that all moisture is first extracted by a vacuum process and then the interstices of the coil are completely filled with an asphalt compound, which is solid at the running temperatures of the machine. This filling, in addition to preventing the accumulation of moisture inside the coil through the movement of the air caused by the variation in temperature, also serves to conduct the heat out of the coil at a much faster rate than if air were present, and therefore leads to a lower temperature of the winding. The coils thus filled are covered with a number of layers of tape, each treated in such a manner that a glaze of oxidised oil is formed, which is practically infusible, and which acts as a permanent seal to the fibres of the tape. The finished coils are entirely moisture and oil-proof, remaining at the same time sufficiently flexible to lend themselves readily to bending and clamping, so that vibrations or severe strains, such as caused by wrong paralleling or short circuits of the system, have hardly any effect. The method of clamping these coils is clearly seen in the sectional drawings of the machine in the previous articles already alluded to. It

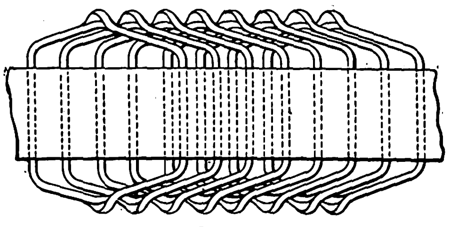

Fig. 6.

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* Illustrations of the stator with and without winding were published in the article already referred to (*The Electrician*, Vol. LV., p. 165, Figs. 11 and 12.—Ed. *E.*]

may be added that it has been experimentally proved that machines supplied with such windings can be subjected to momentary short-circuits or paralleling, when in opposition of phase, without the slightest injury to the coils.

Individual coils for this machine are subjected to a flashing test of 25,000 volts; while the complete winding both between phase and to ground is tested with 22,000 volts while hot. The coils are held in the slots by strong wooden wedges. A diagram of winding is given in Fig. 9.

*Rotor Body.*—The rotor body is completely built up of laminations, which eliminates the danger of blow-holes such as may be present in solid-steel castings. As will be seen from Figs. 2 and 5, the poles are keyed to the spider, and the spider is keyed to the shaft. In view of the high peripheral speed, careful calculations have to be made to guard against undue strains; some of these calculations referring to the limiting points are given below. Referring to Fig. 5 the highest stresses occur in the form of bending stress across the section a b, tension across the sections c d and e f, and also tension in the keys holding the **V**-brackets, and the strap holding the ends of the coils. The forces causing bending on section a b are those due to the centrifugal force of the coils and the supporting flanges, and of the pole tip itself. As the outside ends of the coil are supported independently by straps, and the structure is laminated, the calculation is simplified if the forces acting on a section 1 in. wide in the direction of the shaft are considered. There are 300 turns of strip 0·035 × 1 in., making a weight per inch of $0{\cdot}035 \times 1 \times 300 \times 0{\cdot}32 = 3{\cdot}35$ lbs. The two flanges weigh together 37 lbs. or 0·5 lbs. per inch; the insulation 5·5 lbs. or 0·08 lbs. per inch, making a total of 3·93 lbs. per inch. The radius of the centre of gravity of this mass is approximately 19 in.

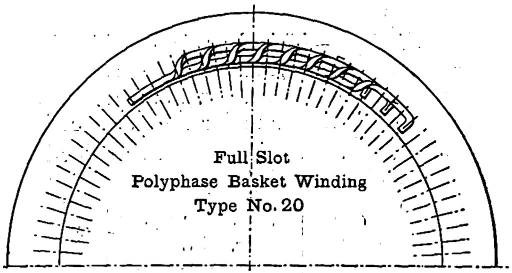

FIG. 7.

The centrifugal force of a particle of $w$ lbs. at radius $r$, revolving at 1,000 revs. per min., is $28{\cdot}4\, wr$. Hence the centrifugal force due to the coil is $3{\cdot}93 \times 19 \times 28{\cdot}4 = 2{,}120$ lbs. The direction of this force makes an angle of approximately 20 deg. with the centre line of the pole, and this force can, therefore, be resolved into two components: one 2,120 × cos 20 deg. = 1,990 lbs., and the other 2,120 sin 20 deg. = 730 lbs. It is the former which has now to be considered. If this be assumed to act uniformly along the inside of the pole tip, the bending moment will be 1,990 × 1·5 in. = 2,980 in. lbs. per inch of length of the pole. The area of the pole tip is approximately 3.3 sq. ins., and its mean radius 22·6 in. As every third packet is cut away for ventilating purposes, the centrifugal force will be $3{\cdot}3 \times 0{\cdot}666 \times 0{\cdot}28 \times 22{\cdot}6 \times 28{\cdot}4 = 395$ lbs. This force has a direction inclined at 16 deg. to the centre line of the pole, and acts at a point 1·2 in. from a b; hence a bending moment $= 1{\cdot}2 \times 395 \times \cos 16$ deg. = 455 lb. This gives a total bending moment of a b of 2,980 + 455 = 3,435 in. lb.

If $f$ be the maximum intensity of stress across a b, and the moment of resistance $= \frac{1}{6} f \times \frac{2}{3} \times 1{\cdot}6^2 = 0{\cdot}284 f$; equating this to the previously-obtained value of the bending moment, $f = \frac{3{,}435}{0{\cdot}284} = 11{,}700$ lb. per square inch.

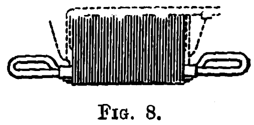

FIG. 8.

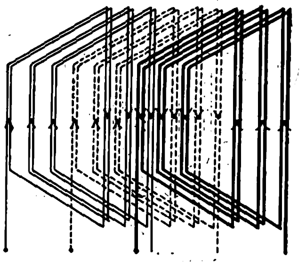

FIG. 9.

The **V**-brackets have to take up the lateral component of the centrifugal force of the coil, amounting, as shown above, to 730 lb. per inch length. The forces from two coils meet at an angle of 120 deg., and are, therefore, equivalent to a resultant force equal to and acting at an angle of 60 deg. to either of them; hence the key holding the **V**-bracket to the centre has to carry this force plus the centrifugal force due to the weight of the bracket itself. There are four brackets in a length of 23 in., and the key is 3 in. × 0·5 in. This gives a stress and intensity in the key of $\frac{730 \times 23}{4 \times 3 \times 0{\cdot}5} = 2{,}800$ lb. per square inch. If allowances be made for the weight of the bracket itself the actual force will be slightly higher than this.

The weight of a section of the pole 1 in. thick is approximately $100 \times 0{\cdot}95 \times 0{\cdot}28 = 26{\cdot}5$ lb. The radius of the centre of gravity = 19·2 in.; hence the centrifugal force $= 28{\cdot}4 \times 26{\cdot}5 \times 19{\cdot}2 = 14{,}400$ lb. To this must be added the component of the forces on the field coils acting in the same direction, amounting to 2 × 1,990 = 3,980 lb., or a total force of 18,380 lb. per inch length. This gives a tension across section c d of $\frac{18{,}380}{2 \times 2} = 4{,}600$ lb. per square inch.

The forces tending to cause failure across section e f are the centrifugal forces acting on half on the centre punchings, the resultant of the forces acting on three poles, and of the keys holding the brackets in place.

The weight of one-half of the centre punchings is $207 \times 0{\cdot}95 \times 0{\cdot}28 = 55$ lb. per inch. The mean radius 6·9 in., giving a centrifugal force of $28{\cdot}4 \times 55 \times 6{\cdot}9 = 10{,}800$ lb. The total force will, therefore, be 10,800 + 18,380 + 2 (18,380 cos 60) + 2 (1,000 cos 30) = 49,290 lb. This gives a stress on the section e f of $\frac{49{,}290}{10{\cdot}8} = 4{,}550$ lb. per square inch.

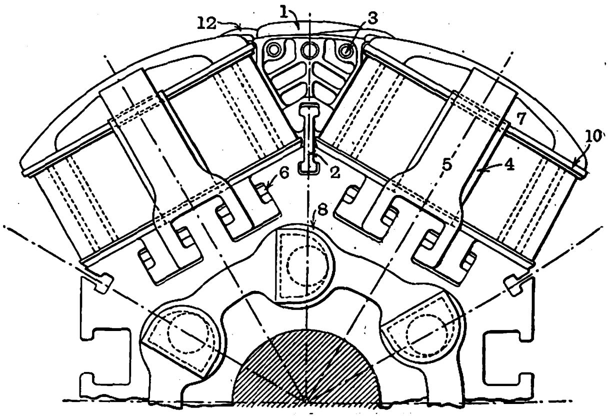

FIG. 10.

The strap has a cross-section of $3\frac{1}{4}$ in. × 0·5 in., and has to support the centrifugal force due to the outside ends of the coil. This amounts to $28{\cdot}4 \times 51 \times 19 = 27{,}600$ lb., giving a stress of $\frac{27{,}600}{3{\cdot}25} = 8{,}500$ lb. per square inch. If the weight of the strap and other small accessories be taken in, this force will be slightly higher.

The deflection of the shaft is insignificant and need not be considered, but the torsion in case of a short-circuit may be appreciable, say, between 4,000 lb. and 5,000 lb. per square inch.

The steel used in the construction of the rotor has an elastic limit of approximately 40,000 lb. per square inch, so that it will be seen that the above stresses are well within this limit, and that the factor of safety, even for the highest stress, is approximately 3·5 at normal speed and 2·6 at 15 per cent. above normal speed, at which speed the emergency governor of the turbine will act.

*Fieldwinding and* **V**-*Brackets* (see Figs. 10-12).—The field spools consist each of two concentric coils, 9, separated by an air space. Each coil is built up from copper ribbon wound on edge, the turns being insulated by red paper pasted to the copper. To locate the coils mechanically they are assembled between two brass flanges, 10, by means of insulated rivets, 11. It is essential for high speed work to obtain as rigid a structure as possible so as to prevent alterations after the machine has been running, since this would tend to upset the balance of the machine, therefore all spools before assembly are subjected to high pressure and heat. The spools are fastened to the rotor at both ends through straps, 5, of laminated phosphor bronze, which are held in place by keys, 6. As discussed above, the stress on these straps is relieved by brass **V**-brackets, 1, resting against insulation, 4, on the side of the spools and held likewise to the rotor by means of steel keys, 2. Lateral displacement of the brackets is prevented by horns, 12, which fit into the ventilating spaces of the pole shoes.

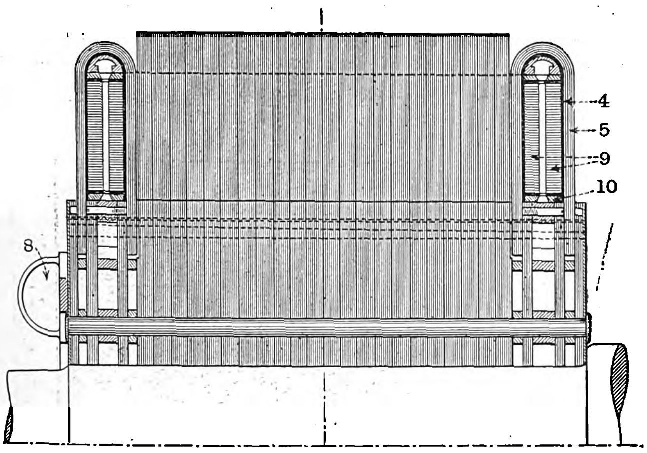

FIG. 11.

*Assembly and Balancing.*—In view of the high peripheral speed, the question of balancing, both statically and dynamically, assumes the greatest importance with this type of machine. Therefore the rotors of the turbogenerators under consideration are built up in sections 1 in. wide, the weight of each being first adjusted within ½ oz. The sections are held together by countersunk rivets and the proper static balance is obtained by boring holes. The sections are then assembled on a dummy shaft, and finally riveted together, as shown in Fig. 11. The finished rotor is statically balanced by adding weights to the **V**-brackets. In Fig. 10 the receptacles for such balancing weights are marked 3.

After the completed machine is assembled and carefully lined up on the turbine, the adjustment for dynamic balance is carried out both mechanically and magnetically. The mechanical balance is obtained by bringing the machine up to as nearly normal speed as possible and observing the running of the shaft, then shutting down and adding judiciously balancing weights in various points of the circumference on top and bottom. This is repeated until all vibrations have disappeared, thus indicating that the balance is perfect. The above process may take anywhere between 12 and 48 hours.

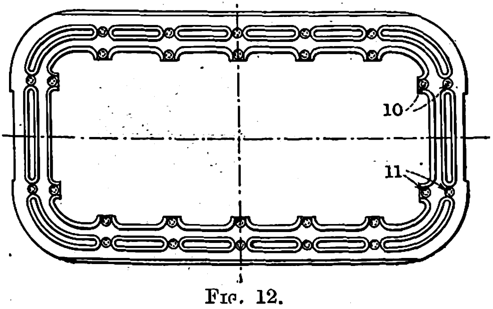

FIG. 12.

The magnetic unbalancing due to inequality of the flux in the various pole-pieces is overcome by short-circuiting turns of the winding on the strong poles through special taps brought out from each spool. The play of several thousandths of an inch which exists between the bearing and the shaft makes it possible to observe in which direction the field is drawn when the field exitation is applied. This test is first made at low speed with the middle bearing removed, and afterwards it is repeated at full speed with the bearing in place.

Another more complicated method of investigating the magnetic balance consists in taking oscillograph readings on an exploring coil, the various poles being marked on the film by a special contact device. The resulting record indicates directly the weak and strong poles. Fig. 13 is from a photograph of the assembled rotor.

*Ventilation*—Careful consideration has been given to the questions of ventilating the field winding and obtaining a down-draught as protection against any hot air or steam which might tend to rise from the turbine end. The former is obtained through the use of ventilating cups on top of the turbine (marked 8 in Figs. 10 and 11), which force the air through special channels arranged in the rotor punchings, between and around the field coils, and hence through the stator air ducts.

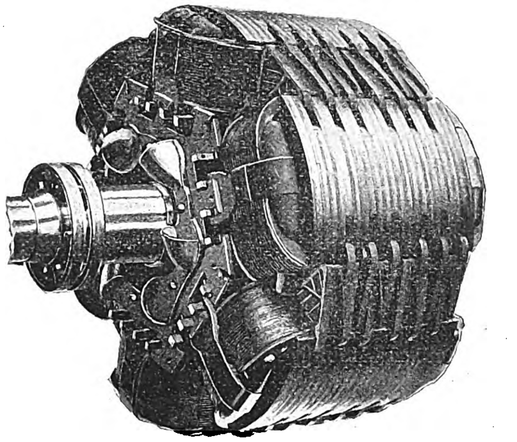

FIG. 13.

The down-draught is obtained by shaping the **V**-brackets between the poles in such a manner that they will act as fan blades, which divert the air in the gap downwards, thus preventing the steam and hot air from rising (see Fig. 14).

WEIGHTS AND FLYWHEEL EFFECTS.

| | | |
|---|---|---|
| Stator complete with end shield | =25,000 lb. | |
| Rotor complete with shaft and half coupling | =11,000 lb. | |
| Turbo alternator total | =36,000 lb. | |
| Active material, sheet iron | =16,000 lb. | (stator and poles). |
| ,, ,, copper | = 2,500 lb. | (stator and rotor). |
| Moment of inertia as found by retardation tests | =115,000 lb. ft.$^2$ | |
| Flywheel effect | =8,750 ft.-tons, | |

or about 5·5 ft. tons per kilowatt.

It is interesting to compare the above figures with the corresponding ones of a slow-speed generator of the same output and similar specifications, except the speed, which is 94 revs. per min., and the number of poles, which is 64. The generator in question has a separate flywheel, which means more favourable figures than a machine would show where the necessary flywheel effect is embodied in the rotor, thus requiring an appreciably larger diameter for the whole machine:—

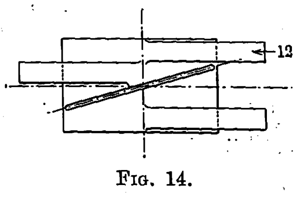

FIG. 14.

| | | |
|---|---|---|
| Stator complete with out-board bearing ...... | = 40,000 lb. | |
| Rotor complete with shaft and half coupling .. | = 30,000 lb. | |
| Flywheel to give satisfactory parallel operation | = 90,000 lb. | |
| Slow-speed alternator and flywheel ............ | =160,000 lb. | |
| Active material, sheet iron | =16,000 lb. | (stator and poles). |
| Active material, copper | = 8,500 lb. | (stator and rotor). |

Flywheel effect (flywheel and rotor) = 3,700 ft.-tons, or about 2·5 ft.-tons per kilowatt.

The above comparison thus demonstrates for the high-speed alternator: (1) Greater economy in the material, especially copper; (2) more efficient use of the material for obtaining flywheel effect.

D

## LINCOLN CORPORATION TRAMWAYS.

An opportunity was given on Tuesday last to a number of representatives of the Press to inspect the new system of tramways which have now been running at Lincoln for about a month. The Electricity committee, after fully investigating the various possible systems, decided on the recommendation of the chairman, Ald. C. H. Pratt, to equip the line on the "G.-B." surface-contact system. Although the system was a new one, and had only been seen in operation on a short experimental track, the Corporation were satisfied from the very complete guarantees which the originators of the system were prepared to give, that the confidence they exhibited in their system indicated a more than probable chance of success. So far the working has been satisfactory, but it will be interesting to learn at the expiration of the guarantee period how the cost of maintenance has compared with that of the overhead trolley system.

A description of the track at Ilford, where the preliminary experiments with the system were carried out, was given in *The Electrician*, Vol. LII., p. 456. The apparatus in use at Lincoln is substantially of the same design, differing only in detail. $1\frac{1}{4}$ miles of double track and $\frac{1}{2}$ mile of single track of 4 ft. $8\frac{1}{2}$ in. gauge have been laid, but another 3 miles of track will probably be equipped in the near future. Rails of British standard section No 3, weighing 100 lb. per yard, are used on the straight portions of the track in 45 ft. lengths, and heavier sections, up to 106 lb. per yard, are employed on the curves. The fish-plates are of the "Dicker" pattern, 2 ft. long and with six holes to take bolts 1 in. diameter and 4 in. long, Ibbotson's lock nuts and Bayliss-Jones "Eureka" nuts being used. The rails and fish-plates were supplied by the North-Eastern Steel Co., of Middlesbrough. Anchor joints of the "Cooper" type, 2 ft. long, are riveted to the flanges of the rails, and intermediate anchors, 16 in. long, are provided midway between these. The section of the tie bars is 2 in. by $\frac{1}{2}$ in., and these were obtained from Messrs. William Bain & Co., of Coatbridge. All the track, with the exception of a portion paved with Jarrah blocks, is paved with 4 in. × 5 in. setts supplied partly by Messrs. W. Griffiths & Co. and partly by the Mountsorrel Granite Co. These are mounted on a bed of 7 : 1 concrete, the cement for which was supplied by Messrs. C. & T. Earle, of Hull. The rails are bonded by protected copper bonds (4/0 B. & S.) 12 in. long, supplied by the Forest City Electric Co., of Manchester, screw compressors having been used for fixing. At points and crossings, long stranded bonds are used of the same type as those employed for the inter-rail and inter-track bonding.

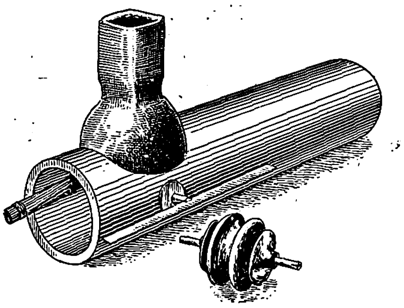

FIG. 1.—CONDUIT, CABLE AND INSULATOR.

At two points in the High-street there are level crossings where the tramway crosses the double tracks of the Great Northern and Great Central Railways. Catch points supplied by Messrs. Edgar Allen & Co. are provided on each side of these crossings and connected up with the crossing gates. The special work for these crossings, for the Cross o' Cliff junction and the car shed entrance is of Messrs. Hadfield's construction, who also supplied the "Era" manganese steel points and crossings at all other parts of the line. As will be seen from the details, given below, of the electrical system, it is necessary to have short lengths of non-magnetic rail in the loops and cross-over roads at all points where the rail crosses the line of the contact studs. These are made of a special quality of non-magnetic manganese steel from the works of Messrs. F. H. Lloyd & Co., except for the main line crossings referred to above, where special sections supplied by Messrs. Hadfields are used.

The most interesting feature of the line is, of course, the electrical equipment of the track and the ingenious method adopted for picking up the current, invented by Messrs. Griffiths & Bedell. As mentioned above, the G.-B. system has been already described in *The Electrician*, but a short résumé of the arrangement will not be out of place. The underground conduit itself consists simply of an ordinary glazed vitrified stoneware pipe of 5 in. internal diameter, which is laid under the centre of the track and embedded in concrete. The total depth of excavation necessary is small, as the depth of the underside of the conduit below the rail level is only 16 in.; but even this figure can be reduced for passing over bridges and in other situations where the available depth is limited. The thickness of the concrete between the top of the conduit and the granite setts is $5\frac{1}{4}$ in. Access boxes are provided at intervals of 200 yds. to 400 yds. along the track.

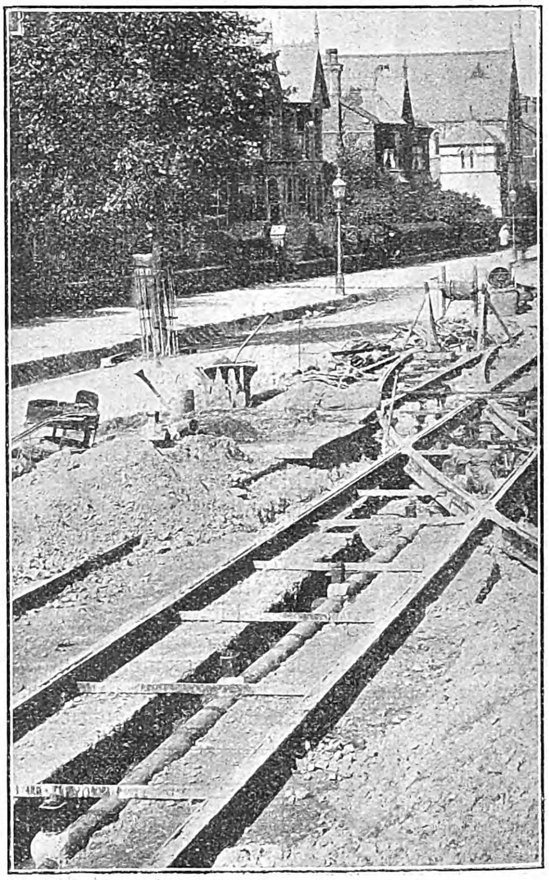

FIG. 2.—VIEW SHOWING CONDUIT IN PLACE.

The conductor consists of a stranded galvanised iron cable $1\frac{1}{4}$ in. in diameter, and is supported on circular corrugated insulators, as shown in Fig. 1, placed at intervals of 9 ft. Above each insulator is the apparatus which makes contact between the surface stud and the cable while the car is passing. The conduit and the projections containing the contacts are clearly shown in Fig. 2, which is from a photograph of a portion of the Lincoln track under construction. The studs themselves are of cast iron with a surface 10 in. by $2\frac{1}{2}$ in., wider studs being used in a few special cases at crossings. The studs are embedded in solid granite blocks recessed out to receive them, bitumen being run in between the stud-head and the block. They do not project at all above the road surface, thus presenting a great advantage over most other surface-contact systems. The insulators are supported on galvanised steel pins which pass through the conduit on one side, and through a hole in the centre of the insulator into a stopped hole on the opposite side of the conduit. The ends of the pins which project through the conduit are connected together by means of a galvanised iron strip (shown in Fig. 1), which is connected at intervals to the rails. The object of this is to ensure that no stud can ever become "live" in consequence of leakage over the surface insulating the source of supply from the stud.

The method by which contact is made between the stud is best understood by reference to Fig. 3, which shows a cross-section of the track. The upright iron stalk bolted to the centre of the stud is forked at the lower end and lined with brass. Within this fork is mounted the moving iron switch piece, normally held up in its place by springs, and electrically connected with the stud by a flexible connection. On the lower end of the switch piece is fixed a renewable carbon contact which hangs directly over and about $\frac{3}{8}$ in. away from the bare cable and ready to make contact with it when depressed. This small switch piece, weighing only about 6 ounces, is the only moving part in connection with the equipment of the track.

When a car passes, the magnet which it carries causes lines of force to pass through the stud, stalk and iron cable, with the result that the iron switch piece tends to move in a direction to bridge the air gap between the stalk and the cable and is thus pulled down and held in contact with the cable as long as the car, with its magnet, is passing over the stud.

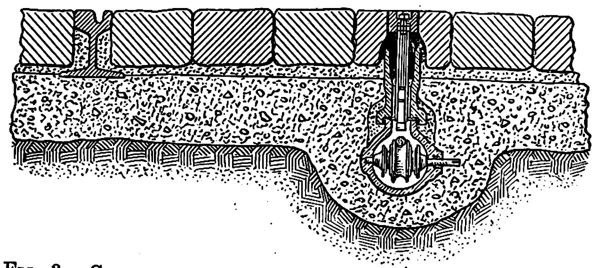

Fig. 3.—Cross-section of Track through Centre of Stud.

The arrangement by which the current is collected by the car from the stud is equally simple. The collector itself is a chain of cast-iron links (shown in Fig. 4) spring suspended within a long slot in one pole of the magnet. The links are simply strung together on a steel cable passing through holes drilled in the body of the links and clamped thereto by set screws. When the car passes over a stud each link is attracted down in turn and makes contact with the stud in an exactly similar manner to the way in which the switch piece under the stud makes contact with the cable, and as each link reaches the end of a stud it is drawn up out of contact with the road by a spring. The magnet is rigidly attached to the car truck and lies in a horizontal position. In consists of two long pole pieces united by three yokes carrying the coils. One pole lies over the centre of the track and contains the contact chain, the surface of which normally lies about $\frac{1}{2}$ in. above the stud-head level—the other lies at the side, near one track rail, about 2 in. above the rail level. The magnetic circuit thus passes from the central pole through the chain stud and cable, where it spreads out and passes through the ground to the track rail and back to the side pole of the magnet. It might be thought that a circuit containing so large an air gap would be hopelessly inefficient, but the section of the gap is so large compared with the section of the stalk of the stud, that the contractors state that even a crowbar laid across the track does not cause appreciably more lines to pass. The magnet is energised by a few accumulator cells connected up in the manner shown in Fig. 5. The coils and battery are so connected that when the motors are taking current, their current, when small, assists the battery in exciting the magnet, and when large recharges the battery; in this way no special arrangements have to be made for charging. The batteries were supplied by Messrs. Pritchetts & Gold. A short-circuiting device consisting of a light-wire brush is provided at each end of the car which would cause a cut-out to open in event of any stud accidentally remaining "live" after the car has passed. The collection of current by this means has been found to be absolutely continuous up to the highest speeds for which the cars are designed, and the leakage is stated not to exceed an average of 0·3 amperes over the three miles of track. The energy required to excite the magnet is 11 amperes at 18 volts, which, at an average speed of 8 miles per hour, works out to 0·0247 kw. per car mile. The cars are moved about over the pits in the car sheds by flexible cables, as it was impracticable to carry the conduit over the pits.

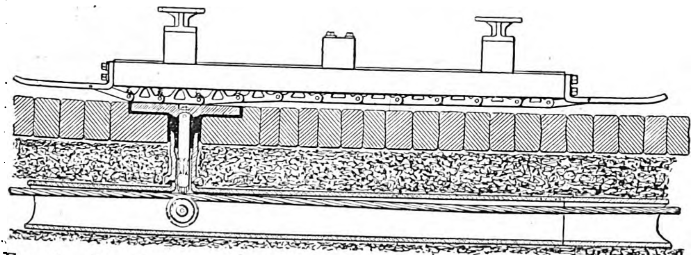

Fig. 4.—Car Magnet and Collector Chain making Contact with Stud.

One advantage claimed for the system is that the cost of maintenance is very low. The life of the stud is expected to be at least as long as that of the rails, and the cost of renewing the stud heads throughout a mile of track is stated to be less than that of renewing an equal length of trolley wire. The cable can be easily drawn out of the conduit at an access box for inspection and replaced, as the insulators are free to revolve on their pins and act as rollers. The carbon switch contacts are also easily renewed by withdrawing the studs from the surface, as the joint between the stud and the block is only made with bitumen.

It must be borne in mind that the main current is never broken on the contact at the cable, as the magnetic lag causes the switch to remain closed until after the chain has left the stud. The only current broken at this contact is, therefore, the leakage between the stud and the rails. Also, it is only on occasions of a neighbouring stud remaining accidentally dead that the main current is ever broken on a stud-head. The sparking visible, even at night in bad weather, is very considerably less than in most overhead trolley systems. In addition to the much greater sightliness of the system, a consideration in a town so rich in architectural beauties as Lincoln, it is pleasant to be without the usual unpleasant "sing" of the trolley wire, as the action of the chain is practically inaudible, even from inside the cars. That the apparatus runs smoothly and well at present there is no doubt, but the results of a few years' working in all weathers can alone determine the suitability of the system for extended use.

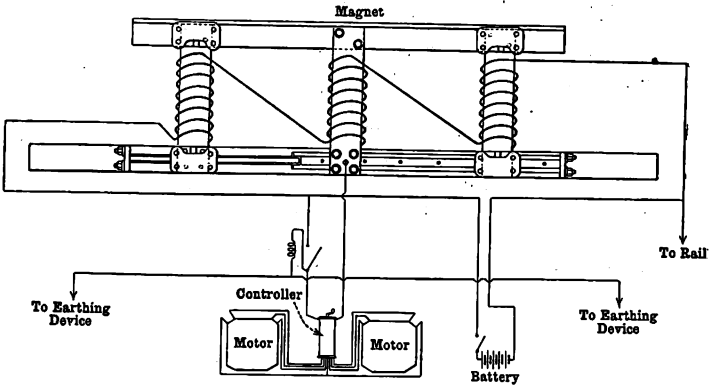

Fig. 5.—Diagram of Electrical Connections on Car.

Eight double-decked cars are at present running, all mounted on the Brush Company's radial trucks, six have open tops, and two closed top cars are also in use. The motor equipment of each car consists of two standard Westinghouse traction motors of 25 H.P. rating for the open cars and 30 H.P. for the larger cars. Standard Westinghouse series parallel controllers with electric braking positions are used, and the introduction of the Westinghouse track brake is contemplated.

The current is supplied through Callendar feeders from the Corporation's combined lighting and traction station. A separate traction board is provided to which any one of the generators can be coupled by a special two-way switch, the same machines being used for lighting and traction. The working of the trams is entirely in the hands of the city electrical engineer, Mr. Stanley Clegg, to whom, in addition to Messrs. Griffiths & Bedell, and their engineer-in-charge, Mr. M. Hird, we are indebted for much of the information in this article.

## THE LONDON-GLASGOW TELEGRAPH CABLE.

The Post Office promised last year that the underground telegraph cable which is being laid from London to the North should be extended to Glasgow by the end of the present financial year—*i.e.*, by the end of next March—and there is no doubt that this promise will be fulfilled. In fact, so great is the progress that has been made that *The Times* and other journals have published premature statements to the effect that the line is already working. The pipe line is now complete and all the cable is safely delivered and most of it is in position, but the final jointing up and testing is still to be done.

While the London-Birmingham section was being laid we published a detailed description of the work that was being done.* This part of the cable is a 38-pair paper-insulated lead-covered cable, the conductors weigh 150 lb. per mile, their capacity is 0 065 mf. per mile, and the diameter over the lead is approximately 2·6 ins. In the extensions from Birmingham to Warrington and from Warrington to Glasgow, different types of cable are used, and they contain a greater number of wires. The external diameter of both cables is not much greater, however, and a 3 in. cast-iron pipe with socket joints is used exactly similar to that employed on the first section. The makers of the cables were the British Insulated & Helsby Cables (Ltd.), W. T. Henley's Telegraph Works Co., Messrs. Siemens Bros. & Co. and the Western Electric Co.

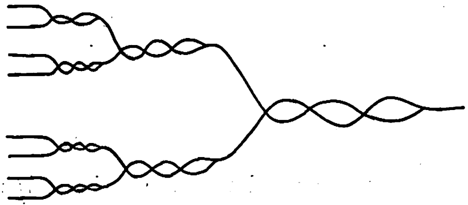

Fig. 1.—Diagram of Dieselhorst-Martin Four-pair Cable.

On the Birmingham-Warrington section, the cable contains 37 pairs of 100 lb. conductors, laid up in the usual way with one pair in the centre and successive layers of six, 12 and 18 pairs. Over this, however, comes a layer of 29 single copper 70 lb. conductors, each protected individually by a screen of copper foil over the paper insulation. This screening tape is of soft 100 per cent. conductivity copper, 3 mils thick and 0·3 in. wide; it is laid on as a tape, with a 30 per cent. overlap in the usual manner, and the diameter over the copper tape is 225 mils. The paper used for the insulation is of the strong variety customarily employed for this purpose, and it was specified that a strip 1 in. in width should be able to support a weight of 4 lb. for each mil thickness of the paper, the minimum thickness of the actual paper employed to be 6 mils. The same paper is used for insulating the pairs and the single conductors, but in the former case different colours are employed to ensure correct jointing and easy identification of the wires. Between each layer of pairs there is a spiral wrapping of paper 3 mils thick, but there is purposely none over the screened single conductors, so that the copper around the latter should come in direct contact with the lead. The lead sheathing is 150 mils thick, and the diameter of the whole cable is 2·7 in. The following maximum capacities and minimum insulation resistances at 50°F. are specified :—

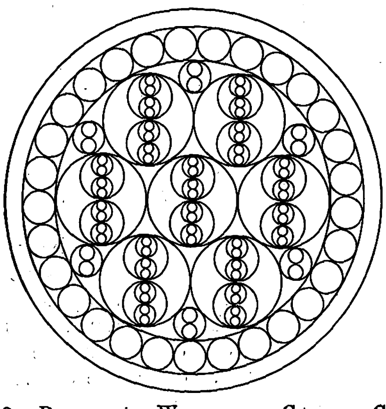

Fig. 2.—Diagram of Warrington-Glasgow Cable.

*Single Conductors.*—0·12 m.f. per mile; 500 megohms per mile after one minute's electrification.

*Paired Conductors.*—0·06 m.f. per mile (wire to wire, others insulated); 5,000 megohms per mile (between one wire and all others earthed) after one minute's electrification.

In the cable from Warrington to Glasgow, the conductor-pairs are laid up on the Dieselhorst-Martin principle. The 100 lb. conductors, after being insulated with paper, are laid up in pairs, then the pairs are "twinned" together into a two-pair cable, and finally a pair of these two-pair cables are laid up together. This is shown diagrammatically in Fig. 1. There are seven of these sets of four pairs in each cable, and they are surrounded by 29 screened 70 lb. conductors as in the Birmingham-Warrington cable, but first six ordinary pairs of 150 lb. conductors are laid in to fill up the interstices. The whole arrangement is shown diagrammatically in Fig. 2. It is seen that this cable gives 65 circuits. The insulation and lead sheathing are similar to those in the Birmingham-Warrington section. A maximum wire-to-wire capacity of 0·06 and 0·065 m.f. per mile was specified for the 100 lb. and 150 lb. pairs respectively, 0·12 m.f. per mile between each screened single conductor and all the others earthed. The object of laying up the pairs in the manner described is in order that they may be employed in parallel if the equivalent of a heavier conductor be required. For instance, if two of the pairs are used in parallel, the equivalent of a 200 lb. copper conductor is obtained, but the capacity is less than if two pairs of an ordinary 28-pair cable were used in parallel.

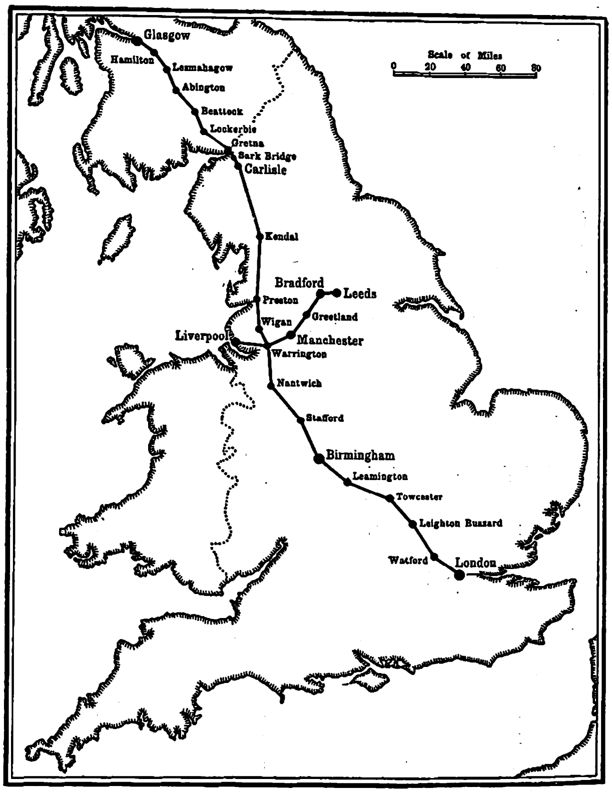

Fig. 3.—Sketch Map showing Route of London-Glasgow Telegraph Cable.

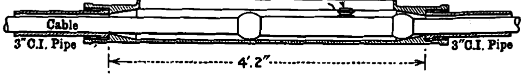

Fig. 4.—Protected Joint with Air-nozzle.

The outer screened single wires of the cables are employed for ordinary telegraph traffic, in many cases for comparatively short distances only, while the paired wires serve for high-speed transmission on the longer distances. Although there is little doubt that the cable might be employed for telephone traffic with the addition of "loading" coils for the longer distances, it is primarily intended for telegraphic purposes.

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* *The Electrician*, Vol. XLII., p. 465.

Fig. 3 is a sketch map showing the line of route, from which it will be seen that the total distance from London to Glasgow is 409 miles, London–Birmingham 117 miles, Birmingham–Warrington 80 miles, Warrington–Carlisle 117 miles, Carlisle–Glasgow 95 miles. As already mentioned, the cable is laid in a 3 in. cast pipe lead-jointed in the usual manner. The jointing of the cable is carried out in a similar way to that described in connection with the London–Birmingham section. Each conductor is jointed by a soldered copper sleeve, and the joint is insulated with a paper sleeve. The insulation is dried by placing a brazier at each side of the joint until no more moisture is driven off, and the test for this is to hold a mirror above the joint and to notice whether it is dulled with water vapour. A lead sleeve previously passed over one end of the cable is then pulled over the joint, and a plumber's "wiped" joint is made on each side. The cable is laid for the greater part in 150 yd. lengths south of Carlisle, and 220 yd. lengths north of that point. At about every ½-mile an air-nozzle is soldered into the lead sleeve of the joint, so that compressed air can be passed through the cable to dry out faults and to test it. After each joint is completed, the lead "wipe" is covered with soap suds, and the joint is tested with compressed air at 25 lb. per square inch pressure. The usual manner of protecting the joint and air-nozzle is with a split cast-iron sleeve, as shown in Fig. 4; but under roadways or pavements the excavation of which would be expensive and troublesome, a regular street box with a cover is employed, as shown in Fig. 5. At intervals of five miles there are test pillars (Fig. 6), containing cable-connection boxes (Fig. 7).

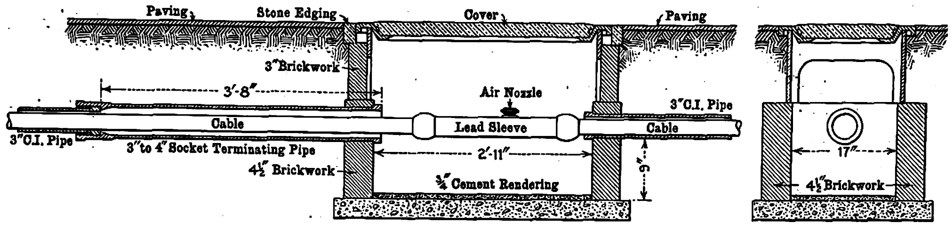

Paving
Stone Edging
Cover
Paving
3" Brickwork
3'-8"
Air Nozzle
3" C.I. Pipe
Cable
Lead Sleeve
Cable
3" C.I. Pipe
3" to 4" Socket Terminating Pipe
2'-11"
4½" Brickwork
¾" Cement Rendering
9"
17"
4½" Brickwork

Fig. 5.—Street Box and Cover for Joint with Air-nozzle.

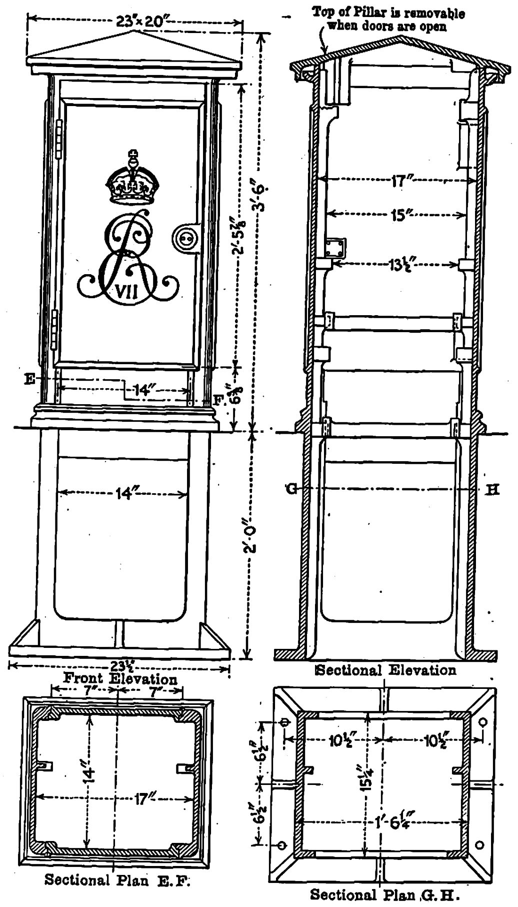

23"×20"
Top of Pillar is removable when doors are open
17"
15"
13½"
3'-6"
2'-5⅝"
VII
E
14"
F
6⅞"
G
H
14"
2'-0"
23½"
Front Elevation
Sectional Elevation
7"
7"
14"
17"
10½"
10½"
6½"
15¼"
6½"
1'-6½"
Sectional Plan E.F.
Sectional Plan G.H.

Fig. 6.—Test Pillar.

For drying-out the cable, and for testing purposes, a dessicating pump, driven by a portable petrol engine, is used, and this is mounted on a lorry, as shown in Fig. 8. The engine is not used to drive the lorry, and is permanently connected to a "Boreas" air-compressor, made by Messrs. Lacy-Hulbert & Co. This supplies compressed air to a receiver, and the air is delivered to the cable through four cast-iron cylinders containing calcium chloride. The engine is supported on springs from the lorry axles, but four bolts are provided to take the weight of the engine off the springs when running. The normal speed of the engine is 700 revs. per min., and the compressor runs at 300 revs. and can supply 10 cubic ft. of air at 30 lbs. per sq. in. pressure when running at this speed. In the illustration the set is shown open, but a light canopy is provided to protect it from the weather.

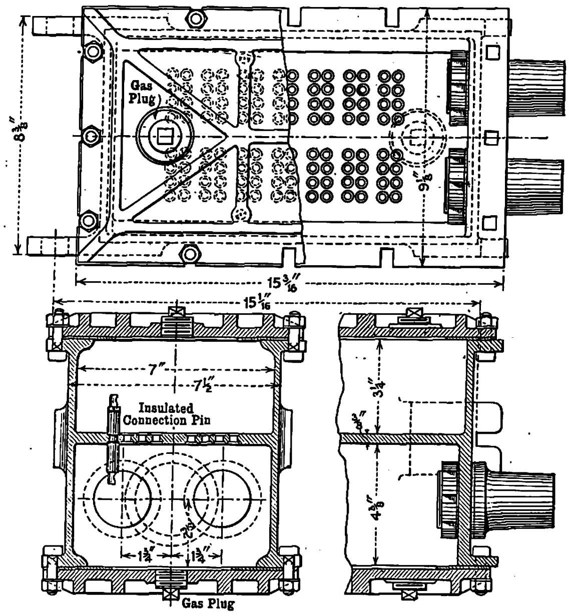

Gas Plug
8⅜"
15 3/16"
15 1/16"
7"
7½"
Insulated Connection Pin
3¼"
4⅜"
Gas Plug

Fig. 7.—Cable Connection Box.

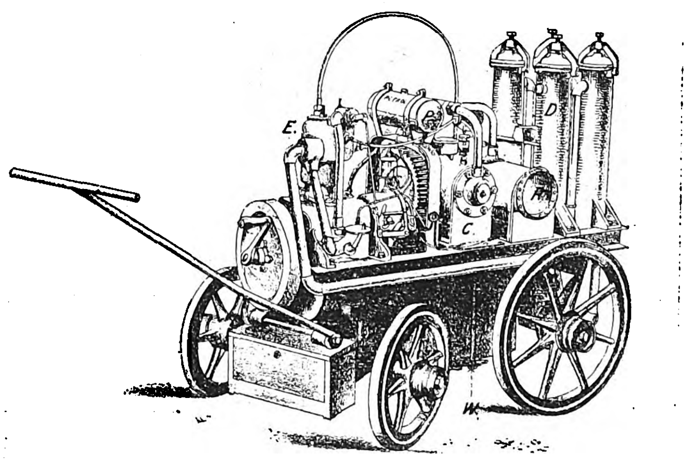


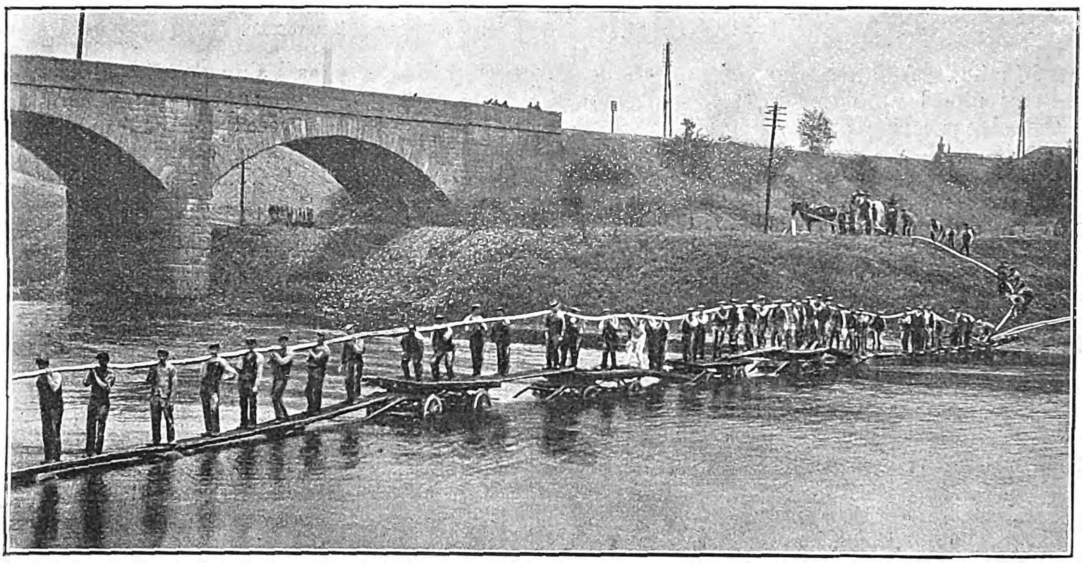
Fig. 8.—Portable Petrol Motor.

**E**, Petrol Engine. **C**, Compressor. **R**, Air-receiver. **D**, Desiccator Cylinders. **P**, Petrol Tank. **W**, Water Tank.

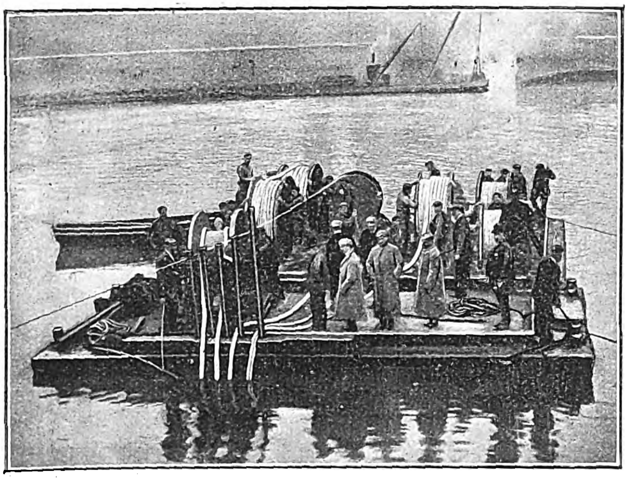
Our thanks are due to the Engineer-in-chief of the Post Office and his staff for placing at our disposal the information contained in this article.

## CABLE LAYING IN THE CLYDE.

The following description of two crossings of the Clyde and accompanying photos may prove of interest to cable men in general. Both crossings were made in connection with the large system of mains at present being laid down by the Clyde Valley Electrical Power Co. to supply power from their generating stations at Yoker and Motherwell. The first crossing carried out was at Boglshole Ford, about 7 miles above Glasgow, and presented no serious difficulty, there being no traffic on the river to contend with; also as the depth of water did not exceed 30 in., the chief point to consider was how to enable men to keep their foothold in the rapid current. The photo makes the method of operation clear. The cables, four in number, were carried one at a time across the improvised bridge and dropped into the water. They were then cleated together and lowered into a trench cut 2 ft. below the river bed. This trench was then left to silt up naturally.



Cable being laid across Bogleshole Ford.



Crossing at Yoker.

Great expedition had to be used at this crossing owing to the fact that the level of the water frequently rises 5 ft. or 6 ft. in as many hours. The ends of the cable lengths are above flood level, so that the joints will never be below water.

The second crossing, illustrated, presented much greater difficulties. The situation is 6 miles below Glasgow Harbour, and the crossing was made to enable the company to transmit energy to the district lying south of the Clyde—embracing the important Burghs of Renfrew, Johnstone, Barrhead, &c. The most important of these difficulties was the traffic up and down the river, as many as 40 vessels, many of large size, sometimes passing a given point in an hour. From observations it was found that low water on a Sunday was the only feasible time, and all preparations were accordingly made during the previous week. Further difficulties lay in the nature of the river bed, which has been proved to a depth of 70 ft. to be of soft mud, and the consequent instability of the stone pitching embankment. To counteract the possibility of the sinkage of the cable and consequent excessive strain on the shore ends, timber "slip ways" were built on either bank, and at the head of each slip way a large pit, semi-circular in plan, was built. In this latter a considerable amount of slack is left, and the position of each cable is marked and inspected at regular intervals.

Preparation had been made for laying by dredging, the river bed being first levelled to 24 ft. 6 in. below low water level, and a trench 10 ft. wide and 3 ft. 6 in. deep being afterwards cut. This trench was made by the Clyde Navigation Trust dredger in 2½ working days. At the bottom of each slipway a length of sheet piling was driven to strengthen the stone pitching.

The cables to be laid were five in number, three being three-core lead-covered and double-armoured 11,000-volt cables, and the remaining two were eight-pair telephone cables, all being of the British Insulated & Helsby Co.'s make. The drums were mounted on three barges lashed together, and the whole was drawn over by a steam winch, starting from the south bank. Mr. H. A. Barnett, who sends us these particulars and illustrations, informs us that the actual time taken in crossing the navigable part of the channel was 45 minutes, during which short period no less than five large steamers passed up or down, and the stoppages thus caused accounted for probably 35 minutes of the time. The barges were kept straight by guy ropes attached to anchors put down one up and one down stream. The greatest difficulty of the whole work was encountered in landing the ends of the cable at the north shore, owing to their great weight—viz., 42 lb. per yard run; but this was again successfully surmounted, the plant landed and everything cleared away within seven hours of the start, which, considering the amount of material involved, shows smart work.

**1,000 kw. Portable Sub-stations.**—The *Street Railway Journal* describes two portable sub-stations which are used for dealing with exceptional traffic and special emergencies on the Long Island Railway. Each consists of an all-steel car, which carries a 1,000 kw. rotary converter and three static transformers. The use of portable sub-stations is by no means new, but it is interesting to note that these are of a size larger than has previously been attempted. At special points on the railway system, such as race tracks, where the traffic is at times abnormally heavy, steel concrete buildings are provided where these portable sub-stations can be housed and connected up.

## DICK, KERR & CO.'S CRANE MOTORS.

The experience gained in tramway and heavy power work has enabled the firm of Dick, Kerr & Co. to design a motor which appears particularly well adapted for cranes, hoists, and purposes where the performance of the motor is heavy yet intermittent. It is semi-enclosed, series wound, and is in most respects similar to the firm's traction motor. The poles are built up of laminations bolted in a cast-steel shell, and the armature is slot wound. The core is built up of discs, which are keyed direct on to a hammered steel shaft, all the windings being impregnated with high insulation black varnish. Attention has been given to the adequate ventilation of the motor, the steel shells being provided with air ducts, the armature core having the usual ventilating grooves. Carbon brushes are employed, these being fixed at all loads. Ring-lubrication is adopted, special provision having been made to prevent oil being thrown on to the insulation. The motors are constructed with or without counter shaft bearings, and can be supplied with a special electric safety brake or clutch. This brake (see the general views, Figs. 1 and 2, and the detail drawing, Fig. 3) is formed in an extension of the commutator bearing, an annular space being provided in which is carried an exciting coil, E. On the extended hub is carried a conical cast-steel ring, R, which is free to move laterally; in this ring steel springs are carried, which normally tend to push the ring away from the face of the magnet. At the extreme end of the motor shaft a malleable-iron crown, C, is keyed. When the motor is disconnected from the power service, the spiral springs thrust the conical steel ring into the crown. If current is switched on the electric magnet becomes energised, and the action overcoming the thrust of the springs, the ring is attracted to the face of the magnet, which leaves the crown and, consequently, the shaft free to revolve. Crane motors are built in 10 standard sizes, ranging from 2 H.P. to 55 H.P., and designed for either 250 or 500 volts.

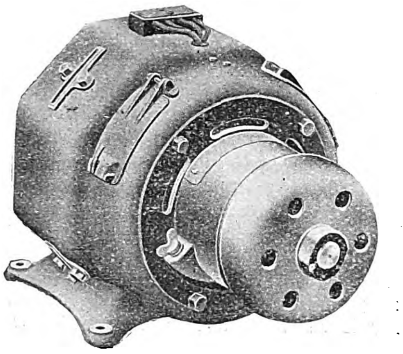


Fig. 1.—General View of Dick Kerr & Co.'s Crane Motor with Magnetic Brake.

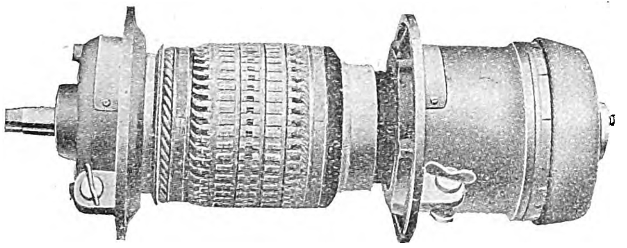


Fig. 2.—View of End-shields, Armature and Magnetic Brake of Crane Motor.

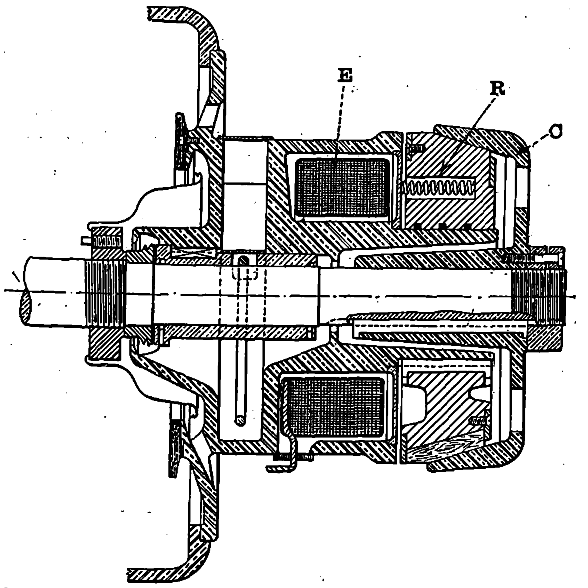


Fig. 3.—Section of Magnetic Brake for Crane Motor.

A special type of controller has been designed for the crane equipment, there being variations in the form according to the work for which it is intended. It is designed to be self-contained with resistances which form part of the underframes. One of its special features is the blow-out solenoid (which forms a notable feature in the firm's tramway controller), embodying the patent metallic shield—*i.e.*, its windings are armoured with hard drawn copper shield rings, on to which, in switching back and off, the arc strikes, flashing away from the contact tips right into the strongest field available, it there tending to encircle the shield, but being extinguished in the attempt.

Fireproof partitions between fingers limit end play of arc, and protect the side frame and sheath end guard to which the windings are screw clamped; the connections to the finger boards being automatic, when the solenoid is dropped home over cylinder, the solenoid may be thrown back on hinges for inspection, or lifted out bodily if necessary. The sheet iron arch is slipped in from above, and covers in all live contacts.

The foregoing particulars are taken from a new catalogue on "Direct-current Stationary Motors" just issued by the firm. In addition to the above information, it contains descriptions, illustrations and much technical data on motors for general purposes.

## THE MAINTENANCE OF UNDERGROUND MAINS.*

BY GEORGE L. BLACK.

### General Lay-out of Glasgow System.

Up to three years ago, the whole of the current required was generated by direct-current machines and sent out from three generating stations by low-tension feeders. The rapid growth in the demand for connection made it necessary, however, to lay down additional plant, and owing to the fact that the tramways department had at that time some surplus plant at its Pinkston Power Station, arrangements were made for taking a supply in bulk at the Waterloo-street Station of the electricity department. The energy so taken was used for driving H.T. induction motors, direct-connected to continuous-current generators. The electricity department has lately laid down some three-phase 6,500 volt turbo-alternators and erected additional sub-stations, and ere long most of the electrical energy required for lighting and power in the city will be handled by means of these converting sub-stations.

*High tension Mains.*—These mains are three-core cables, paper insulated, lead covered, and armoured in accordance with the Board of Trade regulations. For the most part they have been drawn into earthenware ducts laid in concrete. A portion, however, is laid in the solid system in wooden troughing, treated by the Haskinising process. These high-tension cables run direct from the generating station to the sub-stations, and terminate at either end in trifurcating boxes in the station tunnels. They have no disconnecting points en route.

*Low tension Feeders.*—These consist of triple-concentric cables all of 1 sq. in. × 1 sq. in. × 0·3 sq. in., the smaller sectional area being that of the neutral conductor. Some have impregnated jute or paper insulation with a lead sheathing and others paper insulation with vulcanised bitumen sheathing. All these are laid on the solid system in either cast-iron, earthenware or impregnated wooden troughing.

*Low-tension Network.*—Most of the distributing network also consists of triple-concentric cables, and of the same classes of cables, and laid in the same fashion as the feeder mains. After experience of all the above cables and troughing for low-tension work, the paper-insulated bitumen-sheathed cable, laid in wooden troughing filled in with pitch, has been adopted as the standard. The bitumen sheathing obviates the likelihood of electrolysis of a metallic sheathing, and what is perhaps more important, leaves no chance for the trouble experienced when the sheathing of lead has become alive owing to a fault, and has caused arcing at a point perhaps far distant where the lead has been in accidental contact with earth. Wooden troughing is cheap, and is likely to have as long a life as thin cast-iron troughing if one may judge by the condition of cast-iron gas pipes which have been in the ground for a few years. It was the practice at first to use refined bitumen as a filling, but after trying good pitch mixed with a suitable amount of pitch oil, it was concluded that the further use of bitumen was not justified. Experience has proved this to be correct. The pitch filling put down five years ago is found to-day in excellent condition. The melting point of pitch is low compared with that of bitumen, and there is less chance of the bitumen sheathing of the cables being damaged in filling. There are also in use as distributing mains parts of the original network laid out by Professor—now Sir—A. B. W. Kennedy, in 1893. These consist of single armoured cables, jute insulated and lead covered, some copper strip in cast-iron culverts, and single rubber cables drawn three into 3 in. or 4 in. cast-iron pipes. In 1899 the Corporation acquired the undertaking of the Kelvinside Electricity Supply Co., and most of the company's cables are still in use. It was found necessary, however, to open all the joints and branch connections for the purpose of bonding the lead of the cables, which are lead covered and armoured, and to reconstruct the disconnecting boxes in order to make the system suitable for the increased pressure of 250 and 500 volts. The low-tension feeders have been run as far as possible in groups, and at various convenient points, such as feeding-point chambers, are looped in and out again. This allows changes in the feeding arrangements to be easily and quickly made in cases of emergency and as the load varies from time to time during the year. The feeders terminate at the distributing end in large cast-iron underground chambers, to which are brought the whole of the distributing cables for the various streets in the neighbourhood of the feeding point. The feeder is connected directly without fuses to three main 'bus bars, and the distributors are connected through fuses to the positive and negative bars, and directly without fuses to the neutral bar. As a rule, eight or ten distributors radiate from each feeding point. These distributors have no connection with one another nor with any distributor connected to any other feeding point. This arrangement was decided upon only after mature consideration. It is one that certainly conduces to the general safety of supply, both as far as the undertaking and the public are concerned, and in case of trouble lends itself to a less costly and more scientific system of fault localisation than that of waiting for a police report of a column of smoke, which is often the method used on an unfused, linked-up system. The four-way and eight-way disconnecting boxes at street corners are also made of cast iron, and have 'bus bars and fuses similar to those in the feeding-point chambers. During the last two years a considerable number of section pillars have been erected instead of underground manholes. These pillars have the advantage of being somewhat cheaper in first cost, involve a minimum of disturbance to the street during erection and are drier than underground boxes.

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* Abstract of a Paper read before the Glasgow Local Section of the Institution of Electrical Engineers on Tuesday.

### Testing of Mains.

All makers of cables submit the finished article to insulation, pressure and bending tests before allowing the cables to leave their works, with the result that, provided no damage has been received in transit, cables are practically always received in perfect condition. In 10 years' extensive experience of all sizes of cables the author has come across only two cases of faults in manufacture. It is desirable, however, that tests should be made on cables immediately after laying and before jointing the different lengths High-tension cables should be first tested for insulation between cores and to earth, then subjected to a pressure test of at least double the working pressure for 15 minutes and then again tested for insulation as before. Low-pressure cables should be tested for insulation, and may also be subjected to a pressure test, though the necessity for it is not so apparent as in the case of high-tension mains.

For high-tension three-phase systems there are provided in the generating station three electrostatic voltmeters, one instrument being connected between each main 'bus bar and earth. Under normal conditions all will read alike, but in the event of the insulation of one phase dropping, its potential to earth will at once drop and will be indicated on its voltmeter.

Fig. 1 illustrates an arrangement on the low-tension mains which has been devised to meet as far as possible any contingency arising in respect to an "earth" coming on either the positive or negative side of a network. A connection is taken from the neutral 'bus bar in the generating or sub-station to a central zero ammeter reading up to 12 amperes on either side. In series with the ammeter is a solenoid placed on the base of a switch which can short-circuit the ammeter. (This switch is normally in the "off" position.) Next comes a knife switch, to which a long handle can be fitted, and then a fuse proportioned to blow at 50 amperes. As a shunt across the fuse are connected about 12 100 c.p. 250 volt lamps. From the bottom of the fuse, connection is made to the station earth-plate. Should an "earth" come on either positive or negative side, the ammeter will immediately indicate the faulty side of the system. If the leakage current is less than 12 amperes, the only indication of the disturbance will be on the scale of the ammeter. If the current, however, exceeds 12 amperes, the ammeter will be short-circuited by its switch dropping, and if the current exceeds 50 amperes the fuse will be blown and the bank of incandescent lamps will light up. These lamps immediately draw attention to the fault, and it now becomes necessary to locate the district in which it has occurred. The knife switch is opened and a new fuse inserted, and with the long handle fixed in the knife switch, the neutral conductor is flashed to earth by quickly closing and opening the switch. At the same time the feeder ammeters are watched, and the fault will be on the feeder or a section of the network attached to the feeder whose ammeter shows a sudden rise in current at the instant the neutral 'bus bar is earthed.

The circumstances are now reported to the Mains Department staff, who proceed to the feeding point in question, and find the bad section by drawing in turn the various network fuses on the faulty side of the system. Immediately the fault is disconnected, the potential of the neutral conductor comes back to that of earth, and the bank of lamps at the station or sub-station goes out. The man who draws the fuses can test for himself as he goes along, by connecting a lamp between the neutral conductor and the earth bar in the feeding point-chamber. In the case of busy network sections it is not always convenient to disconnect a fault, but the bad section can generally be found by feeling the fuses. Under ordinary conditions the insulation resistance of the neutral conductor throughout the system is fairly low, and this, in parallel with the bank of lamps at the station, allows a current of some 80 or 100 amperes to pass through the fault. Here, of course, an intimate personal knowledge of working conditions comes in handy as some sections at certain times may have a normal load of three or four times this amount.

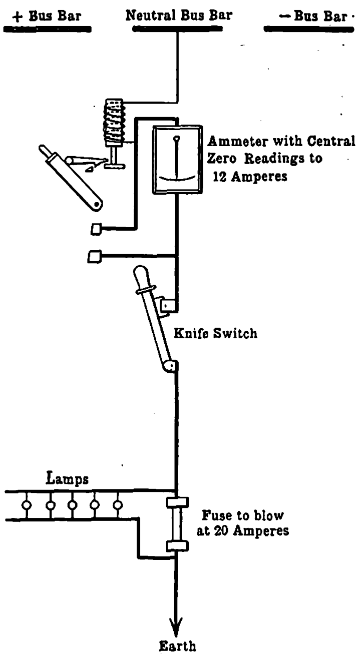
+ Bus Bar
Neutral Bus Bar
− Bus Bar
Ammeter with Central Zero Readings to 12 Amperes
Knife Switch
Lamps
Fuse to blow at 20 Amperes
Earth

Fig. 1.

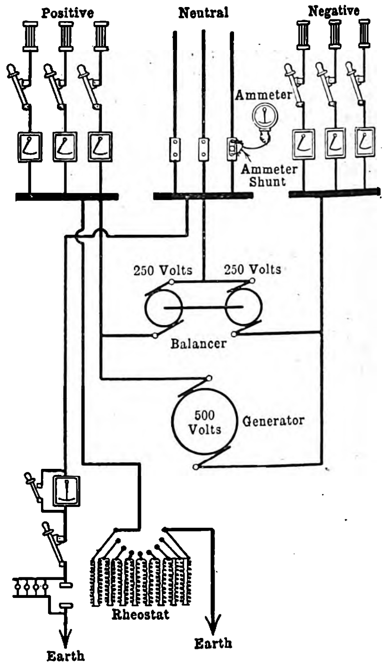

Fig. 2.

The neutral conductor being normally at earth potential, and therefore, so to speak, not under test, it becomes necessary to ascertain that its insulation resistance is not deteriorating, and the following is a useful method of testing it (see Fig. 2). A central zero ammeter, or an ammeter shunt capable of carrying, say, 500 amperes, is connected permanently between the neutral 'bus bar in the station and the neutral conductor of each feeder leaving it. A reading of the out-of-balance current (amount and direction) on each feeder is taken and noted. The positive or negative 'bus bar is then gradually earthed through a resistance, which is cut out step by step until a fairly large current is passing through it. A second set of readings is now taken of the out-of-balance current on the various feeders, and compared with the first set taken. The difference in the readings is the amount of current passing through any weak spot on the neutral conductor and earth. This test should be taken about once a week. In Glasgow it has been the means of discovering several cases of mechanical damage to cables, caused by the operations of other departments of the Corporation engaged in street openings. It is especially useful where the outer or neutral conductor only of a triple-concentric main has been injured, as the warning provided gives an opportunity of having repairs effected before moisture gets in and causes a short-circuit between the outer and inner conductors.

So far, only earths on one pole of the system have been dealt with, but with two or three-core and concentric and triple-concentric mains another source of trouble is that of short-circuiting between conductors. Only in few cases can any warning be got of such occurrences The close proximity of the conductors in the cable makes the short-circuit current so high that in a few seconds, as a rule the controlling fuses have blown. When a network is not "fused," and provided there is ample plant in the power station, great damage may be done to the network. Several years ago in Glasgow, before network fuses were introduced, a length of about 50 yds. of 0·15 triple-concentric lead-covered cable was reduced to ashes in about two hours, and that with a supply pressure of only 200 volts. In another case 15 yds. of 1 sq. in. triple-concentric feeder were destroyed in 15 minutes. The pressure in this case was 500 volts, and the fuse on only one pole of the feeder had melted.

### SYSTEMS AND FAULTS.

*Copper Strip.*—The culverts for containing copper strip are usually made of concrete constructed in position with stone covers, or made up of lengths of cast-iron troughing with cast-iron covers. Working at pressures of 100 or 110 volts a side on the three-wire system comparatively little trouble was experienced with strip. On doubling the voltage, however, on systems having concrete culverts, chunks of sodium salts grew on the insulators, especially near the brick disconnecting pits. It became necessary, therefore, to adopt some system of straining the strip to prevent it touching anything except at very long intervals, and then to be so insulated that no "creeping" could take place. It may be noted that it has not been found necessary to do this in Glasgow, with strip laid in cast-iron culverts. Great trouble has, however, been caused by the buckling of copper strip on the occasions of heavy short-circuits. The "short" may not be on the strip itself, but on some branch or other cable to which it is supplying current. The strip twists itself into fantastic shapes and smashes insulators all along. Some interesting data in connection with the pull of copper strip buckling was presented in the discussion on a Paper read before the Glasgow Local Section four years ago.* Coal gas very often finds its way into copper strip culverts, and has been the cause of explosion. Frequent inspection and notification to the gas company or department is the only way of keeping this down. Any effective system of ventilation would be too costly, and would entail the erection of a large number of shafts on the pavement, which would not be tolerated.

*Rubber Cables.*—The principal cause of breakdown in rubber-covered cables in pipes is damp. This may occur in the length of the cable when water has accumulated in the pipe and gradually caused the deterioration of the rubber. Faults have frequently been found near tee-joints when the joints have been vulcanised. This is apparently caused by the double-vulcanising or over-vulcanising of the rubber. It has first been vulcanised in the manufacture of the cable and then vulcanised still further in the making of the tee-joint. This makes the rubber very hard and brittle, and easily subject to breakdown.

*Armoured Cables, Laid Direct in the Ground or on the Solid System.*—These cables are usually lead-covered, and great care must be taken that the lead sheathing is made electrically continuous and well earthed, otherwise one fault occurring may cause numerous others, viz., where the bonding across joint-boxes is poor, or where the sheathing is touching some gas, water, or other earthed material in the ground. The first fault causes a heavy current to travel along the lead towards the earth plate at the generating station or substation, and on its way may arc at one or other of the above points, causing fusion of the lead and armouring. Sooner or later moisture creeps in and a second fault is caused.

Some idea of the amount of such a current may be conveyed by an experience of the author before earthing arrangement (Fig. 1) was introduced. He was near an exposed joint-box on a length of 0·15 lead-covered main, which box had across it a lead bond, 2 in. by ½ in. section. A fault occurred along the street, and the lead bond went in a puff of smoke. About 2,000 amperes would be required to melt this strip, and the actual current passing would probably be 6,000 or 8,000 amperes. If laid in ground containing ashes, the life of the steel protection of armoured cables is very short. Armoured cables should be spaced a few inches apart, and bricks or other incombustible material placed between to prevent trouble spreading from one cable to another.

*Triple Concentric Cables on the Solid System.*—Lead-covered cable laid in cast-iron troughing has been the least successful of the classes used. Unless an extra large size and correspondingly expensive troughing was used, it was found impossible to prevent the lead sheathing from touching the troughing. This prevented proper filling and was the cause of trouble through arcing, as mentioned in the case of single armoured cables. The arcing might have been prevented by bonding the lead to each length of troughing, but as these lengths are only 6 ft. each, much additional expense would have been occurred, and this was not considered desirable. Earthenware troughing was also used, but again it was costly. Finally wooden troughing creosoted or treated by some similar process was decided upon, and only vulcanised bitumen-sheathed cables used. The first of these cables had jute insulation between conductors; others had vulcanised-bitumen insulation throughout. The V.B. throughout insulation makes the cable of large diameter; the insulation resistance between conductors is low, and there is danger at times of overload of the conductors decentralising and short-circuiting; also the fittings for branch connections and end-boxes have to be much larger, and are therefore more costly. Paper insulation possesses the advantage of having high insulation resistance, does not fray when cut for branches as does jute, and altogether makes a compact, serviceable cable. This class of insulation with the bitumen sheathing has therefore been adopted. Sometimes a fault takes a long time to develop, and meantime water creeps in and runs up the core. Such wet cable has, of course, to be cut out. To stop this as far as possible, all the Glasgow low-tension cables supplied during the last four years have had their conductors impregnated with a heavy sticky oil, almost of the nature of an insulating compound, and the result has been most satisfactory.

To come now to the tests employed for the localisation of faulty spots on cables after the bad section has been found. These faults may be roughly divided into two classes: (1) Earths, (2) short-circuits. In localising earths by the loop test, the faulty main is disconnected from the network and a loop made up in the usual way. The slide wire and a millivoltmeter or galvanometer are connected across the loop, and current for the test is provided by connecting the positive outers of the network to the slider of the bridge through a couple of incandescent lamps. Sometimes in opening at the spot indicated at the test, no sign of the fault is seen. It may be only a yard or so away, but there may be nothing for a guide to indicate in which direction to open up further. If the main be lead-covered, Fig. 3 shows connections for a simple test to indicate this. It is presumed that the lead sheathing is earthed at both ends of the cable. A small bank of lamps taking about 2 amperes is connected to the core of the main at the nearest disconnecting box. The current on getting to the fault will split in two, and travel along the lead to the two ends of the cable. A low reading milli-voltmeter connected across, say, 3 ft. of the exposed lead will indicate in which direction the current is passing, and will show the side the fault is on.

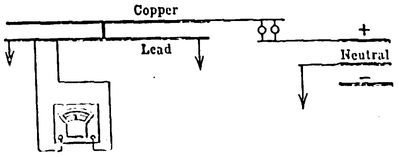

FIG. 3.

Short circuits, which are also "earths," may also be found by the loop test, if a loop can be made by some adjoining cable or other means. Owing to cross streets intervening, it is not always possible to stretch a temporary cable along the street, and Fig. 4 shows a test which has been successful in such cases in finding "shorts" in triple-concentric cables. AB, CD and EF are the three conductors in the cable, EF being the neutral. H is the point of short-circuit. EF is coupled up at one end to the general neutral of the system.

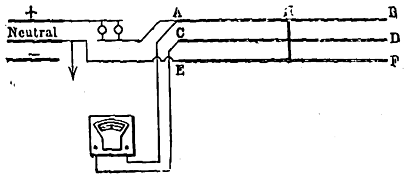

FIG. 4.

Two or three incandescent lamps are connected between the nearest positive live main and the positive conductor of bad cable. A milli-voltmeter or galvanometer is connected across AC, its reading being $g_1$. The test is repeated at the other end, the lamps being connected to B and reading $g_2$ taken across BD.

The length AB is known; then $AH = AB \times g_1/(g_1 + g_2)$.

Care should be taken in carrying out the last test that the drop in potential is not likely to injure the milli-voltmeter. Short-circuits may occasionally be found by measuring the drop of potential of a heavy current passed through the fault, taking the current either from the live mains through a resistance or by means of a motor generator. Arcing, however, is set up at the point of short-circuit, and may interfere seriously with the result.

In any electricity undertaking much attention has to be given to the upkeep of underground chambers, manholes, section-pillars, &c. In Glasgow a regular staff of inspectors go over each of the above once a fortnight, clearing out accumulations of dust, water, or other sediment. They also renew bad fuses and keep the boxes well painted. The different connections are painted distinctively according to polarity. This prevents mistakes, and gives the boxes a smart appearance. In connection with fuses, zinc is now in use instead of tin. It has the advantage of being a non-arching metal and it is very much cheaper than tin.

For indicating the presence of water in manholes on the route of the high-tension mains an interesting device is being fitted. A multiple-core cable containing a wire for each manhole has been run from the generating station, where there is an indicator-board and electric bell. In each manhole is a float, which closes the current when the water rises to a certain height. The corresponding indicator drop falls, and the bell rings, giving warning of the presence of water in the manhole.

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* *Journal* Institution Electrical Engineers, Vol. XXXI., pp. 861, 862.

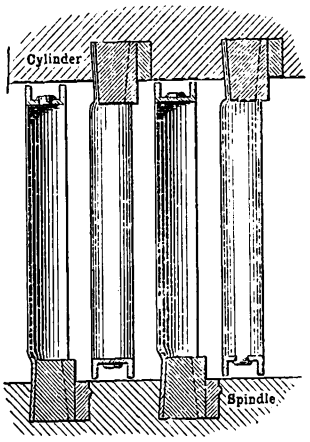
To ascertain the conditions of load and balance on each distributor, readings are taken at time of full load on the network radiating from each feeding point. An ammeter of the shunted type is used, the shunt being of the same size and shape as a fuse. The fuse is first short-circuited by a piece of heavy cable. It is then drawn, and the shunt inserted in its place.

## ELECTRICITY AT THE ROYAL COURTS OF JUSTICE.

Last Saturday a large party of members of the Association of Engineers-in-Charge paid a visit to the Royal Courts of Justice, where they were given the opportunity of inspecting the boiler house, engine room and storage battery and switchboard compartments, through the courtesy of Mr. R. A. Inglis, engineering superintendent Eastern District, H.M.O.W., and his assistants. The machinery and apparatus which lights, heats and ventilates the whole building is situated in underground vaults, below the drainage level, and to which access can only be gained along narrow passages. When the Courts were built, about a quarter of a century ago, the provisions for ventilating, heating and lighting were rather primitive, but the state of things has now been greatly improved. There are great difficulties, however, in getting new machinery into the building on account of the narrowness of the passages. There are four boilers of the Galloway type in the boiler room, two supplying steam at 90 lb. per square in., and the other two at 60 lb. Steam is supplied to two similar generating sets, each consisting of a horizontal steam engine and a belt-driven dynamo of the Edison-Hopkinson two-pole type with upright limbs, capable of an output of 630 amperes at 110 volts. Since the accumulators have been installed, the shunt windings of the dynamos have been connected to the 'bus bars on the switchboard. This enables the dynamo to be quickly started up in case of need. In the old arrangement, when each dynamo had to excite itself, it took about three minutes for the field to build up. The engine flywheel weighs nearly 8 tons and is used as a pulley. Copper brushes are used for the dynamos, and forced lubrication is employed for the bearings. The steam engines originally ran at 75 revs. per min., but after replacing the old slide valves by more modern piston valves, it was found possible to raise the speed to 100 revs. per min. A motor-driven booster for 300 amperes and 25 volts is used for charging the 1,000 ampere-hour storage battery which the Chloride Electrical Storage Co. (Ltd.) supplied about a year ago. The main engines as well as the numerous auxiliary steam engines which are used for air-compressing, ventilating, pumping and other purposes exhaust into a common main, from which steam is supplied to several calorifiers in various parts of the building. In these calorifiers the steam is caused to pass through a suitable system of pipes and to give up part of its heat to the water in which the piping is immersed. If there is not enough exhaust steam, live steam at a reduced pressure of 5 lb. per square inch, obtained through a steam-reducing valve, is admitted. The heated water is circulated through the hot-water heating system by a steam-driven rotary pump, and we are informed that the hot-water pipes in the buildings aggregate about 7½ miles. After passing through the calorifiers, the steam and condensed water are removed by a Knowles pumping set. It is thus seen that the calorifiers act as condensers, the vacuum being maintained at about 10 in. In winter the compressed air used for ventilating is heated by being brought into contact with the hot-water pipes, while in summer the air is cleansed and cooled by passing through a spray of water. The switchboard, by Messrs. Cowans, is situated in a separate compartment near the engine room, and contains all the usual instruments and apparatus for controlling and measuring the current generated. An automatic switch with a no-voltage and reverse-current release is connected to the battery circuit and is set to operate with reverse current of about 10 amperes. This was shown to the visitors in operation. There are about 3,500 electric lamps in the buildings at present, but their number is constantly changing. Most of the lights are 16 c.p. incandescent lamps, but a few arc lamps are also installed. About 15 kw. is consumed in motors. These range in size from ½ H.P. to 5 H.P., and are employed chiefly for driving ventilators. The buildings are wired on the two-wire system, and much of the solid wiring, carried out two decades ago when copper was cheap, remains to this day. In order to ensure a constant supply of electricity under all circumstances, the network can be switched over to the Charing Cross Company's supply mains at a moment's notice. This is done at a special switchboard in a separate compartment. In throwing over the switch from the local supply to the company's supply, the wiring is automatically connected up to form a three-wire network. Recording voltmeters are used in both sides of the system.

## THE ALLIS-CHALMERS STEAM TURBINE.

One of the latest firms to take up the manufacture of steam turbines is the Allis-Chalmers Co., of America, who supplied recently their first turbine to the Utica Gas & Electric Co., Utica, N.Y. This turbine is rated at 1,500 kw. normal load, and runs at a speed of 1,800 revs. per min. It is direct coupled to an Allis-Chalmers two-phase, 2,500-volt, 60-cycle, revolving-field alternator. The chief distinguishing feature of this construction is the blading, which, while it is of the Parsons reaction type as regards the principle of operation, differs in mechanical construction in a number of essential details. The roots of the blades are formed in dove-tail shape by special machinery, and are inserted in slots cut in foundation or base rings, these slots being formed by special machine tools in such a way as to conform exactly to the shapes of the blade roots (see adjoining illustration). The foundation rings themselves are of dove-tail shape in cross section, and are inserted in dove-tailed grooves cut in the turbine cylinder and spindle respectively, in which they are firmly held by key pieces. In order to ensure the integrity of the construction the key pieces or rings, after being driven into place, are upset into undercut grooves. Another noticeable feature of the blading is the method of reinforcing and protecting the tips of the blades. In forming the blades, a shouldered projection is left at the tip. This is inserted in a slot punched in a shroud ring, the slots being punched by machinery so that they will give the proper angles to the blades independent of the slots in the base ring. After the blade tips are inserted in the slots in the shroud rings they are riveted over by specially-arranged pneumatic machinery. The shroud rings are made in channel shape, with outwardly projecting flanges, which, after assembly in the turbine, are turned and bored to give the necessary working clearance. The flanges of the channels are made so thin that, although amply sufficient for stiffness, the shroud ring does not have the disadvantage of a solid shroud which acquires a dangerous temperature by friction in case of an accidental contact of the rotating and stationary parts. The blading is made up in half rings in the blading shop, and is carefully inspected before being inserted in the turbine.



Method of Fastening and Stiffening the Blades in the Allis-Chalmers Turbines.

Another special feature of this turbine is the absence of the usual low-pressure "balance piston." Only two balance pistons are used instead of the three pistons formerly employed in this type of turbine, where it is said to have been found difficult to produce a balance piston of the size required for balancing the low-pressure stage of the turbine and at the same time make it sufficiently rigid to run with the necessary small working clearance. In the Allis-Chalmers construction there is, however, a third balance piston, but instead of being at the high-pressure end of the turbine, as formerly arranged, it is at the low-pressure end, being smaller than the large end of the spindle. By making this piston in such a way that its circular area is equal to the annular area of the pistons used in the older construction, the low-pressure balance piston is made much smaller. Instead of reducing the leakage past this piston by means of "dummy packing," as in the high-pressure and intermediate pistons, and as used in the low-pressure pistons of the older construction, a labyrinth packing of radial baffling type has been adopted, thus eliminating small axial clearances in this turbine.

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"A Practical Treatise on the Steam Engine Indicator and Indicator Diagrams." By W. Worby Beaumont. Second edition. (London: "The Electrician" Printing & Publishing Co.) 6s. net.

"Motive Power and Gearing for Electrical Machinery." By E. Tremlett Carter. Second edition. Revised in part by G. Thomas-Davies. (London: "The Electrician" Printing & Publishing Co.) 12s. 6d. net.

"Wireless Telegraphy and Telephony." By Prof. Domenico Mazzotto. Translated from the original Italian by S. R. Bottone. (London: Whittaker & Co.). 6s. net.

"Proceedings of the Royal Society."—Series A. Vol. LXXVII. No. A514. Mathematical and Physical Sciences. Series B. No. B515. Biological Sciences. (London: Harrison & Sons.) 3s. and 2s. 6d.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

*A New Cement.*—B. Walter reports upon a new cement brought out by the New York & Hamburg Indiarubber Co. under the somewhat awkward name of piceïn, conferred upon it on account of its pitch-black colour. It melts at 80 deg., and the apparatus to be joined need, therefore, not be heated as much as in the case of sealing wax. It possesses, however, sufficient toughness at ordinary temperatures to give a good joint. It is insoluble in water and nearly insoluble in alcohol, but easily soluble in benzine and turpentine. The author does not state the composition of the substance.

[B. Walter, *Annalen der Physik*, No. 14, 1905.]

*Magneto-optic Effects.*—Magnetic rotatory dispersion, or the dependence of the Faraday and Kerr effects upon wave-length, has hitherto been studied almost exclusively in the visible spectrum. L. R. Ingersoll has now taken some measurements in the infra-red spectrum, in order to test the validity of the formulæ put forward for rotatory dispersion. He used carbon bisulphide for the Faraday effect on account of its transparency for heat waves, and worked with wave-lengths up to 4,300 $\mu\mu$. The Faraday effect in the infra-red is correctly represented by a formula which takes account of the absorption band beyond 8,000 $\mu\mu$, showing that an infra-red absorption band may affect the rotatory dispersion, much as it does ordinary dispersion, over a considerable range of spectrum. As regards the Kerr effect, for which the author used two mirrors of the substance to be examined, the dispersion-curves as now completed show a marked resemblance to a typical dispersion curve in the region of an absorption band, thus indicating the existence in metals of something analogous to a region of resonance-absorption, extending over the visible spectrum. The particular cases of nickel and magnetite are notable, for the rotation appears to vanish for a particular wave-length in each case, and then change in sign. But one of the author's most interesting results is that in Heusler's magnetic alloy the Kerr effect is almost imperceptible. This is the only case in which the alloy fails to exhibit its magnetic properties, and the fact may do something towards elucidating the nature of the Kerr effect. Although the results do not allow of definite conclusions as to whether the hypothesis of molecular currents, or of the Hall effect, should be accepted in explaining magnetic rotation, the indications are that the latter theory holds for carbon bisulphide. It presents a case analogous to that of sodium vapour. But the curves of the magnetic metals require the former explanation, although the reversal of nickel might perhaps be considered as evidence for the Hall effect.

[L. R. Ingersoll, *Philosophical Magazine*, January, 1906.]

*Standard of Radio-activity.*—In the course of some investigations on the relation between the radio-activity and the composition of radium compounds, H. N. McCoy had occasion to devise a standard of radio-activity, based upon the fact that the total activity of 1 gr. of pure uranium is 791 times that of 1 sq. cm. of a layer of pure $U_3O_8$ sufficiently thick to be of maximum activity. Ordinary uranium salts are first purified by successive treatment with ammonium carbonate, ammonium sulphide and barium salts. In converting the precipitated ammonium uranate into the oxide $U_3O_8$, it is necessary to ignite in a stream of oxygen to prevent the formation of a lower oxide. The standard film of oxide is prepared by grinding in an agate mortar 0·8 to 1·0 gr. of the substance with a little freshly-distilled chloroform until the former is reduced to an impalpable powder. This is then stirred up with about 15 cubic cm. more of chlorform and poured into a shallow metal dish about 7 cm. in diameter. The dish is covered until the solid is settled. The chloroform is allowed to evaporate spontaneously, and leaves the oxide in a very uniform black adherent film, each square centimetre of which gives $\frac{1}{791}$ of the activity of 1 gr. of pure uranium. Measurements of the activity of uranium ores show an excess, probably due to radium, but possibly also due to actinium or emanium, which may be substances intermediate between uranium X and radium.

[H. N. McCoy, *Philosophical Magazine*, January, 1906.]

*Properties of Alpha-rays.*—E. Rutherford defends his position against Becquerel's contention that the $\alpha$-particles from radium all escape into the air with the same velocity, and that this velocity is not altered by their passage through matter. He shows that when a very narrow beam of rays is employed in a strong magnetic field, there is a distinct "dispersion" of the photographic track of the beam. The effects described by Becquerel are obscured by the scattering of the rays in air. The absence of increased deflection of the rays from a thick layer of radium after passing through aluminium, observed by Becquerel, as well as the decreasing curvature of the rays in air, are necessary consequences of the complexity of the rays.

[E. Rutherford, *Philosophical Magazine*, January, 1906.]

*Cathode Disintegration.*—C. Maurain has made an attempt to elucidate the process whereby a cathode is disintegrated and its substance deposited upon the walls of the vacuum tube. He finds that the particles are projected from such parts of the cathode as are exposed to canal rays or positively-charged atoms, and that they have a charge of their own, which is, however, feeble in comparison with the mass of the particles. When a plate of glass is placed inside the dark cathode space, with one edge touching the cathode and sloping away from it, the largest disintegration deposit is found on the edge furthest from the cathode, and no deposit is found to have been made near the cathode, since it was shielded from the canal rays by the plate. Magnetic fields of strength sufficient to cause a very perceptible deflection of cathode rays have no apparent influence upon the deposits, but the author has succeeded in discovering a magnetic effect by means of an electromagnet giving a field of 2,200 units. He used a cylindrical tube, and cathodes in the shape of rods 2 mm. in diameter, in the axis of the tube. Without the field the deposit was uniform, but with the field the deposit was well marked in a plane containing the cathode and parallel to the lines of force, and another plane normal to the lines of force, but feeble in intermediate planes. The effect is best seen in bismuth.

[C. Maurain, *Comptes Rendus*, December 26, 1905.]

*A New Photo-Electric Effect in Selenium.*—F. Weidert has found that one of the allotropic forms of selenium shows a well-marked photo-thermo-electric effect, the thermal E.M.F. decreasing some 3 or 4 per cent., with an illumination of several hundred meter-candles. This change of the thermal E.M.F. has some connection with the resistance, which also decreases, rapidly at first, and then more slowly. But the author cannot say as yet whether the two effects are in constant proportion. The allotropic form referred to is Siemens' "second modification," and consists of a coarse-grained selenium, obtained by heating the amorphous variety to 200 deg. for 10 hours. The crystalline variety probably shows a similar effect, but the measurements are complicated by its high resistance, its inherent E.M.F., and its polarisation.

[F. Weidert, *Annalen der Physik*, No. 14, 1905.]

*Auto-anti-coherer.*—P. Lohberg describes an automatically-working anti-coherer which has some resemblance to De Forest's Responder. The anode consists of a plate of silver the size of a shilling, attached to an ebonite block and earthed. In the centre it is higher, and a piece of silk gauze is stretched over the excrescence by an indiarubber ring. The gauze is moistened with glycerine, and a piece of silver chloride or other photographic paper is placed on it, with the film towards the gauze. This anode is faced by a cathode, consisting of the bottom plate of a plunger, whose height can be minutely regulated. It is enclosed in ebonite, and near its circumference are mounted a number of gramaphone points. The instrument is put in series with a voltaic cell, a rheostat, a galvanometer and a horseshoe telephone. The gramaphone points are gently pressed against the anode, and partly released, leaving delicate bridges through the glycerine and silk. These are destroyed by Hertzian waves, but re established when they cease. By suitably regulating the gap the restoration can be made instantaneous. The author has made a special contrivance for renewing the glycerine or other liquid. He does not give a theory of the processes involved, which he believes to be very complicated.

[P. Lohberg, *Annalen der Physik*, No. 14, 1905.

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## ELECTRICITY SUPPLY IN THE UNITED KINGDOM.

With this issue of *The Electrician*, in accordance with our annual practice, we present our readers with the first of our series of Sheet Tables containing particulars of the many electricity supply stations for lighting, power and traction purposes in the United Kingdom. A glance back to the first table of the series, published in 1889, brings home clearly the enormous strides which electrical progress has made during the last 16 years. The total number of generating stations then recorded as in operation was only 24, whereas our tables this year will contain details of close on twenty times as many, in addition to those in progress. It is to the engineers of these schemes to whom our thanks are due, for without their courtesy and the trouble they have so kindly taken in supplying us with the latest details of the systems under their charge, the compilation of these statistics would be an impossibility. Following our usual practice, Table I., published to-day, deals with supply stations with no tramway load, and this will be followed next week by Table II. of supply stations with a mixed lighting and traction load. It is interesting to observe that Table I. is slightly shorter and Table II. slightly longer than last year; the number of lighting stations which have added a traction load during the year is greater than that of the new stations opened for lighting supply only. Towns taking supply "in bulk," in the number of which the largest increase is apparent, will be grouped together in Table IA, which will be issued next week with Table II., and Table III. will contain particulars of electric power companies. In a later issue will follow Tables IV. to VI. dealing with Tramways, Light Railways and Heavy Railways.

A fact which strikes one in glancing through the sheet now issued is the small number of new stations in progress. This is largely accounted for by the increasing number of districts in which supply is taken "in bulk" from a large power house outside their area. For example, the former Crystal Palace Company's undertaking has been acquired by the South Metropolitan Company, who are building a large new turbine station and forming a regular "bulk" scheme to supply the districts of Penge and Lewisham as well as their original area in Blackheath and Greenwich. A generating station of which we chronicle the disappearance is the well-known Sardinia-street station of the Metropolitan Electric Supply Co., the tall chimney of which was one of the last structures to be removed for the formation of Kingsway. With regard to systems of distribution, there is little change, three-wire continuous-current 220 and 440 volts or thereabouts continues to hold sway, and one more concern has abandoned the old-time single-phase with transformers in favour of this system. Amongst the new stations which have started supply during the past year is that of the Marylebone Corporation, but we notice that, notwithstanding the fact that the station is supplying a portion of the area formerly served by the Metropolitan Electric Supply Co., the latter's connections have substantially increased. With regard to generating plant, the increasing use of the steam turbine, especially for alternating units of large size, is very noticeable. A few more engineers have put down gas-driven plant, but only in connection with small units. We are pleased to see an almost universal reduction in the price paid for coal; this is no doubt partly due to the further perfection of automatic stoking appliances, which enable cheaper qualities of coal to be used with advantage, but it must not be forgotten that prices for coal are generally lower than they were a year ago. The steady reduction in the price charged for lighting supply has continued, but the decreased charge is more marked in the case of supply for power and heating. A number of the London companies, for example, now supply energy for this purpose at 1d. per unit. Notwithstanding the keenness of the competition of gas lighting, the increase in electric street lighting is well maintained, and the number of Nernst lamps installed during the year is specially noticeable. The new metallic filament lamps are beginning to make their appearance in the streets, and in several places the flame type of arc lamp has been introduced.

With these records of the magnitude of the electric supply industry before us, it forms a curious contrast to turn back to the first number of *The Electrician*, issued in November, 1861, and read as follows in an article headed "Artificial Sunlight": "Owing to the shortcomings to which we have referred, the introduction of a light possessing the optical and actinic properties of sunlight, and which also effects no vitiation of our atmospheric pabulum, still awaits the appreciation of science and of the general public." We think that the figures now published form a good index to the appreciation of the general public of that which science has given them in this direction since this pessimistic paragraph was written.

## REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign book).

◆

**Dynamo-Electric Machinery.** By S. P. THOMPSON, D.Sc., B.A., F.R.S. Vol. II. Alternating-current Machinery. 7th edition. (London and New York: Spon.) 1905. 30s.

The second volume of Prof. S. P. Thompson's latest new edition deals with "Alternating-current Machinery." The author refers to it on the title-page as a "manual for students," and this purpose it fulfils admirably, thanks to the clear language adopted and the numerous explanatory sketches, diagrams and drawings. But it contains more than 800 pages and has grown dangerously near the limit of handiness. Chapter I. deals quite generally with the principles of alternating currents and their representation by clock-face diagrams. The formulæ in this chapter—as, indeed, in the succeeding chapters also—are quite elementary and the calculus is rarely applied. The following chapter is entirely new. It deals with periodic functions which do not follow the sine law, and terminates with the greatly-simplified harmonic analysis described by the Professor himself in these columns not so very long ago. In the third chapter the action of an alternator is explained with the aid of diagrams, the various parts are enumerated and separately dealt with, a classification of these machines is given, and a number of alternators, including some of historic interest, are illustrated and described.

The reader is then initiated, in Chapter IV., into the manner of calculating the induced E.M.F. in an alternator for various arrangements of the armature coils, various kinds of field flux-distribution, &c. Later on in the same chapter a method of pre-determining the E.M.F. curve is explained, its practical application being shown by a numerical example. Chapter V. deals with questions of magnetic leakage and armature reaction, much use being made of the superposition of magnetic fields. A number of methods of determining the "regulation" by calculation or by a short-circuit test are included in this chapter, and an actual case is calculated through. One of the best chapters is Chapter VI., in which single-phase, two-phase and three-phase windings for alternators and induction motors are explained and rendered quite clear by a series of coloured winding diagrams. How to design an alternator to fulfil a given specification is taught in the next (seventh) chapter, and the formulæ quoted, although simple, are serviceable and are certainly as near to the truth as any student would desire. Some familiar methods of compounding alternators are sketched in a brief appendix. Up to this point the subject matter is chiefly interesting to the student, but Chapter VIII., comprising, as it does, full technical particulars and detail drawings of a number of recent alternators, cannot fail to be of value and suggestive to the busy designer. The same remark applies to the chapter on turbo-alternators which contains much information and many drawings which we see here for the first time. Synchronous motors, motor-generators, and rotatory converters are discussed at some length. It seems a pity that the Bragstad–La Cour converter (the cascade converter) is treated so briefly, and a diagram of connections indicating the action of this interesting and promising machine might with advantage have displaced the general view of such a converter (Fig. 378), which looks just like any ordinary motor-generator. A reference might have been included in this chapter to the "permutator," which has been so considerably improved of late as to deserve mention at least. Chapter XI. deals with synchronising, parallel-running, and hunting problems, while the following two chapters go in detail into the theory and design of transformers. Chapters XIV. and XV. deal with the theory and design of the induction motor, while the author gives analyses of a number of actual representatives of this type of motor in the next chapter. Single-phase induction motors and means of starting them are treated at some length in Chapter XVII., but single-phase commutator motors, which are dealt with in the succeeding pages, have not received the detail treatment which their importance warrants. In an appendix the author has tabulated the recommendations of the British Standards Committee and some of the German and American rules regarding standard frequencies, voltages and ratings. A very valuable feature of the book is the great number of references to the technical literature of all countries on the subject matter. Altogether, the book should prove a valuable acquisition to every engineer interested in alternating-current machinery, as well as to students.

**Workshop Costs for Engineers and Manufacturers.** By SINCLAIR PEARN and FRANK PEARN. 2nd edition. (London and Manchester: The Technical Publishing Co.) 12s. 6d. net.

The second edition of this useful work on the internal management and cost-keeping of engineering works is an unaltered reprint of the first edition, which received a favourable review in these columns a year and a-half ago (*The Electrician*, Vol. LIII., p. 564). In order to ensure a wide circulation, the original price of 21s. has been reduced to 12s. 6d., but the printing and general get up has not been allowed to suffer in consequence.

**Die Elektrochemie der Organischen Verbindungen.** By Dr. Walther Löb. (Halle: Wilhelm Knapp.) 1905. 9m.

This book is well known among electrochemists who are interested in organic chemistry, and it is with pleasure one sees it reach a third edition. The former editions have been brought well up to date, and the present edition is in this respect no whit behind its predecessors. The book is divided into two parts. The first Chapter in Part I. deals with theoretical considerations, and although well written is, perhaps, the least useful part of the book. Chapter II. treats of the methods employed in organic electrolysis; it will be found very useful to those desirous of engaging in the electrolysis of organic compounds, because methods which are useful in dealing with inorganic substances are not as a rule applicable to the electrolysis of organic compounds. Chapter III. is divided into nine sub-sections, and treats of aliphatic compounds. This branch of organic chemistry has been more amenable to the action of the electric current than other branches of organic chemistry, and the author has brought the work well together. It is noticeable that much more work has been done with reduction than with oxidation processes. This is due partially to the difficulty of regulating oxidation, and partly to the fact that most organic substances are not readily soluble in ordinary electrolytes. Solvents have therefore to be used, and most solvents are themselves acted upon by anodic oxidation.

The second part of the book is devoted to electrothermic processes and to the action of the silent electric discharge. One is surprised to find how much work has been done along these lines. But anyone who is desirous of carrying out research in this branch of electrochemistry need not be afraid to start, because the work so far carried out has hardly touched the fringe of the subject. We most heartily recommend this book to students of organic chemistry, and consider that no one interested in organic electrolysis should be without it.

## NOTES ON A WIRELESS TELEGRAPH STATION.

BY C. C. F. MONCKTON.

Through the courtesy of the Government of Trinidad I am allowed to publish these few notes on the erection and working of an experimental wireless telegraph system in the tropics, which will not be out of place considering the amount of interest that is now being taken in the subject of wireless telegraphy. The island of Tobago, one of the most verdant of the West Indies, has never been in telegraphic communication with the outside world. This island has lately become a dependency of Trinidad, and the Government of that colony, recognising the importance to Tobago of being in closer touch, decided to establish wireless communication between the two islands. As will be seen from the map, Scarborough, the capital of Tobago, is only 23 miles from Toco, the nearest point of Trinidad; but a telegraph or telephone line would be required between Toco and Port of Spain, the capital of Trinidad, and this line would be difficult to keep in good working condition on account of the dense tropical vegetation.

It was first decided to try if wireless communication could be established direct between the two capitals. The distance between them is only 57 miles, but the difficulty lay in 15 miles of land between Port of Spain and the sea in the direction of Tobago, for most of this land is mountainous. The hills commence within two miles of the sea; they rise to over 3,000 ft., and, as already stated, they are covered for the most part with thick vegetation. As the best site available at Port of Spain, some reclaimed land was selected, which was as far from the rise of hills as possible. At Tobago it was decided to make use of the old fort, standing about 450 ft. above the sea level and half a mile from the sea.

The Lodge-Muirhead system was adopted. A 3 H.P. Petter oil-engine drove a 1½ k.w. alternator having a periodicity of 200 ~ per second, and the general arrangement of connections was similar to that at Heysham Harbour, and described in *The Electrician* of August 4.

The aerial was a carpet of 10,000 sq. ft., at a mean height of about 62 ft., but rising to 70 ft. at the corners, while the earth capacity consisted of iron wire netting 117 ft. square laid on the ground.

The stations at Port of Spain and Scarborough were similar, except that the apparatus shed in the case of the Port of Spain station was erected inside the area of the earth capacity, whilst at Scarborough an existing building about 10 ft. outside the capacity area was utilised. At Port of Spain the brackish waters of the Gulf of Para came to within 3 ft. of the surface, whilst at Tobago the earth capacity was laid on solid rock with practically no soil intervening. Rope guys were used at both stations.

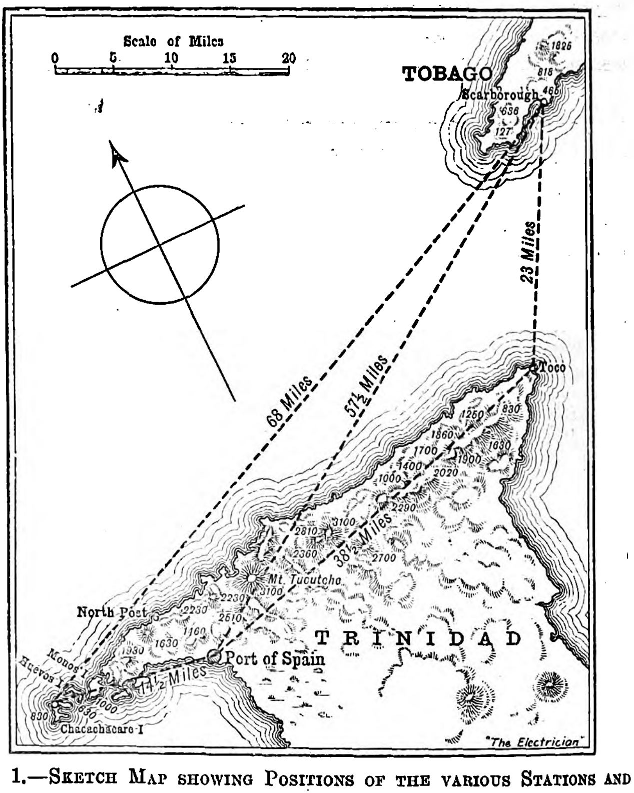

Fig. 1.—Sketch Map showing Positions of the various Stations and Elevations of Intervening Mountains.

The wave lengths were measured by means of a Lodge-Muirhead wave meter. A coil of known self-induction was placed at a convenient distance from a single coil of wire in the aerial circuit, and this single coil was always in the position immediately adjacent to wires leading to the earth capacity. In series with the known self-induction were placed an adjustable calibrated capacity and a Johnson & Phillip's hot wire voltmeter reading to 3 volts. The writer had no means of checking the absolute calibration of this wave meter, but as two inductances were supplied he was able to see that consistent results within at least 10 per cent. were obtained using either inductance.

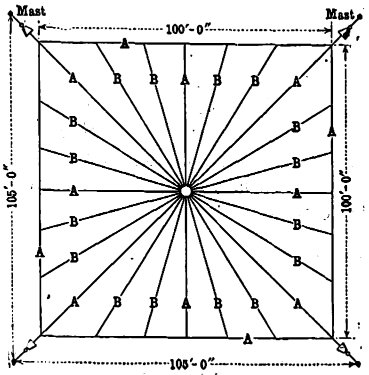

Fig. 2.—Plan of Aerial.

**A** = 7/20 strand bare copper.
**B** = No. 14 S.W.G. bare copper.

The Port of Spain station was completed by the middle of April of last year, and the wave-length measured as 430 metres.

The wave-length was also measured with a coil of inductance in series with the aerial. This inductance consisted of 15 turns of copper tube 1½ in. in circumference, the coil being 7¾ in. diameter centre to centre and the length of the coil being 15 in. With this coil the wave-length was increased to 530 metres. It was found impossible, however, to get a good 2¼ in. spark, the spark recommended by the Lodge-Muirhead Syndicate, though the weather was dry and the insulation good.

Experiments were made with this inductance in series, to find the best spark. With 10 amperes at 100 volts to the transformer the following results were obtained.

| Spark-gap in inches. | Relative current in aerial. | Result. |
|---|---|---|
| 1½ | 2·8 | Inductance coil in series. |
| 2 | 2·4 | ,, |
| 2¼ | 2·1 | ,, |
| 2 | 2·2 | Inductance coil removed. |

On April 24th the wave length at Tobago was measured without added inductance, and it was found to be about 585 metres. Experiments were also carried out to find the best spark-gap.

| Spark-gap in inches. | Volts. | Amperes. | Relative current in aerial. |
|---|---|---|---|
| 1 | 132 | 8¾ | 1·3 |
| 1¼ | 120 | 10 | 1·4 |
| 1½ | 138 | 12½ | 1·3 |
| 2 | 122 | 12 | 1·3 |
| 2¼ | 104 | 12 | 0·9 |

In both cases the sound and appearance of spark confirmed that the best results were being obtained with the largest current reading in the aerial, but the two sets of readings are in no way comparable. At Port of Spain a tuning inductance 0·06 millihenry was used, and the distance between the inductances was 3¾ in. centre to centre, whilst at Tobago the tuning inductance was 0·2 millihenry, and the inductances were 1¾ in. apart. Moreover it was only possible to tune with this coil using a small induction coil and a ⅛ in. spark. When the wave-length was increased at Port of Spain by the addition of such inductance so as to make the wave length the same as at Tobago, using the larger tuning capacity and 1½ in. spark, comparable results were obtained.

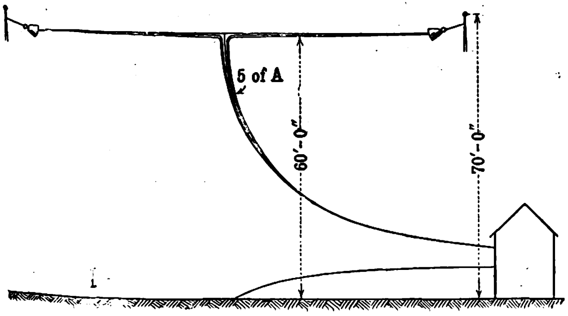

Fig. 3.—Elevation of Aerial.
A=7/20 strand bare copper.

| — | Volts. | Amperes. | Aerial current. |
|---|---|---|---|
| Tobago ........ | 138 | 12½ | 1·3 |
| Port of Spain .. | 130 | 12 | 1·4 |

The attempts at signalling failed completely. It was found impossible to receive a flick at either station from the other, either by day or night, but at night it would have been almost impossible to differentiate any signals from atmospherics which were practically continuous. On the other hand, a ship passing to the north of Trinidad could intercept signals over 10 miles of land when the altitude of the hills between was not great.

As the writer considered it probable that the capacity of the aerial was too large to be fully charged by the plant, the area of the aerial was reduced to half its original size, leaving the earth capacity as before. With a wave-length of 450 metres and sending inductance in series a test for best spark-gap was made at Port of Spain with small tuning inductance and coils 4¾ in. apart.

| Spark-gap in inches. | Volts. | Amperes. | Aerial current. |
|---|---|---|---|
| 1½ | 120 | 10½ | 2·1 |
| 1¾ | 125 | 11 | 2·2 |
| 2 | 120 | 11 | 2·1 |
| .. | 125 | 12 | 2·5 |
| 2¼ | 130 | 11½ | 2·5 |

At Tobago, with a wave length of 495 metres, under the same conditions and no sending inductance in series the measured aerial current was not so great.

| Spark gap in inches. | Volts. | Amperes. | Aerial current. |
|---|---|---|---|
| 2 | 132 | 11¼ | 1·45 |
| 2¼ | 120 | 10 | 1·5 |

A multiple spark gap was received about this time similar to the one used at Heysham Harbour, and a large number of experiments were made to get the best results. These were obtained on May 22 at Port of Spain with a wave length of 495 metres, using five gaps each of ⅜ in. with 100 volts and 13 amperes and coils 4¾ in. apart. An aerial current reading of 2·85 was obtained, but on repeating the next day the transformer broke down.

During these experiments it had been found impossible to receive signals at either station from the other. To show that signals could be received with the apparatus an aerial was erected at the most convenient situation, where an all-sea circuit could be obtained. This happened to be at the lighthouse at Chacachacare and signals were received from Tobago without difficulty. A station was completed at North Post by the end of August, and signalling has been successfully carried on since then from Tobago to North Post. The transformer sent to England for repairs was returned towards the end of November, and satisfactory communication between the two islands has since been kept up. The erection of the stations has been carried out by the Public Works Department of Trinidad, and they are being worked by Colonials who had no previous knowledge of wireless telegraphy.

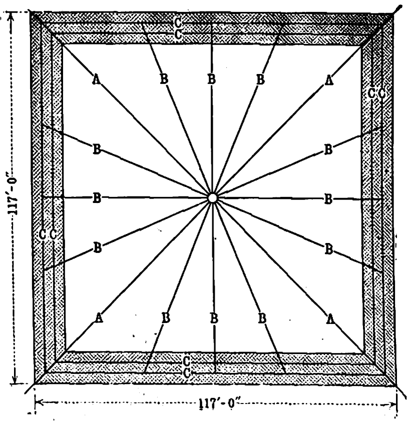

Fig. 4.—Earth Capacity.
A=7/20 strand bare copper.
B=No. 14 S.W.G. bare copper.
C=No. 14 S.W.G. copper wire.

During the first month of the experiments the weather was dry and no difficulty was experienced in keeping good insulation, but after that there was continual trouble. Large hooded ebonite insulators were supplied by the contractors, as shown in Fig. 5, and three of these broke down, the leakage apparently taking place partly along the ebonite and then through to the brass collar. A partial burning of ebonite took place where there was surface leakage, and the path of the spark was clearly visible on taking the insulator to pieces. As a temporary expedient a chain of porcelain cleats was strung together to take the place of the broken down ebonite insulators.

Before the aerial at Tobago had been erected a week the copper was covered with a soluble coating of a bluish-green compound, probably a chloride of copper. This discolouration did not take place on the ground capacity, and became more marked the higher the copper was. The writer considered it as probably due to ozone formed by discharge acting on salt in the air in the immediate vicinity of the copper. On a second visit to Tobago it was found that the group of wires leading from the spark gap to the centre of the earth capacity was touching the ground some distance from the central ring. Where this had occurred there was strong action for several feet of the wire on the spark side and none afterwards. This points to the same conclusion as mentioned above. The importance of connecting the earth wire to the correct place in the earth capacity was clearly brought out in the Paper of Messrs. Duddell and Taylor recently read before the Institution of Electrical Engineers. In a particular experiment at Tobago the earth wires were allowed to touch the iron netting on the way to the centre. A ⅛ in. spark was being used at the time, and the aerial current was reduced from 2·4 to 1·1, showing the very great importance of the proper arrangement of circuits to obtain the greatest surgings in the aerial.

The above experiment, which is only one example of a number, shows the great importance of a correct earth or earth capacity.

The writer understands the damping is considerably less and the resonance curves sharper if the earth capacity is insulated.

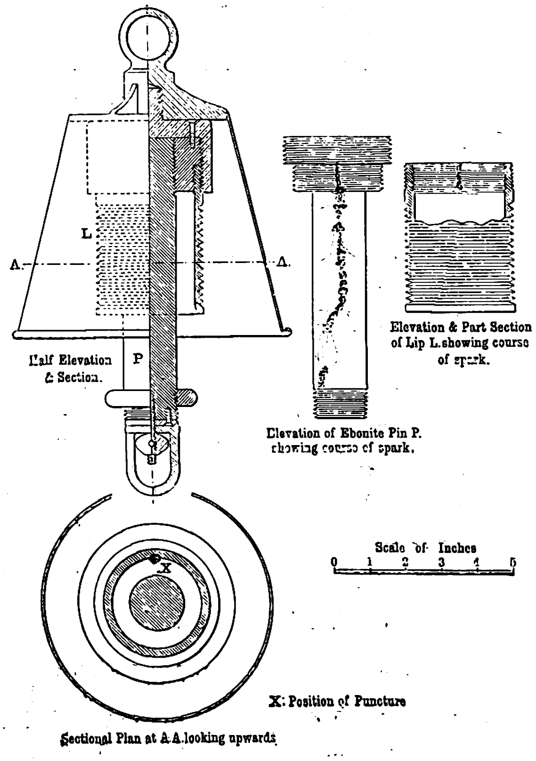
L
A.
A.
Half Elevation & Section.
P
Elevation of Ebonite Pin P. showing course of spark.
Elevation & Part Section of Lip L. showing course of spark.
X
Scale of Inches
0
1
2
3
4
5
X: Position of Puncture
Sectional Plan at A.A. looking upwards

FIG. 5.—ONE OF THE PUNCTURED INSULATORS.

Prof. Fleming, in his recent Cantor Lectures, gave a formula proposed by Bjerknes and Drude for calculating the damping effect. The measurements are not complete enough to make out the logarithmic decrement from this formula, but it was probably about 0·06 for the Port of Spain circuit, but it may have been smaller.

The results of a few characteristic wave measurements are given in Fig. 6.

In these measurements a small 1 in. spark coil was used for giving the surgings in the aerials, the actual spark being ⅛ in. The inductance in the tuning circuit was 0·06 millihenry, and was placed 1¾ in. from the single turn of wire in the aerial centre to centre. Curves 4 and 5 were measurements on a small steamboat with an aerial consisting of three No. 15 B. & S. wires 5 ft. apart in the form of a triangle. The length of the aerial was about 65 ft., with a maximum height of 30 ft. from an iron awning and 45 ft. from the sea. The earthing consisted of four wires soldered to the outside sheathing.

The Chacachacare aerial consisted of a triangular carpet 75 ft. by 75 ft. by 100 ft., about 80 ft. in height, connected in centre by five No. 15 B. & S. wires to the spark-gap. The earth was a large irregular netting laid on the ground.

With the 10,000 sq. ft. aerial 0·2 millihenry inductance was used in the tuning circuit. To obtain readings on the hot-wire instrument it was necessary to bring the tuning inductance very close to the fixed coil, and it was more difficult to measure the correct wave length, and impossible when using the large transformer and spark. At the time, the impossibility of getting reliable results with the large spark greatly puzzled the writer of this article; but after reading Dr. Fleming's Paper, "On the Application of the Cymometer to the Measurement of Small Capacities, Inductances, and Co-efficients of Coupling of Oscillation Transformers as used in Wireless Telegraphy,"* he has little doubt that the co-efficient of coupling between the fixed coil and tuning inductance was too great, and that complex oscillations were set up in the tuning circuit.

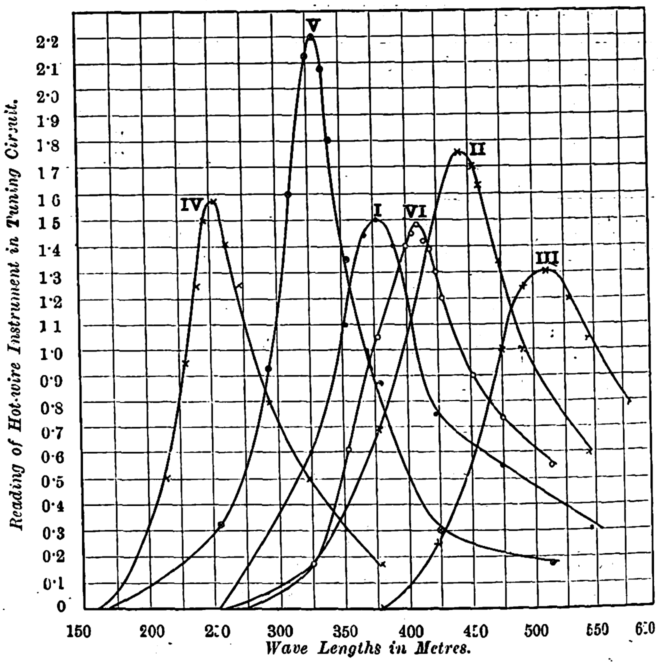

FIG. 6.—WAVE LENGTH MEASUREMENTS.

Curve I.—Port of Spain aerial carpet, 4,900 sq. ft. without added inductance. Maximum height about 66 ft.
Curve II.—The same with 15 turns of inductance added.
Curve III.—The same with 30 turns of inductance added.
Curve IV.—Steamboat aerial without added inductance.
Curve V.—The same with 23 turns of added inductance.
Curve VI.—Chacachacare aerial with 15 turns of added inductance.

A wave length measurement using this coil is depicted in the curve Fig. 7, using ⅛ in. spark. With the ordinary working spark no maximum could be obtained.

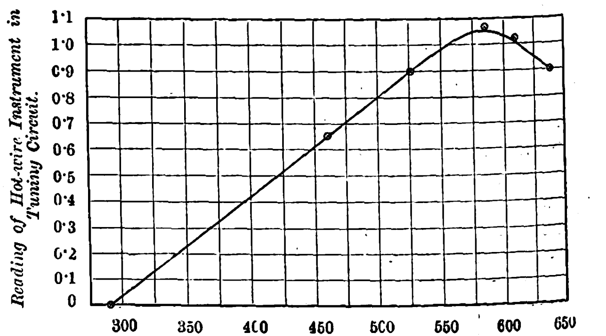

FIG. 7.—WAVE LENGTH MEASUREMENT USING 0·2 MILLIHENRIES IN TUNING CIRCUIT.

At Port of Spain the wave length was in the first instance measured before the central network of wires of the ground capacity had been soldered. Using a 2 in. spark, the measurement taken before soldering the wires agreed with those taken after, but measuring with the ⅛ in. spark, the wave lengths were about 10 per cent. greater with dirty contacts.

A great deal has been written lately on the advantages of earthing the aerial of a wireless telegraph system, and it has been shown that in the Lodge-Muirhead system there is a more or less perfect earth for high frequency currents, even if the earth capacity is insulated from the earth. To get increased wave length and sharp tuning, the Lodge-Muirhead Syndicate have adopted an open sending circuit with large capacity aerials, instead of the more complicated closed sending circuits with simpler aerials that have been used in other systems. Now, the principal objection to the open sending circuit is rapid damping. The Lodge-Muirhead carpet aerial greatly reduces this, but with the large network of wires lying on the ground at Port of Spain the writer has noticed sparking from earth capacity to earth, showing that considerable damping and loss is taking place. The latest arrangement in the Lodge-Muirhead system would greatly reduce this, with a probable increase of general efficiency. The importance of having an undamped aerial circuit in the case of the closed Marconi sending circuit is not nearly so important, for as the damped waves die away in the aerial it is fed from the undamped closed circuit. It would thus appear that it is the use of the open sending circuit that has led to the development of an insulated network capacity in the Lodge-Muirhead system.

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* Read before the Physical Society of London on March 27, 1905.

The open circuit aerial has much to recommend it on the score of simplicity, but where little space is available the closed circuit would seem necessary. The writer believes no independent experiments have been made with the two systems, open against closed circuits, each at its best, to prove which is the most efficient.

## ELECTRICITY METERS.*

BY C. H. W. GERHARDI.

(*Continued from page 463.*)

### ERECTION OF METERS ON CONSUMERS' PREMISES.

So much depends on the careful fixing of meters that the work should only be entrusted to competent and careful men. The choice of a site is of considerable importance, and needs some knowledge of the construction of the meter to be fixed, for the site which might be suitable for one type might be totally unsuitable for another, owing to vibration or space. The space which is required by a meter does not in all cases mean simply the amount of wall area upon which it can be fixed. Many types require head or side room, in order that the case may be removed without taking the meter down. In some instances more than double the actual area required for fixing must be left. Meters should on no account be fixed on partitions or near any banging door, as the shock received by the jewel each time the door is closed is bound to wear it very rapidly. Lath and plaster walls should also be avoided where possible, especially with heavy meters, as trouble is very likely to be caused by the meter falling forward and so getting out of level.

The meter should not be fixed directly on to the wall, but on a "backing board" firmly screwed to the wall.

The next point in connection with installing meters is their correct connecting up. Where many types are used the correct connections are apt to become confusing, as each type requires a different arrangement of the mains. In some cases the polarity of the ends inserted is the important point, whereas in others the polarity is of no consequence, but the choice is between "station" and "house" mains.

The following shows how the type of meter affects the connections:—

*Alternate-current Ampere-hour Meters.*—Connections immaterial.

*Continuous-current Ampere-hour Meters.*—Essential that the positive end of the bight be connected to the proper terminal irrespective of whether it be the "station" or "house" end.

*Continuous-current Watt-hour Meters, and Ampere-hour Meters having a Shunt Circuit.*—As above. The bight should also be in the correct main so as to make it possible to insert the "station" main into the proper terminal also.

*Watt-hour Meters (two-wire) both of the Induction and Non-inductive Types.*—Essential that the "station" end of the bight be connected to the proper terminal, irrespective (on continuous-current) of whether it is the + or − end of the bight.

*Watt-hour Meters (three-wire).*—Essential that the two "station" ends and the two "house" ends of the outers are connected to the proper terminals.

The result of a wrong connection in two-wire meters is to cause the meter to record backwards or not record at all. In three wire meters, if one main is properly connected and the other reversed, the meter will not record at all; if both mains are reversed the meter will record the wrong way and if the two station ends are inserted into the terminals, forming the ends of one of the main coils, a very nasty short-circuit will be the result immediately the current is switched on. It is a good plan for each meter fixer to have a rough sketch of the connections of all the meters he is likely to be called upon to fix, and on these sketches, arrows showing the correct direction of turning of the moving parts of motor meters, leave no excuse for a meter being left by the fixer wrongly connected into circuit.

Meters may be installed on either main of a two-wire system, but in three-wire systems (both alternating and continuous) with earthed neutral, no meters should be connected up on the neutral.

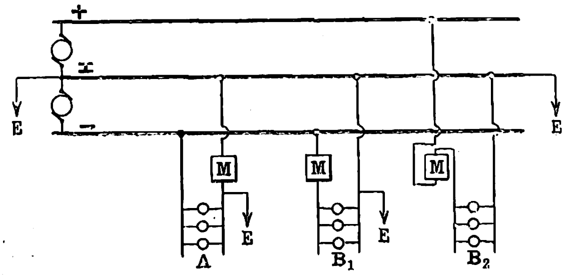

FIG. 165.—INSTALLATION OF METERS ON THREE-WIRE NETWORKS.

It is apparent from Fig. 165 that if the meter M is connected in the neutral lead as in the house "A," and an earth occurs on the house side of the meter (as at E) the meter will be partially short circuited. If the meters are invariably connected up in either outer as at the house B1 the earth will not affect the registration of the meter. (An earth occurring on the same main as the meter would in this case, of course, be a short circuit.)

In connection with three-wire networks another point which—although not relating to the erection of meters—is important as far as their proper working is concerned, is the reversing of the ends of the meter bight in the case of continuous-current ampere-hour meters in all cases where the house is connected on to the other arm of the network. For purposes of balancing it is sometimes necessary to do this. In Fig. 165 if B1 is put on to the other arm as at B2, it is necessary to connect the meter up as at B2, that is to say, to reverse the ends of the meter bight, otherwise the meter will work backwards, if a motor meter, the reading being gradually wiped out. Electrolytic meters will also cease working unless their connections are re-arranged.

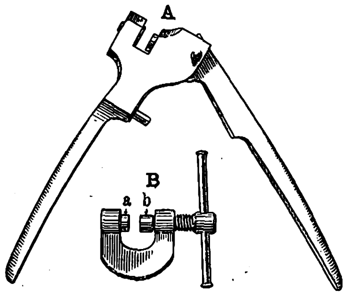

FIG. 166.—SEALING-TONGS AND CLAMP.

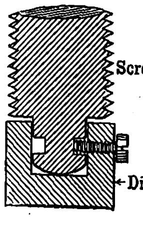

FIG. 167.

Where meters are clamped, the next thing to be done after the connections are made, is to unclamp the moving portion of motor meters provided with clamping gear, after which the terminal box cover should be replaced and sealed up. If the service is on, every meter should be tried for starting with preferably a lamp of the installation, or with a portable should it not be convenient to switch on the former. If the meter does not start when the lamp is switched on the first thing to look at is the clamping gear, for the unclamping may not have been performed completely. The next thing to look at in the case of watt-hour meters is whether there is any break in the shunt lead to the meter, or whether this has been taken off the same main as that to which the main coils are connected. By means of the portable lamp lead this is easily tested by touching one end of the lead on the main and the other lead on the shunt terminals, when the lamp should glow.

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* From a forthcoming book to be published by "The Electrician" Printing and Publishing Co. All rights are reserved.

The circuit having been proved in order up to the meter terminal it is easy to see if the current is flowing through the meter shunt by disconnecting the shunt lead at the meter terminal and flipping to see if the current spark is present. Owing to the fact that in testing watt-hour meters the shunt of the meter is usually disconnected from the main terminal, it may in some cases not have been replaced. The fault is easily remedied if the meter fixer knows what to look out for.

The usual method of sealing meters is by means of lead seals through which wires are passed, the seal then being squeezed by means of sealing tongs which contain a die or dies. The general form of sealing tongs is seen at A (Fig. 166), although different forms—some of which are over 2 ft. long—are used. Those illustrated at A (Fig. 166) are 8½ in. long and weigh 2¼ lb. With a view to reducing size and weight the sealing clamp B (Fig. 166) was designed and found to answer equally well. The difference in size is seen in the figure, and the weight of the clamp is only 8 oz. The one die, "*a*," is screwed into the frame, whilst the other, "*b*," is supported by the screw, as in Fig. 167, so that when pressing on the seal it does not turn as the screw is tightened.

In the case of apparatus such as prepayment meters or demand indicators, which are periodically opened for the purpose of collecting the coins or resetting to zero, a more convenient way of sealing is by means of a padlock seal, such as the Tourtel or the Chubb. In these padlocks the hasp when pressed home is self-locking, and it also locks a small door in front of the keyhole. The keys are all similar. In front of the keyhole a paper ticket bearing a special number is placed before closing the lock. This ticket being placed over the keyhole, and held in position by the door already referred to, it becomes impossible to open the lock without breaking through the paper. If the paper is broken this is at once apparent to the inspector.

(*To be continued.*)

## STORAGE BATTERIES AND THEIR APPLICATION TO PUBLIC INSTITUTIONS.*

BY FRANK CRAWTER.

The reason why modern designs trend particularly towards the improvement and perfection of the Planté type plate is that the demands upon a storage battery are becoming ever more onerous, and the thin pasted positive plate is but ill adapted for heavy work. It is not many years ago that to discharge a battery completely in from three to four hours was the heaviest rating that was expected of it and that it was capable of performing, but to day modern requirements demand that a battery shall be capable of withstanding a complete discharge in one hour, and short discharges at even higher rates than that.

In any installation where it is likely that any appreciable amount of current will be required on the line while charging is in progress, or where the charging rate of the battery is considerably below an amount which will form an economical load for the generator, it is best to arrange for charging to be done by means of a booster. A method of charging which has many demerits is that of arranging a battery in two halves and charging in parallel. It generally results in rapid deterioration of the cells, due to the two halves not receiving an equal amount of charge, although they are, when connected in series, called upon to give the same amount of discharge, and in order to save the trouble of adjusting the resistances, the regulating cells are frequently left in circuit far too long, so that there may be the same number of cells in each half. Nor can anything be said in favour of charging two complete batteries in parallel. This practice should be permitted only when the cells are of considerable size. The disadvantages are: (1) The difficulty of maintaining the proper charging rate. (2) Ensuring that each battery receives its proper percentage of charging. There may be circumstances where it is preferable that two batteries should be installed, but arrangements should then be made to charge them separately, and not in parallel.

The method of charging at constant potential is a common method of charging on the Continent. By this system the battery, instead of being charged at a constant current, is connected at the commencement of charge to a pressure to give about 2·5 volts per cell. This results in an extremely heavy charging current to begin with, a cell of which the normal charging rate at constant current would be 20 amperes, would, at the commencement of charge at constant potential be receiving about 160 amperes for a few minutes. This would rapidly fall off, so that at the end of 20 minutes the rate would be about 120 amperes, at the end of 30 minutes 80 amperes, at the end of 40 minutes 45 amperes, and at the end of one hour would have fallen to 20 amperes. It follows, therefore, that about 50 per cent. of the total charge will be affected during the first hour, about 75 per cent. after two hours, and about 83 per cent. after three hours, but the current has then got down so low owing to the rise in the back E.M.F. of the cell, that the total time occupied to complete a charge is much about the same, whether carried out at constant current or constant potential. The rush of current which occurs when charging at constant potential at the time that the circuit is first closed is so great as to preclude its use in a private installation. Before leaving the question of charging, mention should be made to the danger of allowing the discharge switch to be at a higher contact than the charging switch. If this occurs while charging is in progress, the cells between the charge and discharge switch will be reversed.

If the normal charging rate is continued after the cells are gassing freely for any considerable length of time, it is, of course, well known that the atmosphere in the battery room becomes filled with acid spray, which, in addition to the losses by evaporation, necessitates the addition of pure water for topping up. This of itself reduces the specific gravity of the electrolyte (independently of any impurity which the topping-up water may contain, of which mention will be made later), and, assuming that the gravity was, before the addition of water, below its normal value, this will further accentuate the fact, and, being noted by the attendant, it is possible that still further overcharge will be given the battery in the hope of raising the gravity, with the natural result that more electrolyte is lost by spraying, and still further water has to be added to make good, with the result that the maker is referred to for an explanation as to the gravity being so low, notwithstanding what is sometimes considered to be "extra attention" which the battery is receiving on account of the frequent and excessive chargings given it. If the battery is in regular work, and being discharged to an appreciable percentage of its capacity, not more than about 10 per cent. overcharge is generally required, with the exception of a rather more prolonged charge once a fortnight, the effect of overcharging being quite as deleterious as undercharging, and is a fruitful cause of the drop in specific gravity. Another reason for lowness in gravity is the fact that the battery may be getting very little work.

There has been some considerable discussion among electrochemists as to the precise chemical changes which take place in the active material of the respective elements during the phenomena of charge and discharge, and many theories of more or less hypothetical character have been evolved. There, however, appears to be no doubt that the primary active constituent of the elements is finely divided metallic lead (Pb) in the case of the negative, and lead peroxide ($PbO_2$) in the case of the positive element, these constituents being exceedingly chemically active by virtue of their electrolytic preparation or treatment; further, that when the elements are in a discharged state, a considerable amount of lead sulphate is present, and the electrolyte is reduced in specific gravity consequent upon the absorption of sulphuric acid. On charging the elements are brought back to their original state by the action or nascent oxygen and hydrogen, resulting from the decomposition of the electrolyte.

The following equations are most generally accepted, and serve to show the cycle of changes which take place during charge and discharge:—

Discharge: $Pb + H_2SO_4 = PbSO_4 + H_2$
Neg. plate.
$PbO_2 + H_2 + H_2SO_4 = PbSO_4 + H_2O$
Pos. plate.

Charge: $PbSO_4 + H_2 = Pb + H_2SO_4$
Neg. plate.
$PbS_4 + O + H_2O = PbO_2 + H_2SO_4$
Pos. plate.

When, however, the battery is doing very little work, as frequently happens during the summer months, the chemical changes just described not only do not take place to the same extent, but other chemical changes take place, due to the battery standing idle, which tend to lower the gravity. This, however, need not in itself be a cause for alarm, if the battery is getting a good gassing charge once a fortnight, and it is interesting to note from the records of gravity that when the dark days of autumn are with us, and the capacity taken from the battery therefore increased, how the gravity rises in value, and also works over a wider range than during the period of light load. As it is desirable to maintain the battery during periods of light load with the gravity at its normal value, this can usually be effected by occasionally discharging it at the nine-hour rate to 1·85 volts per cell, and then fully recharging. Another very important question affecting the gravity and indeed the general welfare of the cell to a degree is the quality of the water which is used for topping up, to which attention has been drawn by Mr. Vicarey. One of the most important duties of the chemist attached to an accumulator works is the analysis of the acid used for electrolyte, and the percentage of impurities such as arsenic, copper, iron and chlorine is rigidly defined and insisted on, and yet in many instances the battery is no sooner installed than no regard whatever is paid to the quality of the water used for topping up.

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* Abstract of a Paper read before the Association of Engineers-in-Charge last Wednesday.

In some cases it appears to be considered that good drinking water, which may contain salts of sodium, calcium, magnesia, potassium and ammonia, all of which are highly undesirable in electrolyte, may be used. Speaking generally, it may be said that the water supplied by the London Water Board is not suitable for topping up, chiefly on account of its hardness, the lime in the water tending to neutralise the acid and thus to lower the gravity. The presence of very hard water can frequently be seen by the sulphate of lime thrown down on the bottom of the glass containing boxes. One is occasionally met by the painstaking battery attendant who, on the rejection of the water supplied from the mains as being unsuitable, states triumphantly that he is now using "nothing but pure rain water." Purity is, of course, only a question of degree, and rain water even may contain impurities which in themselves are quite as deleterious as those in the water from the town mains. Even country air contains an appreciable amount of ammonia, varying at any period according to the length of dry weather, while in the air of a large manufacturing town, the amount of ammonia present is many times more than that in country air, and after a heavy shower following a period of drought, the proportion of ammonia in rain water may be as much as 0·25 grains per gallon. Moreover, in situations near salt water the amount of spray which may be blown on to the roofs and washed off into the water butt may contain an amount of salt sufficient to deal material damage to the plates. It does not, therefore, follow that because rain-water is being used for topping up that no impurities are being added to the electrolyte. Moreover, the situation of the battery may be such that impurities in the air may become absorbed. Proximity to a stable is not a good situation for a battery, while a refrigerating plant working on the ammonia process also makes a bad neighbour, and suction gas plants must also be included in this category. There are probably a good many members present who use distilled water from their steam boilers for topping up, and there may be many of those boilers largely treated with boiler fluid to counteract the impurities which are contained in the water with which they are supplied, which forms a hard deposit or incrustation on the inside of the boilers, which has to be softened by the boiler fluid. The majority of these boiler fluids contain a large quantity of alkali, and when this alkali is present in the water in excess and boiled, the resulting vapour contains a considerable proportion of ammonia, which is driven over with the steam, and consequently the distilled water obtained from the steam will contain ammoniated water to a degree which is distinctly dangerous for use as electrolyte, and the presence of ammonia may, moreover, be difficult to detect because the amount present will vary with the amount of boiler fluid which is in the boilers at the time that the condensed water is obtained, and it may be that trouble with the battery is arising and is being investigated by the makers, who may obtain a sample of distilled water from the boiler at a time when the percentage of ammonia is sufficiently low to be harmless, although it may have been present in appreciably greater quantities in the water used for the last topping up. It will therefore be clear that the source from which distilled water is drawn should be, as far as possible, above suspicion, and it is preferable, in installations of any size, to arrange for a small still which can be employed only for furnishing distilled water for topping up the cells.

Many attendants of batteries, in connection with which recording ampere-hour meters are installed, do not recognise that the capacity of a battery will vary according to its discharge rate, and that, therefore, the ampere hours, *per se*, registered on the dials during a given period do not necessarily give an exact indication of the amount of work that the battery has been doing during that period, irrespective of the discharge rate. The percentage of overcharging which a battery should receive to keep it in a healthy condition will depend largely on the amount of work it is called upon to do, and also to some extent therefore on the type of plate employed. Some makers recommend that not more than 5 per cent. ampere-hour excess of charge over discharge shall be given, but it will be found that under these conditions, if the battery is not frequently discharged to an appreciable percentage of its capacity, the specific gravity will gradually diminish in value, more especially if the working rates are low. A safer practice is to put in about 10 per cent. more ampere hours than are taken out, and to give the cells a gassing charge for half an hour once a fortnight. Recording ampere-hour meters should always be installed, so that the input and output can be logged daily, and a permanent record thus obtained, which is of the greatest value in a battery plant. Too much insistance can hardly be laid on the importance of keeping records, which must moreover be strictly accurate, and can with advantage be sent to the makers at regular intervals for advice or criticism. It is preferable that the meters should be dead reading instead of arranging the charge side to add on a fixed percentage as is sometimes done. Another important adjunct which can be used with, and is sometimes employed instead of ampere-hour meters, is a recording voltmeter. Although this gives no indication of the capacity taken from the battery, it is useful in that it shows by the shape of the line it draws whether at any time a heavy discharge has been taken from the cells, or whether the potential has fallen appreciably before the load was switched off. All voltage readings to be of any use should be taken with a current equal to at least one-third of the 10-hour discharge rate. Open circuit readings are comparatively valueless, because a sick cell may be capable of giving on open circuit a voltage which will quickly drop when it is called upon to discharge.

The author would wish to draw attention to the evil effects of a practice which is somewhat common—viz., discharging batteries in parallel. This, while reprehensible at any time on account of the difficulty of apportioning the load, becomes markedly more so when the further error is committed of discharging an entirely new battery in parallel with one or more sets which have been at work, may be for a period during which their capacity has been appreciably reduced. Under such circumstances, the new battery takes many times more than its fair share of the work. A case may be cited in which a new battery was placed in parallel with two others of the same size and make, which had been at work for several years, and out of a total discharge of 200 amperes, the new set gave no less than 180, with the result that, being overworked, its capacity soon fell off, and from the point of work to be got out of it, it became a bad investment. It will be evident, therefore, that a battery to deal with a given load should be considered as one unit—that is to say, if the requirements of the plant call for a 2,000 ampere-hour battery, one set of 2,000 ampere-hour cells should be put down, and not three or four smaller sets of which the aggregate capacity reaches the figure mentioned. In designing a battery plant where early extensions are probable, the load should, if possible, be divided so that when an increase in battery power is needed, the new cells can be put on to a load by themselves, or, if this cannot be conveniently arranged, the containing boxes should be in the first instance of a size sufficiently large to hold the probable ultimate capacity, and when the time for extension arrives, it is preferable that the plates that have been at work should be rearranged in larger groups at one end of the battery, the new plates being connected in series with them, rather than that new plates should be placed in parallel with the old ones, with a consequent unequal division of the load between the old and new plates.

There appears to be some doubt as to what is meant by over-discharging, and the evil effects which may thereby be caused. Taking current from a battery at a high rate of discharge should not in itself be injurious, and may indeed be continued until the voltage has dropped to a figure which at a low rate of discharge would be dangerous, but the chief point to guard against as being distinctly deleterious is continuing a low rate of discharge until the voltage has fallen below 1·80 per cell. It is perhaps not so generally recognised as is desirable that this is damaging to a battery, because under such conditions the plates are entirely exhausted, and if allowed to remain without being charged for any length of time will probably become badly sulphated. It is more conducive to the long life of a battery not to run it down, more particularly on slow discharge rates below 1·9 volt per cell, and it is the practice of some consulting engineers to specify that the output they require shall be obtainable down to that voltage, although it is difficult, once the job has passed out of their hands to ensure that the man in charge of the plant does not allow the cells to discharge every single ampere hour that they are capable of giving.

Where the connections from cell to cell are lead burned together, a small milking booster should be put down in order that single cells which, from any cause, require extra charging may receive it, without it being necessary to charge the entire battery. This "milker," which should consist of two machines in preference to a single machine with a double-wound armature can conveniently be placed in the engine room, a pair of leads being run to terminals in the battery room, from which cables can be clipped on to the channel bar of the cell to be charged.

As regards fixing a standard of specific gravity, which has caused a certain amount of anxiety to battery attendants, it must be borne in mind that the manufacturer fixes a standard gravity which he has specified the cells should reach under normal conditions, and in the majority of cases it will be found that any appreciable variation from the maker's standard of gravity can be found to be due to abnormal working conditions, such as little work, overcharging, undercharging, or the addition of impurities in the water used for topping up, and should the gravity be appreciably lower than the standard fixed by the manufacturers they should be communicated with, intimation being given of the working conditions, instead of an attempt being made by persistent overcharging to raise the gravity to its normal value, and under no circumstances should acid be added except under advice from the makers, because in many cases the lowness of gravity is due to the acid being in the pores of the plates instead of being in the electrolyte, and requires only proper treatment to drive it out.

A point upon which manufacturers are often consulted is as to what variation can safely be permitted from the rate of charge of any given size battery which is fixed as the normal rate. Each type of cell has a certain charging rate at which the maker finds from actual experience that his cell will give the best results as regards ampere hour efficiency, durability, and so forth, and consequently it is recommended that a certain type of cell shall be charged at a certain rate, but in the majority of cases wide variations from the makers' normal rate of charges are permissible if proper precautions are observed to see that the cells receive a sufficient amount of charge at the revised rate. Take, for instance, a cell of a certain make having a capacity of 600 ampere hours at the nine-hour rate, this would have a normal charging rate of 80 amperes, and if any efficiency tests of such a cell were to be made, this would be the rate at which the makers would prefer that the cell should be charged. But this same cell has also a maximum charging rate of 130 amperes, and would suffer no detriment from being charged at that rate, though it is preferable when charging at maximum rates to reduce the rate to normal as soon as the cells show any signs of gassing, as the damage likely to occur from an excessive charging rate is brought about to a large extent while the cells are gassing. But, further, this same cell could, if sufficient time can be devoted to the purpose, be satisfactorily charged at a rate of 60 amperes, or rather less than half the maximum rate permissible, although it will be at once apparent that a considerable period of time will be required to recharge the cells at the rate of 60 amperes should anything approaching its full capacity have been taken out of it, and the chief danger of a very low charging rate is that sufficient time cannot be allowed to put back into the cell the capacity that has been taken out, plus a percentage of overcharge, although there is, of course, a point below which, if the charging rate is taken, the amount of current per unit of surface of the plates is so small as to be almost entirely ineffectual.

Comparatively few changes have been made during a number of years in the materials used in the construction of accumulators. Wood diaphragm separators are however, a comparative novelty in this country. Lead-covered nuts are largely employed on account of their capability of resisting corrosion, and with brass studs are preferable to alloys containing antimony, which are somewhat "short" in the grain, and should any grit or dirt get into the threads are liable to break off. It is advisable not to have any metal other than lead exposed to the acid fumes. Modern practice is tending more and more towards the provision of deeper boxes, sufficient space being allowed underneath the plates to hold all the active material the plates contain without washing out being necessary. This in the case of large plates means quite an appreciable space, but in view of the labour previously entailed by cutting adrift a large set of cells which had been burned together, irrespective of possible damage to the plates, if not properly treated during the operation, is an improvement of direct interest to the user.

## THE MEASUREMENT OF HIGH FREQUENCY CURRENTS AND ELECTRIC WAVES.*

BY PROF. J. A. FLEMING, M.A., D.SC., F.R.S.

### LECTURE I.—MEASUREMENT OF HIGH FREQUENCY, CAPACITY, INDUCTANCE AND RESISTANCE.

On two previous occasions I have had the honour of giving lectures in this room "On Electric Oscillations"† and "On Hertzian Wave Telegraphy."‡ Since that time our knowledge of the subject has made great progress, especially with regard to quantitative measurements. When any branch of scientific research begins to receive technical application, we always find that it calls for processes of exact measurement, and, in truth, we may say that any collection of facts only becomes scientific knowledge, just in proportion as it is capable of being made the subject of precise measurement.

In these lectures, I propose then to direct your attention to the "Measurement of High Frequency Electric Currents and Electric Waves," and the course may be in one sense considered as supplementary to, or a continuation of, the two previous ones. Limitations of time will render it necessary for me to assume that you are familiar to a certain extent with the general phenomena.

The first matter which must engage our attention is the measurement of electric capacity. When a charge of electricity is given to a conductor, the result is to raise what is called its potential, just as when a quantity of heat is imparted to a body, the result is to raise its temperature, or when a quantity of water is put into a vessel the result is to raise the level of the water. Potential is, therefore, to electricity what temperature is to heat and level to liquids. Heat tends to flow from places of high temperature to places of low. Water tends to flow down hill, and electricity to move in the direction in which potential diminishes most quickly. The ratio of charge to potential is called the capacity of the body, and capacity may be defined as the electric charge required to raise a conductor to unit potential. The potential of the earth is taken as the zero. Accordingly we have the following definition:—

*Definition.*—The electrical capacity of a conductor is measured by the quantity of electricity which must be put into it to raise its potential one unit above that of the earth, all other conductors being at a great distance. Since there is no absolute potential any more than absolute level, we take the earth's potential as zero. We have next to settle the units. We have first a definition of the unit of electric quantity.

*Definition.*—The electrostatic unit of electricity is the quantity which repels another equal quantity at a distance of 1 cm. with a unit of force. The unit of force is called one *dyne*, and is $\frac{1}{981}$ part of the weight of 1 gramme. A conductor charged with electricity possesses a store of energy, and requires expenditure of work to charge it. It gives up this energy on discharge. Hence we have a further definition.

*Definition.*—A body is charged to unit potential when a unit of electric quantity on it represents a store of one unit of energy. We may therefore employ a small conductor charged with one electrostatic unit of quantity to measure the potential of any other charge by ascertaining how much work is required to move the unit charge against the electric attraction or repulsion of the other charge to or from an infinite distance, or, which comes to the same thing, to or from the earth. The law governing the electric attraction or repulsion between particles of electricity is the same as that of gravitation between particles of matter—viz., the law of the inverse square.

Imagine, then, a sphere of radius, R, charged with Q units of electricity. It exercises an attraction of $Q/d^2$ units of force on a unit of charge of opposite sign placed at distance of $d$ cm. from its centre, and it can be shown by a simple calculation that the work done in moving a charge to an infinite distance is $Q/d$ units of energy, or ergs. Hence we have $V=Q/R$ or $C=Q/V=R$, and, therefore, that the capacity of a sphere of radius R centimetres is R electrostatic units.

The practical unit of capacity is called 1 mfd., and is equal to 900,000 electrostatic units. The capacity of the whole earth is about 800 mfd., or nearly the same as that of an Atlantic cable. The microfarad is, however, too large a unit for the measurements we have in view, and hence I employ the one-millionth part of it, or the micro-microfarad (mmfd.), as a convenient unit. This is equal to that of a sphere 9 m.m. in radius, about the size of a large cherry, whereas the microfarad is the capacity of a sphere 9,000 metres, or about 5½ miles in radius. It is important to bear in mind the rule that to convert capacity measured in electrostatic units into capacity measuring microfarads we must divide by 900,000.

There are certain regular forms of conductors for which the electrostatic capacity can be mathematically calculated. These are the sphere, a circular disc, an ellipsoid, a long straight wire, and the following Table I. shows the mathematical expressions for these capacities in electrostatic units (E.S) and in micro-microfarads (m mfds.).

**Table I.**

| Capacity of | In E.S. Units. | In m.mfds. |
|---|---|---|
| Sphere.................. | $R$ | $10\,R/9$ |
| Disc...................... | $2R/\pi$ | $20\,R/9\pi$ |
| Vertical Wire............ | $l/2 \log_\epsilon 2h/d$ | $l/4 \log_{10} 2h/d$ |
| Horizontal Wire ........ | $l/2 \log_\epsilon 4h/d$ | $l/4 \log_{10} 4h/d$ |
| Parallel Plates .......... | $A/4\pi t$ | $10\,A/36\pi t$ |
| Concentric Cylinders .... | $l/2 \log_\epsilon \frac{D}{D'}$ | $l/4{\cdot}15 \log_{10} \frac{D}{D'}$ |

The letters in the above formulæ signify as follows:—

$l$=length of conductor; R=radius of sphere or disc; $d$=diameter of wire; $h$=height above the earth; D=diameter of the sphere, disc, or cylinder.

The proximity of any other conductor, even the earth, raises the capacity of the conductor. A large sphere hung up in this room would have a capacity numerically greater than its radius when reckoned in electrostatic units by reason of the proximity of the walls of the room. The only method of finding the capacity of most insulated conductors is to do it experimentally. This is best achieved in the following manner: If we charge the conductor and discharge it through a galvanometer, say 100 times per second, these numerous discharges are equivalent in effect to a continuous electric current. Suppose that the galvanometer has been calibrated so that we can interpret its deflections and ascertain the value of the current in microamperes, which produces any given deflection. Let V be the potential to which the conductor is charged, C its capacity in microfarads, and V the number of discharges per second, we have then the relation, A=CNV. Hence the capacity can be determined when the numerical values of A, N and V are known. This process is best conducted by means of a rotating commutator. The particular form of commutator here exhibited was designed by the author in conjunction with Mr. Clinton. (See Fig. 1.) It consists of a barrel or drum driven by an electric motor. This drum consists of three parts, the two outside portions have projecting teeth like those of a wheel, and there is an intermediate wheel which is insulated from and fixed between the other two. The diagram in Fig. 2 shows the development of the surface of this drum. Against the drum three brass brushes press, two against the outer portions and one against the middle, and it will easily be seen that when the drum rotates the effect is alternately to connect the middle brush first with one and then the other of the two outside brushes. To conduct the measurement we employ a mirror galvanometer and an insulated battery composed of 50 or more small secondary cells. The conductor C, the capacity of which is to be measured, is connected to the middle brush, and the two outside brushes are connected respectively to one terminal of the battery B, and of the galvanometer G, the other terminals of the battery and galvanometer being connected together and to the earth. (See Fig. 3.) On setting the motor in rotation the conductor is connected alternately with the battery and galvanometer, these being charged to a known potential and then discharged through the galvanometer. The number of times per second this operation is performed is ascertained in the following manner: On the shaft of the motor is placed an endless screw gearing in a wheel which rotates once every 100 rotations of the motor. A pin on this wheel is caused once in every 100 revolutions to move the hammer of a small gong and thus to make a sound which announces that the motor has completed 100 revolutions.

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* Cantor lecture delivered before the Society of Arts on Nov. 27, 1905.

† *The Electrician*, Vol. XLVI., pp. 514, 551, 588, 659, 728; and Vol. XLVII., pp. 57, 180, 226, 382, 419, 446, 495 and 531.

‡ *The Electrician*, Vol. L., pp. 796, 845, 886 and 929.

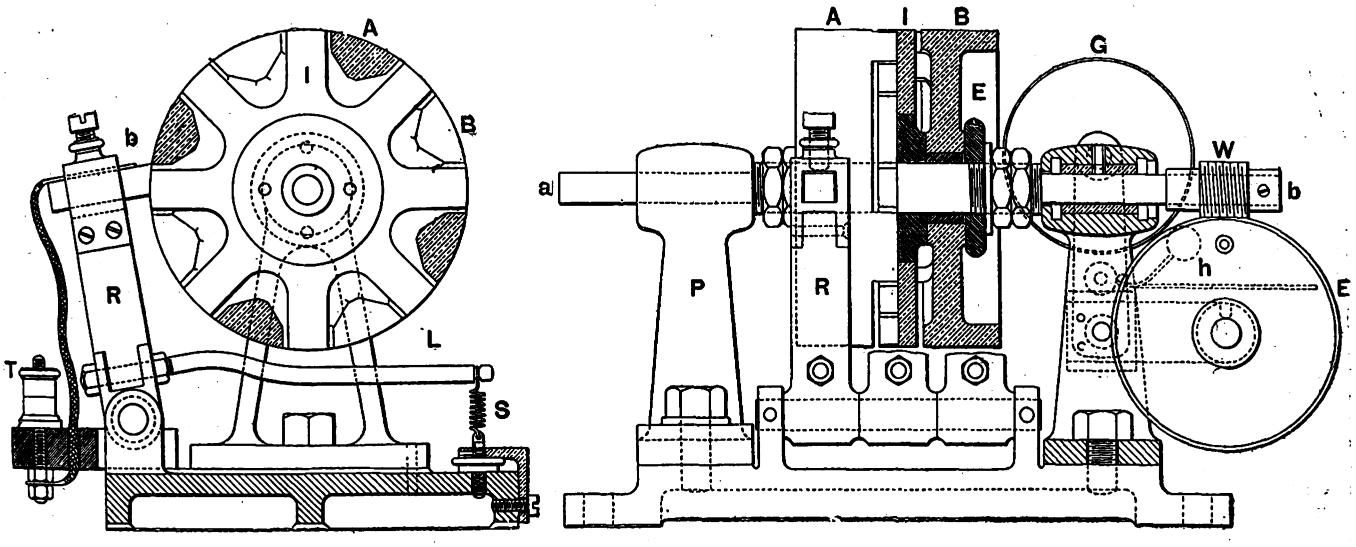

Fig. 1.—Fleming and Clinton Commutator.

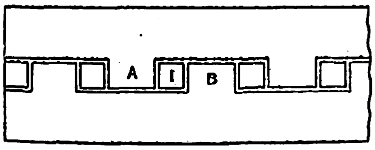

Fig. 2.

In the commutator as constructed in the instrument before you, one revolution of the motor causes four discharges to pass through the galvanometer. Hence, if we take the time by the stop watch in which the motor makes 1,000 revolutions, or in which 4,000 discharges pass through the galvanometer, we can ascertain the number of discharges per second. To reduce the results of observations to numerical values we have to know, first, the potential to which the conductor is charged. This may be done by measuring the difference of potential of the ends of the battery with any good form of voltmeter. The galvanometer may be calibrated by passing through it a known current from the same battery obtained by connecting in series the galvanometer, the battery, and a known high resistance. Having these data and the number of discharges per second obtained as above described, we can measure the capacity of any insulated conductor, such as a large sphere, or disc, or vertical wire, and determine the same in electrostatic units or micromicrofarads.

Again, by the same appliance, we can determine quite easily the capacity of a Leyden jar, or of a parallel plate or condenser, or of a parallel plate condenser having between its plates a sheet of any solid dielectric. We can make use of the above-described commutator to measure the electrostatic capacity of an aerial wire, as used in wireless telegraphy, by simply connecting the insulated wire to the middle brush. Such an insulated wire constitutes a form of Leyden jar, of which the earth is the outer coating, and the space round the wire the dielectric.

In making such a measurement, however, we have to determine the capacity of the commutator itself, and to subtract this from the total capacity as measured. Operating with this appliance we find the capacity of a Leyden jar, which is commonly called a pint size, may be about $\frac{1}{700}$ of a mfd., whilst the capacity of a wireless telegraph antenna 100 ft. in height, constructed of a wire $\frac{1}{10}$ in. in diameter, may be about $\frac{1}{5000}$ mfd. Experiments with the commutator show that if a number of wires are hung up parallel to one another in the air, the capacity of the whole of the wires taken together is much less than the sum of each of them taken individually when the others are removed.

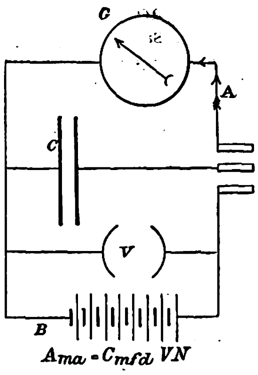

Fig. 3.—Connections for Capacity Measurements.

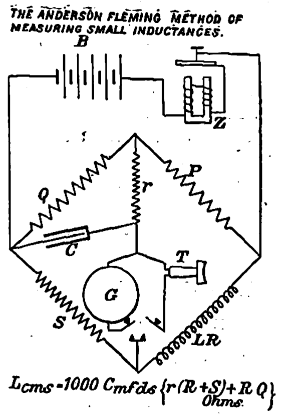
THE ANDERSON FLEMING METHOD OF MEASURING SMALL INDUCTANCES.
B
Z
P
Q
r
C
T
G
S
LR
Lcms = 1000 Cmfds {r(R+S)+R Q}
Ohms

Fig. 4.

Our attention must next be directed to the measurement of a quantity, called the inductance of a circuit. When an E.M.F. is applied to a circuit, the current does not instantly appear at its full value. Time is required to create a current in a conductor by a finite E.M.F., just as time is required to create velocity in a mass of matter by mechanical force. The quality of the circuit, however, on which this fact depends is called its inductance, and it corresponds to inertia in matter. The value of the inductance of a circuit can be calculated for certain simple cases, just as the capacity can be determined. If the wire is not made of magnetic material the inductance depends only on the size and shape of the wire, and is measured for our present purposes in centimetres or in larger units called microhenrys, each of which corresponds to 1,000 centimetres.

The mathematical processes by which these calculations can be made are somewhat complex, but in Table II. below are given the values of the inductance L for a number of cases with which we are concerned in practice, such as a straight wire of length $l$ and diameter $d$, the some wire bent into a circle of perimeter $l$ or into a square of perimeter $l$, or into a rectangle, the sides of which are respectively $a$ and $b$.

### Table II.

*Inductance of Various Standard Forms of Circuit.*

Straight wire $= L = 2l\,(2{\cdot}303 \log_{10} 4l/d - 1)$ cms.
Circular wire $= L = 2l\,(2{\cdot}303 \log_{10} 4l/d - 2{\cdot}45)$.
Square wire $= L = 2l\,(2{\cdot}303 \log_{10} 4l/d - 2{\cdot}85)$.
Two parallel wires $= L = 2l\,(2{\cdot}303 \log 2D/d)$.
Rectangle $= L = 4\left[(a+b)\log_\epsilon \frac{4ab}{d} - a\log_\epsilon\left(a+\sqrt{a^2+b^2}\right) - b\log_\epsilon\left(b+\sqrt{a^2+b^2}\right) + 2\sqrt{a^2+b^2-2\,(a+b)}\right]$.

We have, in the next place, to notice a special characteristic to high-frequency currents—viz., that the current is entirely on the surface of the conductor. An experimental proof of this is given in a later lecture. The formula in the above Table II. give us the inductance for infinite frequency, or when the current is wholly upon the surface of the wire. They need a slight but unimportant correction when we are dealing with currents of finite frequency, such as a million per second. In general, the only method of determining the inductance of a circuit is to do it experimentally. One of the most convenient means of carrying out this measurement is by a bridge measurement suggested by Prof. Anderson and modified by myself. In this method we make the conductor, the inductance of which is to be determined, one arm of a Wheatstone's bridge and complete the circuit as shown in Fig. 4. A variable resistance, $r$, is placed in series with the galvanometer and a condenser, C, connected between one terminal of the bridge and of the galvanometer. In the circuit of the battery is placed a buzzer or electromagnetic interpreter, Z, which breaks and makes the circuit of the battery very rapidly, say, from 200 to 300 times per second, and a telephone, T, is placed in the bridge circuit, which can be substituted for the galvanometer G when required. The first step is to balance the bridge for steady currents.

This is done by employing the galvanometer in the bridge circuit and stopping the buzzer. When the measuring arm of the bridge has been so adjusted that the galvanometer shows no current, the battery key being held down, we know that the relation which holds good between the four arms of the bridge, P, Q, R and S is that $P/Q = R/S$. We then set the buzzer in operation and substitute the telephone for the galvanometer, and alter the value of the resistance $r$ in series with the galvanometer until the telephone yields no sound. If then C is the capacity in the bridge reckoned in microfarads the inductance L in centimetres of the conductor being tested is given by the formula

$$L = 1{,}000C\{r\overline{R+S}+RQ\} \text{ centimetres,}$$

where C is the capacity of the condenser in microfarads, and P, Q, R and S are the bridge-arm resistances in ohms. L is the inductance of the arm of the bridge, of which the resistance is R. In making this measurement of inductance, the capacity which must be employed in the bridge circuit has to be selected with reference to the magnitude of the inductance being measured. We may employ the method to determine the inductance of a wire bent into the form of a square, or, vice versa, we may employ the known inductance of such a wire to determine the value of the capacity being used in connection with the bridge.

Another important measurement is that of the mutual inductance of two circuits. If one circuit acts inductively on another the mutual inductance M of the two circuits is measured by the E.M.F. produced in the secondary circuit when a current of unit strength in the primary circuit is started or stopped uniformly in one second. If a current in a wire is steady, the fall of electric pressure, otherwise called the voltage, dropped down the wire is measured by the product of the resistance and current. If the current is rapidly varying the voltage drop is measured by the product of the inductance and the rate of change of the current. If we are dealing with alternating currents which have a uniform frequency, $n$, then the voltage drop due to inductance is easily shown to be equal to 6·24 times the frequency multiplied by the product of the current and the inductance. Hence if the frequency is very large, the voltage drop may be large, even if the current is small. It is easy to show this by a striking experiment.

We create an oscillatory discharge in a thick wire by sending Leyden-jar discharges through it, and we find that if a small incandescent lamp is connected to two points on this wire a few inches apart, the lamp will light up, although the actual current passing, as shown on a hot-wire ammeter, may not exceed 5 or 6 amperes. If, however, we pass a continuous current of the same value through the wire we should find that the lamp would not light up. This shows that the volt drop down a given wire produced by a high-frequency alternating current may be enormously greater than that produced by a continuous current of the same effective value.

(*To be continued.*)

## CORRESPONDENCE.

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### COMMERCIAL TESTING OF MOTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have to thank you for your paragraph in your issue of December 29th, about my recent Paper on "Commercial Testing of Motors," and I am particularly obliged to you for drawing my attention to the slip—due more to incompleteness of expression than to anything else—about the effect of brush position on efficiency. You will notice that I specially remark, in the full copy of the Paper, in dealing with the neutral position, that "the brushes . . . remain in this position for a reversible motor, but in other cases a better result can usually be got with the lead a little backwards." Then follows the sentence to which you take exception. If the words "the best point" be substituted for the word "neutral,"; making the sentence read "the further the brushes are from the best point, the less efficient is the motor," I think the demands of correctness will be satisfied, and certainly the thought in my mind at the time of writing will be accurately expressed. In fact, in the original copy of the Paper, now before me, I find, sketched down at the time of writing, a copy of the diagram for the best point of compromise as regards commutation, which is given on p. 8 of Punga's "Das Funken von Kommutatormotoren," which I happened to be reading at the time—a book, by the way, which seems worth an English translation, if the opportunity occurred of making one—and this fact makes it appear to me more strange that the error should have come in, in face of the obvious guide to the correct statement in the margin of my manuscript.

In regard to the other point to which you take exception, there is actually a voltmeter on the primary of the transformer, but it is in the power house, and is invisible from most of the places at which breakdown tests have to be made; it is, therefore, of little service to the man making the test. There is, therefore, in this particular case a special reason—more or less geographical, so to speak—for adopting the more crude method of judging the brightness of the filaments of a set of incandescent lamps in series with the secondary. These are made up in portable boxes, each set absorbing 500 volts when fully bright. As the maximum voltage used is 1,000, while undoubtedly the insulations tested would stand considerably more, it is obvious that an error of, say, 10 per cent. in judgment is negligible as far as any damage likely to occur is concerned. In other works, arranged in a different way, the more perfect method of using the voltmeter on the primary might be employed, but in the case described it would actually lead to waste of time which would not be compensated for by the slightly greater constancy of test conditions obtained.

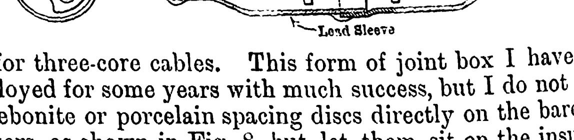
Trusting you may be interested in these remarks, and again thanking you for your paragraph.—Yours, &c.,

Newcastle-on-Tyne, Jan. 6. THOMAS CARTER.

### LEAD SLEEVES FOR CABLE JOINTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In *The Electrician* of December 22, 1905, p. 384, Mr. W. H. Patchell in his article on "The Charing Cross Company's City of London Works," gives an interesting form of cable jointing for three-core cables. This form of joint box I have now employed for some years with much success, but I do not place the ebonite or porcelain spacing discs directly on the bare conductors, as shown in Fig. 8, but let them sit on the insulated conductors (see illustration above). Experience with these joints shows that the creepage is considerably reduced, if not entirely avoided with this construction, and that there is no advantage to be gained by using porcelain. I have even used impregnated wooden spacing discs, and have tested such joints



up to 60,000 volts alternating current with a distance of only ¾ in. between the sweated copper sleeves without breaking down the joint.

There are obvious reasons why the discs should not be in contact with the bare conductors carrying current. In the first place such porcelain or ebonite spacing discs must be carefully cleaned before placing on the bare conductors, and are preferably either dipped in boiling compound or boiled in the insulating compound before making the joint. They should also be handled with wooden tongs and not with the bare hands, as moisture or even dirt prevents the insulating compound from adhering to the discs, and thus creepage between the conductors can take place.

After placing the discs, the conductors to be joined must then be sweated. In doing this it is very difficult to keep the solder from spitting on to the discs or to ensure that the latter are kept free from dust and moisture. Another important point is that the spacing discs should be kept as far as possible from the sweated copper sleeves, otherwise, when filling up the lead sleeves with insulating compound, they cause the compound to be cooled suddenly and thus contract, leaving considerable air-holes in it. These holes are highly conducive to creepage.—Yours, &c., P. W. SNELUS.

Berlin-Westend, Jan. 3.

## WATER PIPES AND ELECTROLYSIS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Owing partly to the holidays and partly to pressure of business I have not studied very carefully the technical papers during the last few weeks, and it was, therefore, not until today that my attention was drawn to the notes in your issue of December 22nd, dealing with a case of lead poisoning on the Twyford Lodge Estate.

I was myself present when the experts retained by the Water Company made their investigation. The facts are these: Twyford Lodge is wired on the concentric system, the engine and battery house being a matter of 160 yds. away, and connected by one insulated lead and one bare copper negative earth return, both being run in the same wooden trough. At the house the negative pole is earthed, but there is no earth plate or earth connection at the engine house. The drop in the return conductor with the maximum number of lights on is about 1½ volts, the maximum found in Messrs. Lucas & Pyke's test being 1·8 volts.

At the time the electrical installation was put in a lead water pipe was run from the cast-iron main in the road to the house, and another one to the gardener's cottage and engine house. This worked for four years without any trouble, and at the present time there is no trace of lead in the water at Twyford Lodge or at the gardener's cottage, nor is the lead pipe even when close to the engine house affected in any way.

About nine months ago a new water pipe was teed in to the old lead main just after passing the engine house in order to run to a new lodge, and quite recently the water was found to be impregnated with carbonate of lead. On cutting the new pipe patches of lead carbonate were found on the inside, these patches becoming denser as one got farther away from the engine house.

I should expect any action resulting from the proximity of this engine house to have taken the form of electrolysis or erosion of the outer surface of the old lead pipe at the nearest point to the engine house, and I have yet to learn of any theory which will account for such electrolysis on the outside being absolutely absent, but, on the other hand, taking place on the inside of the pipe after it had passed the engine house, and not uniformly over the interior surface, but in patches. The fact that there was no earth connection at the engine house would tend to reduce the current travelling back by the lead pipe.

I think it is only due to your readers and the electrical profession generally, that those who have so hastily concluded that this is a case of electrolysis due to the return currents to the engine house should explain the theory on which their conclusions are based. If this is the true cause of the electrolysis in question then I should expect the greater part of the inhabitants of these islands, or at any rate those in towns in which there is a tramway having an earth return, where a drop, not of 1·8 volts, but of 7 volts is allowed, to be permanently suffering from lead poisoning.

The investigations which I have made since this occurrence have led me to the conclusion that there are far more cases of lead poisoning than the public generally suspects, and this in cases where there could be no question of the action of any stray electric currents. An analytical chemist, who is almost daily conducting water analyses, was trying some experiments for me, and drew some water for the purpose from a lavatory in his house at Beckenham. To his surprise he found that the amount of lead in solution was considerably more than was found in the case of Twyford Lodge. The house in question is an old one, but on moving into it about nine months ago a length of new pipe was run to a new lavatory on the ground floor, and it was the water from this pipe that was so strongly impregnated with lead, while the water from all the other taps in the house was found to be quite free. This is practically an analogous case to that at Twyford Lodge. The water in this instance came from the Lambeth Water Works.—Yours, &c.,

Victoria-street, S.W., Jan. 8. A. H. DYKES.

[From the description of the circumstances given in Mr. Latham's Paper there was reason to suspect that there had possibly been electrolysis of the pipe in this case, and we naturally supposed that the consulting engineers responsible for laying down the plant had been given opportunities to investigate the case thoroughly before the facts were laid before the public, and that they would have been invited to take part in the discussion of the Paper. We now understand from Mr. Dykes that he only received a copy of the Paper after it had been read. Whether serious electrolysis occurred or not, however, it is evident that an error was committed in allowing the bare return laid to carry the whole current back from the house to remain partially insulated. Messrs. Lucas & Pyke's report in the Paper states that the resistance between this return and earth was found to be 8 ohms.—ED. *E.*]

## HOW TO SCREW CONDUIT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: At a recent meeting of British conduit manufacturers called, as is now common knowledge, for the purpose of considering an advance in prices, the question of "Standardisation of sizes and standardisation of threads" was raised. It was then decided that another meeting should be called at an early date for the purpose of discussing this all-important question, and for the purpose of appointing a committee to deal with it. I think it advisable to invite the opinion of all concerned—in particular consulting engineers and contractors—with a view to arriving at "the opinion of the trade" on this important matter. This matter is, I think, as important to users of conduit as it is to conduit manufacturers.

My predecessor, the late Mr. Fred. Bathurst, from the very beginning, adopted gas sizes for the conduit system manufactured by my company, and from correspondence and general data in my possession it is quite clear that Mr. Bathurst was always strongly in favour of gas sizes and gas threads for conduit. The only reason why this company did not adopt gas sizes and gas threads from the start was that tube makers anticipated some difficulty about screwing tubes of the comparatively light gauges which were originally used.

So far as gauges of conduit tubes are concerned, my company have moved in the opposite direction to the majority of tube makers. Several makers have made constant and persistent efforts to produce tubes of a lighter and still lighter gauge, until to-day one company, at least, are selling so-called screwed tubes of No. 19 gauge. It is for readers of *The Electrician* and contractors in general to say whether tubes of this absurdly light gauge are satisfactory for conduit work or not, but it is clear that whilst these efforts are being pursued, the tendency is and must remain—"fine threads."

That it is desirable to standardise sizes and threads of conduit tubes I think we are all agreed, and the question which will occupy conduit makers at the forthcoming meeting—and I have no doubt this question will cause a considerable amount of controversy, owing to the interest involved—will be: "What sizes and what threads should be adopted?" I think there is only one answer to it—*i.e.*, Gas sizes, screwed "standard gas."

My company have supplied their standard quality "Armorduct" screwed conduit, screwed standard gas, and the material has been used for a very large number of important installations, and, needless to say, I shall not only advocate standardisation on the basis of gas sizes and gas threads, but also tubes of a still heavier gauge than what is commonly looked upon as heavy gauge in conduit matters to-day.

The position to-day with the number of different sizes and different threads employed by different makers on their conduit is a very vexatious one for everybody—conduit makers, consulting engineers and contractors alike. I think it is quite unnecessary to enlarge on this point. I have during the last few weeks made inquiries of a number of contractors on this important question, and the request in every case has been for "gas sizes and gas threads." I trust some of your readers will give us their views on the matter.—Yours, &c.,

London, E C., Jan. 9. Wm. Schmahl (Director).
The Armorduct Mfg. Co. (Ltd.)

## LEGAL INTELLIGENCE.

### Norwich Corporation v. Norwich Electric Tramways Co.

The Court of Appeal yesterday (Lords Justices Vaughan Williams and Stirling) ordered this case, which has been partly heard, but was allowed to stand over until the decision of the House of Lords in Crossfield *v.* Manchester Ship Canal had been given, to be placed in the final list.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT AND FILLED.

Oldham Corporation Electricity committee require a junior assistant electrical engineer. Salary £80, increasing by annual increments of £10 to £100. Applications to the borough electrical engineer (Mr. S. Wilmott Newington) by Jan. 22. See an advertisement.

Mr. R. M. Mayne, station superintendent at St. Helens, has been appointed mains superintendent at £150 per annum in succession to Mr. C. White, resigned. The salary of Mr. F. Dickinson, works superintendent, has been increased from £160 to £170 a year, and that of Mr. J. W. Warr, overhead equipment and motor superintendent, from £140 to £150.

Dr. R. A. Lehfeldt, professor of physics at the East London Technical College, has been appointed professor of physics at the Transvaal Technical Institute, Johannesburg.

**Award.**—The Board of Trade have issued their award in the appeal of the London Electric Supply Corpn. against the conditions imposed by Greenwich Council upon which certain works were to be performed by the corporation. The appeal is allowed, subject to certain conditions.

**Barnes.**—The Council on Wednesday decided to put down additional plant, including a 300 kw. steam dynamo, boiler, feed pump, &c., at an estimated cost of £4,700, and to apply for sanction to borrow this sum.

**Birmingham.**—The City Council will be invited at their next meeting to sanction a scheme for purchasing and letting out electric motors on hire.

**Blackrock (Dublin).**—The Council's provisional order being on the point of expiry, Dublin United Tramways Co. has been asked to give a supply of electricity.

**Brazil.**—In a lengthy and instructive report upon the trade of Brazil for the years 1902-4 Mr. Consul Mark sets out in detail the imported goods, which were formerly chiefly of British origin, but the supply of which is now shared by other countries than the United Kingdom. These include copper wire, electric lighting and power machinery and apparatus, electrical, mathematical and other instruments, &c. The complete list is a very long one, and seems to indicate that a large proportion of trade formerly transacted between this country and Brazil is shifting over. Throughout the long list Mr. Mark states that at one time hardly a single article but was chiefly imported from the United Kingdom, but out of 147 articles for only 50 is the U.K. still in the ascendancy, and in 68 competes with the fair success of other countries. Of the remaining 79 trade has passed into other hands.

**Brighton.**—At the Council meeting last week it was announced that The application for sanction to a loan of £5,909 for the purchase of the Star Foundry site had been sanctioned, but the application for £38,500 for electric lighting extensions was deferred pending further information.

The Council have decided to appeal against the assessment of the electricity works. At present the works and mains are assessed as follows:—Brighton, £9,971; Preston, £280; Southwick, £6,000; total, £16,251. Mr. P. M. Faraday has been retained as valuer.

**Bury St. Edmunds.**—At Dec. 31 last the equivalent of 10,978 8 c.p. was connected to the mains, a 1,042 8 c.p. increase during the year.

**Cabs and Tramway Competition.**—The local cabmen have complained of the running by Newport (Mon.) Corporation Tramways department of early morning cars for the convenience of people returning home from balls, &c., but a motion that the early morning cars be discontinued was defeated at Tuesday's Council meeting.

**China.**—Canton, with a population of 4,000,000, has enjoyed electricity supply since 1900 and there are now 1,900 consumers on the China Light & Power Co.'s mains, with an equivalent connection of over 15,000 8 c.p. lamps. All wiring installation work is done by the company.

Tientsin has had electricity supply since January, 1903, the owners of the electricity works being the Usine Electrique de la Municipalité Française. There are 138 consumers at present connected, taking the equivalent of 3,200 8 c.p. lamps.

**Clock Dial Illumination.**—Ramsgate Council recently received a communication from the Board of Trade in regard to the illumination of the Pier Yard clock.

This illumination was effected by gas in 1895, at the expense of the Council with the sanction of the Board, but it has now been found necessary to have the clock thoroughly overhauled and cleaned, owing to the action of the gas on the machinery of the clock. The Board have decided that the use of gas to illuminate the clock can no longer be permitted, but if the Council desire to continue the illumination the Board will allow the substitution of electric light for gas, on condition that the Corporation defrays the cost of installing electric light and all necessary fittings, current, &c.

At the Council meeting last week Councillor Wood said it was some advantage to have the clock illuminated at night. They now spent £16 to £18 on gas each year and he was informed that electric current would be even more expensive.

Ald. Hart said they should not assist the electric light company to get the matter into their own hands, considering that the Council owned the gas undertaking. If the Board of Trade considered the clock ought to be lighted by electric light they ought to pay for the lighting of it and also for repairs. He moved that they do not adopt electric illumination.

The Town Clerk said the Board of Trade would not allow gas lighting to continue.

After discussion, the motion was carried.

**Croydon.**—The Tramways committee have reported the receipt of a further offer from the British Electric Traction Co. as to the leasing of the tramways which the Corporation have already decided to acquire and work themselves. The committee recommended that this further offer be not entertained and that tenders be invited for 15 new tramcars for the municipal service. An amendment was, however, moved by Ald. Edridge and carried that instructions be given to the committee to negotiate with the company to ascertain the best offer from a financial point of view which they could make.

**Cuba.**—Mr. G. F. Greenwood, a representative of the Cuban Electric Co., has made application for a concession to construct (1) an electric tramway at Regla and (2) two electric tramway lines in Guanabacoa, which will connect with the tramway already running between Regla and Guanabacoa.

**Darlington.**—It has been decided to supply electricity on the maximum demand system. The following scale of charges for electrical energy for works and factories has been adopted: $1\frac{1}{2}$d. per unit for first 500 units per quarter, $1\frac{1}{4}$d. for next 4,000 units and 1d. for the remainder.

**Douglas (Isle of Man).**—The Tramways committee recommend the Council not to entertain the offer of the Manx Electric Railway Co. in regard to the conversion of the tramways to electric traction.

**Dublin.**—The Corporation have decided to pay to Mr. Robert Hammond, the consulting engineer, the sum of £2,250 in full discharge of all claims whatsoever by him against the Corporation, he releasing all claims against the Corporation as if his agreement of retainer had been unconditionally terminated on June 1, 1905.

**Electric Power in Lancashire.**—A conference of local authorities has been called to consider the question of united opposition to the Lancashire Electric Power Bill. It is asserted that the bill would seriously affect the exclusive right of municipal authorities to supply their own areas with electrical energy for all purposes, and that if such power be granted to private companies it would be most injurious to municipal electricity undertakings.

**Exhibitions.**—The Newport (Mon.) electrical exhibition opened on 4th inst. We briefly referred to this event in our last issue. The display has excited much local interest. The chairman of the Electricity committee (Mr. W. H. Brown) presided at the opening ceremony and gave statistics as to the progress of the municipal electricity department. He said the motor load was steadily increasing: three years ago they had motors representing the aggregate of 25 H.P. connected, now the figure had risen to 1,200 H.P. Public lamps had increased from 42 to 218, lighting consumers numbered 1,100 and power consumers 100. The equivalent of 110,000 8 c.p. lamps was connected and during 1905 they sold 2,700,000 units of energy, the income being £25,000, against £1,449 in 1895, when the undertaking was started. The success of the exhibition is chiefly due to the ability and organising skill of the borough electrical engineer and tramways manager (Mr. H. Collings Bishop).

The fifth automobile exhibition will be held at the Crystal Palace, London, S.E., from 26th inst. until Feb. 3 inclusive.

The projected exhibition which was to be held in Edinburgh in 1907 has been postponed until 1908.

**Electrical Engineers' Ball** —The Electrical Engineers' ball, which proved so successful last year and the year before, is to be repeated on Jan. 19 at the Hotel Cecil. The hon. secretaries are Mr. A. M. Sillar and Mr. H. Alabaster.

**Felixstowe.**—The Suffolk Electricity Co. claim to have the balance of the purchase money (£3,000) paid to them, as the net revenue of the electricity works for the year ended Nov. 11 was sufficient to pay 6 per cent. on capital expenditure at the beginning of the year. The electrical engineer (Mr. R. P. Wilson) has also given his opinion that from the report of the company's auditors the Council could not resist the claim, and the Lighting committee again recommended application being made for sanction to a loan to meet the claim, but after discussion the subject was referred to the Finance committee.

**Gomersal.**—Electrical Distribution of Yorkshire (Ltd.) are applying for a provisional order.

**Great Yarmouth.**—Thirty seven gas standards in the New Town are to replaced by incandescent electric lamps.

Though the Council have not yet obtained the sanction recently sought for a loan for the suction pipe for the new condensing plant, &c, the electrical manager (Mr. G. Bryant) has been instructed to proceed with the work, which is urgent. The cost is to be paid out of the profits of the undertaking.

**Hammersmith (London).**—A further loan of £13,700 for additional electrical plant has been completed.

**Holborn (London).**—The Council have decided to adopt a uniform system of reinstating streets and roads opened by electric lighting and other companies for laying mains, &c., and it has been decided to adopt the direct labour system after April 1.

**Inquest.**—An inquest was held on Friday at Mountain Ash (Glam.) on the body of J. J. Thomas, who met his death on the 2nd inst. at the Lower Duffryn Colliery through coming in contact with a live electric cable.

Thomas Jones, engineman, deposed that deceased had gone up to look at a joint in a pipe, near where the electric wires were situated.

J. F. Flanders, electrician at the colliery, said the wires were not cased. The voltage was 3,300.

Medical evidence having been given,

The Coroner said that the use of electric power at collieries necessitated the management taking every precaution that the wires were properly protected. The fact should be brought home clearly to all engaged in collieries as to the danger which they ran in getting into contact with the electric cables. Deceased had gone to attend to a joint when he lost his footing, and so came into contact with the wires.

A verdict of "Death from misadventure" was returned.

**L.C.C. Electric Power Scheme.**—On Wednesday Holborn Borough Council decided by a large majority to oppose the scheme of the London County Council for the erection of electricity works for supplying electrical energy in bulk for power in London and the suburbs.

**Light Railways** —The secretary to the Tees Commissioners has deposited with the Light Railway Commissioners particulars of objections to the scheme for the construction of a conveyor bridge across the Tees at Middlesbrough and of a light railway to West Hartlepool.

Bournemouth Corporation have decided to oppose the Branksome Park and Swanage light railway scheme.

**Lincoln.**—The charge for electric current supplied to the electric tramways has been fixed by the Council at 2d. per unit.

**Lowestoft.**—The minutes of the Electricity committee, presented on Tuesday by Councillor Fry, gave a very satisfactory account of the progress of the electricity undertaking.

Councillor Fry said the whole of the plant was in good condition, and all repairs and various new works had been executed out of revenue. They started the year in the expectation of receiving 2½d. per unit for power for the trams, but that had been reduced to 2¼d., making a difference of £375. They had for the time being come to an end of the capital expenditure, and he hoped they would now begin to reduce capital account. During the year they had generated 145,000 units more than last year, and had done this at £49 less cost. That was due to the new boilers and to the bonus system, which was working well. Their income was £11,688, against £9,929, their profit £4,139, against £2,332, and if they had been a trading company they would have paid a dividend of 6¼ per cent. on capital, against 3¼ last year. The net result was a deficiency of £550, against £1,471. Private consumers showed £1,400 increase in revenue. Mr. Fry paid a high compliment to the chief engineer (Mr. Bruce) for his economical management.

**Macclesfield.**—The Council have approved the bill of the Macclesfield and District Tramways Co.

**Mail Conveyance by Tramways.**—An agreement has been entered into between Yarmouth Corporation and the Postmaster-General for the conveyance of the mails between Yarmouth and Gorleston by tramway. For seven journeys daily the P.O. authorities will pay the Corporation £22 per annum.

**Manchester.**—The Electricity committee have decided to settle the action brought by the owner of a warehouse adjoining the Dickinson-street station against the Corporation for an injunction to restrain an alleged nuisance.

The Chairman (Mr. G. Howarth) explained that the committee had had to pay plaintiff £1,000 per annum from March, 1899, in order to keep the case from going into court again. They had been unable to prevent the vibration to the extent that they had wished, and rather than face the heavy damages which the court would be likely to give, the committee decided to adopt the course suggested. Mr. Howarth also explained that in the case of the Corporation v. Midwood, though counsel had advised an appeal to the House of Lords, the committee felt that there was little chance of altering the view of the court as to the negligence of the Corporation servants, and that the cost of going to the House of Lords was more than the committee were warranted in incurring.

**Motherwell.**—The Council have decided not to entertain the offer of the Clyde Valley Electrical Power Co. for a supply of electricity in bulk, on the ground that they are at present and will be for some time able to supply all requirements from their own station.

**Motor Ambulances.**—The Metropolitan Asylums Board Ambulance committee have reported that experiments had confirmed them in their opinion as to the suitability of motor traction for their ambulance service, and arrangements are being made to completely equip the south-western station with motor ambulances and omnibuses, and with a properly fitted workshop.

The Hague Municipal Council will consider on Monday a recommendation of the burgomaster and assessors to grant a credit of £650 towards providing an electric motor ambulance.

**Municipal Wiring.**—Bethnal Green Council have decided to support the clauses of the L.C.C. General Powers Bill empowering London borough councils to wire and fit consumers' premises for light and power.

**Overhead Conductors.**—Golcar Council have consented to the erection of overhead wires by Huddersfield Corporation for the supply of electricity to Wellhouse.

**Oxford.**—At a ratepayers' meeting on Wednesday the Council's tramway bill was rejected. A poll will probably take place.

**Plymouth.**—The Council have rejected the Tramways committee's recommendation to purchase four demi-cars for the Pennycomequick tramway route at an estimated cost of £2,000.

In the course of the discussion Mr. Monk said that a proposal had been considered to stop the cars at once, but that had been negatived by the committee, although they were losing £30 a week on that route. The committee agreed that the cars should cease running in Union-street.

**Portsmouth.**—The Council have decided to erect flame arc lamps in some of the principal thoroughfares in Southsea.

**Presentation.**—At the annual supper of the employés of the Scarborough Tramways Co. on 3rd inst. a gold-mounted fountain pen and leather pocket book were presented to Mr. J. E. Edmundson, manager of the company, who is leaving Scarborough to control the electricity supply undertakings at Grantham and Stamford of the Urban Electric Supply Co.

**Sevenoaks.**—The Council are agitating in favour of the erection of electricity works. A provisional order is held by the Kent Electric Power Synd., and a committee has been formed to interview the Board of Trade on the subject of its prolongation. The Kent Co. announce that, having completed arrangements for their power station at Chatham, they are now turning their attention to the outlying districts. Their engineers had estimated that the first portion of the installation, with mains, would cost between £9,000 and £10,000. Of that amount they are prepared to find from £6,000 to £7,000 if £3,000 is taken up locally.

**South Africa.**—The "British & South African Export Gazette" states that:—

*Krugersdorp* Corporation have negotiated a loan of £100,000 in London to cover (among other outlays) cost of establishing electricity works (£16,000).

Latest returns show that the pumps in use in the *Transvaal* mines include 100 electrically-operated (on 36 mines), 73 air-driven (on 23 mines), 69 driven by Cornish engines (on 45 mines) and 92 by other steam engines (on 46 mines).

Large orders are about to be placed by the *Natal* Government Railways Department for electrical machinery for Durban.

Additional machinery is about to be ordered for *Kroonstad* municipal electricity works.

**Southampton.**—Application is to be made for sanction to a further loan of £5,000 for laying additional mains and services.

**Sunderland.**—The Electricity and Lighting committee have considered an offer from a company to take over and work the Corporation's electricity undertaking, including the two power houses, the Corporation receiving £12,000 a year. After discussion, the offer was declined.

**"Sunshine" Arcs v. Incandescent Gas.**—Mr. C. Rockley, of West Ham Corporation electricity department, to whose former pamphlet entitled "Electric Lighting for Retailers" we have formerly had occasion to refer, has issued a new pamphlet entitled "Sunshine Arcs *v.* Incandescent Gas." Mr. Rockley is a firm believer in the value of the electric light, and in his pamphlet has something to tell the ordinary gas consumer which it is well for him that he should know. Mr. Rockley prophesies a great future for the flame arc lamp, which he christens the "Sunshine Arc," and describes how it threatens to supersede the older types of arc lamps, and in any case to arrest any further development in the direction of high pressure incandescent gas, at any rate for outdoor lighting.

**Swansea.**—The Electric Lighting committee have decided to put down additional plant at the generating station at an estimated cost of £7,000. At the meeting of the committee last week the chairman (Major Sinclair) gave an account of the progress of the undertaking.

**Theft of Cable.**—At Woking last week a woman named Nicholls and a lad named Lawrence were convicted of having stolen a quantity of electric cable, the property of the Woking Electricity Supply Co. Thomas Crockford was also convicted of feloniously receiving the cable knowing it to have been stolen, and also of receiving a quantity of scrap iron, the property of Mr. Richard Field. Crockford was sent to hard labour for 15 months, the woman received four months, and the boy one month's imprisonment.

**Tonbridge.**—The Council have approved a scale of charges, drawn up by the electrical engineer (Mr. Horsley), for the maintenance of consumers' lamps. Mr. Horsley has been instructed to change the remainder of the two-arm lamp brackets for street lighting to swan-neck fittings. The alteration will cost 9s. 6d. per column, but will effect a saving in cost of renewals.

**Tramcar Shed Regulations.**—Dundee Tramways committee experience a difficulty in complying with the rules and regulations of the Home Office regarding car sheds.

These regulations were originally intended for locomotive and railway repair shops, but would in the official opinion apply also to the Dundee car sheds where repairing work is done. The rules would seriously affect the Corporation, as by the requirement that there should be a car's length of clear space between each car half of the available space would be wasted, and the regulations in regard to fixed obstacles would involve reconstruction. It has been decided to join other corporations and tramway owners in approaching the Home Office with a view to having tramway sheds exempted from the regulations.

**Walsall.**—To meet the increasing demand for current for lighting and power, the Electricity committee recommend the Council to apply for sanction to a further loan of £13,000 for additional generating plant and mains extensions.

The chairman of the Electricity committee (Ald. W. Brownhill) stated on Monday that previous extensions had proved most advantageous, as the increased income represented 10 per cent. on the outlay, and there was no reason why the present output should not be doubled. The committee had sacrificed £2,000 by reducing its charges for current, and its balance-sheet would show a deficit of £350, but nevertheless a profit was being made. The Tramway committee were being supplied with current at 1½d. per unit, although the actual cost of generation was fully 2d. The recommendation was ultimately referred to the General Purposes committee.

**West Bromwich.**—The Electric Light committee recommend that in future the charge for electrical energy for power for a demand above 3 H.P. when the consumption does not reach 600 units per quarter be 1½d. per unit, and above this figure 1d. per unit. Discounts, varying from 2½ per cent. to 10 per cent. are to be allowed to consumers of between 6,250 and 25,000 units per quarter.

**West Ham.**—It was reported to the Council on Tuesday that several manufacturers of and contractors for electric motors were not pushing their business among power consumers in the district on account of the difficulties connected with single-phase motors.

The electrical engineer (Mr. A. H. Seabrook) had been authorised to announce that two-phase motors are being put in at present and are temporarily running on the single-phase circuits, and that, according to the rapidity with which the load increases, two-phase supply will be introduced.

Mr. Seabrook recommended that, as wiring contractors' show rooms were advertising the sale of electricity as well as the means by which electricity could be used for lighting, cooking, heating, power, &c., a special rate be charged to those contractors in order to induce them to make the most brilliant display possible. The Town Clerk is to report as to the power of the Council to adopt the suggestion.

Mr. Seabrook also reported as to the desirability of reducing the charges for lighting and power under certain conditions to flat rates of 3d. per unit for lighting and 1d. for power. He was instructed to prepare a more detailed report and also as to whether it was desirable to make a universal reduction to the same flat-rate charges.

**York.**—The Board of Trade having declined to send an expert to inspect the machinery stated to have been damaged by the recent accident at the electricity works, the Electricity committee have decided to employ an independent electrical engineer to report.

**Concert and Dance.**—A subscription concert and dance in connection with the London branch of the Electrical Trades Union will be given on the evening of Jan. 19 in the concert hall of the Club Union Buildings, Clerkenwell-road, London, E.C.

**Entertainments, &c.**—Owing to the liberality of Crompton & Co. (Ltd.), Chelmsford, the members of the Arc Works Club were enabled to entertain their wives and children to a tea, Christmas trees and variety entertainment at the Corn Exchange, Chelmsford, on Saturday last. There were present upwards of 900 mothers, children and guests, the last including Mrs. and Col. Crompton, Sir Carne Rasch, Bart., Lady Capel, the general manager (Mr. Hew Stevenson) and Mrs. Stevenson, the works manager (Mr. A. J. Hodgson) and Mrs. Hodgson, Mr. F. R. Reeves and Miss Reeves, Mrs. and Mr. Claud Crompton, the Mayor and Mayoress of Chelmsford, the clergy of the town, &c. The tea was followed by a variety entertainment of a very popular character, the National Anthem concluding a very enjoyable time. Mr. P. G. Cheverton, the newly-appointed hon. sec., and his committee are to be complimented upon the success of their efforts.

Recently the directors and employees of the Simplified Underground Conductor Co. held their annual dinner and concert under the presidency of Mr. F. A. Pocklington, the managing director, in the unavoidable absence of the chairman, Mr. McIver. The chairman reviewed the work of the company during the past year and referred to the success which had attended the work of the staff in the various departments.

## TRADE NOTES AND NOTICES.

### TENDERS INVITED.

*Bristol* Electrical committee invite alternative tenders for 2,000 kw. and 3,000 kw. single-phase turbo-alternator (2,000 volts, 93 periods), together with condensing plant. Particulars from the city electrical engineer (Mr. H. Faraday Proctor), Temple Back, Bristol. See also advertisement.

*Aberdeen* Electricity Committee invite tenders for supply and delivery of one cast-iron disc fly-wheel for fitting to a Willans engine. Tenders to the City Electrical Engineer (Mr. J. Alex. Bell), Electricity Works, Millburn-street, by noon Jan. 22. See also an advertisement.

*Fulham* (London) Council invite tenders for supply and erection of (*a*) steam piping, (*b*) water and exhaust piping. Specifications from the borough electrical and consulting engineer, Mr. Arthur J. Fuller. Tenders to the town clerk (Mr. R. M. Prescot), Town Hall, Fulham, by noon Jan. 31. See also an advertisement.

*Plymouth* Corporation electricity department invite tenders for the supply of stores for the 12 months to March 31, 1907, including paper-insulated cables, transformers, a.-c. meters, lubricating oils, &c. Tenders to Mr. E. G. Okell, borough electrical engineer, by Jan. 24.

*Battersea* (London) Electricity committee want tenders by noon Feb. 5 for a direct-current steam generator (either 750-850 or 1,000 kw. and 460 to 550 volts), piping, ejector condenser, arc lamps, and arc lamp globes and columns.

*Stoke-upon-Trent* Electricity committee invite tenders for 12 months' supply of meters and demand indicators. Tenders to Mr. P. J. S. Tiddeman, Electricity Works, Stoke-on-Trent, by Jan. 31.

The Electric Lighting committee of *Leyton* District Council invite tenders for (1) 500 kw. dynamos and (2) overhead crane. Tenders will be opened on Jan. 18.

*Hackney* (London) Council invite tenders for 12 months' supply of arc-lamp carbons and coal. Tenders by noon Jan. 25.

*West Ham* Corporation invite tenders by 4 p.m. 25th inst. for engine-room stores and incandescent lamps.

The *Spanish Government* have decided to invite tenders for laying a new cable between Cadiz and Teneriffe.

## TENDERS RECEIVED AND ACCEPTED.

Bradford Tramways committee have accepted the following tenders for annual tramway stores:—

General Electric Co., lamp fittings; W. T. Glover & Co., cables; D. B. Rose, brass castings, ears, crossings, frogs, insulators, &c.; R. W. Blackwell & Co., trolley poles and trolley accessories; London Transfer Depot, transfers; J. Rushforth & Sons, timber; Crossley & Davenport, iron and steel; W. Harland & Son, varnishes; Derby Chemical Colour Co., dry colours; Raines, Porter and Seddon, paints; Stephenson Bros., painters' sundries and paint brushes; Saml. Miller's Exors., white lead; Brooksbank & Co., oils; Bradford Incorporated Institution for the Blind, cleaning brushes; Pilkington Bros., glass; Robt. Young & Co., grease; W. M. Towler, malleable iron and steel castings; Salters (Ltd.), springs; Wood & Saberton, bolts, nuts and washers, wood handles, shafts, galvanised iron and tinware, screws, nails, rivets, &c., tools and ironmongery; J. S. Heap & Son, lead and tin; J. W. Rowlands & Co., pinion wheels; and Wm. Parkinson, coal.

The "British & South African Export Gazette" states that Johannesburg Corporation have placed contracts with Weightman & Amery for construction of street islands for tramway poles (£3,539); C. Jowett & Co. for tramway construction work, &c. (£12,915); Gloucester Railway Carriage & Wagon Co. for bodies, and Dick, Kerr & Co. for trucks, wheels, axles and electrical equipment for three electric freight cars (total cost £1,800); British Insulated & Helsby Cables, 200 ft. of 4 in. by ¼ in. copper strip; and Pilkington Bros. for rolled glass. The Corporation have also confirmed their contract with Dick, Kerr & Co. for supply of 100 electric cars.

Hackney Electric Lighting committee received tenders for mains (for one, two or three years at option of Council) from the British Insulated & Helsby Cables, Callender's Co., W. T. Glover & Co., W. T. Henley's Co., Siemens Bros. & Co. and the Western Electric Co. As the schedule of prices quoted by the British Insulated & Helsby Cables was considered the most satisfactory, the committee have, subject to the usual sanction, accepted same.

West Ham Corporation have accepted the tender (the lowest received) of the Glasgow Numerical Printing Co. for tramway tickets for three years as follows: Ordinary ticket (Corporation reserving advertising rights) 3⅛d. per 1,000, extra for coloured overlay ⅛d. per 1,000; section tickets 4¼d., official tickets 4d.

Battersea (London) Council have accepted the tender of Ernest F. Moy (Ltd.) for three switch pillars at £205 11s. 9d., and that of Callender's Company for diverting electric mains in connection with the electrification of the tramways in Battersea Park-road.

Salford Council have accepted the following tenders:—Bowes Scott & Western, water softening plant, £740; F. M. Burley, wiring Higher Grade School for Girls; Key Engineering Co., joint fibre conduit.

Canterbury Council have accepted the tender of E. J. Philpot for wiring the irrigation works, and have also given an order for wiring work for the ensuing half-year to W. Gard.

Southport Council have accepted the tender of the Tudor Accumulator Co. for a storage battery of 252 cells at £1,458 and £93 per annum for maintenance for 10 years.

The Pacific Railway Co. of Argentina have placed an order with the Brush Co. for three 250 kw. turbo-alternators with condensers and pipework for their new Bahia-Blanca (Argentina) station.

Brighton Corporation have accepted the tender of Sattin & Evershed for erecting additional premises for the electricity department on the Star Foundry site at £3,900.

Hammersmith (London) Council have purchased a Hotchkiss boiler cleaner, which has been on trial for some time past at the generating station, for £57. 15s.

West Bromwich Corporation have accepted the tender of Gibbons Bros. & Co. for coal-handling plant.

Swindon Council have accepted the tender of the Brush Co. for three tramcars at £1,786.

Bournemouth Corporation have placed an order for two motor cars at £980 each with Straker & McConnal.

Ilford District Council have accepted a tender of Johnson & Phillips for 0·5 in. triple-concentric armoured cable at £1,689. 9s.

Croydon Corporation have accepted the tender of Dick, Kerr & Co. for a 1,000 kw. direct-current generator at £6,975.

**Switch Gear Contracts.**—The following orders for switch gear, &c., have recently been placed with Ferranti Limited:—

Transvaal: Luipaards Vlei Estate Gold Mining Co., L.T. three-phase switchboard. Japan: D.C. and three-phase switch gear and transformers for H.T. transmission scheme. Glasgow Corporation; D.C. sub-station switch gear. Pontypridd Council: D.C. battery and booster switch gear. Dublin Corporation: E.H.T. main and sub-station and L.T., A.C., sub-station switchboards. Wimbledon: Extensions to H.T. switch gear. Also H.T. three-phase and L.T., D.C. switch gear for abroad.

## BUSINESS NOTICES.

The Cambridge Scientific Instrument Co., Carlyle-road, Cambridge, have been appointed sole agents for the sale in this country of the Grasso flux meters. A pamphlet describing these instruments can be obtained from the company.

The partnership between Josephine Gonne and Wm. Robt. Newbold Gard (trading as Wm. Gard & Co.), electrical engineers, 54, St. Dunstan's road, Canterbury, has been dissolved by the Court of Chancery.

As from Jan. 1 the Sturtevant Engineering Co., 147, Queen Victoria-street, London, E.C., have handed over the control of the electrical side of their business to the Adams Mfg. Co, Ltd, of the same address, whose works are situate at Bedford. The latter company has been formed expressly for the purpose of manufacturing and selling "Igranic" motor controlling gear, &c. The personnel of the business remains exactly as heretofore.

## BANKRUPTCIES, LIQUIDATIONS, &c.

In the failure of Robert Pries (trading as Durnall & Pries, electrical sundriesman), the summary of debtor's amended statement of affairs shows 65 unsecured creditors for £1,255. 2s. 3d., other creditors £6. 4s. 8d., total £1,261. 6s. 11d. The assets have realised sufficient to pay off part only of the preferential claims, leaving a deficiency of £1,261. 6s. 11d.

Debtor is a German subject, who came to this country in 1894 and traded in partnership at several addresses as electrical engineers. He states that he has received about £900 from his father at various times, all of which has been put into the business. The partnership was dissolved in April, 1902. Failure is attributed to want of capital, bad trade and bad debts. Of the deficiency, £189 represents goods supplied and work done, £100 borrowed money and £68 law costs. The official receiver concludes his remarks by inviting creditors to furnish him with any information respecting the bankrupt, his trading and affairs.

The trustee in the bankruptcy of Arthur Edgar Brooks (trading as Brooks & Brooks), electrical engineer, 110, Cheapside, London, E.C., has been released.

The discharge of Gerald Algar (trading as Gerald Leslie), electrical engineer, &c., 5, Denning-road, Hampstead, London, N.W., has been granted, subject to his consenting to a judgment for £5, and £1. 10s. costs.

Claims against W. S., G. E. & H. T. Wright (trading as Wright's Patent Heater Condenser Co.), 16, Great George-street, S.W., and Carlisle-street, Lambeth, S.E., London, to Mr. L. J. Sharp, 191, Corporation-street, Birmingham, by Jan. 25.

A meeting will be held on Feb. 7 at 5, Coleman-st., London, E.C. to receive an account of the winding up of the Hampstead Electric Supply Co. (Ltd.).

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**Sale by Auction.**—Messrs. Horne & Co., 8, Delahay-street, Westminster, S.W., will sell by auction at the Royal Arsenal, Woolwich, on 24th inst., at 11 a.m., some unserviceable and obsolete stores, including a quantity of metals (copper, gun-metal, phosphor bronze, iron and steel, &c., lead, zinc, &c.), electrical stores, telephones, telegraph instruments, &c. Catalogues from the War Office, Pall Mall, S.W.; the Ordnance Office, Tower, E.C.; and the Ordnance Office, Royal Arsenal, Woolwich, S.E. See also an advertisement.

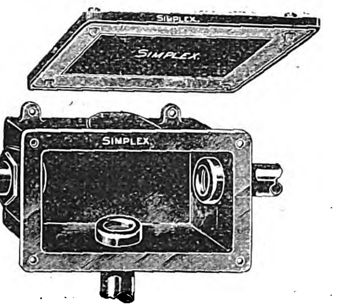
**Sale by Tender.**—Leeds Electricity committee invite tenders for purchase of electric generating plant (about to be replaced by plant of larger capacity), comprising two 500 I.H.P. Belliss engines and two 300 kw. single-phase Ferranti a.-c. generators, with exciters. Tenders to the town clerk (Mr. R. E. Fox) by Jan. 31.

**Electrical Engineering Works for Sale.**—Messrs. Fuller, Horsey & Co., 11, Billiter-square, London, E.C., have for sale some electrical engineering works fully equipped with modern plant and machinery, situate at Fambridge, Essex. Particulars and terms from the auctioneers. See an advertisement elsewhere.

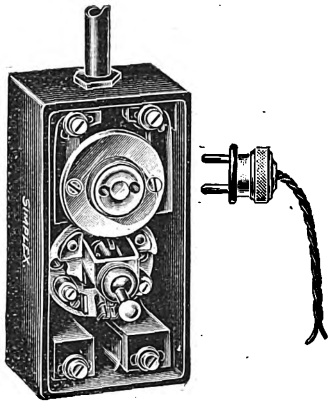
**Increase in Prices.**—Mr. A. P. Lundberg notifies that, owing to the continued rise in the cost of materials, he is compelled to increase the prices of his special class of goods by 5 per cent. on the net amounts as from Feb. 1.

**Turbine Orders.**—That the adoption of steam turbines in this country is making headway is borne out by the orders which Messrs. Willans & Robinson have in hand. The first Willans turbine was not ordered until the beginning of 1904 (after which date drawings, patterns, &c., had to be made), and at the end of 1905 no less than 50,000 kw. of turbines was under construction in the company's shops or at work outside. The largest turbine which has been built to order is of 5,000 kw. normal rating (which is the largest single-flow Parsons type turbine constructed in this country). Messrs. Willans & Robinson have in hand, in addition, or have already set to work six 3,000 kw., seven 1,500 kw., and thirteen 1,000 kw. turbines.

**"Simplex" Specialities.**—An abridged and supplementary list of Simplex fittings and sundries has been issued which amplifies the particulars available regarding these useful appurtenances. The accompanying illustration shows the Admiralty pattern of Simplex universal watertight junction box for screwed conduits up to 1 in. diameter. This box is cast with a raised boss in a central position on each side, and any or all of these bosses can be bored or tapped for screwed conduits. The same box can be used either for drawing through, T-jointing or intersection purposes. A ⅜ in. flange is provided which fits into the recess in the cast cover, a well-fitting rubber washer being inserted to ensure a watertight joint. The boxes are made to several dimensions suitable for ½ in., ⅝ in., ¾ in., ⅞ in. or 1 in. conduits. An adjustable switch and wall-socket fitting, with adjustable cover, is also shown. In this fitting the cover is held in position by metal rings on the switch and wall-socket, and is arranged to come flush with the plaster, enabling the wireman to adjust the alignment of the switch and wall socket after erection, even in cases where a perfectly straight line of conduit has not been kept. These are only a few of the items described and priced in the new supplementary list.

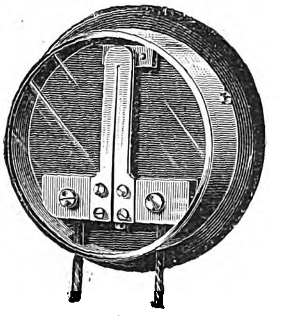


"Simplex" Admiralty Pattern Watertight Junction Box.



"Simplex" Adjustable Switch and Wall Socket Fitting.

**Excess Indicators.**—Our illustration shows an example of the Holden Excess Indicator, which is described in a list recently sent out by James Pitkin & Co., 56, Red Lion-street, Clerkenwell, London. This useful appliance is too little known, seeing that, in accumulator installations especially, it is claimed by the makers to save its cost many times during the year's work. It is equally correct for alternating and continuous-current working. Its operation is to give warning by a bell when the normal working current is excessive, and the bell continues its ringing until the normal conditions are restored. The indicator requires no attention, and has proved to be exceedingly reliable.



"Holden" Excess Indicator.

**"International Handbook for Telegraphists."**—We have received from a German publishing house a copy of a book purporting to be an international handbook for telegraphists, but why for telegraphists in particular we are at a loss to understand. The months and days of the year are given in German, French and English in a set of tabulated pages, the diary is blank paper, but with the repetition of the months and days in German, French and English. There is a list of telegraph companies and their managers and secretaries and of the cables laid by the different companies and their dates, abstracted either from the "Journal Telegraphique" or from "The Electrician" Electrical Trades' Directory and Handbook. Following this is a very brief digest of the Service Regulations, which is of little use to telegraphists, international or otherwise.

**Telephone Directory.**—The yearly issue of the Directory supplemental to the main London Telephone Directory has just been made by the National Telephone Co., who have also sent out a new separate list of public call offices in the metropolitan area in a form suitable for carrying in the coat pocket. The supplemental directory contains a list of the cab shelters connected to the London exchange system, as well as a list of those to which connection is being proceeded with. The supplemental list contains about 15,000 names of London telephone subscribers.

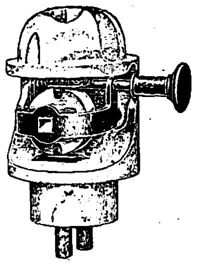
**Willing's "Press Guide" for 1906.**—Our opinion of Willing's "Press Guide" to the United Kingdom, and to the leading journals in the Colonies, in America and on the Continent, is too well known to need any extended notice of the 1906 issue, except to say that there is every evidence of a continued regard to keeping the book well up to date. There is no publication of our acquaintance better worth a shilling than Willing's "Press Guide," which has now reached its 33rd annual issue, and can be obtained from the publishers, 125, Strand, London, W.C. Any business house requiring to communicate press notices and similar items will find this "Guide" a real guide.

**Weights and Measures Tables.**—Mr. T. Fisher Unwin has issued a new edition of Martin's "Up-to-Date Tables of Imperial, Metric, Indian and Colonial Weights and Measures, &c." The popular price of 2s. 6d. has been fixed for the book, which gives a mass of information relating to coinage, interest tables, weights and measures of all kinds and standard time, filling over 250 closely printed pages, bound in strong cloth.

**Catalogues, &c.**—The new catalogue of standard motors and dynamos issued by Electromotors Limited is well printed and illustrated, and contains particulars of the company's continuous-current machines of the semi-enclosed, enclosed ventilated, and totally enclosed types, also crane, lift and hoist motors, together with starters, standard, worm and spur reduction gears and other accessories. Tables of standard outputs for the various sizes are given, but the list is also accompanied by an ingenious device called the "Motorgraphe," which enables the size of motor required to be rapidly determined. This novelty consists of a piece of stout cardboard, in outline resembling a four-pole motor with a circular disc of smaller diameter fixed to it and free to revolve. The fixed and moving portions carry scales of revolutions per minute and B.H.P., which form a circular slide rule. To determine the size of motor required, the B.H.P. is set opposite the speed and the letter denoting the size of motor read off opposite one of the arrow heads on the moving disc, according as the machine is to be of the ordinary semi-enclosed type for continuous running, or a hoist or crane motor at a half-hour rating. Limits of speed for each size are printed on the card. The smallest motors are two-pole, and the remainder, ranging up to about 28 B.H.P., are of the four-pole type, with steel poles provided with laminated pole shoes and cast with the frames. The bearings can be turned round so that the motors can be fixed in any position. Full details of weights and dimensions are given, and the catalogue concludes with a list of standard fans.

Another new list has recently been added to those issued by Ferranti Limited. This is No. 62, which deals with single-pole single-throw slow-break knife switches of 25 to 2,500 amperes. Open and closed positions of these switches are illustrated, and a general specification accompanies the list.

The Edison and Swan Co. have ready a new sheet list relating to the "Ediswan" push-button keyholder. The illustration shows the operation of the holder. The on and off positions are obtained by alternate movements of the button, which turns a small ratchet on its axis; across a diameter of this is fixed the bridging piece which closes the switch. The porcelain is made in two pieces, and the terminals are so arranged that for wiring it is only necessary to remove the top ring and nipple without withdrawing the porcelain from the body. It is claimed that this keyholder is especially reliable on high-voltage circuits. It is well made and has a good appearance.



"Ediswan" Push-Button Holder. (Cap removed.)

A new list of M.P. motors for continuous current and of self-lubricating carbon brushes for motors and dynamos is being sent out by Marryat & Place, 28, Hatton-garden, London, E.C. A large number of M.P. motors (1,200) are priced in this list, representing every combination of the firm's standard motors, both slow and medium speed, all voltages, and with and without covers, rails, starters, D.P. switches, D.P. fuses, and regulators. The list contains a specification and description of the motors and other particulars, and can be slipped into the pocket without inconvenience. The carbon brush list intimates that the goods are manufactured by the National Carbon Co.

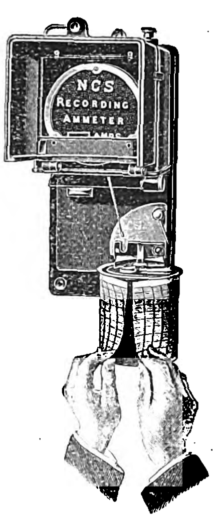
L. E. Wilson & Co., telephone experts and engineers, 20, Cross-street, Manchester, forward a pamphlet setting out some particulars of their experience in telephone installation work. Mr. L. E. Wilson was until recently chief electrician to the National Telephone Co. in the Manchester district, where he gained much experience.

Archibald F. Wright (Ltd.), of Leyton Green-road, London, N.E., have ready a supplementary sheet of electrical novelties and accessories. These include flash lamps, hand lamps, pins, batteries and bulbs, electric clocks, torches, &c.

A new catalogue of springs, wirework, clips and presswork has been compiled by Herbert Terry & Sons, Novelty Works, Redditch, and contains particulars of a large range of these goods, in the manufacture of which the firm have had a half-century's practical experience.

A circular sheet just issued by the Simplified Underground Conductor Co. shows "Simplified" mains laid by the company at Reading.

Nalder Bros. & Thompson, 34, Queen-street, London, E.C., have issued a new edition of their Recorder catalogue, and particular attention has been given in the new list to the type of recorders which give a record upon a continuous coil. Instead of having the paper perforated, as has been the general practice hitherto, needle points are employed to move the paper forward. In all the rocorders listed in the new edition of the catalogue the clocks are of the firm's own make. The accompanying illustration shows the dead-beat moving-coil type of direct-current N.C.S. record instrument and the simple method of re-charting the recorder. The standard paper speed on these instruments is $\frac{9}{16}$ in. per hour, the drum revolving once in 24 hours. Or the drum can be arranged to revolve once in 12 or once in six hours, in which case the paper speed is $1\frac{1}{8}$ in. and $2\frac{1}{4}$ in. per hour respectively. The clock has an eight-day lever movement.



RE-CHARTING N.C.S. RECORDER.

Nalder Bros. & Thompson have also ready a new sheet list of the N.C.S. insulation test set, which consists of a generator and ohmmeter of the electrostatic type, combined in one case, and weighing only $13\frac{3}{4}$ lb.

We have received from the Liverpool Electrical Cable Co. a copy of their latest catalogue of electric wires and cables. This is got up in a very neat style and contains a large quantity of information compressed into the smallest number of pages possible with due regard to legibility.

"Electric Driving of Ring-spinning Frames" is the title of a pamphlet describing Brown-Boveri plant and is issued by the electrical department of Richardsons, Westgarth & Co., Hartlepool, representatives in this country of Brown-Boveri & Co., of Baden. The pamphlet is admirably illustrated to display to best advantage the application of electric driving to ring-spinning frames, one illustration showing a battery of about 30 frames, each direct driven by independent motors. The type of motor used for this special class of driving is totally enclosed without artificial ventilation and with starting apparatus, fuses and automatic arrangement for switching on and off, lifting the brushes from the collector rings and short-circuiting the latter. This requires of the workman at the spinning frame only to turn a hand-wheel to start his machine. The latest design of these motors is supplied with the means of interior ventilation, which reduces the cost of construction. The pamphlet will be read with interest by textile manufacturers, as well as by those interested in the electrical side of the work.

**Calendars, &c.**—The foreign department of the Allgemeine Elektricitäts-Gesellschaft has forwarded us a novel and exceptionally well made "perpetual" calendar and paper-weight combined, which takes the form of a miniature turbo-alternator of this firm's design, both machines being mounted on a common base plate. A horizontal slot is provided in the cylindrical casing of the turbine and alternator respectively, and through them appear the months of the year and the date of the month, the calendar being set by turning the shaft of the turbine or of the alternator. This clever little novelty forms a suitable item for the electrical engineer's desk, and the idea is both novel and pleasing.

A bold and useful hanging calendar, one month to view, has been sent by Mavor & Coulson, 47, Broad-street, Mile-end, Glasgow. A good illustration of an under-type direct current coal cutter on sledges is conspicuously printed on the face. A view of one of this firm's direct-current type of "Pick-Quick" coal cutters on sledges, and adjusted for undercutting, is shown on a monthly card calendar also to hand.

An artistic hanging calendar has reached us from Wilson Hartnell & Co., of Leeds, in the form of an excellent print from a painting by Asti, entitled Lenore, the calendar being mounted below.

A neat and useful little pocket stamp case and calendar comes from the Chloride Electrical Storage Co., of Clifton Junction, near Manchester. The calendar and some particulars of the company's manufactures are interleaved with waxed paper, which provides a safe place for stamps, preventing their sticking or falling out.

Nalder Bros. & Thompson's hanging calendar for 1906 is to hand and is compact and serviceable.

Horace Simon & Co., 43, Mincing-lane, London, E.C., specialists in office lighting installations, havo sent us a neat and useful hanging calendar.

The Simplified Underground Conductor Co., 53, Castle-street, Liverpool, have issued a neat calendar blotter with celluloid face, upon which is illustrated a good view of the company's stand at Olympia.

**Imports.**—The following are official values of imports of electrical machinery, material and apparatus imported into this country during December, 1905:—

Electrical machinery, £44,142 (an increase of £6,761); telegraph cable and apparatus, £4,377 (decrease, £2,087); other electrical goods, £90,606 (increase, £4,370). The values of imports of the three classes for the 12 months ended Dec. 31 were, respectively, £496,710 (decrease, £62,261); £53,532 (decrease, £1,542); and £956,772 (increase, £165,973).

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Dec. 31 to Jan. 9, with the ports of destination:—

*Africa.*—Alexandria, £861 (including £60 telegraph material); Delagoa Bay, £37; Durban, £1,798 (including £622 telegraph material); East London, £648; Port Elizabeth, £38; Port Said, £50; Sekondi, £18. *Argentina*—Rosario, £185. *Australasia*—Auckland, £75; Lyttelton, £14; Melbourne, £502; Otago, £207; Perth, £2,100 (telegraph material); Sydney, £854; Wellington, £1,188. *Austria*—Trieste, £70. *Belgium*—Antwerp, £105; Ostend, £244. *Brazil*—Pernambuco, £65; Rio Janeiro, £3,915 (telegraph material). *Burma*—Rangoon, £9. *Canada*—Montreal, £25. *China*—Shanghai, £485. *Denmark*—Copenhagen, £10. *France*—Boulogne, £262; Paris, £38. *Germany*—Bremen, £200; Hamburg, £10. *Gibraltar*, £43 (including £23 telegraph material). *Holland*—Amsterdam, £109 (including £44 telegraph material). *Hong Kong*, £439. *India*—Bombay, £313; Calcutta, £1,086; Madras, £1,150. *Japan*—Nagasaki, £24; Yokohama, £79. *Italy*—Genoa, £17. *Madeira*, £15. *Malta*, £173 (including £161 telegraph material). *North Atlantic*, £2,000 (telegraph material). Total £19,461 (for 10 days), against £18,880 for seven days last year (Jan. 4 to 10).

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specification. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

December 16, 1905.

26,207 ROBSON. Protective devices for electric distribution by overhead wires.
26,219 VERNUM. Electric light raising and lowering device.
26,223 PEDDIE. Electric tramways on the conduit system.
26,235 HANSON. Trolley-rope protector.
26,237 FOX. Ignition devices for explosion engine. (Date applied for, Oct. 25, 1905.)*†
26,281 FIELD & FERRANTI LIMITED. Electromagnets for alternating-current circuit-breakers.
26,285 BARNETT. Ignition devices.

December 18, 1905.

26,348 OHNESORGE. Systems of connections for branch telephone stations. (Date applied for, Dec. 17, 1904).*†
26,355 HEIN. Electrically driven vacuum cleaning apparatus. (Date applied for, July 26, 1905.)*†
26,376 JOB. Switching apparatus for electric flash advertising.

December 19, 1905.

26,434 RENDER. Fuse heads for electric blasting.*
26,445 CLARKE & STEVENS. Electrical signs.
26,460 MASON. Trolleys of electric cars and the like.
26,467 NEHMER. Electrical apparatus for lighting gas.
26,501 LOWNE & LOWNE ELECTRIC CLOCK & APPLIANCES CO. Electrical means for giving an impulse to a pendulum.
26,510 FAHN & JIROTKA. Transforming direct electric currents.
26,512 WILSON & WILSON. Electrostatic watt and watt-hour meters.
26,522 BOULT. (Joly, France.) Sychronising apparatus.
26,525 LOVEGROVE. Electric shock apparatus.*

December 20, 1905.

26,528 CROFTS, SMITH & WELLS. Telephone message tablet with fall down number register.
26,548 TOPHAM. Continuous-current dynamos.
26,575 ROBERTSAW & ROBERTSHAW. Trolley booms.
26,581 BRIGHT. Electric radiators.*
26,590 LE PONTOIS. Generating and utilising high tension alternating currents for ignition of explosive mixtures.*
26,591 LAMKIN & QUINTON. Register for telephone calls.
26,595 BROWN & BROWN. Electric signalling.
26,601 IMRAY. (Hoffe, Cape Colony.) Automatic electric cut-outs.
26,629 DE KANDO. Connections for two or more three-phase motors.*
26,631 ANDRÉE. Electro-magnetic motors with travelling fields.

December 21, 1905.

26,662 BRAUN. Batteries.
26,688 BROWN. Converting varying alternating current into similarly varying direct current.
26,689 BRAGSTAD. Distribution and supply of current in electric railway systems. (Date applied for, Dec. 21, 1904.)*†
26,691 FÉRY. Thermo-electric galvanometers. (Date applied for, 6/1/'05.)*†
26,713 ROUTIN. Controlling electric current distributing systems.*
26,727 BRADLEY. Ignition devices for internal combustion engines.

December 22, 1905.

26,802 Lake. (Electric Boat Co., U.S.) Controlling and steering submersible or similar boats.

26,807 Davidson. Dynamo electric apparatus.

26,808 Lundell. Alternating-current motors.*

26,813 Ashcroft. Electrolysis of metallic compounds or ores.

December 23, 1905.

26,828 Love. Writing pad upon a telephone desk.

26,852, 26,853 and 26,854. Drake, Jones & Jandus Arc Lamp & Electric Co. Arc lamps.

26,855 Bourdos, Rothschild & Sutcliffe. Filaments of electric lamps.

26,870 Hon. C. A. Parsons & Armstrong. Dynamo electric machinery.

26,876 Boult. (Stebbins, U.S.) Storage batteries.*

26,897 Fynn. Single-phase commutator motors. (Date applied for, 25/3/'05.)*†

26,898 Fynn. Polyphase alternate current motors and generators.

26,903 Cowper-Coles. Anodes.

26,905 Cowper-Coles. Manufacture of metallic wire or strip.

26,925 Rothwell. Electric railways on the surface contact system.

December, 27, 1905.

26,953 Gardner. Controlling operations at a distance.

26,970 La Force. Sparking plugs for combustion engines. (Date applied for, May 12, 1905.)*†

26,987 Hartung. Glow lamps.*

27,002 Bloxam. (Lux, Austria.) Incandescent lamp filaments from tungsten or molybdenum or an alloy thereof.

27,009 Johnson. (Badische Anilin & Soda Fabric, Germany.) Electrolytic production of chromic acid and apparatus therefor.

27,013 Thompson. (Vittorio Gioberti & Co., Italy) Double-armature dynamo.

December 28, 1905.

27,046 Longford. Sparking plugs for internal-combustion engines.

27,052 Wilkins & Woodhouse. Trolley heads.

27,057 Mountain & Gibson. Swivelling contacts for trolley standards.

27,059 Mountain & Gibson. Trolley pole standards.

27,090 B.T.-H. Co. (G.E. Co., U.S.) Electric motor-control systems.

27,096 Hart & Durtnall. Electric propulsion of vehicles, boats, &c.

27,098 Haddan. (Richardson, U.S.) Electric laundry irons.

## SPECIFICATIONS PUBLISHED.

### 1904 Specifications.

24,918 Hyde. Leading-in conductors for incandescent lamps.

27,424 Walker. Magnetising iron by alternate-current dynamo.

27,638 Steinmetz. Vapour electric apparatus. (Date applied for, 19/12/'03.)

27,929 Turner. Electric block signalling apparatus. (Date applied for, Dec. 22, 1903.)

27,986 N. S. Electric Storage Co. & Niblett. Storage batteries.

28,154 Kuzel. Light emitting bodies for incandescent lamps.

28,375 Zingel. Electric bipolar plates accumulator.

28,522 Mackenzie. Electric signalling on railways.

28,525 Mountain & Gibson. Trolley standards.

28,791 Snoeck. Electric current distributers for luminous letters.

### 1905 Specifications.

185 Arnold & La Cour. Leading-in and taking off the armature current of compensated single-phase commutator motors.

401 B.T.-H. Co. (G.E. Co., U.S.) Current collectors for electric railways.

542 Maclean. Switch.

718 B.T.-H. Co. & Wedmore. Reverse current circuit breakers.

1,592 B.T.-H. Co. (G.E. Co., U.S.) Brush holders.

2,488 Peckham. Brakes for railway and tramway vehicles.

2,529 Tweedale & Tweedale. Electric stop motions for weaving.

2,858 Hepke & Diener. Multiple fuse plugs.

2,920 Garside. Resistances.

3,157 Rees. Dynamo-electric machines and motors.

3,394 Morris. Electric ignition apparatus.

3,978 Blessin. Electrical alarm contacts for door locks.

4,076 Wise. (Thomson Electric Welding Co.) Electric welding.

5,982 B.T.-H. Co. (G.E. Co., U.S.) Protective apparatus for systems of electric distribution.

6,542 Hirst & Cash. Electric light fittings.

7,105 W. T. Henley's Telegraph Works Co. & Savage. Cables.

7,416 B.T.-H. Co. (G.E. Co, U.S.) Vapour electric apparatus.

7,972 Paul & Harris. Electrical regulating, testing and measuring apparatus.

12,432 Canizares. Automatic cut-offs. (Date applied for, June 30, 1904.)

12,594 B.T.-H. Co. (G.E. Co., U.S.) Electric controlling arrangements for trains on the multiple unit system.

13,148 Boult. (Mueller.) Jump spark apparatus for ignition purposes.

14,318 Cornilleau & Sainte-Beuve. Electric ignition for explosion motors. (Date applied for, Dec. 29, 1904.)

17,280 Gawron. Magneto ignition apparatus for internal combustion engines. (Date applied for, Aug. 26, 1904.)

17,955 Roos & Roos. Electrical relays.

21,672 Allgemeine Elektricitäts-Ges. Ampere-hour motor meters. (Date applied for, Oct. 28, 1904.)

22,585 Electric Ignition Co. & Hall. Switches.

22,723 Kriéger. Regulating speed of electric motor cars. (Date applied for, Dec. 1, 1904.)

23,097 Siemens & Halske A.-G. Incandescence bodies for electric light. (Date applied for, Nov. 15, 1904.)

23,098 Siemens & Halske A.-G. Glow lamps with incandescence bodies of tungsten molybdenum or similar metals. (Date applied for, Nov. 15, 1904.)

## NEW COMPANIES, MORTGAGES AND CHARGES.

### NEW COMPANIES.

**ALFRED BIST & CO. (LTD.)** (87,071.)—Reg. Jan. 1, capital £2,000 in £1 shares, to acquire the business carried on at Manchester, by Alfred Bist & Co., to adopt an agreement and to carry on the business of mechanical and electrical engineers, decorators, suppliers of electricity, &c. A. Bist is permanent governing director. Reg. office, 18, Tib-street, Manchester.

**HARPER ELECTRIC PIANO CO. (LTD.)** (87,135.)—Reg. Jan. 5, capital £11,000 in £1 shares, to acquire the sole British rights (except for South of England) in the Harper Electric Piano, and to carry on the business of manufacturers of electric pianos, manufacturers of and dealers in electric lamps, fittings, motors, batteries and accumulators, &c. First directors, S. C. Harper, W. E. Garstin (chairman) and F. S. Groom. Reg. office, 266-8, Holloway-road, London, N.

**HIGHWAYS TRANSIT (LTD.)** (87,136).—Reg. Jan. 5, capital £100 in 1s. shares, to adopt an agreement for the acquisition and working in the United Kingdom and the British Colonies and Dependencies of certain inventions relating to vehicles and trains for railways and roads, and to carry on the business of manufacturers of and dealers in motor and other cars, waggons and vehicles, &c. First directors, W. Blackwell and E. Surcouf. Reg. office, 59, City-road, London, E.C.

**MOTOR & ELECTRICAL ENGINEERING CO. (LEEDS) (LTD.)** (87,081.)—Reg. Jan 1, capital £5,000 in £1 shares, to acquire the business of motor car manufacturer and dealer, electrical and general engineer, &c., carried on as the Motor & Electrical Engineering Co. First directors, James Rebecca, P. N. Hirst and A. Matthews. Reg. office, Sheepshanks Yard, North-street, Leeds.

**L. RENE & CO. (LTD.)** (87,043.)—Reg. Dec. 29, capital £8,000 in £1 shares, to adopt an agreement with T. F. L. René, and to carry on the business of manufacturers, vendors, buyers and repairers of and dealers in motors, motor accessories and fittings, electric and gas fittings and appliances, lamps and metal ware, electrical and general engineers, &c. First directors, T. F. L. René, W. Osmond, S. Feast and F. Best. Reg. office, 6, Snow-hill, London, E.C.

### STATUTORY RETURN.

**BUENOS AYRES GRAND NATIONAL TRAMWAYS CO. (LTD.)**—In return to Nov. 17, capital is £625,000 in 50,000 ordinary, 65,000 first preference and 10,000 second preference shares of £5 each, all of which have been taken up. £5 per share has been called up on 40,000 and £200,000 has been received. £425,000 is considered as paid on £85,000 shares. A further £930 has been paid on 3,488 forfeited shares. Mortgages and charges, £852,023.

### MORTGAGES AND CHARGES.

**AUTOMATIC ELECTRIC CO. (LTD.)** (Liverpool).—A debenture dated Dec. 19, 1905, to secure £100, charged on company's undertaking and property, present and future, including uncalled capital, has been registered.

**SUNDERLAND DISTRICT ELECTRIC TRAMWAYS (LTD.)**—A charge dated Dec. 29, 1905, to secure £2,500, has been registered. Property charged, company's undertaking and property, present and future, subject to trust deed dated Dec. 8, 1903, has been registered. Holders, Bruce Peebles & Co. (Ltd.

## CITY NOTES.

**MEMORANDA** (Jan. 11).—Bank rate 4 per cent. since (Sept. 28, 1905). Price of silver $30\frac{1}{4}$d. per oz. Consols $89\frac{1}{8}$—$89\frac{1}{4}$ for money, $89\frac{5}{16}$—$89\frac{7}{16}$ for account; $2\frac{1}{2}$ per cent. annuities 88—$88\frac{1}{2}$. Consols Pay Day, Feb. 1. Stocks and Shares Continuation Day, Feb. 6; Ticket Days, Jan. 24 and Feb. 7. Pay Days, Jan. 25 and Feb. 8; Mining Share Carry-over Day, Jan. 22.

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**EASTERN EXTENSION AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.)**—The interest on this company's 4 per cent. mortgage debenture stock for the half-year ending 31st inst. will be paid by warrant on Feb. 1. The register will be closed from 27th to 31st inst. inclusive.

**GLOBE TELEGRAPH & TRUST CO.**—The directors have declared interim dividends of 3s. on the preference and 2s. on the ordinary shares.

**NOTTING HILL ELECTRIC LIGHTING CO. (LTD.)**—An extraordinary general meeting will be held at Winchester House, London, E.C., on Jan. 16, for the purpose of considering a resolution approving a bill to be introduced into Parliament authorising the association of electric supply undertakers in the West of London and for other purposes. The following explanation of the bill is given:—

The Notting Hill Company in 1889, in conjunction with the Kensington & Knightsbridge Company, obtained powers and made arrangements for supplying in bulk any possible requirements in its area of supply from a joint station in Wood-lane, Hammersmith. The neighbouring companies in Westminster (the St. James' and Pall Mall Company and the Westminster Company) had made arrangements for bulk supply to themselves from the Central Electric Supply Co.'s station, as had the Metropolitan Company from Willesden, but the benefit of all these arrangements has hitherto been confined to the companies owning the stations. In view of the possible demand for further bulk current in other parts of the West End of London, the Notting Hill Company and the Kensington & Knightsbridge Company have agreed to join forces with the St. James' and Pall Mall and Westminster Companies, and the bill referred to above is being promoted to take power for linking up the bulk supply stations belonging to the respective companies, with a view to the interchange of current; provision is also made for a connection with the Metropolitan Company's

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. | | |
|---|---|---|---|---|---|---|
| | | | | No. of weeks. | Amount. | Inc. or Dec. (a) |
| | | £ | £ | | £ | £ |
| Aberdeen Corporation | Jan. 6 | 1,603 | + 42 | 32 | 45,363 | - 1,124 |
| Airdrie | Dec. 29 | 212 | + 20 | 52 | 10,755 | + 817 |
| Anglo-Argentine | Jan. 7 | 15,669 | + 1,299 | 1 | 15,669 | + 1,299 |
| Ayr Corporation | ,, 6 | 233 | - 18 | 33 | 10,712 | - 100 |
| Barnsley | Dec. 29 | 218 | + 15 | 52 | 8,400 | - 803 |
| Barrow | ,, 29 | 282 | + 29 | 52 | 12,410 | + 2,800 |
| Bath Electric Trams, Ltd. | Jan. 8 | 657 | + 87 | 1 | 657 | + 87 |
| Birkenhead Corporation | ,, 7 | 1,419 | - 86 | 1 | 1,419 | - 86 |
| Birmingham Corporation | ,, 6 | 383 | + 26 | 40 | 14,823 | + 1,853 |
| *Birmingham & Mid. | Dec. 29 | 1,507 | - 517 | 52 | 81,365 | - 1,283 |
| Blackpool Corporation | Jan. 4 | 346 | + 9 | 1 | 346 | + 9 |
| Blackpool and Fleetwood | ,, 6 | 195 | + 15 | 1 | 195 | + 15 |
| Bolton Corporation | ,, 7 | 2,368 | + 217 | 41 | 79,183 | + 8,568 |
| Bournemouth Corporation | ,, 8 | 1,386 | + 363 | †40 | 56,901 | + 12,887 |
| Bradford Corporation | ,, 6 | 8,839 | - 182 | 40 | 176,490 | - 4,169 |
| Brighton Corporation | ,, 7 | 791 | - 8 | 41 | 43,872 | + 477 |
| Bristol Trams & Carriage | ,, 5 | 4,718 | + 139 | 21 | 67,816 | + 1,305 |
| Buenos Ayres & Belgrano | ,, 7 | 4,059 | + 568 | 1 | 4,059 | + 568 |
| Buenos Ayres Elec. Trams | Dec. 9 | 1,430 | ... | 49 | 58,825 | ... |
| Burnley Corporation | Jan. 6 | 1,152 | + 62 | 40 | 54,885 | + 2,874 |
| Burton Corporation | ,, 7 | 292 | - 19 | §42 | 12,567 | - 1,467 |
| Bury Corporation | Dec. 31 | 898 | ... | §39 | 29,403 | ... |
| Calcutta Tramways Co. | Jan. 6 | R62,024 | + R13,186 | 1 | R62,024 | + R13,186 |
| Camborne-Redruth | ,, 6 | 114 | + 10 | 10 | 1,096 | - 13 |
| Cardiff Corporation | Dec. 31 | 1,928 | - 185 | 39 | 8,585 | - 158 |
| Carlisle Tramways Co. | ... | ... | ... | ... | ... | ... |
| Central London Railway | Jan. 6 | 6,985 | - 30 | 1 | 6,985 | - 30 |
| Chatham & Dist. Lt. Rys. | ,, 4 | 612 | + 24 | 1 | 612 | + 24 |
| *City of Birm'gh'm Tram Co. | Dec. 29 | 5,635 | + 29 | 52 | 278,7[illegible]8 | - 162 |
| City & South London Rly. | Jan. 7 | 3,149 | - 30 | 1 | 3,149 | - 30 |
| Colchester Corporation | ,, 4 | 149 | - 19 | 23 | 5,811 | - 1,421 |
| †Cork Electric Trams Co. | ,, 4 | 260 | - 41 | †1 | 260 | - 44 |
| Devonport & Dist. Trams | Dec. 29 | 473 | - 64 | 52 | 23,731 | - 3,517 |
| Dover Corporation | Jan. 6 | 193 | + 13 | ‡40 | 9,201 | - 28 |
| Dublin & Lucan Railway | ,, 5 | 61 | - 16 | § 1 | 61 | - 16 |
| ‡Dublin United | ,, 5 | 8,536 | + 158 | ‡1 | 8,536 | + 289 |
| Dudley—Stourbridge | Dec. 29 | 913 | + 27 | 52 | 46,241 | + 1,752 |
| Dundee Corporation | Jan. 3 | 1,311 | + 133 | §33 | 31,041 | + 2,151 |
| East Ham Council | ,, 6 | 796 | + 168 | 40 | 33,342 | + 4,324 |
| Gateshead & Dist. Trams | Dec. 29 | 1,093 | + 117 | 52 | 48,224 | + 1,279 |
| Glasgow Corporation | Jan. 6 | 18,175 | + 1,108 | 32 | 487,143 | + 29,377 |
| Glossop | Dec. 23 | 121 | + 23 | 52 | 6,888 | + 640 |
| | ,, 30 | 129 | + 18 | | | |
| Gloucester Corporation | Jan. 3 | 231 | - 2 | 40 | 11,870 | ... |
| Gravesend—Northfleet | Dec. 29 | 263 | + 18 | 52 | 11,968 | - 819 |
| Gt. Northern & City Rly. | Jan. 6 | 1,831 | + 53 | 1 | 1,831 | + 53 |
| Greenock & Port Glasgow | Dec. 29 | 572 | + 83 | 52 | 33,352 | + 3,840 |
| Halifax Corporation | Jan. 3 | 1,331 | + 95 | 40 | 63,616 | + 4,380 |
| Hartlepool Tramways | Dec. 29 | 301 | + 22 | 52 | 13,854 | - 1,142 |
| Hastings Elec. Trams Co. | Jan. 4 | 365 | ... | 1 | 365 | ... |
| Huddersfield | ,, 6 | 1,287 | + 63 | 40 | 51,863 | + 2,653 |
| Hull Corporation | ,, 6 | 2,[illegible]83 | + 103 | 40 | 89,647 | + 1,151 |
| Ilford Dist. Coun. | ,, 6 | 402 | + 44 | 40 | 19,088 | + 678 |
| Ipswich Corporation | ,, 6 | 328 | - 9 | 40 | 17,517 | - 1,873 |
| Isle of Thanet Co. | ,, 6 | 216 | + 2 | 14 | 3,812 | - 485 |
| Kidderminster & District | Dec. 29 | 137 | - 1 | 52 | 6,215 | - 346 |
| Kilmarnock Corporation | Jan. 6 | 247 | - 51 | 31 | 5,420 | ... |
| Kirkcaldy Corporation | ,, 3 | 3[illegible]5 | - 10 | 18 | 3,751 | - 86 |
| †Lanarkshire Trams Co. | ,, 4 | 930 | + 117 | †1 | 930 | + 117 |
| Leamington | Dec. 29 | 152 | + 46 | 24 | 4,301 | + 1,569 |
| Leeds Corporation | Jan. 6 | 5,370 | + 77 | 40 | 242,524 | + 6,920 |
| Leicester Corporation | ,, 6 | 2,121 | + 369 | 1 | 2,121 | + 639 |
| Leith Corporation | Dec. 30 | 461 | + 242 | 32 | 11,302 | + 9,128 |
| Liverpool Overhead Rly. | Jan. 7 | 1,419 | - 86 | 1 | 1,419 | - 86 |
| *London County Council | Dec. 30 | 18,933 | + 1,419 | ... | 678,900 | + 79,412 |
| Lowestoft | Jan. 6 | 151 | + 15 | 14 | 2,098 | - 23 |
| Maidstone Corporation | ,, 4 | 84 | - 11 | 40 | 5,014 | ... |
| Manchester Corporation | ,, 6 | 12,473 | + 477 | 40 | 518,051 | + 24,850 |
| Mersey Railway | ,, 6 | 1,779 | + 88 | 1 | 1,779 | + 88 |
| Merthyr | Dec. 29 | [illegible]68 | ... | 52 | 9,869 | - 518 |
| Metropolitan Dist. Railway | Jan. 7 | 8,130 | + 602 | 1 | 8,130 | + 602 |
| *Metropolitan Elec. Trams | Dec. 29 | 8,655 | + 1,2[illegible]7 | 52 | 189,[illegible]53 | + 58,055 |
| Middleton | ,, 29 | 328 | + 55 | 52 | 17,426 | + 912 |
| Musselburgh | ,, 28 | 164 | ... | 54 | 11,472 | ... |
| Nelson Corporation | Jan. 6 | 124 | + 18 | 41 | 5,395 | + 659 |
| Newcastle-on-Tyne Corp. | ,, 6 | 3,763 | - 45 | 40 | 153,057 | + 3,971 |
| Newport (Mon.) | ,, 6 | 563 | + 83 | 14 | 7,674 | + 524 |
| Northampton Corporation | ,, 5 | 392 | + 35 | 39 | 16,696 | + 4,948 |
| Oldham, Ashton & Hyde | Dec. 29 | 610 | + 103 | 52 | 29,048 | + 1,016 |
| Oldham Corporation | Jan. 7 | 1,594 | + 240 | 41 | 67,317 | + 16,470 |
| Perth (W. A.) Elec. Trams | ,, 5 | 1,761 | - 18 | ‡1 | 1,236 | ... |
| Peterborough | Dec. 29 | 154 | + 10 | 52 | 6,922 | - 677 |
| Pontypridd Dist. Council | Jan. 6 | 143 | ... | 40 | 6,516 | ... |
| Portsmouth Corporation | ,, 6 | 1,552 | + 37 | 40 | 80,213 | + 1,261 |
| Potteries | Dec. 29 | 2,020 | + 206 | 52 | 89,718 | + 1,532 |
| Preston Corporation | Jan. 3 | 580 | ... | 14 | 8,351 | ... |
| Reading Corporation | ,, 4 | 575 | - 14 | 1 | 575 | - 14 |
| Rotherham Corporation | ,, 4 | 448 | - 25 | 40 | 18,405 | - 408 |
| Rothesay | Dec. 29 | 45 | + 11 | 52 | 9,664 | + 2,718 |
| Salford Corporation | Jan. 8 | 4,183 | + 186 | 41 | 175,453 | + 10,182 |
| Sheerness | Dec. 27 | 62 | - 2 | 52 | 3,646 | + 218 |
| Sheffield Corporation | Jan. 7 | 4,897 | + 330 | 41 | 203,112 | + 10,919 |
| Southampton Corporation | ,, 8 | 890 | + 19 | 13 | 11,789 | - 289 |
| Southend Corporation | ,, 8 | 223 | + 4 | 40 | 15,418 | + 813 |
| Southport Tramways | Dec. 29 | 221 | + 14 | 52 | 15,816 | - 543 |
| S. Staffordshire Trams. | ,, 29 | 977 | + 156 | 52 | 38,[illegible]53 | + 2,830 |
| Stockport Corporation | Jan. 5 | 811 | + 359 | 40 | 30,580 | + 8,008 |
| Sunderland Corpn. | ,, 7 | 1,336 | + 111 | 40 | 53,608 | + 2,109 |
| Swansea Trams | Dec. 29 | 957 | + 201 | 52 | 57,869 | + 10,049 |
| Swindon Corporation | Jan. 3 | 165 | - 12 | 40 | 7,895 | ... |
| Taunton | Dec. 29 | 68 | - 1 | 52 | 2,910 | - 226 |
| Tynemouth and District | ,, 29 | 205 | + 9 | 52 | 13,109 | - 1,574 |
| Tyneside Trams Co. | ... | ... | ... | ... | ... | ... |
| Wallasey District Council | Jan. 6 | 718 | + 28 | 40 | 31,477 | + 1,128 |
| Walsall | ,, 6 | 412 | - 26 | 1 | 412 | - 26 |
| Warrington Corporation | ... | ... | ... | ... | ... | ... |
| West Ham Corporation | ,, 4 | 1,938 | + 362 | 40 | 78,029 | + 31,221 |
| Weston-super-Mare | Dec. 27 | 35 | + 2 | 52 | 6,865 | + 600 |
| Wolverhampton Corpn. | Jan. 8 | 768 | ... | ... | ... | ... |
| Wolverhampton District | Dec. 29 | 508 | + 42 | 52 | 20,689 | + 532 |
| *Worcester | ,, 29 | 297 | - 38 | 52 | 15,504 | + 318 |
| Wrexham | ,, 29 | 138 | + 3 | 52 | 5,750 | - 349 |
| Yorkshire W.R. Trams | Jan. 7 | 679 | + 155 | 1 | 679 | + 155 |
| Yorkshire Woollen District | Dec. 29 | 1,142 | + 419 | 52 | 35,570 | + 5,626 |

(a) These comparisons are with the corresponding period last year. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days. * Partly electrical.

station at Willesden, and compulsory powers are asked for the purchase of two sites on the banks of the Thames, one in Westminster, the other in Fulham, for further stations, if hereafter found necessary. The resources then available would enable the federated companies to supply not only all the companies and Borough Councils having powers of distribution in the so-called "residential district" of London (*i.e.*, the district North of the Thames from the Eastern boundary of the City of Westminster to the Northern and Western limits of the County of London), but also to supply any future possible demand for power for industrial purposes and for traction. As the Notting Hill Company does not at present possess powers to supply electrical energy for traction to be used outside its district, clauses to give such powers are included in the Bill, and if such facilities are granted it may not be necessary for future tramways and railways in the West of London to erect power stations for themselves. The directors do not anticipate that any considerable capital expenditure will be involved in this application to Parliament, and the close connection between the four companies concerned should result in advantages not only to their respective shareholders, but also to the public, and it is hoped that Parliament will permit the proposed arrangements to be carried into effect.

**RAND CENTRAL ELECTRIC WORKS (LTD.)**—The result of working for December was 871,000 units generated, yielding a gross revenue of £8,100, against 798,000 units and £7,400 for the corresponding period of last year.

**STOCK EXCHANGE NOTICES.**—The Stock Exchange Committee have been asked to grant quotations to a further issue of £164,824 sterling 500-year 4 per cent. debenture stock (redeemable) of the *Commercial Cable Co.* and 15,000 £10 fully-paid 6 per cent. cumulative preference shares of *J. G. White & Co. (Ltd.)*.

**WESTMINSTER ELECTRIC SUPPLY CORPN (LTD.)**—An extraordinary meeting will be held on Monday next for the purpose of approving a bill to be introduced into Parliament entitled "A Bill to Authorise the Association of Electric Supply Undertakers in the West of London, and for other purposes."

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Jan. 10. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Jan. 10. | |
|---|---|---|---|---|---|---|---|
| | | | | £ s. d. | | Highest. | Lowest. |
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | | | | |
| 5 | 3/0 | Anglo-Argentine Ord. Shares | 8½—8¾ | 4 11 6 | Ap, Oct | $8\frac{11}{16}$ | $8\frac{9}{16}$ |
| 5 | 2/9 | † Do. 5½% Cum. Pref. | 5¾—6 | 4 10 0 | — | 6 | 5⅞ |
| St. | 6% | † Do. Permanent 6% Deb. Stock | 140 —143 | 4 3 6 | — | .. | .. |
| St. | 5% | †Auckland Elec. Trams 5% Deb. (red.) | 103 —105 | 4 15 0 | — | 105 | 104 |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1 —1½ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | [illegible]⅞—4⅛ | 6 1 4 | — | [illegible] | [illegible] |
| St | 4½% | † Do. 4½ per Cent. Db. Prov. Cts. | [illegible]3 —[illegible]6 | 4 13 9 | — | .. | .. |
| St | 6% | British Columbia Elec. Rlwy. Def. Ord. | 120 —123 | 4 17 6 | — | 121¾ | .. |
| St. | 5% | Do. Pref. Ord. Stk | 109 —112 | 4 8 8 | — | .. | .. |
| St. | 5% | Do. 5% Cum. Perp. Pref. Stock. | 110 —113 | 4 8 6 | — | .. | — |
| 4 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%—105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 102 —105 | 4 5 9 | — | .. | .. |
| 1 | 2/6 | Buenos Ayres and Belgrano Ord. | [illegible]½—[illegible]¾ | 5 6 8 | — | [illegible] | $8\frac{15}{32}$ |
| 1 | 3/0 | Do. 6 per Cent. "A" Cm. Pref. | 5¾ - 6 | 5 0 0 | — | $5\frac{31}{32}$ | .. |
| 1 | 3/0 | Do. "B" | 5 —5½ | 5 9 1 | — | .. | .. |
| St. | 5% | † Do. 5 per Cent. Debs. | 105 —107 | 4 13 6 | — | .. | .. |
| St. | 5% | † Do. 5% 2nd Deb. (red.) | 100 —103 | 4 17 0 | — | 102½ | 101½ |
| St. | 5% | †Buenos Ayres Elec. Trams (1901) Ltd. | 96 —98 | 5 2 0 | .. | .. | .. |
| 100 | 5½% | †Buenos Ayres Grand National 5½% Pref. Debs. | 100 —104 | 5 5 9 | .. | .. | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 100 —104 | 5 17 0 | .. | .. | .. |
| [illegible] | 3/6 | Calcutta Tramways (Nos. 1 to 105) | [illegible]¼—[illegible]¾ | 4 7 2 | — | $9\frac{1}{16}$ | $9\frac{3}{16}$ |
| 5 | 2/6 | † Do. Nos. 105,001 to 137,610 | 8½—9 | .. | .. | 8⅝ | .. |
| 10 | 4½% | † Do. 4½% 1st Deb. Stock (red.) | 104 —106 | 4 6 0 | — | 105¾ | 105 |
| 1 | 6/6 | Cape Electric Tram Shares | ⅞—1⅛ | 4 8 10 | — | .. | — |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 102 —104 | 4 16 0 | — | .. | .. |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 97 —99% | .. | .. | 9[illegible]½ | 97¼ |
| 1 | .. | Lisbon Elec. Trams Ord. | $1\frac{7}{16}$—$1\frac{9}{16}$ | .. | .. | .. | .. |
| 1 | 0/7½ | † Do. 6% Cum. Pref. | 1⅛—1⅜ | 4 7 4 | .. | .. | .. |
| 100 | 5% | † Do. 5% Reg. Mort. Debs. | 100 —103 | 4 17 0 | .. | .. | .. |
| St. | 5% | †Madras Elec. Trams 5% Deb. Stk. | 101 —103 | 4 17 0 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101 —104 | 4 16 2 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102 —104 | 4 6 7 | — | .. | .. |
| St. | 5% | †Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 103 —106 | 4 14 0 | .. | 104½ | .. |
| .. | $2 | †Sao Paulo Tramway, Light and Power Co. $100 Stock | 147 —149 | 5 7 4 | .. | 147¾ | .. |
| .. | 5% | Do. 5% 1st Mt. $500 Dbs. | 97%—99% | 5 1 0 | .. | 98½ | 98 |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | .. | Adelaide Elec. S'ply Co. 6% Cu.Pr. | 4¾—5¼ | — | .. | 5 | 4⅞ |
| 5 | 3/8 | Calcutta Elec. (1-80,000) | 8¾ 9¼ | 4 9 0 | — | 8¾ | .. |
| 10 | 5% | †City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbr. | 50 —52 | 4 16 0 | .. | 50⅞ | 50⅜ |
| .. | 5% | †Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 94 —96 | 5 4 0 | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½—3 | .. | .. | .. | .. |
| St. | 5% | † Do. 5% Debs. | 85 —90 | 5 10 0 | — | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | 9 —10 | — | — | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92 —94 | 5 6 8 | .. | .. | .. |
| St. | 16/2 | †Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. | 108 —110 | 5 10 0 | .. | 10[illegible]¾ | 10[illegible]¼ |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞—1 | 6 0 0 | — | $\frac{15}{16}$ | — |
| 1 | 1/0 | Rand Electric | 1¼—1⅜ | .. | — | .. | — |
| 1 | .. | River Plate Electricity Co. Ord. | [illegible] | .. | .. | .. | .. |
| 1 | 1/2⅔ | Do. 6% Non. Cum. Pref. | $\frac{15}{16}$—$1\frac{1}{16}$ | .. | .. | .. | .. |
| St. | 5% | † Do. 5% Deb. Stock | 101 —103 | 4 17 0 | .. | .. | .. |
| 5 | 3/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5¼—5¾ | 5 4 4 | .. | .. | — |
| 5 | 9·23d | Do. (12,001-20,000) | 5 —5½ | 8 8 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100 —103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 5% | †Shawinigan Water and Power 5% Bds., Scrip | 101 —103 | 4 17 0 | .. | 101½ | .. |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Share. | Last Dividend | Name. | Price Wed. Jan. 10. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business, Week to Jan. 10. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| 1 | .. | Bath Elec. Trams Pref. Ord. | 29/32—31/32 | .. | | .. | .. |
| 1 | 0/6 | † Do. 5% Cum. Pref. | 15/16—1 1/16 | 4 14 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) .. | 102½—105½ | 4 5 0 | .. | [illegible] | .. |
| St. | 4½% | † B'ham & Midland Trams 4½ 1st Db. Stk. | 101—103 | 4 7 9 | .. | 102¼ | 102 |
| 10 | 9% | Bristol Tramways and Carriage Ord. | 17—17½ | 5 2 11 | Feb, Aug | .. | .. |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10—10¼ | 3 18 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Debs. | 104—106 | 3 15 6 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 8⅜—8⅞ | 6 15 0 | .. | 8¾ | 8 15/32 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 10¾—11¼ | 5 7 0 | Feb, Aug | 11 3/16 | 10¾ |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 119—121 | 4 2 8 | .. | 120½ | 119 |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 98—100 | 4 10 0 | .. | .. | .. |
| St. | 4% | Central London Ordinary Stock | 95—97 | 4 2 6 | June, Dec | 96½ | 95¼ |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 102—104 | 3 17 0 | .. | 104 | 103 |
| St. | 4% | Do. Deferred Stock | 86—89 | 4 10 0 | .. | 88 | 87¼ |
| 100 | 4% | Do. 4 per Cent. Debs. | 111—113 | 3 10 3 | .. | 112¾ | .. |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 4⅞—5⅛ | 4 17 6 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 101—104 | 3 17 0 | .. | .. | .. |
| St. | 2% | City and South London Rly. Con. Ord. | 44—46 | 4 1 6 | Feb, Aug | 44½ | 44 |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 119—122 | 4 2 0 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 117—120 | 4 8 4 | .. | .. | .. |
| St. | 5% | Do. (1901) | 115—118 | 4 4 8 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 105—108 | 3 14 1 | May, Nov | .. | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13½—14½ | 4 2 8 | .. | 14⅜ | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½—15½ | 3 17 8 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5—5½ | 7 5 6 | .. | 5⅝ | .. |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8—9 | 4 8 11 | .. | .. | .. |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 101—103 | 4 7 6 | .. | .. | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 17—18 | 5 0 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 13¼—13¾ | 4 7 8 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 110—112 | 4 0 4 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼—2¾ | 9 8 6 | — | .. | .. |
| St. | 4% | † Do. 4 per Cent. Deb. Stock | 82—87 | 4 12 0 | — | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8 1/16—8 3/16 | 3 13 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾—10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99—102 | 3 19 3 | Jan, July | .. | .. |
| 10 | 5/0 | † London United Trams. 5% Cum. Pref. | 9½—10 | 5 0 0 | — | 9¾ | .. |
| St. | 4% | † Do. 4% 1st Mort. Deb. Stock | 98—101 | 3 19 6 | — | 99½ | 98½ |
| St. | .. | Mersey Con. Ord. Stock | 7—9 | — | — | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8—11 | — | — | .. | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32—9/32 | .. | — | 4 5/32 | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1—1 1/16 | 4 14 1 | — | 1 1/16 | 31/32 |
| St. | 4½% | † Do. 4½% Deb. Stock | 104—106 | 4 5 0 | — | 105 | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½—1½ | .. | May | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾—9¼ | 5 5 8 | .. | .. | .. |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9¾—10¼ | 4 17 6 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103—106 | 4 5 0 | — | .. | .. |
| 100 | 5% | † Sunderland Dist. Elec. Trams. 5% 1st Mort. Debs. | 92—97 | 5 3 0 | .. | .. | .. |
| .. | 5% | Underground Elec. Rys. Co. of London | 98—99 | 5 1 0 | .. | 98½ | .. |
| St. | 3% | Waterloo and City Ord. | 94—97 | 3 2 0 | June, Dec | 96 | .. |
| St. | 4½% | † Yorkshire W.R. El. Trs. Co. 4½% 1st Debs. | 94—96 | 4 13 9 | .. | .. | .. |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | *† African Direct Tel. 4% Mrt. Deb. (red.) | 99½—101½ | 3 18 6 | Jan, July | — | .. |
| 10 | — | Amazon Telegraph | 3¾—4¼ | .. | Jn, Dec | .. | .. |
| 100 | 5% | † Do. 5% Debs. (red.) | 82—87 | 5 15 0 | .. | 84¼ | .. |
| St. | 15/0 | Anglo-American | 63—65 | 4 12 4 | F,My,Ag,N | 62½ | .. |
| St. | 30/0 | Do. Preferred | 110—111 | 5 8 6 | F,My,Ag,N | 110¾ | 109½ |
| St. | 2/0 | Do. Deferred | 17⅛—17⅜ | .. | F,My Ag,N | 17½ | 16 15/16 |
| St. | 4% | † Commercial Cable 4 per Cent. Deb. Stk | 98—100 | 4 0 0 | Jn Ap,Jy,O | 99 | 97½ |
| 10 | 5/0 | Cuba Submarine Ord. | 8½—9 | 5 11 0 | Feb, Aug | 8½ | .. |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17—18 | 5 11 2 | Feb, Aug | 17⅞ | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜—3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 8¼—8¾ | 5 14 0 | April, Oct | .. | .. |
| 50 | 4½% | † Do. 4½ per Cent. Deb. | 99%—102% | 4 3 0 | Jan, July | .. | .. |
| 20 | 3/0 | Direct United States Cable. | 14—15 | 4 6 6 | Ja,Ap,Jy,O | 14½ | 14⅜ |
| 100 | 4½% | † Direct West India Cable 4½% Rg. Db. (rd.) | 99—101 | 4 9 0 | Jn, Dec | .. | .. |
| St. | 25/0 | Eastern Ordinary | 146—149 | 4 14 8 | Ja,Ap,Jy,O | 148½ | 145 |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 91—93 | 3 15 4 | Ja Ap,Jy,O | 92½ | 90¾ |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 106½—108½ | 3 13 8 | May, Nov | .. | .. |
| 10 | 2/6 | Eastern Extension | 14½—15 | 4 13 4 | Ja,Ap,Jy,O | 14 11/16 | 14 11/32 |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 107—109 | 3 18 4 | Feb, Aug | 108 | 107½ |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 101—103 | 3 18 3 | Feb, Aug | .. | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101%—103% | 3 18 8 | May, Nov | 100½ | .. |
| 10 | 5/0 | G. N. (of Copenhagen) ex coupon 64 | 37—39 | 6 3 0 | Jan, July | 37⅜ | 37¼ |
| 100 | 4½% | † Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 99—101 | 4 7 6 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57—59 | 5 10 0 | May, Nov | 58 | 57½ |
| 100 | $1 | Mackay Companies Common | 60 5/16 | 3 6 0 | Jan, July | .. | .. |
| 100 | 4% | Do. Preference | 74 15/16 | 5 6 6 | Ja,Ap,Jy,O | .. | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1⅛—1¼ | .. | .. | .. | .. |
| 100 | 4% | † Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 99—102 | 3 18 6 | June, Dec | .. | .. |
| 10 | 4/0 | West African Telegraph Shares | 9½—10 | 5 0 0 | .. | .. | .. |
| 2½ | — | West Coast of America | 9/16—11/16 | .. | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 99½—101½ | 3 18 9 | Jan, July | .. | .. |
| 10 | — | West India and Panama | ½—¾ | .. | May, Nov | .. | .. |
| 10 | 6/0 | Do. 6% 1st Pref. | 8¼—8¾ | 6 6 8 | May, Nov | .. | .. |
| 10 | — | Do. 6 per Cent. 2nd Pref. | 6½—7½ | .. | May, Nov | .. | .. |
| 100 | 5% | *† Do. 5 per Cent. Debs. | 100—103 | 4 17 0 | Jan, July | .. | .. |
| 10 | 3/0 | Western Telegraph | 14—14½ | 4 18 0 | Mr,Jn,O,D | 14 5/16 | 14 3/32 |
| 100 | 5% | *† Do. 5% Debs. (2nd Series, 1906) | 100—102 | 4 18 0 | June, Dec | .. | .. |
| St. | 4% | † Do. 4% Deb. Stock (red.) | 102—104 | 3 16 10 | .. | .. | .. |
| | | **TELEPHONES.** | | | | | |
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 102—104 | .. | .. | .. | — |
| 6 | 5/0 | Chili Telephone (fully paid) | 7⅞—8⅛ | 4 18 6 | August | 8 1/16 | 7 15/16 |
| 1 | 0/9⅜ | Monte Video Telephone Ord. | ⅞—1 | 4 0 0 | — | .. | .. |
| 1 | 1/0 | Do. 5% Pref. | ⅞—1 | 5 0 0 | .. | .. | .. |
| St. | 6% | National Co. Pref. Stock | 112—113 | 5 6 0 | — | 112⅜ | 111 |
| St. | 5% | Do. Def. Stock | 111—112 | 4 8 8 | — | 111¼ | 109⅝ |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13—15 | 4 0 0 | Feb, Aug | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 11—13 | 4 12 4 | Feb, Aug | 13½ | 12⅛ |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅝—5⅞ | 4 5 2 | Feb, Aug | [illegible] | [illegible] |
| St. | 3½% | *† Do. Deb. Stock 3½ per Cent. (red.) | 98½—100½ | 3 9 6 | June, Dec | .. | .. |
| St. | 4% | † Do 4 per Cent. Deb. Stock (red.) | 103—105 | 3 16 3 | — | 104¾ | 103⅜ |
| 1 | 0/7½ | Oriental | 1¼—1⅜ | 4 14 6 | April, Oct | 1 11/32 | 1 5/16 |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1¼—1⅜ | 4 7 0 | — | .. | .. |
| St. | 24/7½ | † Do. 4% Red. Deb. Stock | 95—97 | 4 2 6 | .. | 96¾ | .. |
| St. | 4½% | † Telephone Co. of Egypt 4½% Db. Stk. Rd. | 101—104 | 4 6 6 | .. | .. | .. |
| 5 | 3/0 | † United River Plate | 7¼—7½ | 5 6 8 | July | 7¼ | .. |
| 5 | 2/6 | † Do. 5 per Cent. Cum. Pref. | 5½—5¾ | 4 7 0 | June, Dec | .. | .. |
| St. | 5% | *† Do. 5 per Cent. Deb. Stock (red.) | 110—112 | 4 9 8 | June, Dec | — | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | † Elec. & Gen. Investment 6% Cum. Pref. | 4¾—5¼ | 5 14 0 | .. | .. | .. |
| 10 | 9/0 | Globe Telegraph and Trust | 11⅛—11⅜ | 4 17 0 | Ja,Ap,Jy,O | 11¼ | 10⅞ |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14½—14¾ | 4 1 6 | Ja,Ap,Jy,O | 14⅝ | 14 7/16 |
| 10 | 6% | Submarine Cables Trust (Cert.) | 125—128 | 4 18 9 | April, Oct | 126 | — |

| Share. | Last Dividend | Name | Price Wed. Jan. 10. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Week to Jan. 10. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12⅜—12⅝ | 5 11 0 | .. | 12¾ | 12⅝ |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10¼—10¾ | 4 8 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11¼—12¼ | 4 18 0 | .. | 11 15/16 | .. |
| St. | 4½% | † Do. 4½ per Cent. Deb. Stock (red.) | 105—107 | 4 4 0 | .. | .. | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼—5¾ | 4 15 8 | .. | 5 5/16 | .. |
| St. | 4½% | Do. Do. 1st Debs | 102—105 | 4 5 9 | — | 103½ | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 8½—9½ | 5 5 0 | — | .. | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 9—9½ | 3 14 5 | Mar, Sept | — | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 102—105 | 3 16 3 | — | .. | .. |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 5¾—6¾ | 4 16 0 | Feb, Aug | 6¼ | .. |
| 5 | 2/8 | Do. 4½ per Cent. Pref. | 5¼—5¾ | 3 18 8 | Feb, Aug | 5½ | [illegible] |
| St. | 4% | Do. 4% Deb. Stock (red.) | 101—103 | 3 17 6 | — | .. | .. |
| 5 | 2/8 | † Do. City Undertaking 4½% Cm. Pref. | 4⅝—4⅞ | 4 12 6 | — | .. | .. |
| 5 | 2/8 | † Do. Do. (1908) | 4⅝—4⅞ | 4 12 6 | .. | .. | .. |
| 5 | 2/8 | Chelsea Electric Supply Ord. | 5—6 | 5 0 0 | March | .. | .. |
| St. | 4½% | *† Do. 4½ per Cent. Deb. Stock (red.) | 108—110 | 4 1 6 | Jn, Dec | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 11—12 | 5 0 0 | Feb, Aug | 11⅞ | 11½ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 14¼—14¾ | 4 4 2 | Jan, July | .. | .. |
| St. | 5% | *† Do. 5 per Cent. Deb. Stock (red.) | 122—125 | 3 19 4 | Jn, Dec | .. | .. |
| St. | 4½% | † Do. 4½% 2nd Deb. Stock (red.) | 101—103 | 4 7 6 | .. | 102¾ | .. |
| 5 | .. | County of Durham Elec. P.D. Ord. £2 pd. | 2 1/16—2 5/16 | .. | April, Oct | .. | .. |
| 5 | 5% | Do. Do. 5% non cum. pref. | 5¼—5½ | 4 12 7 | April, Oct | .. | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 8½—9½ | 4 6 6 | — | 9⅛ | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅜—12⅞ | 4 13 2 | Mar, Sept | 12 11/16 | .. |
| St. | 4½% | † Do. 4½% Deb. Stock (all paid) (red.) | 110—113 | 3 19 6 | .. | .. | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 101—103 | 4 7 6 | .. | .. | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5—5½ | 4 11 9 | .. | 5 5/16 | 5¼ |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101—104 | 4 6 6 | — | — | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8¼—8¾ | 4 17 2 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100—103 | 4 7 5 | — | 102 | — |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 10¾—11¾ | 5 0 0 | .. | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½—7 | 4 5 9 | Jan, July | — | — |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) .. | 98—101 | 3 19 2 | .. | 99 | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101—103 | 3 17 8 | .. | 101½ | .. |
| 8 | 1/9⅜ | London Electric Supply Ord. | 1¾—2¼ | 4 0 0 | .. | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5—5½ | 5 9 0 | .. | 5⅜ | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb | 98—101 | 3 19 2 | Mr,Jn,S,D | .. | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 9½—10½ | 4 15 0 | April, Oct | 10⅛ | 9⅞ |
| 5 | 2/3 | † Do. 4½ per Cent. Cum. Pref. | 5¼—5½ | 3 18 0 | Jan. July | 5 7/16 | .. |
| St. | 4½% | † Do. 4½ per Cent. Deb. Stock 1st Mort. | 107—111 | 4 1 0 | Jn, Dec | .. | .. |
| St. | 3½% | † Do. 3½ per Cent. Mrt. Db. Stock (red.) | 95—97 | 3 12 3 | — | 96 | 95½ |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 99—101% | 4 9 0 | — | 100½ | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 12—12½ | 5 11 1 | Feb, Aug | .. | .. |
| 100 | 4½% | † Do. 4½% Deb. | 102—104 | 4 6 6 | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8—8½ | 4 14 2 | Feb, Aug | .. | .. |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6¼—6¾ | 3 14 1 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 98—99 | 4 0 10 | Jan, July | .. | .. |
| 1 | 8% | Northern Counties Elec. Sup. | [illegible] | 3 1 6 | Mar, Aug | — | .. |
| 100 | 4½% | † Do. 4½% Deb. | 102—103 | 4 7 6 | Jan, July | — | — |
| 10 | 6/0 | Notting Hill Electric Ord. | 13¾—14¾ | 4 15 0 | March | .. | — |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98—100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅜—6⅞ | 5 1 6 | March | .. | .. |
| St. | 4% | Do. 4% Deb. Stock | 100—102 | 3 18 5 | — | .. | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 12½—13½ | 5 11 0 | Feb, Aug | 13⅛ | 12 15/16 |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 7½—8½ | 4 2 6 | Feb, Aug | — | .. |
| St. | 3½% | † Do. 3½ per Cent. Deb. Stock (red.) | 87—89 | 3 10 9 | — | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2—2½ | 8 0 0 | .. | .. | — |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76—80 | 5 0 0 | — | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 3—3½ | 5 10 0 | .. | .. | .. |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | 13/16—15/16 | .. | .. | .. | — |
| 1 | 0/8¾ | Do. 7% Cum. Pref. | 1 5/16—1 7/16 | 4 17 2 | .. | — | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105—108 | 4 3 8 | — | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4⅝—4⅞ | 5 2 6 | — | 4 21/32 | 4 9/16 |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5—5¼ | 4 15 8 | — | 5 1/32 | — |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 105—107 | 4 4 0 | .. | 105½ | .. |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 11½—12½ | 5 12 0 | Mar, Sept | 12 | 11⅝ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | — | 4 1 8 | .. | 6⅛ | .. |
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝—⅞ | 5 6 6 | — | .. | .. |
| 1 | 10½d. | Aron El. Met. 6% Cm. Pf. | ½—⅝ | .. | .. | ½ | — |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3¾—4 | 5 0 0 | .. | 3⅞ | .. |
| 1 | 7½d. | Do. Pref | 1 7/16—1 9/16 | 3 16 10 | .. | .. | — |
| 5 | 4/0 | British Insulated & Helsby Cables Ord. | 6½—7 | 5 14 0 | July, Feb | 6 27/32 | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾—6¼ | 4 16 0 | Jan, July | 5 15/16 | 6 |
| St. | 4½% | † Do. 4½% 1st Mort. Deb. (red.) | 103—106 | 4 4 11 | .. | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98—100 | 4 10 0 | .. | .. | .. |
| 5 | .. | British Westinghouse 6% Pref. | 1¾—2¼ | .. | .. | 2 9/32 | 2 |
| St. | 4% | † Do. 4 per Cent. Mort. Deb. Stock | 79—83 | 4 16 6 | .. | — | .. |
| 2 | — | Brush Electrical Engineering | ¼—½ | .. | March | .. | .. |
| 2 | 2/4½ | Do. 6 per Cent. Pref. Non-Cum. | 1¼—1¾ | 6 17 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 96—100 | 4 10 0 | Mar, Sept | .. | .. |
| St. | 4½% | † Do. Perpetual 2nd Deb. Stock | 82—84 | 5 7 4 | Jan, July | .. | .. |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11—12 | 5 0 0 | Jan, July | 11⅝ | 11 1/16 |
| 5 | 2/6 | † Do. 5 per Cent. Cum. Pref. | 5⅝—5⅞ | 4 5 0 | Jan, July | 5¾ | .. |
| St. | 4½% | † Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 107—109 | 4 2 6 | Nov, May | 108¼ | .. |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1 1/16—1 3/16 | 5 1 0 | .. | 1 3/16 | 1⅛ |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 97—102 | 4 8 8 | — | 100 | .. |
| 1 | 9⅝d. | Chadburn's (Ship) Telegraph Ord. | 1—1¼ | 8 0 0 | .. | 1⅛ | 1 3/32 |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1 1/16—1 3/16 | 5 2 7 | .. | .. | .. |
| 8 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 2—2¼ | 3 7 6 | Jan, July | .. | .. |
| 100 | 5% | *† Do. 5 per Cent. 1st Mort. Debs. (red.) | 95—98 | 5 2 0 | Jan, July | .. | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8½—9 | 5 11 1 | Sept | .. | .. |
| 5 | 3/0 | Do. 6% Cum. Pref. | 5¾—6¼ | 4 18 0 | Sept | .. | .. |
| St. | 4½% | † Do. 4½% Deb. Stock | 104—106 | 4 5 0 | .. | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅜—1⅝ | — | Feb, Aug | 1 9/16 | 1 7/16 |
| 5 | 2/6 | Do. (£5 paid) | 2¼—2¾ | — | Feb, Aug | 2 5/16 | .. |
| St. | 4% | † Do. 4 per Cent. Mort. Deb. Stock (rd.) | 86—88 | 4 11 0 | June, Dec | — | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92—97 | 5 3 1 | .. | .. | .. |
| 5 | 4/6 | Edmundson's Elec. Corp. Ord. | 5¼—5¾ | 6 1 9 | H'lf-yearly | 5 7/16 | .. |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5¾—6 | 5 0 0 | .. | [illegible] | 5¾ |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 107—109 | 4 2 6 | .. | .. | .. |
| 2 | 1/7½ | Electric Construction Co. | ½—¾ | 9 6 0 | July | — | .. |
| 2 | 2/9¾ | Do. 7 per Cent. Cum. Pref | 1⅞—2⅜ | 5 18 8 | July | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 92—95 | 4 4 2 | Jan, July | .. | .. |
| 10 | 5/0 | † General Electric (1900) 5% Cum. Pref. | 9—9½ | 5 5 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96—100 | 4 0 0 | .. | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 12¼—12½ | 5 11 1 | Feb, Aug | 12 3/16 | 12 1/16 |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼—5½ | 4 2 0 | Feb, Aug | 5 1/16 | 5 1/16 |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | — | 4 1 1 | Feb, Aug | .. | .. |
| 10 | 15/0 | † India Rubber, Gutta Percha, &c., Wrks. | 18—19 | 2 12 6 | Feb, Aug | 18⅜ | 18 |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99—102 | 3 18 5 | Mar, Sept | — | .. |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¼—11¾ | 4 5 1 | Mar, Sept | .. | — |
| 12 | 12/0 | Telegraph Construction & Mainten'ce. | 33—35 | 5 2 6 | Mar, July | 33 5/16 | .. |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 100—102 | 3 13 6 | Jan, July | .. | .. |
| 5 | — | Willans and Robinson Ord. | 1¾—2¼ | — | Apr, Oct | 2 | 1⅞ |
| 5 | — | Do. 6 per Cent. Cum. Pref. | 3¾—4¼ | — | Apr. Oct | 3⅛ | 3¾ |
| .. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 82—87 | 4 12 0 | May Nov | 84 | .. |

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* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

# WHEATLEY KIRK, PRICE & CO.

*(Established 1850.)*

ELECTRICAL AND MECHANICAL VALUERS, ARBITRATORS AND AUCTIONEERS.

**TRAMWAY & ELECTRICITY SUPPLY VALUATIONS.**

Periodical Valuations, Stock-takings and Reports for DEPRECIATION, RENEWALS, &c., in conformity with the Acts.

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**And Albert Chambers, Albert Square, MANCHESTER.**

Telephones { **5077** Bank London. **3218** Central Manchester.
Telegraph Addresses { Indices London. Indicator Manchester.

## SALES BY AUCTION.

**TO ELECTRIC LAMP MAKERS, ELECTRICIANS AND OTHERS.**

WHEATLEY KIRK, PRICE & CO. have received instructions from the Receiver, Sydney Wiltshire. Esq., to SELL BY PUBLIC AUCTION, commencing at 12 noon prompt, on TUESDAY, February 6th, 1906, ON THE WORKS PREMISES, 48 and 49, BRITANNIA STREET, CITY ROAD, HOXTON, N., the whole of the

**MACHINERY, PLANT, FIXTURES AND STOCK,**

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The Council does not bind itself to accept the lowest or any tender.

H. THOMPSON, Town Clerk.

Town Hall, Hammersmith, 13th January, 1906.

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By order of the Board,
A. R. HARDIE, Secretary.

Electra House, Finsbury Pavement,
London, E.C., 15th January, 1906.

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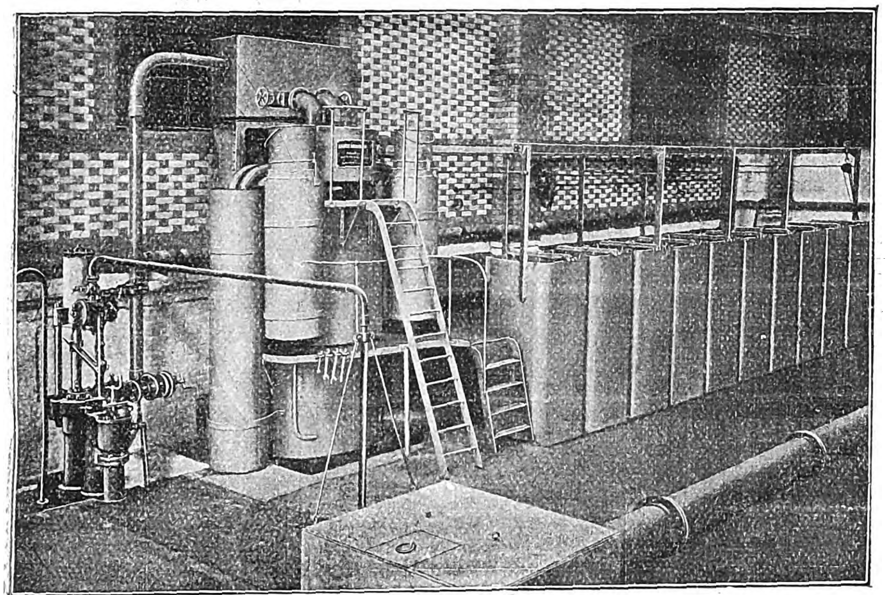

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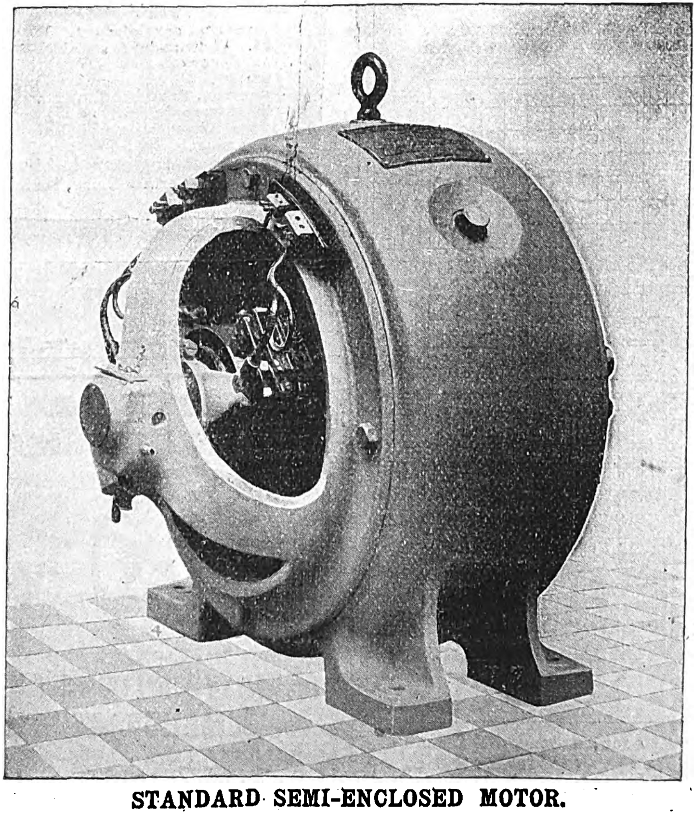

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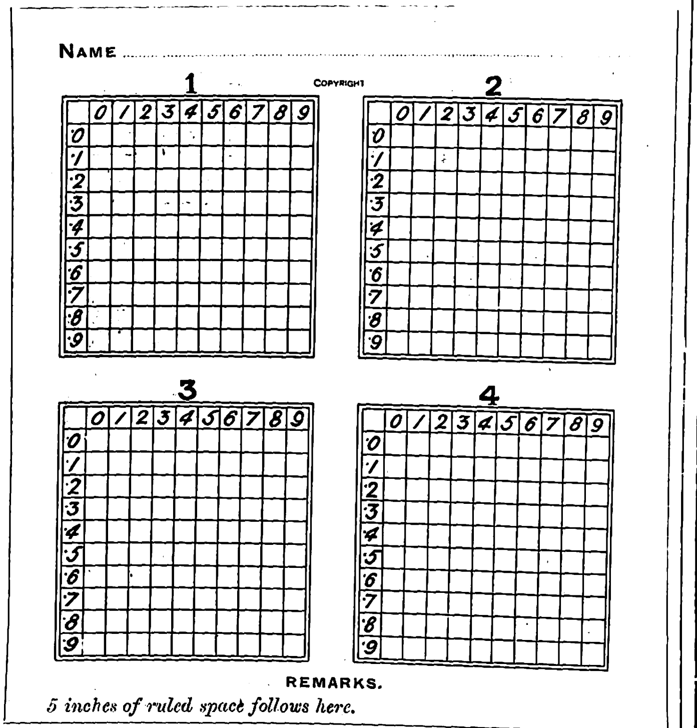

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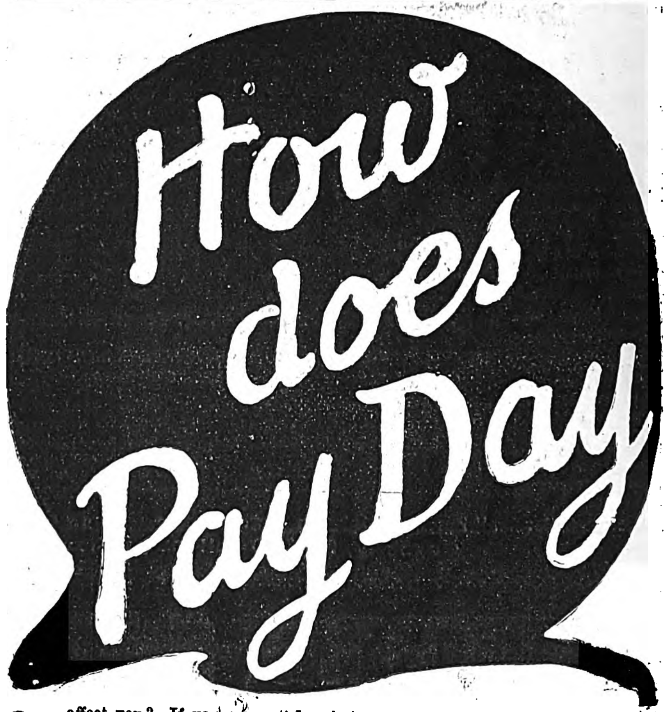

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It is proposed, at the start to run a five-minute service in the centre of the city, and a ten-minute service in the out-lying districts, which will represent a total of about 1,500,000 car miles to be run in the year.

The company's consulting engineer reports that the central station will, after meeting the demands of the tramways, and after making all due provision for spares, be able to supply for lighting and power purposes 3,000,000 units of energy. Of this supply, the Municipal Committee have agreed to take 824,000 units at 2¼d. per unit as a minimum, leaving available for general purposes 2,176,000 units, of which the consulting engineer is of opinion that there will be an immediate demand for not less than 900,000 units, with every prospect of such demand increasing in the near future He is further of opinion that the cost of production, having regard to the public supply already secured, will on the average, not exceed 2 1-3d per unit.

The directors are of opinion (basing their estimates on the results attained in Calcutta) that this company should derive from its undertaking a profit of not less than £36,714 per annum, made up as under:

| | £ | £ |
|---|---|---|
| Receipts from the 1,500,000 car miles to be run on the new tramway system at 8 45d. per car mile ... ... ... ... ... ... | 52,800 | |
| Working cost at 48.93 per cent. ... ... ... ... ... ... | 25,800 | |
| Leaving as the estimated net profit from the tramways ... ... | | 27,000 |
| Receipts from the minimum of 824,000 units to be taken by the municipality at 2¼d. per unit ... ... ... ... ... ... | 7,725 | |
| Receipts from the supply of 900,000 units for the estimated present demand for private lighting and power purposes at the average price of 5d. per unit ... ... ... ... ... ... ... ... | 18,750 | |
| | 26,475 | |
| Cost of production of 1,724,000 units at 2 1-3d. per unit ... ... | 16,761 | |
| Leaving as the estimated net profits from the electric supply ... | | 9,714 |
| Total estimated net profits from both undertakings ... ... ... | | 36,714 |
| The amount required to meet interest on Debenture stock and sinking fund is ... ... ... ... ... ... ... ... ... | 10,000 | |
| To pay the Preference share dividend is ... ... ... ... ... | 9,000 | 19,000 |
| Leaving from the business at present in sight a surplus, to provide for head office expenses, directors' fees, depreciation, and dividend on £150,000 Ordinary share capital, of ... ... ... ... ... | | 17,714 |

And a plant ready to deal with a greatly increased demand.

Applications for shares and Debenture stock should be made on the forms accompanying the prospectus, and sent to the company's bankers, the North and South Wales Bank (Ltd.), Castle-street, Liverpool, or to any of their Branches, or to their London Agents, the London and Westminster Bank (Ltd.), Lothbury, London, E.C., or to the Chartered Bank of India, Australia and China, Hatton-court, Threadneedle-street, London, E.C., together with a remittance of the amount of the deposit.

An official quotation on the London, Liverpool, and Glasgow Stock Exchanges will be applied for.

The Prospectus, on the basis of which applications will alone be received, and Forms of Application can be obtained at the Office of the Company, or from the Bankers.

**NOTICE.**—A PROSPECTUS is being issued which contains, inter alia, the following information:—

The SUBSCRIPTION LIST will OPEN on TUESDAY, 23rd inst., and CLOSE on or before 3 p.m. on THURSDAY, 25th inst.

# THE
# RANGOON ELECTRIC TRAMWAY & SUPPLY COMPANY, LIMITED.

(Incorporated under the Companies Acts, 1862 to 1900.)

**SHARE CAPITAL - - - - - £500,000**

**Divided into 50,000 Six per Cent. Cumulative Preference Shares of £5 each, and 250,000 Ordinary Shares of £1 each.**

The COMPANY is ISSUING at PAR

**£150,000 FOUR AND A-HALF PER CENT. FIRST MORTGAGE DEBENTURE STOCK and 30,000 SIX PER CENT. £5 CUMULATIVE PREFERENCE SHARES.**

Messrs. J. W. DARWOOD & CO., the vendors to the company, are transferring to the company the Rangoon Steam Tramways and the new concessions they have obtained for electric lighting and traction in Rangoon in consideration of the allotment to themselves and their nominees of £65,000 in the company's Ordinary shares as fully paid, and will, in addition, subscribe and pay for in cash at par £85,000 of the Ordinary shares.

---

The First Mortgage Debenture stock and the interest thereon will be secured by a first mortgage to the trustees for the Debenture stockholders on the freehold and leasehold properties of the company, and by a floating charge upon its whole undertaking and other assets, both present and future. The trust deed will provide that no mortgage or charge shall be created ranking in priority to or pari passu with stock, except that the company shall be at liberty to create and issue further stock, ranking pari passu with the present issue, not exceeding £100,000; provided that there shall have been allotted and further subscribed in cash in respect of share capital of the company an amount equal to the par value of the further stock so issued.

On the 31st day of December, 1908, and on each succeeding 31st day of December, the company will pay to the trustees for the Debenture stockholders a sum equal to the difference between £10,000 and the amount paid in interest on the Debenture stock outstanding during the preceding 12 months, to be applied in the redemption of the stock by drawings at 105 per cent., or in the purchase of stock under such price. As further Debenture stock is issued the annual sum to be paid to the trustees will be proportionately increased.

The company reserves the option to redeem all or any part of the stock, on six months' notice being given, or at any time after the 31st December, 1915, at 105 per cent.

Any stock not previously redeemed will be redeemed on the 31st day of December, 1930, at 105 per cent. The redemption price is in every case 105 per cent.

Interest on the Debenture stock will be paid half-yearly in London, in sterling, or, if desired, in Rangoon, at the current rate of exchange, on the 1st day of January and 1st day of July. The first payment, calculated from the dates of payment of the several instalments, will be made on the 1st day of July, 1906.

The Preference shares are cumulative as to dividend, and rank for capital in priority to the Ordinary shares. The dividends will be payable half-yearly in London, in sterling, or, if desired, in Rangoon, at the current rate of exchange, to the 30th day of June and 31st day of December in each year. Preference shareholders will be entitled to attend and vote at all meetings.

Subscriptions for the above-mentioned Debenture stock and Preference Shares will be payable as under:

| DEBENTURE STOCK. | Per cent. |
|---|---|
| On application | £10 |
| On allotment | 10 |
| On 31st March, 1906 | 30 |
| On 31st May, 1906 | 50 |
| | £100 |

| PREFERENCE SHARES. | Per share. |
|---|---|
| On application | £0 10 0 |
| On allotment | 0 10 0 |
| And the balance as required in calls of not more than £2 each, and at intervals of not less than three months, but so that the last call shall not be later than the 31st December, 1906 | 4 0 0 |
| | £5 0 0 |

Interest at 3 per cent. per annum will be allowed on payments made in advance of calls on any of the above dates.

### Trustees for Debenture Stockholders.

Sir JOHN GRAY HILL (Hill, Dickinson, and Co.), 10, Water-street, Liverpool.

RICHARD HENDERSON, Esq. (Chairman Anchor Line, Henderson Brothers, Limited), Liverpool and Glasgow.

### Directors.

FRANK TOBIN, Chairman (Horsfall Brothers Stock and Share Brokers), Queen Insurance-buildings, Liverpool.

SAMUEL BALTHAZAR (Balthazar and Son, Merchants), 66, Merchant-street, Rangoon.

JAMES HALLIDAY (the Arracan Company, Limited), 57½, Old Broad-street, London, E.C.

JAMES TAYLOR (British Insulated and Helsby Cables, Limited), Prescot.

JOHN WEST WOOD DANSON (J. W. Darwood and Co., Merchants, Gresford Lodge, Denbighshire.

JOHN WILLIAM DARWOOD (J. W. Darwood and Co., Merchants), Lower Kemendine-road, Rangoon.

**Bankers.**—NORTH and SOUTH WALES BANK, (Ltd.), Castle-street, Liverpool, and Branches, and as their Agents, The LONDON and WESTMINSTER BANK (Ltd.), Lothbury, London, E.C., and Branches; and CHARTERED BANK of INDIA, AUSTRALIA, and CHINA, Hatton-court, Threadneedle-street, London, E.C.

**Solicitors.**—HILL, DICKINSON, DICKINSON, HILL, and ROBERTS, 10, Water-street, Liverpool.

**Brokers.**—HORSFALL BROTHERS, Queen Insurance-buildings, Liverpool. FAITHFULL BEGG and CO., Bartholomew House, London, E.C.

**Auditors.**—CRAIG, GARDNER & HARRIS, 20, Copthall-avenue, London, E.C.

**Consulting Engineer.**—FRANK BOURNE, M.A.I.E.E., 62, London-wall, London. E.C.

**Secretary** (pro tem.) and **Office.**—ALEXANDER GOODLET, 16 and 18, Dale-street, Liverpool.

**Rangoon Office.**—J. W. DARWOOD and CO., Lower Kemendine-road, Rangoon.

CONCESSIONS.—In 1902 the Municipal Committee of Rangoon, being desirous of securing for the city an adequate supply of electricity for lighting and power purposes, invited tenders, and it was a term of such invitation that the undertakers should (inter alia) equip and work the existing steam tramway system (which was to be acquired be the Municipal Committee at their own cost) by electric traction.

In tendering in response to this invitation, Messrs. J. W. Darwood and Co. offered, at their own cost, to purchase from the Steam Tramway Company the existing system. Their tender was accepted, and accordingly there have been granted to the partners in the firm of J. W. Darwood and Co., by the Governments of India and Burma, under the Indian Tramways Act, 1886, the Rangoon Tramways Order, 1905, and under the Indian Electricity Act, 1903, the Rangoon Municipal Electric License for Public and Private Supply, 1905, the Rangoon Municipal Electric License for Traction, 1905, and the Rangoon Cantonment Electric License for Electric Traction, 1905.

Messrs. J. W. Darwood and Co. have entered into an agreement with the Municipal Committee to light the principal streets for the term of 21 years, and have also entered into an agreement with the Government of Burma to supply the public lamps under the control of the Government.

NEW WORKS.—Messrs J. W. Darwood and Co. have taken over the undertaking of the Steam Tramway Company. They have also purchased a freehold site containing 20,618 square yards, with a frontage to the Rangoon River of 750ft., and well placed for the economical supply of the whole district, and are proceeding with the erection thereon of a central generating station. They have also secured, on long lease, a convenient site for the tramway depot.

The central generating station will be equipped by the British Thomson-Houston Company (Limited) with a plant having a capacity of 2,900 kilowatts of electrical energy, and the site will allow of the plant being added to.

Feeder mains will be at once laid in the streets which under the agreement with the Municipal Committee have to be lighted. These mains will be extended as occasion arises.

The existing tramway routes, which are formed by 7.44 miles of single track, will be increased to 24 miles of single track, and will serve the principal streets of the city. Messrs J. W. Darwood and Co. have relaid about 3.55 miles of old track, and have in addition laid about 3.32 miles of extensions.

Unless unforeseen difficulties arise, the central station should be opened and the new tramway system will be at work before the end of March, 1907. In the meantime the steam tramways will be run as from the 31st December, 1905, for the benefit of this company.

PURCHASE OF EXISTING TRAMWAYS.—Messrs. W. Q. Rowett and Co., of Rangoon, who were the Managing Agents of the Rangoon Steam Tramway Company, have certified that the existing tramways, working on 7·44 miles of single track, have shown the following results:

| Year ending. | Car miles run. | Total number of Passengers carried | Average number of Passengers carried per car mile. | Average receipts per car mile run. Pence. |
|---|---|---|---|---|
| 31st Dec., 1901 | 245,098 | 2,620,989 | 11.14 | 13.83 |
| „ 1902 | 235,776 | 2,752,223 | 11.67 | 14.55 |
| „ 1903 | 238,943 | 3,204,166 | 13.41 | 16.63 |
| „ 1904 | 247,591 | 3,499,930 | 14.13 | 17.54 |

Mr. J. Stuart Smith, Chartered Accountant, of Rangoon, has certified that the profits derived from the existing tramways, after charging maintenance of permanent way, track rent, repairs and renewals, traffic and running expenses, and all other outgoings, but before deduction of income tax, interest on loans, depreciation, and managing agents' salary and commission, have been as under:

| | |
|---|---|
| Year ending 31st December, 1901 | £6,356 17 5 |
| „ „ 1902 | 6,388 7 7 |
| „ „ 1903 | 8,825 16 6 |
| „ „ 1904 | 9,999 7 9 |

Messrs. J. W. Darwood and Co. have entered into an agreement to transfer to this company, as from the 30th June, 1905, the whole of the assets (except the existing depot and the work already executed for the new system and the profits on the running of the existing tramways to the 31st December, 1905) of the Rangoon Steam Tramways, the three licenses and the tramways order above referred to, and the benefit of the agreements with the Government of Burma and Municipal Committee of Rangoon, in consideration of the allotment to themselves and their nominees of 65,000 £1 Ordinary shares of this company as fully-paid.

They will, in addition, subscribe and pay for in cash £85,000 of the Ordinary shares.

Messrs. J. W. Darwood and Co. have further agreed to accept from this Company the actual amount (including a fair and just proportion of their office, plant, and other establishment expenses) expended and to be expended by them upon the land and works for the new undertaking up to the date of the completion of the purchase as certified by this company's auditors, with interest thereon from the dates of expenditure at the monthly average Bank rate current in Rangoon, and an allowance of 5 per cent. on the total expenditure subsequent to the 30th June, 1905, as remuneration for the partners' personal services in relation to the work of construction as from that date.

Messrs. J. W. Darwood and Co. have also given a guarantee of the dividends of the Preference shareholders down to the end of two years from the 31st December, 1905, being nine months after the estimated date of completion of the new undertaking.

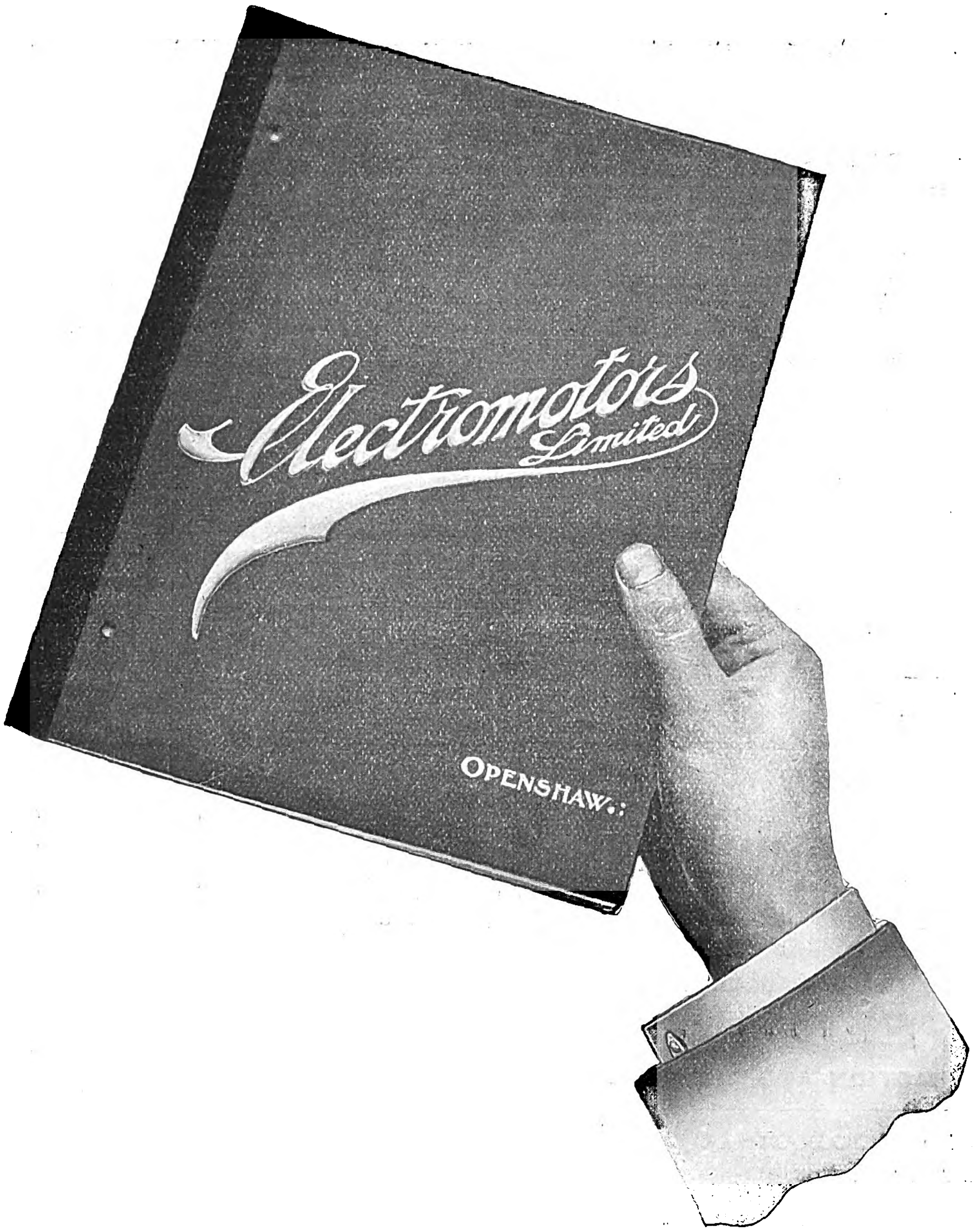
The CAPITAL EXPENDITURE by this company on its undertaking now in contemplation is estimated by the company's consulting engineer at—

| | | |
|---|---|---|
| The cost of acquisition of the Rangoon Steam Tramways and the new concessions | £65,000 | |
| Outlay on the Central Station, new tramway track, distribution system, and equipment | 345,000 | £410,000 |
| Leaving out of the capital now issued to provide for the cost of formation and issue and for working capital and extensions | | 40,000 |
| | | £450,000 |

ESTIMATE OF PROFITS.—On the present routes, formed by less than 7½ miles of single track, the number of passengers carried increased from 2,600,000 in

[Continued on page xxiii

OUR NEW CATALOGUE.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# WILLANS & ROBINSON,

**LIMITED,**

**VICTORIA WORKS, RUGBY.**

## STEAM TURBINES.

(Manufactured under Licence from C. A. PARSONS & CO.)

**List of Turbines at Work and under Construction. (Jan. 1, 1906.)**

**(First Order placed Feb. 2, 1904.)**

| No. | Size. | |
|---|---|---|
| 1. | 5,000 kw. | for shipment abroad. |
| 5. | 3,000 kw. | for the Glasgow Corporation E. L. Dept. *Chief Engineer*, W. W. LACKIE, Esq. |
| 1. | 3,000 kw. | for the Willesden Station of the Metropolitan E. S. Co. London. *Chief Engineer*, J. S. HIGHFIELD, Esq. |
| 1. | 1,500 kw. | for the Borough of Islington, London. *Chief Engineer*, A. GAY, Esq. |
| 2. | 1,500 kw. | for the Vestry of Shoreditch, London. *Chief Engineer*, C NEWTON RUSSELL, Esq. |
| 2. | 1,500 kw. | for the South Metropolitan E. S. Co., London. *General Manager*, H. W. BOWDEN, Esq. |
| 1. | 1,500 kw. | for shipment abroad. |
| 1. | 1,400 kw. | for the Glasgow Corporation. *Chief Engineer*, W. W. LACKIE, Esq. |
| 1. | 1,000 kw. | for R. & W. Watson, Linwood. *Consulting Engineer*, R. D. MUNRO, Esq. |
| 2. | 1,000 kw. | for the Corporation of Bristol. *Chief Engineer*, H. FARADAY PROCTOR, Esq. |
| 3. | 1,000 kw. | for the Durham Collieries Electric Power Co. *Consulting Engineers*, Messrs. HARPER BROS. |
| 4. | 1,000 kw. | for the Cleveland & Durham County Electric Co. *Consulting Engineers*, Messrs. BRAMWELL & HARRIS. |
| 2. | 1,000 kw. | for the Scottish Central Electric Power Co. *Consulting Engineers*, Messrs. BRAMWELL & HARRIS. |
| 1. | 1,000 kw. | for Messrs. Vickers, Sons & Maxim, Ltd., Sheffield, for supplying power to their own works. |
| 3. | 750 kw. | for Messrs. the English McKenna Steel Process Co., Birkenhead, for supplying power to their Rolling Mills. |
| 1. | 750 kw. | for Messrs. Drake & Gorham, Manchester, for supplying power to a Textile Mill. |
| 31. | 49,400 kw. | |

# DAVEY, PAXMAN & Co., LD.

**SINGLE AND DOUBLE-ACTING**

**HIGH-SPEED ENGINES**

**FOR TRACTION AND LIGHTING.**

**PAXMAN "ECONOMIC"**

AND ALL TYPES OF

**BOILERS.**

SUPERHEATERS and
CONDENSING PLANTS.

*WORKS.:* ***COLCHESTER,***
***ENGLAND.***

LONDON OFFICE:
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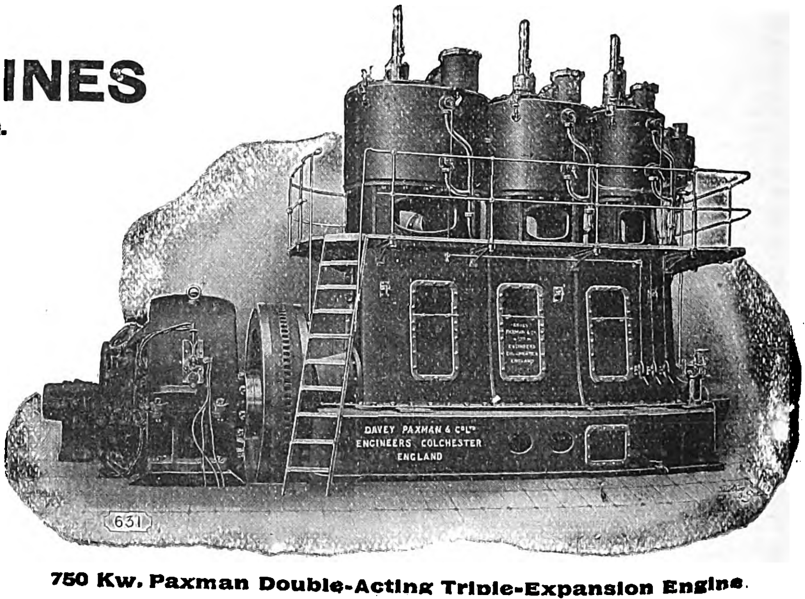

**750 Kw. Paxman Double-Acting Triple-Expansion Engine as supplied for Paisley, &c.**

# THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,444. [No. 14. Vol. LVI.] FRIDAY, JANUARY 19, 1906. PRICE SIXPENCE (by post, 6½d.), *Abroad 9d., or 18 cents, or 90c., or 80pf.*

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## NOTES.

◆

FOLLOWING our Supplement Sheet Table of Electricity Supply Undertakings with no tramway load, issued last week, we publish to-day Tables IA. and II., dealing with towns taking electricity supply "in bulk" and electricity works supplying both lighting and tramways. In connection with these sheets, we print an article in another column which gives in graphic and tabular form some interesting totals and comparisons between this and former years. The total of connections to lighting stations in the United Kingdom now amounts to just over one million kilowatts, or the equivalent of some thirty-four million 8 candle-power lamps. That electric lighting and power is still growing at an increasing rate is clearly shown, and the increase is of a much higher order of magnitude than in the gas industry, as the following comparison will show. From figures recently published, the gas consumption in the United Kingdom has during the last year been 178,699,989,000 cubic feet, as compared with 173,577,186,000 cubic feet in 1904, thus showing an increase of about three per cent. Also, the number of consumers during the same period rose from 4,955,706 to 5,260,747, or about six per cent., this figure being higher than the above, as a large proportion of the new consumers are penny-in-the-slot customers, taking only small quantities. On the other hand, the connections to electric supply stations have during the last three years increased from 503,570 kw. to 1,030,300 kw., which gives an average increase of 142,243 kw. for each year, or over 28 per cent.

◆

THOSE of our readers who have followed the various stages of the tariff reform controversy during the past decade will read with interest the note by one of our correspondents in Australia with regard to a Bill which has been introduced into the Australian Parliament to authorise the imposition of a close approximation to a preferential tariff. We need hardly say that the tariff to which we refer is the system of charging for electricity supply, for at the present moment, when our readers have a surplus of politics offered to them in their daily newspapers, the discussion of such matters will be rigidly excluded from these columns. The Corporation of Melbourne had introduced the Wright system of charging, but either their Electric Lighting Act is worded differently to ours in this respect, or the interpretation put upon the clause in question was more rigid, for the Supreme Court had granted an injunction restraining them from charging on any other than the flat rate. A new Bill has, therefore, been introduced by which differential tariffs are to be permitted provided that the tariff is uniform over the whole of the supplier's area, and that no special contracts are entered into with particular customers. In this country there has been no test case with regard to the meaning of Clause 19 of the Electric Lighting Act of 1882, which provides that everybody within that part of an area in which supply for private electric lighting is available shall be entitled to a supply "on the same terms on which any other company or person in such part of the area is entitled under similar circumstances to a corresponding supply." The words "under similar circumstances" is given the widest possible meaning by many managers of electricity undertakings, and widely varying charges or discounts are often in force in the same area, amounting in many cases almost to the "undue preference to any local authority, company or person" forbidden in Clause 20 of the same Act.

◆

WE summarise elsewhere in this issue the reply made by the Sheffield Corporation Electric Light Committee to the complaints made by the Sheffield Electrical Contractors' Association with regard to municipal wiring in that town. The only statement which can be deemed in any way to justify the action of the Corporation is that all the present electrical contractors in Sheffield have started their business since the business now carried on by the Corporation was first established. From the wording of the statement, however, it is not clear whether the date referred to is the start of the old Sheffield Electric Light & Power Co. in 1893, or the taking over of the undertaking by the Corporation in 1899. We can hardly credit that the wiring industry in Sheffield was so belated that there were no independent wiring contractors at work there at the later date. In any case, there is competition, and keen competition, now, and unless the Corporation can establish that they have a right to wire houses under the provisions of the Electric Lighting Acts—a right which has hitherto never been proved in a court of law—they will have to close this portion of their electricity undertaking.

◆

THE compound transmitter, first suggested by Prof. BRAUN and now used in nearly every wireless telegraph system, has brought with it, of course, many problems of its own. Several years ago Prof. BRAUN was actively engaged in one of the most important of these problems—that, namely, of increasing the store of energy given to the oscillator circuit of the transmitter before each spark—and he gave in our columns in 1904 an account of his progress up to that date. Readers of that article may recall that his solution of the problem consisted in building together to form one oscillator circuit several independent but equal circuits that co-operated to produce a prolonged and energetic series of electrical oscillations. Here arose, however, the necessity of providing that the constituent circuits should discharge simultaneously, that the several vibrations should, in fact, be in phase. This requirement suggested in turn the more difficult problem of coupling two or more circuits so that they should vibrate any desired angle out of phase; a task whose solution will form the basis of a method of despatching radiation in any determined direction. On this more general question, an article by Prof. BRAUN appears in this issue. It will be seen from this article that progress is being made slowly and gropingly, but surely, in this very difficult subject. The author is moving along the right lines in keeping close to practical conditions. Mere mathematics are of very little use on account of the cumbrousness of the equations that arise in these complicated networks. In few subjects more than in this does calculation need to be prompted at every turn, and reserved for application at points shown by experiment to be accessible and important.

◆

A CORRESPONDENT writing from Florence to the *Saturday Review* objects to the use of the word "electrification" as applied to the changing over of railways and tramways to electrical from some other form of traction, and tells us that the word grates upon his ear. He points out that a man is said to "electrify" another when he makes a startling or unexpected statement, or in common parlance, makes him jump, and hitherto that has been the only connotation of the term. We can distinctly remember having heard the word used in quite another sense in connection with what is now known to be a transfer of an abnormal number of electrons to a body. To apply the word to the adoption of electric traction is certainly somewhat straining its strict scientific meaning, but the substitute proposed, "electricization," although of possible value as a test for alcoholism, grates on our ears far more than the word in use by the average man in the street or the hanger on the strap.

◆

**Metropolitan District Railway.**—The long-promised acceleration of the service on the "Underground," which has been rendered possible by the new system of signalling, was inaugurated yesterday, the trains now running on the south side of the Inner Circle at intervals of approximately two minutes.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Tarifa—Tangier | Jan. 18, 1904 |
| Jamaica—Colon | Jan. 10, 1905 |
| Cadiz—Teneriffe | July 20, 1905 |
| Puerto Plata—Martinique | Dec. 15, 1905 |
| St. Thomas—St. Kitts | Dec. 29, 1905 |
| Manila—Iloilo | Dec. 29, 1905 |

**The Electrical Engineers Volunteers and the Charing Cross Disaster.**—It is officially announced that the Army Council has expressed its high appreciation of the valuable services rendered by the Corps of Electrical Engineer Volunteers on the occasion of the accident to the roof of Charing Cross railway station, when the work of rescue was materially assisted by the aid of the searchlights of the corps.

**Personal.**—Prof. Ing. Giovanni Giorgi, M.I.E.E., President of the Associazione Elettrotecnica Italiana, has been appointed chief electrical engineer to the Municipality of Rome. For the years 1906, 1907 and 1908 the Associazione has elected Signor Jona as general president, and Prof. Ascoli, Ing. Morelli, and Ing. Piarolli as general vice-presidents. According to the statutes of the Association, the central office is accordingly transferred from Rome to Milan, where it will remain up to December 31, 1908.

It is announced that Mr. C. B. Stuart-Wortley, M.P., has been appointed Chairman of the City & South London Railway Co. in succession to the late Mr. C. G. Mott.

**Electricity at the Royal Courts of Justice**—In the article which we published under this heading last week, we should have stated that, in spite of the existence of a private plant at the Law Courts, the Metropolitan Electric Supply Co. have for some time past supplied a large proportion of the total number of lamps there. Last year, in fact, the Law Courts were one of the company's largest consumers. Provision is also made by which the circuits supplied from the private plant can be switched on to the mains of the Metropolitan Electric Supply Co., and not those of the Charing Cross Company, as incorrectly stated in our last issue.

**The Benjamin Franklin Bicentenary.**—Wednesday was the two-hundredth anniversary of the birth of Benjamin Franklin, who was born at Boston, Mass., on January 17, 1706, and a number of functions have been held to celebrate the date in America. Starting life in humble circumstances as a printer, in which capacity he visited England in 1724, Franklin became a journalist of some distinction in the United States, and held later some responsible positions in the American Post Office. It was not till he was forty years of age that Franklin commenced those researches which have made his name so famous in the annals of electrical and meteorological science. These investigations, including the well-known "kite" experiment, were only continued throughout some seven or eight years, for the pressing calls of his country in other spheres claimed his genius, which for the remainder of his life was given up to a brilliant career as a statesman. He died on April 17, 1790, at the advanced age of 84.

**Telephonic Communication in Agricultural Districts.**—The Board of Agriculture and Fisheries has addressed a circular letter to the various fruit and horticultural associations and societies in the United Kingdom on the question of an extension of telephonic communication to small provincial towns and agricultural districts, as recommended by the recent Departmental Committee on the Fruit Industry. This circular points out that having been in communication with the Postmaster-General, the Board of Agriculture has been assured that such a development has been carried out to a large extent during recent years, and that in 1904 Parliament granted additional funds with this object in view. Among other extensions particularly affecting the fruit industry, it is stated that exchanges have been established in the districts of Swanley, Farningham, Hextable, Crockenhill, and Westerham in Kent and at Winchcombe in Gloucestershire. The Postmaster-General, however, is anxious to receive any suggestions on behalf of fruit growers as to the localities where the needs of the telephone are most pressing for the purposes of the fruit industry.

**An Interesting Private Power Transmission.**—The Riebeck brewery in Leipzig receives its water from a waterworks of its own, nearly two-thirds of a mile distant. Until recently the requisite water was supplied by means of three steam-driven pumps at the waterworks, but this plant has now been superseded by an electrically-driven one. According to the *Elektrotechnischer Anzeiger*, three-phase current at 2,000 volts is generated at the brewery by a 50 kw. three-phase generator driven by a variable-speed shunt motor of corresponding size, the high-tension current being transmitted through a three-core cable to the waterworks and fed here to a three-phase induction motor having a short-circuited rotor. This motor drives the pumps which are capable of delivering a maximum of 52,800 gallons per hour into the reservoir. A float in this reservoir rises up and down with the water, the float being connected with a field rheostat and a switch. As soon as the reservoir is full, the current to the three-phase motor is switched off, but is switched on again when the water level has fallen to half its full height. In order to obviate the frequent switching on and off, the speed of the driving motor at the brewery is increased when the water level in the reservoir is nearing its lower value, and decreased when the reservoir is nearly full. This is done automatically by the field rheostat which is mechanically connected to the float as mentioned. In this way the speed of the motor (and the frequency of the three-phase supply) can be varied by 50 per cent. above and below the normal.

**Signalling Election Results.**—Of all the schemes devised by the various daily papers for acquainting the public in London with the results of the elections on the evening of the day of the poll, that hit upon by the *Daily Mail* is probably the most novel. With the aid of several firms of electrical engineers, and the co-operation of some members of the Corps of Electrical Engineer Volunteers, powerful searchlights were mounted on high ground in different parts of London, and by means of a shutter working in front of the carbons, the results were signalled about London in the Morse telegraphic code. The points selected for carrying on this work were the Crystal Palace, Alexandra Palace, Hotel Cecil, Shooters Hill, Hampstead Heath and the roof of the Lot's-road (Chelsea) electrical generating station of the Underground Electric Railways Co. of London. The results were first given by the searchlight at the Hotel Cecil to which they were telephoned, and were read and repeated by the remaining stations. Party gains were recorded by sending up coloured rockets. To help its readers take advantage of its enterprise, the *Daily Mail* published the Morse alphabet, but it would be interesting to learn how far the general public benefited by this method of publishing the results, as we should think the percentage understanding the Morse alphabet is very small. Many ways are reported, however, by which advantage was taken of the signals, such as the employment of persons acquainted with the code, which was done by hotel keepers, who subsequently posted the results in their establishments. The electrical firms who have contributed to the successful carrying out of this scheme are Messrs. Siemens Bros. & Co., Crompton & Co., General Electric Co. and Clarke, Chapman & Co., and M. Barbier, of Paris, the lighthouse expert. Electricity was also made use of in Hull for recording election results, a huge screen 34 ft. square having been rigged up in a prominent place in Hull for this purpose.

**A Single-Phase Electric Crane Equipment.**—The large single-phase motor has been chiefly developed in connection with traction work. But an interesting application to hoisting machinery is found in some wharf cranes which have recently been erected at Cologne, and which are described in a recent number of *Engineering*. The particulars as to the construction of the motors are not very complete, but we extract from them the following particulars: The supply available is single-phase alternating at 2,100 volts and 50 cycles per second. It is transformed for the cranes to 500 volts. The lifting motor is of 40 H.P. and is provided with 10 poles. Armature and commutator resemble those of a continuous-current motor. There are 10 sets of carbon brushes, two of which serve for the introduction of an auxiliary current, which, being out of phase with the main current, produces a rotating field. This auxiliary current, it is stated, is interrupted as soon as full speed has been reached. The motor develops a very high starting torque. At a torque of 2½ times the normal no sparking or heating can be noticed. The two 10 H.P. motors for travelling and slewing are also of the above design, each having six poles. One controller with auto-transformer is provided for the lifting motor, and one controller with auto-transformer for both the slewing and travelling motors together, the current being directed to either of them by means of a switch. By means of the controller the tranformer is connected to the high-tension mains, while the motor is connected to one of the steps of the transformer according to speed desired. The cylinder of the lifting controller is fitted with seven steps, and the cylinder of the travelling and slewing controller with six. Both controllers, with their transformers attached, are mounted on the same base-plate. One lever actuates the two controllers by universal gear, the movements of the operator's hand being in accordance with the intended movements of the crane hook. The band brakes on the drums are operated by small single-phase motors supplied at a lower voltage through a transformer. The brakes can also be released by a hand-lever in order to allow of lowering the load without current when required.

**Water-Power Schemes in India.**—Following the success of the Cauvery power scheme in Mysore, the next power scheme to be undertaken in India, according to the *Engineer*, is the installation on the Jhelum River in Kashmir. This power plant is to be installed near Rampur, about fifty miles below Srinager, where an installation of about 20,000 H.P. is contemplated. It is intended to use the power partly for operating the Kashmir section of the Jhelum Valley Railway electrically along its entire length of 180 miles, where a single-phase system of traction will probably be installed. An important immediate use to which the power will be put will be in operating dredgers for the purpose of deepening the Jhelum River in the Kashmir Valley, and thus minimising the floods, which periodically devastate the country. The gravity conduit line for the power plant will be approximately 34,000 ft. in length, and for the upper 8,500 ft. will consist of an excavated ditch lined with masonry. The remaining portion of the water channel will consist of a rectangular flume with a capacity of over 500 cubic ft. per second. The pressure lines will vary in diameter from 30 in. to 36 in., and for each there will be a 54 in. to 36 in. taper pipe, 10 ft. long, at the upper end. The pipes will be 790 ft. in length, and will deliver the water under an effective head of 400 ft. Twelve main units and three exciter units will form the equipment of the power house. Each main unit will consist of a tangential water wheel with automatic oil-pressure governor delivering 1,765 B.H.P. Each wheel will be direct connected to a 1,000 kw. alternator, running at 500 revs. per min. The exciter units will each consist of a tangential water wheel of 285 B.H.P. The water wheels will be equipped with buckets, needle-regulating nozzles and centrifugal water guards. The regulation of the main units will be effected by means of hydraulic governors operating jet deflectors. For the exciter units hand regulation will be provided by means of the needle nozzles. The entire installation will be constructed under the supervision of Major A. J. de Lotbinière, R.E. Mr. A. C. Jewett, formerly of the General Electric Co., will serve as installing engineer for the Government.

**Report on the Mill Hill Park Collision on the District Railway.**—It may be remembered that on a foggy day last November, a collision took place between two electric trains near Mill Hill Park station on the Metropolitan District Railway, one train running into the rear of another train which was standing. This accident, which was fortunately of no serious nature, was followed by the usual Board of Trade inquiry, and the report of the Board of Trade inspector, Major J. W. Pringle, has just been issued. The part of the line in question is equipped with the Westinghouse electro-pneumatic system of signalling such as has been installed for a considerable time—originally for test purposes—on the section between Hanger-lane Junction and South Harrow. An illustrated description of this installation was published in *The Electrician*, Vol. LIV., p. 616. The signalling arrangements provide a semaphore arm and lamp, and, as an additional precaution, there is a trigger on the track which trips the valve of the continuous brake on the car should the motorman pass the signal when it is at danger. Major Pringle comes to the conclusion that the automatic signal was at danger at the time the accident happened, although the evidence on this point was contradictory. But the trip gear on the leading car had become twisted in some way so that the brakes were only partially applied and this partial application, which would have been a warning to the motorman on a level track, passed totally unnoticed as the car was running down a gradient at the time. Major Pringle concludes :—

> On a railway where, to obtain a frequent and fast service of trains, block sections are comparatively short, and distant signals have practically been dispensed with, the efficiency of the train tripping apparatus is of great importance. Further than this, in foggy weather or falling snow, the arrangements must be absolutely reliable if fogmen and fog-signalling are to be dispensed with. The existing apparatus and arrangements, as this case proves, call for improvement in several respects, as follows :—
>
> 1. The triggers are mounted on the side frames of the cars, and are thereby liable to movements caused by swing of the frames, or action of the springs—direct attachment to the axles is desirable.
>
> 2. Only one trigger (on the leading car) on a moving train is in the striking position. The present case points to advisability of having a second trigger available in case of failure of the first. Both triggers might be attached to one car.
>
> 3. At all terminals, and other places where brakes are tested, car examiners, as well as the motorman or front conductor of a train, should actually test the movement of the striking triggers by moving them until the air valves are fully open.
>
> The railway authorities are fully aware of the importance of the efficiency of the tripping arrangements, and either have made or are making improvements in the directions named.

**Tests of Lightning Arresters in Actual Service.**—A Paper recently read before the American Institute of Electrical Engineers by Mr. N. J. Neall gives the results of a large number of tests on the performance of lightning arresters extending over a number of transmission systems in the United States. The method adopted was to insert slips of paper between the cylinders of non-arcing metal forming the spark gaps of the arresters employed. These test papers were changed at regular intervals and clearly showed by means of perforations and marks whenever a discharge had passed. On examining the files of the records obtained in this way, some interesting information was obtained. It was found that all arresters come into action much more frequently than has been hitherto supposed to be the case. The perforations made through the test papers by discharges through the older forms of multi-gap arrester, without series resistance, were compared with the effect of discharges through the standard Westinghouse "low-equivalent" arrester, which has a section of the gaps shunted and is provided with a series resistance. It was seen that no greater difficulty in discharge is encountered in the latter case, as evidenced by the ragged edges or torn appearance of the holes in the papers. Previous experiments had shown that these are characteristic of free static discharges, whereas discharges through a high resistance produce holes with smooth edges, even if the current continues to pass and the paper is charred. It was also found that the arrester with shunted gaps gives quicker suppression of the short circuit, after the discharge has passed, than the plain gap. In order to obtain a good basis for comparison, and to know how severe the induced disturbances on a line may be, independently of the stored energy which endeavours to readjust itself, some further experiments were made with arresters connected to idle lines. The holes in these test papers were chiefly of the smooth-edge variety, which at first sight appears not to agree with the facts given above. The author of the Paper explains this difference as follows : The charge may be induced at a particular part of the line which is remote from the discharge path. The intervening impedance reduces the abruptness of the discharge at the arrester. In practice this induced disturbance is the one that first breaks down the gaps between the line and ground, and following closely on this comes the stored energy of the system trying to adjust itself to the new conditions. Lastly, but most serious of all, the generator current endeavours to establish a short-circuit following the discharge. It is possible for only the first two effects to occur, but generally all three come into action. The most important information given by these tests is that the lightning disturbances on a line are not of the magnitude generally supposed. The small holes made in the papers are substantially the same as those made in insulation, yet these small holes pave the way for very serious breakdowns of apparatus, due to the normal current following. A comparison of results seems to indicate that arresters, constructed after the style of the "low-equivalent" apparatus with low resistance, have freer discharge than the straight gaps with high resistance, and show the ability of arresters to discharge automatically and repeatedly without attention. At 55,000 volts the records show as free discharges as are obtained at the lower voltages. The extensive tables of records published in the Paper have been carefully studied and summarised, and a number of disturbances due to such causes as insulators breaking down during the winter months have been differentiated from those due to the effects of lightning. The same method of investigation is applicable to various other forms of arrester, such as the horn type, by connecting a small tell-tale gap, with a test paper, in series with the earth wire.

## ARRANGEMENTS FOR THE WEEK.

**(To-day) FRIDAY, January 19th.**

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse by Prof. J. J. Thomson, F.R.S., on "Some Applications of the Theory of Electric Discharge to Spectroscopy."

**SATURDAY, January 20th.**

INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.

*10 a.m.* Visit to the Works of the India Rubber, Gutta Percha & Telegraph Works (Ltd.) at Silvertown.

**THURSDAY, January 25th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Ordinary General Meeting. Paper to be read : "Technical Considerations in Electric Railway Engineering," by F. W. Carter.

SOCIETY OF ARTS.

*8 p.m.* "Howard" Lecture II., on "High-Speed Electric Machinery with Special Reference to Steam Turbine Machines," by Prof. Silvanus P. Thompson, F.R.S.

**FRIDAY, January 26th.**

INSTITUTION OF ELECTRICAL ENGINEERS : MANCHESTER STUDENTS' SECTION.

*7:30 p.m.* Meeting at the Municipal School of Technology, Sackville-street, Manchester. Paper to be read : "Electric Lamps," by F. Shaw.

ELECTRO-HARMONIC SOCIETY.

*8 p.m.* Smoking Concert in the King's Hall, Holborn Restaurant.

JUNIOR INSTITUTION OF ENGINEERS

*8 p.m.* Meeting at the Westminster Palace Hotel, when a lecture will be delivered by Prof. J. D. Cormack on "Notes on Boiler Trials."

**SATURDAY, January 27th.**

JUNIOR INSTITUTION OF ENGINEERS.

*3 p.m.* Visit to the Engineering Laboratories of University College, Gower-street, during which Prof. J. D. Cormack will demonstrate the methods of conducting a boiler trial.

## CONNECTIONS TO ELECTRICITY SUPPLY WORKS.

With the completion of our Supplement Tables I., Ia. and II., which represent the first half of our series of four supplements, we are able to give some diagrams showing at a glance the total connections to electricity supply stations in the United Kingdom.

Diagram 1 sets forth the growth of electric supply in London and the provinces and clearly shows the way the provincial connections have overtaken those for London, and the steady way the increase is maintained. The figures from which this and the following diagram are prepared include not only private lighting, but also private motors, public lighting and the tramway load supplied by those stations which supply both lighting and traction.

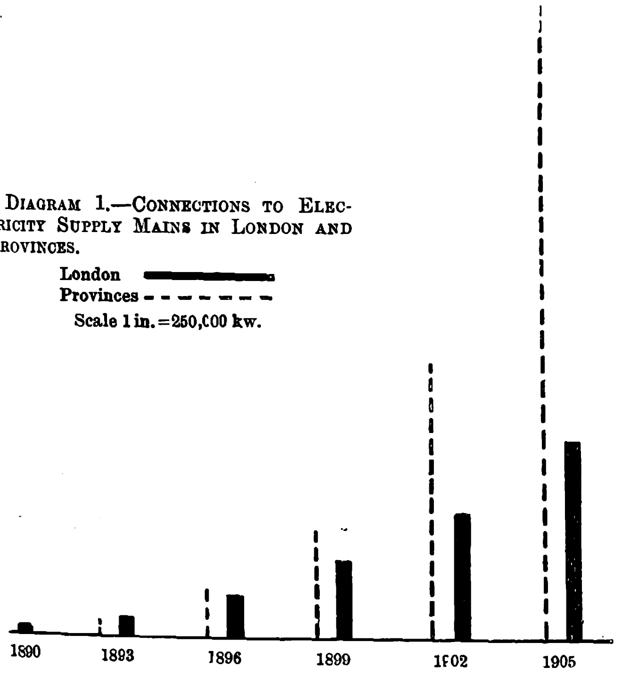

Diagram 1.—Connections to Electricity Supply Mains in London and Provinces.

London ▬▬▬
Provinces - - - - - - -
Scale 1 in. = 250,000 kw.

In Diagram 2 we have the proportions of the connections to stations owned by local authorities and companies respectively in London and the provinces, and in Diagram 3 the connections to continuous, alternating and combined continuous and alternating stations are given. Glancing at these two diagrams it is interesting to contrast the large proportion of connections to municipal undertakings in the provinces with the relatively greater number to stations owned by companies in the metropolitan area. The figure for connections to stations which supply both continuous and alternating currents has greatly increased. This is partly accounted for by the number of cases in which additional alternating plant has been laid down in stations formerly generating only continuous current, for supplying outlying districts, and the cases where additional continuous-current plant for traction purposes has been installed in stations from which previously only an alternating supply was given. The general tendency, however, of grouping together existing continuous-current notworks through substations to large high-tension two and three-phase generating stations, both in London and the provinces, is perhaps the largest factor in this direction.

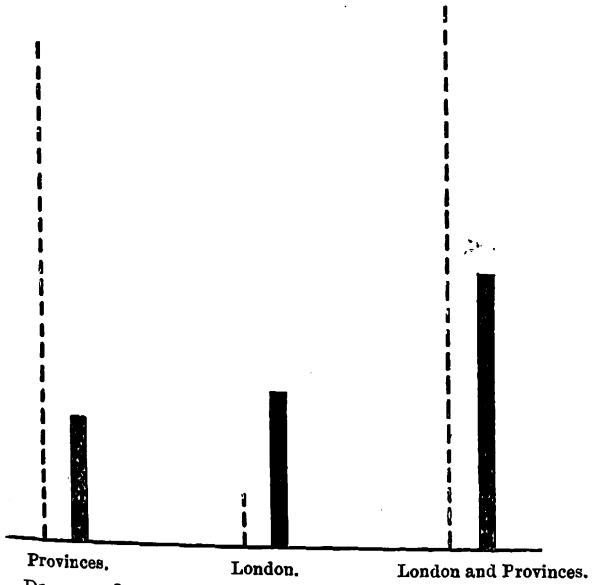

Diagram 2.—Municipal and Company Connections.

Municipal - - - - - - - Company ▬▬▬
Scale 1 in. = 250,000 kw.

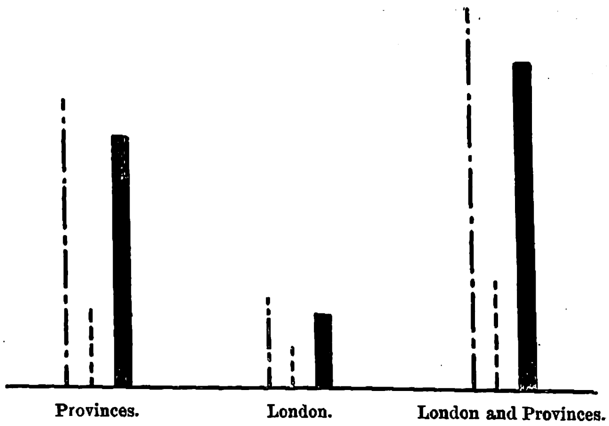

Diagram 3.—Connections to Continuous and Alternating Current Stations.

Alternating current - - - - - - - - Continuous current ▬▬▬
Alternating and continuous —·—·—
Scale 1 in. = 250,000 kw.

The figures from which these diagrams have been prepared are given in tabular form below. The totals are in all cases expressed in kilowatts, and include lighting as well as power connections, with the traction load in cases where a lighting station also supplies tramways.

**Table I.**—*Details of Connections in Provinces and London.*

| | | | |
|---|---|---|---|
| **PROVINCES** (783,300 kw.) | **Municipal** (627,600 kw.) | ▬ | 261,200 kw. |
| | | - - | 73,700 kw. |
| | | —·— | 292,700 kw. |
| | **Companies** (155,700 kw.) | ▬ | 72,300 kw. |
| | | - - | 9,600 kw. |
| | | —·— | 73,800 kw. |
| **LONDON** (247,100 kw.) | **Municipal** (57,800 kw.) | ▬ | 25,100 kw. |
| | | - - | 19,400 kw. |
| | | —·— | 13,300 kw. |
| | **Companies** (189,300 kw.) | ▬ | 58,900 kw. |
| | | - - | 29,800 kw. |
| | | —·— | 100,600 kw. |

**Table II.**—*Details of Connections to Stations owned by Municipalities and Companies in London and Provinces.*

| | Provinces. | London. | Total. |
|---|---|---|---|
| Municipal ............ | 627,600 kw. | 57,800 kw. | 685,400 kw. |
| Companies .......... | 155,700 kw. | 189,300 kw. | 345,000 kw. |
| Total .............. | 783,300 kw. | 247,100 kw. | 1,030,400 kw. |

**Table III.**—*Details of Connections to Continuous, Alternating and Mixed Stations in London and Provinces.*

| | Provinces. | London. | Total. |
|---|---|---|---|
| Continuous .......... | 333,500 kw. | 84,000 kw. | 417,500 kw. |
| Alternating .......... | 83,300 kw. | 49,200 kw. | 132,500 kw. |
| Cont. and Alt. ........ | 366,500 kw. | 113,900 kw. | 480,400 kw. |
| Total ............. | 783,300 kw. | 247,100 kw. | 1,030,400 kw. |

We have this year prepared a new diagram on the same scale as the foregoing to illustrate the proportion of the load in municipal and companies stations in London and the provinces due to private lighting and motors respectively. For the sake of clearness, neither public lighting nor traction load is included in these totals. The most noteworthy point brought out by Diagram 4 is the much higher proportion of motor load to lighting load in the case of companies than in the case of municipal undertakings, in the case of the provinces. Some difficulty was experienced in obtaining totals for motor connections in London, as the engineers at three of the largest concerns—the City of London, County of London and Westminster Companies—were unable to give their lighting and motor connections separately. We were, however, enabled to arrive at approximate totals for the motor connections of these companies by utilising the figures which were published in *The Electrician* of May 26, 1905 (Vol. LV., p. 225), in an article on "Motor Connections in London." An average increase at about the same rate as between 1903 and 1904 was assumed, although in all probability the rate of increase has been higher during the past year. The figures from which Diagram 4 was prepared are given in the following table, the connections as before being expressed in kilowatts.

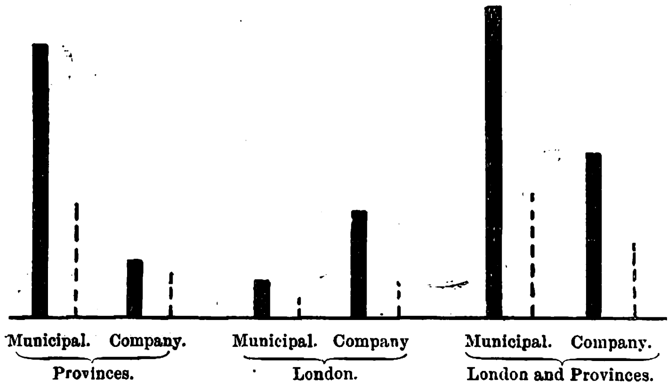

Diagram 4.—Private Lighting and Motor Connections.

Private lighting ▬▬▬ Motors - - - - - -

**Table IV.**—*Comparison between Private Lighting and Motor Connections.*

| | Provinces. | London. | Total. |
|---|---|---|---|
| **Private Lighting.** | | | |
| Municipal........ | 351,000 kw. | 43,000 kw. | 394,000 kw. |
| Companies ...... | 69,400 kw. | 138,800 kw. | 208,200 kw. |
| Total............ | 420,400 kw. | 181,800 kw. | 602,200 kw. |
| **Motors.** | | | |
| Municipal........ | 141,900 kw. | 14,600 kw. | 156,500 kw. |
| Companies ...... | 54,100 kw. | 38,300 kw. | 92,400 kw. |
| Total............ | 196,000 kw. | 52,900 kw. | 248,900 kw. |

The above total for private lighting represents a lamp connection equivalent to over 20,000,000 8 c.p. lamps, whereas the total connections given in Tables II. and III., including power and public lighting, are equivalent to over 34,000,000 8 c.p. lamps.

Diagram 5 represents the growth of electricity supply in London, and gives separate curves for all the different undertakings in the London area. In this, as in the other diagrams and tables, the connections are expressed in kilowatts. It will be seen that the business of all the undertakings continues to grow, mostly at an increasing rate, and an appreciable portion of the new load has been due to the rapid increase of late in the use of electric motors.

The Metropolitan Electric Supply Co. still maintains the lead, showing a remarkably steady increase in the additional connections for each year, but this year it is run close by the Charing Cross & City Company whose business has increased during the last five years at a rate not approached by any other London undertaking. The City of London and the Westminster Companies are steadily rising in their totals, as indeed are almost all the other concerns, the only two cases showing any approach to finality being the Borough Councils of St. Pancras and Fulham.

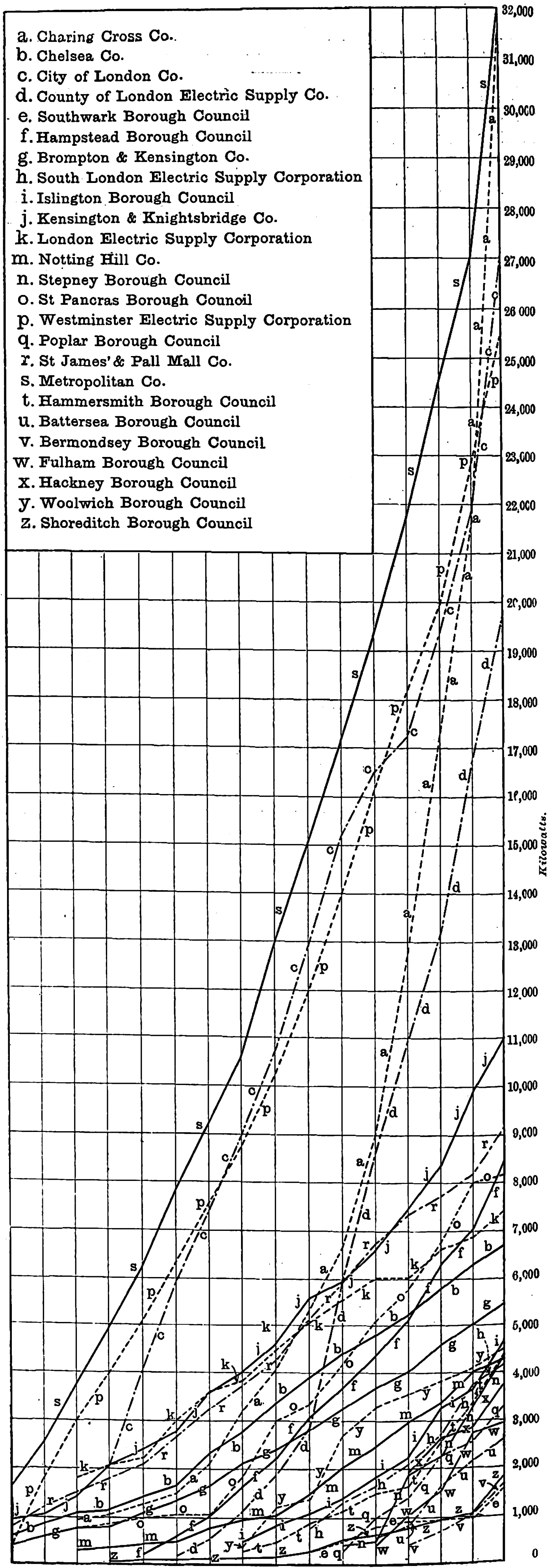

Diagram 5.—Connections to Electricity Supply Stations in London.

# THE CHARING CROSS COMPANY'S CITY OF LONDON WORKS.

Below we give an abstract of the conclusion of the discussion which took place at the Institution of Electrical Engineers on Thursday last week, January 11th, in connection with Mr. W. H. Patchell's Paper on the above subject. The Paper, slightly abridged, was published in our issues for December 15th, p. 341, December 22nd, p. 382, and December 29th, p. 420. The discussion which took place on December 7th and December 14th was given in abstract in our issue for January 5th.

Mr. V. A. FYNN said that Mr. Patchell and Mr. Highfield differed considerably on the question of the formation of nitric acid in armature insulation, but, for the sake of the rapid development of high-tension plant, he most sincerely hoped that Mr. Patchell's view would prove to be the correct one. It was true that Mr. Highfield had proposed remedies, but these, even if they really answered their purpose, only put greater difficulties in the way of the manufacturer. Personally, he thought that impurities in the insulating material were in the main responsible for the formation of the various acids which had been discovered and which occasionally destroyed the insulation of the conductors. He did not wish to cast any aspersions on the makers, however, for the difficulty was novel and quite unexpected, and it would be quite unfair to expect anybody to provide against such contingencies. It simply appeared to him that some of the insulating materials which had been recognised as excellent for all practical purposes failed when used in conjunction with the extra high voltages now often called for. The process by which the various acids were formed was a very complicated one, and could hardly be fully predetermined, but he thought that during the operation of a machine any unattached or incompletely attached acids which were present in the insulating material were set free and absorbed by the insulation covering the conductors destroying the covering and attacking the conductors. The influences which helped to release these acids were first of all the heat imparted to the insulating tubes by the armature laminations and by the armature copper, which, of course, were heated by the working of the machine, also the heat generated in the tubes owing to the stress imposed on them through their being subjected to a very high difference of potential. It was also probable that the silent discharge contributed in a small degree to the formation or liberation of these acids, and that a damp atmosphere materially furthered this process. He purposely said *acids*, because although nitric acid seemed to be in some cases the predominant partner, other acids were always present in varying quantities. It was very difficult to say which material forming part of a tube was responsible for the damage, and it could only be ascertained by a process of elimination. Personally he suspected that the solvents made use of to dissolve the shellac, which was generally used, were the most prominent offenders. It seemed to him that the test upon which Mr. Highfield based his theory only reproduced the exact conditions which prevailed in the faulty machine, and he ventured to say that this test was quite inadequate to prove anything beyond the fact that the combination of tubes composed of certain materials with conductors raised to a high alternating potential, was responsible for the production of a number of acids, amongst which nitric acid was most conspicuous. If Mr. Highfield had made comparative tests with a number of tubes all composed of different materials, having approximately the same dielectric strength and the same opening (one of these tubes might, for instance, be a glass tube), and had obtained uniform results in all these cases, then he could have endorsed his conclusions; but, failing such conclusive tests, he inclined to think that Mr. Patchell's view more nearly approximates to the true facts of the case.

Mr. A. A. CAMPBELL SWINTON said he regarded Mr. Patchell's reasons for having purchased all his machinery abroad as totally inadequate. The Paper stated that the only reason given for it was that "no risk could be run with experiments," and that the author had therefore "felt compelled to adopt such types of plant as could be seen in satisfactory work." He would like to know what some of the older engineers of this country would have said at such a reason; what would people like Watt, Stephenson and Brunel have said to a reason that because they could not experiment a little they should place their orders abroad. He did not believe for one moment that they would have hesitated to keep the work at home and to have run some little risk. He personally had no interest whatsoever in any British electrical manufacturing company and therefore he thought he was a most suitable person to raise this question. If this station were only more portable and could be carried round the country, it would be a most apt illustration of the advantage that might possibly be gained by tariff reform.

Mr. D. WILSON, of the B. & W. Co., spoke on the question of boiler house design, in the absence of Mr. Rosenthal. The Paper, he said, did not give sufficient information to enable a comparison with other stations to be made in order to see if the Bow station was really economical. From the Paper it was not clear that it was as efficient as many of the older works. Dealing with some of the remarks of the speakers in the discussion with reference to the horizontal and vertical boiler, he said that there was no water tube boiler with truly horizontal tubes. In the Babcock boiler the inclination was 15 deg., and after 30 years' experience, Messrs. Babcock & Wilcox were still convinced that this angle was all that was necessary to establish a full and definite circulation. The suggestion that no soot or scale could adhere to a vertical tube was absurd and would not stand investigation. In this connection there could not be a better example than the Green economiser, where it was necessary to have external scrapers and to clean the tubes from time to time. There was no difficulty in designing a boiler to give an evaporation of 100,000 lb.; it was not in the heating surface nor in the arrangement of the heating surface that the difficulty lay, it was in the design of the grate and the brickwork of the furnace. In the opinion of his firm, however, a boiler of this size was wrong, and from his own experience in the design of large stations he believed that the limit was about 30,000 lb. With reference to a question by one of the speakers on the height of the combustion chamber and the so-called triangular furnace, this was very much overrated. There was a limit both ways, and it was just as possible to have too large a furnace as it was to have one too small. It was possible to get perfect combustion with smokeless burning with the ordinary horizontal tube boiler, and he had carried out some very elaborate tests at the Islington Borough Council's works, one of which extended over 24 hours, working at an overload of about five per cent., when the efficiency came out to about 79·6 per cent. But what was more important from a commercial point of view was that the cost of evaporation on this trial came out to slightly under 5s. per 1,000 gallons. This was conclusive proof of the qualities of the horizontal boiler. As far as the evaporation per square foot of heating surface was concerned, the figure mentioned by Mr. Anstey was exceeded every day with the horizontal tube boiler. 3½ lb. was nothing exceptional. It might be interesting to know that in the Navy they had to evaporate from 8 lb. to 10 lb. per square foot of heating surface during the full load trials, and this was done without any damage to the boiler, or any scale production in the economiser. Probably too much attention had been paid to the question of floor space. A mere calculation of pounds per square foot was not the whole story, and one could cram this space at the expense of other important considerations. In Paris, at the new stations of the Metropolitan Railway Co., the plant had a capacity of 15,000 kw., and the station measured 123 ft. by 66 ft., which worked out to a very low value per square foot. In conclusion, however, he pointed out that the Bow station was one of the most modern reciprocating stations in the country, and it would be of the greatest interest to have figures which would enable a comparison between this and a turbine station.

Mr. A. H. SHAW (Ilford) said he doubted whether it was advantageous to use large capacity boilers when dealing with generating sets of 4,000 kw. to 5,000 kw. The boilers required shutting down periodically for cleaning, &c., and if these large sets were supplied by one boiler, or by two boilers with a common grate, the generating set would be thrown out of commission when cleaning took place. If a battery of boilers were adopted to supply each generating set, as in the case of the Carville station, each boiler could be shut down without interfering with the working of the set. The capital cost would be somewhat increased, but he thought this would be more than compensated for by the availability of each generating set for a very much greater period, than when supplied by one boiler. One or two speakers had referred to the periodicity, and had stated that 25 cycles would have been more suitable with motor generators. It was generally held that a periodicity of 25 cycles was not suitable for incandescent lighting, but he remembered seeing in a paper some weeks since that over 18,000 16 c.p. lamps were being supplied in Buffalo by alternating current generated at Niagara. He would like to know if this was a fact, and if they could use current at 25 cycles for lighting on the other side, why should not we do so here if it was required in any particular case. He could appreciate Mr. Patchell's desire to avoid surface condensers, for he had had similar trouble with the cleaning to that referred to in the Paper. He had also found that the only real method of dealing with surface condensers used with cooling towers was by means of hydrochloric acid, although this was rather a costly process. He would very much like to have from Mr. Patchell some figures with regard to the steam consumption of his engines as a figure of "under 4 lb." was rather vague, and he believed that in some very much smaller stations this figure had been reached.

Mr. HORACE BOOT (Tunbridge Wells) agreed with Mr. Patchell as to economisers. He had found that if plenty of tubes were put into the boilers, and also superheaters, there was very little extra gain by putting in economisers. He was surprised to hear Mr. Patchell speak of the trouble of keeping the condensers clean. It may have been due to allowing the cooling water to get to too high a temperature. Would Mr. Patchell kindly give in his reply the capital cost per kilowatt demanded of the additional mains required by placing the station some distance out from the area of supply, and also give the capital cost of all the items separately.

Mr. J. R. WALKER said he had been particularly interested in the part of the Paper relating to the boilers. He was of the same opinion as Mr. Patchell regarding the use of large steam-raising units, and was very pleased to see that the adoption of such large water-tube boilers had been a success. He did not, however, think that the way the boilers were treated was right, or that the treatment was such as one would expect to be meted out to them after proving such good friends to Mr. Patchell when he wanted an extra pound or two of water evaporated. He gathered that they were expected to act as water heaters or economisers, and also as water purifiers. He was decidedly of opinion that any boiler, more particularly a good boiler such as this upright boiler had proved to be, was the last place in which water purification should be attempted. He had no particulars as to the quality of the water supplied by the artesian wells at Bow, but he should think that Mr. Patchell had been very fortunate indeed if he found that the water contained neither temporary nor permanent hardness. Taking it that the back sections acted as purifiers, then he was of opinion that the quantity of impurities present in the water would have to be very slight in order that the action should be completed in the back sections alone. His experience of water purification in connection with feed water for boilers had been that the trouble was not so much to purify the water from matters in solution as to get rid of the impurities when they reached the solid state. He had found that it was generally necessary to have a filter or plenty of tank space in which the water could stand until the suspended matter could settle. For this reason he did not think that the action of the purifier part of the Hornsby boiler could be completed there as the time for settlement or deposit was so short, and he felt sure that a good proportion of the deposit, however little the whole might be, was very likely to be carried into the hotter parts of the boiler. Further, as they were told that the back sections acted as a water heater, then he thought it too much to expect that any sediment would also be deposited at high temperatures, such as would be found in the front sections of the boiler. Mr. Patchell had evidently found a water containing no permanent hardness, as he stated that the front sections were kept quite clean. At the last meeting it had been stated, to show the clean habits of the upright Hornsby boiler, that it could be run for three months without cleaning. Now, he did not think that this was anything but a very moderate performance, as he had been using water of 15 deg. hardness treated with a home-made softener, and had run a horizontal boiler for a period of six months without internal cleaning, and then found very little scale present. Of course, it might be that, in the case of the boiler described in the Paper, it was on account of the purifier part of the boiler becoming dirty that the boiler was shut down for cleaning. If this were so, it was a shabby way to treat such an efficient steam generating part. If this were so, then the sooner Mr. Patchell carried out the production of artificial marble in a purifier apart from the boiler the sooner he would get the continued use of his boilers proper. He was of opinion that no stone should be left unturned in order that the full value of the boiler could be obtained. He had heard it stated that water should not be too pure, but if proper precaution were taken in the way of keeping the alkalinity of the boiler water at safe value, and in the judicious application of zinc plates he thought that very little trouble would be found in running the boiler with water and water alone. In a considerable experience which he had had in running boilers at sea using the same water over and over again and with a make up of evaporated sea water, he had never seen any ill effects due to the water being too pure, and no difficulty was found in running for long periods. He felt sure that any action which was taken by central station engineers towards supplying the boilers with pure water would be amply repaid by the increased length of time it would be possible to run the boiler without shutting down for cleaning. He was inclined to think that with scale-forming water the upright tube was not so much in front of the horizontal as some people would like to believe. He had brought with him a section of a very nearly vertical tube from a boiler working at 140 lb. per square inch, and the only treatment meted out to the feed water was the addition of a boiler composition. (The specimen was not passed round, but from the view we could gain of it, it appeared that the scale occupied the greater part of the bore of the tube.) With regard to the feed water, the Paper stated that the method of pumping adopted was the air-lift system. He had been told, or had read somewhere, that when water was raised by an air-lift a difficulty was experienced in the boilers through the air which was used to raise the water becoming intermixed with the water and being pumped into the boiler, causing corrosion of the plates. Would Mr. Patchell say whether he had had any trouble of this sort? Could Mr. Patchell also say what the reading of the $CO_2$ recorder gave when it was recording, what percentage of $CO_2$ was present in the flue gases of the upright boilers when only one grate was being used? If they could get a figure showing this, then there might be some clue as to why the consumption of coal approached 4 lb. per unit generated. He had another question which he had not yet heard asked: Could Mr. Patchell say what staff he required in each of the departments of his generating station? So much was heard nowadays of the labour-saving properties of turbine-driven sets, mechanical stokers, &c., that he would like very much to be enabled to make a comparison.

Mr. DUDDELL referred first to the destruction of the insulation of the stator coils which had been observed by Mr. Highfield, and of which Mr. Patchell had found no trace. There seemed no doubt, from what Mr. Highfield had told them, that the prime cause of the destruction was one of the oxides of nitrogen. The oxides of nitrogen were always produced when a brush discharge took place in air. A brush discharge would take place if the potential gradient exceeded a certain limiting value: according to a recent Paper by Mr. Alexander Russell this limiting value was 38,000 volts per centimetre for air. Fig. 1 represented diagrammatically a single conductor, the adjoining wall of the mica tube and the iron frame of the machine. The frame of the machine was assumed at zero potential and the ordinate CC′ represented the potential of the wire above the iron frame. The ordinates of the curve AB′C′ represented the potential at any point in the dielectric. The maximum potential gradient in the air part would be at C, next the surface of the wire—*i.e.*, where the curve was steepest. If this potential gradient exceeded the limit for air, a brush discharge would take place with the formation of greater or less quantities of the nitrogen compounds. The maximum potential gradient and the shape of the curve AB′C′ depended chiefly on the difference of potential CC′ between the wire and the frame; the thicknesses of the air, cotton, &c., and of the mica wall; the radius of the wire and of the mica, &c., if curved; the specific inductive capacities; and the conductivities of the two media between AB and BC. In Mr. Patchell's three-phase 10,000 volt machines with earthed neutral the maximum P.D. CC′ was about 8,200 volts, whereas in Mr. Highfield's two-phase 10,000 volt machines it was about 14,100 volts; and at first sight this seemed like the explanation of the difference. It could not, however, be the whole explanation, as, if he understood Mr. Highfield correctly, he had observed the destruction of the insulation in coils in which the P.D. between the wire and the frame was only 2,000 R.M.S. volts. Of the relative thicknesses of the mica wall AB and the air cotton layer BC in the two cases no information had been given, but it was probably very similar, as it was determined by questions of dielectric and mechanical strength. The radius of curvature of the wire at the corners was smaller in the Highfield machine, judging by the rectangular tube he showed at the last meeting, which would greatly increase the potential gradient and destruction at the corners, as was well shown in the test piece exhibited. It remained, however, in the relative specific inductive capacities and conductivities of the two media that the greatest differences might exist. To reduce the potential gradient near the wire was a similar problem to that considered by Mr. O'Gorman in his Paper on cables before the Institution in 1901, and the method he proposed was called "grading" the dielectric, which consisted in so arranging the conductivity and specific inductive capacity as to obtain the required distribution of the potential through the dielectric. In the present case they required to concentrate the stress on the wall AB that was to raise the point B′ in Fig. 1 so as to relieve the air and cotton of as much stress as possible. If the material of the wall AB was fixed, this could be done by increasing the specific inductive capacity and the conductivity of the layer BC. Thus it seems that a bad insulating material for BC would give better results. By bad insulating material he only meant one that insulated badly and not one which contained acid, &c. It was to be noted that the high specific inductive capacity of mica and shellac was unfavourable to their use for the wall AB, as they lowered the point B′. There were two other methods by which this difficulty might be overcome, one of which was fairly self-evident —viz., impregnate the coil so as to exclude the air altogether. The second method was mentioned by Prof. Epstein at the last meeting—namely, place a metallic shield between the wire and the mica tube. It seemed to him that this method should give excellent results provided that the metal shield was connected electrically to the coil and that the mica tube was built upon the metal shield so as to exclude all air from between the metal and the mica. It was probable that the shield would have to be thin and of high-resistance material to prevent eddy-current losses in it. The speaker then referred to the switching tests he had carried out for Mr. Sparks. He explained that the conditions which prevailed on switching in and out apparatus differed so much from one station to another that he only proposed to refer to the difference between the break in air and the break under oil, and the effect of a transformer connected to the cable. The feeders used for the tests were 6,000 volt rubber cables, and the tests were all carried out at 2,000 R.M.S. volts to avoid any risks to them. The alternator gave a very square-topped P.D. wave form, which was

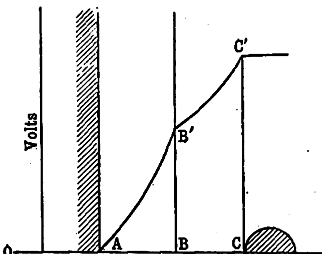

FIG. 1.

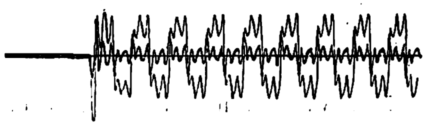

FIG. 2. Scale 1mm. = 500 volts or 3·33 amp.

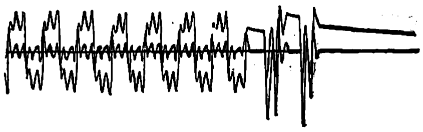

FIG. 3. Scale 1mm. = 500 volts or 3·33 amp.

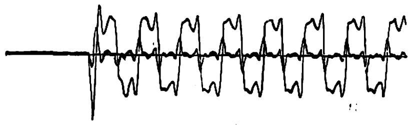

FIG. 4. Scale 1mm. = 500 volts or 6·67 amp.

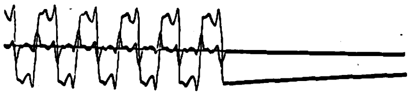

FIG. 5. Scale 1mm. = 500 volts or 6·67 amp.

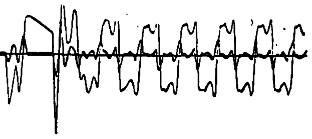

FIG. 6. Scale 1mm. = 500 volts or 6·67 amp

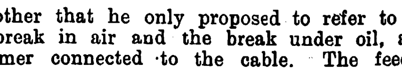

FIG. 7. Scale 1mm. = 500 volts or 6·67 amp.

further distorted by the capacity, as would be seen in the following figures. (As the result of these and other tests made on the machines, the pole tips were re-designed and the wave form was made almost sinusoidal.) In all cases the larger curve was the P.D. curve, and the inner smaller curve the current.

All the P.D. curves are drawn to the scale of 500 volts per mm.; the current curves in Figs. 2 and 3 to $3\frac{1}{3}$ amperes per mm.; and the rest $6\frac{2}{3}$ amperes per mm. The tests had been all carried out single-phase to simplify results. The rises did not, of course, occur at every operation of the switch. It was therefore necessary to make a large number of tests to find out what might occur. Figs. 2 and 3 showed switching on and off of about $4\frac{1}{2}$ miles of cable on open circuit, using brass contacts in air. Fig. 2 was typical of the sudden instantaneous rise in P.D. which occurred on switching on a feeder or open circuit; the maximum volts recorded were 4,200, or 2·1 times the R.M.S., and this was quite a normal case. The switch-off (Fig. 3) was a bad one, sparking having taken place at the contacts, the maximum volts rising to 5,100, or 2·55 times the R.M.S. value. Fig. 4 was a switch-on of twice the length of cable, using brass contacts in air; the rise was to 4,500 volts, or 2·25 times the R.M.S. value. Switching off this same length of cable with contacts under oil no rise at all was obtained (Fig. 5). Referring to Mr. Highfield's practice of leaving his instrument transformers connected across his mains when he switched in, Mr. Duddell thought that this did not tend appreciably to prevent the rises. To illustrate this point, the speaker continued, the test illustrated in Figs. 4 and 5 was repeated with a 400 kw. transformer on open circuit connected to the far end of the cable. The results (Figs. 6 and 7) showed a rise at switching on of 5,400 volts, or 2·7 times the R.M.S. value. At the switch-off, with the break under oil, there was no rise. If, however, the transformer had its secondary closed on a low resistance, so that it was heavily loaded, then, when it was switched on with the cable, it would tend to reduce the rises. It was of interest to compare the way the voltage died away on the cable after switching off. In the first case (Fig. 5) the cable discharged through a non-inductive leak (the oscillograph), and in the second (Fig. 7) through the inductive transformer giving slow oscillations, which were quickly damped out. In conclusion, Mr. Duddell stated that the results obtained with Mr. Sparks' plant were quite typical of the records he had obtained in the many other cases he had investigated.

Mr. W. H. PATCHELL, who was then called upon to reply, thanked the President for not allowing any other speaker to ask further questions. The most flagrant offender on the last occasion had been Mr. Rider, and he had afterwards suggested to Mr. Rider that he should accept the "Encyclopædia Britannica"—with the Appendix—in full settlement of all claims, but Mr. Rider had refused. He would still endeavour to reply to the discussion in detail; and he was fortunately enabled to do this by the aid of the report of the two previous evenings' discussion published by his good friend *The Electrician*. He had arranged his replies under the various headings given in the Paper. First with regard to the position of the site, the fact was that they were not exactly free agents. There was a special purchase clause in the bill which stipulated that should the generating station be placed outside the City of London, the consent of the City Corporation was to be obtained, and it had not been suggested to the latter that the station should be placed at Cambridge or the North Pole, although for an overhead system this might have had advantages. They obtained the best site offered out of a somewhat limited number which pleased the authorities that they had to please, and another reason which limited the distance at which the new works could be placed was that the more local authorities whose districts had to be traversed, the more trouble was likely to be encountered.

The next matter was Mr. Campbell Swinton's question: Why did they go abroad? He would ask Mr. Campbell Swinton why he went abroad for his motor cars. The last time he saw Mr. Swinton he had told him that owing to his motor car breaking down in the country he was unable to be present at the last meeting. Fortunately, he (Mr. Patchell) had had better luck than Mr. Swinton, for he could not have got better electrical machinery than he had at Bow, if he had bought it in England. Moreover, he denied absolutely that it was possible to have bought this plant in England in 1900. Tenders were asked for here, on the Continent, and in America, and the best English tender was withdrawn at the last moment, due to patent questions. Although Mr. Swinton had commented on the remark that they could not run any risks, there was a big load waiting for them, as not only had they the City to pick up in the face of competition, but they were relying on their new works for supplying their existing area, the demand in which had grown at a very satisfactory rate. Therefore that was not a time to recommend his board to risk experimental machinery. That settled the first order, and when he got a contractor who did his work well and gave satisfactory plant, he treated that contractor like an Englishman and as he had always treated English contractors: he gave him repeat orders.

It was very valuable to get such a thoroughgoing tribute to three-phase over two-phase from such an unbiassed gentleman as Mr. Highfield, who had not got to stick up for his own plant, as it had been designed by other people. On the question of frequency he had been asked why he did not adopt 25 cycles, and one advantage of this he had been told was that he could avail himself of supply from some of the power companies which were promoted last year. But the power companies were not promoted in 1900, nor even thought of. The only benefit accruing to the 25 periodicity was on the line; there was very little in the generator and very little in the motor-generating plant. After weighing the whole thing out they had come to the conclusion that 50 ∽ was the best. He could, if necessary, work motors or lamps or anything else with the interposition only of static transformers. At the present moment, it was true, he was motor-generating everything, but he was not tied to it. The matter was also very thoroughly threshed out in 1904 at the big meeting which was called to consider the question by the Engineering Standards Committee, and the number of people who had stood out for 50 ∽ entirely was astonishing, and they brought forward very good arguments. He believed that 25 ∽ plant had been mainly upheld because when the type of plant was designed there were very few people who could make any other, but since then, with better experience and knowledge, rotaries which would run at 50 cycles had been designed. Prof. Epstein and Mr. Mordey, who both had had considerable experience in this matter, had upheld the 50 periodicity. Out of curiosity, he had looked up the question of the weight of static transformers, and from two of the known makers' lists he had got an interesting result. A 150 kw. 25 ∽ transformer weighed 6,000 lb., and at 60 ∽ it weighed 4,950 lb.—*i.e.*, very considerably less for the higher frequency. A 300 kw. machine weighed 9,900 lb. at 25 cycles, and 7,500 lb. at 60 cycles. This gave an idea of the cost of transformers when working at the lower frequency.

There had been practically no criticisms of the buildings, except that the crane was too low. He had mentioned on the first evening that at the time the building was designed he only had the drawings for the horizontal engines. He knew that vertical engines must come, and he intended to use them as soon as they did. The only vertical engine available was the triple expansion tandem cylinder engine, which he objected to on account of the difficulty of inspecting the cylinders. The roof, as originally designed, was nearer to the traveller with the traveller at the present level, but for symmetrical reasons the architects suggested that the roof of the engine-room should be raised to the level of the boiler-house, and he saw no objection to this. Looking at the arrangement now, it did appear that the traveller ought to have been higher to give more room over the engine.

Turning to the boiler-house, he regretted that he had not made it plainer in his Paper as to what was a boiler and what was a unit. Mr. Sparks and other gentlemen had rather missed his point here, and seemed to think that it was possible to steam one boiler of a pair without the other; but this was impossible, as the combustion chamber was common, and it would possibly have been made plainer if, instead of putting what was obtained by one boiler in the last column of Table I., he had doubled these figures. Several gentlemen had stated that he ought to use mechanical stokers. He had tried for several years to do this, and he had used a great many mechanical stokers, but the results had not shown superiority over hand firing. He had used underfeed stokers, but had had to abandon the experiment for the time being, although he hoped to resume it again in the spring. He was still hoping to use mechanical stokers, but he could not be satisfied with a mechanical stoker which would merely evaporate continuously at the normal rate. He wanted the elasticity on his plant that he now got with hand firing. He knew of a case in which the whole of the works had been equipped with mechanical stokers, and they found that they got the normal rates comfortably enough, but there was no elasticity. When the time came for increasing those works they moved half the stokers into the new boiler room, and they now had half of each boiler room mechanically stokered and the other half hand fired, and it would be found that a works that ran on loads which varied, not at the will of the man who owned the works but at the will of the public, would have to run that portion of its boiler plant which was mechanically stokered as a secondary works. At Newcastle there were two stations, one to help the other, which was the same as working half the plant mechanically stokered and half by hand firing. The same thing happened in Chicago, and in many other large towns. They must do this or work the stokers below the normal rate, so that when the pinch came the stoker would respond to it. With regard to the back section of the boilers acting as economisers, he did not know that he illtreated his boilers, but they did act as economisers, and he would show why. When the boiler shown in Fig. 3[*] was first erected, the back sections were nippled to the sections in front, both at the bottom and the top. The place of these nipples had, after experiment, been taken by small studs, and it was found that, by putting a suitable temperature in that back section, the water that was fed into it did not get mixed with the water in the boiler which was at the temperature due to the steam, until it got nearer to the fire. This enabled the back of the boiler to be worked at the lower pressure which some speakers regarded absolutely with suspicion when he made the statement. Mr. Walker, who had spoken so well that evening, must admit that whether scale or granulated sediment was created depended not only on the temperature, but on the time that was allowed for the solids to crystallise out. He realised this when he was experimenting with the Babcock boiler many years ago with an American apparatus consisting of a feed pipe let into the top of the boiler instead of below the water line, that discharged through a small nozzle over a cone, and the cone was fitted with a blow off pipe which went out where the water used to come in. That had the effect of discharging the whole of the water into the steam space, with the result that the whole of the solids in that water crystallised out, and it was possible to blow them out by the discharge pipe into a tank; when they were dried they were like so many grains of corn. This showed that if the water was evaporated quickly instead of slowly, and so giving it time to form scale, granulated crystals were obtained instead of scale. That was what he got in the back of his boilers, and it was dealt with by blowing off from time to time, for as the boiler was cooled down the egg shell scale which was actually formed fell to the bottom. The water at Bow was not like the Greenwich water. It was chalk water, but the Greenwich chalk was on the outcrop, and the water from it was therefore absolutely different to water from chalk overlaid with a thick mass of London clay as at Bow. Instead of boiling to a hard scale and practically keeping to the same density, as the Greenwich water, the Bow water boiled to a much softer scale and was absolutely alkaline. The specific gravity was 1·22. In the matter of water supply with only two wells, he was not so tied up as some people imagined. There were plenty more wells in 8 acres of land, and a great deal of water was as yet untouched. They would see by the illustration of his boiler that it was very easy to change tubes, for the firemen stood on chequer plates, over a basement, so that the tube could be drawn out into the basement. Up to the present, however, no tube had been changed. Mr. Venning had put in some figures of the Stirling boiler as about to be used at Carville. If they referred to his figures it would be seen that the only question between them was the nominal evaporation. This was the same as talking of the nominal horse-power of an engine; it meant nothing. Mr. Venning had put into two columns 33,000 lb. per hour for both the Stirling and the Hornsby boilers, but the normal evaporation per square foot of the latter was given as 3·04 lb., and in the case of the Stirling it was 5·17 lb. If this latter figure were applied to the Hornsby boiler they obtained the normal evaporation to the point to which it had been taken, viz. 100,000 lb. per hour. But they must not be misled by Carville. The gentleman who was concerned with Carville was very enthusiastic when giving nominal values to his plant. A 3,000 kw. turbine here was 4,500 kw. up there, and a 10,000 kw. machine became 15,000 kw. up there, so that one would not expect a 33,000 lb. boiler to be what an ordinary man would call a 33,000 lb. boiler. The only point about his chimneys was that one gentleman envied them, and he could only reply that they were not patented.

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[*] *The Electrician* of Dec. 15, p. 343.

The water heating had not been quite clearly followed out by the speakers. He did not put the boiler pressure on to the feed heaters which were put in between the low-pressure cylinders and the condensers, because he did not wish to get these large vessels at boiler pressure in the engine room in case of a joint blowing out. He did not agree that the closed type of heater was better than the open type. Then, again, he had been very much railed at for not putting in stage heating, but he thought that, after what he had told them about the boilers, it would be seen that they were not altogether without stage heating. One speaker had asked what the duty of these steam pumps was. A test had been made on two of them, and one came out at $43\frac{1}{3}$ lb. of steam and the other at $40\frac{1}{2}$ lb. of steam per pump horse-power-hour. He was not concerned, however, whether it was 35 or 135, because he got it back in the open heater; but, as a matter of fact, they were extremely efficient. He would not go into the question of cleaning condenser tubes, because he had dealt with it very fully last year in the discussion on Mr. R. W. Allen's Paper before the Institution of Civil Engineers, and reference must be made to the *Journal* of that Institution. He had there described how, when he had been responsible for the working of surface condensers he had cleaned them without removing the tubes. But he thought Mr. Sayers' was quite right in saying that the concentrating of the water and the trouble with tubes was worse with cooling towers than if fresh water was used every time. In reply to a question by another speaker, he used natural draught at Bow; there were no fans.

He now came to the black spot on the Paper; it was green at first, but had since become black, due to a letter which was sent to the Press instead of being sent in as a contribution to the discussion, and having the matter out on the floor. He now wished to tell the gentleman in question that he very much regretted having hurt his feelings in any way. There was not one idea of that sort in his mind when he wrote the Paper, and he was still of the opinion that his criticism was absolutely justifiable; he did not see that it reflected in any way upon either the persons who sold the machines or anyone connected with them. It was open to all of them to hold different opinions, and he certainly was not convinced by Mr. Highfield's experiment. Other gentlemen had not agreed with it either, and the letter he had referred to had absolutely garbled his statement. The words in his Paper, he maintained, did not bear the interpretation which had been put upon them. In fact, if the letter had been written that week it might have been mistaken for an electioneering letter. Mr. Highfield had stated his case very fairly and very frankly, and the information from Mr. Duddell that evening and other gentlemen had been very valuable, but he did not think that we yet knew all about these Willesden machines. He did not think Mr. Highfield was there at the time, but it had not been stated what form of insulation was used, how much there was of it and how thick were the mica tubes. Then, after the machines were wound, how long elapsed before they were put to work; where were the machines meantime; when the machines were about to be put to work, how were they dried; were they dried by putting "devils," as they were called in the works, about the machines, or were they dried from the inside by putting current through them? If they referred to Mr. Highfield's original article in *The Electrician* it would be observed that some of his coils were damp. He maintained that if these machines were what they ought to have been, or handled as one would expect, these coils ought not to have been damaged. When he spoke of the impurities, he had in his mind a further case of a man who was put to make lead secondary cells. He was practically working from a recipe, like a cookery book, and the plates did not always come out the same. He wondered why. The materials were analysed and returned as commercially pure. The mechanical engineer appealed to the technical chief of the company and to the Board and asked for a complete chemical analysis, but he was refused because such an analysis would cost five guineas. But as time went on everyone now knew that material for secondary batteries containing microscopic quantities of arsenic and foreign impurities of all descriptions now known as absolute impurities, were then classed as commercially pure. He (Mr. Patchell) had no more at the back of his head when he wrote that criticism of Mr. Highfield's tests than this; and he was only very sorry indeed that he had caused any ill-feeling.

With regard to trunk mains, he had been told that he should have laid a lot of spare ways. If he had his own way he should have done so, but he had no option. He was compelled to lay mains either on the solid system or armoured cables buried in the ground. He elected to put in the solid system. There was no chance to have any spare ways, and there was not to be a single inch of void between Bow and London on his mains. He quite agreed with one speaker that the cost of laying mains in London was quite under-estimated in some quarters. Last year figures were put forward for laying mains which, to his certain knowledge, would not pay for reinstatement. Then, a joint which was mentioned as better than his own was the B.I.W. which was wrapped with linen tape. He had lately heard of an even better one than that, using micanite tubes differently to the usual manner. The micanite tubes were made and boiled in the factory, then boiled by the jointer and then slipped on so that there was no dirt in it, whereas a man was apt to get his tape dirty. The porcelain insulators had given no trouble. The cable charging gear had been found fault with, and from what they had heard from Mr. Duddell that night he hoped he would not have to use it now that oil switches were available. Mr. Duddell's experiments were extremely interesting and backed up what he had been told elsewhere—viz., that the oil switch would enable a cable to be put on or taken off at full pressure. The criticism of his cable-charging gear, however, that he had to run up through a range of frequencies, was incorrect. He could get full frequency at 4,000 volts, and this was what was usually done; then the volts were increased with the normal frequency. Another speaker tackled the motor-generator question, and asked why synchronous machines had been preferred to induction machines. But this gentleman was working at 6,000 volts, whereas he (Mr. Patchell) was using 10,000 volts, and if that particular speaker were using 10,000 volts he had no doubt that he would change his opinion.

As to working results, he had been asked for no end of things. The cost of coal was about 13s. per ton delivered. Then as to the load factor and the coal consumption, he had not the least objection to giving the items year by year since the commencement. They were as follows:—

| Year. | Units delivered into trunks. | Lbs. per unit delivered into trunks. | Load factor. |
|---|---|---|---|
| 1902 | 1,406,663 (7 months only) | 4·17 (large Welsh) | 7·85 |
| 1903 | 7,070,463 | 3·46 do. | 10·66 |
| 1904 | 10,340,657 | 3·36 (partly large and partly small) | 13·07 |
| 1905 | 12,171,104 | 3·58 (all small) | 13·69 |

Mr. Sparks had mentioned some of his results. Last year he had also given some in a place not far away, where many of them met for so many days, but with these figures he could not find quite the same figure as that which had been given the other night. The City-road works were not high tension. The bulk of it, he believed, was 500 volts direct, which went out for motors in the Clerkenwell district. According to these particular figures, up to March 28th last year, Mr. Sparks' coal cost 11s. 8d. per ton, and per unit delivered into the mains cost ·295d. That worked out to 4·72 lb. per unit, and it was on the basis, not of a 13 per cent. load factor, as at Bow, but a 26·4 per cent. load factor. Mr. Sparks' 1904 accounts did not give the price of coal, but it showed a 10,000,000 unit output, and, taking the same price of 11s. 8d., this was 5·6 lb. of coal per unit. Probably the coal was dearer in the early part of 1904 than later. Then, if he turned these figures into cash, it would be found that in 1904 Mr. Sparks' coal cost was ·35d. per unit generated, and from his evidence in another place it would be seen that his pounds of coal per unit delivered to the mains was 3·73 with a 17·86 per cent. load factor for all his stations. Against this his (Mr. Patchell's) own figure was 2·26 lb. on a 13·69 per cent. load factor for 1905. From these figures he was justified in saying that his station was not altogether a bad one. Then there was the large Neepsend station, which was a turbine station, whose figures for the year were recently published by *The Electrician.** The units delivered into trunks were $3\frac{1}{2}$ millions and the load factor 13·4 per cent. The pounds of coal per unit delivered into trunks were 4·04. He would take this a little further. Earlier in the year the Neepsend station was said to be using Shireoaks slack. He had tested that slack and he had found it to have 13,000 B.Th.U. calorific value. They therefore got $52\frac{1}{2}$ thermal units per watt-hour in the turbine station. At Bow, for 1904 he got 51·45 thermal units per watt-hour, and for 1905 50·12 thermal units per watt-hour. Figures for other English stations were not available, but he had looked up several of the large German stations, which were as below:—

| — | Lbs. of coal per unit generated. | B.Th.U. per lb. | B.Th.U. per watt-hour. |
|---|---|---|---|
| Berlin | 3·1 | 12,400 | 38·464 |
| Hamburg | 3·28 | 13,200 | 44·616 |
| Dresden, L. | 7·6 | 7,392 | 56·179 |
| ,, P. | 6·7 | 7,392 | 49·526 |
| Frankfort | 3·92 | 13,200 | 51·744 |
| Charlottenburg | 4·5 | 11,088 | 49·896 |
| Elberfeld | 4·37 | 12,144 | 53·069 |
| Neepsend | 4·04 | 13,000 | 52·52 |
| Bow, 1904 | 3·43 | 15,000 | 51·45 |
| ,, 1905 | .. | 14,000 | 50·12 |

These figures went to show that this was not a bad way to compare the value of a station, and he would prefer to take a 12 months' performance on this basis than a 20 hours' test. The trunk mains on a 1,000 kw. basis dropped 3 per cent. A Hopkinson test had been made on the motor-generators, and although it was an extremely difficult thing to take he had arrived at 86 and 87 per cent. efficiencies. With regard to the appendix, Mr. Duddell had thrown very great light upon it. He had hoped that other speakers would have taken it up, because this and the surging troubles were to an electrical engineer really the most important parts of the Paper, and he hoped yet that somebody would come to the rescue, and tell them more about these points. He thanked the members for having discussed the Paper so fully, and for having listened so patiently to his reply.

On the motion of the President (Mr. J. Gavey) a hearty vote of thanks was accorded Mr. Patchell.

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* *The Electrician*, December 8th, p. 297.

## BRAKES.*

BY A. L. C. FELL,

Chief Officer London County Council's Tramways.

With light horse and cable tramcars, travelling at a moderate speed, only a hand brake is necessary, but with heavy mechanical traction and higher speeds the necessity for more efficient brakes is recognised. Trials by Sir Douglas Galton and Westinghouse on the London, Brighton & South Coast Railway in 1878 were the first reliable attempts made to solve practically and scientifically some of the problems relating to the question of braking vehicles running on rails. The most important conclusion arrived at in these tests was that concerning the effect of skidding the wheels. I have ventured to reproduce two of the curves and letterpress relating to this point included in the Paper which Galton read in 1878.

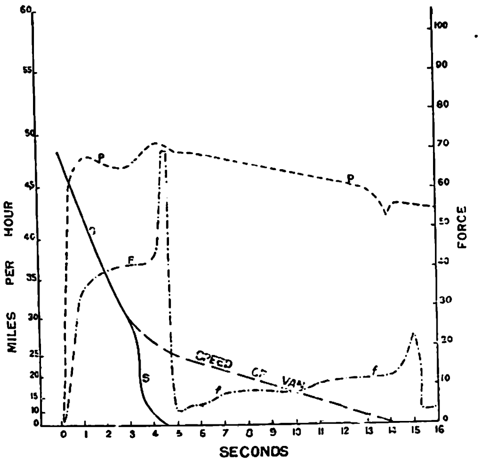

Fig. 1.—Diagram illustrating the Effects of Skidding.

"The above copies of two sets of diagrams, Figs. 1 and 2, taken during the experiments, show, more clearly than can be explained, the difference in the retarding force, before the wheels begin to slide upon the rails, and after. These two experiments were made with a single van slipped from the engine, the brakes going on automatically at the moment when separation from the engine took place. The line SS shows the speed of the braked wheels at each instant, the scale for which is given in miles per hour. The line PP represents the pressure against four blocks acting upon one pair of wheels; the vertical height of P on the scale headed 'force,' when multiplied by 240, gives the total pressure in pounds upon the four blocks collectively. The line FF shows the retarding effect of the four blocks upon the one pair of wheels before the wheels began to slide upon the rails, and *ff* shows the effect while the wheels were sliding upon the rails. The vertical height of F or *f* on the scale of force, multiplied by 60, gives the total retardation in pounds upon that pair of wheels.

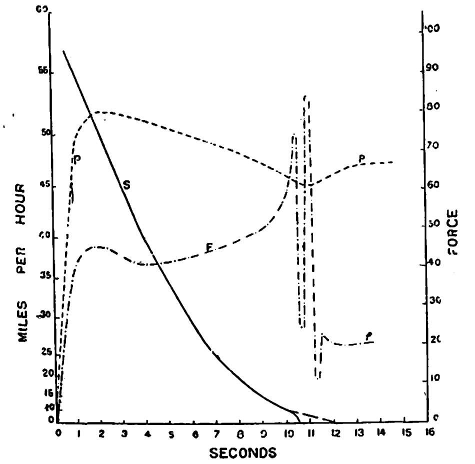

Fig. 2.—Diagram illustrating the Effects of Skidding.

The calculations show that the friction between the wheel and the rail, when the wheel is sliding on the rail, is *less than one-third* of the friction produced between the brake-blocks and the wheel, when the brake-blocks are so applied as to allow the wheel to continue revolving."

It is now absolutely necessary to obtain sanction for an increase of speed of tramcars. It is unquestionably somewhat of an anomaly that petrol-driven vehicles are permitted to travel at any speed up to 20 miles per hour, whereas tramcars, which travel in an undeviating line, are not allowed to run at the same speed. The demand for rapid transit is daily increasing, and tramway authorities are fully alive to the fact, but I have drawn attention to this point because as the efficiency of braking apparatus increases many of the existing objections to higher speeds on tramways will disappear.

A very large number of brakes have been developed, and the chief object of this Paper is to present, as concisely as possible, the results obtained when making comparative tests with some of these brakes.

1. *Hand Brakes.*—Being a friction brake the co-efficient of friction is directly proportional to the pressure, and inversely proportional to the speed. Consequently, to obtain a properly graduated braking effort the pressure should be reduced as far as possible as the speed of the car decreases, in order to avoid skidding. An ideal brake should automatically adjust the pressure in proportion to the speed; this is a quality possessed by brakes of the electric, magnetic, air and momentum patterns, which will presently be referred to. The developments which are now proceeding in this direction almost seem to indicate that for electric traction, at least, the ordinary hand brake is likely to be superseded as an ordinary service brake. Curves 00D, 0D, No. V.D*, show the results recently obtained from some emergy stop experiments with the ordinary hand brakes upon dry and greasy rails respectively.

1a. *Peacock Brake.*—The Peacock brake is an improvement on the ordinary hand brake. An arrangement is made with an eccentrically geared cam fixed at the lower end of the ordinary brake spindle; the brake chain is wound round this cam. By means of this apparatus the slack chain can be more quickly wound up and the brakes can be applied more rapidly than with the ordinary hand brake. The cam is so arranged that it is impossible for the chain to overlap and slip. By this arrangement there is less wear on the chain and it is less liable to break. The author had an opportunity of inspecting this brake in service on the cars in Buffalo, where it apparently gives very good resu'ts in daily service.

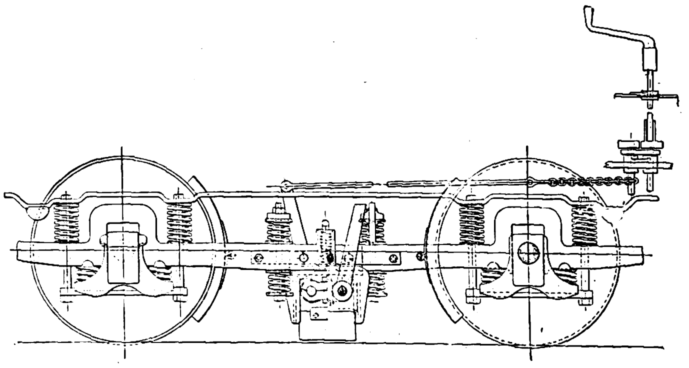

Diagram No. 1.—Arrangement of Hand-operated Slipper Brake.

2. *Mechanical Slipper Brakes* (*Diagram No. 1*).—The slipper or mechanical track brake is arranged so that wooden blocks can be depressed on to the rails by means of levers or screws. This type of brake possesses certain distinctive advantages over the ordinary hand brake, though it is by no means so useful as a service brake. It can be applied to give a steady retardation, whilst the finer adjustments of speed can be made by means of the hand brake. It must be remembered, however, that the adjustment of the pressure for the gradient and the speed is not automatic, and requires the constant attention of the motorman. In my opinion, the mechanical slipper brake is not sufficiently rapid or delicate for an ordinary service brake. The operating wheel has to be carefully designed to minimise the tendency to lift the weight off the car wheels, so as not to decrease the efficiency of the wheel brake. When cars are travelling at slow speeds down steep gradients, very excellent steady running results can be obtained by the combination of independent wooden slipper brakes and hand brakes, especially where the gradients are numerous and the cars do not have to run considerable distances through congested traffic, but in London, I believe, the magnetic track brake more nearly fulfils the requirements of rapid transit. One of the advantages of a slipper brake is that powerful retardation can be produced without skidding the wheels. By using wooden blocks very good results can be obtained when sand is applied, as the block becomes permeated with grit. Another advantage of the slipper brake is that the wooden block thoroughly cleans the surface of the rail. In the earlier forms the maintenance charges of slipper brakes were somewhat high; this was chiefly on account of the weak mechanical design, the upward thrust being taken entirely on the bolts by which the apparatus was attached to the side frames of the truck, causing them to work loose and twist and shear. This difficulty has been overcome.

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* Paper read before the Tramways and Light Railways Association on Wednesday, January 10th, Mr. Stephen Sellon in the chair. Slightly abridged.

* These curves form part of the second half of the Paper, to be published next week.

3. *Pneumatic Slipper Brake* (*Diagram No. 2*).—An interesting development in connection with slipper brakes is shown on diagram No. 2, in which the slipper blocks are depressed on to the rails by means of compressed air, thus obviating manual labour on the part of the motorman. This is now being tested on several tramways.

The brake itself consists of cylinder A carried on a bracket D attached to the truck. The piston B of the cylinder is connected by a swinging rod G to two levers E E, which have their fulcra on the bracket at *e* and *e*. The levers carry the slipper shoe H, on which is fixed a brake block of oak, beech, or other hard wood. Compressed air is supplied from either an axle or motor-driven compressor. The brake is operated by means of a valve conveniently placed on the platform at each end of the car, and there is also a gauge on each platform so that the driver can see at a glance what pressure he has available at any time. Single truck cars are equipped with two brakes per car and bogie cars with four brakes. The brakes are so constructed that the maximum pressure that can be exerted is less than the total weight of the car, so that the possibility of the car being derailed is minimised.

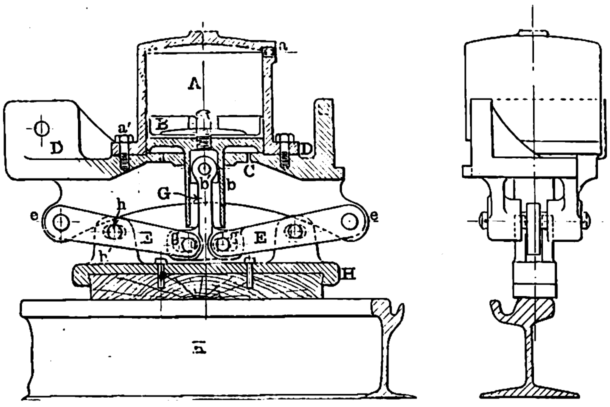

Diagram No. 2.—Arrangement of Pneumatic Slipper Brake.

4. *Air Brakes.*—Though air brakes have been very generally adopted on railways the application in connection with tramways is somewhat limited in this country, but in other countries, where high speeds are allowed and the conditions of traffic are more favourable, air brakes can be used to greater advantage. The air passes from the storage reservoirs through a reducing valve to the auxiliary reservoir from which the brakes are operated. The brakes are controlled by means of a valve conveniently placed on the platform at each end of the car, and a pressure gauge is provided to indicate to the driver the air pressure available at any time.

5. *Momentum Brake.*—The momentum is a newer form of mechanical brake, which has been adopted to some extent in America, but has not yet been used extensively on the tramway systems in this country. As its name implies, the momentum of the moving vehicle regulates the braking effect. The general arrangement of the latest form of this brake is shown on diagram No. 3, and may be briefly described as follows:—

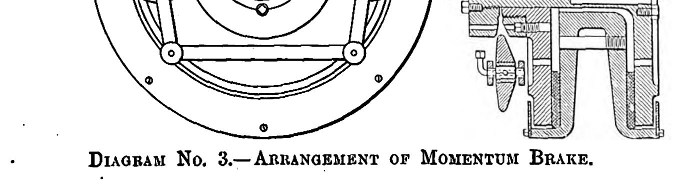

Diagram No. 3.—Arrangement of Momentum Brake.

A friction disc is formed on a sleeve keyed to the car axle, and a second friction disc sliding longitudinally with a feather key on the sleeve. A flanged drum is journaled on the sleeves between the friction discs, and on this drum is wound a chain which operates the brake levers. Circular friction surfaces of compressed wood fibre are fixed on the sides of the drum. It will be noticed from the diagram that the flanges of the drum overlap the friction discs, and cover plates are fixed thereto to enclose the discs, exclude dust, and form an oil bath for the friction surfaces. On the end of the sleeve is secured a bevel-sided collar, and the hub of the movable friction disc is similarly bevelled to form with the collar a V-shaped groove with which tapered wedge wheels mounted on levers connected with the brake rods may be engaged to force the friction discs and drum into contact. Compression springs are provided between the wedge wheels and the brake rod, ensuring an elastic action of the brake. In this brake the friction surfaces are set as far as possible from the axle, and the winding surfaces of the drum for the brake chain as near as possible to the axle; by this means not only the power of the brakes is increased, owing to the greater leverage of the friction surfaces, but the brake is steadier in action, and more responsive to small variations in the power applied to it by the motorman.

Tables and curves Nos. V.D, VI.D, VII,D, VIII.D, IX.D, give the results obtained with a momentum brake which has been fitted for trial purposes on one of the London County Council cars. These results show a great improvement over the other mechanical types of brake now in use. In a momentum brake the force of application is automatically reduced as the speed is decreased, and the ideal conditions in this respect are more nearly obtained with this, than with any other form of mechanical brake. This type of brake is very powerful and can be applied rapidly with small effort on the part of the driver; it will be seen from curve No. V.D which gives the best results of the tests made with one of these brakes, fitted to a single-truck car, that at the lower speed the retardation is quite equal to that of the other brakes tested on a bogie car, but as the speed rises it becomes rather less effective. One important point is that a momentum brake will give good results without throwing any strain on the costly electrical equipment of the car, but as it is entirely dependent on the weight of the car for its efficacy it does not have the great advantage possessed by magnetic track brakes. I may say, however, that the sample equipment which was sent to me from Canada was not suitable for a bogie car, so that the results obtained may not be quite comparable with those of the other types of brake.

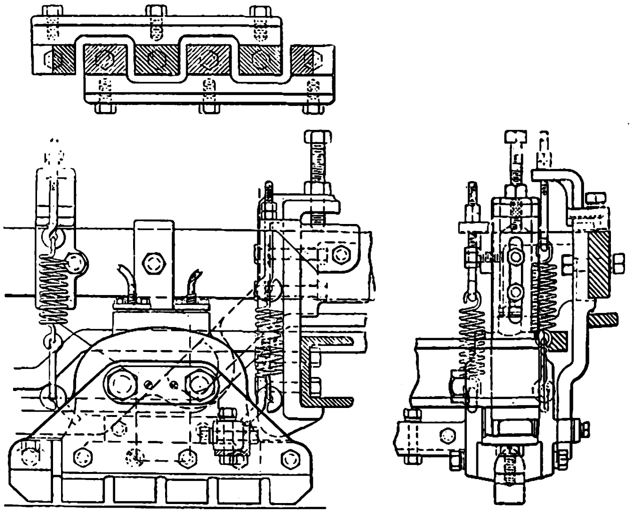

Diagram No. 4.—Magnetic Track Brake, Type A.

6. *Emergency Electric Brakes.*—For a time the so called emergency brake was used; this has proved to be the most destructive arrangement ever introduced on an electric car, that is, as far as the motors are concerned, as they were practically short-circuited when acting as generators and running at a very high speed; happily the cars were only stopped by this means in real cases of emergency.

7. *Rheostatic Brakes.*—The next development was the rheostatic brake, where, instead of short-circuiting the motors by one step, a graduated resistance was introduced and better results were obtained. This arrangement is still employed on many electric tramcars. It will be seen from the tests that the results obtained with this brake are very poor when compared with those of the electro-magnetic track brakes. See curves Nos. I.D to V.D and I.A to IV.A.

8. *Electro-Magnetic Disc Brakes.*—The electro-magnetic disc brake was then introduced; this consists of two iron discs, one of which is fixed to the motor frame and the other is keyed to the axle. A coil is embedded in the stationary disc, which is magnetised by connecting the coil, in series, with a rheostat to the motors when acting as generators By this means braking action is set up as follows:—

(1) The retardation due to the negative torque of the motors acting as generators; (2) The drag due to eddy currents set up in the revolving brake disc; (3) The mechanical friction between the revolving and the fixed discs.

The chief disadvantage with this brake is the difficulty in adjusting the discs so as to obtain a constant width of air gap; this makes the action somewhat uncertain, and motormen, when trying to make assurance doubly sure, cut out the whole resistance in circuit with the discs and suddenly short-circuit the motors when running at a high speed and the wheels are skidded. This uncertainty has been increased in many cases by want of proper attention. The uncertainty, especially at low speeds, has also induced motormen to depend on their hand brakes in cases of emergency; frequent cases have occurred where motormen have tried to stop cars with the magnetic disc brake, and finding that it will not act immediately, they have applied the hand brake and skidded the wheels. The disc brake is very slow in action for any speed under 5 miles an hour, and is therefore unsuitable as a service brake.

9. *Electromagnetic Track Brakes.*—The recent developments in electromagnetic track brakes have created a new factor for consideration in the design and equipment of tramway rolling stock, and the aim of tramway engineers and managers is to obtain an apparatus which will combine the functions of both an emergency and an ordinary service brake. There are at present two types of electromagnetic track brakes: (1) Referred to as type A, in which the track shoes act direct on the track only; (2) Referred to as type B, in which the track shoes are coupled to, and act in conjunction with, the ordinary brake shoes on the wheels.

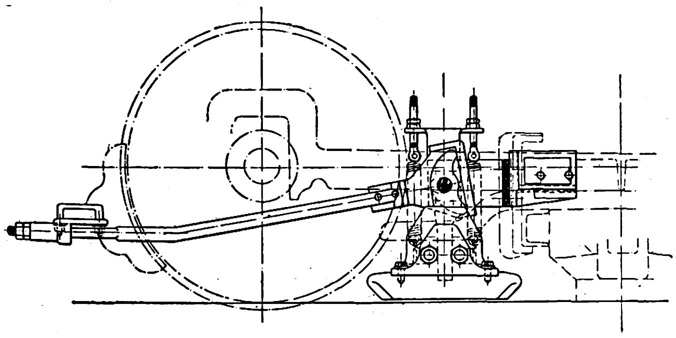

Diagram 5.—Arrangement of "B" Type Electromagnetic Track Brake.

Type A brake consists of two track shoes, designed as shown on Diagram No. 4. These are rigidly connected together by a cross-bar placed between the side frames of the truck and supported by a pair of tongue-shaped steel brackets bolted to the truck frame and arranged to take the thrust of retardation. A set of spiral springs is provided for supporting the shoes clear of the track. Each shoe is a simple form of magnet, consisting of two steel plates connected by a yoke carrying the exciting coil of the electromagnet. The lower edges of the plates are planed and fitted with wearing shoes made to gauge.

The equipment for the type B electromagnetic track brake for each truck also consists of double-track shoes of special construction. These are shown on Diagram No. 5, and are arranged in a similar manner to those of the type A brake, but with links and levers for simultaneously transmitting the downward pull and resultant drag of the magnetic track brake to lateral pressure upon the wheels through the ordinary wheel-brake blocks. A set of spiral springs is provided for supporting the shoes clear of the track.

In both brakes the exciting coils of each shoe are completely enclosed in watertight metal cases which effectively prevent any injury to the winding or insulation through moisture or mechanical abrasion. In each case the electromagnets are energised by current produced by the motors acting as generators, and are strongly attracted to the rails. In the case of type A brake, the drag resulting from the adhesion of the track shoes to the rails stops the car, whereas with the B type brake this drag also actuates the ordinary brake shoe on the wheels. Both brakes are applied by the same controller handle which is used for operating the car; consequently the motorman can apply the brake in a fraction of a second. The controller is so arranged that the retardation depends upon the position of the handle and the speed at which the car is travelling. Electromagnetic brakes may be used under all conditions, and are not dependent on the ordinary power supplied from any outside source.

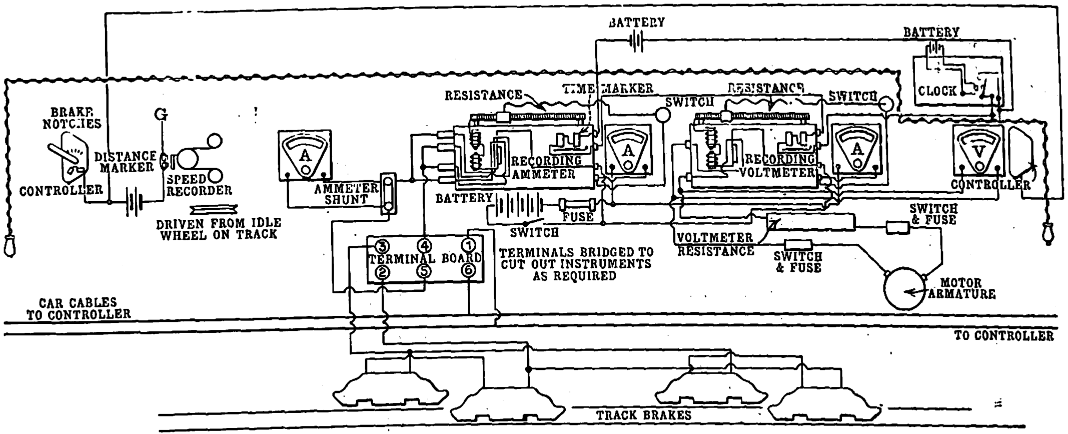

Diagram No. 6, showing Connections and Instruments on Test Car.

## Brake Tests.

Exhaustive tests have been carefully carried out under the many varied conditions which obtain in the daily working of tramways, including the surface variation of the rails caused by the diverse weather conditions. The majority of the trials were carried out after the service cars stopped running on Saturday night and before the cars had commenced running again on Sunday morning, when a clear road free from traffic could be assured. The whole of the comparative trials were, as far as possible, made on the same lengths of line. The trial car was equipped with the following delicate instruments, which were calibrated at the National Physical Laboratory: (*a*) A Boyer speed and distance recorder fitted with a dial to indicate the speed at any particular moment; (*b*) A recording voltmeter specially constructed for rolling stock tests; (*c*) A recording ammeter specially constructed for rolling stock tests; (*d*) A time relay clock, by which marks were made upon the chart of each instrument once every five seconds; (*e*) A special contact fitted to each controller by which a mark was made on the speed distance record immediately the brakes operated by the controller were applied.

*Description of Testing Instruments used in Tests.*—As the recording ammeter and the recording voltmeter are identical in design and operation, a description of one of them will suffice. The instrument consists essentially of a coil moving in a field produced by the current to be measured, against the action of a spiral steel spring. The current in the moving coil is obtained from a storage battery and is kept constant during the test at a predetermined value. The torque, therefore, exerted by the moving coil is proportioned by the current in the fixed field coil, and the deflection obtained against the spiral steel spring follows practically a straight line law, being directly proportional to current. The spiral steel spring also performs the office of a suspension for the moving parts of the instrument, rendering the use of jewels unnecessary, a very important point in an instrument designed to stand severe vibration. The pen comprises a syphon dipping into a small well, an aniline ink being used. The paper is driven by a spring, phonograph motor, the speed being very steady and adjustable within wide limits. In addition an auxiliary pen is arranged to make a definite mark on the record sheet every five seconds, being operated by a special relay clock. The recording ammeter, recording voltmeter and speed time-recorder were provided with these auxiliary pens, and the magnets operating these were connected in series so as to insure that the times of marking were identical. The current used with these scales for exciting the recording ammeter was 1·0 amperes, that for the recording voltmeter being 1·1 amperes.

The Boyer speed indicator consists of a rotary pump which should be driven from a pair of idle wheels running on the track rails, and a cylinder to which is fitted a piston operating the pencil. A slot is cut in the cylinder wall parallel to the direction of the piston; the area of this slot is increased as the piston rises. While the indicator is running, a continuous flow of oil is supplied to the cylinder from the rotary pump and escapes through the slot in the cylinder wall to a reservoir from which the pump takes its supply. As the speed increases the flow of oil is greater and the piston is pressed upwards, and the area of outlet is regulated in proportion to the speed. A paper chart is moved in direct proportion to the distance the car travels and a diagram is drawn combining the vertical movement of the piston and the horizontal movement of the paper. Calibration is secured by regulating the width of the slot in the cylinder wall and the diameter of the driven pulley. The drum driving gear is arranged to move the paper always in the same direction, irrespective of the direction of motion of the car, so as to obviate the necessity of changing the paper at the end of each run and making it possible to make a continuous record of a complete round trip. These instruments recorded simultaneously the speed, the distance, amperes, volts and time, on continuous paper charts throughout each trial stop; in addition a log book was kept for recording any special conditions. The connections are shown on Diagram No. 6.

(*To be concluded.*)

# PHASE-SHIFTED HIGH-FREQUENCY OSCILLATIONS.

BY PROF. FERDINAND BRAUN.

[Translation.]

I described in *The Electrician*, Vol. LIII., p. 19, a number of arrangements of electric oscillatory circuits (such as indicated in Figs. 10 and 11 in that article, for example), and I now propose to deal further with the subject.

The object of the arrangements explained in the previous article was to make two or more oscillatory circuits (each being supplied with electrical energy) dependent on one another in such a manner that the circuits begin to oscillate either simultaneously or successively, the time interval in the latter case being a fraction of a period. This was done by placing the spark-gaps in further oscillatory circuits which I called "coupling circuits." The simultaneous occurrence of the sparks was calculated to increase the transmitter energy, while the sole reason for trying to obtain phase-displaced sparks was because the successful solution constituted the necessary preliminary condition for the solution of a further problem—viz., to create unequally distributed electromagnetic fields around the sending station.

§ 1. The method of measuring phase-displacements was described by me in the *Physikalische Zeitschrift*, 1904, p. 194, the following being the gist of that article :—

The method is based on the production (by induction) of E.M.F.'s in the two secondary coils $s_1$ and $s_2$, coupled as "loosely" as possible, and on the measurement of a quantity proportional to the E.M.F. resulting from the two individual E.M.F.'s in the coils, $s_1$ and $s_2$ being connected in "series" in one measurement and in opposition in the other.* Both components must previously be made exactly equal. Measurements may be based either on spark-lengths or on the heating effect produced in a fine wire enclosed in a glass bulb with a liquid measuring column. If $f_1$ and $f_2$ denote the spark-gaps measured in the two cases, and $T_1$ and $T_2$ the thermometer readings observed, then (assuming the thermometer readings to be proportional to the square of the current) the phase-difference $\phi$ is given by the equation

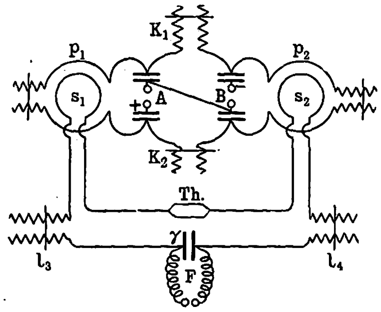

Fig. 1.

$$\tan\frac{\phi}{2}=\frac{f_2}{f_1}=\sqrt{\frac{T_2}{T_1}}.$$

Figs. 1 and 2 illustrate two cases; the oscillatory circuits, which were charged in parallel in the case illustrated in Fig. 11 in *The Electrician* article referred to above, are here connected in series as shown.

In Fig. 1 $s_1$ is excited by $p_1$ and $s_2$ by $p_2$. The "measuring" circuit is tuned by means of the condenser $\gamma$ and the self-inductions $l_3$ and $l_4$ which serve at the same time to weaken the coupling. The measurements are made either with the thermometer Th. or a spark-gap F connected in parallel with the condenser. In order to increase the length of spark-gap, the leads must not be made too short: the spark-length is a maximum when the leads are nearly one-quarter of the wave in length. It is also well to make the arrangement as symmetrical as possible in respect to the measuring instrument, since (as can be shown by taking measurements with the thermometer Th. in various positions) the current is not necessarily the same at all points. Due consideration must be given to the disturbing induction effects from other parts of the current circuit. Disturbances are also often caused by change-over switches, even if small and of paraffin. These influences must be borne in mind when testing the effects on $s_1$ and $s_2$ as to equality, and when verifying that the points of resonance remain the same in all three cases (*i.e.*, $s_1$ alone, $s_2$ alone and $s_1 \pm s_2$). It is better to replace the thermometer by a more sensitive instrument.

The same remarks apply even more forcibly to the arrangement of Fig. 2. We have here nearly half a wave length in the secondary circuit. It is quite possible to work without a condenser in the secondary circuit, but a small condenser $\gamma$ is advisable, as the whole then becomes less sensitive to undefined changes in capacity.

In spite of the difficulties mentioned, the method can supply qualitative indications at any rate, and, by restricting oneself to the solution of suitable problems, even good results are obtained. I have found, for instance, that quite a number of results obtained by these methods with high-frequency oscillations (above $10^6$) were verified in connection with oscillations of lower frequency (about $10^4$), which were investigated by means of the cathode-ray tube. The arrangements illustrated in the previous article in the *The Electrician* had the object of increasing the transmitting energy of wireless telegraph systems. They related to the case in which there was no phase displacement. Experiments with such a system containing four condensers (see Fig. 14 of the *Electrician* article), gave the following results: Two coils of the system to be tested were used for inducing currents in two coils, $s_1$ and $s_2$. For $s_1$ and $s_2$ connected in series $(s_1+s_2)$ it was found: Spark 3·6 mm. long, thick and bright; the thermometer read 170 scale divisions. For $s_1$ and $s_2$ in opposition $(s_1-s_2)$: A weak spark about 0·1 mm. long; the thermometer read barely one division.

The absence of a phase-displacement is just as readily observed if the "coupling-arcs" $K_1$ and $K_2$ are devoid of self-induction (Fig. 1). When $s_1$ and $s_2$ are connected in series there appears a lively and noisy spark some 2 mm. long; when the coils are in opposition the spark which occurs is barely visible. But it *never* happens that a bright spark occurs in between—indicating the absolutely certain manner in which the sparks, generally so capricious, are made dependent on one another. This capricious and uncertain behaviour becomes noticeable at once, however, if a "coupling-arc" is removed.

I may add that the method has proved very satisfactory provided the precautions above mentioned are strictly observed. It is necessary to use a sensitive bolometer or thermo-couple, and it is best to have the bolometer wire or the thermo-couple in a very high vacuum. Undesirable induction effects are excluded (1) by employing as self-induction solenoids which are closed within themselves as far as possible, or else suitably wound and placed side by side; (2) by making those parts of $p_1$ and $s_1$ (Fig. 1) which transmit energy to the bolometer circuit small and arranging them near together; and (3) by arranging the bolometer connections and leads in such a manner as to exclude external induction as far as possible.

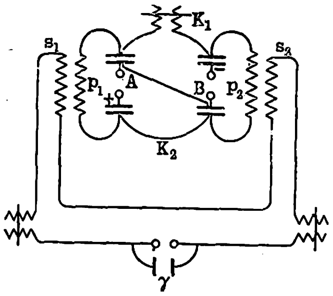

Fig. 2.

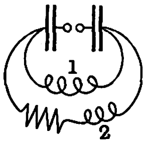

Fig. 3.

§ 2. *Phase Displacement by Ohmic Resistance.*—In the arrangement of Fig. 3, the condenser discharges through the two branches 1 and 2. If the ohmic resistances of the two circuits differ, the currents $i_1$ and $i_2$ have, as a rule, the same frequency but are displaced in phase. The conditions are then similar to those in ordinary alternating-current practice, with the following exception: In the case of ordinary alternating currents a certain frequency is impressed upon the system, while in our case the frequency is a function of the constants of the circuit. In the former case, large self-inductions are required to render the inductive resistance larger than the ohmic resistance, and the ohmic resistance inevitably attached to large self-inductions makes it impossible for the phase difference between voltage and current ever to reach 90 deg. In our case, owing to the high frequency, it is the self-induction which governs the phenomenon and causes, in a single circuit, a phase displacement which does not practically differ from 90 deg. To produce considerable phase-displacements in branched circuits it is thus necessary to introduce considerable resistances. It was found possible to obtain phase-displacements of about 60 deg. in this way, the frequencies being of the order $10^6$ to $5\times10^6$ cycles per second. But the large amount of valuable energy absorbed by the ohmic resistance renders this method useless for practical purposes, except, perhaps, occasionally or for measuring purposes. Of course, it is also possible to obtain a phase-displacement by introducing a capacity in *one* branch of the circuit (as is done in ordinary alternating-current practice).

§ 3. *Phase-displacement by Resonance.*—In the case of acoustic resonance, as is well known, phase-differences occur between the acting force (of a frequency $n$) and the amplitude of the forced oscillation. This phase-difference lies between 0 and $\pi/2$ if the natural frequency ($n_0$) is higher than the frequency of the acting force; it assumes the value $\pi/2$ when the two frequencies concerned are equal, and ranges between $\pi/2$ and $\pi$ if $n_0$ is smaller than $n$. For an electric oscillatory circuit having a self-induction $p$, a capacity $c$ and an ohmic resistance $r$, we have

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* A special case has been dealt with in an article by the author in *Annalen der Physik*, 1902.

$$\frac{d^2 i_1}{dt^2} + \frac{r}{p}\frac{di_1}{dt} + \frac{i_1}{pc} = \frac{1}{p}\frac{de}{dt},$$

in which $e$ denotes the E.M.F. acting in the circuit. If $e$ is of the form $e = e_0 \sin nt$, we obtain the angle $\phi$ (*i.e.*, the angle by which the current lags behind the E.M.F.) from the equation

$$\tan\phi = \frac{1}{crn} - \frac{pn}{r}.$$

From this it is seen that there is no phase-difference if $n^2 = \frac{1}{cp} = n_0^2$. This is the condition for resonance. If the E.M.F. $e$ be produced by induction from a second circuit with a periodic current $i_2$ and if, further, the coefficient of mutual induction be $\rho$, the E.M.F. $e$ is of the value $\rho\frac{di_2}{dt}$. But $\frac{di_2}{dt}$ and $i_2$ differ in phase by 90 deg.; hence, $i_1$ and $i_2$ should also differ in phase by 90 deg.

These qualitative considerations regarding the production of high-frequency phase-displaced oscillations by resonance effects were already described in the German patent No. 152,300 of August 1, 1903, and their correctness would appear to be confirmed by tests. Two identical circuits containing capacity were inductively coupled in such a manner that only 12 per cent. of the self-induction contained in each circuit was utilised as mutual induction, this 12 per cent. being only loosely coupled by placing the coils at a suitable distance. Nevertheless, 30 per cent. of the energy in the first circuit was transmitted to the second circuit. The phase-displacement was calculated from a thermometric measurement to be about 72 deg.

Actually, however, the conditions are more complex. It is well known that if two identical circuits (having a natural frequency $n_0$) be coupled, there appear in each circuit two oscillations of the frequencies $n_1$ and $n_2$ respectively ($n_1 < n_0 < n_2$). A closer mathematical investigation, carried out for me by Dr. Papalexi, goes to show that these two separate oscillations become phase-displaced if the conditions of damping differ in both circuits (which can also arise from radiation) and that the phase-displacement between the two separate oscillations is constant.

On the other hand, the movement resulting from the superposition of the oscillations $n_1$ and $n_2$ may be regarded as *one* oscillation, having a frequency $(n_1 + n_2)/2$ and a phase which changes with the time.

Its form (in the exciting circuit) is given by

$$i_1 = A_1 \sin\left(\frac{n_1 + n_2}{2} t + \epsilon_1\right),$$

no account being taken of the damping.

In the excited circuit (whose conditions at the commencement of the phenomenon are different) it is of the form

$$i_2 = A_2 \sin\left(\frac{n_1 + n_2}{2} t + \epsilon_2\right).$$

And

$$\tan\epsilon_1 = \frac{n_1 - n_2}{n_1 + n_2} \tan\left(\frac{n_1 - n_2}{2} t\right)$$

$$\tan\epsilon_2 = \frac{n_1 + n_2}{n_1 - n_2} \tan\left(\frac{n_1 - n_2}{2} t\right).$$

The determining phase-difference is $\epsilon_2 - \epsilon_1$; $t$ is the time measured from the moment of excitation, and includes, practically speaking, only a comparatively small number of oscillations. For this reason the effect produced is that of a nearly constant phase-difference, and this is especially the case for small values of $n_1 - n_2$ (*i.e.*, a loose coupling). The values obtained with the aid of integrating measuring instruments appear to confirm this view. For $n_1 - n_2 = 0$ the phase-difference assumes the constant value $\pi/2$.

I obtained a direct proof of this contention by means of the cathode-ray tube. Since this tube seems to be little known in England it might be well to add here a few remarks concerning it.*

Fig. 4 indicates the approximate form and size of the tube. The method is based on the deflection of cathode rays by magnetic means (and, if desired, electrostatic means). K denotes the aluminium cathode, A is the anode, C is a diaphragm of aluminium or glass with a centre hole of about 2 mm. diameter, and D is a screen of mica or glass (the latter material is better for photographic purposes) provided with a coat of phosphorescent paint. In order to obtain a smaller speck of light, a second diaphragm may be provided, this diaphragm being placed some 20 cm. in front of C. The back of the cathode K is embedded in glass. The cathode ray deflects under the action of the earth's magnetism, but is given the desired direction by a small magnet placed near the tube. In order to deflect the cathode ray by the current under investigation, I provide a small coil (called "indicator" coil) which is placed near to the diaphragm, and whose axis is at right angles to the tube axis. Since the lines of force from this coil are divergent, thus leading to a distortion of the cylindrical flux of cathode rays (and to a speck of light more or less elliptical in shape), it is of advantage to employ two coils, one on the right-hand side and the other on the left-side of the tube. A more homogeneous magnetic field is secured in this way. Such tubes are supplied by Franz Müller (the successor of Dr. Geissler). They do not all turn out equally good. The dimensions given in Fig. 4 refer to one of my first tubes. Since that time the dimensions as also the form of the anode, &c., have undergone changes in a number of ways. When the oscillations are rapid and of a high voltage, the tube is surrounded near the diaphragm by moistened filter paper (or provided with a layer of glycerine) so as to prevent electrostatic effects which may otherwise become very troublesome.

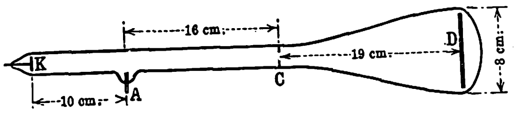

FIG. 4.

Fig. 5 shows the arrangement for carrying out a test. The condenser in the primary circuit (I) discharges itself through the self-induction $p_1$ and an "indicator coil" $J_1$ in parallel. This coil is wound with fine wire, and its ohmic resistance is 20 times that of the self-induction coil; $p_1$ is loosely coupled with $p_2$, which is identical with $p_1$. $J_2$ is identical with $J_1$, being connected in parallel with $p_2$ as shown. The capacities of both circuits are also nearly equal. Each circuit contains two groups of three jars, each jar having a capacity 3,000 cm. I estimate the frequency to range from 6,000 to 10,000 complete oscillations per second. Another arrangement, in which $p_1$ and $J_1$ were connected in series, appeared to give the same results generally, but the respective tests could not be carried out in an entirely satisfactory manner with the coils at my disposal. Electrostatic deflection of the cathode ray led to excessive disturbances in the tube, so that I had to fall back on the arrangement of Fig. 4.

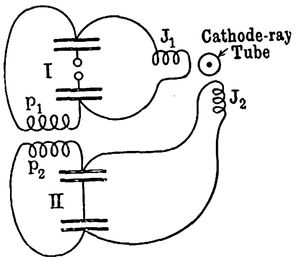

FIG. 5.

One observes quite plainly on the screen a system of ellipses which undergo transformation from one to another. I have sketched from observation, as well as I could, a few characteristic pieces of the curves (Figs. 6A to 6C). Of course, none of sketches lay claim to great accuracy, but they indicate, at least, the character of the picture where it is clearly observed. The explanation of the figure is as follows: When the discharge in circuit I takes place, the high and steep curve, commencing at O (Fig. 6B) is traced. This point O is the point where the undeflected cathode ray meets the diaphragm. But the energy of the primary circuit diminishes while that of the secondary circuit increases, and it is clearly observed how the latter (which is damped to a smaller extent than the primary circuit because it contains no spark-gap) finally oscillates practically alone. At the end there remains only a small horizontal line. In Fig. 6B the arrow indicates the direction of movement of the cathode ray. The figures have been sketched without any prejudice whatever. For comparison, a number of ellipses have been drawn (Fig. 7) on the following basis: The ellipses shown are the resultants of two oscillations which act at right angles and are displaced in phase by a constant angle ($\phi$) of 60 deg. It has been assumed, furthermore, that the amplitudes A and B of the respective oscillations are in the ratio 4:1. The amplitude A assumes successively the constantly decreasing values $A_1$, $A_2$ . . . ., while the amplitudes B of the other oscillation grow successively to $B_1$, $B_2$ . . . In constructing the ellipses, the further and arbitary assumption has been made that the ratio of $A_1/A_2 = B_2/B_1 = 4/3$. The resemblance of the observed ellipses with those constructed on the above assumptions is unmistakable. If it were possible to procure as large a phase displacement as 90 deg. or thereabout, one might think of producing rotating magnetic fields with the aid of which currents of any phase desired might be obtained.

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* See F. Braun, *Wiedemann's Annalen*, 60, p. 552, 1897.

§ 4. *Linked Oscillatory Circuits.*—The combination to be presently described may be called "interlinked," or, briefly, "linked" oscillatory circuits. Such an arrangement is shown in Fig. 8, which is reproduced from the previous article in *The Electrician*; $W_1$ and $W_2$ are large inductive or non-inductive resistances sufficiently small to allow the condensers connected to them to be charged to the same potential, yet large enough to prevent any current worth mentioning passing through them when the discharge takes place. Assuming a spark to jump across the spark-gap $A_1$ $B_1$, but not yet across $A_2$ $B_2$, then two oscillations take place at the same time. One is in the circuit I (with $p_1$), and the other occurs in the "coupling arc" $K_1$, the coil $p_2$, and the coupling-arc $K_2$. This second oscillation may be termed "coupling oscillation." The potential difference between the knobs $A_2$ and $B_2$ increases in consequence, so that, after a time, the second spark-gap also breaks down. Circuit II is now closed, and there are at least three different oscillations in the system. The conditions change from the moment the second circuit closes, and the capacities and self-inductions of circuit II must now be regarded as being in parallel with respect to the "coupling oscillation." Fig. 8 is an arrangement for charging in parallel; arrangements for charging in series are indicated in Figs. 1 and 2. The metallic connection AB will be referred to as a "connecting arc."

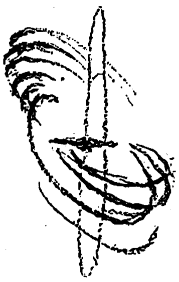
Fig. 6A.

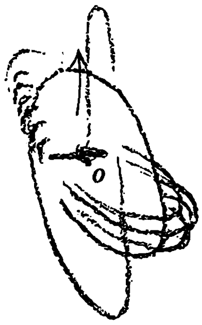

Fig. 6B.

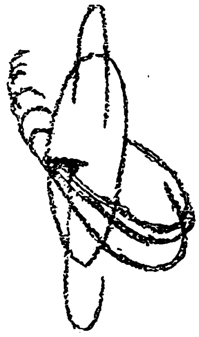
Fig. 6C.

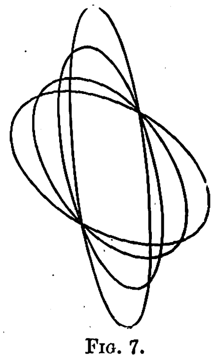
Fig. 7.

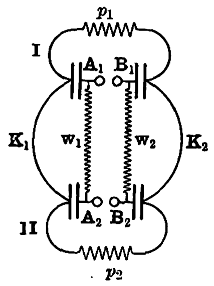

Fig. 8.

By choosing a suitable "coupling oscillation" it is possible to determine at will the rise of potential at the secondary spark-gap with the time, and thus the difference in time between the commencement of the first and second identical oscillations. In order to ensure reliable operation, the spark-gaps are fixed so near together that the ultra-violet light neutralises the spark retardation. The illumination from a separate source or by radium rays is of advantage. This influence is of special value when adjusting for phase-differences. If the adjustments are made for equality of phase, the sparks start absolutely simultaneously, especially if the connections of Figs 1 and 2 are used.

I shall first describe the results of the combination for the latter case, which can be investigated experimentally with certainty. The following are the results of measurements with high-frequency oscillations ($n = 5 \times 10^6$) and a tuned condenser circuit. These results were verified by experiments (carried out with the cathode tube) with oscillations of lower frequency ($n = 9 \times 10^3$). The arrangement in the latter case is shown in Fig. 9. $J_1$ and $J_2$ are the self-inductions of the circuit I. and II., and serve as "indicator" coils at the same time. Adjustable self-induction may be inserted in the "coupling" and "connecting" arcs. Measurements with frequencies of the order $5 \times 10^6$ gave the following results:—

(*a*) If two "linked" circuits contain equal capacity and self-induction, the oscillations are the same in both circuits. I have not been able to detect a difference between this oscillation and the "free" oscillation of the uncoupled circuit.

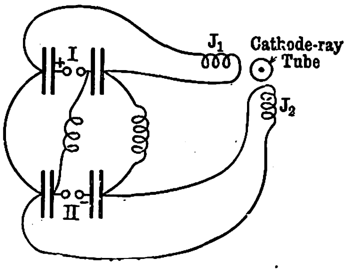

Fig. 9.

(*b*) If only the self-induction in one of the "linked" circuits is increased, so that the circuits become unequal, then the oscillations are, nevertheless, of the same value in both circuits, although this value is not, of course, the same as before. But the current in the circuit possessing more self-induction has grown smaller, and it is probable that the currents are divided inversely as the self-inductions (or the apparent resistances).

(*c*) If ohmic resistance be introduced in one of the "linked" circuits the damping changes in both circuits. Quite generally, energy abstracted from one circuit is at once supplied by the other.

(*d*) If self-induction be introduced into the "connecting arc" (assuming the coupling arcs to be without self-induction) no appreciable phase-displacement occurs, but one of the sparks becomes dim.

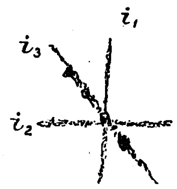

Fig. 10.

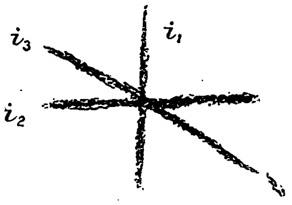

Fig. 11.

The observations with the cathode-ray tube lead to the following results:—

(*a*) First of all we separate the two circuits I. and II. completely and excite each separately in succession; circuit I. then gives a horizontal line of light, while circuit II. alone gives a vertical line of light.

(*b*) We now provide the "connecting arcs," but leave out the "coupling arcs," and charge the circuits in series. The two lines $i_1$ and $i_2$ (Fig. 10) are now observed on the screen, and it is seen that the two circuits do not commence to oscillate at the same time. The sparks occur with a considerable time interval. The foregoing is what generally takes place, especially if the spark-gaps are at a distance from each other. If they are near ellipses occur occasionally—*i.e.*, the time-interval has diminished and has become comparable with the period of oscillation of the circuit.

(*c*) We now connect up the coupling arcs and observe on the screen always only one straight oblique line, $i_3$—*i.e.*, the oscillations set in simultaneously with the greatest regularity.

(*d*) We add self-induction in circuit I.; the figure on the screen remains a straight line but rotates as indicated in Fig. 11—*i.e.*, both oscillations are of the same frequency, both are damped to the same extent, but the current has dimished in the circuit with the larger self-induction.

(*e*) We now add also ohmic resistance in the one circuit. The figure on the screen, and notably the inclination of the straight line, remain as before —*i.e.*, the damping is the same in both circuits but has an increased value.

(*f*) This is best seen by removing one "indicator" coil and investigating the oscillations of one circuit only. With no resistance we obtain Fig. 12 and with resistance Fig. 13. In the first case we obtain more points of reversal than in the second case (on the determination of the damping with the aid of the points of reversal, see Zenneck, *Annalen der Physik*, 7, p. 801, 1902). The amplitude at starting does not show any unmistakable change, but the damping has increased.

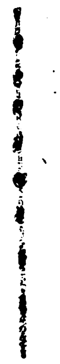

FIG. 12.—WITHOUT RESISTANCE.

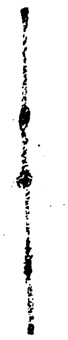

FIG. 13.—WITH RESISTANCE.

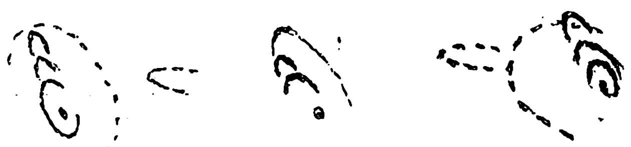

FIG. 14A.—RATIO OF AMPLITUDES 1 : 1.

(*g*) The foregoing is only true, however, so long as the value of the ohmic resistance is not great compared with the apparent resistance; if we increase the ohmic resistance very much, then the original distribution of current changes, and a phase-displacement appears at the same time (as could be expected from paragraph 2). So far, therefore, the circuits (each of which discharges through a spark-gap) behave in respect to duration of oscillation, current distribution and damping through metallic or electrolytic resistance, like *one* circuit with *one* spark-gap and divided, "closing arc." How they behave with regard to the spark-damping has not yet been investigated.

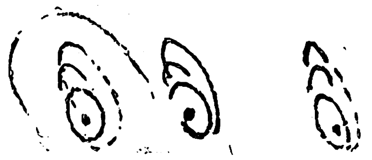

FIG. 14B.—OTHER RATIOS OF AMPLITUDES BY CHANGING THE DISTANCE BETWEEN THE DEFLECTING COILS.

(*i*) We now insert self-induction in a coupling arc, and there appears a series of figures of the kind indicated in Figs. 14A, 14B and 14C. These figures change with the magnitude of the self-induction introduced in the coupling arc, with the ratio of the amplitudes and with the position. The reason why Fig. 14C, for instance, differs from Figs. 14A and 14B is because the self-induction of the coupling arc has been altered.

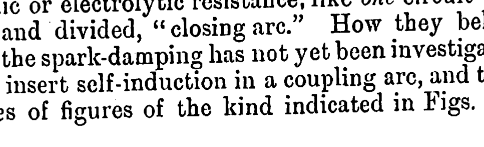

FIG. 14C.

It is hardly possible to give a detailed explanation of these figures, which frequently repeat themselves for long stretches of time in almost identical form, but suddenly change (sometimes to very complicated figures), these changes being indicated at once by the altered appearance of the spark. In addition, the cathode-ray tube also flashes up occasionally. Much depends on the quality of this cathode-ray tube. One tube, which was selected from a number of others, produced by far the best figures. Such sudden irregularities, it may be mentioned, were also observed in the experiments of paragraph 3) in which there was only *one* spark-gap.

## SOME EXPERIENCES WITH LIGHTNING PROTECTIVE APPARATUS.*

BY JULIAN C. SMITH.

This Paper will deal with some experiences with lightning protective apparatus which the operating department of the Shawinigan Water & Power Co. has had during the years 1903, 1904, and 1905. The generating station at Shawinigan Falls has three generators, each of 3,750 kw. capacity, 2,200 volt 30-cycle two-phase, and one generator of 6,600 kw. capacity, 2,200 volt 30-cycle two-phase. Each of these generators is direct-connected to a water-wheel operating under a head of 130 ft.

Referring now only to the long-distance lines, it is sufficient to note that the energy is delivered through a double set of 'bus bars to the low-tension side of the step-up transformers. These transformers are T-connected for transforming from two-phase to three-phase. The ratio of voltage transformation is 2,200 : 50,000. The neutral point of these transformer banks is grounded, giving about 29,000 volts between each wire and earth. In 1903 only the No. 1 Montreal line was operating. This line connected the generating station at Shawinigan Falls with the Montreal terminal station, situated just outside the city of Montreal. The distance from the generating station to the terminal station is 85 miles. The transmission line consists of three seven-strand aluminium cables each of 185,000 circular mils cross-sectional area, spaced 60 in. apart and arranged in the form of an equilateral triangle with the apex upward. These cables are supported on 35 ft. poles, with cross-arms 6 ft. long fastened with through bolts. The top of every pole is bored to receive a pin. All pins are 18 in. long, and were boiled in stearine. The voltage at Shawinigan is normally about 50,000; at the Montreal terminal station it is 44,000 volts.

In the spring of 1904, a sub-station was built in Joliette, distant about 45 miles from the generating station, and from this sub-station a branch line was built to the city of Sorel. This line is about 20 miles long and is operated at 12,500 volts. The only special point of interest is a submarine cable about 5,000 ft. long by means of which the line crosses the St. Lawrence River. In the Montreal terminal station the voltage is reduced to 2,400 and supplied to a set of 30-cycle 'bus bars. From these 'bus bars the frequency-changes are operated. Each frequency-changer consists of a 30-cycle synchronous motor connected to a 60-cycle generator. There are at present installed in this station five of these motor-generators each of 1,000 kw. capacity and one of 5,000 kw. capacity. In addition to these machines there are two synchronous converters, each of 1,000 kw. capacity, operating street railway circuits. It is interesting to note that the whole load of the long-distance line consists of synchronous apparatus, and that by properly regulating the fields of this apparatus the power factor can be kept at unity.

In the fall of 1904 the No. 2 Montreal line was completed. The No. 2 line is parallel to the No. 1 line for nearly the entire distance, and in most places is not more than 100 ft. distant. The second line is similar to the first except for the size of the conductor and for the fact that a ground wire is strung along the line at the neutral point of the triangle. This ground wire is connected to the earth at each pole by a wire running down the pole. When the No. 1 line was put into service the lightning apparatus installed was as follows: At each end of the line was a bank of Westinghouse lightning arresters of the low-equivalent type and a bank of static interrupters. The number of gaps in these arresters was decided upon only after a series of tests had been made to determine the lowest practicable break-down voltage. These arresters were set to discharge at about 65,000 volts. In 1904 a bank of General Electric arresters was placed on the 50,000-volt line in the Joliette sub-station. This bank was also adjusted to discharge at about 65,000 volts. In 1904 three banks of horn arresters were put on the No. 1 Montreal line. These arresters consist of bent copper rods. The horns were spaced 6·25 in. apart at the gap, this distance corresponding to a break-down voltage of 90,000. In 1905, when the No. 2 line was equipped with lightning arresters, three banks of low-equivalent arresters were put in, one at each end and one at Joliette. In addition to these arresters three banks of the 1905 type of horn arresters were put in. Some changes were made in the setting of these arresters as will be noted farther on.

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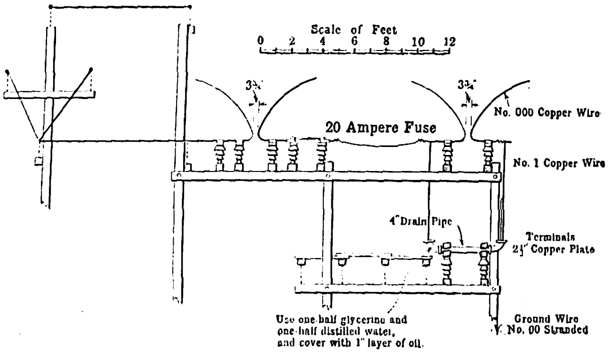
* Paper read before the American Institute of Electrical Engineers.

The Montreal lines run in a general south-westerly direction, parallel to the St. Lawrence river and about 20 miles distant from it. The elevation of the power house is about 200 ft. above sea-level, that of the sub-station being nearly the same. Some 10 miles farther north, and parallel to the transmission lines, the Laurentian mountains bound the north side of the St. Lawrence Valley. In general, the country over which the lines pass is a flat farmland, but near the power station the country is very rough. The prevailing winds are westerly, and the general course of the electrical storms is parallel to the lines. The storm period extends from March to October. Nearly all the storms occur during the latter part of June and in July, August and early in September. The storms are most severe during July and August. In the territory covered by the lines of the Shawinigan company there occurs during each year about 15 thunderstorms. As these storms move along in an easterly direction and sometimes take days to cover the 100 miles, we have found that from June 25th to September 10th a storm is reported nearly every day from some part of the line. In general, however, there are not more than four or five severe storms during each year, and these storms are most severe in well-defined localities. The discussion of our experiences with lightning will be simplified if these experiences during 1903, 1904 and 1905 are considered separately, year by year.

As stated above, the only line in operation in 1903 was the No. 1 Montreal line. That line was protected by low-equivalent arresters at each end. During the summer of 1903, several disturbances occurred, which may be summarised as follows: (1) Poles splintered by heavy discharges. (2) In a few instances, insulators broken. (3) Flashes across the static-interrupter terminals. (4) Arcs on the transformer terminals. (5) Arcs inside the transformer cases at the top between adjacent leads. (6) Damage to apparatus caused by (3), (4) and (5). (7) Interruption to service, due usually to excessive voltage-drop, causing synchronous apparatus to fall out of step.

1. On several occasions poles were splintered. In most cases two or three poles were torn to pieces; the adjacent poles on both sides were less damaged, the damage decreasing as the distance increased from the point of disturbance. One of the worst cases recorded by us shows that five poles were torn to pieces, while 10 poles on each side were somewhat splintered. This disturbance extended over a distance represented by 25 poles, or about 2,500 ft. This case, however, is exceptional, usually not more than one pole is badly damaged, and a few of the near-by poles slightly splintered.



Horn Lightning Arrester and Resistance. Type 1905.

2. In only one or two instances were insulators broken; in each instance it was the top insulator. In these cases the breakage seemed due to the flashing over and consequent heating, as the insulator was not in any case punctured. In no case was an insulator so badly damaged as to need immediate replacing.

3. At the same time that the poles were splintered on the line, there would be evidences of excessive potential in the stations. The most frequent occurrence was an arcing over on the terminals of the static interrupters. In some cases this flash would reach across to an adjacent static interrupter and establish a short-circuit between the lines. In most cases, however, it was simply a flashing from the ends of the terminal to the case, or between the incoming and outgoing wires of a single static interrupter, thereby short-circuiting the reactance coil.

4. The arcs on the transformer terminals were more rare, only occurring when the static-interrupters were put out of service by the flashing over mentioned above.

In view of the above disturbances and damage it was decided to put in a type of horn lightning arrester affording a low resistance path to ground, to depend on a fuse for the interruption of the short circuit which would occur if the horns did not break the arc, and to set these horns so that only the heavier discharges would break them down. The horns were consequently adjusted to discharge at about 90,000 volts.

At the end of 1903, it was determined that the arresters installed were sufficient to meet the conditions caused by ordinary storms. They protected the line from abnormal rises of potential due to switching or short circuits; but in those cases when the lightning-stroke damaged poles on the line the rise of potential was so high and took place so rapidly that the arresters could not carry enough current to keep the potential of the line within safe limits. The horns installed were especially designed to meet only the conditions which were not met by the standard arresters.

In 1904 there were more than the usual number of storms. On the following dates the horns discharged:—

| Date. | Shawinigan. | Joliette. | Montreal. |
|---|---|---|---|
| July 11 | 3 horns | 1 horn | None |
| Aug. 5 | 2 " | 3 horns | " |
| Sept. 20 | 2 " | 2 " | " |

One or two storms did not cause any disturbance.

The storm of July 11th was central near the power station, and one pole about 5 miles distant was splintered. The Joliette horns discharged about an hour before the discharges took place at Shawinigan. On August 5th, the storm was central at Joliette. Both the horn arresters and the standard arresters discharged violently, the horns at Shawinigan discharging at the same time. There was evidently a rise of potential in the Joliette station, as one of the glass windows through which the wire enters the building was cracked, due to the flashing over which must have occurred. At the same time that this disturbance occurred in the station, some 25 poles about 5 miles away were splintered, a few of them very badly. No disturbance other than the discharge of the arresters occurred in the other stations. The service was not interrupted, a rather severe blow being felt, lasting only about a second.

On September 20th the storm was central about midway between Shawinigan and Joliette. Fifteen poles were struck. No excessive potentials were noticed in the stations, nor was the service interrupted. During 1905, the number of storms was less than usual, but there were two very violent storms, both near Shawinigan. Poles on the No. 1 line were damaged. At various times during the summer the horns of both lines discharged, but it is noteworthy that the horns of the two lines did not discharge at the same time—that is, the two lines only about 100 ft. apart would not be equally affected by lightning discharges.

The horn arresters on the No. 2 line were designed to take less current than those on the No. 1, as a resistance consisting of a mixture of glycerine and water was put in the ground connection; in parallel with this resistance was a horn gap. During the first storms it was noticed that the resistance had "an equivalent spark-gap" greater than the horn, although the resistance was about 10,000 ohms and the gap about 3 in. The resistance was greatly decreased early in the summer by pushing the terminals closer together and the gap was slightly increased. After this was done the lightning discharge went through the resistance. Another factor came into play in 1905. The two long-distance lines are operated in parallel on the low-tension sides at both ends. As stated previously, the neutral point of the transformer banks is grounded at Shawinigan. A series transformer was placed in the ground wire leading from each bank of transformers, and an overload relay connected to this series transformer, so that if any considerable amount of current flowed into the neutral the relay would open the low-tension side of all of the transformers connected to that line. The operators in the Montreal terminal station were depended upon to separate the two lines in cases of trouble. By this means a ground or heavy disturbance on one line would cut that line out of service. Our experience during the past year shows that this scheme works satisfactorily. To some extent, however, it masks the action of the lightning arresters, as in case of heavy discharges over the horns the relay would cut off the line.

Summing up our experience with reference to the horns, I would say that we consider them a valuable addition to the standard equipment. Since the installation of the horn arresters we have had no arcs in our station. No damage has been caused to our apparatus. No interruptions to our service have been caused directly by lightning. On the other hand, each time the horns discharged a more or less severe short-circuit occurred, in no case, however, being severe enough to cause trouble or to cause our synchronous apparatus to fall out of step.

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Electricity as Applied to Mining." By Arnold Lupton, G. D. Aspinall Parr and Herbert Perkin. 2nd edition. (London: Crosby Lockwood & Son.) 12s. net.

"Handbuch der Physik." Edited by Dr. A. Winkelmann. 2nd edition. Vol. III., first half; Vol. VI., second half. (Leipzig: Ambrosius Barth.) 16m. and 30m.

"Einführung in die Thermodynamik auf energetischer Grundlage." By Dr. Julius Meyer. (Halle-a-S: Wilhelm Knapp.) 8m.

"Les Télégraphes en Europe." By Emile Guarini. (Paris: Mme. Vve. Dunod.) 5fr.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

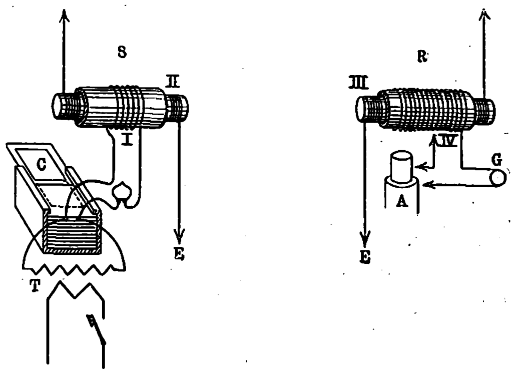
*Constitution of the Electron.*—W. Kaufmann has repeated his measurements of the mass of the electron at various speeds with greatly increased accuracy, in order to decide, if possible, between the rival theories of Abraham, Lorentz and Bucherer with regard to the structure of the electron. As a source of electrons he used radium, and instead of an electromagnet he used two highly aged permanent magnets. He photographed the magnetic and electric deflection curves on films cast on plate-glass, and compared them with the curves demanded by the three theories. The final result is stated as follows. The value of *e/m* for infinite slowness, as derived from cathode-ray experiments, is $1{\cdot}885 \times 10^7$. The curves of deflection of the $\beta$-rays of radium, interpreted according to the theories of Abraham, Lorentz and Bucherer respectively, give 1·823, 1·660 and $1{\cdot}808 \times 10^7$ for the same ratio. The theory of Lorentz, according to which the electron in motion is reduced in the direction of motion, but not laterally, is, therefore, least probable. The experiments do not, however, decide between the the theory of M. Abraham, who assumes an absolutely rigid electron, and that of Bucherer, who assumes that the electron in motion becomes a Heaviside ellipsoid with unchanged volume, and thus incompressible. But so far, the figures support Abraham's theory.

[W. Kaufmann, *Sitzungsberichte der Akademie*, Berlin, Nov. 16, 1905.]

*Ionisation in Gases from Coloured Flames.*—The velocity of the ions in gases from a colourless bunsen flame was measured in 1898 by McClelland. His results showed specific ionic velocities of from 0·53 cm. to 0·09 cm. per second per volt-centimetre in regions having temperatures ranging from 230°C. to 105°C. P. Lewis has now determined similar velocities in flames coloured with metallic salts. He finds that the rate of discharge of an electroscope brought near a bunsen flame is reduced when a salt of any alkali metal is introduced into the flame. As the conductivity of the flame itself is greatly increased under such conditions, it seemed probable that the reduced conductivity of the hot gases could not be due to diminished ionisation, but either to a much greater rate of recombination or to greatly-reduced velocity of the ions. The experiments showed that the rate of recombination of the ions from the coloured flame as well as their velocity is much less than that of the ions from the colourless flame, and tend to confirm the views of J. J. Thomson and H. A. Wilson that the great conductivity of coloured flames is principally due to the incandescent electrodes, particularly the cathode. It is stated by Wilson than an earthed strip of incandescent platinum between electrodes just outside the flame greatly increased the conductivity. It was found, however, that the introduction of incandescent platinum or carbon in the flame produced no noticeable increase in the conductivity of the flame gases. These experiments are not wholly free from contradictory features. As we do not know that ionisation within the flame and that just outside of it are strictly the same in character and proportional to each other, they do not determine whether the ionisation within the flame is a volume or surface effect; but the most consistent interpretation seems to be that there is a volume ionisation in coloured flames somewhat, though not greatly, in excess of that in uncoloured flames; that the part of the ionisation due to the salt solution varies with the concentration of the solution in a proportion lying between the fourth root and the square root of the concentration; and that the conductivity of the flame is greatly increased by the insertion of the electrodes into the flame.

[P. Lewis, *Physical Review*, December, 1905.]

*Resonance in Wireless Telegraphy.*—G. W. Pierce deals with the resonance conditions in wireless telegraph circuits of the electromagnetically connected type. A sketch of this type is shown in the diagram, where S is the sender and R the receiver, the two being 187 metres apart. With a source of waves of constant wave-length and approximately constant intensity, variations were made at the receiving station, and the effects of the variations were studied by means of the deflections obtained in a high frequency dynamometer. The variables at the receiving station were the height of antenna, the coefficient of coupling $\tau$, the capacity of the air condenser A, and the deflections. When the antenna is long the deflections are roughly proportional to $\tau^2$. When the height of the antenna is diminished the ratio of the deflections varies in a complex manner, on account of the occurrence of a maximum and a minimum at different heights of antenna in the four cases. Experiment confirms the theoretical deduction that with decrease of the coefficient of coupling the sharpness of resonance is increased. The gain in sharpness of resonance is, however, paid for by a loss in energy. For with constant sending station in order to improve the sharpness of resonance two-fold, it was necessary to change the coefficient of coupling at the receiving station to such an extent that the energy received was decreased twenty-fold. The coefficient of coupling was decreased at the sending station without appreciable gain in the sharpness of resonance. This result may be due to the fact that with the condensers employed at the sending station in these experiments the changes of capacity were made step-wise, and possibly the steps were not small enough to afford the proper adjustments when the coefficient of coupling at the sending station was small.



[G. W. Pierce, *Physical Review*, December, 1905.]

*Purification of Mercury.*—It is commonly supposed that, on distilling amalgams, metals distil over with the mercury. Michaelis found that electrical conductivity offers a very delicate means of detecting a trace of a metal in mercury. Such traces may, as a rule, be ascribed to bumping of the mercury during ebullition. This may be prevented by allowing a gas or vapour to bubble up through the liquid mercury. According to G. A. Hulett and H. D. Minchin, cadmium and zinc amalgams may be distilled in this manner under reduced pressure, and no trace of the metal will be discovered in the distilled mercury, though the resistance method would detect one part of zinc in a billion of mercury. Not only zinc, but also zinc amalgam, gives a measurable vapour pressure of zinc at 200 deg., and therefore the Weinholdt still will not completely separate zinc from mercury. A trace of zinc has an extraordinary effect on the E.M.F. of a mercury electrode. This fact is the basis of the method developed for testing the distillates. In previous work the combination $Hg \mid H_2O\ CO_2HgO \mid Zn$ was used, and satuturated with $CO_2$ at 25 deg., gave an E.M.F. of 1·445 volts. This cell was very constant, and on replacing the mercury by an amalgam containing only one part of zinc to $10^7$ or $10^8$ parts of mercury a slightly lower E.M.F. was noticed. The authors have tested a number of combinations and find two which give some quantitative knowledge of the amalgams. The combination Zn-amalgam | $ZnSO_4$ (saturated solution) | Zn-amalgam, allows us to calculate the concentration of one amalgam if we know that of the other and determine the E.M.F. Richards and Lewis have shown that the theoretical and observed values for zinc and cadmium amalgams of moderate concentration are in very good agreement.

[Hulett and Minchin, *Physical Review*, December, 1905.]

**The Baker-street & Waterloo Railway.**—It was stated in the first edition of the new London morning paper, the *Tribune*, on Monday that it is expected that the Baker-street & Waterloo Railway will be open to the public by Easter.

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## MR. PATCHELL'S PAPER.

A large amount of our space to-day is taken up with our special report of the conclusion of the discussion on Mr. PATCHELL'S Paper at the Institution of Electrical Engineers. Mr. PATCHELL'S reply to the discussion, which occupied three-quarters of an hour in its delivery, is, we believe, a record, and was one of the finest speeches which have been delivered at the meetings of the Institution. We were glad to hear that it was *The Electrician* report of the first two evenings' discussion which enabled Mr. PATCHELL to reply in detail to the multitudinous matters of a highly technical nature which were raised during the debate. Our columns are always open for the ventilation of questions of real interest to the electrical engineering industry, and we have no hesitation in stating that since Mr. MERZ'S Paper on the design of power stations, the Institution of Electrical Engineers has had no Paper and discussion of equal importance to the electricity supply interest until the one to which we now refer. It has been our sad duty during the past session to call attention to the lamentable falling off in Papers and discussions at the London meetings of the Institution, and we trust that a turning point has now been reached, and that we may be able to chronicle this year a session of real practical utility to the great industry which we represent.

The fact that the electricity works described in the Paper were designed in 1900 and not in 1906 detracts in no way from the usefulness of the three evenings devoted to the consideration of the Paper. It affords, on the contrary, a gauge of the progress that has been made in the interim. This progress has been chiefly apparent in the substitution of the steam turbine for the reciprocating engine in electricity works of modern design, and in the experience which British manufacturers have now gained in the construction of generating plant of the very largest sizes. That is to say, if Mr. Patchell were to build a similar station now, to meet the same conditions of supply, it would probably contain British-made turbo units, but in other respects it might very well be similar to the one running at Bow. It is possible, however, that the employment of steam turbines would have offered Mr. Patchell greater incitement to find a better site, for although a natural and unlimited supply of water for condensing purposes is a desideratum with reciprocating engines it is of still greater importance in the case of turbines. However, as Mr. Patchell pointed out, there were reasons other than technical considerations which tied his hands as to the position which was chosen for the new works. The further the station was from the distribution area, the greater would have been the difficulty in obtaining Parliamentary powers for its establishment, for everyone of the local authorities, through whose districts the trunk mains passed, opposed the scheme as a matter of course. The position of the works having been fixed comparatively near to the district, rendered it unnecessary to adopt a higher pressure for the transmission part of the scheme; otherwise there is no reason why direct high-tension generation at 15,000 volts three-phase should not have been adopted, for this represents the pressure between phases of the 11,000 volts two-phase alternators at the Willesden works of the Metropolitan Electric Supply Co. which are now running without giving any trouble. As however the pressure drop from Bow to the City is only about 3 per cent., if we understand Mr. Patchell aright, a higher pressure at the generating station was certainly not called for. In connection with the system adopted, a question arises which was not raised in the discussion. There would have been much to say in favour of three-phase distribution on the new City network, as this would have implied a considerable saving in copper on the distributors and low-tension feeders as compared with three-wire continuous current distribution, and there would also have been considerable saving in the sub-stations. Here again, there may have been reasons of policy which placed any alternating-current system out of court at once, for many of the past sins of the City of London Company were put down to the unsuitability of alternating current for this supply. Before leaving this question of mains we would refer to the warning sounded by Mr. Patchell and other speakers as to the high cost of laying cables in London. Mr. Patchell referred to estimates which had been made last year—meaning, of course, those in connection with the Administrative County of London Power Bill—which would, in his opinion, not even be large enough to pay for the reinstatement of the streets.

By far the greatest part of the discussion was devoted to the boiler equipment. Considered as a single unit, the pair of Hornsby boilers with a common grate, described in the Paper, probably constitute, as Mr. Patchell surmises, the largest steam-raising unit in existence. On the relative merits of the nearly-vertical and nearly-horizontal water tubes we need not enter here; the two points of view were sufficiently enlarged upon by the various speakers. Those who are interested in the question and its various side issues, will do well, however, to look at Mr. Patchell's explanation of his figures, which he gave in his reply, before they study the remarks of the individual speakers, for the Paper itself left it doubtful whether some of the numbers relating to the steaming properties of the boilers related to the double boiler as a whole or each of the boilers singly. The advocates of mechanical stokers expressed their views boldly in opposition to Mr. Patchell, who had preferred hand firing, and the case for and against this labour-saving and coal-economising device was clearly brought out. The advantages of mechanical stoking are too well known to need repetition here, and the disadvantage is the risk of being unable to force the boiler above a certain rate. So great is the importance of forcing in a works supplying the City of London that Mr. Patchell has found it expedient to adopt the ingenious device of adding a side furnace to each of his boilers, at the expense, as Mr. Booth pointed out, of creating a possible source of increased air leakage. On the subject of condensing, several practical hints were given during the three days that the Paper was considered at the Institution. The reason for the trouble sometimes experienced with tubes of surface condensers is not so widely known as it might be, and many engineers are unaware that it is often one of the results of using cooling towers. The remedy, however, is not too difficult to apply when it is known.

Another section of the Paper which merits attention is that relating to the experiments with switches. The simple method used for recording when the protective spark-gaps come into operation should be adopted by others who desire to guard against "surgings"—a terrible word that has become the bugbear of many mains engineers. As a still more instructive device, Mr. Duddell's oscillograph is invaluable, and the clear demonstration of the action of the oil-break switch given in the curves contained in the Paper and in those which we reproduce this week will be welcomed by many of our readers. The statement often made, and emanating, we believe, from America, to the effect that the oil switch always breaks at the zero point of the curve is proved to be a myth, but the oscillograph records show clearly the nature of the advantage of an oil break as compared with an air break. Incidentally, the value of the oscillograph in calling Mr. Sparks' attention to the necessity of altering the shape of his pole-pieces to change the square topped curve of his alternator may be mentioned. This, it is true, could have been done by means of any of the less elaborate recorders of periodically-varying currents, but for the other purposes mentioned an instrument of the oscillograph type is essential. The tests point to the possibility of doing away with the cumbrous cable-charging gear in many power houses, although in cases where the extra high-tension network is large it will probably be a wise precaution to retain it.

The question of whether or not Mr. Highfield's alternators generated nitric acid we may leave as it stands. Dynamo designers are doubtless making themselves acquainted with the whole facts, and are following the controversy from Mr. Highfield's original article in *The Electrician* to the further expressions of opinion which we publish this week, and, as a result, the design of armature coils will continue to improve.

Lastly we come to the question of costs, and here we refuse to join in the general condemnation of Mr. Patchell's reticence. The object of presenting the Paper was to obtain a good discussion on technical matters, and if the Paper had contained elaborate tables of costs the result might have been merely a discussion of figures and of the methods of apportioning the various costs among the different items. Other opportunities arise for such debates as these, and we are glad that the temptation was removed from the debaters in this instance. Every speaker who criticised Mr. Patchell on this head will readily admit that the Paper as it stood was of exceptional merit, and that the character of the discussion which it promoted is worthy of being set up as a standard of what a debate at an engineering institution should be.

# OBITUARY.

## HERMANN J. P. SPRENGEL.

With the death of Dr. Sprengel, the inventor of the well-known Sprengel pump for the production of vacua, there passes away a pathetic figure from amongst the men of science. It was his good fortune to have made several notable contributions to chemistry and physics, contributions that have secured his claim to permanent recognition, while at the same time some sinister fate forbade his adequate enjoyment of the rewards and distinctions which fall to men who have not achieved a tithe of that which he accomplished: and in his later years some sense of this developed in an otherwise delightful character an irritability that frustrated even the efforts of his friends to advance his interests.

Born near Hanover in 1834, he was trained at Göttingen and Heidelberg Universities, in the latter of which he graduated in 1858. After serving three years as assistant in the chemical laboratory of the University under Brodie, he came to London. While working at the laboratories of Guy's and St. Bartholomew's Hospitals he, in 1865, described before the Chemical Society the vacuum pumps on which his claims to recognition mainly depend. In this Paper he describes the principle of letting mercury or any other liquid run down a tube, to the upper part of which a receiver is attached by means of a lateral tube, so that the air or other gas is thus dragged down the full tube between falling portions of the gravitating liquid. This downward acting pump may be regarded as the inverse of the much older apparatus known as a trombe for driving air under pressure by means of falling water. It is well known that Sprengel's device, though highly original, was not the first mercurial air-pump, having been preceded by the upward-driving intermittent mercurial pumps of Swedenborg and of Geissler. Sprengel's pumps soon met with practical applications, by Graham in the extraction of gases in his researches on diffusion, and by Bunsen for hastening filtration, in which latter adaptation falling water was preferred to mercury.

The Sprengel pump was further developed in the seventies by Sir William Crookes and by his assistant, the late Mr. C. H. Gimingham, for the purpose of obtaining very high vacua in the classical researches on radiant matter and the radiometer. And it was to the use of the Sprengel pump that was due, unquestionably, the successes of Sir Joseph Swan and of Mr. Edison, in the production of the carbon wire glow lamp in 1879. Sprengel could never endure to hear the filter pump called the Bunsen lamp, and even went so far as to print on his visiting card the words: *Der eigentliche Erfinder der Bunsen'schen Pumpe.*

He was elected a Fellow of the Royal Society in 1878, and had from 1865 to 1876 been partner in a firm of manufacturing chemists. In the years which followed Dr. Sprengel devoted himself largely to the study of explosives.

Dr. Sprengel, whose funeral takes place to-day at Brompton Cemetery, was never married; his restless mind was active to the end. He breathed his last on the 14th inst.

## JAMES McDONALD ANGUS.

Mr. J. McDonald Angus, who died on Monday last at Leven, Fifeshire, at the age of 65, had been since 1897 engaged principally in the construction of tramways, chiefly in connection with the undertakings of the British Electric Traction Co., and was at the time of his death resident engineer on the Wemyss and District tramways.

He served his apprenticeship in the locomotive works of the North Staffordshire Railway, and was afterwards employed at Stephenson's, Newcastle-on-Tyne, and at Crewe. He was articled to Mr. J. C. Forsyth, and afterwards became agent and engineer for Mr. William Moss, railway contractor of Stafford. Joining the London & North-Western Railway Co. as resident engineer for permanent way works, he had charge of the three sections of the railway and all the London goods warehouses, depots and docks belonging to the company. He afterwards accepted an appointment as engineer-in-chief to the New South Wales Government railways, which post he held till 1893. Mr. Angus' personality impressed itself on all with whom he was brought into contact, and the news of his death will be a source of regret to a very large circle of engineers. He continued hale, hearty and in good working condition up to a very few days of his death.

# REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign book).

**Graphic Methods of Engine Design.** By A. H. Barker. 2nd edition. (Manchester: The Technical Publishing Co.) 3s. 6d.

This is a collection of graphical exercises combined with arithmetical work which should be useful to many young engineers who are practically engaged in steam engine design or steam engine construction. The first few chapters deal with such matters as the proportioning of the engine cylinder to obtain a given power, the proper design of the valves and steam passages, valve gears, the question of compounding and the general design of flywheels. All these subjects are treated in an elementary manner and from the practical point of view. Following these are chapters on inertia forces. The author has not been careful regarding units. For instance, on page 98, force is said to be "mass × acceleration/*g*," and on page 102 it is made equal to "weight × radial acceleration/*g*." The confusion of the units in this way is very perplexing to a young student. The last six chapters are devoted to the subject of "Balancing." The author states in the Preface that he "does not know of any work which treats this important and somewhat difficult subject in such a way that it can be understood by the elementary students, for whom this book is intended." We do not think that the author has succeeded in dealing with this subject very clearly, nor in a way which will make the principles easily understood by the class of student for whom he specially writes.

**Electrical Instruments and Testing.** By N. H. Schneider. (London: E. & F. N. Spon, Ltd.) 4s. 6d. net.

This is an American book, possessing no very special merit. Mainly, it consists of descriptions of the construction of several common types of instruments, and directions for using the Wheatstone bridge and the execution of a few ordinary tests. The entire ground is covered just as well, and perhaps a little better, by a number of English books, although the latter do not describe so many purely American instruments.

**Berechnung und Entwurf Elektrischer Maschinen, Apparate und Anlagen.** Vol. III. Elektrische Schaltanlagen und Apparate. By Dr. F. Niethammer. (Stuttgart: F. Enke.) 16m.

The book under review forms the third volume of a *magnum opus*, with which it is proposed to cover the whole field of electrical engineering. Considering the number of publications which the same author has brought out during the last few years, the length of this new book is astonishing. Almost 500 pages, with about 600 illustrations, deal with the subject of switchboards and auxiliary apparatus. In addition, another 150 pages deal with the general lay-out of electrical installations such as are required for industrial and marine purposes. As there is no connection whatever between the first and second parts it would seem better if the latter had been left for the next volume, which, according to the author, will deal exclusively with this subject.

The book as it stands has somewhat the character of a well-illustrated pocket-book, but its dimensions are vastly greater. It should be of value to those engaged in this class of work. Chiefly Continental and American practice is referred to.

As it is difficult to review a book which in itself is nothing but a detailed review, we must limit ourselves to give the headings under which the subject is treated:—

(1) Switchboards. (2) Switches. (3) Fuses. (4) Automatic switches. (5) Instruments. (6) Protection against lightning and excess voltages. (7) Rheostats. (8) Regulators. (9) Starters. (10) Various apparatus.

The excellent illustrations of this part deserve special praise. The second part gives a collection of data which might be called the stock-in-trade of a consulting engineer; the engineering as well as the financial end have been considered. However, no originality can be claimed for this chapter.

## AUSTRALIAN NOTES.

[FROM OUR ADELAIDE CORRESPONDENT.]

**South Australia.**—Under the Electric Tramways Act, 1904, the S.A. Government gave notice in December of that year for the purchase of the various horse tramways of Adelaide, and in accordance with its provisions, arbitrators were appointed to determine the price to be paid. Owing to a want of clearness in the various acts, the Supreme Court was appealed to to decide the basis of valuation, the companies maintaining that their goodwill was to be bought, while the Government's contention was that the decision of the English courts in the case of the London Street Tramways Co. applied here also, and that the bare valuation of stock and plant taken over was all that need be paid for. A decision was given in favour of the companies, but a rehearing was granted to the Government on technical grounds. The court's decision has again been given in favour of the companies on most points, and in particular compensation is to be paid for the expected profits of the current septennial period, it being held that a notice of purchase given by the Government last year prior to the expiry of the previous septennial period was informal. Prior to the announcement of this new decision the present Government—a labour ministry—had brought in an amending act, whose object, they claimed, was to remedy the carelessness of the previous Government and render valid the notice of purchase given last year. This naturally met with much opposition on the part of the tramway companies, who declared it to be a barefaced attempt to rob them of their legal and moral rights; and though passed by the House of Assembly, the bill was rejected in the Legislative Council by a large majority. It is, however, not at all improbable that the whole of these proceedings will be dropped for the time being, the Electric Tramways Act, 1904, being passed by the previous Government in opposition to the Labour party. In any case a new act will be required before the tramways of Adelaide can be converted into a State-worked system of electric traction, and that is the object of the outside members of the Labour party, if not the actual policy of the present Ministry.

**Victoria.**—A short act has been introduced into Parliament to amend the General Electric and Gas Lighting Acts, the principal clause empowering any supplier of gas or electricity to adopt a sliding scale or similar tariff. This has been rendered necessary by an injunction of the Supreme Court recently obtained against the Melbourne Corporation, restraining them from charging for electricity upon the maximum demand system or any other than a uniform flat tariff to all customers alike. It seems that the clause governing the matter of tariff under which the Corporation operate—taken from the Gas Acts, where it was introduced to prevent undue favouritism—is worded a good deal more stringently than in the English Act; and that it is illegal, at present alike for gas and electricity suppliers to make even a concession to a large consumer over the terms offered a smaller one.

Following upon the issue of this injunction a conference was held between the Melbourne Corporation and the local Gas Company, and of this the present bill is the outcome. It will apply universally to all authorised suppliers of gas and electricity in the State, whether municipal or company, and under its terms a tariff may be framed which will differentiate between customers in accordance with their total consumption, load-factor, &c.; but, none the less, the tariff must be uniform throughout the supplier's whole area, and no favouritism is to be granted to particular customers by means of special contracts.

The Standing committee of the Victorian Railways has reported to the Legislative Assembly, after an inquiry lasting several weeks, upon the proposed electric tramways which were to act as feeders to the suburban railways. Mr. F. E. Bradford, electric engineer to the railways, had submitted estimates for six such tramways, but the committee have reported that his estimates appear unduly optimistic, and have rejected four of the lines as certain to be financially unsuccessful. A fifth, to North Fitzroy, appears more favourable; but as this suburb is already well served by cable trams, the necessity for the line is not considered commensurate with the risk of failure. The sixth line. from Prahran to Malvern, is reported on favourably, and it is proposed to test the traffic of the district by the temporary use of motor 'buses, which are to be run at the same fares and frequency of service as suggested on the tramway, the trial to be continued for six months. Five motor 'buses have recently arrived to the order of the railways, and these have now been put into active service between Prahran and Malvern.

The committee stated that the question of electric tramways is complicated by the fact that the Melbourne and suburban corporations have the right to acquire the extensive cable tramway system in about 10 years' time, and competition between State and municipally owned tramways is undesirable. This is particularly the case with respect to the proposed Fitzroy tram, which parallels a cable line almost its whole length. The Prahran–Malvern route would not be in actual competition with cable trams, but even here, if an electric line is decided upon, the Prahran Council will probably be given the option of constructing it.

In the course of the inquiry, the electrification of the suburban railway to St. Kilda had been mooted, and figures were submitted by Mr. Bradford for this. But while pointing out that this was not within the actual scope of their inquiry, the committee stated that it appeared inadvisable to enter upon any railway electrification until it is seen whether the single-phase working, now being tried in both America and Europe, is commercially successful.

**New South Wales.**—Though the second largest town of New South Wales, with a population of over 30,000, Broken Hill has hitherto made no pretence at street lighting, and this in spite of the presence of flourishing gas and electric companies in its midst. This state of things, which naturally is a frequent matter of complaint, is shortly to be remedied, and as a preliminary step to extensive electric street illumination, the Municipal Council have acquired the local electric lighting station.

Twenty-five years ago, the site of Broken Hill was a barren and outlying field of a large sheep-run, but upon the discovery of its famous silver and lead deposits a "rush" took place, and by 1891 its importance was sufficient to induce the opening of an electric lighting station by a private syndicate. For several years this enterprise ran a chequered career, involving sundry changes of proprietorship; and as far back as 1897 its acquisition by the Corporation was proposed by the then Mayor, Mr. George Strachan. This proposal, however, was not carried into effect, so in 1900, the undertaking being again upon the market, Mr. Strachan purchased it in conjunction with Mr. F. J. Mars, and under their management the concern has been brought to a thoroughly sound condition.

At the present time the excessive price prevailing for lead and the increased value of silver have caused quite a boom at Broken Hill, a strong impetus being given to all the mines, and several that were shut down now being re-opened. The time was therefore felt to be opportune for municipal expenditure, and negotiations casually opened by the Council for the acquisition of the electric works were brought to a head by a direct offer from Messrs. Strachan & Mars to sell out for £12,000, with full permission to the Council to make every examination of their plant and books. The Council thereupon nominated Mr. Erskine electrical engineer to the Sulphide Corporation (resident at Broken Hill) to report upon the plant and to give his valuation of the same, while Messrs. L. H. Beck and G. F. Job were appointed auditors to examine the company's books and report upon the financial position.

Mr. Erskine's report valued the plant at £10,215, made up as follows:—Freehold and buildings, £950; boilers, chimney, steam piping, &c., £2,200; engines and generators, £3,100; switchboard and wiring, £340; stores, £375; pole lines, transformers, and meters, £3,250. While the auditors stated that for the last three years the figures of income and expenditure had been:—1903: gross revenue, £3,402; expenditure, £2,570; profit, £832; 1904: £4,102, £2,303, £1,799; and 1905: £4,658, £3,457, £1,201, giving an average profit of £1,277, or $10\frac{3}{4}$ per cent. upon the price asked.

The Council had already obtained authority to borrow £12,000 for electric purposes—the money being, in fact, at hand—and, after consideration, it was agreed that the sale should be effected as from December 1st at the price named, the peculiar provision being made that if so desired within the next six months the vendors will grant the Council a loan of £4,000, bearing interest at five per cent., in order to provide the necessary money for arc lighting the principal streets and for providing the additional generating plant that will be required when this is done. The vendors also agree to continue to run the station until the Council have made the necessary arrangements for taking it over.

The station comprises one direct-coupled Belliss-Brown Boveri set of 110 kw., one 60 kw. Allgemeine alternator belt-driven from a Westinghouse engine, and one similarly driven Mordey alternator, each with its own exciter, current being generated at 1,100 volts single phase and 100 periods. There are three Babcock & Wilcox boilers of 100 H.P. each. The distribution system consists of overhead wires, both high and low tension, with General Electric Co.'s oil insulated transformers mounted on the poles, the low tension network, which is isolated but in part extending over about 5 miles of streets. There are 150 customers, nearly half of whom are supplied on contract without meter, those having meters being charged upon the maximum demand system at 1s. 3d. for the first hour and 6d. after, a rate which is not unreasonable considering that coal, water and labour all are dear, and that gas costs 12s. 6d. per 1,000 cubic. ft. None of the mines are customers of the company, and in the city motors are used, but to a small extent (always excepting fan motors, of which there are 60), totalling 22 H.P., the principal customer being the local newspaper, and the price charged 6d. per unit. The output, of which exact records have not been kept, is estimated at 150,000 units for the past year, making the average price obtained $7\frac{1}{2}$d.

Nothing has yet been decided respecting the street lighting to be carried out, but probably the two principal thoroughfares, Argent-street and Oxide-street, will be lit at an early date. More than this can hardly be done at present, the large generator being now barely sufficient for the heaviest load; but as soon as this has been duplicated there is every reason to expect a steady progress in the street illumination.

# THE MEASUREMENT OF HIGH FREQUENCY CURRENTS AND ELECTRIC WAVES.*

BY PROF. J. A. FLEMING, M.A., D.SC., F.R.S.

*(Continued from page 522).*

Returning then to the mutual inductance M of two circuits, we may define this quantity by saying that the E.M.F. produced in the secondary circuit by an alternating primary current is 6·28 times the frequency multiplied by the product of the primary current and the mutual inductance M. If we have two coils of inductance, L and N, which form primary and secondary circuits of a transformer we can join them up in two ways; first, so that a current flows the same way round both coils, or secondly, we may join them up so that a current may flow in opposite currents round the two coils when these are joined in series. It is easy to show that, in the first case, the whole inductance of the two circuits is $L+2M+N$, and in the second case it is $L-2M+N$. Hence the difference of these two inductances divided by 4 gives us the value of the mutual inductance. We can, therefore, determine the mutual inductance of two circuits by making two measurements with the above-described bridge and telephone, and can thus easily measure small mutual inductances.

It was mentioned just now that the principal property of high frequency currents is that they are entirely on the surface of conductors. A wooden rod, covered with the thinnest coating of gold leaf, is just as good a conductor for very high-frequency currents as a solid copper one. On the other hand, the copper rod has a far higher resistance for high-frequency currents than it has for steady currents. Lord Rayleigh has given a well-known formula for tabulating the high-frequency resistance $R^1$, of a nearly straight conductor of length $l$, of which the steady resistance is R ohms, for high-frequency currents of frequency $n$. If the metal is non-magnetic, the formula is

$$R' = \sqrt{R\pi n l},$$

and for a round-sectioned copper wire of diameter $d$ the above formula becomes

$$R' = R\frac{\pi d}{2}\sqrt{n},$$

where R′ is the high-frequency resistance, R the ordinary steady resistance and $l$ is the length of the conductor. We find, then, that for high frequencies the value of R′ is very different from R. Thus, for instance, with a frequency $10^6$ and a diameter of 1 cm., R′ is nearly 40 R. On the other hand, if $d=\frac{1}{40}$ cm., which is the size of a No. 36 S.W.G., then for the same frequency $R'=R$.

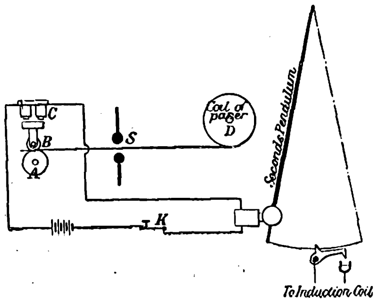


FIG. 5.—FLEMING'S SPARK COUNTER.

It is important to notice that the above formula only applies to straight or nearly straight wires, but not to closely-wound spirals, because, in the latter case, there is a displacement of the cylindrical distribution of the current over the cross-section, which results in the production of eddy currents in the metal. Accordingly, in making high-frequency circuits, all the conductors should be made of very thin strips of metal or of fine silk-covered wires bunched together, and then the value of the high-frequency resistance is known, and is equal to that of the ordinary or steady resistance.

Another measurement of considerable importance is that of a spark resistance. The usual mode of producing a high-frequency current, as explained in my previous courses of lectures, is by the oscillatory discharge of a condenser. To the secondary terminals of the induction coil we attach one terminal of a condenser, which may consist of a battery of Leyden jars; the one coating of this condenser is attached to one terminal of the induction coil, and the other coating is attached to the other spark ball through an inductance coil. We have thus in series a spark-gap, a condenser and an inductance coil, and when the latter is put into operation we have an oscillatory spark at the spark-gap, and trains of electric oscillations in the inductance coil. If we insert in series with this condenser an ammeter suitable for measuring high-frequency currents, as described in the next lecture, we can by this means determine the effective value of the current in the oscillatory circuit. Again, if we know the length of the spark-gap, we can determine the potential to which the condenser is charged, and if we know the capacity of this condenser we know the energy stored up in it.

If, then, we can determine the number of sparks per second, we can tell the power in watts given to the condenser, because this latter is equal to $\frac{1}{2}N\frac{C}{10^6}V^2$ where N is the number of discharges per second, C is the capacity in microfarads, and V the charging potential in volts, the resulting power being given in watts. Suppose we assume that the inductance coil has no sensible resistance, then the whole resistance of the circuit is concentrated in the spark-gap, and its resistance in ohms is given by the quotient of the power put into the condenser by the square of the current in amperes flowing in the condenser circuit. The measurement of the spark-gap resistance, therefore, can be effected if we can determine the number of oscillatory sparks per second.

I have lately devoted particular attention to the construction of an instrument intended to effect this measurement. The instrument is constructed in the following manner: A small electric motor has a flanged pulley put upon its shaft over which lies loosely a strip of telegraph paper tape, the pulley being just wide enough to allow the paper to lie on it. Over the pulley of the motor rests another pulley, called a jockey pulley, carried at the end of a long, weighted rod, which is upheld by an electromagnet. As long as the jockey pulley is held up, the paper tape will not travel when the motor revolves, but when the jockey pulley is dropped the paper is gripped and travels with a speed determined by the speed of the motor. This paper tape is made to pass in part of its course between two spark balls, and at every oscillatory spark it is pierced with a hole. The primary circuit of the induction coil contains a switch which can be closed by an electromagnet. This electromagnet is operated by a pendulum (see Fig. 5) so arranged that when the pendulum takes one swing, occupying a period of one second, it breaks an electric circuit and then makes it again for exactly one second, and this interruption is caused to drop the jockey pulley on to the motor pulley for one second, and at the same time to close the induction-coil circuit also for one second. When the operation is over we find, therefore, that the paper tape is perforated with a number of holes which correspond to the number of sparks per second—that is, to the number of oscillatory discharges (see Fig. 6). Accordingly we have the means of reckoning the value of the letter N in the above formula.

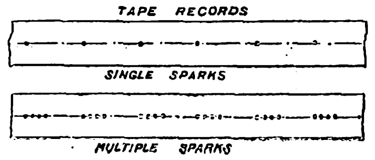
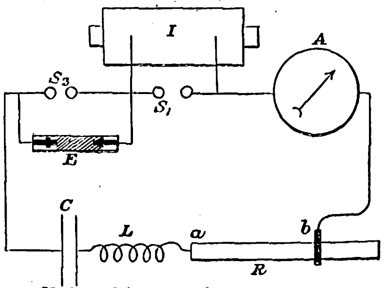


FIG. 6.



*Slaby's Method of Measuring Spark Resistance.*

FIG. 7.

We have already seen how the capacity of the Leyden jar can be measured, and in the next lecture figures will be given to you showing the manner in which the charging voltage can be estimated from the length of the spark-gap. By means of this spark counter we are enabled to estimate the power put into the condenser, and from the measured value of the current in the oscillatory circuit we can determine the spark-gap resistance. This spark-gap resistance is found to be a function of many quantities. It depends first upon the length of the spark, increasing very rapidly with the length. In the second place, it varies with the quantity of electricity stored in the condenser and released at each discharge, the spark-gap resistance decreasing with increasing discharge current. In the next place, it depends somewhat on the inductance of the circuit and upon the frequency of the sparks; moreover, a careful examination of the subject of the spark-gap resistance shows that the resistance of the spark is not constant over the whole operation of the spark, but increases towards the end of the discharge as the oscillations die away in amplitude. We cannot therefore speak of any particular length of spark as having a fixed resistance. A spark of 5 milliamperes in length may have a resistance of 5 or 10 ohms or it may have a resistance of very much less depending upon the quantity of the discharge.

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* Cantor lectures delivered at the Society of Arts, Nov. and Dec 190

Prof. Slaby, of Berlin, has made some interesting experiments on spark resistance by the following method:—He places in series with one another two spark-gaps, $S_1$ and $S_2$ (see Fig. 7). Across one spark-gap are joined the secondary terminals of an induction coil and the other spark-gap is short-circuited by a tube, E, containing the solution of sulphate of copper, which has a resistance of about 410 ohms. The circuit is completed by a condenser, O, a variable inductance, L, and a hot-wire ammeter, A, suitable for measuring high-frequency currents and also a variable carbon resistance, R. An experiment was conducted in the following manner: The spark balls across which the induction-coil terminals were connected will be called the main spark, the other spark-gaps shunted by the tube of sulphate of copper will be called the spark-gap under investigation. This last spark-gap could have its length varied and measured by means of a micrometer. The first measurement consisted in closing this last spark-gap entirely, and then varying the amount of resistance inserted by the carbon rheostat, whilst at the same time observing the value of the current as read on the hot-wire ammeter. In this manner a curve could be plotted showing the variation of current with resistance in the oscillatory circuit. In the next place the carbon rheostat was cut out and the length of the spark-gap under observation was varied, whilst at the same time the readings of the hot-wire ammeter were taken corresponding to observed spark-gaps. From these two observations a curve could be set out showing the spark resistance in terms of the spark length.

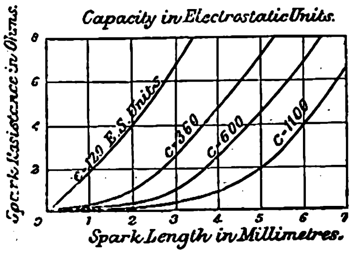


FIG. 8.—RELATION BETWEEN SPARK-RESISTANCE AND SPARK-LENGTH (SLABY)

Some of these observations by Prof. Slaby are given in the following table, and plotted out on the curves in Fig. 8.

Table III.—*Measurement of Spark Resistances.* (*Slaby.*)

| Spark-length in mm. | Spark resistance in ohms for various capacities C in electrostatic units in the circuit. | | | |
|---|---|---|---|---|
| | C=120. | C=360. | C=600. | C=1,100. |
| 1 mm. | 2 ohms | 0·4 | .. | .. |
| 2 „ | 4 „ | 1·0 | 0·25 | .. |
| 3 „ | 7 „ | 2·7 | 1·0 | 0·4 |
| 4 „ | .. | 5·0 | 2·5 | 0·8 |
| 5 „ | .. | 7·5 | 5·0 | 2·0 |
| 6 „ | .. | .. | 7·2 | 4·2 |
| 7 „ | .. | .. | .. | 6·5 |

I have repeated Slaby's observations in the Pender Electrical Laboratory of University College, London, with some slight modifications. In place of the carbon rheostat which I found liable to heat, I used a U-tube containing dilute sulphuric acid, having in it two movable pistons, by means of which the length of the column of sulphuric acid in it could be varied (see Fig. 9). A thermometer, placed in this tube, served to give the temperature, and from the known resistivity it was possible to estimate the resistance for any position of the pistons. In place of short-circuiting the spark-gap by a tube of sulphate of copper I employed an inductance coil, and so arranged the ammeter that it measured only the current passing through the spark to be measured. These experiments were made with spark balls of different materials, and it was found that for lengths of spark-gap, greater than 2 mm., there was a very decided difference between the resistance of sparks taken between iron balls and those between brass or zinc balls of about 3 cm. in diameter (see Fig. 10). For spark lengths of about 5 mm. or 6 mm. the resistances of spark between iron balls is nearly double that between zinc balls of the same size; this is no doubt connected with the greater infusibility of iron.

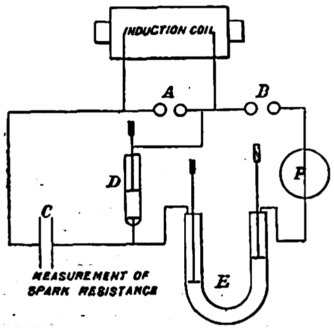


FIG. 9.—FLEMING'S ARRANGEMENT FOR MEASURING SPARK-RESISTANCE.

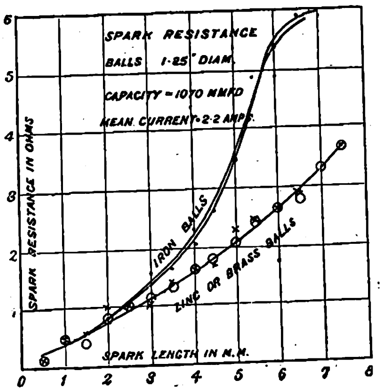


FIG. 10.—RELATION BETWEEN SPARK-RESISTANCE AND SPARK-LENGTH OF IRON AND ZINC OR BRASS BALLS.

Further experiments on spark-gap resistance have recently been made by Rempp. He employed rather long spark-gaps, and took a spark between zinc balls varying in diameter from 1½ cm. to 5 cm. His results show that the spark resistance has a minimum value corresponding to a spark length of about 4 mm. or 5 mm., the spark resistance increasing for shorter spark lengths, and also for longer spark lengths (see Figs. 11 and 12). Rempp confirmed the observations of Slaby and also my own, which show that in proportion as the capacity in the oscillating circuit is greater, so the spark resistance for a given spark length is smaller. The smallest spark length by Rempp was about half an ohm when using a capacity somewhere near 7,000 m.mfds.

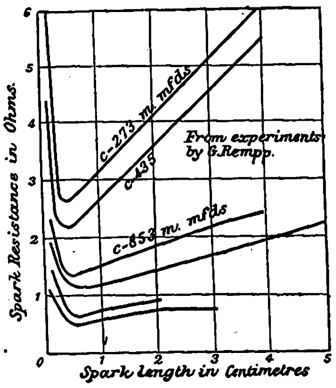


FIG. 11.—RELATION BETWEEN SPARK-RESISTANCE AND SPARK-LENGTH FOR ZINC BALLS OF VARYING DIAMETER (REMPP).

By means of the spark counter above described, I have made some interesting researches lately on the phenomena of the spark when using an alternative current transformer instead of an induction coil. Employing a transformer worked with an alternator having a frequency of about 50, I find that so far from there being a spark for alternation, as might naturally be supposed, in some cases there were far fewer than 50 sparks per second and in some cases a far greater number. When employing very short spark-gaps, I found it was necessary to insert inductance in between the spark gap and the transformer, in order to destroy the alternating-current

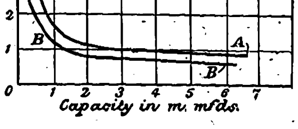
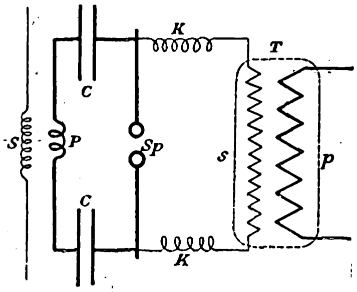


FIG. 12.—RELATION BETWEEN SPARK-RESISTANCE AND CAPACITY OF THE OSCILLATING CIRCUIT.

arc that would otherwise form and enable the condenser to become charged (see Fig. 13). Under these circumstances, it is found that the oscillatory discharges sometimes rose to as many as 500 per second.

The explanation of this anomaly is as follows: When an alternating-current transformer is employed to charge a condenser placed in series with an inductance coil as a shunt across a spark-gap, the interval between the spark balls is occupied not only by a condenser discharge, but by a true alternating-current arc, and unless this arc is quenched at each alternation, the condenser cannot become charged again. The simplest way to quench this arc is to insert inductance between the spark balls and the transformer. This inductance, however, causes a drop in voltage when a current is taken out of the transformer. Consider then the instant before discharge. The transformer gives a certain voltage, the condenser is charged to that voltage, and if that voltage exceeds the voltage corresponding to the spark-gap length, a discharge commences. At this moment, however, the voltage drops in consequence of the inductance inserted between the transformer and spark balls. The discharge then ceases, but it immediately commences again, and in this manner five or six discharges in the same direction may take place during one semi-period of the transformer current. On the other hand, if the condenser capacity is very large, and if the spark-gap is long, it may require a time equal to several complete periods of the transformer current before the P.D. of the spark balls rises to a value which will cause a discharge to take place. It therefore follows that great errors may be committed if, in estimating the power put into the condenser, we always assume that the number of periods of the condenser is equal to the number of alternations in the alternating current; it may be much fewer and it may be much greater with corresponding difference in the resistance of the spark.



*Transformer Plant for creating Electric Oscillations.*

FIG. 13.

(*To be continued.*)

## SECONDARY BATTERIES.

A practical Paper on the above subject was read by Mr. F. W. Crawter before the Electrical Contractors' Association last Tuesday, Mr. E. L. Berry in the chair. Much of the information given coincided with that embodied by the author in his recent Paper on "Storage Batteries and their Application to Public Institutions," read before the Association of Engineers-in-Charge and published in abstract in *The Electrician* last week, p. 518. The following is a résumé of some of the new points touched upon by Mr. Crawter :—

In order to satisfactorily bear the weight of the cells, it is as well, where it can be done, to have a concrete floor in the battery room, the surface being rendered, and if on the top of the concrete 2 in. of asphalte be added it will make a better job. Some objection is raised to the use of asphalte on account of the bearers sinking into it with very heavy cells, and as an alternative vitrified brick may be employed, arranged with a set for drainage. The use of tiles is to be deprecated unless laid in pitch, as when cement is used the acid quickly gets underneath the tiles and causes the floor to bulge and loosen.

With regard to the use of hydrometers for indicating the condition of the cells of a battery, if, as is sometimes specified by the consulting engineer, a hydrometer has to be provided for each individual cell, the discrepancies between the various instruments may be, and probably will be, considerable, and they ought to be tested previously against each other for this reason.

A time may come in the life of a battery when its capacity may not be equal to what is required of it, and it is difficult sometimes to determine from the appearance of the plates whether it is the negatives or the positives or both that require renewal, and the well-known cadmium test is then the easiest method of settling the point. If, when a cell has been discharged down to 1·8 volts, and current is still being taken from it at normal rate, a piece of cadmium is introduced into the electrolyte (care being that it does not touch any of the plates), and the voltage taken between it and the plates, their relative conditions can be ascertained. When a battery is discharging, cadmium is negative to both positive and negative elements, consequently, if the negative cadmium reading be subtracted from the positive cadmium reading, the P.D. of the cell is obtained, but when charging, cadmium gives a negative reading to the positive element and a positive reading to the negative element, therefore the P.D. of the cell is represented by the sum of these readings. From this it will be seen that the metal cadmium offers a convenient standard by which the potential of either plates can be determined at any period of work. A single cadmium reading, however, would have very little significance to anyone but an expert, and in order to determine which element is actually giving out when the voltage of a cell on discharge is falling fast, it is advisable to take a series of readings on each plate : it will then be seen to which plate the falling voltage is attributable.

If a battery is to be put out of commission for not more than a few weeks it will hardly be worth while to "dry off," if arrangements can be made to give a charge at least once a fortnight, but if the cells are to stand entirely idle for many months, it is better to dry them off. After the cells have been fully charged they should be discharged down to 1·8 volts per cell, the electrolyte should then be removed from the cells and pure water substituted. The discharge should then be continued until the cells are short-circuited, the elements being afterwards removed and stored away. The method of drying off differs however in detail with the various makes. It may here be mentioned that charged negative plates should never be exposed to the air, as they rapidly oxidise and harden, and it is a matter of great difficulty to restore them to their former condition.

Very warm situations are unsuitable for battery rooms. Sometimes the room which is to contain the cells has a plaster ceiling and care should be taken that this is in such a condition that portions of it do not flake off and fall into the cells, as the addition of matter containing lime is highly undesirable. Some plants are arranged without any regulators at all, the battery being charged and discharged as a whole, the fictitious E.M.F. arising from the gas effect immediately after charging being corrected by a resistance in series with the battery which is gradually cut out until the normal discharge voltage is reached. This system is hardly applicable where any appreciable drop in the mains is likely to occur at times of heavy load, but is giving satisfaction in cases where the heaviest discharge called for does not occasion any fall in voltage.

A lively discussion ensued after the Paper had been read. Mr. W. R. Rawlings said he had had to lay up two large batteries, and had pursued the course of charging them up every two or three weeks and discharging them slowly. This procedure gave very good results, but could not always be enforced. Turning to the author's objection to working two batteries in parallel, he said that it was unfortunate this should be so, as it meant increased cost all round. He himself had run two batteries (having thin plates) in parallel with fair results. A booster, so strongly recommended by Mr. Crawter, was a running machine, and was often objected to because of the attendance it required. One firm of consulting engineers he knew always arranged the battery to be near the house which was to be lighted, being sometimes a considerable distance from the generator. In a certain case the generator was ½ mile distant from the battery, and the drop in volts between the two amounted to 20 volts. This plan appealed to him, as the butler could switch on more or less cells according to requirements. Mr. F. Suter instanced a case where the drainage of the battery room attached to a country mansion had unwisely been left to the architect, who emptied the drains into a lake, the result being that the fish in the lake were poisoned. That contractor lost his customer. The instructions sent out by battery makers were generally too meagre. A record ought to be sent up by the battery attendant once a week. A bell ought to be included in the battery connections so as to give an indication when the battery was being overworked. Mr. A. R. Phipps agreed with the author as to the bad effect of running two batteries in parallel, and complained that hydrometers did not always agree in their readings. Mr. E. Ratcliff asked when was the proper time for topping-up. Attention was drawn by another speaker to the fact that a battery could be too large, although this was a rare case. He instanced a battery designed for 60 amperes normal, but generally only working at 15 amperes. This battery proved to be very short-lived. Mr. C. Edwards asked whether batteries could not be run in parallel if water resistances were connected in series with the halves. Boosters, requiring much attention, could not be used for country houses, &c. Mr. L. G. Tate mentioned the case of a battery which became bad after three years' successful operation. This battery was working in conjunction with a compound generator whose series coils could be cut out. It transpired that the generator had been charging the battery for a whole year in the wrong direction, and he would like to know if this would account for the failure. After several other gentlemen had spoken upon details of battery treatment, Mr. Crawter replied to the discussion. He said that under-charging affected the negative plate chiefly, while over-charging affected both plates. He agreed with Mr. Rawlings that drying-off was not as good as charging the battery from time to time and discharging slowly, but this could not always be carried into effect. It might happen that batteries worked satisfactorily in parallel, but this could not be depended upon. Battery makers did not like the accumulators away from the generating plant because of the lack of proper attendance. Batteries were generally too small for the work they had to perform, but they could also be too large, in which case local actions might set in. He had come across a cell which not only did not require topping up, but produced an overflow of water. His theory was that moisture was absorbed by the acid of this cell which was situated in a draught of moist air. He warned his audience not to get up the gravity by adding acid, as the original amount of acid was still in the plates and had only to be got out of them. Fictitious readings were obtained if the gravity was read off while the cells were gassing. Vaseline was the best protection against corrosion. The Planté type of cell would stand reversing without damage; in fact, this was sometimes done intentionally when the battery began to fall off. Wood boards were good as separators. Ordinary wood would carbonise and thus required special treatment before it could be used for the purpose mentioned. Mr. Berry, before proposing the vote of thanks, said that contractors ought to insist upon (1) the attendant keeping a daily log-book and (2) upon a recording ammeter being connected in the discharge circuit. In country houses, having from 600 to 700 lamps, he had found from experience that the consumption ranged from about 80 to 90 amperes at 100 volts.

## SOME NEW ELECTRICAL INSTRUMENTS.

The new "Thermo-galvanometer" of Mr. W. Duddell should prove of great use for accurately measuring alternating currents of small magnitude, in cases where the high resistance of electromagnetic instruments is an objection, and where a sufficient P.D. does not exist to render an electrostatic instrument suitable. Mr. Duddell's instrument has practically no self-induction, and can be used to measure currents down to 20 microamperes at frequencies up to about 120,000 ∽ per second. Another important advantage of the instrument is that it can be accurately standardised by continuous current and used without error on circuits of any frequency or wave form. At the same time, it is very dead beat, and is unaffected by magnetic fields. The apparatus is illustrated in Fig. 1 and is shown diagrammatically in Fig. 2. In the field between the pole pieces N, S (Fig. 2) of a permanent magnet is suspended by means of a quartz fibre, Q, a single-turn coil or loop of wire, L, to the lower ends of which is fixed a thermo-couple. This loop is surmounted by a glass stem, G, which carries a mirror, M. Beneath the lower junction of the thermo-couple is fixed the heating resistance or "heater," one end of which is connected to the frame of the instrument to avoid electrostatic forces. The current to be measured passes through the "heater," raising its temperature, causing the lower junction of the thermo-couple to rise in temperature above the upper, thus producing a current round the loop L, which is deflected by the magnetic field against the torsion of the quartz fibre Q. The deflections of the instrument are practically proportional to the square of the current when the heater is central under the junction. The sensibility of the instrument depends on the resistance of the "heater" and on its distance from the thermo-junction. The "heaters" are set up in small protecting cases with contact rings, so that they can be interchanged quickly when it is desired to greatly alter the sensibility of the instrument. An adjusting screw, F, is provided so that the distance between the "heater" and thermo-junction can be varied, and by this means small changes in the sensibility can be made without altering the "heater" or changing the shunts in use for the experiment. Shunts may be used with the instruments for measuring low-frequency, (under 1,000~) and continuous currents, but for high frequency currents, such as those employed in wireless telegraphy, there is great uncertainty as to the ratio in which the current will divide between the instrument and shunt circuits. In actual use, the thermo-couple is protected by a heavy metal plate, E, which is removed in the figure, and a cover is used to protect the instrument from dust and radiation. The mirror M (Fig. 2) is plane, but the instrument is used in conjunction with a lens, which gives an image on a scale at a distance of 1,000 cm. when used with the ordinary lamp and scale.

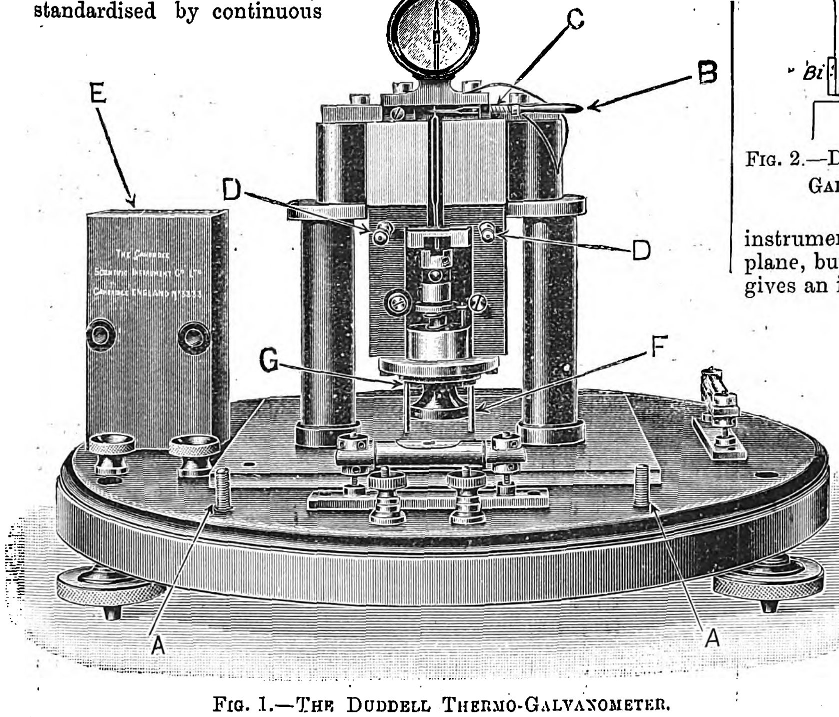


Fig. 1.—The Duddell Thermo-Galvanometer.

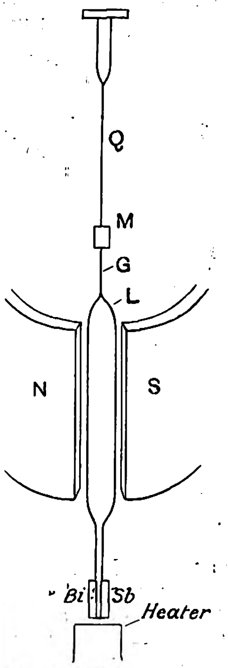


Fig. 2.—Diagram of Thermo-Galvanometer.

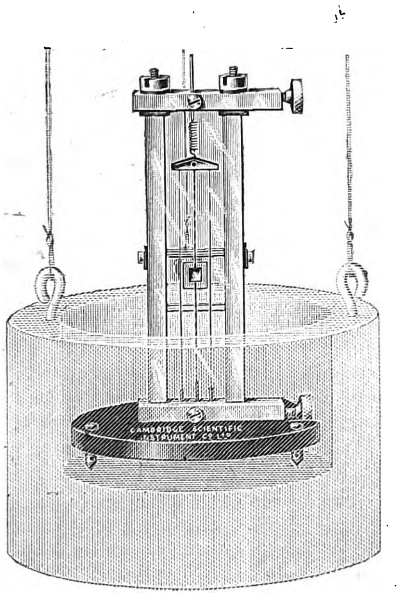


Fig. 3.—Ayrton–Perry–Duddell Twisted Strip Ammeter.

A number of different heaters can be used, varying in resistance from 1 to 1,000 ohms, so that the sensibility of the instrument can be varied from 22 micro-amperes per 10 mm. deflection to 2,000 micro amperes per 10 mm. deflection. The heater from 40 ohms downwards are metal wires, those above 40 ohms consisting of a deposit of platinum on quartz. The instrument can be used for measuring the currents in the receiving aerial in wireless telegraphy, for telephone currents, for the currents used in X-ray tubes and medical induction coils, and a variety of similar purposes. The Cambridge Scientific Instrument Co., who are the makers of this instrument, announce that they are about to introduce a form of thermo-galvanometer with pointer and scale, in addition to the type described above.

Another new instrument which the same makers are now putting on the market is the Ayrton-Perry-Duddell twisted-strip ammeter. This remarkably simple apparatus consists essentially of a very sensitive Ayrton-Perry twisted strip on which the mirror is mounted, and a temperature-compensation device to minimise the zero-creep when the temperature of the whole instrument changes. The instrument is shown in Fig. 3. In the centre is seen the Ayrton-Perry twisted strip, of which the upper part is twisted in one direction and the lower part in the opposite. The mirror, with a very thin mica damping vane is fixed at its centre. The strip is stretched in a frame formed of the lower brass block, which forms one terminal, and a piece of ebonite, the sides of the frame being formed by the compensating wires. This frame itself is stretched by means of a spiral spring fixed to the upper terminal block.

The twisted strip and the compensation wires are made of the same metal; in fact, the strip is actually rolled from a piece of the same wire, so that they all have the same temperature-coefficient of expansion. If the wires and strip rise in temperature equally, then the whole frame simply gets longer and no twist of the mirror ensues. If, however, a current be sent through the twisted strip, then it is caused to heat and twist up, deflecting the mirror. Owing to the fineness of the strip (0·025 mm.) which is heated by the current the instrument is very quick in action. The mechanical periodic time is very short, about $\frac{1}{15}$ sec., so that it is able to follow currents which vary over a small range as rapidly as 1 or 2 cycles per second.

An instrument with a resistance of 20 ohms will give a deflection of 250 mm. at 1,000 mm. scale distance with a current of $22 \times 10^{-3}$ amp., or with a P.D. of 0·44 volt.

The instrument requires screening from quick vibrations of the order of $\frac{1}{15}$ sec. This is accomplished by standing the instrument in a heavy metal block, shown in Fig. 3, which is suspended by means of three wires. This form of apparatus, which has very small self-induction and capacity, can be used for observing the quick variations of the R.M.S. voltage in supply stations produced either by cyclic irregularity of the engine or by phase swinging between alternators or convertors and other similar purposes. By working to a false zero a sensibility of 10 mm. change in deflection for 1 per cent. change in the P.D. may be obtained. By observations of this kind it is often possible to trace the causes of alternators not operating properly in parallel, and to find which engine and which particular defect is the cause.

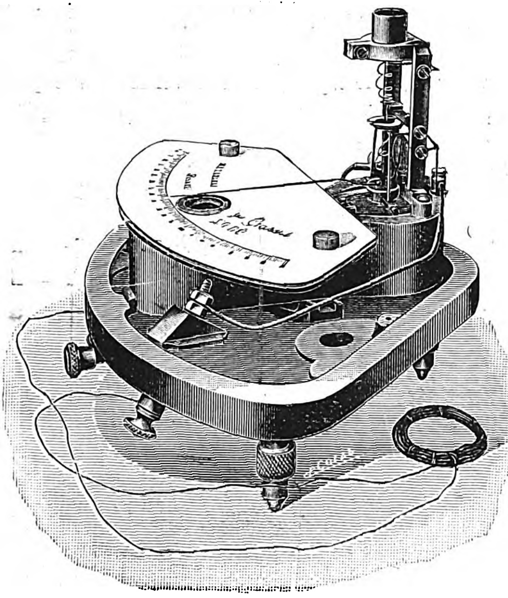


FIG. 4.—GRASSOT FLUXMETER.

The apparatus can be used as a voltmeter down to 0·1 volt and in series with high resistances up to 10,000 volts; it can also, of course, be used with a shunt to measure large currents. The robust nature of the construction renders the instrument suitable for carrying in the pocket.

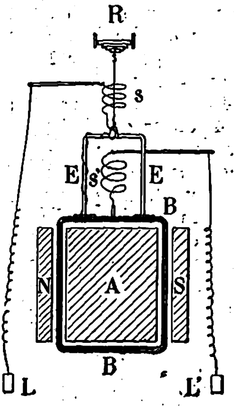


FIG. 5.—GRASSOT FLUXMETER, DIAGRAM OF CONNECTIONS.

The same company are also introducing the Grassot Fluxmeter into this country. This is a suspended ballistic instrument based on a new principle and has the important advantage that its indications are determined solely by the total flow which has traversed the suspended coil, and are independent of the suddenness or slowness with which that flow has taken place. It has the further advantage over the ordinary ballistic galvanometer, that the index, or spot of light, comes permanently to rest at the limit of its deflection. If an exploring coil be connected to the terminals of the instrument and brought into some definite position in a magnetic field, the instrument can be used to measure the flux of magnetic induction embraced by the turns of the coil. When the exploring coil is moved to a position where it is traversed by a greater or less flux than that in its original position, the induction of the instrument starts into motion, and comes to rest again in a new position, the deflection registered being determined solely by the change in the total flux of induction embraced by the coil. Whether the exploring coil is moved suddenly from its initial to its final position, or whether it is moved gradually, the deflection observed is precisely the same. When the exploring coil is withdrawn to its original position, the index returns once more to the reading zero, where it comes to rest. The external appearance of the instrument is shown in Fig. 4, a mirror as well as a pointer being fitted to the moving system. In place of the usual type of suspension, possessing some appreciable torsional stiffness, a single cocoon fibre is employed, the upper end of this fibre being attached to a flat spiral spring, R (shown in Fig. 5), to minimise the effect of shocks. The arrangement of the stiff wire frame E fixed upon the coil B allows of a central attachment of both $s$ and $s'$, which are very thin silver strips, serving to lead the current to and from the coil B. The soft-iron core A is supported within the coil, between the pole-pieces N, S of a permanent magnet, the field in the air-gap being of great and uniform intensity. An arrestment, controlled by a milled ebonite button in front of the instrument, serves to lock the coil when not in use, at the same time bringing the pointer back to zero. The circuit being closed, if the coil is displaced from its zero position and then left to itself, so small a controlling force is exerted by the silk-fibre supension and the two silver-strip spirals that the index only creeps back excessively slowly towards zero. The restoring forces due to torsion in the suspension are practically negligible, the excursions of the coil when once set moving being limited only by damping influences—chiefly electromagnetic damping.

The theory on which the action of the instrument is based is as follows:—

Suppose an exploring coil be joined in series with the suspended coil. Let $r$=total resistance of the circuit, E=E.M.F. induced in the exploring coil at any instant, I=current which at any instant is flowing in the circuit, $\omega$=angular velocity with which the suspended coil is turning at any instant, $\theta$=angular displacement of the coil reckoned from tho zero position, L=co-efficient of self-induction of the whole circuit, $Mk^2$=moment of inertia of the suspended coil, $-K\omega$=E.M.F. induced in the suspended coil B owing to its angular velocity $\omega$, CI=mechanical turning moment experienced by the coil B in virtue of the current I flowing through it, $-A\omega$=mechanical turning moment exerted on the coil B owing to the resistance of the air.

Now the pole pieces and the core are so shaped that, throughout the range of its possible motion, the coil lies in a field of unvarying strength, the other circumstances affecting it being likewise invariable; accordingly L, K, C, A are all constant. Thus we have

$$E - Ir - K\omega - L\frac{dI}{dt} = 0 \text{ and } Mk^2\frac{d\omega}{dt} = -A\omega + CI.$$

Whence

$$I = \frac{E - K\omega - L\,dI/dt}{r},$$

therefore

$$Mk^2\frac{d\omega}{dt} = -\left(A + \frac{CK}{r}\right)\omega + \frac{C}{r}E - \frac{CL}{r}\frac{dI}{dt}.$$

In integrating with respect to the time, we will confine ourselves to the practical case, in which the swinging coil rests initially in the zero position with no current flowing in the circuit; while after exploring coil has been introduced into a magnetic field and brought to rest there, we observe the new position in which the index of the instrument comes to rest, the current being then, as at first, zero. Thus at both limits of the time-integration we have $\omega=0$, $I=0$, consequently the above may be written

$$0 = -\left(A + \frac{CK}{r}\right)\int\omega\,dt + \frac{C}{r}\int E\,dt, \quad \text{or} \int E\,dt = \left(\frac{A}{C}r + K\right)\theta.$$

Since A, C, $r$ and K are all constants of the instrument and its connections, we have the interesting result that the deflection $\theta$ is determined solely by the total value of the electromotive impulse $\int E\,dt$; and is the same whether that impulse is suddenly or gradually applied. In the last equation the coefficient of $\theta$ is made up of two terms, of which the first arises from air damping, and the second from electromagnetic damping. The air damping is relatively very slight, so that the term $\frac{A}{C}r$ may be neglected, that is to say, the resistance of the circuit has a negligible effect on the result.

The instruments are standardised experimentally. With an exploring coil of about 100 turns, with a mean area of about 6 sq. cm., field strengths up to about 1,700 lines per square centimetre can be measured.

The fluxmeter has a wide range of usefulness besides the measurement of field strengths in air gaps, &c., of dynamos and motors. Investigations can be made on the distribution of magnetism in various forms of permanent magnets, and measurements of permeability and hysteresis as well as the quantity of electricity discharged by a condenser.

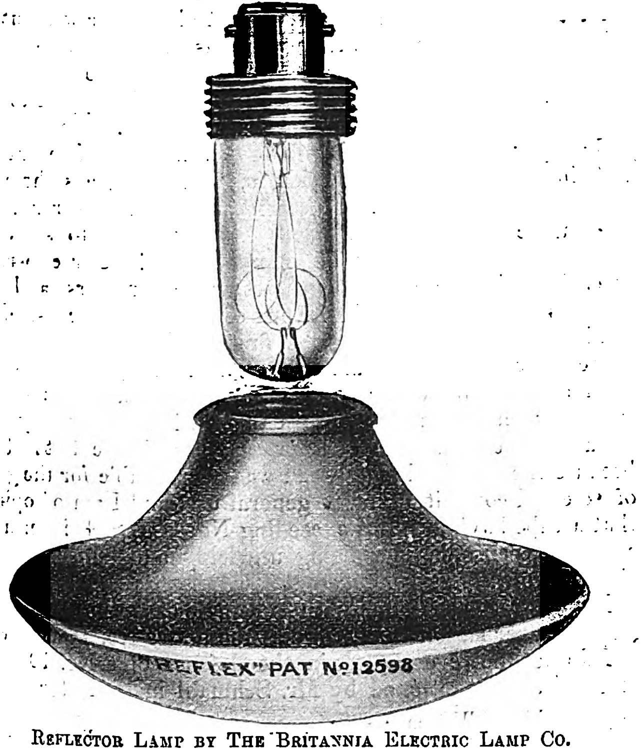
## A NEW INCANDESCENT LAMP.

A new form of reflector lamp has been recently brought out by the Britannia Electric Lamp Works (Ltd.) of South Tottenham. The lamp, which is known as the "Reflex," consists of an outer bulb of special form, shown in the illustration, with a reflecting surface. The lamp itself, which is of the short tubular type, is inserted in the centre of the reflector, and secured by a screw thread on the enlarged portion of the lamp cap. The outer bulb is of glass silvered on the back, and is provided with a ventilation hole. The distribution of light is very uniform, and the gain in illumination over a lamp without reflector is very marked.

The following figures are taken from a test made on one of these lamps by the Westminster Electrical Testing Laboratory :—

| | |
|---|---|
| Maximum horizontal candle-power without reflector .... | 19·0 |
| Vertical candle-power without reflector ................ | 10·9 |
| Vertical candle-power with reflector ................. | 84·9 |
| Watts.............................................. | 68·5 |
| Watts per max. hor. candle-power without reflector...... | 3·60 |
| Watts per vertical candle-power without reflector ...... | 6·28 |
| Watts per vertical candle-power with reflector .......... | 0·93 |

The distance from the photometer screen to the centre of the lamp was 49 in. when the measurement with the reflector was made. At any other distance, probably, some slight difference in the candle-power would have been found on account of the focussing effect of the reflector.



Reflector Lamp by The Britannia Electric Lamp Co.

These lamps are manufactured by the Britannia Electric Lamp Works (Ltd.) at their South Tottenham Works under the supervision of Mr. S. Howath, to whom we are indebted for the information contained in this article. The works has not been long established, but already turns out a very considerable output of incandescent lamps of the ordinary type, as well as these reflector lamps. We understand, however, that large extensions are about to be made, and when these are complete we hope to give some further particulars of the methods of manufacture, including some new improvements upon which the company have now concluded their experiments, and look forward to a justification of their belief that their old friend the carbon filament lamp has received a new lease of life.

**A New Method of Protecting Cables.**—Herr Ernst Kuhlo, manager of the Stettin electricity works, describes, in a recent issue of the *Elektrotechnische Zeitschrift*, a new method of armouring electric cables devised by him and used with satisfactory results in connection with some 20 miles of network in Stettin. The method consists in surrounding the conductor or conductors with insulation and pressing a hard metallic cover around the whole so as to leave no air-space between the armouring and the insulation. Brass has been largely used so far, but copper and steel are also suggested. Although the thickness of metal is sufficient to protect the conductors from mechanical injury and chemical influences, it is stated that the tube formed has a certain flexibility all the same. Cables protected in this manner are laid directly in the ground.

# CORRESPONDENCE.

## THE WILLANS AND ALLIS-CHALMERS STEAM TURBINES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: With reference to the description of the Allis-Chalmers steam turbine which appeared in your last week's issue, we would like to point out that this turbine is of the standard pattern made by Messrs. Willans & Robinson, subject to some later improvements, and that it includes methods of blade-fixing embodied in the now well-known patents of Willans & Robinson and Captain Sankey, the property of Messrs. Willans & Robinson, the American rights in which have been assigned to the Allis-Chalmers Co. Though it is not so stated, it might possibly be inferred by a reader not acquainted with this fact, that some features of the design are of American origin, and it may be of interest to say that such is not the case.—Yours, &c.,

Willans & Robinson (Limited),
Rugby, Jan. 16. C. S. Essex, Secretary.

## Dr. ERSKINE-MURRAY'S PAPER ON WIRELESS TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your article of December 15, 1905, on "Recent Advances in Wireless Telegraphy," I find on page 357, under the paragraph "Limited Distance in Transmission," the following: "If the electric waves used in wireless telegraphy retained this form (hemispherical electric wave) we should find that the currents resulting from their action on the receiving aerial would vary inversely as the square of the distance."

In none of these discussions concerning limited distance have I ever seen mention of the very important factor of atmospheric condition at the sending and receiving stations. In my opinion, no formula for power necessary to produce readable signals at a certain distance will be complete until the atmospheric conditions are taken into account. I experimented for an entire year in Alaska at the sets erected by the United States Army at Nome and St. Michael, and found that when a high wind containing much moisture was present at either station or at both stations the strength of the signals in the receiver fell off appreciably. Daily observations were made of barometer, thermometer, and anemometer, at both stations simultaneously, and in connection with these readings, the direction of the wind, the amount of moisture in the atmosphere, and the incoming strength of the signals received. At the sending station the high wire is charged to a high potential, and is quite small in amount of current. It is, therefore, quite reasonable to suppose that before this potential breaks down over the spark-gap, a certain amount of it is taken away by vapour globules driven against it by the wind, which particles are charged to the full voltage on the antenna at the time and carried away. All particles so charged take away from the effective strength of the signals at the receiving end. The same thing occurs to a less degree at the receiving end during the building up of the current, due to the continued train of waves cutting the receiving antenna, although to a much lesser degree.

These experiments were not contemplated at the time the stations were erected in Alaska, and the apparatus was, in consequence, quite crude. My method for determining the relative strength of the receiving impulse was to shunt a certain portion of the current in the telephone receiver by a resistance box placed across the telephone cords. By decreasing the resistance, the signals, of course, became fainter as the greater portion of the current was shunted from the spools. By cutting the sounds down so that the test letter was just distinguishable, a relative measure was obtained by the amount of resistance unplugged. The receiver used was an electrolytic one, and the strength of the signals was therefore in direct proportion to the amount of wireless current passing through this receiver, and was not entirely due to the secondary current, as would be the case if a filings coherer had been used.

If my theory is tenable, it would seem that a large spread of wires in a moist, windy locality, would be inadvisable, and that the smaller the impinging surface, upon which the vapour particles could strike, the better would be the signals between any two stations.—Yours, &c.,

L. D. Wildman,
Captain, Signal Corps, U.S.A.,
Chief Signal Officer, Dept. of California.
San Francisco, Cal., Jan. 2.

[If our correspondent's view of the matter is correct, it should, we think, be easy to remedy the evil. If, instead of bare wire—which, we presume, he used—insulated wire were employed, no such direct discharging action could occur. Covered wire has been widely used already in ordinary climates, and possesses, we believe, no property deleterious to signalling.—Ed. *E.*]

TO THE EDITOR OF THE ELECTRICIAN.

Sir: On further consideration I find that the part of a hemispherical wave close to the conducting plane is approximately cylindrical. The two theories are therefore identical as regards the earth's surface. In either case the divergence of the waves at the surface should follow the law I have given. In regard to the upper atmosphere I did not deny that dissipation of energy would take place. It undoubtedly does take place there, and the loss caused is one factor of the dissipation term in the equation. It is possibly the factor which determines the day and night variation. It is thus undeniably correct to say that on either theory the waves near the earth are cylindrical; and as to the upper layers of the atmosphere, is not a theory which takes into account the known facts in regard to these better than one that does not? particularly when by so doing the theory lends itself readily to the explanation of the phenomena of dissipation.

I have to thank you for drawing my attention to Oliver Heaviside's article on Telegraphy in the Encyclopædia Brittanica, and am much pleased to see that my theory, though arrived at independently, is really an elaboration of one of his suggestions. In regard to the distance of penetration of the waves into the conducting layer of the upper atmosphere, I may point out to what an extremely small distance high frequency waves penetrate a conductor. In one of J. J. Thomson's experiments a layer of rarified air, about ½ in. thick, formed a perfect screen for electric waves.—Yours, &c.,

Glasgow, Jan. 10. J. Erskine-Murray.

## MAINTENANCE OF UNDERGROUND MAINS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Referring to your editorial on my Paper, "The Maintenance of Underground Mains," I should like to correct the impression it may convey that the Glasgow mains have been laid by contractors. Practically, the whole of the extensive distribution system of the Glasgow Corporation Electricity Department has been put down by the department's own workmen under the superintendence of the Corporation's mains engineers.—Yours, &c., G. L. Black.

Glasgow, Jan. 16.

## HOW TO SCREW CONDUITS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your last issue, Mr. Schmahl of the Armorduct Mfg. Co., under the heading of "How to Screw Conduits," appeals for uniformity in gauges and threads for tubing used for electric wiring purposes, on the basis of "Gas Sizes, Screwed Standard Gas." While there can be no question that standardisation is advisable, I cannot agree that gas standards should be adopted, nor with the reasons which Mr. Schmahl adduces in support of his arguments for their selection.

My own impression is that in the early days electric development was to an appreciable extent retarded by the too slavish copying of gas methods; the clumsy heavy electroliers manufactured after the pattern of the old gas chandeliers were an eyesore to everyone; but it was apparently taken for granted that what was necessary for the old illuminant was equally required in the new, despite the fact that the conditions were altogether different. The gas tube, with its rough and uneven surface was even taken as a standard conduit, until experience taught differently, and so on.

To deal with Mr. Schmahl's arguments in order: "So far as conduit tubes are concerned, my company has moved in the opposite direction to the majority of tube makers." Is this to imply that the whole of the conduit manufacturers have been developing on wrong lines, and the Armorduct alone, under the guiding hand of Mr. Schmahl, producing the ideal conduit? If we are to believe this startling announcement, very strong evidence is required to show that conduit manufacturers are gifted with such a small amount of foresight as he attributes to them.

Mr. Schmahl next endeavours to support his contention by telling us: "My company have supplied their standard Armorduct screwed conduit, screwed gas size, and the material has been used for a large number of important installations." Here we have dished up the old trade puff, and probably every conduit manufacturer desirous of a free advertisement could say the same thing about his conduits, screwed with Whitworth threads; if it were not so the presumption would be that they would not be doing business in screwed conduit.

The statement, "Needless to say I shall not only advocate standardisation on the basis of gas sizes and gas threads, but . . . . tubes of heavier gauge," is not altogether without bias. The Armorduct Co. sells tube with gas threads, and obviously for this reason, though ostensibly on the broader question of uniformity Mr. Schmahl is willing to lend his support to standardisation, provided gas threads are adopted.

Lastly, "I have made inquiries of a number of contractors, and in every case the opinion is, 'Gas sizes, gas threads.'" Once again the free advertisement, the manufacturer telling the public that his (unbiassed) inquiry tends to show that everyone demands what he manufactures! Our experience is entirely in the opposite direction, contractors and consultants being strongly in favour of the exclusive use of the Whitworth thread, which was first used by the company I represent some seven years ago. This thread, which has since been adopted by other conduit companies, and has become generally known as the Simplex thread, is in every way more suitable for conduit work. It was selected in the first instance because the standard gas thread was not suitable for the gauge of screwed conduit in most general use, and I am of opinion that a tube having a wall exceeding No. 14 L.S.G. is an unnecessary expense, besides being unwieldy and unnecessary for electric work.

My company have not, with the single exception of the ½ in. conduit, ever supplied a screwed tube under No. 16 L.S.G.

I do not, however, speak in the defence of a No. 19 gauge screwed tube mentioned by Mr. Schmahl in his letter, as this must be mechanically weak.

The so-called advantages of adopting gas standards for the electrical conduit trade are, in my opinion, illusionary, for the following reasons:—

1. They necessitate the use of a special size conduit (gas size), which, with the exception of a few instances, do not conform to the standard conduit tube sizes used by the conduit trade in this country for electric wiring.

2. The fact so often urged that a contractor may have a set of gas stocks and dies is hardly worth consideration, as the initial cost is not heavy, and the state of the dies due to the rough usage to which they are subjected in the gas trade unfits them for use in conduit wiring.

3. The fact of using gas sizes gives rise to the very grave risk incurred when, for the sake of convenience, cheapness, &c., rough cast-iron gas fittings are used in place of properly-designed malleable conduit fittings.

It seems to me that all Mr. Schmahl's statements present no argument in any way favourable to the adoption of gas sizes and threads. I submit that unless very strong reason to the contrary is shown, it is permissible to assume that whatever sizes and gauges are in most general use at the time, are those which taken all round are the most advantageous for their purpose, and although I am quite prepared to take part in any meeting with the object of standardisation in the conduit business, I hardly think such a meeting will have much chance of achieving any useful purpose if others like Mr. Schmahl attend it with the avowed object of only supporting it on the basis which happens to be the most suitable for their own purposes.—Yours, &c.,

THE SIMPLEX STEEL CONDUIT CO. (LTD.),
L. M. WATERHOUSE,
London, Jan. 16. Director and General Manager.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read Mr. Schmahl's letter in your last issue, but am unable to understand the purport of it. If his desire is to advertise the fact that he is now using gas standard threads, I may be allowed to compliment him on following the example of my company (the General Electric Co.) and others, who have always employed them.

As I understand the case, however, the *proposed meeting* is to decide what standard shall be adopted, and the pros and cons to be considered do not concern the user or the consulting engineer. I, as well as others, have fully understood the idea of the trade for years, and you will find it clearly illustrated by the specifications of the leading consulting engineers, which invariably call for standard gas threads.

If, however, it is thought advisable to settle this matter by public correspondence, the manufacturers who were present at the last meeting may consent to waive their right of being considered in the matter; but as it is necessary that a uniform decision should be arrived at for any good purpose to be served, and seeing that Mr. Schmahl has already made up *his* mind on the point, I am forced to conclude that either our sympathy is due to those firms who now employ special threads, or, as is more probable, the discussion will result in a waste of time and your valuable space.—Yours, &c., C. E. GUNNER.

London, E.C., Jan. 16.

# LEGAL INTELLIGENCE.

### Swansea Corporation v. National Telephone Co.

In the Appeal Court on Tuesday Lord Justice STIRLING, in referring to this case, said it was proposed to refer certain questions for inquiry and report to a referee. The Court had made inquiry as to the person to whom such a matter might be referred, and were of opinion that Major Cardew, late R.E., would be a proper person to whom the matter might be referred on the following lines:—

*First*, whether the laying down of sufficient junction wires between the several exchanges of the Corporation and the company respectively at Swansea, Mumbles and Morristown will afford all proper facilities for the transmission of telephonic messages between persons using the systems of the company and of the Corporation. *Secondly*, if not, whether, in order that all such proper facilities should be furnished, it is necessary that the company should provide junctions, circuits, and directly connect its principal exchanges in Swansea with nine other places mentioned, or any and each of such places. *Thirdly*, whether any and what additional steps ought to be taken by the Corporation and the company respectively in order to afford such proper facilities.

Mr. DANCKWERTS thought this did not make provision for what appellants considered the crux of the matter—namely, that wherever exchanges were connected the connection should be by means of double wires—one for all messages from the company's station to the Corporation station and another for messages in the opposite direction.

Lord Justice STIRLING thought that was clearly provided for in the second clause.

In the result, Lord Justice VAUGHAN WILLIAMS said the better plan would be for counsel to exchange views, and mention the matter to the Court on Monday next.

### In re Delmico (Ltd.)

In the Chancery Division (Dublin) on Monday, Mr. Justice Barton dismissed an application on behalf of the General Electric Co. (Ltd.) for the compulsory winding up of defendant company. The registered office of the company was in Dublin, and the nominal capital £2,000 (in £1 shares), the objects of the company being to acquire the business of the Modern Electric Appliance Co. The company was indebted to petitioners for £45. 16s. 10d. for goods sold and delivered. On April 13, 1904, defendant company passed a resolution to wind up, and appointed Mr. R. Stephens liquidator. The petition was brought for information as to what had become of the assets. Plaintiffs wanted an explanation from Mr. Stephens. The balance-sheet showed an apparent surplus of assets over liabilities of £200. The creditors had, however, received nothing. The principal portion of the stock consisted of Delmico lamps and fittings, the voltage of which was unsuited for use in Dublin. The liquidator had unsuccessfully endeavoured to sell the business as a going concern.

### J. Defries & Son (Ltd.) v. Hare and Brown Potter.

In the King's Bench Division last Monday the hearing was concluded of an action in which plaintiffs sought to recover £154 for work done and goods supplied at and to Savoy Theatre, London. The goods consisted of electroliers which were used for a particular scene, and also a number of bracket lights. As the defendant, Mrs. Brown Potter had become bankrupt since the action was brought, and Mr. Justice Bingham had decided that her debts had become capable of proof, the only action was against the defendant, Mr. Gilbert Hare, who denied that the work was done for him or by his authority.

In the result his Lordship said he should act on the assumption that the business was carried on by Mrs. Brown Potter for her own benefit, and that Mr. Hare was in no sense a principal or partner. That being so plaintiff's case failed on that point. But plaintiffs said that Mr. Hare had held himself out as principal, and that, therefore, he was liable. On the facts of the case, he came to the conclusion that such was not the case, and he gave judgment for defendant with costs.

### Dickson v. R. W. Blackwell & Co.

At Perth Sheriff Court on Monday Sheriff Sym delivered his judgment in this action, brought by a labourer named Dickson to recover £300 damages under the Employers' Liability Act, 1880, or, alternatively, £178 at common law. On May 22, 1905, pursuer was engaged, along with five other workmen, in lifting tramway rails on to a lorry at the Shore, Perth, when one of the rails canted and fell and injured pursuer and another workman. Pursuer averred that defenders were at fault in not employing a larger number of men for the job and carrying out the work with the assistance of a crane. Defenders pleaded that the operation was a usual and proper one, and that the accident was caused solely through the fault or negligence of the fellow-servants of pursuer in releasing their hold of the rail in course of its being lifted after it had been slightly raised from the ground. They also pleaded that it was common knowledge that the rails could be safely and properly loaded without the assistance of machinery, and that the work was merely labouring work, which required neither knowledge nor skill.

The Sheriff upheld defenders' contention and held the action to be irrelevant.

### Greaves v. Stalybridge, Hyde, Mossley and Dukinfield Tramways and Electricity Board.

A decision was given at Stalybridge County Court on Jan. 11 by Judge Brown, K.C., in an action wherein plaintiff claimed £30 damages for injuries sustained whilst travelling in an electric car on June 10 last.

For the Board it was contended that under sec. 1 of the Public Authorities Protection Act, 1893, that as plaintiff did not commence proceedings until Dec. 11 he was one day after the six months' limit.

For plaintiff it was argued that as the last day of the six months fell on a Sunday he was entitled to commence the action on the following day.

The judge ruled that plaintiff was not entitled to the extra day, and gave judgment for defendants.

### In re Bahia Blanca and North-Western Railway Co. (Ltd.)

In the Chancery Division on Tuesday Mr. Justice Warrington granted a petition of the company to alter the memorandum of association.

Mr. HAMILTON, K.C., said the company had an electric tramway between the town and the port of Bahia Blanca, and, as it had to produce electricity for that, the directors thought they could work it more economically if they were allowed also to supply electricity to other people in the port.

**Electrical Ore Finding Co. (Ltd.)**—In the Winding-up Court on Tuesday the petition for compulsory winding up was withdrawn, the company having gone into voluntary liquidation.

**British Pioneer Electric Light & Power Co. of India (Ltd.)**—The Court of Appeal (the Master of the Rolls and Lords Justices Romer and Cozens Hardy) last week dismissed the appeal of S. T. Biggs and G. R. Sawyer against the dismissal by Mr. Justice Joyce of a petition for the compulsorily winding up this company. Voluntary liquidation has been decided upon.

# MUNICIPAL, FOREIGN & GENERAL NOTES.

## APPOINTMENTS VACANT AND FILLED.

Oldham Corporation Electricity committee require a junior assistant electrical engineer. Salary £80, increasing by annual increments of £10 to £100. Applications to the borough electrical engineer (Mr. S. Wilmott Newington) by Jan. 22.

Two junior demonstrators and lecturers are required (to begin work on May 1, 1906) at University College, Nottingham, one for physics and the other for engineering. Applications by Feb. 10 on forms to be obtained from the registrar. See an advertisement.

A well-known firm of electrical engineers (a limited company) require a gentleman to act as secretary or commercial director. Would be required to invest £2,000 to £5,000, and should possess good commercial and some engineering knowledge. Applications to Thos. Bowden, Son & Nephew, 42, Mosley-street, Newcastle-on-Tyne.

The Brush Electrical Engineering Co. invite applications from competent engineers to fill an appointment abroad. Applicants must have good all-round business-engineering experience and be capable of estimating for, negotiating and carrying through engineering schemes, &c. Applications to "A," Brush Co., Belvedere-road, London, S.E.

The Brush Co. also invite applications from engineers competent to act as district representatives. Applications to "J.," Brush Co., Belvedere-road, S.E.

A professor of physics is required at the East London College in succession to Dr. Lehfeldt. Salary £400 per annum. Applications by Feb. 8.

Hackney (London) Council require an electrical draughtsman. Salary £130 per annum. Applications by 4 p.m. Jan. 29.

Leyton Council want a clerk of works to superintend the construction of the permanent way of new tramways. Salary £3. 5s. per week. Applications by noon 27th inst.

Mr. J. P. Kemp, recently representing Sir A. B. W. Kennedy on the Mersey Tunnel contract, has been appointed resident engineer at the Summer-lane station of Birmingham Corporation.

Mr. Frank Forrest, of the Charing Cross, West End & City Electricity Supply Co., has been appointed sub-stations superintendent in the Birmingham electricity supply department. Mr. Forrest takes up his duties in Birmigham on March 1.

Mr. John Eustace, formerly mains superintendent to West Ham Corporation electricity department, has been appointed deputy engineer and manager of the department, at a salary of £200 per annum.

Mr. J. E. H. Preedy, of Southampton, has been appointed mains engineer at Dartford.

Liverpool Electric Power and Lighting committee recommend the appointment of Mr. Alfred G. Smith, assistant lighting engineer, as gas inspector and superintendent of street lighting, at £400 per annum.

**Alleged False Pretences.**—At Marlborough-street (London) Police Court, recently, John Saunders Sayer, engineer, was committed for trial on a charge of having obtained by false pretences sums of £1. 10s. 6d. and £2. 2s. from Mr. Duncan Watson, electrical engineer, Charing Cross-road, London.

Mr. Watson stated that in September Sayer called at his office and asked if he would tender to specifications (which he produced) for electric lighting of certain country residences. Believing the specifications to be bona fide, he tendered, and when Sayer asked for deposits he advanced them, but declined to lend him money to pay expenses for a visit to the country in connection with the matter. One of the tenders amounted to £630 and another to £1,160. Later defendant wrote stating that two of the contracts had fallen through. He (Mr. Watson), since the arrest, had received from prisoner a cheque for the money advanced, but had not paid it into his bank.

Detective-sergeant Curry said he had ascertained that the prisoner had obtained about £200 during the past few years.

**Australasia.**—At Broken Hill, N.S.W., the local Electricity Supply Co. serve a district with a population of about 30,000. Single-phase current has been supplied for private lighting and power since 1891, overhead distribution, with transformers on posts. The municipal authorities have under consideration the question of buying out the present company and adopting electricity for street lighting. The Broken Hill mines are commencing to employ electricity for power, and the "Block 10" and "Central" mines have three-phase plant at work aggregating respectively 600 H.P. and 750 H.P. The "Proprietory" mine is using electric haulage (direct current trolley wire) on its tailing dumps, while several of the other mines are, we understand, seriously considering the question of electrification. In fact, most of the mines already have small electric plants for lighting their offices and in some cases the shafts, but none are systematically lighted underground up to the working faces. Adelaide, Melbourne, and Sydney are the source of supply of all kinds of electrical goods to the Broken Hill district, British, American and Continental houses being well represented in these cities.

**Bermondsey.**—The Council have agreed with the London Electric Supply Corpn. for the supply by the company of current for lighting the new St. Olave's library at 3½d. per unit.

**Birmingham.**—The Board of Trade have withdrawn their objection to the use of covered-roof tramcars. Some time ago the Corporation gave an order for 200 new cars, and 50 of these are too far advanced for the top decks to be added except at considerable expense. The remaining 150 will, however, be constructed according to the design originally approved by the committee.

**Birmingham and District Electric Club.**—The Presidential address read by Mr. J. A. Jeckell to the members of this club on Saturday last dealt with general rather than technical problems. The greater part of Mr. Jeckell's address was taken up in comparing British and foreign characteristics and methods, and numerous instances were cited with the object of proving that some of our methods were slipshod and antiquated compared with those of our competitors of other nationalities. The speaker attributed much of this to a lack of proper technical education, and pointed out how the extraordinary ease and accuracy with which calculations could be made in connection with electrical engineering problems had undoubtedly formed one of the chief factors in developing this great industry. Men whose minds were trained to these accurate scientific calculations naturally looked critically into other branches of manufacture, and wondered why the same extraordinary accuracy could not be at any rate imitated in connection with these branches of work.

**Birstall.**—The Council have received sanction to a loan of £2,000 for electricity supply.

**Bolivia.**—On Dec. 1 last the line of railways built by the Bolivian Government (and to be worked on full completion by the Peruvian Corpn., Ltd.) was opened at La Paz. The line, which consists of 6 miles of single track, is built to metre gauge and is worked on the overhead trolley system. The total length of railway at present in operation is 9 km. of electric and 87 km. of steam. The power house equipment includes two 600 H.P. gas engines, made by the Premier Gas Engine Co., of Sandiacre, Nottingham, and driven by Mond gas plant, manufactured by the Power Gas Corpn., Stockton-on-Tees. La Paz is the chief city of Bolivia, and lies in a cup-shaped hollow. The steam railway stops at a place called the Alto, 1,500 ft. above the city, and the electric line has been built to bring down the passengers into the city proper, an operation which has hitherto been performed by mules and antiquated vehicles. The track of the electric line, due to the gradient (max. 1 in 16, ruling gradient 1 in 18, sharpest curve 325 ft. radius) is of engineering and scenic interest. The reason for adopting gas plant as motive power is that coal at La Paz costs £6 sterling per ton.

**Brandon and Byshottles.**—A meeting of ratepayers has passed a resolution protesting against the action of the Council in withholding their assent to the application of the County of Durham Electrical Power Distribution Co. for a provisional electric lighting order. The company offered to supply current at 3¾d. per unit less 5 per cent., and the present price of gas in the district is 3s. 2d. per 1,000.

**Chili.**—A decree has been issued granting the Compañia General de Electricidad a concession for supplying current for lighting and power to the town of La Cruz (Quillota).

**Colchester.**—The Council have agreed to reduce the charge for electric current supplied to Colchester Barracks to 3½d. per unit.

**Devonport.**—At the end of 1905 the equivalent of about 30,000 8 c.p. lamps was connected to the electric lighting mains. An agreement has been entered into between the Admiralty for the supply of electricity to the Royal Marine barracks and long room.

**Dundee.**—The Caledon Shipbuilding & Engineering Co. are about to adopt electric driving for their larger machines, some of which require to run continuously throughout the night, and have suggested that the Corporation should allow them a throw-over switch, permitting of power being drawn from the public mains, when required. This, however, the Electricity committee recommend the Council, on the advice of the borough electrical engineer (Mr. H. Richardson), not to concede.

The electric lighting mains are to be extended to San Salvador Church.

**Electricity in Mining.**—Reporting upon the employment of electrical machinery and apparatus in the South Wales district, a contemporary states that

> The exceptionally gaseous nature of South Wales steam coal prohibits the general use of coal cutting machines, but for haulage, lighting and various surface as well as underground purposes electricity has been introduced on a very large scale. A few of the collieries (notably the Powell Duffryn) have laid down their own producing plant, but the majority of the collieries obtain their supply from the South Wales Power Distribution Co. The electric power plant at the Powell Duffryn Steam Coal Co.'s Aberaman collieries is at Middle Duffryn, in a central position for the supply of power and light to seven of the company's collieries, and the horse-power of motors at each colliery at the present time is as follows:—Aberaman 1,020, Cwmneol 340, Fforchaman 765, Old Duffryn 545, Lletty Shenkin 450, Abercwmboi 230, Washery 100, Lower Duffryn 1,200. Total 4,650 H.P.

**Exhibition.**—The North Eastern Counties Electrical Exhibition will be held in the Exhibition Hall, St. Mary's-place, Newcastle-on-Tyne, from March 24 to April 21 inclusive. The exhibition, which is under the auspices of the local electricity supply companies, Sunderland Corporation electricity department, the Electrical Contractors' Association (northern section), &c., is being organised for the purpose of displaying the latest developments in electric lighting, traction, power, heating, &c.

**Falmouth.**—The Council have approved the plans for the erection of electricity works, and the work of cable laying has commenced.

**Fatalities.**—A sad fatality occurred at Bath on Sunday last. A little boy having fallen into the river Avon, an engine-man named Jas. Gibbons and a stoker named Geo. Wood, employed at the Corporation electricity works, and who happened to be passing, immediately plunged into the water and made a gallant but unsuccessful attempt to rescue the child. Unfortunately, Gibbons was carried down by the flood and lost his life. The Mayor (Mr. C. B. Oliver) has opened a fund on behalf of the widow and children of Gibbons, and amongst the subscribers are the borough electrical engineer (Mr. Francis Teague) and several members of the Council.

At an inquest which was held at Manchester on Monday into the death of a man who died from the effects of a fall from a tramcar on the previous Friday the coroner (Mr. E. A. Gibson), asked if the accident would have occurred had the staircase been enclosed, and a tramway official said the enclosed staircases were being condemned by the Board of Trade. In fact, there was now a regulation that they would not be passed as this type of staircase obstructed the view of the motor-man. A verdict of accidental death was returned.

**Fire Alarm Systems and Fire Risk Rates.**—The Fire Offices Committee have at length decided to reduce the cost of insurance to users of approved automatic alarms. The extent of the reduction has not yet been announced, nor are the regulations yet issued, but the committee have notified the May-Oatway Fire Appliances (Ltd.) that their system has been approved and will carry the rebate. At the end of 1904 the May-Oatway Co. put in a petition, headed by the Glasgow Corporation and very influentially signed, asking the committee to recognise the company's automatic alarm in this country, and pointing out that they had already done so abroad for nearly two years. The result is that the committee after a lengthened and patient investigation, have not confined the recognition to the May-Oatway Co.'s excellent system, but have included others as well. The decision should have the effect of greatly extending the use of automatic fire alarm systems, which have now reached a high degree of reliability. We understand that the Pearson fire alarm system has also been approved by the Committee.

**Glasgow.**—The Electricity committee recommend that in future where a supply of electricity is taken for power purposes of 500,000 units or more per annum, with not less than 2,000 hours' use per annum, the charge shall by $\frac{3}{4}$d. per unit.

**Handsworth.**—The Council have decided to oppose the Shropshire, Worcestershire and Staffordshire Electric Power Bill.

**Harrow-road and Paddington Tramways.**—The Board of Trade have approved the plans submitted by the Harrow-road & Paddington Tramways Co. for the reconstruction of their tramways. On the request of the company approval has been given to the use of Thermit welded joints.

**Huddersfield.**—For the nine months ended Dec. 31 the tramway traffic receipts amounted to £56,750, and total working expenses to £28,913, the gross profit being £27,837. After meeting capital charges and paying rent of leased lines (£18,386), the net profit was £9450.

**Hythe.**—The Council have decided, by the mayor's casting vote, to support the National Electric Construction Co.'s tramways scheme, subject to the company entering into an agreement to carry out certain street widenings and to deposit the money promised for the Council's assent.

New Romney Council will support the Sandgate & Hythe Tramway Co.'s scheme for the construction of electric tramways in this district, provided the company pay the Council's expenses and deposit £500.

**Isle of Thanet Tramways.**—The Isle of Thanet Electric Tramways & Lighting Co. notify that a portion of the line in Ramsgate will be altered in accordance with the suggestion of the Board of Trade inspector, and that investigations are proceeding with a view to discover the most satisfactory apparatus for the application of the slipper brake.

**Italy.**—Official sanction has been granted to the Postal Telegraph Department for the expenditure of about £95,000 on the erection of new telegraph lines and the improvement of the existing telegraph service of the following towns: Genoa and Messina, Naples and Turin, Bari and Florence, Reggio (Calabria) and Naples, Rome and Venice, Genoa and Milan, Florence and Milan, Milan and Venice. The expenditure is to be spread over seven years.

**Korea.**—A correspondent informs us that the political upheaval in Korea has caused numerous changes, extending, he understands, to those who have hitherto been directly associated with the Korean Government telegraph and electricity departments. The former Director-General of Korean telegraphs (Gen. Min Sang Ho) has been replaced, and Mr. Muhlensteth, who has for many years occupied the post of Superintendent of the Imperial Korean Telegraphs and telephones, has also had to make way for a Japanese official. Mr. Muhlensteth, we believe, is remaining at Seoul, exercising his profession as an electrical engineer and open to transact business in Korea on behalf of British firms. We understand that English capital is shortly to be invested in the extensions and improvements, and the American-owned and managed tramway system. These extension works and new lines of tramways are to commence construction in the early spring of 1906.

**Lanark.**—The County Council have decided to proceed with their applications for provisional electric lighting orders for Bothwell, Uddington, Bellshill, Blantyre, Shettleston and Tollcross. The Council have also decided to oppose the Rutherglen (Burgh) Order.

**Light Railways.**—Cirencester Council will oppose the Cirencester-Fairford light railway scheme unless the promoters abandon a proposed level crossing and substitute a bridge.

Objections to the transfer of the Halesowen Light Railways Order to the Empire Electric Light & Power Co. must be lodged with the Light Railways Commissioners by 27th inst.

**Liverpool.**—During the past year 119,124,644 passengers were carried on the Corporation tramways and the car-miles run were 12,066,963, the receipts being £550,121, an increase of £9,205 for 1904.

**London County Council Tramways.**—Successful trial runs were made on the new section of the electric tramways between Lewisham Obelisk and a junction with the Greenwich route at the "Marquis of Granby," New Cross. The new line will probably be opened early next week. Another extension from Lewisham Obelisk to Rushey Green is being constructed and will be ready for working in two or three months.

**Longton.**—The Council have fixed the charges for current supplied between 6 a.m. and 6 p.m. for power at $2\frac{1}{2}$d. per unit up to 500 units per quarter, $2\frac{1}{4}$d. up to 1,000, 2d. up to 1,500, $1\frac{3}{4}$d. up to 2,000 and $1\frac{1}{2}$d. up to 10,000 units.

**Maidstone.**—The Electricity and Light Railways committee have been authorised to organise an electrical exhibition to be held in the early spring.

**Municipal Telephony.**—Manchester Telephone committee considered on Thursday last week a further communication from Messrs. W. Thomson and F. Scott (representing the Mutual Telephone Synd.) emphasising their claim to reimbursement by the Corporation of certain expenses incurred by them prior to the decision of the Council to undertake a municipal telephone service for Manchester. Claimants assert that they were induced to cease their efforts to establish a company on the representation that a municipal service would be established, and that as that undertaking has not been carried out it is only right that they should be refunded some of their outlay. The subject is to be discussed at a future meeting of the committee.

**Municipal Wiring and Motor Letting.**—Hull Chamber of Trades has protested against the clauses in the Corporation's bill which confer powers as to wiring, letting motors on hire, &c.

**Old P. & O. Electrical Engineers.**—A meeting of old Batti-Wallahs, with the object of an annual reunion, will be held at Westinghouse-buildings, Norfolk-street, London, W.C., on 29th inst., at 5 p.m. It is requested that those who have not been communicated with will attend, or communicate with Mr. E. Sheppard, 20, Bucklersbury, E.C., the hon. sec. pro tem.

**Personal.**—Mr. T. Boyden has recently resigned the general managership of the Lister Electric Mfg. Co. in order to take up the management of the "Morganite" brush and other electrical manufactures of the Morgan Crucible Co. at Battersea Works, London, and was recently the recipient of a presentation by the members of his staff and the employés of the Lister works of a complete set of Dickens' works, as a mark of personal appreciation on the severance of his connection with the firm.

**Royton.**—The Council have been granted an extension of time until April 30 to comply with the terms of their 1901 electric lighting order.

**Sheffield.**—The Electric Light committee have made the following reply to the resolution of the Sheffield Chamber of Commerce in support of the objections of the Sheffield Electrical Contractors' Association to the business of wiring consumers' premises, &c., carried on by the Corporation electric supply department.

The committee regret that the Chamber of Commerce should lend itself to supporting the efforts of persons who desire to benefit themselves at the public expense, and that the Chamber should have passed the resolution without first communicating with the Corporation to ascertain the facts of the case.

The committee recommend the City Council to inform the Chamber of Commerce that the wiring and fittings department of the electric supply department was necessarily puchased, at great cost, under Parliamentary sanction, as part of the undertaking of the Sheffield Electric Light & Power Co.

That work is executed by the department only for persons already consuming electric current supplied by the Corporation, or for persons about to become consumers.

That in the opinion of the committee it is necessary, in the public interest and for the maintenance of a high standard of work, that the Corporation should continue to execute work of the kind referred to.

That all persons and firms in the city carrying on the electric wiring and fittings business have commenced to do so since the business now carried on by the Corporation was first established.

That if it be, as stated, that the wiring and fitting contractors cannot carry on their business profitably, it is due to undue competition amongst themselves.

That the committee have, on several occasions, received deputations of the wiring and fittings contractors, and fully investigated their complaints, and they have entirely failed to substantiate any grievance against the electric supply department, or to show why the wiring and fittings business, purchased at great cost out of public moneys (the debt for which is still largely unpaid), should be discontinued for the benefit of private traders.

The committee have no desire to injure the wiring and fitting contractors in their business. The committee simply carry on the wiring and fittings departments as purchased by them with as little competition to the electrical contractors as possible.

**Shoreditch (London).**—Application is to be made by the Council to the L.C.C. for an advance of £14,905, balance of a loan of £91,905 sanctioned in respect of electricity supply. It was resolved by the Borough Council on Tuesday to also apply to the L.C.C. for sanction to borrow an additional £23,555 for electric lighting.

**South London Tramways.**— In regard to Wandsworth Council's appeal as to certain tramway feeder pillars in three thoroughfares, the Board of Trade have, without coming to any conclusion on the legal question as to arbitration, appointed Mr. A. P. Trotter, the Board's electrical adviser, to visit the streets in question and confer with the parties with the view of finding a satisfactory solution.

**Sowerby Bridge.**—The Board of Trade have extended the Council's 1900 electric lighting order for another year.

**Spanish Telegraphs.** – A special credit for about £3,300 has been sanctioned as the cost of repairs to submarine telegraph cables belonging to the Spanish Department of Posts and Telegraphs.

The Eastern Tramways Co. of Madrid have been granted a concession for the construction of an electric tramway in that city.

**Speed of Tramcars.**—Dublin United Tramways Co. recently applied to the Board of Trade for permission to increase the speed of their electric tramcars, and Lieut.-Col. von Donop, R.E., held a conference on the subject with the company and Dublin Corporation, and has fixed the speeds generally at 8 miles with special exceptions of 12, 10, and 4 miles an hour in certain places. The city engineer and the Paving committee at the Council meeting last week recommended that these speeds be approved. Much opposition was offered, and in the end the report of the committee was withdrawn. In the course of the discussion Councillor P. J. Daly "protested against a holocaust of children being offered up to inflate the dividends of bloated capitalists"!

**Surbiton.**—At a ratepayers' meeting the Council's Omnibus Bill, for further electric lighting powers, &c., has been rejected.

**Swanage.**—The Council last week sealed the agreement between themselves and the Bournemouth & Poole Electricity Supply Co. with regard to the supply of electricity in the district by the company and has decided to consent to the application of the company for the necessary provisional order.

**Thornaby-on-Tees.**—The Board of Trade have sanctioned the transfer of the Council's electric lighting order to the Cleveland & Durham County Electric Power Co.

**Warrington.**—The Council have decided to apply for sanction to a further loan of £10,000 to cover the cost of electric lighting extensions during the next three years.

**Willington.**—The Council have notified the County of Durham Electrical Power Distribution Co., who are applying for a provisional order, that they object to the laying or placing of high-tension mains or cables within the Council's district other than underground in the town areas and also to applicants obtaining a monoply in the district.

**Woodford.**—The Council have resolved to oppose the application of the National Provincial Electricity Corpn. for a provisional electric lighting order.

**Dinners.**—The annual dinner of the staff and officials of Glasgow Corporation electricity department was held on the 11th inst., Lord Provost Bilsland presiding. There were also present ex-Bailie Willock, convener of the Electricity committee, Bailies Burrell and P. G. Stewart, ex-Bailie Mackenzie (Edinburgh), &c.

Ex-Bailie Mackenzie, in proposing the toast of the Corporation of Glasgow, said nobody objected in principle to municipalities carrying on electrical undertakings, because it was perfectly evident that no private person or company could do it equally well. Glasgow was making extraordinary strides with its electrical undertaking.

The Lord Provost, replying, said among the various departments of municipal work there was none more interesting than the one under whose auspices they were met that evening. In the electricity department they had one of the most recent instances of municipal service claiming the most recent discoveries of science, and in the work of the Glasgow department the twofold effort to supply light and power was meeting with great success, and was doing excellent service in the interests and for the well-being of the citizens in contributing towards making the atmosphere of Glasgow purer, because more free from smoke.

Col. Young, proposing the toast of the Electricity committee, commented upon the immense progress which the electricity department had made during the 13 years of its existence. In 1892 it had only 37 customers, but it was not long before the advantages of the light became known, as a result of which there was very soon a great demand from all classes. In 1892 the committee laid down generating plant of 1,000 H.P., and at present they had a generating power of 25 times that amount.

Ex-Bailie Willock, replying, said the committee's desire was as far as possible to reduce the price of electricity for power and lighting so that it might be placed within the reach of every one.

The employés of Norwich Electric Tramways Co. were entertained to dinner on Tuesday evening by the directors of the company.

The engineer and manager (Mr. A. W. Banister), who was in the chair, said that the past year's record was a most creditable one. They had run 1,082,568 miles, and had carried 7,796,514 passengers. They had only had two accidents.

## TRADE NOTES AND NOTICES.

### TENDERS INVITED.

*Hammersmith* (London) Council invite tenders for stores for 12 months ending March 31, 1907, including arc lamp carbons, &c., brooms, brushes, electrical goods, files, firebricks, &c., gauge glasses, meters, oilman's goods, packing and jointing materials, screws, tools, Welsh smokeless and other steam coal. Forms of tender, &c., from the borough electrical engineer (Mr. G. Gilbert Bell), Electricity Works, 85, Fulham Palace-road, London, S.W. Tenders to the town clerk (Mr. H. Thompson), Town Hall, Hammersmith, by 4 p.m., Feb. 7. See also an advertisement.

*Hammersmith* (London) Council also want tenders by 4 p.m. Feb. 7 for Welsh smokeless steam coal for the electricity works.

*Barnes* District Council invite tenders for supply, delivery and erection of 300 kw. steam dynamo, together with switchboard panels and connections. Specifications, &c., from the electrical engineer (Mr. C. S. Davidson). Tenders to the Town Clerk, Council House, High-street, Mortlake, S.W., by Feb. 12.

*Bristol* Electrical committee invite alternative tenders for 2,000 kw. and 3,000 kw. single-phase turbo-alternator (2,000 volts, 93 periods), together with condensing plant. Particulars from the city electrical engineer (Mr. H. Faraday Proctor), Temple Back, Bristol.

*Bristol* Docks committee want tenders by 10 a.m. 25th inst. for the electric lighting of two sheds and for the maintenance of the work for 12 months.

*Aberdeen* Electricity Committee invite tenders for supply and delivery of one cast-iron disc fly-wheel for fitting to a Willans engine. Tenders to the City Electrical Engineer (Mr. J. Alex. Bell), Electricity Works, Millburn-street, by noon Jan. 22.

*Fulham* (London) Council invite tenders for supply and erection of (*a*) steam piping, (*b*) water and exhaust piping. Tenders to the town clerk (Mr. R. M. Prescot), Town Hall, Fulham, by noon Jan. 31.

*Plymouth* Corporation electricity department invite tenders for the supply of stores for the 12 months to March 31, 1907, including paper-insulated cables, transformers, a.-c. meters, oils, &c. Tenders to Mr. E. G. Okell, borough electrical engineer, by Jan. 24.

*Battersea* (London) Electricity committee want tenders by noon Feb. 5 for a direct-current steam generator (either 750-850 or 1,000 kw. and 460 to 550 volts), piping, ejector condenser, arc lamps, and arc lamp globes and columns.

*Stoke-upon-Trent* Electricity committee invite tenders for 12 months' supply of meters and demand indicators. Tenders to Mr. P. J. S. Tiddeman, Electricity Works, Stoke-on-Trent, by Jan. 31.

*Birmingham* Electric Supply committee want tenders by noon Feb. 6 for the erection of four sub-stations at Bordesley and by 10 a.m. Feb. 7 for the erection of a fifth sub-station at Balsall Heath.

*Cheltenham* Corporation want tenders by Feb. 3 for 12 months' supply of stores, including electric light fittings, ironmongery, oils, coal, &c.

*Camberwell* (London) Council want tenders by 5:30 p.m. Jan. 29 for 12 months' supply of stores, &c., indluding electric lamps, ironmongery, &c., and the maintenance of telephones and electric bells.

The directors of the *Manchester* Ship Canal want tenders by 10 a.m. 12th inst. for six months' supply of stores, including carbons, ironmongery, &c.

*Pontypridd* Council want tenders by Feb. 13 for supply, &c., of 300 kw. steam dynamo.

*Hull* Corporation want tenders by 10 a.m. of Feb. 12 for air space telephone cable and extension of telephone multiple switchboard.

*Kilmarnock* Corporation want tenders by 5 p.m. 30th inst. for construction of a railway into Riverbank electricity and gas works.

*Shipley* Council invite tenders until noon Jan. 26 for an electrical installation at the new fire station.

Tenders are invited by Jan. 26 for the supply of electric light and power to the commune of *Gilly* (Belgium). Tenders to the Communal Offices, Gilly, where further information can be obtained.

## TENDERS RECEIVED AND ACCEPTED.

Bermondsey (London) Council have received the following tenders for supply and erection of a steam dynamo:—

Brush Co. (*accepted*) ........ **£2,609.**

British Thomson-Houston Co., £3,129, £3,450, £3,838, £3,570, £3,348, £3,497; British Westinghouse Co., £3,766, £4,046, £3,696, £3,764. 10s.; Bruce Peebles & Co., £3,333, £3,667, £3,412; Crompton & Co., £3,356, £3,522, £3,867, £3,523, £3,434, £3,474; Browett Lindley & Co., £3,190, £3,253, £3,363, £3,302, £3,297, £3,273, £3,196; Dick, Kerr & Co., £3,150, £3,434, £3,585, £3,272, £3,482; Vickers, Sons & Maxim, £3,158; Electrical Co., £3,844; Electrical Construction Co., £3,178, £3,439, £3,478, £3,572, £3,872; Fairbairn Combe-Barbour-Lawson, £4,240; J. Fowler & Co., £3,008, £3,147. 10s.; General Electric Co., £3,646. 10s., £3,930. 10s., £3,525, £3,212. 15s.; J. Howden & Co., £3,346; Mather & Platt, £3,410, £3,555, £3,455; C. A. Parsons, & Co., £3,476; Phœnix Dynamo Mfg. Co., £3,074, £2,820; £3,164; £3,474; Thomas Parker (Ltd.), £3,386, £3,290, £3,534, £3,685; British Electric Plant Co., £3,190, £3,310, £3,284, £3399, £3,400, £3,655; Siemens Bros. & Co., £3,045; £3,088, £3,219, £2,586, £2,915, £3,739 10s.

The following tenders were sent in after date: Johnson & Phillips, £3,174, £2,490, £3,360, £3,460, £3,610, £3,505; Industrial Engineering Co., £3,400. The electrical engineer's covering estimate (including concrete foundations) was £3,540. The Brush Co. guarantee delivery in 14 weeks.

Bermondsey (London) Council have accepted the tender of Babcock & Wilcox at £1,500, for a marine-type boiler with Babcock chain-grate stoker. Tenders were also received from Davies' Patent Boiler Co. £1,791, Clarke, Chapman & Co. £1,993, Rowland & Co. £1,589, Stirling Co. £1,567, Willans & Robinson £1,673. The electrical engineer's covering estimate was £1,850.

Fulham Steel Works Co. has obtained from the Natal Government a contract in connection with the new harbour works at Durban. Designs were submitted in competition with manufacturers in France, Germany and America. In addition to electrical and other machinery, quantities of steel work will be required, which will be manufactured at the company's works at Fulham, and this will find employment for a large number of men in the London district.

Contracts for the supply of telegraph and telephone material have been placed by the Australian Commonwealth Postmaster-General with Siemens Bros. & Co.; the British Insulated & Helsby Cables (Ltd.); the India Rubber Co.; J. A. Newton & Co.; Lawrence & Hanson; J. Slater & Co.; Dalgety & Co.: J. Bartram & Son; Noyes Bros.; Dott & Co.; Clemenger Bros. & Co.; Cole Bentley: Zwicker, Todd & Co.; F. Vanderkelen & Co.; J. G. Black; and A. J. Sage & Co. (all of Melbourne); Davies, Shephard & Co. (South Melbourne); R B. Hungerford (Sydney); Mephan Ferguson (Footscray); and A. Chillingworth (Richmond).

Marylebone Council received the following three tenders for purchase of 40 tons of old h.-t. rubber cable:—

J. Levy & Son (*accepted*), **£41. 10s.** per ton; Percy Huddlestone & Co., £36. 12s.; A. Brown & Sons, £35.

East Ham Council have accepted the tender of W. H. Allen, Son & Co. for a combination of steam and electric-driven storm water and sewage pumping plant.

Buckingham Council have renewed the contract with the local electric lighting company for street lighting for five years at £165 per annum.

Stepney Council have accepted the tender of W. Badger for supplying and fixing pipes in connection with the water softening plant of the generating station at £80.

The contract for the electric lighting installation at Waltham Abbey Royal gunpowder factory has been placed with H. A. Jackson & Co.

Marylebone Council have extended Wm. Cory & Son's contract for coal to end of March next at prices from 12s. to 12s. 6d. per ton.

Redditch Council have accepted the tender of E. M. Mountford for the supply of oil for the electricity department at 2s. 3d. per gallon.

Gravesend Council have accepted the tender of W. E. Thomas for extensions of generating station building at £1,678.

Hyde Council have accepted the tender of the Electrical Engineering Co. for wiring the baths.

## BUSINESS NOTICES.

Electromotors Limited, Openshaw, Manchester, have appointed Mr. J. H. Headley as their London representative in succession to Mr. G. H. Congdon, who terminated his engagement last month. Mr. Headley has been with the company for some years in the capacity of representative engineer.

Messrs. Eckstein, Heap & Co. have started in business as manufacturing electrical engineers, suppliers of electrical accessories, &c., at Queen's-chambers, 7, Market-street, Manchester, with showrooms and warehouses at 5, Chapel-walks, Manchester, and works at Waverley Mills, St. Simon's-street, Salford. Telegraphic address "Reaction Manchester"; Telephone 5155. The senior partner is Mr. August Eckstein, late managing director of the General Electric Co., Peel Works, Salford.

The name of the Howard Conduit Co. (Ltd.), Trafford Park, Manchester, has been altered to the Howard Asphalt Troughing Co. (Ltd.)

E. C. Wallis and E. H. Watson, electrical engineers, 36, Trinity-street, Leeds, carrying on business as Wallis & Watson, have dissolved partnership as from Aug. 31, 1905. Mr. Wallis will carry on business at the same address under the style of Wallis & Watson, and all debts owing to or by the late firm will be received and paid by him. The motor car business carried on by Mr. Watson in his own name has been transferred to George & Jobling, Trinity-street, Boar-lane, Leeds.

A new steel company has been formed with the title of the Manchester Steel Castings Co. (Ltd), Trafford Park, Manchester.

The registered office of the Electric Ozone Synd. (Ltd.) has been removed to 5, New Union-street, Moorfields, London, E.C.

## BANKRUPTCIES, LIQUIDATIONS, &c.

At Bradford Bankruptcy Court on Wednesday, the examination was concluded of Walter Binns, tramway contractor, &c., formerly of 23, Cheapside, Bradford.

Bankrupt said that in 1902 he was concerned (with two other persons) in promoting a bill for powers to construct tramways in Mexborough, Swinton and Rawmarsh. [He also took over certain electric lighting orders. The bill was promoted at his own cost, but he found himself unable to proceed for want of funds. He agreed with the New General Traction Co. that they should carry out the work and pay him £10,000 in cash and £10,000 in shares of the company which they proposed to form, but that agreement was never carried out. About September, 1904, he was introduced to a G. C. Isaacs, a London company promoter, who agreed to promote a company to carry out the work and pay Binns £15,000 in cash and £10,000 in fully-paid shares of the company. The attempt to form a new company failed, and Isaacs then obtained a power of attorney from debtor which gave him power to deal with the various Councils and to approach the National Electric Construction Co. to get them to construct and equip the lines. Isaacs agreed with them that the company should pay £12.000 in cash and £11,000 in shares, with which he was to pay about £10,000 liabilities, the balance to be handed to bankrupt. At present the tramways were more than three-parts completed, and he was told that Isaacs had received £10,000 cash and £7,500 shares. He had been unable to get any account from Isaacs, who was indebted to him to the extent of £12,675, which, he contended, would leave him a surplus of £3,480 over his liabilities.

At Blackburn County Court last week the public examination took place of James Wood Smith, "electrical engineer," 55, Bolton-road, Darwen, trading as Smith & Co. Liabilities £128. 17s., assets estimated £30. Debtor started business on his own account in Jan., 1905, on £12 borrowed capital, since repaid. Before starting business debtor had been a journeyman wireman, earning, when in work, 37s. 6d. a week. Examination adjourned.

William Leslie, of H.M. Prison, Brixton, lately carrying on business as an electrical engineer at Putney, London, S.W., has been adjudicated bankrupt.

An application for the discharge of Albt. John Harris (trading as A. J. Harris & Co.), electrical engineer, Borough Mills, Bower-street, Bradford, will be heard on 30th inst. at the County Court, Bradford.

The trustee in the bankruptcy of Albt. Smith, lately trading as the Electric Motor Supply Co., at 54, Houndsgate, Nottingham, has been released.

Claims against Carl Vigault Tyge De Falbe (lately trading as the Electrical & General Contracting Co., at 17, Shaftesbury-avenue, London, W.C.) to Mr. E. H. Hawkins, 3, Barbican, E.C., by 27th inst

Claims against the Patent Automatic Bells Synd. (Ltd.), to Mr. E. T. Medd, 49, Finsbury-pavement, London, E.C., by 27th inst.

The Pollak-Virag Telegraph Synd. (Ltd.), is being wound up voluntarily. Mr. W. S. Ogle, 90, Cannon-street, London, E.C., is liquidator.

The Miller Signal Synd. (Foreign Patents), Ltd., is being wound up voluntarily. Mr. E. H. Stringer, 110, Cannon-street, London, E.C., is liquidator.

**Sales by Auction.**—Messrs. Wheatley Kirk, Price & Co. will sell by public auction at noon, Feb. 6, on the works premises, 48 and 49, Britannia-street, City-road, London, N., the whole of the machinery, plant, fixtures and stock (including motors from $\frac{}{20}$ H.P. to 10 H.P., gas engine, &c., and a quantity of new incandescent lamps, &c.). Further particulars from Mr. S. Wiltshire, 19, St. Dunstan's-hill, London, E.C.; Messrs. J. J. Edwards & Co., solicitors, 28, Sackville-street, Piccadilly, W.; or of the auctioneers, 46, Watling-street, London, E.C., and Albert-square, Manchester. See an advertisement.

Messrs. Wheatley Kirk, Price & Co. will also sell by public auction for St. Marylebone (London) Borough Council electricity department, at the Marylebone electric light station, on an early day, about 4,500 meters of various types. Further particulars, catalogues, &c., from the auctioneers, 46, Watling-street, London, E.C. See also an advertisement.

**Plant for Sale.**—Robertson Electric Lamps (Ltd.), having decided to change their factory entirely to electric driving, and having entered into a contract with Hammersmith Borough Council for a supply of power, have for sale a Davey-Paxman engine, surface condenser, two Mordey alternators, two D.C. generators and two B. & W. boilers, shafting, &c. The plant can be inspected, on application to the company, at Brook Green Works, Hammersmith, London, W. See also an advertisement.

**Factory Sites for Sale or to be Let.**—Messrs. Faraday & Rogers, 77, Chancery-lane, London, W.C., have for sale freehold land in Middlesex (or for letting on lease for 99 years at nominal ground rent) within 7 miles of Liverpool-street station. See an advertisement.

Mr. J. W. Watson, 21, New Station-street, Boar-lane, Leeds, advertises for sale some good factory sites in Leeds, Hull and Tadcaster.

Factories are advertised to let in Holloway, London, N. Applications to 4, Pembroke-street, Islington, N.

**An Organ-blowing Regulator.**—We have received from Marples, Leach & Co. a sheet illustration of a new automatic organ-blowing regulator which only requires the organist to close a main switch at starting. So far as can be gathered from the illustration the apparatus simply consists of a circular regulating switch acting also as a starter operated by a chain from the bellows, so that when they are nearly full the motor speed is decreased and on the last contact stopped, ready to start again as the bellows tend to empty.

**The Evershed "Megger."**—Messrs. Evershed & Vignoles have issued a circular letter in which they put forward a guarantee of their well-known "megger" which they claim to be unique. They will in future maintain all meggers sold by them free of charge for five years, by extending the ordinary guarantee given with their instruments for that period, and undertaking to test the scale gratis for any customer who will send his instrument to their works. Messrs. Evershed & Vignoles inform us that since the introduction of the megger they have not sent out a single account for repairs in other than a few cases of actual breakage due to accident.

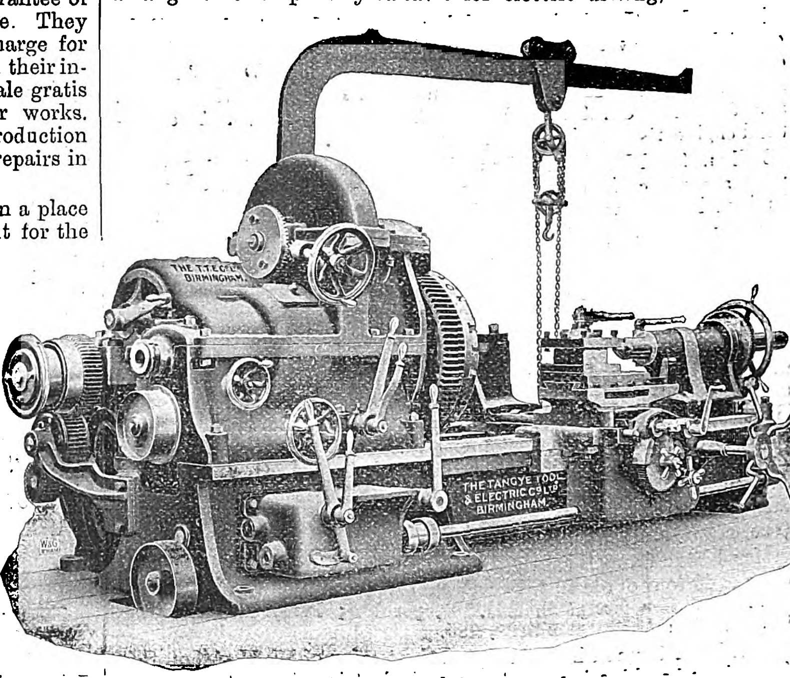
**Rubber Gloves.**—Moseley's electricians' gloves have won a place among those little improvements which are so important for the advance of practical electricity, and it is, therefore, satisfactory to learn from the manufacturers, Messrs. David Moseley & Sons, of Ardwick, Manchester, that, in spite of the comparatively high price of these gloves, they are finding their way to all parts of the world, orders coming even from such highly-protected countries as America, Germany, France, Spain and Argentina. We have seen and examined these articles from time to time and we feel sure these gloves are all the manufacturers claim for them. We know also that Messrs. Moseley & Sons have conducted considerable research work upon them at the Municipal School of Technology, Manchester, before placing them on the market. Messrs. Moseley & Sons will furnish full particulars and prices immediately on request.

**Lockwood's Price Book.**—The 1906 edition of Lockwood's "Builders' and Contractors' Price Book" has just been issued by Crosby Lockwood & Son, price 4s. The editor, Mr. F. T. W. Miller, records that no great change has occurred during the past year in the price of either labour or materials in the building trades, and that business has remained steady throughout the past year, with a notable upward tendency at the present time. Mr. Miller states that the electric lighting section of the work has been "again carefully scrutinised, revised and added to." The full text of the London Building Act, 1905, is given, as well as a large number of other enactments which affect the building and allied industries.

**Catalogues, &c.**—Messrs. Dick, Kerr & Co. are issuing a booklet giving a full technical description, supplemented by exceptionally clear drawings and a series of fine half-tone illustrations of their alternating-current turbo-alternators, which are built for single, two and three-phase currents. The alternators supplied so far range in size up to 3,000 kw., and have been designed for voltages up to 11,000 volts. Most of the information given is already familiar to our readers from our recent illustrated article on these turbo-alternators (*The Electrician*, Nov. 24, p. 218), but many engineers will undoubtedly be glad to have the information also on their files of manufacturers' publications.

A catalogue of the standard rolling stock manufactured and supplied by the Brush Co. is now ready, and besides some interesting particulars relating to these vehicles, a series of well-executed photographic prints gives a good idea of the extensive works of the company at Loughborough. Some fine exterior and interior views, as well as a number of sectional drawings, of different types of vehicles as supplied by the Brush Co., are also shown. The list contains a section dealing with electric and steam locomotives, and in this part of the catalogue the illustrations include several examples of Brush electric locos for factory sidings, for underground and overground electric railways, &c. In a second list issued by the Brush Co. steel rolling stock is dealt with, and the particulars and illustrations furnished regarding this special branch of the company's business afford the reader an excellent idea of the facilities which the company possess for executing orders for a class of vehicle which is destined to come into extended use with the development of electric main line railway enterprise all over the world.

A neat and well arranged catalogue of T.T.E. high-speed lathes, manufactured by the Tangye Tool & Electric Co., Birmingham, is to hand, and contains some excellent illustrations of a number of very compact electrically-driven high-speed lathes for a variety of engineering purposes. These lathes are made from entirely new designs and patents after an exhaustive series of experiments in high-speed steel tools, and the experience of nearly four years' constant running on a wide range of work has proved the lathes to be fully capable of giving the best results in all conditions. By the company's arrangement of "single-pulley" headstock the difficulties attendant upon the use of the fast-running cone pulley on a large diameter of spindle are avoided, as this single-pulley headstock has no cone pulley, but a single pulley which can be made any required diameter and width carried on a side shaft, enabling the changes in speed to be quickly made, and securing ample belt power, with a moderate speed of driving pulley. It also removes the pull of the driving belt from the spindle to a separate shaft running in long gun-metal bearings with oil-ring lubricators, which will work for long periods without attention. Such an arrangement is specially suitable for electric driving, either direct or by belt. Considerable advantage is also offered by the fact that the lathe can be supplied with a countershaft for driving in the ordinary way, and can be afterwards changed to electric drive. The whole of the gear is totally enclosed, the covers provided affording easy means of examination. The accompanying illustration shows an example of an 18 in. centre high-speed chucking and boring lathe, with front and back rests, driven by variable-speed electric motor.


THE T.T.E.C. BIRMINGHAM
THE TANGYE TOOL & ELECTRIC C° LTD BIRMINGHAM

T.T.E. 18 IN. CENTRE HIGH-SPEED CHUCKING AND BORING LATHE, WITH VARIABLE SPEED ELECTRIC MOTOR DRIVE.

A list which will be welcomed by the industry has been compiled and put into a binding cover by Messrs. A. Reyrolle & Co., of Hebburn-on-Tyne. This list comprehends the complete range of manufactures which this company are now well prepared to supply, including quick-break and oil switches, motor starters, fuses, distributing boxes, dividing boxes, wall plugs, sockets and switchboards. The list is admirably arranged, and by means of a set of foredge linen tabs each section of the catalogue is easy of reference. Messrs. Reyrolle & Co. have had long and special experience in the manufacture of these goods, and the company claim that all the apparatus has been designed by experts to fill all the conditions met with in actual practice; that their factory is up to date, both in arrangement and equipment; and that the small parts of the apparatus are entirely interchangeable, and are so constructed that all the hard usage and other disabilities which most of this apparatus has to meet is amply provided for. The list is replete with good illustrations.

Ferranti Limited have issued list 63, dealing with double-pole single-throw, slow-break knife switches for from 25 to 1,400 amperes. This list can be obtained on application to the works at Hollinwood.

**Weather Forecasts.**—We recently noticed a useful card calendar of small size showing in very clear form the day of the week of every day of the month for 25 years, new and full moons, &c., published by Mr. R. Morgan, of 65, Westow-street, Norwood, S.E. We have to acknowledge the receipt from the same publisher of the 20th annual issue of the British Weather Chart (1906), compiled by the same author, Mr. B. G. Jenkins, F.R.A.S. The chart is based on the author's Paper on "Forecasting the Weather." We must leave our readers to judge of the merits of Mr. Jenkins' sheet, which is published in two sizes, large and small, price 6d. and 1d. respectively. The chart is accompanied by a pamphlet, price 2d., entitled "The British Astronomical Weather Almanac and Chart," also by the same author.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Jan. 10 to Jan. 16, with the ports of destination :—

*Aden.*—£260 (telegraph cable). *Africa.*—Alexandria, £147; Capetown, £189; Durban, £542; East London, £51; Mombasa, £70 (including £22 telegraph material); Mozambique, £50. *Argentina*—Buenos Ayres, £632 (including £1997 telegraph material); Rosario, £4591. *Australasia*—Adelaide, £17; Auckland, £344; Brisbane, £280 (telegraph material); Fremantle, £326 (including £165 telegraph material); Hobart, £436; Lyttelton, £35; Melbourne, £153; Napier, £48; Otago, £3,593; Perth, £147; Sydney, £975; Wellington, £2,591. *Austria*—Fiume, £45; Trieste, £63. *Belgium*—Ostend, £20. *Borneo*—Sarawak, £20. *Burma*—Rangoon, £28. *Ceylon*—Colombo, £21. *Denmark*—Copenhagen, £81. *France*—Marseilles, £240; Paris, £48. *Germany*—Hamburg, £242. *Gibraltar*—£417 (including £162 telegraph material). *Greece*—Piræus, £31 (telegraph material). *Holland*—Amsterdam, £292 (including £212 telegraph material); Rotterdam, £30 (including £10 telegraph material). *Hong Kong*, £32. *India*—Bombay, £1377 (including £302 telegraph material); Calcutta, £5,011 (including £239 telegraph material); Madras, £458. *Italy*—Palermo, £64. *Japan*—Kobe, £1,420; Tokyo, £600; Yokohama, £1,483. *Java*—Balek Pappan, £112. *Portugal*—Oporto, £221. *Siam*—Bangkok, £17. *Straits Settlements*—Penang, £14; Singapore, £54. *Spain*—Bilbao, £47. *Sweden*—Gothenburg, £12. *Turkey*—Constantinople, £131 (telegraph material). *Uruguay*—Monte Video, £50. Total, £28,158, against £43,151 in the corresponding week last year (Jan. 11 to 17)

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specification. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

December 29, 1905.

27,138 COMINGS. Switches.
27,140 HILDBURGH. Dynamo electric machinery.
27,152 PORSCHE & LOHNER. Cores of electro-magnetic machine.*
27,159 DANVILLE. Accumulators.
27,175 GARRARD & FERRANTI LIMITED. Electrical measuring instruments.
27,180 SMART. Automatic suspension gear, and cable coupling for arc lamps.
27,187 BROWN & VANDERVELL. Electric sparking for internal-combustion engines.

December 30, 1905.

2,004A BASTIAN & CALVERT. Electrode material for vapour electric apparatus. (Date applied for, Feb. 1, 1905.)
27,197 B.T.-H. CO. & CARTER. Electric traction systems.
27,198 ALLGEMEINE ELEKTRICITÄTS GESELLSCHAFT. Dynamo-electric machines. (Date applied for, Jan. 20, 1905.)*†
27,224 SUTTON & GREGSON. Conduits.*
27,225 SUTTON & GREGSON. Manufacture of conduits.*
27,234 COMINGS & TUFFLEY. Applying electricity to display boxes, delivery boxes, &c.
27,241 BERRY. Armour-clad combined switchfuse plugs.
27,242 CLATWORTHY, A. HOLMES, J. HOLMES, L. W. HOLMES & E. HOLMES. Control of electric motors.*
27,251 MÜLLER. Continuous-current arc lamps, particularly search lights, and the like. (Date applied for, Dec. 31, 1904.)*†
27,256 WEBSTER. Advertising shades for electric lamps.
27,260 FYNN. Alternate-current commutator motors and generators.
27,271 MOFFAT, BOTT, MANLEY & ELECTRIC SAFETY APPLIANCES CO. Method of winding the coils of electrical apparatus and to instruments for detecting and obviating leakage from conductors.
27,276 JOHNSTON & WARDELL. Ignition gear of internal-combustion engines.
27,290 A. HORSTMANN, S. A. HORSTMANN, G. O. H. HORSTMANN, E. H. HORSTMANN & EDGAR. Time switches for switching on electricity.*

January 1, 1906.

1 COWLEY. Trolley poles and swivelling head.
18 HATFIELD. Improvements in electric resistances, contacts and the like.
21 SIDEBOTHAM. Automatic circuit-breakers.
24 HITCH. Electric cable conductors.
40 LAWRENCE. Fuse plugs. (Date applied for, Feb. 8, 1905.)*†
52 JEANTAUD. Active material for accumulators. (Date applied for, Jan. 5, 1905.)*†
53 RAWORTH. Regenerative control of vehicles.
57 ROUSSEAU. A magnetic differential gear for automobiles.
69 REICHENBACH. Preventing premature ignition.*
76, 77, 78 and 79 COWPER-COLES. Electrolytic manufacture of copper wire, strip or ribbon.

January 2, 1906.

131 and 132 PETTIT. Electric furnaces.
134 SMITH. Mouthpiece for telephones and speaking tubes.
140 MEEK. Outside sign illuminated by electricity.
146 ASHCROFT. Electrolysis of alloys, fused salts, solutions, ores or chemical compounds.*
151 HOWORTH. (Winton & Anderson, U.S.) Igniting mechanism for explosive engines.*
152 HOWORTH. (Winton, U.S.) Circuit closers and breakers.*
159 STANLEY & ANGER. Route indicators for tramcars.
176 JOHNSON-LUNDELL ELECTRIC TRACTION CO. & LANG. Regulation or control of electric motors.
180 B.T.-H. CO. (G.E. Co., U.S.) Signalling systems.
187 WILLANS & ROBINSON & PEACHE. Steam turbines.

January 3, 1906.

215 POOL. Arc lamp.
222 THOMAS. Vapour electric converters. (Date applied for, Jan. 13/05.)*†
223 LEE. Mercury vapour electric lamps.
226 BROWN. Obtaining and working currents of high periodicity.
234 FEMERLING & PÖRSCKE. Galvanic cells.
235 LIENEKAMPF. Electrically operated photographic copying apparatus. (Date applied for, Oct. 23, 1905.)*†
238 FYNN. Single-phase alternate-current commutator motors. (Date applied for April 15, 1905.)*†

January 4, 1906.

250 EARNSHAW. Automatic switches for overhead electric tramway systems.
260 SCHAEFER. Automatic locking device for arc lamp couplings.
289 STANLEY & ANGER. Ventilators for tramcars.
290 B.T.-H. CO. (G.E. Co., U.S.) Controlling devices for electric motors.
292 BOULT. (Koch, Germany.) High-pressure electrical apparatus.*
295 MARKS. (Barkley, U.S.) Telegraphic transmitters.
297 SAYERS. Turbines.
302 SIEMENS BROS. & CO. (Siemens-Schuckert-werke G.m.b.H., Germany.) Electricity meters.*

January 5, 1906.

342 WATSON & SMITH. Tremblers of induction coils.*
351 THOMPSON. Electric motors of variable speed.
368 WHYTE. Switches.*
374 KELLEY. Thermal electric switch. (Date applied for, Aug. 30, 1905.)*†
376 SIEMENS BROS. & CO. (Siemens Schuckertwerke G.m.b.H., Germany.) Influencing an electric circuit in dependence upon the load of a continuous-current motor situated in another circuit.
377 SIEMENS BROS. & CO. (Siemens & Halske A.-G., Germany.) Fluid pressure brakes.*
378 SIEMENS BROS. & CO. (Siemens & Halske A.-G., Germany.) Electrical signalling apparatus.*
385 B.T.-H. CO. Electric measuring apparatus.

January 6, 1906.

396 STATTER. Automatic circuit makers or breakers.
398 WILLIAMS. Electrical indicators.
402 GIBSON & COLLIE. Apparatus for indicating the magnitude of torque in shafting.
418 SCHUER. Casings for arc lamps.*

### SPECIFICATIONS PUBLISHED.

1904 SPECIFICATIONS.

25,839 THORP. Electrolysing apparatus.
28,017 SIEMENS BROS. & CO. (Siemens Schuckertwerke, G.m.b.H.) Safety devices for lifts.
28,036 PETICKY, CIZEK & SUCHANEK. Automatically connecting up telephone subscribers.
28,254 RITCHIE. Electric telegraphs.
28,255 RITCHIE. Electrical relays.
28,329 MURRAY & JACKSON. Working of telephonic systems.
28,459 MIESS. Incandescence vapour lamps.
29,082A DAVIES & BLIEDEN. Mutual electrical control of oppositely rotating members of turbines. (Date applied for, Dec. 30, 1904.)
29,126 JOB. Switching apparatus for "flash" advertising.
29,368 SULLIVAN. Induction coils.
29,422 DAWSON & BUCKHAM. Transmitting and receiving electric signals.
29,495 DE FERRANTI. Turbines.
29,645 INGLEFIELD. Telephone and like plug cords.

1905 SPECIFICATIONS.

123 WISE (Thomson Electric Welding Co.) Electric welding.
790 B.T.-H. CO. (G.E. Co., U.S.) Operating guns or similar mechanism.
2,793 CHEVALIER & REGNAUT. Automatic igniting devices for explosion motors having a plurality of cylinders.
3,431 ATKINSON. Electrolytic meters.
3,815 B.T.-H. CO. (G.E. Co., U.S.) Electric potential indicators.
4,740 ANGOLD. Arc lamps.
7,095 WELLINGTON & DANIELL. Arc lamps.

8,531 KIRKUP, STOKER, BOWMAN, ALDERSON & JONES. Leads for electric coal-cutting and other machines.
9,110 SWEET. Indicating leakage in electric circuits.
9,884 HOWORTH. (Deutsche Telephonwerke, R. Stock & Co. G.m.b.H.). Main distributors for telephone exchanges.
14,491 B.T.-H. Co. (G.E. Co., U.S.) Incandescent lamps and making same.
14,808 SINE & ROSENTHAL. Telephones.
19,819 OPRENDEK. Strengthening telephone currents.
20,467 ABEL. (Siemens Schuckertwerke G.m.b.H.). Signalling apparatus for single line electric railways and tramways.
21,834 McINTYRE. Contact breakers for Ruhmkorff coils. (Date applied for, Dec. 8, 1904.)

## NEW COMPANIES, STATUTORY RETURNS.

### NEW COMPANIES.

**HUDSON ENGINEERING CO. (LTD.)** (87,149.)—Reg. Jan. 8, capital £5,000 in £1 shares, to carry on in Manchester or elsewhere the business of electrical, mechanical and general engineers, &c. The subscribers are L. C. Anderson, R. R. Patterson, engineer, W. H. Taylor, engineer, A. E. Sudlow, electrical engineer, J. M. Wallwin, electrical engineer, J. H. Stagg and J. M. Hewitt, engineer. Reg. office, 30, Spring Gardens, Manchester.

**N.A.G. AUTOMOBILE CO. OF GREAT BRITAIN & IRELAND (1906) LTD.** (87,220.)—Reg. Jan. 13, capital £5,000 in £1 shares, to carry on the business of automobile store and garage keepers, motor car and carriage manufacturers and agents, suppliers of electricity and motive power of any description for motor cars and vehicles, electricians, electrical engineers, generators and storers of electricity, &c. Reg. office, 11, Gresham House, Old Broad-street, E.C.

### STATUTORY RETURN.

**A.B.P. ACCUMULATOR CO. (LTD).**—Return to Jan. 5 gives capital as £20,000 in 6,000 preference and 14,000 ordinary shares of £1 each, of which 3,106 preference and 14,000 ordinary have been taken up. £1 per share has been called up and paid on 3,106 preference and 14,000 ordinary are considered as full paid. Mortgages and charges, £17,500.

**ARC LAMPS (LTD.)**—The return to Jan. 3 gives capital as £60,000 in £1 shares, of which 55,300 have been taken up. £1 per share has been called up on 7,300 and £7,250 has been received, leaving £50 in arrears. 48,000 shares are considered fully paid. Mortgages and charges, nil.

**BRITISH COLUMBIA ELECTRIC CO. (LTD.)**—Capital is given in return to Oct. 30 as £1,000,000 in £115,000 5 per cent. cumulative perpetual preference stock, £300,000 deferred ordinary stock, £300,000 preferred ordinary stock, £85,000 5 per cent. cumulative preference shares of £1 each, and 200,000 other shares of £1 each, of which all the perpetual preference, deferred ordinary and preferred ordinary stock have been taken up, exclusive of seven shares which have been forfeited. £200,000 deferred ordinary stock is considered as fully paid and £529,376. 15s. has been received in cash, including premiums on stock, and £1. 15s. paid on forfeited shares. Mortgages and charges, £460,400.

**BRITISH THOMSON-HOUSTON CO. (LTD.)**—Return to Nov. 23 gives capital as £800,000 in 40,000 ordinary and 40,000 4 per cent. cumulative preference shares of £10 each, all of which have been taken up. £10 per share has been called up on 32,531 ordinary and 40,000 preference and £725,310 has been received. £74,690 is considered as paid on 7,469 ordinary. Mortgages and charges, £212,000.

**DRAKE & GORHAM (LTD.)**—According to return to Nov. 30, capital is £125,000 in £1 shares, all of which have been taken up. £1 per share has been called up and paid on 85,000 and 40,000 are considered as fully paid. Mortgages and charges, nil.

**ENGINEERING INSTRUMENTS (LTD.)**—In return to Jan. 3, capital is £50,000 in 37,500 ordinary and 12,500 deferred shares of £1 each, of which 15,000 ordinary and 12,500 preference have been taken up. £15,000 has been paid on the ordinary and £12,500 is considered as paid on the deferred. Mortgages and charges, £2,000.

**MONO-RAIL CONSTRUCTION CO. (LTD.)**—In return to Jan. 3 capital is £70,000 in 3,000 " A " ordinary, 1,000 " B " ordinary, 1,000 first preference and 2,000 second preference shares of £10 each, of which 3,000 " A " ordinary 510 first preference and 2,000 second preference have been taken up. £10 per share has been called up on 510 first and 2,000 second preference, and £25,100 has been received. £30,000 is considered as paid on 3,000 " A " ordinary. Mortgages and charges, Nil.

**PROVINCIAL TRAMWAYS CO. (LTD.)**—Return to Dec. 28, gives capital as £400,000 in 10,000 preference and 30,000 ordinary shares of £10 each, of which 10,000 preference and 24,912 ordinary have been taken up. £287,260 has been received and £61,680 is considered as paid. Mortgages and charges, £53,000.

**HARPER ELECTRIC PIANO CO. (LTD.)**—This company is inviting applications for an issue of 10,000 £1. 10 per cent. cumulative preference shares. As briefly stated on p. 530 of our last issue the company has been formed to acquire from Robert William Jay and Edith Maud Garstin, trustees of the will of the late Daniel Harper (trading as D. Harper & Co.) the book debts, stock in trade, &c., of their electric piano department, and the sole right of dealing in the Harper Electric piano in the British Isles (exclusive of the South of England).

## CITY NOTES.

**MEMORANDA** (Jan. 18).—Bank rate 4 per cent. since (Sept. 28, 1905). Price of silver $30\frac{3}{16}$d. per oz. Consols $89\frac{3}{4}$—$89\frac{7}{8}$ for money, $89\frac{7}{8}$—90 for account; $2\frac{1}{2}$ per cent. annuities $88\frac{3}{4}$—89. Consols Pay Day, Feb. 1. Stocks and Shares Continuation Day, Feb. 6; Ticket Days, Jan. 24 and Feb. 7. Pay Days, Jan. 25 and Feb. 8; Mining Share Carry-over Day, Jan. 22.

**ADELAIDE ELECTRIC SUPPLY CO. (LTD.)**—At the meeting last week the chairman (Mr. J. B. Braithwaite) moved the adoption of the report, which stated that the net profit for the period from April 10 to Aug. 31 was £3,268. 5s. 8d., which the directors recommended should be applied in payment of an interim preference dividend at rate of 6 per cent. per annum (£708. 15s. 11d.), and an ordinary dividend of 1s. 10d. per share (£2,386. 7s. 2d.), the balance (£173. 2s. 7d.) being carried forward. The directors, on the advice of the company's engineer in Australia, have decided to proceed actively with the development of the undertakings, and have authorised the extension of the mains into important residential districts surrounding Adelaide City. They have decided to close down the small generating station at Port Adelaide, and to supply that district in future from Adelaide station. The equivalent of 63,202 8 c.p. lamps was connected at Aug. 31, 1905 (against 49,430 8 c.p. in 1904), being 34,050 8 c.p. for lighting and 911 H.P. in motors.

**CAIRO METROPOLITAN ELECTRIC RAILWAY & HELIOPOLIS OASIS CO.**—This is the title of a company which is being formed to acquire a concession for building a railway granted to Bogas Pasha and M. Empain.

**CITY & SOUTH LONDON RAILWAY CO.**—The Right Hon. C. B. Stuart-Wortley, K.C., M.P., has been appointed chairman of this company in succession to the late Mr. C. G. Mott.

**DIRECT UNITED STATES CABLE CO. (LTD.)**—An interim dividend of 3s. 6d. per share (tax free), being at the rate of $3\frac{1}{2}$ per cent. per annum for quarter ended Dec. 31, has been declared; payable on and after 31st inst. £10,000 has been set aside for reserve, and a balance of about £5,848 carried forward. The transfer books will be closed from Jan. 16 to 30 inclusive.

**DUBLIN UNITED TRAMWAYS CO. (LTD.)**—The directors recommend a dividend for the half-year ended Dec. 31 at rate of 6 per cent. on the ordinary shares, after setting aside £4,000 to reserve, £1,000 to accident insurance fund, £2,500 towards maintenance and carrying forward £7,107.

**EASTERN TELEGRAPH CO. (LTD.)**—The report of the directors for the half-year ended Sept. 30 last will be presented to the shareholders at the 67th half-yearly ordinary general meeting on Wednesday next. The revenue for the period amounted to £607,703. 11s. 3d., from which are deducted £181,398. 16s. 10d. for ordinary expenses, and £49,849. 9s. 2d. for expenditure relating to maintenance of cables, depreciation of spare cable and income tax payable abroad, leaving £376,455. 5s. 3d., to which is added £1,147. 15s. brought forward, making £377,603. 0s. 3d. After providing for income tax payable here, for interest and for two quarterly preference dividends, absorbing £88,131. 8s. 5d., there remains £289,471. 11s. 10d. The directors have placed £10,000 to reserve for maintenance ships, £140,000 to general reserve, and have allocated £100,000 to meet the two interim dividends of $1\frac{1}{4}$ per cent. each on the ordinary stock, the balance (£39,471. 11s. 10d.) being carried forward.

The Eastern Telegraph Co. announce the payment by warrants on Feb. 1 of six months' interest to Jan. 31 on their 4 per cent. registered mortgage debentures, 1909. The transfer books will be closed from 27th to 31st inst. inclusive.

**EASTERN & SOUTH AFRICAN TELEGRAPH CO. (LTD.)**—This company announce payment by warrants on Feb. 1 of six months' interest to Jan. 31 on their 4 per cent. registered mortgage debentures, 1909. The transfer books will be closed from Jan. 27 to Jan. 31 inclusive.

**RANGOON ELECTRIC TRAMWAY & SUPPLY CO. (LTD.)**—The subscription list will open on Tuesday next (Jan. 23) and will close on or before 3 p.m. Thursday, Jan 25, in the issue at par of £150,000 (equal to 22,50,000 rupees) $4\frac{1}{2}$ per cent. first mortgage debenture stock and 30,000 6 per cent. £5 (equal to 75 rupees) cumulative preference shares in the above company. An abridged prospectus will be found in another part of this issue of *The Electrician*, from which it will be seen that the company has been formed to acquire from Messrs. J. W. Darwood & Co. the existing Rangoon Tramways and the Rangoon Tramways Order, 1905; also the Rangoon Municipal Electric and Electric Traction licences, and the Rangoon Cantonment Electric Traction licence of 1905. One of the objects of the new company is to convert the existing steam tramways, established in 1882, to electric working. It was in 1902 that the Municipal committee of Rangoon invited tenders for the establishment and maintenance of an electricity undertaking to supply electric energy for private and public lighting and for power, and to equip and work the steam tramway system by electric traction. Messrs. Darwood & Co. were the successful tenderers, and it is the rights and privileges connected with this contract and with a number of orders, licences and agreements with the Government and the Municipal committee which the new company will take over and operate. A map which accompanies the full prospectus shows the large area over which the company's operations will extend. For these rights and privileges the new company will allot to Messrs. Darwood & Co. as vendors, and their nominees £65,000 (equal to 9,75,000 rupees) in fully-paid ordinary shares, and Messrs. Darwood & Co. will, in addition, subscribe and pay for

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. | | |
|---|---|---|---|---|---|---|
| | | | | No. of weeks. | Amount. | Inc. or Dec. (a) |
| | | £ | £ | | £ | £ |
| Aberdeen Corporation | Jan. 13 | 1,140 | + 49 | 33 | 46,503 | - 1,076 |
| Airdrie | ,, 5 | 804 | + 16 | 52 | 10,837 | + 884 |
| Anglo-Argentine | ,, 14 | 14,424 | + 901 | 2 | 80,093 | + 2,900 |
| Ayr Corporation | ,, 13 | 173 | + 5 | 35 | 11,119 | - 109 |
| Barnsley | ,, 5 | 154 | ... | 52 | 8,459 | - 286 |
| Barrow | ,, 5 | 901 | + 22 | 52 | 12,479 | + 2,822 |
| Bath Electric Trams, Ltd. | ,, 10 | 647 | + 60 | 2 | 1,203 | + 147 |
| Birkenhead Corporation | ,, 14 | 1,004 | + 50 | 2 | 2,428 | - 86 |
| Birmingham Corporation | ,, 13 | 389 | + 55 | 41 | 15,212 | + 1,908 |
| *Birmingham & Mid. | ,, 5 | 1,335 | - 421 | 52 | 81,747 | - 1,176 |
| Blackpool Corporation | ,, 11 | 311 | - 19 | 2 | 46,013 | + 1,872 |
| Blackpool and Fleetwood | ,, 13 | 157 | - 11 | 2 | 323 | - 25 |
| Bolton Corporation | ,, 14 | 758 | + 167 | 42 | 80,892 | + 8,786 |
| Bournemouth Corporation | ,, 10 | 1,404 | + 493 | †41 | 58,308 | + 12,885 |
| Bradford Corporation | ,, 13 | 4,080 | + 300 | 41 | 180,571 | - 3,869 |
| Brighton Corporation | ,, 14 | 799 | + 46 | 49 | 42,361 | + 528 |
| Bristol Trams & Carriage | ,, 12 | 4,686 | + 25 | 22 | 72,802 | + 1,880 |
| Buenos Ayres & Pelgrano | ,, 14 | 3,335 | + 79 | 2 | 7,594 | + 680 |
| Buenos Ayres Elec. Trams | Dec. 16 | 1,176 | ... | 2 | 2,606 | ... |
| Burnley Corporation | Jan. 13 | 1,148 | + 154 | 41 | 56,083 | + 3,098 |
| Burton Corporation | ,, 14 | 266 | - 24 | §48 | 12,833 | - 1,492 |
| Bury Corporation | ,, 7 | 888 | ... | §40 | 30,891 | ... |
| Calcutta Tramways Co. | ,, 13 | R49,415 | + R 5,403 | 2 | R111,489 | + R18,589 |
| Camborne-Redruth | ,, 13 | 101 | + 6 | 11 | 1,197 | - 7 |
| Cardiff Corporation | ,, 6 | 1,925 | - 14 | 41 | 84,379 | - 180 |
| | ,, 13 | 1,918 | - 9 | | | |
| Carlisle Tramways Co. | ,, 13 | 160 | + 8 | 2 | 337 | - 4 |
| Central London Railway | ,, 13 | 7,010 | - 352 | 2 | 18,995 | - 882 |
| Chatham & Dist. Lt. Rys. | ,, 11 | 615 | + 7 | †2 | 965 | - 31 |
| *City of Birm'gh'm Tram Co. | ,, 5 | 5,190 | - 865 | 52 | 280,178 | - 198 |
| City & South London Rly. | ,, 14 | 8,024 | - 38 | 2 | 6,178 | - 68 |
| Colchester Corporation | ,, 11 | 153 | - 15 | 24 | 5,979 | - 1,486 |
| Cork Electric Trams Co. | ,, 11 | 440 | + 30 | †2 | 700 | - 14 |
| Devonport & Dist. Trams | ,, 5 | 445 | - 53 | 52 | 23,850 | - 3,590 |
| Dover Corporation | ,, 13 | 199 | + 29 | ‡41 | 9,400 | ... |
| Dublin & Lucan Railway | ,, 12 | 95 | - 11 | §2 | 159 | - 27 |
| ‡Dublin United | ,, 12 | 4,686 | + 178 | ‡2 | 8,222 | + 397 |
| Dudley—Stourbridge | ,, 5 | 739 | + 33 | 52 | 46,449 | + 1,805 |
| Dundee Corporation | ,, 10 | 993 | + 162 | §34 | 32,089 | + 2,317 |
| East Ham Council | ,, 13 | 801 | + 192 | 41 | 34,146 | + 4,516 |
| Gateshead & Dist. Trams | ,, 5 | 1,042 | + 64 | 52 | 48,581 | + 1,407 |
| Glasgow Corporation | ,, 13 | 13,903 | + 1,574 | 33 | [illegible],046 | + 20,952 |
| Glossop | ,, 6 | 116 | + 18 | 2 | 242 | + 39 |
| | ,, 13 | 126 | + 21 | | | |
| Gloucester Corporation | ,, 10 | 239 | + 11 | 41 | 12,110 | ... |
| Gravesend—Northfleet | ,, 5 | 196 | + 8 | 52 | 12,027 | - 799 |
| Gt. Northern & City Rly. | ,, 13 | 1,802 | + 82 | 2 | 3,633 | + 85 |
| Greenock & Port Glasgow | ,, 5 | 717 | + 49 | 52 | 33,575 | + 8,906 |
| Halifax Corporation | ,, 10 | 1,245 | + 83 | 41 | 64,901 | + 4,467 |
| Hartlepool Tramways | ,, 5 | 281 | - 6 | 52 | 15,944 | - 1,115 |
| Hastings Elec. Trams Co. | ,, 11 | 899 | ... | 2 | 764 | ... |
| Huddersfield | ,, 13 | 1,380 | + 179 | 41 | 56,243 | + 179 |
| Hull Corporation | ,, 13 | 2,[illegible]83 | + 2[illegible]7 | 41 | 91,930 | + 1,868 |
| Ilford Dist. Coun. | ,, 14 | 407 | + 52 | 41 | 19,495 | + 730 |
| Ipswich Corporation | ,, 13 | 352 | + 18 | 41 | 17,869 | - 1,856 |
| Isle of Thanet Co. | ,, 13 | 248 | + 10 | 15 | 4,060 | - 475 |
| Kidderminster & District | ,, 5 | 95 | + 2 | 52 | 6,250 | - 333 |
| Kilmarnock Corporation | ,, 13 | 138 | + 4 | 35 | 5,659 | ... |
| Kirkcaldy Corporation | ,, 10 | 204 | - 8 | 19 | 3,965 | - 94 |
| Lanarkshire Trams Co. | ,, 11 | 776 | + 207 | †2 | 1,706 | + 324 |
| Leamington | ,, 5 | 148 | + 54 | 24 | 4,340 | + 1,780 |
| Leeds Corporation | ,, 13 | 5,517 | + 3[illegible]0 | 41 | 248,[illegible]01 | + 7,225 |
| Leicester Corporation | ,, 13 | 2,000 | + 298 | 2 | 3,841 | + 688 |
| Leith Corporation | ,, 6 | 576 | + 282 | 33 | 11,858 | + 9,410 |
| Liverpool Overhead Rly. | ,, 14 | 1,441 | - 39 | 2 | 2,860 | - 125 |
| Liverpool Corporation | Dec. 30 | 10,469 | + 92 | 52 | 550,122 | + 9,806 |
| | Jan. 6 | 10,449 | + 177 | 2 | 10,449 | + 177 |
| Lowestoft | ,, 13 | 137 | ... | 15 | 2,235 | - 23 |
| Maidstone Corporation | ,, 11 | 90 | - 6 | 41 | 5,105 | ... |
| Manchester Corporation | ,, 13 | 12,410 | + 852 | 41 | 530,461 | + 25,833 |
| Mersey Railway | ,, 13 | 1,723 | + 53 | 2 | 3,502 | + 141 |
| Merthyr | ,, 5 | 177 | + 5 | 52 | 9,927 | - 499 |
| Metropolitan Dist. Railway | ,, 14 | 8,267 | + 528 | 1 | 16,397 | + 1,130 |
| *Metropolitan Elec. Trams | ,, 5 | 2,783 | + 839 | 52 | 140,180 | + 58,595 |
| Middleton | ,, 5 | 301 | + 35 | 52 | 17,536 | + 956 |
| Musselburgh | ,, 4 | 297 | ... | 55 | 11,769 | ... |
| Nelson Corporation | ,, 13 | 127 | + 21 | 42 | 5,622 | + 580 |
| Newcastle-on-Tyne Corp. | ,, 13 | 3,674 | + 222 | 41 | 158,731 | + 3,833 |
| Newport (Mon.) | ,, 13 | 558 | + 37 | 15 | 8,333 | + 562 |
| Northampton Corporation | ,, 12 | 883 | + 69 | 40 | 16,984 | + 4,987 |
| Oldham, Ashton & Hyde | ,, 5 | 530 | + 81 | 52 | 29,337 | + 1,128 |
| Oldham Corporation | ,, 14 | 1,007 | + 243 | 42 | 68,924 | + 16,713 |
| Perth (W. A.) Elec. Trams | ,, 12 | 1,604 | + 185 | ‡2 | 2,838 | + 80 |
| Peterborough | ,, 5 | 106 | - 1 | 52 | 6,964 | - 665 |
| Pontypridd Dist. Council | ,, 13 | 140 | ... | 41 | 6,656 | ... |
| Portsmouth Corporation | ,, 13 | 1,665 | + 100 | 41 | 81,778 | + 1,861 |
| Potteries | ,, 5 | 1,701 | + 69 | 52 | 80,270 | + 1,721 |
| Preston Corporation | ,, 10 | 599 | ... | 1 | 619 | ... |
| Reading Corporation | ,, 11 | 596 | + 22 | 2 | 1,171 | + 8 |
| Rotherham Corporation | ,, 11 | 899 | + 84 | 41 | 18,805 | - 378 |
| Rothesay | ,, 5 | 101 | + 16 | 52 | 9,682 | + 2,719 |
| Salford Corporation | ,, 13 | 4,157 | + 421 | 42 | 179,610 | + 10,608 |
| Sheerness | ,, 3 | 51 | - 10 | 52 | 8,676 | + 218 |
| Sheffield Corporation | ,, 14 | 4,840 | + 490 | 42 | 207,952 | + 11,409 |
| Southampton Corporation | ,, 10 | 916 | + 60 | 14 | 12,705 | - 228 |
| Southend Corporation | ,, 10 | 241 | + 17 | 41 | 15,659 | + 831 |
| Southport Tramways | ,, 5 | 257 | + 1 | 52 | 15,869 | - 541 |
| S. Staffordshire Trams. | ,, 5 | 758 | + 107 | 52 | 39,157 | + 2,445 |
| Stockport Corporation | ,, 12 | 725 | + 312 | 41 | 31,316 | + 8,331 |
| Sunderland Corpn. | ,, 11 | 1,212 | + 124 | 41 | 54,820 | + 2,232 |
| Swansea Trams | ,, 5 | 801 | + 383 | 52 | 38,152 | + 10,212 |
| Swindon Corporation | ,, 10 | 159 | - 11 | 41 | 8,054 | ... |
| Taunton | ,, 5 | 49 | + 7 | 52 | 2,222 | - 221 |
| Tynemouth and District | ,, 5 | 179 | - 11 | 52 | 13,165 | - 1,552 |
| Wallasey District Council | ,, 13 | 714 | + 61 | 41 | 32,192 | + 1,190 |
| Walsall | ,, 13 | 477 | + 41 | 2 | 889 | + 15 |
| Warrington Corporation | ,, 11 | 339 | + 26 | 41 | 11,013 | + 825 |
| West Ham Corporation | ,, 11 | 1,990 | + 870 | 40 | 75,010 | + 32,091 |
| Weston-super-Mare | ,, 8 | 27 | ... | 52 | 6,880 | + 601 |
| Wolverhampton Corpn. | ,, 10 | 750 | ... | 1 | 750 | ... |
| Wolverhampton District | ,, 5 | 375 | + 15 | 52 | 20,796 | + 563 |
| *Worcester | ,, 5 | 261 | - 10 | 52 | 15,578 | + 326 |
| Wrexham | ,, 5 | 87 | - 4 | 52 | 5,180 | - 842 |
| Yorkshire W.R. Trams | ,, 14 | 706 | + 222 | 2 | 1,884 | + 877 |
| Yorkshire Woollen District | ,, 5 | 819 | + 288 | 52 | 35,892 | + 5,806 |

(a) These comparisons are with the corresponding period last year. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days. * Partly electrical.

in cash at par £85,000 (equal to 12,75,000 rupees) of the ordinary shares. The prospectus gives full particulars of the vendor firm's past operations, of the various orders, licences, &c., of the agreements entered into by the vendors and now taken over by the new company, and other information which will enable subscribers to the issue of capital now made to fully acquaint themselves with the merits of the investment now offered. The new company will engage in extension and conversion works which will involve an expenditure of about £410,000, and the estimate of profits from the combined undertakings has been carefully calculated to amount to £36,714. The charges of the debenture stock, preference share dividend and sinking fund is put at £19,000, leaving for dividend on £150,000 ordinary share capital, head office expenses, directors' fees and depreciation, £17,714. It is pointed out that the plant, which has been estimated for in the above calculations, will be competent to deal with a greatly increased demand for current over and above the estimate which is set out in the prospectus. The prospectus gives in unusual detail information and particulars calculated to be of assistance to investors in this class of stock. It will be seen that the directorate is composed of practical men well known in commercial circles at home and in India. Copies can be obtained at the offices of the company, 16 and 18, Dale-street, Liverpool, and of the bankers and brokers.

**WEST LONDON ELECTRICITY SUPPLY SCHEME.**—At an extraordinary meeting of the Notting Hill Electric Lighting Co. (Ltd.) on Tuesday, the resolution approving the bill to be introduced into Parliament, entitled "A Bill to authorise the Association of Electric Supply Undertakers in the West of London and for other purposes," was passed on the motion of the chairman, Sir William Crookes. For further particulars see pp. 530–531 of our last issue.

At an extraordinary meeting of the Westminster Electric Supply Corpn. on Monday a similar resolution was approved.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Jan. 17. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Jan. 17. | |
|---|---|---|---|---|---|---|---|
| | | | | £ s. d. | | Highest. | Lowest. |
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| 5 | 8/0 | Anglo-Argentine Ord. Shares | 8 9/16—8 11/16 | 4 11 3 | Ap, Oct | 8¾ | 8 9/16 |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5¾—6 | 4 10 0 | — | 5 31/32 | .. |
| St. | 6% | Do. Permanent 6% Deb. Stock | 140 —143 | 4 3 6 | — | .. | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 101 —106 | 4 14 3 | — | 105 | 104 |
| 5 | .. | Brisbane Electric Trams. Invest Ord. | 1 —1½ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 3⅞—4⅛ | 6 1 4 | — | 4 | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 93 —96 | 4 13 9 | — | .. | .. |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 120 —123 | 4 17 6 | — | .. | .. |
| St. | 5% | † Do. Pref. Ord. Stk | 110 —113 | 4 8 4 | — | 112¼ | 111 |
| 100 | 5% | Do. 5% Cum. Perp. Pref. Stock | 103 —111 | 4 10 0 | — | .. | — |
| [illegible] | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%—105% | 4 5 9 | — | .. | — |
| 100 | 4½% | † Do. Vancouver Power Debs. | 100 —103 | 4 7 4 | — | .. | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | 4⅝—4⅞ | 5 3 0 | — | [illegible] | .. |
| [illegible] | 8/0 | Do. 6 per Cent. "A" Cm. Pref | 5¾ - 6 | 5 0 0 | — | .. | .. |
| [illegible] | 8/0 | Do. "B" | 5 —5½ | 5 9 0 | — | 5 7/16 | 5⅜ |
| St. | 5% | Do. 5 per Cent. Debs. | 105 —107 | 4 13 6 | — | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 101 —104 | 4 13 0 | — | 103½ | 103¼ |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | [illegible]6 — 93 | 5 2 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 100 —104 | 5 5 9 | .. | .. | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 100 —104 | 5 17 0 | .. | .. | .. |
| 5 | 8/6 | Calcutta Tramways (Nos. 1 to 105) | 9½—10 | 4 5 0 | — | .. | .. |
| 5 | 2/6 | Do. Nos. 105,001 to 137,610 | 8¾—9¼ | .. | .. | .. | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 104 —106 | 4 5 0 | — | 10[illegible]¾ | 10[illegible]½ |
| 1 | 0/6 | Cape Electric Tram Shares | ⅞—1⅛ | 4 8 10 | — | .. | — |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 102 —104 | 4 16 0 | — | .. | .. |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 97 —99% | .. | .. | 98 | .. |
| 1 | .. | Lisbon Elec. Trams Ord. | 1 7/16—1 9/16 | .. | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅜—1⅝ | 4 7 4 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 100 —103 | 4 17 0 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 101 —103 | 4 17 0 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101 —104 | 4 16 2 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102 —104 | 4 6 7 | — | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 104 —107 | 4 13 6 | .. | .. | .. |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 147 — 149 | 5 7 4 | .. | 147½ | [illegible] |
| .. | 5% | Do. 5% 1st Mt. $500 Dbs. | 97%—98% | 5 1 0 | .. | [illegible] | [illegible] |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | — | Adelaide Elec. S'ply Co. 6% Cu.Pr. | 4¾—5¼ | — | .. | .. | .. |
| 5 | 3/8 | Calcutta Elec. (1-50,000) | 8¾ 9¼ | 4 9 0 | — | [illegible] | [illegible] |
| 50 | 5% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbr. | 50 —52 | 4 16 0 | .. | .. | .. |
| .. | 5% | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 94 —96 | 5 4 0 | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½— 3 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Debs. | 85 —90 | 5 10 0 | .. | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | 8½—9½ | — | — | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92 —94 | 5 6 8 | — | .. | .. |
| St. | 6/2 | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. | 108 — 110 | 5 10 0 | .. | .. | .. |
| [illegible] | 5 38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞ - 1 | 6 0 0 | — | [illegible] | — |
| 1 | 1/0 | Rand Electric | 1 5/16 — 1 7/16 | .. | — | .. | — |
| 1 | .. | River Plate Electricity Co. Ord. | [illegible] | .. | .. | [illegible] | .. |
| 1 | 1/2⅔ | Do. 6% Non. Cum. Pref | [illegible] - 1⅛ | .. | .. | .. | .. |
| St. | 5% | Do. 5% Deb. Stock | 101 — 103 | 4 17 0 | .. | 10[illegible]½ | .. |
| 5 | 8/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5¼—5¾ | 5 4 4 | .. | .. | .. |
| 5 | 9·23d | Do. (12,001-20,000) | 5 —5½ | 3 8 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100 —103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 5% | Shawinigan Water and Power 5% Bds., Scrip | 101 —103 | 4 17 0 | .. | 102 | .. |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Share. | Last Dividend | Name. | Price Wed. Jan. 17. | Rate per Cent. Yielded. | Dividend Due | Business, Week to Jan. 17. Highest. | Business, Week to Jan. 17. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | £ s. d. | | | |
| 1 | .. | Bath Elec. Trams Pref. Ord. | 29/32–31/32 | .. | .. | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16–1 1/16 | 4 14 9 | .. | 31/32 | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 103½–105½ | 4 5 0 | .. | .. | .. |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 101–103 | 4 7 9 | .. | 102½ | 101¾ |
| 10 | 9% | Bristol Tramways and Carriage Ord. | 17–17½ | 5 2 11 | Feb, Aug | .. | .. |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10–10¼ | 3 18 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Debs. | 104–106 | 3 15 6 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 8⅝–8⅞ | 6 15 0 | .. | 8 11/16 | 8 7/16 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 10⅞–11⅜ | 5 5 6 | Feb, Aug | 11 5/16 | 10⅞ |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 119–121 | 4 2 8 | .. | 120½ | 119½ |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 98–100 | 4 10 0 | .. | 98½ | 98⅛ |
| St. | 4% | Central London Ordinary Stock | 95–97 | 4 2 6 | June, Dec | 96 | 95⅝ |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 103–105 | 3 16 3 | .. | 104¼ | 103 |
| St. | 4% | Do. Deferred Stock | 86–89 | 4 10 0 | .. | .. | .. |
| 100 | 4% | † Do. 4 per Cent. Debs. | 109–111 | 3 12 0 | .. | 110¼ | .. |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 4⅞–5⅛ | 4 17 6 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 101–104 | 3 17 0 | .. | .. | .. |
| St. | 2% | City and South London Rly. Con. Ord. | 44–46 | 4 1 6 | Feb, Aug | 44½ | 44 |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 120–123 | 4 1 4 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 117–120 | 4 3 4 | .. | .. | .. |
| St. | 5% | Do. (1901) | 115–118 | 4 4 8 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 105–108 | 3 14 1 | May, Nov | .. | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13½–14½ | 4 2 8 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½–15½ | 3 17 8 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5¼–5¾ | 6 19 0 | .. | 5 9/16 | 5 7/16 |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8–9 | 4 8 11 | .. | .. | .. |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 101–103 | 4 7 6 | .. | 102 | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 17–18 | 5 0 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 18¼–18¾ | 4 7 8 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 110–112 | 4 0 4 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼–2¾ | 9 8 6 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 82–87 | 4 12 0 | — | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8 1/16–8 5/16 | 8 13 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9⅝–10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99–102 | 3 19 3 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9½–10 | 5 0 0 | — | .. | .. |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 98–101 | 3 19 6 | — | 98¾ | .. |
| St. | .. | Mersey Con. Ord. Stock | 7–9 | — | — | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8–11 | — | — | — | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32–9/32 | .. | — | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1–1 1/16 | 4 14 1 | — | 1 1/16 | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104–106 | 4 5 0 | — | .. | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½–1½ | .. | May — | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾–9¼ | 5 5 8 | .. | .. | .. |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9¾–10¼ | 4 17 6 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103–106 | 4 5 0 | — | .. | .. |
| 100 | 5% | Sunderland Dist. Elec. Trams. 5% 1st Mort. Debs. | 92–97 | 5 3 0 | .. | .. | .. |
| .. | 5% | Underground Elec. Rys. Co. of London | 98–99 | 5 1 0 | .. | 98¾ | 98½ |
| St. | 3% | Waterloo and City Ord. | 94–97 | 3 2 0 | June, Dec | .. | .. |
| St. | 4½% | Yorkshire W.R. El. Trs. Co. 4½% 1st Debs. | 91–96 | 4 18 9 | .. | 91½ | 90⅝ |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | *African Direct Tel. 4% Mrt. Deb. (red.) | 99½–101½ | 3 18 6 | Jan, July | — | .. |
| 10 | — | Amazon Telegraph | 3¾–4¼ | .. | Jn, Dec — | .. | .. |
| 100 | 5% | Do. 5% Debs. (red.) | 82–87 | 5 15 0 | .. | 85½ | 84 |
| St. | 15/0 | Anglo-American | 64–66 | 4 11 0 | F,My,Ag,N | 64¼ | 64 |
| St. | 30/0 | Do. Preferred | 112–113 | 5 2 0 | F,My,Ag,N | 112¼ | 111¼ |
| St. | 2/0 | Do. Deferred | 17–17¼ | .. | F,My,Ag,N | 17¼ | 16⅞ |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 98–100 | 4 0 0 | Jn,Ap,Jy,O | 99½ | 98⅜ |
| 10 | 5/0 | Cuba Submarine Ord. | 8½–9 | 5 11 0 | Feb, Aug | .. | .. |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17–18 | 5 11 2 | Feb, Aug | .. | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜–3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 8½–8¾ | 5 14 0 | April, Oct | .. | .. |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 99%–102% | 4 8 0 | Jan, July | .. | .. |
| 20 | 8/0 | Direct United States Cable | 14½–15½ | 4 4 6 | Ja,Ap,Jy,O | 15⅛ | 14 11/16 |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 99–101 | 4 9 0 | Jn, Dec | .. | .. |
| St. | 25/0 | †Eastern Ordinary | 146–149 | 4 14 8 | Ja,Ap,Jy,O | 148 | 147½ |
| St. | 17/6 | † Do. 3½ per Cent. Pref. Stock | 91½–93½ | 3 14 9 | Ja,Ap,Jy,O | 93¾ | 91¼ |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 107–109 | 3 13 4 | May, Nov | 108¼ | 107 |
| 10 | 2/6 | †Eastern Extension | 14½–15 | 4 13 4 | Ja,Ap,Jy,O | 14¾ | 14½ |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 107–109 | 3 18 4 | Feb, Aug | 107½ | .. |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 101–103 | 3 18 3 | Feb, Aug | .. | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101%–103% | 3 18 8 | May, Nov | 102 | .. |
| 10 | 5/0 | G. N. (of Copenhagen) with coupon 65 | 37½–39½ | 6 1 6 | Jan, July | 38 | .. |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 99–101 | 4 7 6 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57–59 | 5 10 0 | May, Nov | 58½ | 57¼ |
| 100 | $1 | Mackay Companies Common | 61 5/16 | 3 5 3 | Jan, July | .. | .. |
| 100 | 4% | Do. Preference | 76 1/16 | 5 5 4 | Ja,Ap,Jy,O | .. | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1⅛–1¼ | .. | .. | .. | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 99–102 | 3 18 6 | June, Dec | .. | .. |
| 10 | 4/0 | West African Telegraph Shares | 9½–10 | 5 0 0 | .. | .. | .. |
| 2½ | — | West Coast of America | 9/16–11/16 | .. | — | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 99½–101½ | 3 18 9 | Jan, July | .. | .. |
| 10 | — | West India and Panama | ¼–¾ | .. | May, Nov | .. | .. |
| 10 | 6/0 | Do. 6% 1st Pref. | 8¼–8¾ | 6 6 8 | May, Nov | 8½ | 8¼ |
| 10 | — | Do. 6 per Cent. 2nd Pref. | 6½–7½ | .. | May, Nov | .. | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 100–103 | 4 17 0 | Jan, July | .. | .. |
| 10 | 8/0 | Western Telegraph | 14¼–14¾ | 4 17 0 | Mr,Jn,O,D | 14 7/16 | 14¼ |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 100–102 | 4 18 0 | June, Dec | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 102–104 | 3 16 10 | .. | .. | .. |
| | | **TELEPHONES.** | | | | | |
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 102–104 | .. | .. | — | — |
| 5 | 8/0 | †Chili Telephone (fully paid) | 7⅞–8⅛ | 4 18 6 | August — | .. | .. |
| 1 | 0/9⅗ | Monte Video Telephone Ord. | ⅞–1 | 4 0 0 | — | 31/32 | .. |
| 1 | 1/0 | Do. 5% Pref. | ⅞–1 | 5 0 0 | .. | .. | .. |
| St. | 6% | National Co. Pref. Stock | 112½–113½ | 5 5 9 | — | 114 | 112¼ |
| St. | 5% | Do. Def. Stock | 111–112 | 4 8 8 | — | 111⅞ | 111 |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13–15 | 4 0 0 | Feb, Aug | 14⅝ | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 11–13 | 4 12 4 | Feb, Aug | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅝–5⅞ | 4 5 2 | Feb, Aug | 5⅞ | 5¾ |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 99–101 | 3 9 4 | June, Dec | 100 | 99⅜ |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 104–106 | 3 15 6 | — | 104½ | .. |
| 1 | 0/7½ | Oriental | 1 5/16–1 7/16 | 4 11 0 | April, Oct | 1 7/16 | 1 13/32 |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1¼–1⅜ | 4 7 0 | — | .. | .. |
| St. | 24/7⅔ | Do. 4% Red. Deb. Stock | 96–98 | 4 1 6 | .. | 98 | 97½ |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 101–104 | 4 6 6 | .. | .. | .. |
| 5 | 8/0 | United River Plate | 7¼–7½ | 5 6 8 | July — | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5½–5¾ | 4 7 0 | June, Dec | .. | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 110–112 | 4 9 8 | June, Dec | — | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 5–5½ | 5 9 0 | .. | 5 5/32 | .. |
| 10 | 2/0 | Globe Telegraph and Trust | 11¼–11½ | 4 15 0 | Ja,Ap,Jy,O | 11½ | 11⅜ |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14⅝–14⅞ | 4 0 6 | Ja,Ap,Jy,O | 14 13/16 | 14½ |
| 10 | 6% | Submarine Cables Trust (Cert.) | 126–120 | 4 18 0 | April, Oct | .. | — |

| Share. | Last Dividend | Name | Price Wed. Jan. 17. | Rate per Cent. Yielded. | Dividend Due. | Business Week to Jan. 17. Highest. | Business Week to Jan. 17. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | £ s. d. | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12⅝–12⅞ | 5 9 6 | .. | .. | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10¼–10¾ | 4 8 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11¾–12¼ | 4 18 0 | .. | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 105–107 | 4 4 0 | .. | 106½ | 106 |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼–5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 102–105 | 4 5 9 | — | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 8½–9½ | 5 5 0 | — | 8⅞ | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 8½–9½ | 3 14 5 | Mar, Sept | — | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 102–105 | 3 16 3 | — | .. | .. |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 6–6½ | 5 0 0 | Feb, Aug | .. | .. |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼–5¾ | 3 18 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 101–103 | 3 17 6 | — | .. | .. |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4⅝–4⅞ | 4 12 6 | — | .. | .. |
| 5 | 2/3 | Do. Do. (1903) | 4⅝–4⅞ | 4 12 6 | .. | .. | .. |
| 5 | 2/3 | Chelsea Electric Supply Ord. | 5¼–5¾ | 5 4 6 | March .. | 5⅜ | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 108–110 | 4 1 6 | Jn, Dec .. | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 11–12 | 5 0 0 | Feb, Aug | 11⅞ | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13¼–14¼ | 4 4 2 | Jan, July | 13⅞ | 13¾ |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 122–126 | 3 19 4 | Jn, Dec .. | 125 | 124 |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 101–103 | 4 7 6 | .. | 102¼ | .. |
| 5 | .. | County of Durham Elec. P.D. Ord. £2 pd. | 2 1/16–2 3/32 | .. | April, Oct | 2 1/16 | 2 1/16 |
| 5 | 5% | Do. Do. 5% non cum. pref. | 5¼–5⅜ | 4 13 0 | April, Oct | 5¼ | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 8½–9½ | 4 6 6 | — | 9⅛ | 8⅞ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅝–12⅞ | 4 13 2 | Mar, Sept | 12⅞ | 12 11/16 |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 110–113 | 3 19 6 | .. | .. | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 101–103 | 4 7 6 | .. | 102¼ | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼–5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5–5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101–104 | 4 6 6 | — | — | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8½–8¾ | 4 17 2 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100–103 | 4 7 5 | — | .. | .. |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 10¾–11¾ | 5 0 0 | .. | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½–7 | 4 5 9 | Jan, July | — | — |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98–101 | 3 19 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101–103 | 3 17 8 | .. | .. | .. |
| 3 | 1/9⅗ | London Electric Supply Ord. | 1¾–2¼ | 4 0 0 | .. | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 4¾–5¼ | 5 14 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb | 98–101 | 3 19 2 | Mr,Jn,S,D | .. | — |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 9–10 | 5 0 0 | April, Oct | 9¾ | 9⅝ |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5¼–5½ | 3 18 0 | Jan. July | 5 9/16 | 5 5/16 |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 107–111 | 4 1 0 | Jn, Dec — | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 95–97 | 3 12 8 | — | .. | .. |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 99–101% | 4 9 0 | — | 96 | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 12–12¼ | 5 11 1 | Feb, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 103–105 | 4 6 6 | Jan, July | — | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8 3/16–8 5/16 | 4 17 0 | Feb, Aug | .. | .. |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6⅜–6½ | 3 16 11 | Feb, Aug | 6⅜ | .. |
| 100 | 4% | † Do. 4% Mort. Deb. red. 1907 | 99–101 | 3 19 7 | Jan, July | 100 | .. |
| 1 | 3% | Northern Counties Elec. Sup. | 15/16–31/32 | 3 2 6 | Mar, Aug | 31/32 | .. |
| 100 | 4½% | † Do. 4½% Deb. | 101–102 | 4 7 6 | Jan, July | — | .. |
| 10 | 6/0 | Notting Hill Electric Ord. | 13½–14½ | 4 16 8 | March — | 13 13/16 | 13⅝ |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98–100 | 4 0 0 | .. | .. | — |
| 5 | 2/6 | Oxford Electric Ord. | 6⅜–6⅞ | 5 1 6 | March — | .. | — |
| St. | 4% | Do. 4% Deb. Stock | 99–103 | 3 19 5 | — | 98¼ | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 12–13 | 5 15 0 | Feb, Aug | 12⅜ | 12¼ |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 7–8 | 4 7 0 | Feb, Aug | 8⅛ | 7⅞ |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 97–99 | 3 10 9 | — | .. | — |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2–2½ | 8 0 0 | .. | .. | — |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76–80 | 5 0 0 | — | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 3–3½ | 6 10 0 | .. | 3 5/16 | .. |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | ¾–⅞ | .. | .. | .. | — |
| 1 | 0/8¾ | Do. 7% Cum. Pref. | 1 5/16–1 7/16 | 4 17 2 | .. | 1 11/32 | 1 5/16 |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105–108 | 4 3 8 | — | .. | — |
| 5 | 2/6 | Urban Electric Supply Ord. | 4⅝–4⅞ | 5 2 6 | — | .. | .. |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5–5½ | 4 15 8 | — | 5⅛ | — |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 105–107 | 4 4 0 | .. | 105½ | .. |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 11¼–12¼ | 5 14 0 | Mar, Sept | 12 | 11 15/16 |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝–5⅞ | 4 9 0 | .. | 5 21/32 | .. |
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝–⅞ | 5 6 6 | — | .. | .. |
| 1 | 10½d. | Aron El. Met. 6% Cm. Pf. | ½–⅝ | .. | .. | .. | — |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3¾–4 | 5 0 0 | .. | 3⅞ | 3 11/16 |
| 1 | 7½d. | Do. Pref | 1 7/16–1 9/16 | 3 16 10 | .. | .. | .. |
| 5 | 4/0 | British Insulated & Helsby Cables Ord. | 7–7½ | 5 6 8 | July, Feb | 7 3/16 | 7⅛ |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 6–6½ | 4 12 8 | Jan, July | 6 1/32 | 6 |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103–106 | 4 4 11 | .. | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98–100 | 4 10 0 | .. | .. | .. |
| 5 | .. | British Westinghouse 6% Pref. | 1⅞–2¼ | .. | .. | 2 5/32 | 2 1/32 |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 77–82 | 4 17 6 | .. | 80 | 79⅛ |
| 2 | — | Brush Electrical Engineering | ⅜–⅝ | .. | March — | .. | .. |
| 2 | 2/4⅘ | Do. 6 per Cent. Pref. Non-Cum. | 1½–1¾ | 6 17 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 99–101 | 4 9 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 82–84 | 5 7 4 | Jan, July | .. | .. |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11–12 | 5 0 0 | Jan, July | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝–5⅞ | 4 5 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 108–110 | 4 1 6 | Nov, May | 1⅛ | .. |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1 7/16–1 9/16 | 5 1 0 | .. | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 97–102 | 4 8 8 | — | .. | — |
| 1 | 9⅜d. | Chadburn's (Ship) Telegraph Ord. | 1–1¼ | 8 0 0 | .. | .. | .. |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1 1/16–1 3/16 | 5 2 7 | .. | .. | .. |
| 3 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 1⅞–2⅛ | 3 10 6 | Jan, July | .. | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 98%–99% | 5 2 0 | Jan, July | 97 | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8½–9 | 5 11 1 | Sept — | 8¾ | .. |
| 5 | 3/0 | Do. 6% Cum. Pref. | 5¾–6¼ | 4 18 0 | Sept — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104–106 | 4 5 0 | .. | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅝–1⅞ | .. | Feb, Aug | .. | .. |
| 5 | 2/6 | Do. (£5 paid) | 2¼–2¾ | .. | Feb, Aug | 2 19/32 | 2 17/32 |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 86–88 | 4 11 0 | June, Dec | .. | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92–97 | 5 3 1 | .. | .. | .. |
| 5 | 2/6 | †Edmundson's Elec. Corp. Ord. | 5–5½ | 6 7 0 | H'lf-yearly | 5⅝ | 5 1/16 |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5⅛–5⅞ | 5 2 0 | .. | 5 3/32 | .. |
| St. | 4½% | † Do. 4½ per Cent. 1st Mort. Deb. (red.) | 104–106 | 4 5 0 | .. | 105⅛ | 105 |
| 2 | 1/7½ | Electric Construction Co. | ½–¾ | 9 6 0 | July — | .. | .. |
| 2 | 2/9⅗ | Do. 7 per Cent. Cum. Pref | 1⅞–2⅛ | 5 18 8 | July — | .. | .. |
| St. | 4% | † Do. 4 per Cent. 1st Mort. Deb. (red.) | 90–93 | 4 6 0 | Jan, July | 91½ | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9–9½ | 5 5 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96–100 | 4 0 0 | — | 96 | 94 |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 12¾–13½ | 5 11 1 | Feb, Aug | 13⅛ | 12⅞ |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼–5½ | 4 2 0 | Feb, Aug | 5 11/16 | 5⅝ |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | — | 4 1 1 | Feb, Aug | .. | .. |
| 10 | 15/0 | India Rubber, Gutta Percha, &c., Wrks. | 18½–19½ | 2 10 6 | Feb, Aug | 18¾ | 18½ |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99–102 | 3 18 5 | Mar, Sept | — | — |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¾–12¼ | 4 1 8 | Mar, Sept | .. | .. |
| 12 | 12/0 | Telegraph Construction & Mainten'ce. | 34½–35½ | 5 0 0 | Mar, July | 34½ | 34 |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 100–102 | 3 18 6 | Jan, July | .. | .. |
| 5 | — | Willans and Robinson Ord. | 2–2½ | — | Apr, Oct | 2¼ | 2⅛ |
| 5 | — | Do. 6 per Cent. Cum. Pref. | 4–4½ | — | Apr. Oct | 4 5/16 | 4 |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 82–87 | 4 12 0 | May Nov | .. | .. |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

# WHEATLEY KIRK, PRICE & CO.

*(Established 1850.)*

ELECTRICAL AND MECHANICAL VALUERS, ARBITRATORS AND AUCTIONEERS.

**TRAMWAY & ELECTRICITY SUPPLY VALUATIONS.**

Periodical Valuations, Stock-takings and Reports for DEPRECIATION, RENEWALS, &c., in conformity with the Acts. Sales or Valuations and Arbitrations for transfer under local or other powers. Purchases of Entire Undertakings by Private Treaty negotiated.

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**And Albert Chambers, Albert Square, MANCHESTER.**

Telephones { 5077 Bank London. 3218 Central Manchester.
Telegraph Addresses { Indices London. Indicator Manchester.

## SALES BY AUCTION.

1905. E. 395.

In the High Court of Justice,
Chancery Division,
Mr. JUSTICE JOYCE.

*In the matter of* BELL *v.* THE ELECTRIC LAMP RENOVATING CO., LTD.

### TO ELECTRICIANS, ENGINEERS, LAMP MAKERS AND OTHERS.

TUESDAY, 6th February, 1906.

WHEATLEY KIRK, PRICE & CO. have received instructions from the Receiver, Sydney Wiltshire, Esq., to SELL BY PUBLIC AUCTION, on the WORKS PREMISES, 48 & 49, BRITANNIA STREET, CITY ROAD, HOXTON, LONDON, N., commencing at 11 o'clock prompt, on TUESDAY, February 6th, 1906, the whole of the

**INCANDESCENT LAMP RENOVATING PLANT AND STOCK**

comprising 1-20th to 10 H.P. Motors, Main and Branch Switchboards, 600 volt Alternator, Transformers, Wattmeters, Photometers, Exhausting Benches, Vertical and Horizontal Duplex Exhausting Pumps, 10 B.H.P. Gas Engine, Root's Blower, Glass Blowing Benches, Flashing Tables, Resistances, Volt Regulators, New and Regenerated Electric Lamps; also Automatic Mechanical Advertising Cabinets driven by Motor, and other Effects.

Admission by Catalogue only, which may be obtained from the Receiver, SYDNEY WILTSHIRE, Esq., of Messrs. Wright & Wiltshire, Incorporated Accountants, 19, St. Dunstan's Hill, Great Tower-street, London, E.C; J. J. EDWARDS & CO., Solicitors, 28, Sackville-street, Piccadilly, London, W.; or the AUCTIONEERS, 46, Watling-street, London, E.C., and Albert-square, Manchester. Telegrams: Indices London; Indicator Manchester. Telephones: 5077 Bank; 3218 Manchester.

WEDNESDAY, 31st, JANUARY, 1906.

### TO ELECTRIC LIGHT COMPANIES, ELECTRICAL ENGINEERS AND OTHERS.

WHEATLEY KIRK, PRICE & CO. are instructed to SELL BY PUBLIC AUCTION, for the Metropolitan Borough of St. Marylebone Electricity Department, on the premises of the Marylebone Electric Light Station, North-street, Marylebone, London, W., on WEDNESDAY, 31st January, 1906, commencing at 11 a.m. prompt, about **4,500 SECOND-HAND ELECTRICITY METERS** of the British Thomson-Houston, Reason, Vulcan, Chamberlain & Hookham, Ferranti, and other types.

For further particulars, catalogues, etc., apply to the AUCTIONEERS, 46, Watling-street, London, E.C.; and Albert-square, Manchester. Telegrams: "Indices London." "Indicator Manchester." Telephones: London: 5077 Bank. Manchester: 3218 Central.

## FOR DISPOSAL.

THE WEBSTER ELECTRICAL ENGINEERING CO., LIMITED, Thornton-road Bradford:—To be SOLD by Private Treaty the BUSINESS and ASSETS of ths Company; excellent opportunity for anyone wishing to acquire a well-established business.—For particulars and to view apply WILLIAM MARTELLO GRAY, C.A., District Bank Chambers, Bradford.

**For MISCELLANEOUS PLANT, &c., FOR SALE see next page**

Telegrams: Turnstile London.

# STANLEY

GOLD MEDAL St. Louis, 1904

**SURVEYING & DRAWING INSTRUMENTS.**

*NOTICE OF REMOVAL OF THE RETAIL DEPARTMENT*
from GREAT TURNSTILE to
**286, HIGH HOLBORN, LONDON, W.C.** Price List post free.

## TENDERS INVITED.

### COUNTY BOROUGH OF SUNDERLAND.

ELECTRICITY DEPARTMENT.

### TO MANUFACTURERS OF FEED PUMPS, COOLING TOWERS AND SURFACE CONDENSERS.

The Corporation of Sunderland are prepared to receive TENDERS for the Supply of:—

(a) ONE BOILER FEED PUMP.
(b) ONE WOODEN COOLING TOWER.
(c) ONE SURFACE CONDENSER with Motor-driven Pumps.
(d) COAL BUNKERS, GANTRY and other Steel Work.

The Specifications and Forms of Tender can be obtained on application to the Borough Electrical Engineer, Mr. J. F. C. Snell, M.Inst.C.E., at his Office, Town Hall, Sunderland, and on payment of a deposit of £1 1s (One Guinea) for each Specification, which will be returned on receipt of a bona fide Tender.

Sealed Tenders, addressed to the Chairman of the Electricity and Lighting Committee, Town Hall, Sunderland, must be delivered at my office not later than 12 o'clock noon on FRIDAY, the 2nd day of March, 1906. Tenders to be endorsed "A, B, C or D," according to item tendered for.

The Corporation do not bind themselves to accept the lowest or any Tender.

FRAS. M. BOWEY, Town Clerk.

Town Hall, Sunderland, 22nd January, 1906.

### SHANGHAI.

MESSRS. PREECE & CARDEW are instructed by the Shanghai Municipal Council to invite TENDERS for the Supply and Delivery, c.i.f. Shanghai, of the following plant:—

**ONE 800 KILOWATT HORIZONTAL STEAM-TURBO-ALTERNATOR**

(Single Phase) with Condensing Plant.

Specification, General Conditions and form of Tender may be obtained from Messrs. Preece & Cardew, 8, Queen Anne's Gate, Westminster, S.W., after January 30th, on payment of a deposit of £2, which amount will be refunded on receipt of a bona-fide Tender and the return of the Specification and General Conditions.

Extra copies of the Specification and General Conditions can be obtained on payment of 5s. each (non-returnable).

Sealed Tenders endorsed "Shanghai," are to be delivered to Messrs. Preece & Cardew, 8, Queen Anne's Gate, Westminster, S.W., before 12 o'clock noon on THURSDAY, February 22nd, 1906.

The Council do not undertake to accept the lowest or any Tender.

January 25th, 1906.

# GAMBRELL BROS.

Durham House, North Side,
Clapham Common, London, S.W.

MANUFACTURERS of ELECTRICAL TESTING INSTRUMENTS.

CATALOGUE ON APPLICATION.

# "The Electric Accumulator."

No. 1, Vol. 1. Jan. '06.

**The ONLY Storage Battery Paper.**

*Particulars*:—8, St. Ann's Road, WANDSWORTH, LONDON, S.W.

Telegrams: ELECTROLYT.

# DOULTON TROUGHING

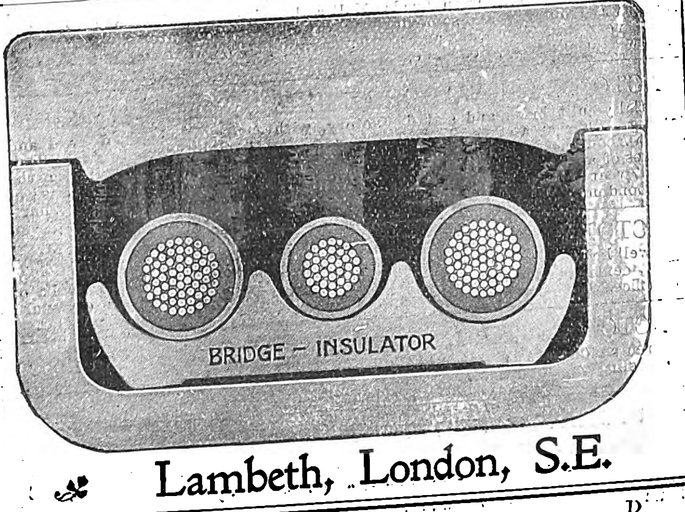
AND BRIDGE-INSULATORS

**For SOLID SYSTEM CABLES.**

**This troughing is made of strong, hard-burnt glazed stoneware, with socket joints, in a variety of sizes, to take one or several cables.**

**The bridges are of a special admixture of clay, fired and enamelled at a high temperature, and not dependent upon the glaze for insulation.**

*FURTHER PARTICULARS & QUOTATIONS ON APPLICATION.*



Royal Doulton Potteries ❧ Lambeth, London, S.E.

## CHEAP PREPAID ADVERTISEMENTS.

**MISCELLANEOUS PLANT, &c., WANTED, FOR SALE OR FOR EXCHANGE.**

| | |
|---|---|
| *Three Lines and under (Minimum)* ... ... ... | **1s. 6d.** |
| *Per Line after* ... ... ... ... ... ... | **6d.** |

Ten Words to the Line.

Where answers to any of the above, Advertisements are to be sent to the Publishing Offices to be forwarded, the sum of 3d. must be sent with the order to pay for postage of these replies. Six Words must be allowed for the address of the Publishing Offices.

### MISCELLANEOUS PLANT, &c., WANTED.

WANTED, 150 kw. 230 volt, shunt-wound, direct-coupled Steam Generator, for a working steam pressure of about 100lbs. Must be in good condition.—State lowest price and all particulars to HENRY FAULDER & Co., LTD., Cocoa Works, Stockport.

WANTED, LAMP TOPS, with Platinum, Scrap Platinum, &c.—EDEY & Co., 29, Ludgate-hill, London, E.C.

### MISCELLANEOUS PLANT, &c., FOR SALE.

DYNAMO, 4-pole, well-known make, about 400 light, 110-135 volts, 1,000 revs., with slide rails and shunt regulator, flywheel and pulley, compound or shunt wound, being removed to replace a larger machine. Can be seen running by appointment. Could be used as motor.—C. T. B., *Electrician* Office, Salisbury-court. Fleet-street, London.

DYNAMO, 2-pole, well-known make, with shunt regulator, flywheel and pulley, about 50 amperes, 110-140 volts, 1,200 revs. compound or shunt wound. Could be used as motor.—C. T. C., *Electrician* Office, Salisbury-court, Fleet-street, London.

ELECTRIC LIGHTING PLANT for SALE.—Two Dynamos, 110 volts, 380 amperes, each belt driven by separate vertical steam engine, 60 lb. steam pressure. All in first-class working order.—Full particulars given on addressing 5994, *Electrician* Office, Salisbury-court, Fleet-street, London.

FOR SALE or HIRE, high-class Dynamos, Motors, Alternators, Cable and Electrical Apparatus.—PERCY HUDDLESTON & Co., 72, Finsbury Pavement, London, E.C.

WATCHES, Non-magnetic. Each Watch warranted, unaffected by the strongest current. Oxydised cases, 5s. 6d. post free.—SWITHENBANK, Coral-street, Saltburn.

THE PROPRIETORS of an OIL SEPARATOR desire to meet with a Firm of Engineers to acquire the PATENTS, or to take up the Manufacture on Royalty.—6010, *Electrician* Office, Salisbury-court, Fleet-street, London.

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FACTORY SITE, Middlesex.—Freehold Land (from 5 to 20 acres) FOR SALE, very cheap, or on lease for 99 years, at a nominal ground rent. Within 7 miles from Liverpool Street Station, and with railway frontage on main line. Gravel soil, level land, and ripe for the immediate erection of a factory. Abundant labour in neighbourhood. Plans can be inspected by appointment, and further particulars obtained from Messrs. FARADAY AND RODGERS, 77, Chancery-lane, London, W.C.

WAREHOUSES to be LET or SOLD, with a frontage of 140 ft. to Belvedere-road, Lambeth, containing three floors with an area of about 11,000 sq. ft., with office and hydraulic lifts; also flat roof with crane and stairway and small yard. Recently erected, and suitable for electrical business.—For further particulars and orders to view apply to T. R. PORTER, 34, New Bridge-street, London, E.C. Tel. 1336 Holborn.

SITES FOR WORKS.—FACTORY SITES FOR SALE, very choice positions in Leeds, Hull and Tadcaster. Many of these sites have railway frontages, and some have railway sidings, good water supply, and the price is very low.—For plans and particulars apply J. W. WATSON, Estate Offices, 21, New Station-street, Boar-lane, Leeds.

FACTORY and WAREHOUSE to be LET.—A substantially-built brick and slated Factory, with covered and paved Yard and Stabling. Floor area of nearly 6,000 super feet. Also eight-roomed private Residence. About a mile north from the Bank. Also steam engine and boiler on the premises of about 20 H.P., the use of which is included in the rental. Lease of about 17 years unexpired. Can be viewed any time. Low rent.—31, Eagle Wharf-road, London, N.

FACTORY or WAREHOUSE.—Large, exceptionally well-lighted, and all ground-floor premises. Within 5 minutes' walk of G.P.O., centre of City. About 12,000 ft. Fitted with power, shafting, &c. (optional); good offices, large open yard.—Keys with MASON & Co., Barbican, London, E.C.

FACTORIES TO LET, ground floor, and second floor; rents moderate; situated in Holloway, North London.—Apply 4, Pembroke-street, Islington, London, N.

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I JUST want you to look into this. It will cost you nothing to do so, but it will mean money to you later on. It doesn't matter what position you hold to-day, I can improve it. I have a system that is perfect. It has cost us many thousands of pounds and years of work to bring it to this stage, and it is now waiting for you. I have, under our system, qualified thousands of people for good positions as Engineers, and I can do the same for you.

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**Electrical Engineering,**
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*SECRETARY,*

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**408, Norwich House, Southampton St., Holborn, London.**

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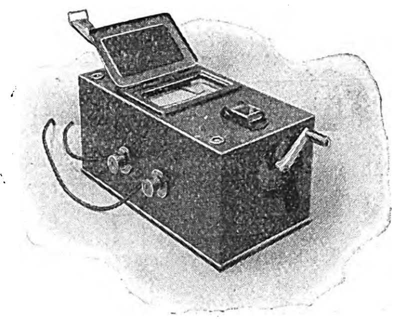
*Many people make rash statements*
*in Advertisements.*
*But when we say that Evershed's Megger is better*
*and will give less trouble than any other*
*Insulation Tester in the Market, we make*
*a Statement we are prepared fully to substantiate.*
*Look here!*
*With every Megger we now give*



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## FOR FIVE YEARS.

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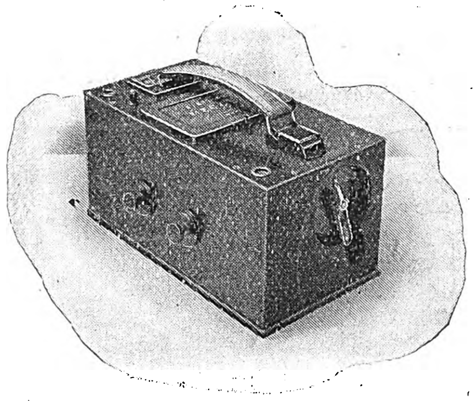
*Unless you, deliberately or accidentally,*
*Smash it!*
*Of all other eventualities*
*We take the risk!*
*That is*



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***And you can get it from***

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# FESSENDEN Wireless Telegraph System

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The above Council require the services of an **IMPROVER** at their Electricity Works, who has had some previous experience of high and low tension work. The wages will be at the rate of 15s. per week

Applications, stating age, and including copies of recent testimonials, to be addressed to the undersigned, and to reach this office not later than 12 noon on TUESDAY, the 30th inst.

Electricity Department,
Gothic Villa, Millhill Grove, Acton, W.

J. MARTIN BLAIR,
Resident Electrical Engineer.

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**TWO JUNIOR DEMONSTRATORS AND LECTURERS** are required to begin work on May 1st, 1906. One for Physics; the other for Engineering.

Applications by FEBRUARY 10th on Forms which can be obtained from the Registrar. Salary £130, rising by £10 a year to £180.

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YOUNG FRENCH ELECTRICIAN, ENGINEER, with experience, graduated from the Electricity School of Paris and from Arts et Métiers, wants to EXCHANGE LESSONS.—Write to Box 1321, Agence Havas, 98, Cheapside, London.

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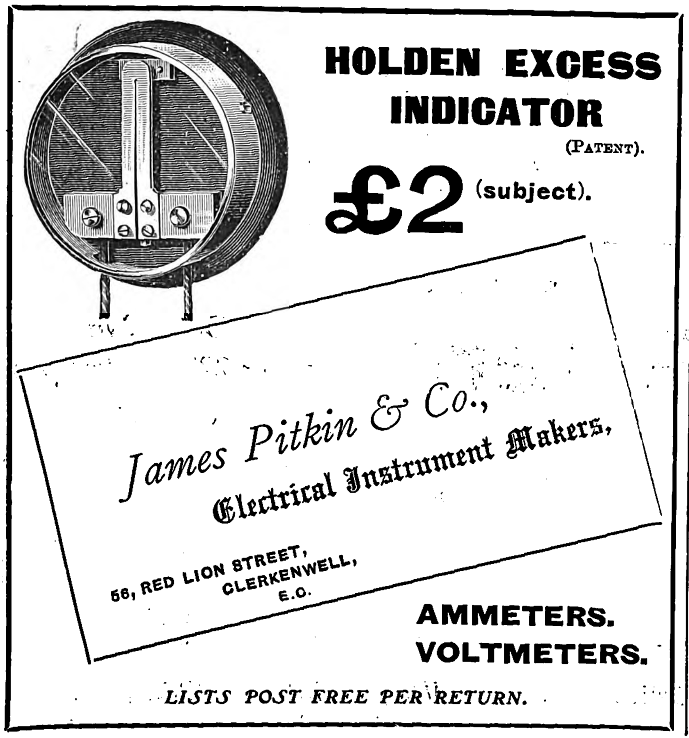

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**£2** (subject).

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Electrical Instrument Makers,
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*LISTS POST FREE PER RETURN.*

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Ten Words to the Line.

**SITUATIONS WANTED.**

*Sixpence per Line of Ten Words, minimum One Shilling.*

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THE BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd, Belvedere-road, S.E., invite APPLICATIONS from competent Engineers to fill an APPOINTMENT ABROAD. Applicants must possess a good, all-round Business-Engineering training and experience; capable of estimating for, negotiating, and when necessary carrying through engineering schemes on a large and small scale, and dealing generally with the Company's business interests. Experience in three-phase work a recommendation. Full particulars should be given of commercial and engineering experience, age, knowledge of foreign languages, &c, and applications addressed to "A," Brush Company as above.

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THE BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd, Belvedere Road, S.E., invite APPLICATIONS from Engineers competent to act as DISTRICT REPRESENTATIVES, the essential qualification being that the applicant shall be a good Salesman-Engineer.—Write stating full particulars of present and past appointments, age, salary expected, &c., to "J," Brush Company as above.

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VACANCY occurs in a leading Electrical Company manufacturing power plant, traction apparatus, etc., for a young engineer with theoretical and practical training to assist in compilation of catalogues, lists, descriptive articles, advertisements. &c.—Apply, with copies of testimonials, and, if possible, specimens of literary work, to C. T. D., *Electrician* Office, Salisbury-court, Fleet-street, London.

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ELECTRICAL ENGINEER, A.I.E.E., with good all-round experience in central station work, seeks post of responsibility at home or abroad; 26; single; excellent testimonials.—6,019, *Electrician*, 1, 2 and 3, Salisbury-court, Fleet-street, London.

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WANTED at once, by a North of England engineering firm a first-class HEAD DRAUGHTSMAN having a good experience in all classes of hydraulic and electric lifts, cranes, pumps, presses, &c. A good salary will be paid to a suitable man.—Applications, which will be treated as strictly confidential, to give full particulars as to age, experience, salary required, &c., and to be addressed to Box 565, care of R. F. White & Son, 33, Fleet-street, London.

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DRAUGHTSMAN, with shop experience in instrument factory, and successful record as a designer of electrical instruments of precision. Technical graduate preferred. Salary proportionate to capability. London district.—6005 *Electrician* Office, Salisbury-court, Fleet-street, London.

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WANTED, by large electrical firm in the North, first-class ELECTRICAL DESIGNER. Must be fully conversant with latest practice for continuous-current and multiphase machinery. State full particulars and salary expected. Applications treated confidentially.—Reply, C. T. M., *Electrician* Office, Salisbury-court, Fleet-street, London.

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Late Member of Council Inst.C.E., and Electrical Engineer to the City of Manchester; Electrical Engineer-in-Chief to the Admiralty.

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"Can be heartily recommended to all electric power station engineers and to all concerned in electric power work."—*Power.*

"One of the MOST VALUABLE CONTRIBUTIONS to Central Station literature we have had for some time."—*Electricity.*

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## SITUATIONS, &c., VACANT—*continued.*

WANTED, JUNIOR ASSISTANT DESIGNER for D.C. work.—State age, experience and salary required, to Box 521, at Horncastle's, 61, Cheapside, London, E.C.

WANTED, a LEADING HAND for electrical switch making. State age, experience and wage required.—Apply, Box 519, Manchester G.P.O.

PUPIL without premium.—VACANCY occurs in company's central station in the South-Western area of London. Direct current. Apply, stating age and full particulars to COUNTY, Moorgate-court, Moorgate-place, London, E.C.

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ELECTRICAL and MECHANICAL ENGINEER (age 27) desires ENGAGEMENT at home or abroad; 11 years' practical experience in all branches of installation, steam, gas and oil engines.—Apply, C., 6022, *Electrician* Office, Salisbury-court, Fleet-street, London.

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ELECTRICIAN, WIREMAN, disengaged. Light, bells, telephones, motors, charge of plant.—S.W., 82, Woodbridge-road, Guildford, Surrey.

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PARTNERSHIP.—WANTED a CONSULTING ELECTRICAL ENGINEER for the electrification of railways and tramways with a connection, to join an electrical engineer who holds a valuable Patent for an entirely new Shallow Conduit System, which offers great advantages over any yet attempted in any part of the world.—6000, *Electrician* Office, Salisbury-court, Fleet-street, London.

ELECTRICAL ENGINEERS and CONTRACTORS.—Old-established firm wants thoroughly business-like, energetic, well-educated ENGINEER who understands contracting and estimating work. Gentlemen with capital, with view to PARTNERSHIP, preferred. Also experienced OFFICE MANAGER wanted. All replies treated in strict confidence.—Apply, X., 6016, *Electrician* Office, Salisbury-court, Fleet-street, London.

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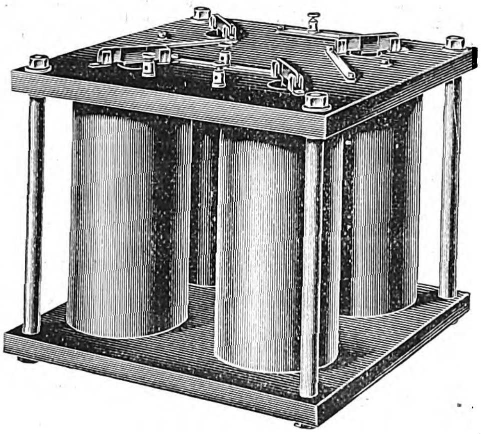

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ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,445. [No. 15. Vol. LVI.] FRIDAY, JANUARY 26, 1906. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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## NOTES.

◆

AN announcement of some interest to the promoters of electric power bills in London this year, and to all interested in London's electric power supply, referred to in our Parliamentary Intelligence, is that all these measures will be considered in the first place by the House of Commons, and not, as last year, by the House of Lords. This may or may not be significant in view of the alteration in the representation in the Lower House brought about by the General Election; in any event we feel it safe to prophesy that some of the bills in question will be strongly opposed before the Committee stage is reached, presuming that a Royal Commission is not appointed to deal with the whole question. All the bills have passed the Examiners of Standing Orders without question, and have been reported for first reading in the House of Commons.

◆

THE new Post Office City telephone exchange described in this issue represents a departure in telephone practice which will be followed with interest by telephone engineers. It will be seen by a perusal of the article that the subscribers' multiple has been abandoned on the answering positions of the exchange, and that the 20 per cent. of the incoming calls that are "local" are dealt with in a similar way to calls for subscribers in other exchanges. The reason for this is, not in order to unify the system of operating, but chiefly to render it possible to deal with a greater number of subscribers than hitherto in a single switchroom, and, secondly, to save a considerable item in the cost of wiring the switchboard. The practical limit of a subscriber's multiple has hitherto been 14,400 subscribers, and proposals to introduce a divided multiple with a selective calling key on the subscriber's instrument have not met with favour, nor has it been deemed advisable to reduce the size of the multiple jacks which are already placed at ⅜ in. centres. Thus the method of confining the multiple to junction and transfer positions was adopted, and it is evident that further extensions can be dealt with almost to an unlimited extent by making suitable arrangements for dividing the multiple. In fact, this is practically what is being done in the new exchange, for the "City" and "Central" exchanges are simply represented by different boards in the same switchroom.

◆

APART from the general system, the details of construction also include several new features. Chief among these are the employment of an iron skeleton construction for the switchboards, and the independent connection of each cord circuit to a main fuse board. A new pattern of cord has been adopted which promises to have a longer life than previous designs. Attention may also be directed to the use of fuses on the main distributing frame, the arrangement of which is to be improved still further when the "Central" distributing frame is remodelled, by placing the fuses on the horizontal side instead of on the vertical side of the frame. Another advance is the employment of separate iron racks for the relays at the back of the switchboard instead of the relays being fixed on the back of the board itself. This enables the inspection of the cords to be carried out without disturbing the operators, and renders the back of the board more accessible generally for repairs; it also prevents any trouble due to vibration to which relays were occasionally subject to some extent in the old position. The work, which is now almost completed, has been carried out in a thorough manner, and both the Post Office engineers and the contractors are to be complimented on the excellence of design and the practical methods which are in evidence throughout.

◆

WE are informed that the Röntgen Society of London, on the suggestion of Mr. C. E. S. Phillips, have under consideration the possibility of formulating a unit of radiant energy, "which, while applying more strictly to radio-active bodies and other ionising agents, may be widened so as to include all known radiations." Mr. Phillips informs us that a set of preliminary experiments are already in hand, and that he is to open a discussion upon the subject before the Society in March. This announcement is not very explicit. We have already a unit of energy, and presumably what Mr. PHILLIPS proposes to "formulate" is rather a method of measurement than a unit. In any case, however, he has set himself a difficult task if he endeavours to place "all known radiations" on the same basis. The general method of measuring radiant energy is to absorb the rays completely and to observe the rise of temperature of the absorbing matter. In the case of radio-active bodies and other ionising agents, the difficulty is that there is no substance which will absorb the highly-penetrating rays in question. If, on the other hand Mr. PHILLIPS wishes to solve the problem by comparing ionising powers, he has still to establish a law, for every variety of radiation, connecting the radiant energy and the ionisation it produces. This relation is not the same for $\alpha$-rays as for $\gamma$-rays, and is very different when, for instance, ultra-violet light and rays from radiant matter are in question. We have still to see the methods that Mr. PHILLIPS has devised for circumventing these difficulties,—difficulties which have stood in the way of some of our leading physicists who have tackled the question, and have so far been insurmountable.

◆

ALTHOUGH the question between third rail and overhead traction was settled, so far as the greater part of the "Underground" is concerned, by the results of the famous arbitration, the matter has come up again in connection with the East London Railway. A considerable portion of the traffic on this line has fallen off since the electrification of the District Railway, as passengers now have to change trains in order to reach New Cross—and this can only be regained by the adoption of electric working. Lord CLAUD HAMILTON, who presided at the meeting of the company on Tuesday, said that he was by no means convinced that the third-rail system was the best method, and that his opinion was confirmed by what he characterised as the unsatisfactory working of the Metropolitan and District Railways. The Brighton Company, he pointed out, was so convinced that the third-rail system was not the best, that it had decided to adopt the overhead system on its suburban lines, and this being so this railway, as one of the companies leasing the East London line, would not be likely to agree to the third-rail system being adopted until their own overhead system had been tested. It would be, however, obviously useless to equip the East London line on the high-tension single-phase system with overhead conductors, when the line had to form part of a through route in connection with the continuous-current low-tension third-rail system of the Metropolitan and District Railways. We are afraid the East London Company is at present to some extent situated "between two stools," as the economical working of a combination system would present some considerable difficulties; but we do think that Lord CLAUD HAMILTON was not well advised to place these difficulties in a crude way before his shareholders, for there can be little doubt that electrical engineers, in combination with the railway engineers, could well lay down a suitable and economical system for the working of this auxiliary line of railway.

◆

THE President of the Local Government Board has appointed a Departmental Committee to inquire into, and report with regard to, the question of municipal accounts. The reference to the Committee is as follows:—

1. The systems on which the accounts of local authorities in England and Wales are at present kept.
2. Generally as to the system on which the accounts of the various local authorities in England and Wales should be kept, and in particular whether such accounts should be prepared on a system requiring the entries of receipts and payments to be confined as far as possible to actual receipts and payments of money or not; and
3. The regulations which should be made on the subject, regard being had to the necessity for showing accurately the amounts raised by local taxation and the purposes for which they are applied.

The Committee will consist of Mr. WALTER RUNCIMAN, M.P. (Chairman), who is Parliamentary Secretary to the Local Government Board; Mr. J. BROMLEY, C.B. (Accountant General to the Board of Education), Mr. E. P. BURD (Inspector of Audits to the Local Government Board), Mr. T. PITTS, C.B. (an Assistant Secretary to the Local Government Board), Mr. R. BARROW, Mr. J. J. BURNLEY, Mr. J. GANE (President of the Institute of Chartered Accountants) and Mr. F. MERRIFIELD; with Mr. G. R. SNOWDON, of the Local Government Board, as secretary. As it is mainly a Departmental Committee, an unbiassed consideration of the question may be looked for, which should be beneficial in the direction of systematising the present methods of keeping municipal accounts. We have frequently had occasion to refer to this matter in connection with electric lighting accounts, and we welcome the appointment of the above Committee for this reason. It is stated that the idea of conducting such an enquiry originated with the President of the Local Government Board in the late Government, Mr. GERALD BALFOUR, and that his successor, Mr. JOHN BURNS, at once took the matter up.

◆

A NOTICE was published in the daily press yesterday, to the effect that the City of London Electric Lighting Co. had approached the Public Health Department of the City of London with a proposal to carry out a demonstration of the most modern system of arc lighting in Newgate-street and Holborn and in Farringdon-street and New Bridge-street. This is, in the main, correct, but it should have been stated that the proposal was made last November and has been repeatedly shelved. The demonstration would be made at the Company's own expense. In this connection we may mention that new mantles were put in the incandescent gas lamps in Fleet-street on Tuesday, and photometric tests were being carried out on Wednesday, so as to allow no time to elapse for deterioration. These tests, moreover, were carried out at nine o'clock in the evening, when Fleet-street is brilliantly lighted by the private arc lamps outside the newspaper offices and other premises, which contribute more to the illumination of many parts of Fleet-street than do the gas lanterns. In view of these two conditions, the tests will be of little value, and we warn our readers from attaching too much importance to them when they are published in the gas journals, as presumably will be the case.

**The "Electrical World."**—Owing to the recent consolidation of the *Electrical World and Engineer* of New York, and the *American Electrician*, our two American contemporaries now appear under the common title *Electrical World.* The change was effected at the commencement of this year and the publication is to be a weekly one.

**Electric Headlights on Locomotives.**—We understand from one of our Australian correspondents that the Victorian Government have adopted powerful electric headlights on the Mildura branch of their railways, as a portion of this line is unfenced, and trouble is experienced through cattle straying on the track. These lamps enable obstacles to be seen on the line up to half-a-mile away.

**The New York Elevated Railway.**—An accident, the consequences of which were not quite as serious as might have been expected, occurred on the New York Elevated Railway on Friday, when a train left the rails at Brooklyn and one car crashed into the street 40 ft. below. Two persons were killed and several injured. The cause of the accident is attributed to a point having been left open by mistake, and the driver being unaware of the fact.

**Cable Interruptions and Repairs.**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Tarifa—Tangier | Jan. 18, 1904 | — |
| Jamaica—Colon | Jan. 10, 1905 | — |
| Cadiz—Teneriffe | July 20, 1905 | — |
| Puerto Plata—Martinique | Dec. 15, 1905 | — |
| St. Thomas—St. Kitts | Dec. 29, 1905 | — |
| Manila—Iloilo | Dec. 29, 1905 | Jan. 18, 1906 |
| Bolama—Bissao | Jan. 19, 1906 | — |

**The "Faraday House Journal."**—The last number of the "Faraday House Journal," with which the title page and index to Vol. II. are issued, contains some notes on economical steam raising and an illustrated description of the Lancashire Electric Power Co.'s power station. A few of the exhibits at the recent Olympia Electrical Exhibition are described and a number of personal notes of interest to "Faradians" are given, including the results of examinations which have taken place since the publication of the last issue of the journal.

**Royal College of Science.**—In the official announcement made by the President of the Board of Education with regard to the appointment of Prof. W. W. Watts, F.R.S., to the Professorship of Geology at the Royal College of Science in succession to Prof. Judd, it is stated that in view of the changes in organisation that may be found desirable in the Royal College of Science and the Royal School of Mines after the consideration of the report of the departmental committee on the college, it has been thought best to make this appointment a temporary one.

**Armstrong College, Newcastle-on-Tyne.**—It is announced that the Council of the Armstrong College of Durham University in Newcastle has resolved to found a Chair of Electrical Engineering, and has voted the sum of £2,600 towards the equipment of electrical engineering laboratories. The Council has also decided to offer for competition at the end of the current session two Fellowships of £125 a year, each tenable by graduates of the college for two or three years at a time, on condition that the holders should spend their time in the prosecution of definite research or in the pursuance of a definite line of advanced study. This decision was made with a view of establishing eventually six such Fellowships.

**The Charing Cross & City Company's Lamp Connections.**—We regret that owing to a slight misunderstanding the connections to the mains of the Charing Cross, West End & City Electricity Supply Co. were somewhat overstated in our supplement sheet No. 1 and the curves on p. 538 of our last issue. The total connections should have been given as 24,700 kw., and the figures in the table for the private lighting connections as 316,000 and 247,050 8 c.p. lamps for the West End and City portions of the undertaking respectively, the motor connections remaining unaltered. The rate of increase in the company's business is still remarkable, but the lead still held by the Metropolitan Company is greater than we had represented.

**The Journal of the Junior Institution of Engineers.**—The Journal and Record of Transactions of the Junior Institution of Engineers is now published in monthly parts, the first of which has just been issued. The number commences with a few editorial remarks on the new form which the Journal takes, and some notes on doings of the members. The Institution has now been in existence for 22 years, and the annual report contains evidences of undiminished activity, the increase of membership during the last year being 109. Accounts are given of visits to the Electrical Exhibition at Olympia, and Messrs. Barclay, Perkins & Co.'s brewery; but the most interesting part of the number is Professor Dugald Clerk's Presidential Address on the problem of the gas turbine, which has already appeared in our columns (*Electrician,* Nov. 10th, pp. 144 and 147).

**Mechanical Stoking.**—We have received a letter from a firm of makers of underfeed mechanical stokers objecting to the inference drawn in Mr. Patchell's Paper, that mechanical stokers will only suit boilers worked at a low steaming duty. Our correspondents maintain that, although this is the fact where the furnace area is so small that the full steaming duty can only be attained by burning smokeless Welsh coal without the smoke question arising, if the furnaces are properly designed it should be possible to burn sufficient slack coal efficiently on mechanical stokers to give the maximum steaming duty. They state that they have often got 100 per cent. over the boiler rating under these conditions without smoke. In conclusion, our correspondents express their regrets that boiler makers "persist in selling boilers with absurdly small furnaces, so that it is only possible to get their full rating when burning best Welsh coal."

**Tramway Accident in Liverpool.**—A serious accident, not, however, attended by fatal results, occurred on Monday morning last on the Liverpool tramway system. A car was descending Leece-street, one of the steepest gradients in the city, when it came out of control of the driver and ran away down the hill, leaving the metals at a sharp turn and colliding with an iron pallisade which the Corporation Streets Committee had erected to protect the group of buildings between Renshaw-street and Bold-street in consequence of the large number of accidents which have already occurred at this dangerous point. The car, which had gathered considerable speed, was overturned and completely wrecked. The driver escaped unhurt, but over 20 persons were more or less seriously injured out of about 70 who were on the car at the time. It is reported that on an examination of the car after the accident it was found that both brakes were hard on. A report has been sent to the Board of Trade, but it is not known yet whether an inquiry will be held.

**The Royal Society.**—Among the Papers down for reading yesterday were the following: "Note on Heusler's Magnetic Alloy of Manganese, Aluminium and Copper," by Prof. A. Gray, F.R.S.; "On the Overstraining of Iron by Tension and Compression," by Dr. J. Muir. Communicated by Prof. A. Gray, F.R.S.: "On the Effect of High Temperature on Radium Emanation," by W. Makower. Communicated by Prof. A. Schuster, F.R.S.: "Galvanic Cells Produced by the Action of Light; the Chemical Statics and Dynamics of Reversible and Irreversible Systems Under the Influence of Light," by Dr. M. Wilderman. Second communication. Communicated by Dr. L. Mond, F.R.S.: "Artificial Double Refraction Due to Æolotropic Distribution, with Application to Colloidal Solution and Magnetic Fields," by T. H. Havelock. Communicated by Prof. J. Larmor, F.R.S.: "An Electrical Measuring Machine for Engineering Gauges and Other Bodies," by Dr. P. E. Shaw. Communicated by Prof. J. H. Poynting, F.R.S.: "The Relation Between the Osmotic Pressure and the Vapour Pressure of a Solution," by W. Spens. Communicated by W. C. D. Whetham, F.R.S.: "The Elliptic Integral in Electromagnetic Theory," by Prof. A. G. Greenhill, F.R.S.

**A New Surface-contact System.**—Yet another system of surface-contact traction, which, however, has not as yet got beyond the working model stage, has been introduced by Messrs. M. G. Waggott & Co., who are showing the chief features of their method at the Builders' Exchange and Exhibition, Birmingham. One of the principal advantages claimed is the reduction in the size of the actuating magnets on the car and the diminution of the braking effect which the large magnets in use on some other systems are said to produce. Two small electromagnets are mounted at the two ends of the car. The moving iron switch piece under the stud is in a field produced by a permanent magnet within the stud box, this field being not of sufficient strength to lift the switch piece into its contact position, but being able to retain it in place when once lifted. The forward car magnet is of such a polarity as to assist the permanent magnet in the stud and close the switch which is held up by the influence of the permanent magnet until the magnet at the rear of the car passes, this opposing the permanent magnet and causing the switch piece to drop off. Contact with the studs is made by a long skate, and the studs are provided with ball-shaped heads which can be turned round to expose a new surface when badly worn. A similar apparatus has been designed for signalling on railways, but is not as yet in actual operation.

**The Venezuela Incident.**—The story of the dispute which led up to the expulsion of a high official of one of the French cable companies from Venezuela by President Castro, and culminated in the withdrawal of the French Minister from that country, is given particularly clearly in a leading article in *The Times* of Wednesday last. The company originally contracted to lay a cable direct between Venezuela and the United States. Seventeen years ago they laid a cable, but it was landed at Santo Domingo. The Venezuelan Government at the time made no objection, and the cable was taken into regular service until the end of 1904, when President Castro asserted that not only had the company broken their contract by touching at Santo Domingo, but had also supported and subsidised the traitor Matos. He therefore caused the Venezuela Courts to tear up the contract. The owners of the cable naturally protested, whereupon M. Brun, the president of the company, who had gone to Venezuela to try to negociate with the Government, was expelled, and all the telegraph stations belonging to the company were seized without any mention of compensation. The French Government promptly sent in a protest through their Minister, M. Taigny, but President Castro's reply was simply a personal insult to M. Taigny. A withdrawal of this reply was demanded by France, but the demand was only met by the President's offer to withdraw the note on condition that France withdrew hers. This was, of course, refused. Further insults to M. Taigny followed, and the Minister was eventually recalled to France.

**Obituary.**—We regret to record the death of Mr. Francis Alexander Taylor, which took place under painful circumstances at Liverpool on the 20th inst. The son of Dr. R. H. Taylor, a well-known physician of Liverpool, he was born in 1857, and educated partly at Liverpool College. In 1874, at the age of 16, he entered the service of the Eastern Telegraph Co., and, having shown special electrical aptitude, was appointed an electrician on board one of the company's ships two years afterwards. After 10 years' service afloat in various parts of the world, he was made assistant superintendent at Gibraltar, and afterwards served in the same capacity at Porthcurnow. Unfortunately ill-health dogged his footsteps all through his career, and in spite of electrical qualifications of no mean order he was never able to take up the position that his service and abilities warranted. In 1896 he was appointed to the Chief Electrician's department of the Company under Mr. H. A. C. Saunders, and retained that post until he was made inspecting superintendent of the line about a year ago. Reaching Aden on his first tour of inspection he was seized with illness and had to return to England, after which his continued ill health obliged him to retire on a pension in June last. Quite recently he became greatly depressed, and on Saturday morning last was found lying on his bedroom floor with a bullet wound in his head and a revolver at his right hand; he was quite unconscious and death ensued an hour after. How he became possessed of the revolver is a mystery. An inquest was held and a verdict of "suicide whilst temporarily insane" was returned.

**Electrical Trades Benevolent Institution.**—The rules and full particulars of the Benevolent Institution in connection with the National Electrical Manufacturers' Association are now available. The object of the fund, which we briefly referred to in our issue for December 15, p. 368, is to grant pensions and to dispense temporary relief to deserving or necessitous persons who are, or have been, engaged in the electrical trade in the United Kingdom or to their widows and families. All applicants for pensions must have been subscribers to the fund for at least five years. The Institution will be supported by donations, annual subscriptions and bequests. The affairs of the Institution will be conducted at present at the offices of the National Electrical Manufacturers' Association, Ridler-place, Holland-street, Blackfriars, and the management will be in the hands of trustees and a committee of not more than 30. The first committee is constituted as follows:—

H. Bevis, G. B. Birnbaum, H. H. Berry, G. Braulik, E. J. Clark, Justus Eck, T. J. Grainger, E. F. Johnson, A. P. Lundberg, F. H. Nalder, C. S. Northcote, H. Oppenheimer, W. L. Packenham, W. Schmahl and L. Thurnauer.

The committee will be elected annually by the donors and subscribers to the fund. The amount and term of any pension or temporary relief will be determined by the committee, but in the case of the latter, no grant will exceed £20. As stated in our previous note, £260 was collected for the fund at the beginning, and a good sum is expected from the surplus of the Electrical Exhibition at Olympia. In addition to donations of £10 each, the committee pledge themselves to raise £100 each for the fund. A complete copy of the rules can be obtained on application to Mr. Walter Davenport at the address given above.

**Superheated Steam.**—A lecture on the above subject was recently given before the Bradford Engineering Society by Mr. Michael Longridge. The lecturer commenced with a short general description of the physical properties of steam, in the course of which attention was called to the lack of information at present available as to the variations of the specific heat of superheated steam with pressure and temperature, a matter which is now being investigated at the National Physical Laboratory. The application of superheated steam to engines as a means of improving their economy was next considered. The two theories, due respectively to Adolf Hirn, who attributed the losses to cylinder condensation, and Callender and Nicholson, who ascribed them mainly to leakage past valves and pistons, were considered, and it was seen that from either point of view superheating could be proved to be conducive to economy. Some interesting reproductions of the late Mr. Donkin's curves, showing the temperature changes in the cylinder walls, were shown, and formulæ were explained for estimating the probable saving with superheated steam. It was pointed out that the saving in triple and quadruple expansion engines could only be fully utilised by employing reheaters between the successive cylinders. Indicator diagrams and results of tests were given to illustrate the gain in actual practice. Steam could be superheated in two ways, either by allowing it to expand without doing work or by supplying it with heat from an outside source. The former method was occasionally employed for moderate degrees of superheat, as in the case of some of the water-tube boilers in the British navy, but the latter method was far more common, a well-known example being the Schmidt superheater. The McPhail and Simpson superheater was also described and Mr. Patchell's testimony as to the utility of superheating in electric light stations during the peak of the load was mentioned. After giving some formulæ and figures relating to the amount of superheat obtainable with different sizes of superheaters, the lecture concluded with some general notes on the design of engines intended for use with superheated steam. We should have liked to see some comparison of the way in which turbines and reciprocating engines are able to take advantage of the economies attendant on the use of superheated steam, but this was a point not touched on by the lecturer.

**Sixteenth Annual Dinner of the General Electric Co.**—A pleasant evening was spent at the Criterion Restaurant last Saturday, when a party of some 400 persons, including most of the General Electric Co.'s staff and a number of invited friends, met together at an excellent dinner, followed by a musical entertainment. After the Royal toasts had been duly honoured, Mr. H. Hirst, who occupied the chair, proposed the toast of "The Army, the Navy, and the Reserve Forces." This toast was replied to by Col. Crompton, who was confident that our army and navy were to-day in as healthy a condition as ever. On rising again, the chairman first extended his welcome to the visitors, and then dwelt on the prosperity of the company during 1905, alluding to the extensions already carried out at the Witton works, &c., and to be carried out elsewhere in the near future. A feeling tribute was paid to the memory of those friends who had been removed by death from the service of the firm. In concluding his speech, Mr. Hirst referred to the internal changes in the organisation of the company which had taken place during the past year, and exhorted the members of the staff to do their best for the company, which they might be assured would in its turn take the best care of the interests of their staff. Mr. R. Dumas, works manager at Witton, replied on behalf of the staff, his toast to the directors being coupled with the name of Mr. H. Bevis, who replied on behalf of his colleagues. Mr. Max Byng, who humourously posed as a candidate seeking election, counselled the audience to vote for the General Electric Co., promising in return all the advantages which long experience and up-to-date methods of manufacture guaranteed. His toast was to the guests, coupled with the names of the Hon. Walter James and Prof. W. E. Ayrton. The former replied in a political strain, while Prof. Ayrton, in a happy speech, full of reminiscences, struck the key-note by his remark that, whatever the political convictions of the company, their business and dinner were conducted on thoroughly liberal principles. He proposed the health of the chairman. Sir R. Awdry, K.C.B., the next speaker, proposed the health of Mr. G. Byng, the chairman of the company. Mr. Hirst replied to both toasts, regretting that Mr. G. Byng was unfortunately absent through ill-health. The musical entertainment after the dinner was of a high-class order, and kept the company together until a late hour.

**High-speed Electric Machinery.**—The first of a series of three "Howard Lectures" was given at the Society of Arts by Prof. Silvanus Thompson, F.R.S., on Thursday, January 18th, the subject chosen being high speed electric machinery, with special reference to steam turbine machines. The first lecture was devoted to general consideration of dynamo design as affected by speed and rated output, and commenced with a historical sketch of the conditions leading up to present day practice. Although in the early days of slow-speed engines and small high-speed generators, belt-driving was almost universal, a few examples of direct-driven machines are to be found at comparatively early dates, such as the magneto machine of Holmes at the exhibition of 1862, and later Edison's famous "Jumbo" type, and the late J. E. H. Gordon's pioneer two-phase alternators at Paddington, machines most remarkably in advance of their time. Slides of historical early machines were shown, including the familiar "A" Gramme and some curious views of stations planned in the early 80's in America with one large slow-speed engine driving regular batteries of diminutive dynamos through elaborate systems of belts, often with countershafts on an intermediate floor of the building. There were two lines along which development took place from these early conditions. On the Continent the dynamo speed decreased to meet the engines, resulting in the development of the large slow speed direct-coupled machines, of which such an imposing array was seen at the Paris Exhibition of 1900. In England, on the other hand, thanks to the pioneering work of Willans and Belliss, the engine speeds increased to meet the dynamos. The use, however, of really large units, which had become common on the Continent, was delayed in this country by the limitations of the Electric Lighting Act of 1882. During all this time the influence of the steam turbine, due mainly to the untiring work of Parsons, was beginning to be felt, and was causing designers to turn their attention to much higher speeds than had previously been thought possible for large units, as the high speed reciprocating engine began to find a rival in the still higher speed steam turbine. Another factor, having influence in the same direction, was the increasing use of motor-generators, the speed of which was independent of engine considerations. The remainder of the lecture dealt with the fundamental principles of dynamo design and an exposition of limitations to the output of a machine, as affected by what the lecturer described as speed, magnetic loading and electric loading. Several aspects of considering the output obtainable from machines were dealt with, particularly the "active-belt" method originally introduced by Mr. H. A. Mavor. The later developments of recent years in the direction of more rational formulæ, and the work of Mr. Hobart, were dwelt on, and the lecturer concluded by throwing on the screen some interesting tables of machine constants taken from modern designs, all tending to show the improvements consequent on the use of higher peripheral speeds. The second lecture of the series, of which we give a syllabus below, was delivered last night.

TURBO-DYNAMOS.—The problem of commutation—Use of carbon and metal brushes—Natural and forced commutation—Peripheral speed in relation to commutation—Loading of armatures—Armature distortion—Problem of centrifugal forces as affecting dynamo design—Turbo-dynamo design.

## ARRANGEMENTS FOR THE WEEK.

**(To-day) FRIDAY, January 26th.**

PHYSICAL SOCIETY.

*5 p.m.* Meeting at the Royal College of Science, Exhibition-road, South Kensington. Agenda: (1) "The Isothermal Distillation of Nitrogen and Oxygen and of Argon and Oxygen," by I. K. Inglis. (2) "On the Use of Chilled Cast Iron for Permanent Magnets," by A. Campbell. (3) "Experiments on the Propagation of Longitudinal Waves of Magnetic Flux along Iron Wires and Rods," by Prof. T. R. Lyle and J. M. Baldwin.

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER STUDENTS' SECTION

*7:30 p.m.* Meeting at the Municipal School of Technology, Sackville street, Manchester. Paper to be read: "Electric Lamps," by F. Shaw.

ELECTRO-HARMONIC SOCIETY.

*8 p.m.* Smoking Concert in the King's Hall, Holborn Restaurant.

JUNIOR INSTITUTION OF ENGINEERS

*8 p.m.* Meeting at the Westminster Palace Hotel, when a lecture will be delivered by Prof. J. D. Cormack on "Notes on Boiler Trials."

**SATURDAY, January 27th.**

JUNIOR INSTITUTION OF ENGINEERS.

*3 p.m.* Visit to the Engineering Laboratories of University College, Gower-street, during which Prof. J. D. Cormack will demonstrate the methods of conducting a boiler trial.

INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' VISIT.

*3 p.m.* Visit to the Post Office Central Telephone Exchange, Addle-hill, London, E.C.

**TUESDAY, January 30th.**

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER SECTION.

*7:30 p.m.* Meeting at the University. Paper to be read: "Gas Engines applied to Electric Driving," by James Atkinson.

FARADAY SOCIETY.

8 *p.m.* Meeting at the Institution of Electrical Engineers, 92, Victoria-street, Westminster, S.W. Papers to be read: (1) "The Electric Furnace; its origin, transformations, and applications," Part 3, by Adolphe Minet. (2) "Demonstration of a New Electrolytic Tube Furnace," by Dr. J. A. Harker. (3) "Note on the Production of Ozone by Electrolysis of Alkali Fluorides," by E. B. R. Prideaux.

**WEDNESDAY, January 31st.**

INSTITUTION OF CIVIL ENGINEERS: STUDENTS' SECTION.

*2:30 p.m.* Visit to the Greenwich generating station of the London County Council.

**THURSDAY, February 1st.**

SOCIETY OF ARTS.

*8 p.m.* "Howard" Lecture II., by Prof. Silvanus P. Thompson, F.R.S., on "High-Speed Electric Machinery with Special Reference to Steam Turbine Machines."

RUGBY ENGINEERING SOCIETY.

*8 p.m.* Meeting in the Benn Building, High-street, Rugby. Paper to be read: "The Transmission of Electric Energy," by C. McCarthy Jones.

**FRIDAY, February 2nd.**

JUNIOR INSTITUTION OF ENGINEERS.

*8 p.m.* Meeting at the Westminster Palace Hotel. Paper to be read: "Some Recent Electrical Engineering Measuring Instruments," by Kenelm Edgcumbe.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse by Prof. Silvanus P. Thompson, F.R.S., on "The Electric Production of Nitrates from the Atmosphere."

## ELECTRIC POWER DISTRIBUTION IN NORTH WALES.

Through the courtesy of the consulting engineers, Messrs. Harper Bros. and Sir Douglas Fox & Partners, and the hospitality of Mr. W. V. Waite, who is in charge of the construction work on behalf of Messrs. Bruce Peebles & Co., the contractors, we were enabled last week to visit the power house of the North Wales Electric Power & Traction Co., and to inspect their transmission lines. The work has made considerable progress during the last couple of months, and before the spring is far advanced power will be supplied to some of the large quarries in the district surrounding Snowdon. The system of the North Wales Company is unique in this country, for it is to be driven entirely by water power, and it will transmit power over considerable distances by the means of overhead wires at extra high pressure.

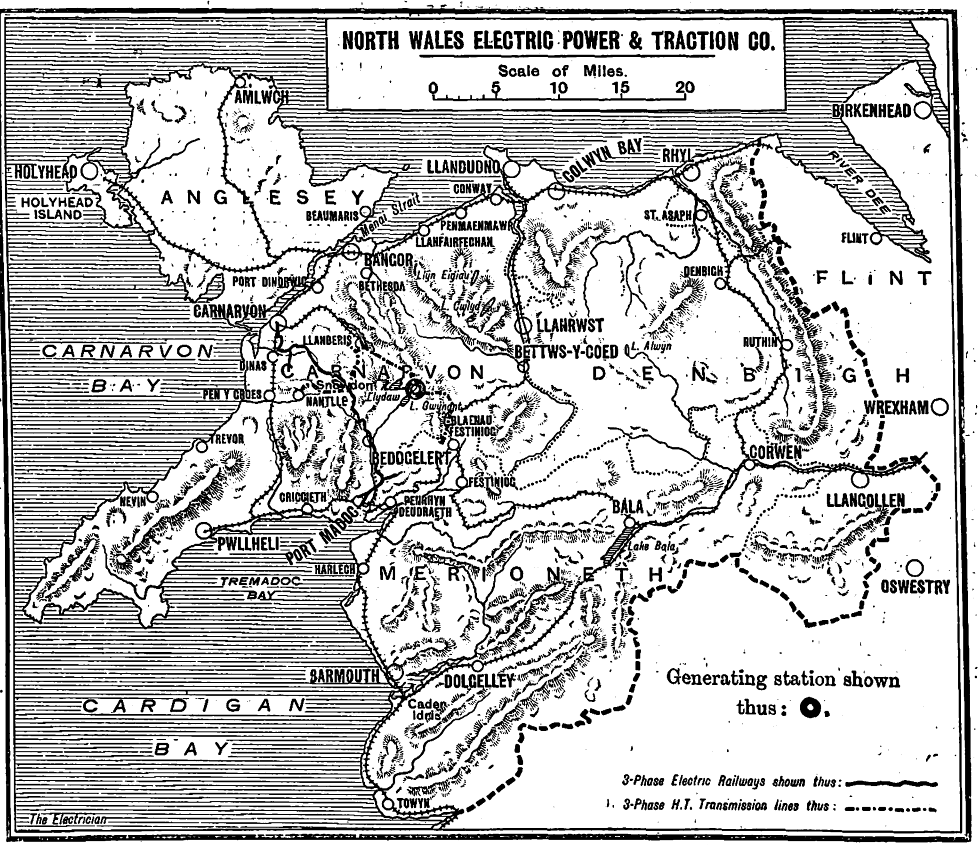
NORTH WALES ELECTRIC POWER & TRACTION CO.
Scale of Miles.
0 5 10 15 20
AMLWCH
HOLYHEAD
HOLYHEAD ISLAND
A N G L E S E Y
BEAUMARIS
Menai Strait
LLANDUDNO
CONWAY
COLWYN BAY
RHYL
BIRKENHEAD
RIVER DEE
ST. ASAPH
FLINT
PENMAENMAWR
LLANFAIRFECHAN
BANGOR
PORT DINORWIC
BETHESDA
Llyn Eigiau
L. Cwlyd
DENBIGH
F L I N T
CARNARVON
LLANBERIS
LLANRWST
BETTWS-Y-COED
L. Alwyn
RUTHIN
C A R N A R V O N
D E N B I G H
CARNARVON BAY
DINAS
PEN Y GROES
NANTLLE
Snowdon
Llydaw
L. Gwynant
BLAENAU FESTINIOG
WREXHAM
TREVOR
BEDDGELERT
FESTINIOG
CORWEN
NEVIN
CRICCIETH
PENRHYN DEUDRAETH
LLANGOLLEN
BALA
Lake Bala
PWLLHELI
PORT MADOC
HARLECH
M E R I O N E T H
OSWESTRY
TREMADOC BAY
BARMOUTH
DOLGELLEY
Cader Idris
C A R D I G A N B A Y
TOWYN
Generating station shown thus:
3-Phase Electric Railways shown thus:
3-Phase H.T. Transmission lines thus:
The Electrician

Fig. 1.—Map of North Wales Power & Traction Co.'s Area.

Before entering upon a description of the many interesting details of the equipment of the power house and the construction of the transmission lines, we will give an outline of the general features of the scheme. High up on the slopes of Snowdon 1,420 ft. above the level of the sea, there is one of the largest of those peculiar mountain lakes which are a remarkable natural feature of the rugged country of North Wales. This lake, Llyn Llydaw, is over a mile long and about 350 yds. in width, and the water in it is maintained continuously at a high level by a long watershed, which includes the summit of Snowdon. From the lake down to the Gwynant valley beneath, there is a sharp descent, and the power house has been built at Cwm Dyli, at the base of this slope 1,150 ft. below the lake, to which it is connected by a pipe line about $1\frac{1}{2}$ miles long. It is estimated that the high fall and the large amount of water available will suffice to supply some 6,000 H.P. or more continuously, and that this may be added to by increasing the height of the natural dam of the lake to 30 ft. or 40 ft. The water from the power house is discharged into the Afon Glaslyn.

Within a radius of 15 miles of the power house there are several big slate quarries, the owners of which are quite ready to utilise electric motors for winding, pumping and drilling, and for cutting the slate. In addition to this, a narrow-gauge steam railway serving some of the quarries is to be "electrified," and extensions are being carried out which will, it is hoped, attract a large tourist traffic in the summer. By the use of overhead lines worked at a sufficiently high voltage it will be possible to supply current at a very low cost for these purposes.

Fig. 1 is a map of the whole area, in which the company is empowered to supply by its Act of 1904, and Fig. 3 shows on a larger scale the area of the present operations. The consumers at the start will all be slate quarries. Of these, the three principal ones are the Oakeley Quarry at Blaenau Festiniog, the Dinorwic Quarry near Llanberis, and the Pen-yr-Orsedd Quarry at Nantlle, which will be supplied with 2,000, 700 and 720 H.P. respectively. Their positions are all shown in Fig. 3, in which also an effort has been made to indicate the mountainous character of the country by showing the principal elevations. The longest transmission line from the power house is to Nantlle, a distance of nearly 14 miles. The

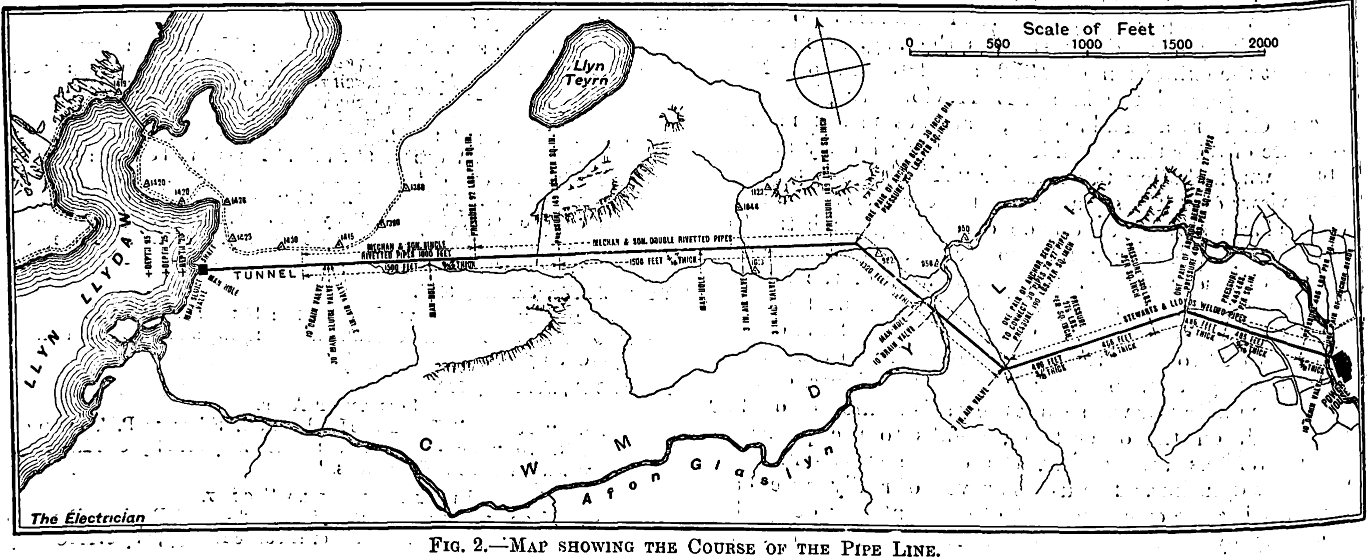
Scale of Feet
0 500 1000 1500 2000
Llyn Teyrn
L L Y N L L Y D A W
TUNNEL
MECHAN & SON DOUBLE RIVETTED PIPES
STEWARTS & LLOYDS WELDED PIPES
C W M D Y L I
Afon Glaslyn
The Electrician

Fig. 2.—Map showing the Course of the Pipe Line.

steam-driven narrow gauge railway already referred to (the North Wales Narrow Gauge Railway) has been running for some years between Dinas Junction on the L. & N. W. Railway and Rhyddu or Snowdon Station, chiefly to serve some quarries. This will ultimately be electrically equipped, and will be extended to Beddgelert, where it will connect with a new electric line to Portmadoc, the Portmadoc, Beddgelert and South Snowdon Railway. There will also be a line of narrow gauge from Dinas Junction to Carnarvon. The railway work will not be completed for some time, but a certain part of the civil engineering portion has been done including tunnelling, cuttings and embankments. Fig. 4 is a view of one of the open cuttings. The line is of the uniform 1 ft. 11½ in. gauge, which has been adopted by all the N. Wales quarries. Three-phase locomotives will be employed at low pressure, and transformers will be placed at intervals along the railway line. We hope to describe the details of the equipment at a later date.

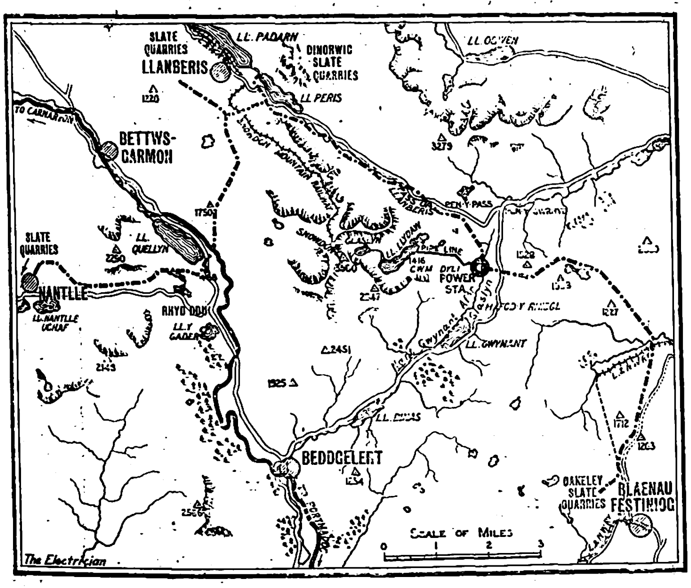
SLATE QUARRIES
LLANBERIS
LL. PADARN
DINORWIC SLATE QUARRIES
LL. OGWEN
LL. PERIS
1220
TO CARNARVON
BETTWS-CARMON
SNOWDON MOUNTAIN RAILWAY
3279
PASS OF LLANBERIS
PEN-Y-PASS
1750
SLATE QUARRIES
LL. QUELLYN
2250
NANTLLE
LL. NANTLLE UCHAF
RHYD DDU
LL. Y GADER
SNOWDON
3560
LL. LLYDAW
PIPE LINE
1416
CWM DYLI POWER STA.
1528
2547
HAFOD Y RHISGL
LL. GWYNANT
Gwynant
Glaslyn
2451
1925
2143
LL. DINAS
1712
1263
BEDDGELERT
1234
2566
PORTMADOC
OAKELEY SLATE QUARRIES
BLAENAU FESTINIOG
SCALE OF MILES
0
1
2
3
The Electrician

Fig. 3.—Sketch Map showing Positions of Generating Station, Pipe Line, Transmission Line and Electric Railways.

———— Three-phase Electric Railway under construction
—·—·—·— Three-phase H.T. Transmission Line.

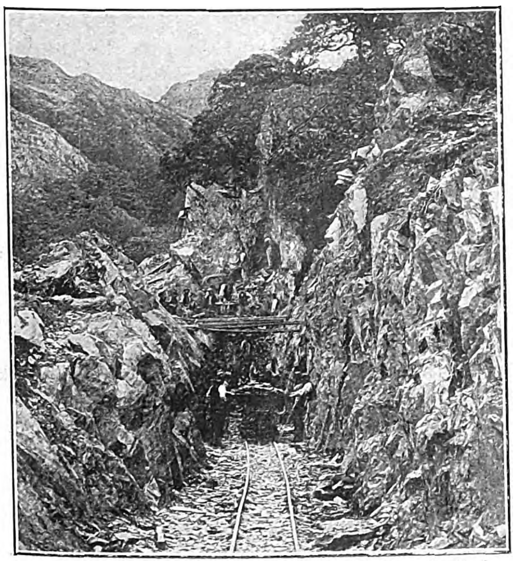

Fig. 4.—An Open Cutting on the Railway during Construction.

Fig. 4 shows the route taken by the pipe line. At the intake, a tunnel has been cut to a point in the bed of the lake at a depth of about 30 ft. from the surface, and between the top of the pipe line and the main intake valve at the edge of the lake, the water flows partly in tunnel (48 in. diameter) and partly in an open cutting, the latter having been necessary owing to the ground being too loose to tunnel right through. The tunnel is lined with concrete. The open cutting in the lake is 200 ft. long, and the tunnel about 200 yds. long. The tunnel and cutting are run through the natural dam of the lake, which rises at a sharp angle to some 10 ft. higher than the usual surface of the water; the company has the right of artificially increasing the height of this dam by 20 ft., should it be found necessary. At the intake two shafts have been sunk, in one of which is the screen and a safety valve, and in the second the ordinary sluice valve. The main shaft is 8 ft. by 8 ft., and the auxiliary shaft 8 ft. by 6 ft. in section, and both are lined with 3 : 1 concrete 3 ft. thick. Above the shafts is the usual tower and a capstan for lifting the valves. The pipe line is divided into three sections, the upper part being of 30 in. single-riveted pipe, the middle portion 30 in. double-riveted pipe, and the bottom portion, on which,

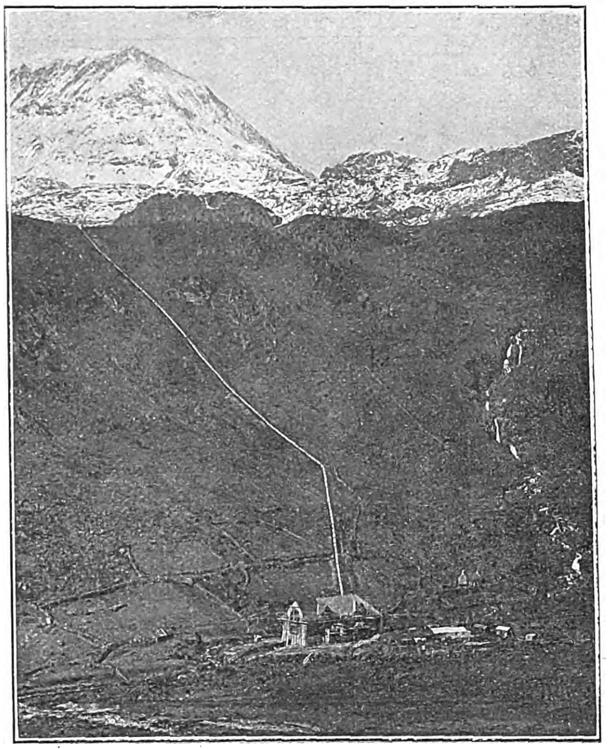

Fig. 5.—General View showing Position of Power House and Pipe Line.

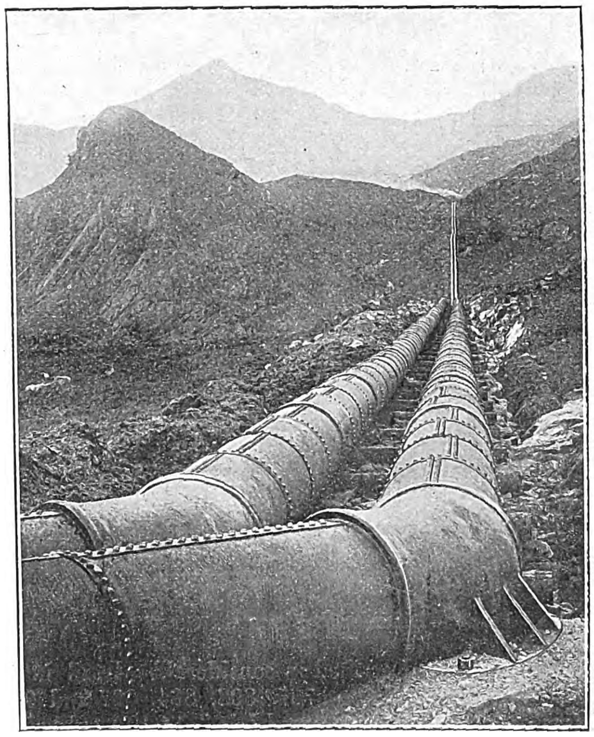

Fig. 6.—View of Part of the Pipe Line.

of course, the pressure is very high, of 27 in. welded pipe. Two pipes run down the whole way. They rest on creosoted sleepers and are held well off the ground. The sleepers are on a made line similar to railway formation. In places, the slope of the pipe is as great as 30 deg. with the horizontal, and at all steep parts $1\frac{1}{2}$ in. back straps are employed to anchor it to the ground. The two concrete blocks which support the pipe on the steepest slope near the power house weigh 38 tons each, and the buttresses with cast-iron anchor bends 42 tons. They are all made of 4 : 1 concrete.

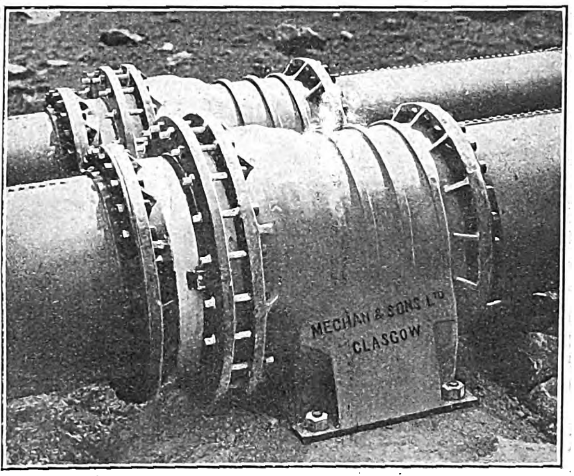
MECHAN & SONS LTD
GLASGOW

Fig. 7.—Expansion Joint in Pipe Line.

(*To be continued.*)

## THE NEW POST OFFICE CITY TELEPHONE EXCHANGE.

So rapid has been the increase in the number of subscribers to the Post Office Central telephone exchange in London that the whole capacity of the switchboard (14,400 subscribers) has been nearly taken up. The central exchange was opened in April, 1902, and was described in considerable detail in *The Electrician* (Vol. XLVIII., pp. 767, 808, 864, 897 and 930). The ultimate capacity of the "multiple," 14,400 subscribers with jacks at $\frac{5}{8}$ in. centres is practically the limiting size of a board of this class, and it was not expedient to make any endeavour to extend it. Although smaller jacks at $\frac{3}{10}$ in. centres are, we believe, obtainable, this represents a very close board, and, moreover, it was obviously inadvisable to replace the board with a new one which would only defer for a comparatively short time a more drastic alteration in the system. After careful consideration of the question, Mr. Gavey, the engineer-in-chief of the Post Office, decided to erect a new exchange in the same building on the floor below the old one. Instead of equipping this with an ordinary multiple board, however, which in its turn would soon become full, it was decided to dispense altogether with the subscribers' multiple on the answering positions, and to treat every call in the same way as a junction call. In spite of the large number of subscribers to the central exchange, it is found that over 80 per cent. of the calls are for subscribers on other exchanges, so that the answering operator only makes use of the subscriber's multiple in front of her on an average every fifth call. In the new exchange, therefore, every call will be treated in the same way as a junction call, and the only multiple on the answering operator's sections is that of the outgoing junction lines, some of which are the ordinary junction lines to other exchanges, and others transfer lines to local subscribers' multiples in the same switchroom.

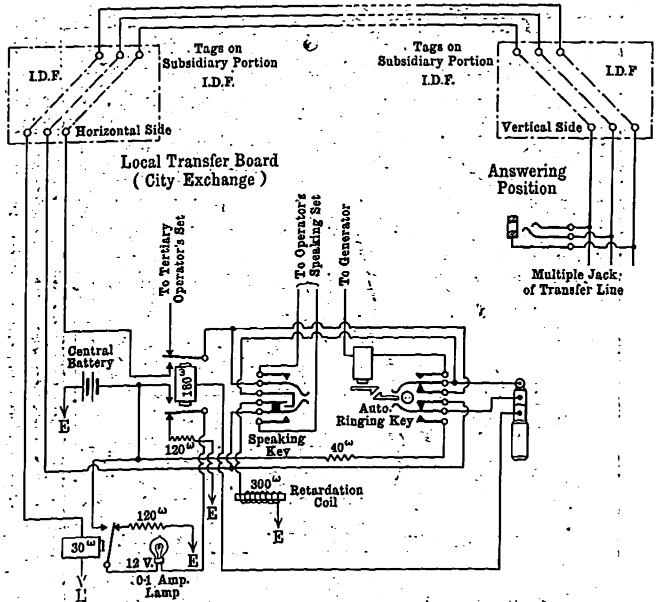
I.D.F.
Tags on Subsidiary Portion I.D.F.
Tags on Subsidiary Portion I.D.F.
I.D.F
Horizontal Side
Vertical Side
Local Transfer Board (City Exchange)
Answering Position
To Tertiary Operator's Set
To Operator's Speaking Set
To Generator
Multiple Jack of Transfer Line
Central Battery
E
180ω
120ω
Speaking Key
40ω
Auto. Ringing Key
300ω Retardation Coil
E
E
120ω
30ω
12 V.
E
0·1 Amp. Lamp
L

Fig. 1.—Diagram of Transfer Circuit.

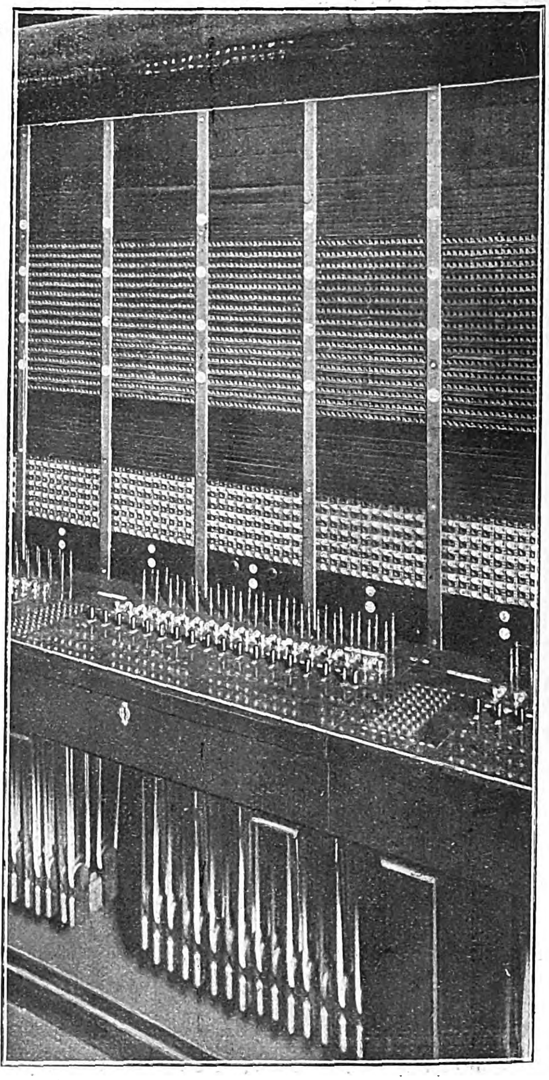

Fig. 2.—Answering Board.

The new exchange will probably be in regular operation by the end of this month. Through the kindness of Mr. Gavey and his engineering staff, who have taken pains to show us all the details of the exchange and have placed all possible information at our disposal, we are able to publish a complete description of the new arrangements, and it should be noted that in addition to the alteration in the circuits to which we have alluded vast improvements have been made in the construction of the switchboards and the general arrangement of the exchange, which conduce to easier inspection and maintenance and, what is more important than all, reduce enormously the chance of a fire spreading should it break out in any portion of the building.

We will commence our description by tracing out the circuit of the new transfer arrangement, which constitutes practically the only alteration of the switching circuits; in other respects these are practically identical with the existing practice on common battery exchanges. The ordinary junction circuit connections might have been employed for this, but this entails a repeating coil on the junction-cord circuit as well as on the subscribers' board-cord circuit; the former is done away with in the simplified arrangement that has been adopted. On the operator receiving a call for the local exchange, she depresses a junction call-wire key, which puts her into communication with one of the operators at the local junction or "transfer" board on which all the local subscribers are multipled, and asks for the number wanted. The operator there answers in the usual way by giving her a junction or rather a transfer line, and she plugs into the corresponding outgoing jack (on the right-hand side of Fig. 1) in the ordinary way. If the subscriber is not engaged the operator at the transfer board plugs into his multiple jack with the plug associated with that transfer line, shown in the figure, and the 180-ohm relay is energised from the central battery through the barrel of the multiple jack on the transfer board and the sleeve of the transfer-line plug. This relay connects the tip of the plug to the transfer line, the sleeve is already connected through, and it is seen this circuit passes through the automatic ringing key in the ordinary way. The ringing key is then depressed, ringing the subscriber as usual. Although the other tongue of the 180 ohm relay is attracted too, connecting the clearing lamp on the transfer position to one side of the battery, the 30-ohm relay is also energised, as it is connected through the sleeve of the plug on the answering position to the battery, and its contacts short-circuit the lamp back to the same side of the battery. As soon as the plug on the answering board is withdrawn, to clear, this contact falls back, and the lamp glows until the transfer operator withdraws the transfer-line plug.

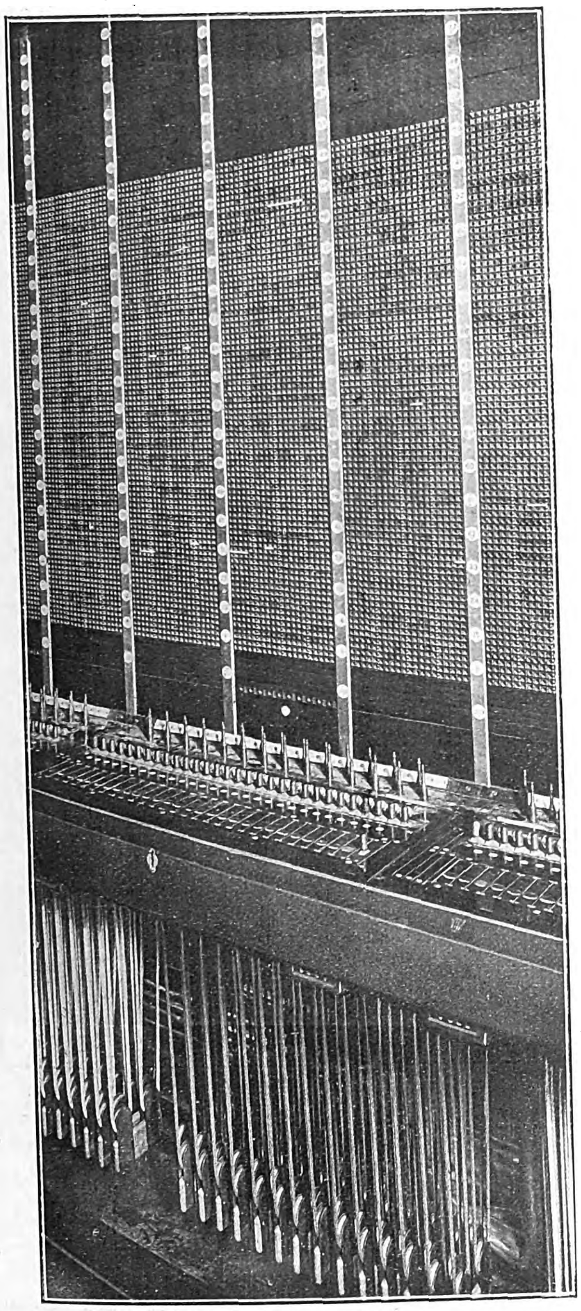

Fig. 3.—Transfer Board

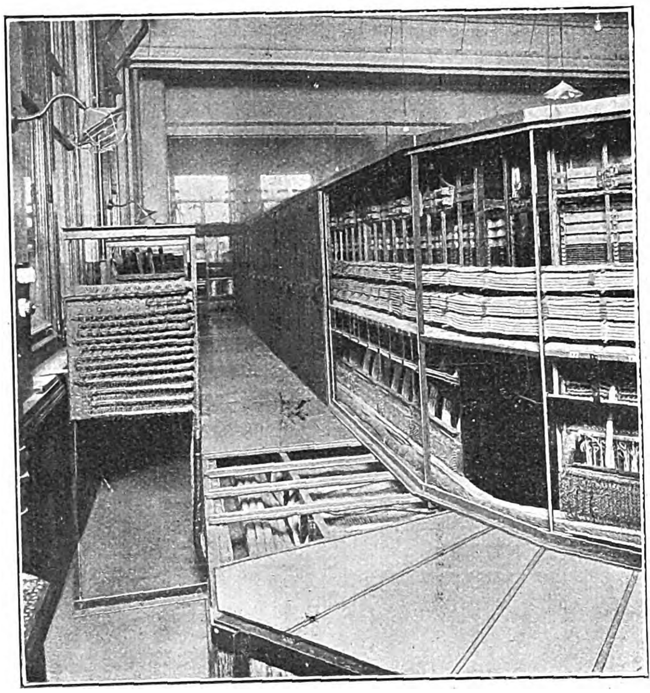

Fig. 4.—Back of Answering Board, showing Back of Relay Racks.

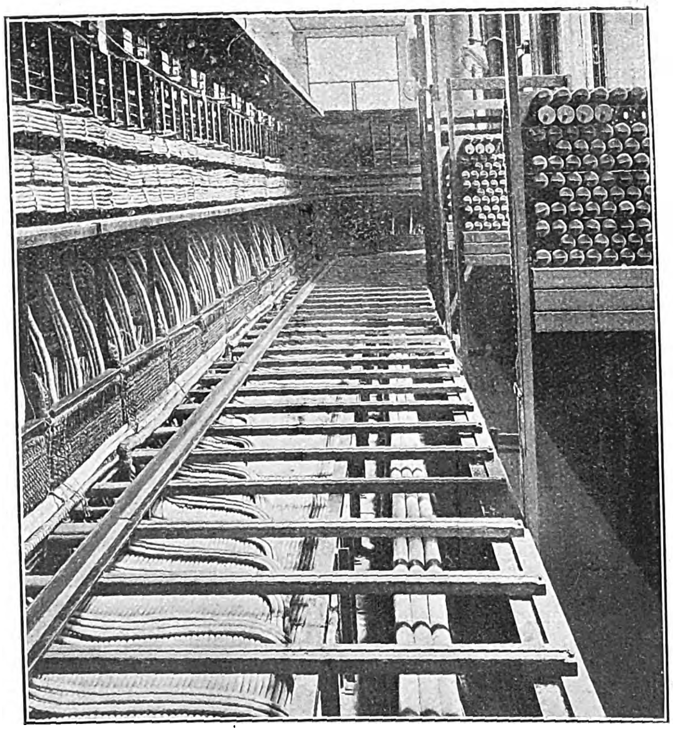

Fig. 5.—Back of Answering Board with Covers Removed, showing Cables and Front of Relay Racks.

Subscribers in new districts in the city area will be connected to this exchange instead of to the "Central," and it will be given the appellation "City." The erection of a second exchange, making the total capacity 30,000, virtually divides the multiple into two sections, for there are independent transfer boards named "Central" and "City" just as if they were incoming junction boards at separate exchanges. There are six "City" and four "Central" transfer positions, each equipped with 28 junction lines. In addition to these 280 transfer lines, there are 1,080 incoming junctions from CB and CBS exchanges and the trunk exchange, and 560 from magneto exchanges, making a total of 1,920. These lines are all multipled on the answering board, and there are two operators' positions for each multiple, instead of three as on an ordinary subscriber's multiple. Figs. 2 and 3 show the answering and transfer (or junction) boards respectively. On the former the height of the keyboard is 2 ft. 6 ins. from the ground, and the height of the ultimate multiple is 5 ft. 5 in.; on the transfer board the corresponding heights are 3 ft. and 7 ft. 2 in. The ultimate capacity of the junction multiple on the answering board is 2,400, and the ultimate capacity of the junction and transfer sections 20,700 subscribers; the latter have been equipped at once for 15,480 subscribers. Fig. 6 shows the relative position of the boards in the switchroom. It is seen that the answering positions go all round one side of the room, and that the transfer and junction positions occupy the opposite side.

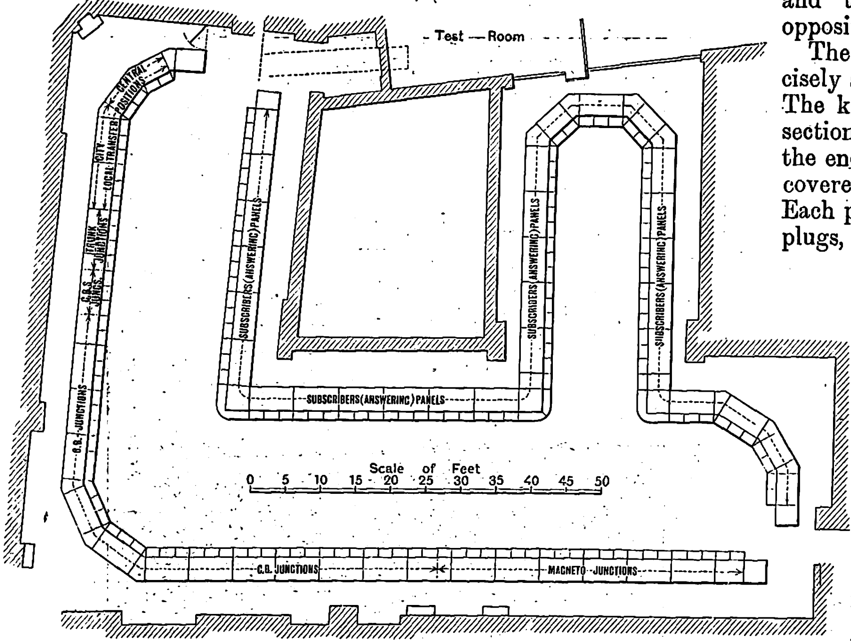
Test — Room
Central Positions
City
Local Transfer
Trunk Junctions
C.B.S. Juncs.
C.B. Junctions
Subscribers (Answering) Panels
Subscribers (Answering) Panels
Subscribers (Answering) Panels
Subscribers (Answering) Panels
Scale of Feet
0 5 10 15 20 25 30 35 40 45 50
C.B. Junctions
Magneto Junctions

Fig. 6.—Sketch Plan of Switchroom to show Position of Answering, Transfer and Junction Positions.

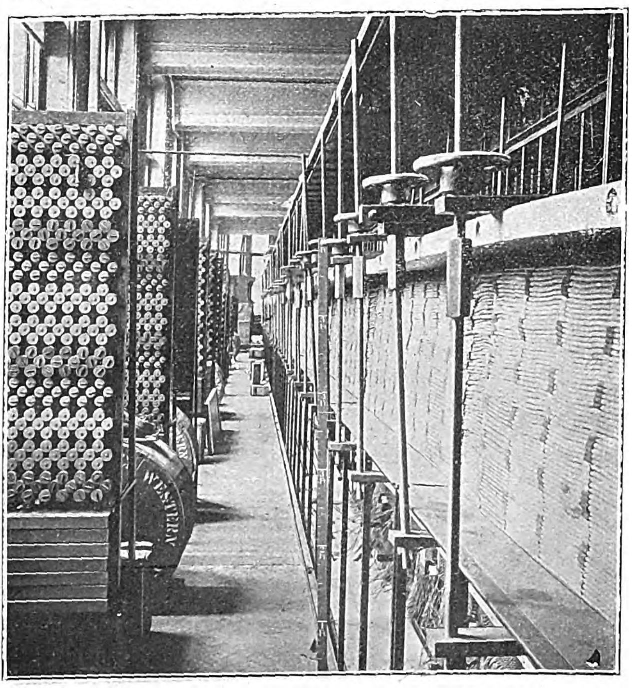

Fig. 7.—Junction Board under Construction showing Method of Clamping Down Cables, and Front of Relay Racks.

The equipment of the junction and transfer positions is precisely similar to that which is customary on incoming boards. The keyboard shelf is level (as it is also on the answering sections), and not sloping. A new pattern of cord is used, the end of which from the plug downwards for about 1 ft. is covered with a spiral of flat wire under the outside braiding. Each position deals with 28 junction lines, ending in cords and plugs, and for each cord there is a clearing lamp, an automatic ringing key and a speaking key. The multiple extends almost down to the keyboard, and covers three operators' positions.

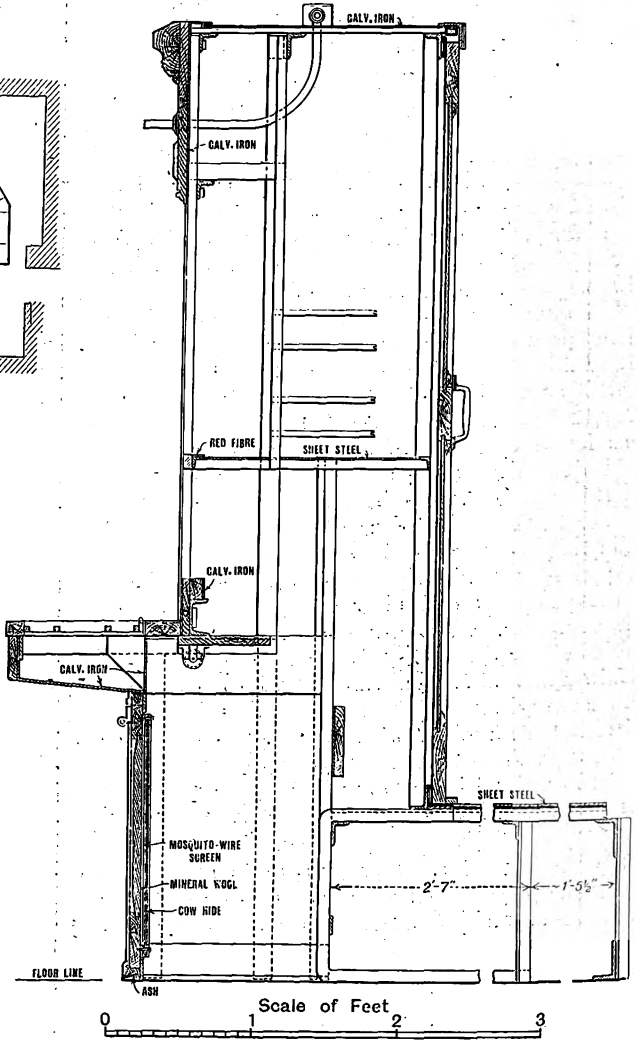
Calv. Iron
Calv. Iron
Red Fibre
Sheet Steel
Calv. Iron
Calv. Iron
Sheet Steel
Mosquito-wire Screen
Mineral Wool
Cow Hide
2′-7″
1′-5½″
Floor Line
Ash
Scale of Feet
0 1 2 3

Fig. 8.—Transverse Section through Answering Board, showing Skeleton Iron Construction.

On the answering positions there are jacks for 180 subscribers to each position, although an average of 150 only are utilised at present. Each position has 51 pairs of plugs and cords, each with its pair of supervisory lamps and combination ringing and speaking key. The ringing side of the key is doubtless provided mainly to enable operators to ring back and for occasional use when speaking to exchanges with ringing junctions, for the ringing up of local subscribers is done with the automatic keys on the junction board. The number of call-wire keys needed on each answering position is, of course, very large on this system. Each position is provided with 50 call-wire keys—six to the "City" and four to the "Central" transfer boards, and the remaining 40 to other exchanges in the London area.

Instead of the call-wires being simply multipled from position to position in the usual manner, they are divided into two parallel circuits multipled on alternate positions. Each of these two "cross-connection circuits" is taken through a break-jack, so that the lines can be tested. A similar arrangement is provided for the call-wires on the incoming, junction and transfer sections, so that testing and inspection is greatly facilitated, and a faulty wire or key effects the least possible disturbance to traffic.

Two extremely important details in the arrangement of the new switchboards are the absence of relays at the back of the board, and the provision of a fuse on each cord circuit in the exchange—*i.e.*, between the cord-circuit and the central battery. These fuses are grouped together on a board in the power room in the basement, and this new feature is considered by the Post Office engineers to be a great advance, from the point of view of fire risk, over the former practice of grouping together several circuits on to one pair of fuses. The connection to the fuse board is made through multiple lead-covered cables.

The relays and resistance coils, instead of being placed at the back of the board, are fixed on independent iron racks, one to every operator's position, placed at right angles to the board. These racks are clearly seen in Figs. 4, 5 and 7, and there is about 3 ft. gangway between the back of the board and these racks. In the case of the answering board, the cables leading to the board are placed beneath this gangway, which is raised about 14 in. above the floor level and covered with steel plates. The junction lines, being fewer to each operator's position, are led up in lead-covered cables. These arrangements leave the back of the board so free from encumbrance that the cords can be got at from the back, and repairs and maintenance are greatly facilitated. In Fig. 4 some of the floor plates have been lifted to show the cable run beneath, and the wooden panels have been removed from the back of the board in the foreground, and in Fig. 5 all the covers are removed. The panels, it may be mentioned, are protected with steel plates.

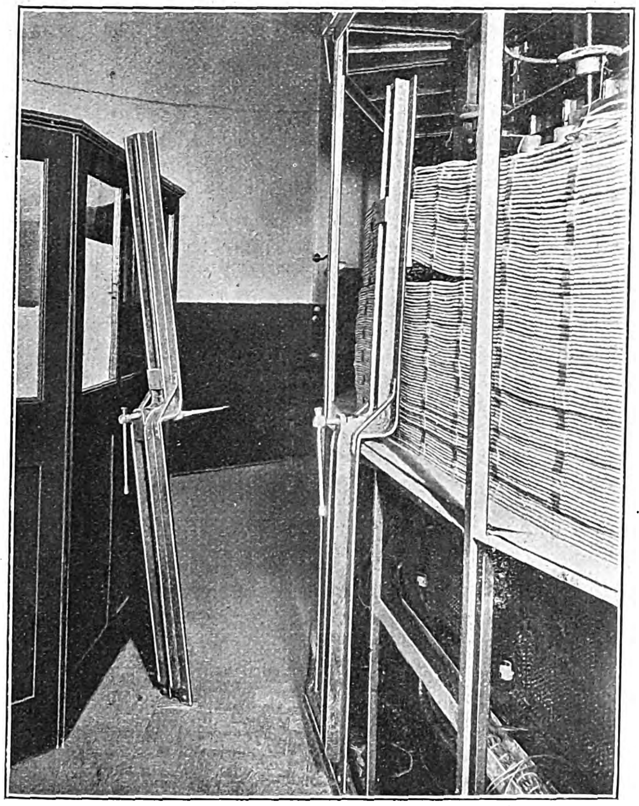

Fig. 9.—Cable Lifters.

The iron construction of the board itself is shown in Fig. 8. Except for the panelling, which is steel lined, as already stated, and the keyboard, there is practically no wood on the board, and the jack strips are fixed directly to the iron frame of the board by means of a simple device. The "blanks," which occupy the upper part of the board until jacks are wanted there, are made of thin brass, blackened in front. The wiring behind the keyboard shelves is separated from the rest by removable "transite" partitions, and there are similar partitions in a vertical direction between every three positions, so that fire cannot spread from one part of the board to another.

Owing to the fact that all the 15,480 jacks on each multiple of the junction and transfer boards could be wired from the outset, it was possible to clamp the wires down tight as the work proceeded. Fig. 7 shows clearly the method of doing this. As a result, the cable is all beautifully flat and hardly rises at all above the level of the jacks. 63-wire flat switchboard cable, asbestos insulated, is used for this, containing 20 threes and one spare three.

The method of lifting the cables for the purpose of examining or withdrawing the jacks is illustrated in Fig. 9. A pair of "cable lifters" are used, one of which is shown in position in the figure, and the other lying idle to the left of the illustration. The cable lifter consists of an iron upright of the shape seen, the lower end of which takes a bearing on the lowest channel iron of the switchboard frame. A screw is fixed to this, and the projecting tongue is screwed up or down to the proper position below the cable next above the one to be examined. When the pair are placed in position in this way, the two tongues are screwed up simultaneously, lifting the bundle of cables above them.

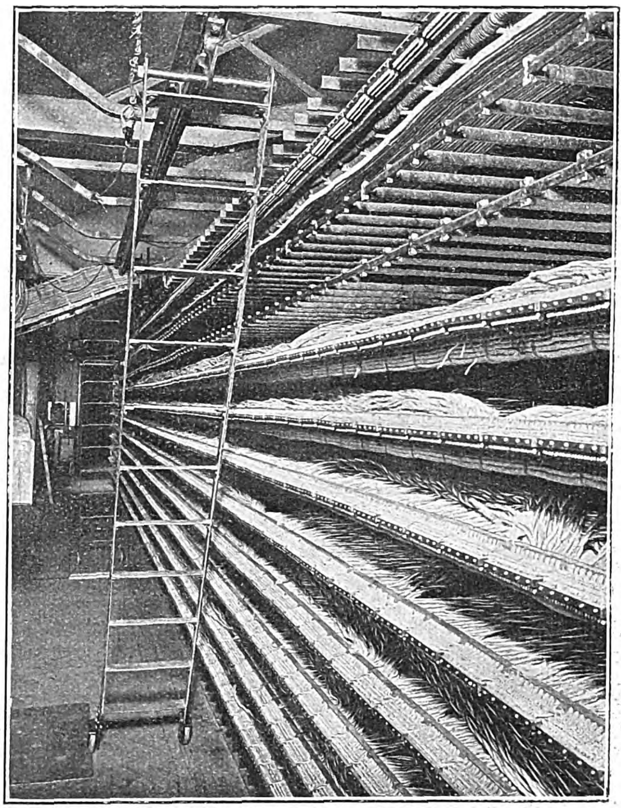

Fig. 10.—Intermediate Distributing Frame.

The usual desks for monitors and for the switchroom superintendent and assistant superintendents are provided, and a new feature is an "inquiry" table of four positions. This table is in the centre of the room, and measures 6 ft. by 4 ft. and contains shelves for directories, &c. Inquiries for new subscribers, changes of number and miscellaneous information are switched on to one of the operators at this table.

The new intermediate frame (Fig. 10) is of much solider construction than in previous practice; the extra stiffening bars are seen in the illustration. Sliding ladders on rubber-tyred rollers are provided two on each side of the frame to facilitate running the wires and subsequent work on the board. Uralite sheets are placed between the iron of the frame and the cross connecting wires. The frame has eleven shelves, each of which will accommodate 2,000 lines. This frame is on the same floor as the switchboard, and the relay and meter racks, which are made of H iron, are in the same room. There is also a subsidiary intermediate frame for 6,240 lines between the "City" and the "Central" exchanges.

The main distributing frame for the "City" exchange, which is in the basement, in the same room as the power plant, has one new feature—namely, the provision of a fuse, in addition to the heat coil, on each wire that comes into the exchange. These fuses are of the tubular pattern—a wire drawn through an insulating tube. They are placed on the vertical side of the frame, as is seen in Fig. 11, which represents a portion of one vertical line of the frame; but we understand that in the remodelling of the main frame of the "Central" exchange fuses will be placed on the horizontal side, so that they are practically at the point of entry of the cable. These new fuses will be wires stretched over porcelain blocks of a rounded shape, designed to prevent the spread of an arc.

The power plant is the largest in any telephone exchange in this country, but it follows standard practice. It may be mentioned, however, that the motor-generator for charging the cells will supply a current of 1,000 amperes. The battery consists of two sets of 11 40-plate Chloride cells, each having a capacity of 3,000 ampere-hours at an 8-hour discharge rate; plates can be added to bring up the ultimate capacity to 6,820 ampere-hours.

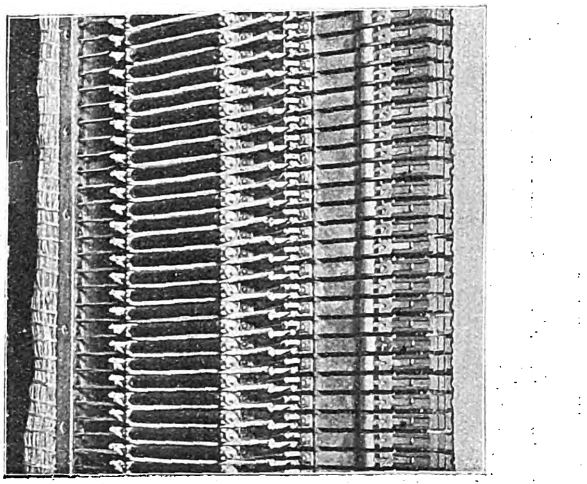

FIG. 11.—PART OF ONE VERTICAL LINE OF MAIN DISTRIBUTING FRAME, TO SHOW FUSES AND HEAT COILS.

The Western Electric Co. were contractors for the whole equipment of the exchange, to the specifications of the engineer-in-chief to the Post Office, and the whole workmanship and finish reflects great credit upon them.

## THE DURHAM COLLIERIES ELECTRIC POWER SCHEME.

The power house of the Durham Collieries Electric Power Co. is now practically complete, and the supply will be commenced in a few weeks' time. The idea of supplying power to the large groups of collieries and works in the eastern part of the county of Durham was first mooted in January of last year. A company was formed, and it was decided to proceed with the scheme in the following February. No time was lost, and by May 2nd the plant had been ordered and the ground opened. The undertaking is a private one, and the company does not possess statutory powers.

The consulting engineers to the scheme are Messrs. Harper Bros. & Co., and we wish to express our indebtedness to them and to the company's chief engineer, Mr. C. W. Nicholl, who kindly devoted considerable time in showing our representative over the works. Mr. Nicholl's resident staff during the erection of the station consists of Mr. W. J. S. Jones (resident engineer) and Mr. F. H. Carter (assistant engineer), Messrs. D. Balfour & Sons, civil engineers of Newcastle, acted as consulting engineers in connection with the buildings and reservoirs. The main contractors for the whole scheme were Messrs. Bruce Peebles & Co, the sub-contractors for various portions of the plant being mentioned below.

The power house is situated at Philadelphia, near Penshaw, county Durham, on a siding of the Lambton Colliery Railway, and close to the mouth of one of the Lambton pits, so that coal is obtained at a remarkably low price. Considerations of cheap coal supply had more influence on the choice of the site than facilities for obtaining water, for it was found worth while to lay down a long pipe line for the water supply. The water will be taken from a convenient point on the River Weir about 2 miles distant from the power house, and a 10 in. main has been laid, which will deliver the water at the power house 274 ft. above the level of the river. The pumping station at the lower end of the pipe line contains two Gwynnes' centrifugal pumps running at about 1,500 revs. per min., and each capable of delivering 500 gallons per minute against the above head. These are driven by a pair of 80 B.H.P. three-phase motors taking current at 230 volts. The starting of these motors is to be effected by automatic starters operated by means of an auxiliary three-core cable from the power house, so that the pumps will be controlled entirely from the main switchboard. This and the main pump motor cable are run in a trench alongside the pipe line, which also contains a telephone cable and one of the main H.T. feeders supplying a colliery some distance beyond. All are lead covered, armoured and laid direct in the ground.

The arrangement of the generating plant forms a good example of the independent unit system, each turbo-generator having its own boilers, condensing plant and switch gear, which can be worked independently of any of the others. The five Babcock & Wilcox boilers with which the supply will be started are arranged in 2½ batteries, and are set with a special kind of serrated and perforated bricks to improve their efficiency; each has a normal evaporative capacity of 21,000 lb. of water per hour. They are provided with internal superheaters and work at 180 lb. per square inch with 150°F. superheat. Three Erith underfeed stokers, designed to burn Peas and Duff coal, are fitted to each boiler. The two steam-driven Hall feed pumps are situated in a separate pump house adjoining the boiler house, together with the fans for supplying draught to the stokers. The main flue runs between the engine and boiler houses, and contains the economiser which was supplied by the Clay Cross Co. There is ample room for boiler extensions both by lengthening the building, which at present is provided with a temporary end and by the addition of another row of boilers. Coal is taken from the trucks by a Graham-Morton conveyor to the overhead bunkers, which are of 50 tons capacity each, another overhead bunker of 25 tons capacity being provided for storage of ashes pending their removal by trucks.

The engine room at present contains five main sets, all of the same size, three driven by Parsons turbines, and the remaining two by turbines of Messrs. Willans & Robinson's make. The engineer looks forward to some comparative tests of the two makes when working under identical conditions. It is interesting to note one or two differences in the mounting of these machines. The Willans turbines are bolted down to their foundations and are rigidly coupled to their condensers, the latter being mounted on springs and provided with pipes, which are to a certain extent flexible, leading to the pumps. The Parsons machines are without holding-down bolts, and are connected with their condensers by flexible joints, the condensers themselves being rigidly bolted to their foundations. The condensing plant, situated in each case directly under the turbines, is of Messrs. Cole, Marchant & Morley's make with pumps driven by Bruce Peebles continuous-current motors. The condensing water passes through three large cooling towers and a cooling pond, back to a trench running alongside the engine house. A large storage reservoir is also provided at the point where the water is delivered by the pipe line.

The alternators coupled to each turbine are of Messrs. Bruce Peebles' standard high-speed revolving field type, running at 1,500 revs. per min. The normal output is 1,000 kw. each, but they are capable of working up to 1,250 kw. for lengthy periods. Three-phase current is generated at 6,600 volts, 50∼; the generators are star connected, with the middle point earthed. Exciters are not coupled direct to the shafts, but form a part of the independent auxiliary sets. Two of these auxiliary sets are provided, each consisting of one 180 kw. continuous-current generator, working at 550 to 600 volts for driving the various motors, &c., in the station and a 40 kw. exciter on the same shaft, the sets being driven by Willans reciprocating engines of 3 I's size. It is intended ultimately to put down two 400 kw. 550 volt, Bruce Peebles "La Cour" motor converters to supply the Sunderland and District Tramways, which are now run from a gas plant adjoining the station and also the property of the Durham Collieries Electric Power Co.

The generator and feeder oil switches are mounted in separate cells in the usual way under the operating gallery. The control boards are of the desk type, all the switches are hand operated by levers in the front of the "desk," the ammeters and voltmeters being mounted on the top. The operator standing behind the board has a clear view of the whole of the engine room and of the synchronising apparatus on a bracket at the end of the board. No special feeder charging apparatus is installed, and the voltage is switched direct on to the feeders. We hope to publish some further details of the switching arrangements when the station is in actual operation, as the switch-gear was only partially complete at the time of our visit.

The load consists principally of collieries and works, although, as mentioned above, the lines of the Sunderland and District Tramways Co. are shortly to be supplied from this station. We understand that as many as 17 collieries, including some of the Lambton and Hetton groups have already installed a quantity of electric plant and are now ready for taking power, and that the electrical equipment of a large number more is in progress. Electrical driving is to be applied to pumping, coal cutting, underground haulage and practically all power purposes in these collieries except the main winding engines, the colliery proprietors apparently desiring to wait until the present controversy upon the merits of steam and electrical winding engines is settled. Some 37 miles of underground feeders have been laid, partly of Messrs. Callender's make, laid on the solid system, and partly Glover's and St. Helen's armoured, and laid direct in the ground. In some cases, however, overhead lines will be used, consisting partly of No. 4/0 solid and partly of bare stranded copper cable of equivalent section mounted on wooden poles. Sub-stations are being erected at each colliery to transform from 6,600 volts down to 230 volts for the smaller motors and 2,000 volts for the larger motors. It is, however, intended to transform up to 11,000 volts for transmission to some of the more outlying districts.

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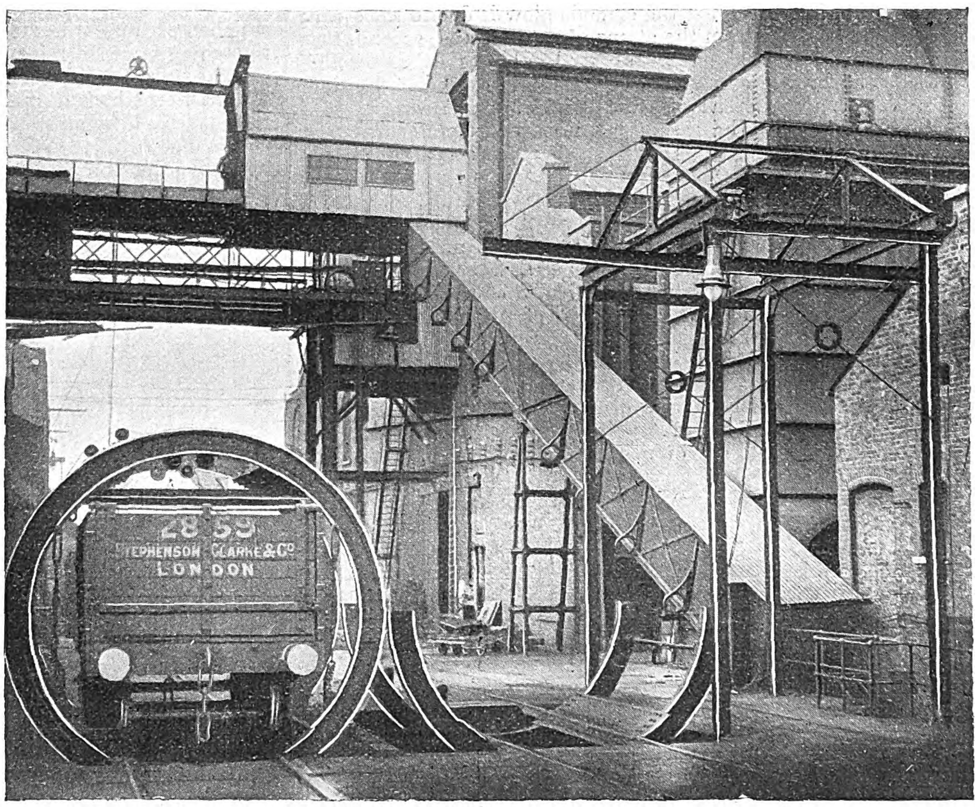
# COAL HANDLING PLANT AT THE WILLESDEN STATION OF THE METROPOLITAN ELECTRIC SUPPLY CO.

In our issue of December 15th we described some forms of coal conveying apparatus which have recently been installed in various electricity stations. Another example of an interesting coal handling plant of a somewhat different nature to those then described is in use at the Metropolitan Electric Supply Co.'s station at Acton-lane, Willesden, for conveying fuel from the railway trucks to the boilers. The chief feature of the system is the revolving truck tipper by which the contents of the loaded coal truck are turned over bodily into a hopper, entirely doing away with any form of bucket elevator.

Opposite the boiler house are two main lines of railway. A coal receiving bunker of 70 tons capacity has been built below the coaling lines. Immediately over the top of this bunker are mounted two rotary side-truck tippers, shown in the figure, which enable the trucks to be run on the table of the revolving "tipplers." Each of these has a diameter of 18 ft., which permits of an engine passing right through. The waggon is secured in the tippler, so that it cannot move, by booms which, when tightened up, firmly secure the waggon in the tippler, and are provided with a compensating mechanism to take up any shock. When the truck is fixed, the attendant sets a 5 H.P. electric motor in operation, which rotates the tippler containing the truck, and delivers the fuel into the receiving hopper, from which it is taken by the conveyor. One specially interesting point to be noticed in the design of this tippler is that by its complete revolution it saves trimming, while clearing every ounce of coal. Each tippler rests on a series of rollers, one side being actuated by a reversible electric motor, and is capable of emptying 100 tons of coal per hour.

Very little power is required to tip the trucks, as the rings are so proportioned that their centres coincide with the centre of gravity of the truck in end elevation.

The conveyor from the hopper under the trucks consists of a series of chains in specially-constructed troughs. The cross chain is placed immediately beneath the coal-receiving bunker. This cross conveyor partly elevates the fuel and delivers it on to the main inclined elevator conveyor, which runs at an angle of 30 deg., elevating its load through a height of 40 ft., and delivers it on to the main distributing conveyor running the full length of the overhead storage bunkers. The bottom of the distributing conveyor is fitted with openings and cut-off slides at intervals of 3 ft., which enable the fuel to be delivered at any point in the length of the bunker. Each section of the conveyor is driven by means of a separate motor through substantial spur wheel reduction gear. The elevator conveyor is sheltered from the weather by galvanised iron sheeting.



TIPPLER AND INCLINED CONVEYOR AT METROPOLITAN ELECTRIC SUPPLY CO.'S WILLESDEN STATION.

The principal dimensions of the plant are as follows :—

The trough in which the U-shaped chains run is $\frac{5}{8}$ in. thick, 15 in. wide and 8 in. deep. The chain itself consists of a series of U-shaped links made out of $2\frac{1}{4}$ in. by $\frac{1}{2}$ in. flats formed into links of 12 in. pitch, and secured at the joints by special $\frac{7}{8}$ in. rivets and washers. The links are made of Siemens-Martin acid steel of a tensile strength from 28 to 32 tons to the square inch, with an elongation of 20 per cent. in 8 in. The length of cross conveyor under the tippler is 38 ft. The length of incline conveyor is 106 ft., the length of bunker conveyor 395 ft., giving a combined length of 519 ft.

The entire system of conveyors, which is capable of moving from 60 to 80 tons per hour, requires about 25 H.P. for its working.

The whole of the plant described above was supplied by Messrs. E. Bennis & Co., whose mechanical stokers are in use in the same station.

## ELECTRIC DISCHARGE AND SPECTROSCOPY.

The evening discourse at the Royal Institution last Friday was by Prof. J. J. Thomson, and the subject was the application of the electric theory of the atom to spectroscopy. In introducing his subject, the lecturer remarked that the discovery that the oxides of the alkaline earths evolved negative corpuscles copiously on being heated had made possible experiments that had thrown considerable light on certain peculiarities of the spectra of the elements. The P.D. necessary to make negative corpuscles pass from such an oxide into a gas is much less than that required with other materials, so that if lime be used as the cathode in an exhausted tube the usual blue cathode-ray discharge can be started and maintained under voltages easily produced and adjusted. This property of facilitating the discharge through gases is possessed by these earths for only one direction of current flow, and thus these tubes can act as rectifiers. One of the remarkable properties of the lime cathode—one that was demonstrated on the lecture table—is the suddenness with which the cathode glow starts as the voltage on the tube is gradually raised.

For instance, in some cases, while the voltage rises through the small step of a hundredth of a volt, the blue glow will flash out and the current through the tube increase sixtyfold. Prof. Thomson explains this by postulating, first, that the cathode glow is due to the escape of negative corpuscles from the atoms of the gas, and, second, that this event occurs when atomic instability has been reached through bombardment by the corpuscles from the lime cathode. In other words, the corpuscles emitted by the cathode, by following up continually the shocks to the gas atoms, impart to them energy that accumulates till the atom becomes unstable and a corpuscle escapes from its orbit. The consequent atomic oscillations give rise to light waves. Now, the hotter the lime the more plentifully it supplies corpuscles. Thus by heating the cathode the atomic shocks are better followed up, and the glow, with the corresponding discharge current, can start and continue at lower and lower voltages. Prof. Thomson used in all his experiments cathodes consisting of a thin film of oxide deposited on a small strip of platinum foil. The foil could be heated to any desired temperature by means of a steady current from outside the tube. By thus varying the temperature of the lime sufficiently it was demonstrated that the discharge current could be started or stopped under constant P.D. But another way of starting and stopping the glow was also exhibited. It appears that the stream of negative corpuscles from the hot oxides of the alkaline earths is very sensitive to a magnetic field. Thus a magnet may be so approached to the tube as to concentrate the stream. Of course, the gas atoms in the beam of cathode rays are now more persistently shaken than before; and, as the lecturer showed, the glow in a tube can be started by raising the voltage to a point just high enough not to produce the glow and then approaching a magnet.

This knowledge, recently gathered, is applicable to several problems of spectroscopy. The two principles to be used are: First, the atom can store internally the energy imparted to it from without; second, the atom's internal energy must reach a certain critical value before radiation can occur. Consider an atom that contains within it two systems of corpuscles possessing different aptitudes for receiving energy from the cathode stream shocks, different powers of radiating energy, and different periods of vibration. The behaviour under the cathode stream of two systems so differing is analogous to the career of two men, A and B, of different earning and spending powers. Let A's income be £1,000 per annum, and his annual expenditure always one-thirtieth of his accumulated capital, while B's income is £5,000 and his expenditure one-third of his capital. Further, suppose that not till a man's capital reaches £20,000 is he regarded as a shining light in his community. Then in times of long-continued prosperity, though B can never accumulate more than £15,000, A can easily pass the £20,000 mark and become luminous, his maximum capital being £30,000. On the other hand, if these men were set down in times of high prosperity but short duration, if, say, each income were quadrupled for a period of two or three years only, it would be B alone that would reach the luminous state. These economical conditions are precisely analogous to the physical conditions ruling in the electric arc and electric spark respectively; or in the wide part and the capillary part of a Plücker tube; or, again, in vacuum tube discharges controlled by self-inductance or by capacity in the discharge circuit. For in the arc, in the wide parts of vacuum tubes, and in discharges through self-inductance there is (comparatively) long-continued and moderate supply of energy by the flying corpuscles; while in the spark, in the capillary of a vacuum tube, and in the discharge from a condenser there is more intense, but shorter-lived or more intermittent energy supply than before. And thus in arc and spark spectra, in the spectra from the two regions of the Plücker tube, and in vacuum tube spectra with inductance or with capacity we may get, separately, from a gas atom possessing internal two-foldness, two distinct spectra, one due to the less absorbing, the other due to the more absorbing system within the atom. At this point the lecturer showed the striking change of an argon glow tube from blue to red when self-inductance is switched into the circuit. Here, also, the lecturer showed a rough electrical model of the argon atom—or, rather, a model to illustrate how the result of an energy supply may depend on the manner of its application. Two circuits are arranged in parallel, one containing a filament lamp coloured blue and some other resistance, the other a red lamp and some inductance. Energy supplied in the form of continuous-current lights the red lamp, but supplied as alternating-current lights only the blue.

Passing quickly over some suggestions that different gas pressures, by affecting the speed of the negative corpusles, may produce differences in the spectrum of a gas, the lecturer turned to the consideration of the spectra of solids bombarded to phosphorence in a highly exhausted tube. In this connection the most remarkable fact brought out was that from certain substances, such as lithium chloride, two different spectra could be obtained by bombarding it by heavy and by light particles. The small negative corpuscles cause lithium chloride to glow green, while bombardments by positive particles—that is, whole atoms—causes a red phosphorescence. Metallic lithium gives no spectrum, while a piece of metallic sodium, placed in a vacuum tube, glows only where its surface shows traces of oxidation.

Referring briefly to the flame method of producing spectra, the lecturer characterised it as extremely wasteful. Most of the energy supplied became translational energy of whole atoms, only a fraction going towards raising the internal energy of the atom to its critical value. This is like burning the home to boil the kettle. Electrical methods of producing spectra, on the other hand, directly increase the internal store of enery of the atom up to radiating point.

The discourse concluded with an experiment to show that if in a lime tube the bombardment is allowed to heat the cathode till the emission of corpuscles and the current flow become excessive, an arc starts and bridges the gap between cathode and anode and quickly destroys the tube.

## BRAKES.*

BY A. L. C. FELL,

Chief Officer London County Council's Tramways.

(*Concluded from page 545*).

*Programme for Each Series of Tests.*—Trials to be made of the brakes operating under the following conditions upon *dry* and *greasy* rails. (No sand to be used when stopping the car during any of the tests.)

(*a*) *Emergency stops*: *i.e.*, bringing the car to a standstill in the shortest possible distance.

(*b*) *Quick service stops*: *i.e.*, bringing the car to a standstill without discomfort to the passengers.

(*c*) *Coasting*: *i.e.*, descending a grade under control of the brake.

The following records and notes to be made of all tests:—

(1) Speed at which the car travels when brake application is made. (2) The distance car travels from application of the brake to dead stop. (3) The time which elapses between the application of the brake and dead stop. (4) Amperes passing in armatures during the application of brake. (5) Volts across motor terminals during application of brake. (6) The brake notch of controller employed in each application of the brake. (7) The condition of the rails. (8) The gradient over which the car travels.

In considering the value of any braking apparatus special attention has to be paid to the following particulars, which I have placed in the order of their importance: (*a*) Reliability; (*b*) facility of operation by the motorman; (*c*) rapidity of application; (*d*) distance necessary to stop a car after the brake has been applied; (*e*) length of time during which the current is passing through the motors and brake coils—viz., the ampere seconds; (*f*) first cost of equipment; (*g*) the cost of maintenance. Under the conditions of congested traffic, such as in London, it is of primary importance to have a brake which will stop a car in the *shortest possible distance, especially at the lower speeds.* I would here point out that the majority of accidents at the present time occur when the cars, not fitted with electro-magnetic track brakes, are running at the lower speeds; but with apparatus which can be more rapidly applied with adequate retarding power the cars can be stopped in a much shorter distance and before serious damage, if any occurs. It will be noted, therefore, that, providing the conditions (*a*) and (*b*) are fulfilled, items (*c*) and (*d*) may be taken as a direct measure of the value of the braking apparatus. Condition (*e*) refers to the electrical equipment of the car, and is an indication of the deteriorating effect that may be expected due to electric or magnetic brakes.

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* Paper read before the Tramways and Light Railways Association on Wednesday, January 10th, Mr. Stephen Sellon in the chair. Slightly abridged.

### RESULTS OF TESTS.

*Speed and Ampere-seconds obtained with Types A and B New Pattern Brakes, A and B Old Pattern Brakes, and Rheostatic Brake (Dry Rail).*

**I. A and I. AN.**—EMERGENCY STOPS. **II. A and II. AN.**—SERVICE STOPS.

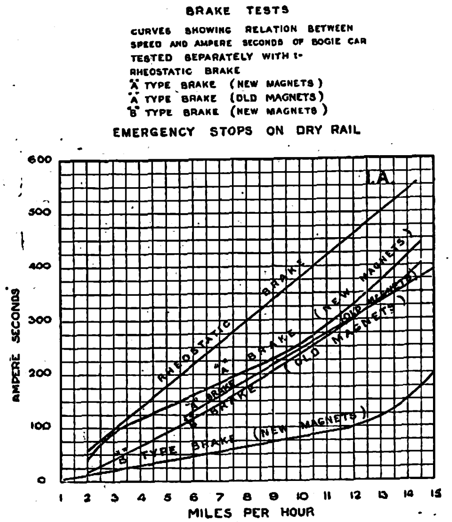
| Speed. | Old type A. | Old type B. | Rheostatic. | Old type A. | Old type B. | Rheostatic. |
|---|---|---|---|---|---|---|
| M.P.H. | Amp.-sec | Amp.-sec | Amp.-sec. | Amp.-sec | Amp.-sec | Amp.-sec. |
| 2 | 12 | 15 | 67 | 12 | 9 | 70 |
| 3 | 43 | 40 | 100 | 35 | 27 | 110 |
| 4 | 72 | 65 | 142 | 58 | 53 | 152 |
| 5 | 100 | 90 | 183 | 82 | 84 | 193 |
| 7 | 160 | 145 | 263 | 127 | 160 | 275 |
| 9 | 215 | 205 | 344 | 173 | 203 | 360 |
| 11 | 275 | 267 | 425 | 218 | 263 | 445 |
| 13 | 335 | 340 | 505 | 265 | 322 | 530 |
| 14·5 | 380 | 405 | 565 | 333 | 367 | 595 |

| Speed. | New type A. | New type B. | Rheostatic. | New type A. | New type B. | Rheostatic. |
|---|---|---|---|---|---|---|
| 2 | 40 | 12 | 67 | 30 | 10 | 70 |
| 3 | 90 | 20 | 100 | 55 | 15 | 110 |
| 4 | 116 | 30 | 142 | 80 | 20 | 152 |
| 5 | 138 | 38 | 183 | 105 | 27 | 193 |
| 7 | 182 | 55 | 263 | 160 | 38 | 275 |
| 9 | 227 | 74 | 344 | 210 | 50 | 360 |
| 11 | 290 | 92 | 425 | 260 | 73 | 445 |
| 13 | 375 | 118 | 505 | 300 | 118 | 530 |
| 14·5 | 445 | 170 | 565 | 330 | 168 | 595 |

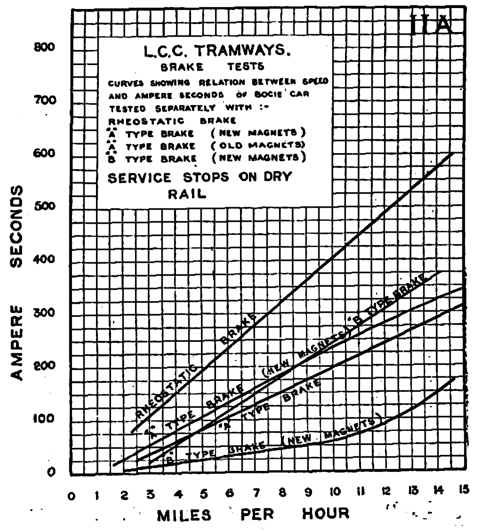
**III. A and IV. A.**—*Greasy Rail.*

| Speed. | New type A. | New type B. | Rheostatic. | New type A. | New type B. | Rheostatic. |
|---|---|---|---|---|---|---|
| 2 | 30 | 7 | 200 | 30 | 7 | 125 |
| 3 | 44 | 12 | 255 | 39 | 10 | 185 |
| 4 | 62 | 16 | 310 | 50 | 14 | 242 |
| 5 | 83 | 20 | 360 | 75 | 16 | 300 |
| 7 | 143 | 30 | 470 | 132 | 25 | 415 |
| 9 | 215 | 40 | 575 | 207 | 30 | 532 |
| 11 | 292 | 50 | 682 | 297 | 38 | 647 |
| 13 | 377 | 58 | 790 | 385 | 45 | 765 |
| 14·5 | 440 | 65 | 870 | 455 | 50 | 850 |

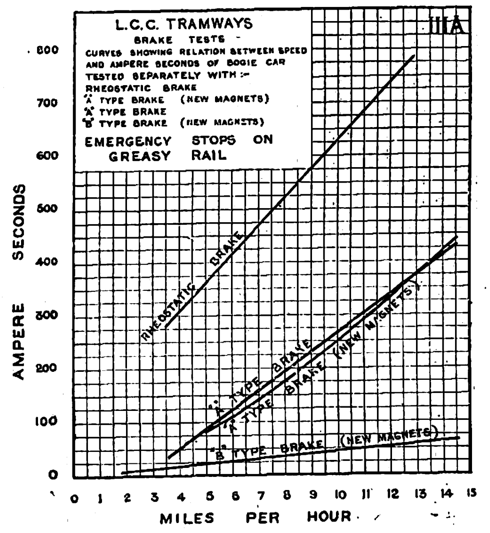
*Comparative Results of Electromagnetic Brake Tests.*—It will be seen from the foregoing tabulated results and the curves that the newly-developed equipments of both types of electromagnetic track brake are such an improvement on the older types that it is only necessary to compare the results obtained with the former. After carefully examining the figures and general behaviour of the brakes during the tests, I am of opinion that the following are reliable comparisons of the new types of each brake. With regard to the conditions: *a*, "reliability"; *b*, "facility of operation by the motorman"; and *c*, "rapidity of application," magnetic track brakes of both the A and B types fulfil the requirements. With regard to condition *d*—viz., "the distance necessary to stop a car after the brake has been applied," the curves on diagrams I.D and II.D give the results obtained with emergency and service stops respectively *on a dry rail*; up to speeds of 14·5 miles per hour the B type of brake is slightly better, but judging by the curves at higher speeds the A type is apparently superior. The curves on diagrams III.D and IV.D, giving the results obtained on what appeared to be a greasy rail, show that the B type of brake was more effective, but the results of the tests made are rather better than those which were obtained *on a dry rail*. This is due, in all probability, to the fact that the brakes were manipulated more skilfully in the later tests. It was most difficult to obtain exactly similar conditions in each test, as the time each week during which tests could be made was very limited. Unhappily this test could not be repeated, as the instruments were destroyed by fire and have not yet been replaced. Condition *e* is the next point to consider—viz., "the length of time during which the current is passing through the motors and brake coils—*i.e.*, the ampere seconds." Diagrams



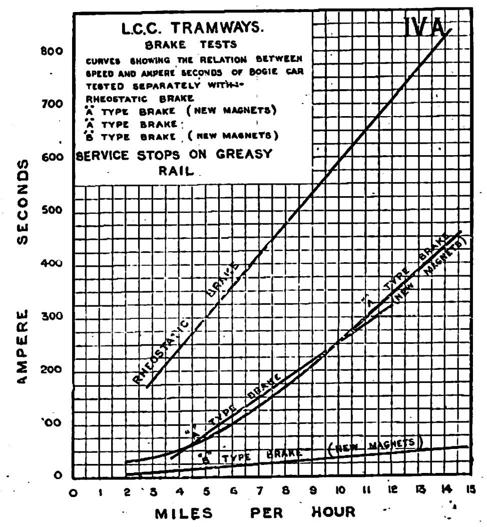
Curve No. I. A.



Curve No. II. A.



Curve No. III. A.



Curve No. IV. A.

**I. DN and II. DN.**—*Stopping Distances, with Magnetic Brakes of New and Old Pattern, and Rheostatic Brake (Dry Rail).*

| | *Emergency Stop.* | | | *Service Stop.* | | |
|---|---|---|---|---|---|---|
| Sp'd miles per hour. | New type A. | New type B. | Rheostatic. | New type A. | New type B. | Rheostatic. |
| | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. |
| 2 | 2½ | 2 | 2 | 6½ | 3 | 2 |
| 3 | 4 | 2½ | 5 | 11 | 6 | 5½ |
| 4 | 6½ | 3 | 9½ | 16 | 9 | 9 |
| 5 | 9 | 4 | 14½ | 25½ | 12½ | 14 |
| 7 | 15½ | 8 | 26½ | 31½ | 20 | 28½ |
| 9 | 24 | 12½ | 43½ | 47 | 29½ | 50½ |
| 11 | 33 | 19½ | 75 | 74 | 47 | 80 |
| 13 | 43½ | 31½ | 107 | 102 | 67 | 115 |
| 14·5 | 52 | 45 | 130 | 123 | 81½ | 143½ |
| — | Old type A. | Old type B. | Rheostatic. | Old type A. | Old type B. | Rheostatic. |
| 2 | 13 | 2 | 2 | 10 | 5 | 2 |
| 3 | 11½ | 4 | 5 | 13 | 9 | 5½ |
| 4 | 10 | 6½ | 9½ | 16½ | 14 | 9 |
| 5 | 9 | 9 | 14½ | 21 | 19 | 14 |
| 7 | 11½ | 19½ | 26½ | 34½ | 30½ | 28½ |
| 9 | 22½ | 37 | 43½ | 52 | 42 | 50½ |
| 11 | 40 | 54½ | 75 | 68 | 56 | 80 |
| 13 | 52 | 71½ | 107 | 71 | 73 | 115 |
| 14·5 | 56½ | 85 | 130 | 80 | 95 | 143½ |

**III. D.** *Greasy Rail.* **IV D.**

| — | New type A. | New type B. | Rheostatic. | New type A. | New type B. | Rheostatic. |
|---|---|---|---|---|---|---|
| 2 | 6½ | 1½ | 4 | 6 | 3 | 3 |
| 3 | 8 | 2½ | 10 | 7½ | 7½ | 9 |
| 4 | 11½ | 3½ | 19 | 11 | 12 | 18½ |
| 5 | 16 | 4½ | 30 | 15½ | 16½ | 30 |
| 7 | 26½ | 7 | 52 | 25 | 22½ | 56 |
| 9 | 37 | 10 | 75 | 35 | 28 | 82½ |
| 11 | 48 | 13 | 102 | 48½ | 34½ | 109 |
| 13 | 63 | 18½ | 135 | 64 | 42 | 142½ |
| 14·5 | 80 | 30 | 175 | 77½ | 51 | 192 |

**V. D.**—*Speed and Stopping Distance in Feet with Rheostatic, Type A—New Magnets, Type B—New magnets, and Ordinary "Hand" Brakes. Emergency Stops on Dry Rail.*

| Miles per hour. | Rheostatic | Type A, new magnets. | Type B, new magnets. | Momentum. | Ordinary hand brake. |
|---|---|---|---|---|---|
| 1 | .. | .. | .. | .. | 1 |
| 2 | 1 | 2 | .. | 1 | 2 |
| 3 | 5 | 4 | 2 | 2 | 4½ |
| 4 | 9 | 6 | 3 | 3½ | 7½ |
| 5 | 14 | 9 | 4 | 6 | 11½ |
| 6 | 20 | 12 | 6 | 9 | 16 |
| 7 | 26 | 15½ | 8 | 13 | 22 |
| 8 | 34 | 19½ | 10 | 17½ | 29 |
| 9 | 44 | 24 | 12 | 23 | 37 |
| 10 | 58 | 28 | 15½ | 29 | 46 |
| 11 | 74 | 33 | 19½ | 35½ | 56 |
| 12 | 90 | 38 | 24½ | 42 | 68 |
| 13 | 107 | 43½ | 31 | 50 | 81 |
| 14 | 122 | 49 | 40 | 57 | 96 |
| 15 | .. | .. | 52 | 67 | 111 |

I.A and II.A show that with the B type of brake there is less tendency to overheat the motor armatures, field coils and resistances.

The braking effect of type A apparatus depends upon—(*a*) The friction between the electromagnetic brake shoes and the track; (*b*) the retardation of the wheels due to the motors which they drive acting as generators.

In the case of the type B apparatus, the braking is affected by—(*a*) The friction of electromagnetic brake shoes and track; (*b*) the retardation of the wheels due to the motors which they drive acting as generators; (*c*) the friction of the wheel brake shoes pressed against the wheel-tyres in direct proportion to the speed at which the car is travelling.

With each brake the energy dissipated in stopping the car in a given time or distance must be the same. In the case of type A equipment, it is divided as follows:—In wear between the magnetic brake shoes and the rails; in wear between the pinions and gear wheels; in heating the armatures, fields and resistances.

In the B type of brake equipment the energy is dissipated:—In wear between the magnetic brake shoes and the rails; in wear between the pinions and gear wheels; in heating the armatures, fields and resistances; in wear between the wheel-brake, shoes and tyres.

**VI. D.**—*Service Stops on Dry Rail. Momentum Brake.*

| Speed miles per hour. | Time in seconds. | Distance in feet. |
|---|---|---|
| 1 | 0·85 | 1 |
| 2 | 1·5 | 2½ |
| 3 | 2·0 | 3 |
| 4 | 2·5 | 5 |
| 5 | 2·9 | 7½ |
| 6 | 3·3 | 12½ |
| 7 | 3·8 | 17 |
| 8 | 4·2 | 23 |
| 9 | 4·6 | 29 |
| 10 | 5·1 | 36 |
| 11 | 5·5 | 43 |
| 12 | 5·9 | 50 |
| 13 | 6·5 | 58½ |
| 14 | 6·8 | 67 |
| 15 | 7·3 | 75 |

**VII. D.**—*Emergency Stops on Dry Rail. Momentum Brake.*

| Speed miles per hour. | Time in seconds. | Distance in feet. |
|---|---|---|
| 1 | 0·75 | .. |
| 2 | 1·2 | 1 |
| 3 | 1·7 | 2 |
| 4 | 2·0 | 3½ |
| 5 | 2·4 | 6 |
| 6 | 2·8 | 9 |
| 7 | 3 2 | 13 |
| 8 | 3·7 | 17½ |
| 9 | 4·0 | 23 |
| 10 | 4·5 | 29 |
| 11 | 4·7 | 35½ |
| 12 | 5·1 | 42 |
| 13 | 5·5 | 50 |
| 14 | 5·9 | 57 |
| 15 | 6·6 | 67 |

**VIII. D.**
*Service Stops on Greasy Rails.*

| | | |
|---|---|---|
| 1 | 1·1 | 3 |
| 2 | 2·0 | 5 |
| 3 | 2·8 | 9 |
| 4 | 3·5 | 14 |
| 5 | 4·2 | 19 |
| 6 | 4·8 | 25 |
| 7 | 5·3 | 32 |
| 8 | 5·8 | 40 |
| 9 | 6·3 | 48 |
| 10 | 6·7 | 57 |
| 11 | 7·2 | 67 |
| 12 | 7·6 | 77 |
| 13 | 8·0 | 88 |
| 14 | 8·3 | 100 |
| 15 | 8·8 | 113 |

**IX. D.**
*Emergency Stops on Greasy Rails.*

| | | |
|---|---|---|
| 1 | 0·8 | 2 |
| 2 | 1·6 | 5 |
| 3 | 2·3 | 8 |
| 4 | 3·0 | 12 |
| 5 | 3·6 | 17 |
| 6 | 4·2 | 22 |
| 7 | 4·7 | 27·½ |
| 8 | 5·2 | 34 |
| 9 | 5·7 | 41 |
| 10 | 6·2 | 49 |
| 11 | 6·7 | 57 |
| 12 | 7·1 | 66 |
| 13 | 7·6 | 76 |
| 14 | 8·0 | 85·½ |
| 15 | 8·4 | 96 |

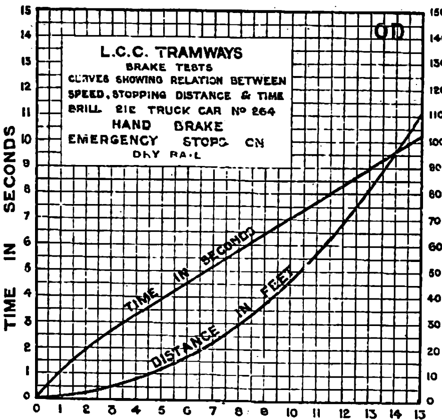
**X. C.**—*Speed Miles per hour Attained with each Brake Notch, Coasting down an Incline 1,100 ft. long, Maximum Gradient 1 in 21, Minimum 1 in 77.*

| Brake notch. | Rheostatic. | | A type brake. old magnets. | | B type brake, old magnets. | | B type brake, new magnets. | |
|---|---|---|---|---|---|---|---|---|
| | Speed. | Amp. | Speed. | Amp. | Speed. | Amp. | Speed. | Amp. |
| 1 | .. | .. | .. | .. | .. | .. | 12·2 | 16·0 |
| 2 | 12·5 | 45·5 | 13·0 | 19·0 | 12·5 | 15·0 | 10·0 | 15·5 |
| 3 | 8·4 | 45·5 | 9·8 | 13·0 | 7·5 | 12·5 | 7·8 | 14·5 |
| 4 | 5·3 | 44·5 | 6·5 | 12·5 | 5·5 | 11·5 | 5·8 | 13·0 |
| 5 | 3·3 | 42·5 | 4·4 | 11·5 | 4·0 | 10·5 | 4·2 | 13·0 |
| 6 | 2·5 | 40·0 | 3·3 | 11·0 | 2·5 | 9·5 | 3·4 | 15·0 |
| 7 | 1·0 | 36·0 | 2·3 | 10·0 | 1·5 | 6·0 | 2·3 | 20·0 |

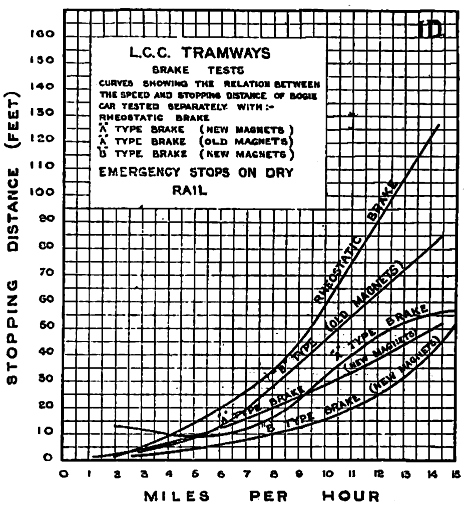
*General Conclusions.*—It is quite clear from the results of the tests that the hand and rheostatic brakes are not to be compared with the results obtained with electro-magnetic track brakes. Hand brakes are too slow in action, and entail much unnecessary labour on the part of the motormen. Rheostatic brakes are cheap as regards first cost, but the maintenance charges owing to the short life of the motors and resistances are very much increased. With this type of brake the efficiency is very low, and the power developed by the motors can be used to a much greater advantage in connection with magnetic track brakes. The results obtained with the momentum brake are very good and should receive careful consideration. I think that the pneumatic slipper brake for use on long steep gradients is a development which will be watched with interest.

The trials with both the A and B types of magnetic track brake show excellent results, and, although as far as the tests are concerned, there is no doubt that the latest form of type B brake, with the supplementary wheel brake attachment, gave the best results, there are two important points which must also be taken into consideration—viz., the first cost and the cost of maintenance. The cost of the A type of brake is naturally much lower than that of the B type of brake, as the arrangement is simpler, and for the same reason, in all probability, the cost of maintenance of the A type will be less as there are fewer working parts. It is therefore a question of experience as to whether the cheaper brake is sufficiently good for all practical purposes. Speaking personally, after a short experience, so many good points have been found in both types of brake that we are now giving them a thorough practical test under ordinary working conditions. I consider that even with electro-magnetic track brakes there is room for improvement, and shall not feel satisfied until a supplementary attachment is provided, so that the magnetic track-brake shoes can be operated by hand if necessary.

*Improved Brakes and Increased Speeds.*—It is quite clear that the Board of Trade recognise the importance of increased speeds, but at the same time the safety of the public has to be taken into



Curve No. 0. D.



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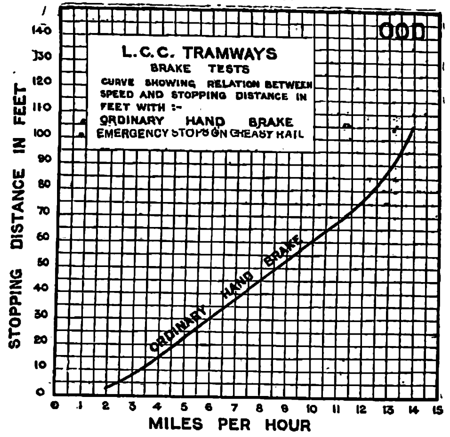

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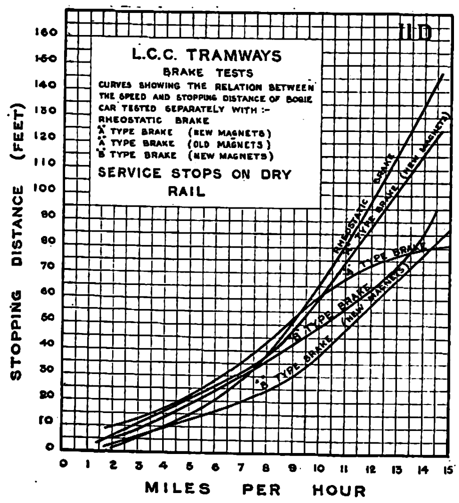

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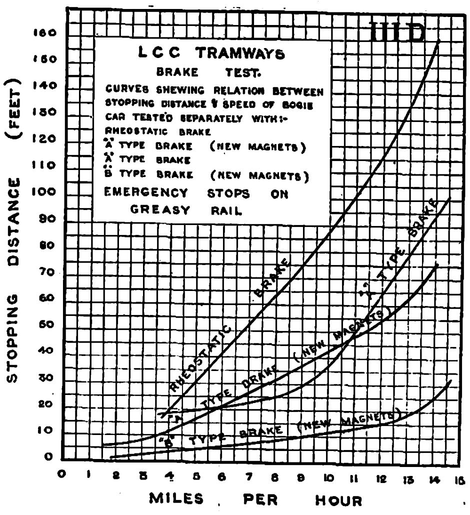

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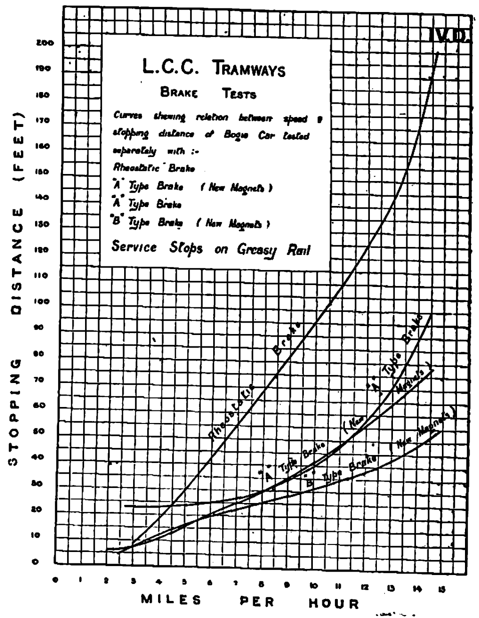

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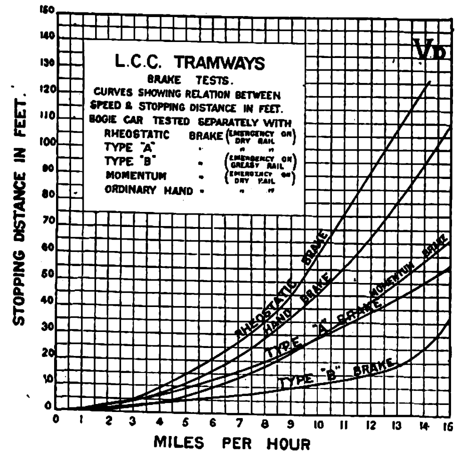

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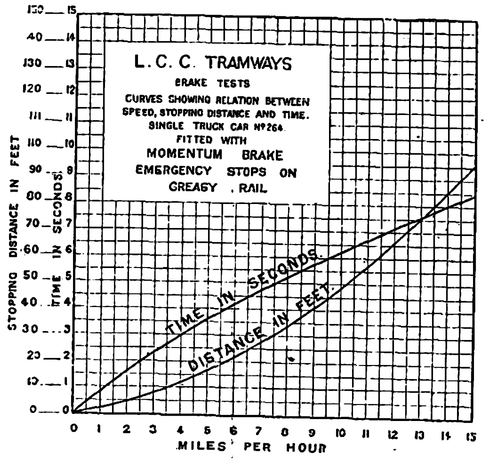

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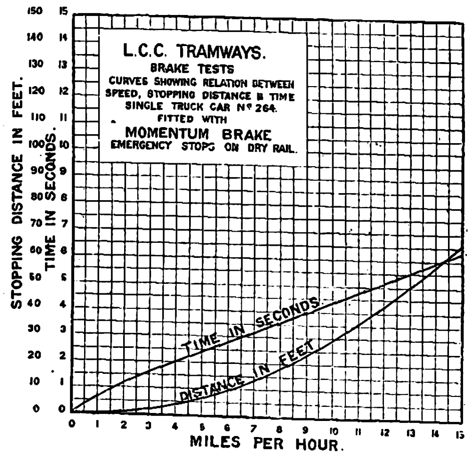

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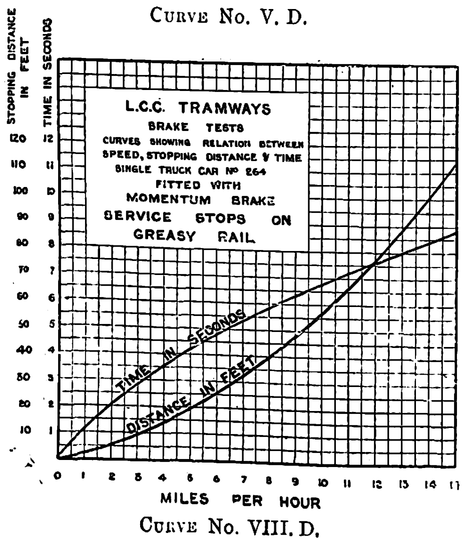
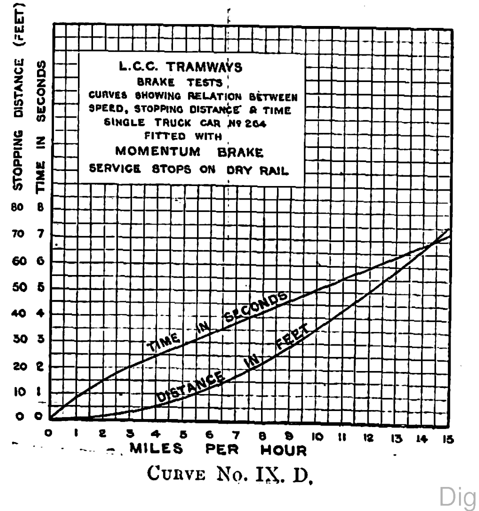


Curve No. VIII. D.



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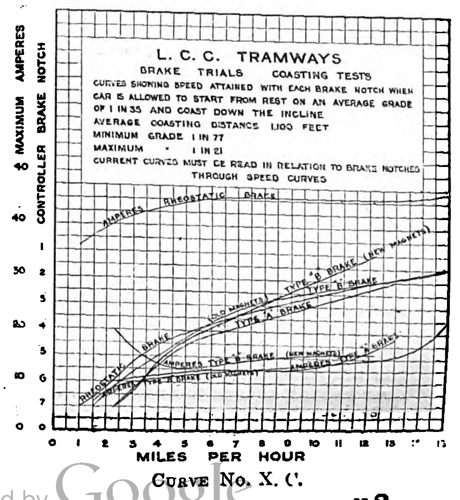


Curve No. X. C.

consideration. If I may be allowed to say so, I consider the procedure adopted by the Board of Trade very reasonable. With a new tramway undertaking, with new equipments and cars, inexperienced drivers and the general public unaccustomed to rapid transit, low speeds are very desirable, but when the undertaking has been run for a few years, and the necessary experience has been gained, an application for modified regulations receives very favourable consideration. As an example :—

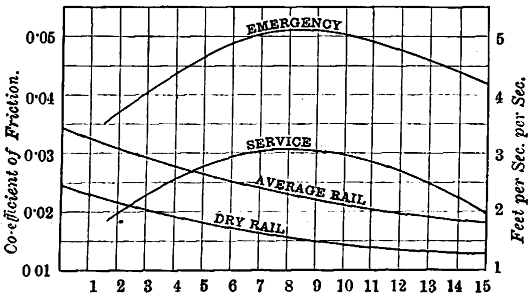
When the L.C.C. electric tramways were originally inspected by the Board of Trade the following speeds were allowed :—

| | | | | | |
|---|---|---|---|---|---|
| Percentage of total length of track.. | 23·07 | 57·55 | 17·5 | 1·63 | 0·25 |
| At miles per hour................ | 12 | 10 | 8 | 6 | 4 |

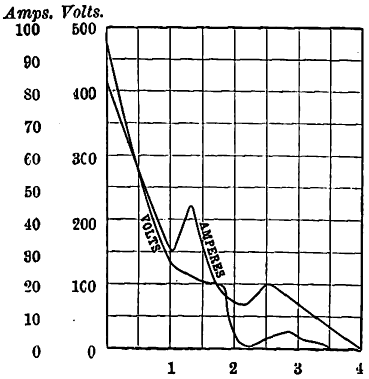
But after the foregoing series of tests had been carried out, and it was ascertained that excellent results could be obtained with the latest forms of electromagnetic track brakes, an application was made to the Board of Trade for an increase of speed. Practically the whole of the tramways were then re-inspected, and the Board are prepared to approve the following speeds on condition that the cars are fitted with electromagnetic track brakes :—

| | | | | |
|---|---|---|---|---|
| Percentage of total length of track.. | 25·44 .. | 71·40 .. | 1·15 .. | 2·01 |
| At miles per hour................ | 16 .. | 12 .. | 8 .. | 4 |

The increase in speed thus secured by more effective braking apparatus possesses very far-reaching advantages. A better service can be given with a fewer number of cars, so that the capital outlay on cars and car sheds, &c., is reduced; also the cost of operation per car-mile is very much reduced, as fewer motormen, conductors, inspectors and cleaners are required. The cost of upkeep per car is somewhat higher, but as a fewer number of cars are in service the total cost is not greater. For cars driven at higher speeds (within reasonable limits) the total cost of power is not materially increased. It appears that although more power is required for rapid acceleration, a car will coast a greater distance, without power being applied, when nearing a stopping station. Another point is that the efficiency of the motors as a rule is higher at the increased speed. It simply becomes a question of applying a large amount of power efficiently for a short time or supplying a small amount of power inefficiently for a long time. The chief advantage of the latest forms of electromagnetic brake is that they can be used in the thickest traffic when the cars are travelling at very low speeds. In the improved designs, with longer magnets, the ampere-seconds are very much lower, and the motors are not over-heated, as was the case with the older forms of magnets.



Curve No. X. I, showing Average Retardation in Feet per Second per Second with a Magnetic Brake; also the Coefficient of Friction.



Curve No. X. II.—Example Chart taken on Recording Ammeter and Voltmeter during a Single Emergency Stop with a Magnetic Track Brake.

If these brakes are adopted several very important points require attention. In the first place, the controller should be designed with not less than seven brake notches, so that the brakes may be applied gradually; also that the brake connections in the controller are entirely disconnected from the power circuit. The controller connections have to be arranged specially, so that when one motor is cut out the brake-winding will not be short-circuited. It must be remembered that electromagnetic track brakes are useless if applied at junctions where manganese rails and special work are used throughout. It must be remembered also that the new brakes are very powerful in their action, and great care has to be exercised in teaching motormen how to use them. It is also essential that the cars to which these brakes are fixed should be substantially built, especially when roof covers are fitted, as the strain caused by the rapid application of the brake when the cars are travelling at high speeds may develop serious defects.

## A NEW CALL RELAY FOR WIRELESS TELEGRAPHY.

With the extension of the distances over which signals are sent at sea, necessitating the use of very sensitive apparatus with which signals can only be satisfactorily received by means of the telephone, a great want has been felt for an apparatus which will give a clearly audible call signal when working at great distances. In order to meet these conditions, Mr. H. W. Sullivan has designed a specially sensitive call relay for use with electrolytic coherers and similar wireless detectors.

The instrument consists essentially of a very sensitive moving-coil galvanometer, of a form somewhat similar to Mr. Sullivan's well-known marine galvanometer, to which contacts are fitted. A specially strong magnetic field is obtained by permanent magnets, and some idea of the sensibility may be obtained from the fact that with one dry cell working through 8 megohms the limit of working has not been reached. This is a great improvement on most of the relays at present on the market, which as a rule will not work satisfactorily with a less current than that given by one cell through 250,000 ohms. The success of such an instrument as a relay naturally depends on the material, design and method of adjustment of the contacts. The material is a special alloy, the outcome of many years of experience in this class of work. If both the fixed and moving contacts were mounted on rigid arms trouble would be experienced in the moving arm rebounding and never making more than a momentary contact insufficient to ring an ordinary trembler bell. Mr. Sullivan gets over that by not only mounting the "fixed" contacts on springs, but by also making the light moving arm of springy material. When the position and strength of the springs is correctly adjusted, both yield slightly when the arm strikes the contact, and this not only diminishes the rebound by softening the blow, but also prolongs the contact by following up the return movement. A very neat adjustment is provided for the fixed springs, one screw shifting a slider which alters the effective length of the spring, and another swinging the carriage on which the spring is mounted. A contact system is provided at each side, so that it is immaterial which way current is sent through the instrument. Another interesting detail is the provision of a stop limiting the return movement of these springs, so that all possibility of sticking is avoided.

The moving coil is mounted between top and bottom suspensions of phosphor bronze strip, and is fully damped electromagnetically, and balanced for use on board ship. As in the case of the Sullivan "speaking" galvanometer for submarine cable work,* the frame carrying the coil suspension and relay contacts can be bodily removed by sliding out vertically, and as the connections to both the line and local circuits are made by stout springs bearing on pillars, a new coil can be substituted in a few seconds in case of a suspension becoming defective, or a coil otherwise damaged. The whole instrument is simple, strong and not liable to be affected by vibration, notwithstanding its high degree of sensibility.

Although primarily designed as a call relay, the apparatus would seem capable of recording signals at slow speeds at distances considerably in excess of those already accomplished with recorded signals, but experiments in this direction have not yet been carried out. In addition to the relay contacts the instrument is provided with a mirror, so that if desired a visual signal can be made by the movement of a large rectangular "spot" of light on a wall or bulkhead of the ship. The movement of a large spot of this kind would be visible to all in the room without close watching, and a useful check would be provided in the case of an accidental interruption of the local bell circuit. Mr. Sullivan is a firm believer in the advantages of the "electrolytic coherer" over other detectors, and is perfecting several pieces of apparatus designed to work with this system.

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* See *The Electrician*, Vol. XLIII., p. 919.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. FOURNIER D'ALBE.]

*Polarisation in Gases.*—Mebius showed in 1896 that probes inserted in the path of a vacuum discharge became polarised on transmitting a current through them, the anode becoming positively charged and the cathode negatively. The nature of this polarisation is still very obscure. Schuster supposed it to have some analogy with electrolytic polarisation, but that this analogy is very feeble has now been proved by G. C. Schmidt, who found that the polarisation disappears instantly on breaking the main current, and that it is not affected by the temperature. The conductivity, or product of ionic density into ionic mobility, is the same throughout a vacuum tube, as the author proved by means of a very rapid interruptor, and since the transverse current differs widely in different parts of the discharge, it follows that this must be due to differences of polarisation. The polarisation consists of layers of ions of the same sign as the electrodes, which are produced by the absorption of ions of the opposite sign. A positively charged electrode will absorb the negative ions in its immediate neighbourhood, and the positive ions which form the "polarisation" will only gradually diffuse away. In the dark cathode space, which is poorest in ions, especially negative ones, the polarisation is greatest, and it is least in the glow light.

[G. C. SCHMIDT, *Annalen der Physik*, No. 15, 1905.]

*Luminosity of Electric Lamps.*—P. Vaillant has made some interesting observations on the relation between the power consumed and the spectrum luminosity in various types of electric lamps, including the mercury lamp, the carbon and tantalum incandescent lamps, and the Nernst lamp. In the Cooper-Hewitt mercury-vapour lamp he made the curious observation that the greater the power the lamp consumes the yellower is the light. Measuring the luminous intensities at wave-lengths 577, 546 and 492 $\mu\mu$ respectively, he found that when the power fell from 200 watts to 99 watts, the luminosities in those three regions fell from 1,000 to 341, 398 and 449 respectively, thus leaving a distinct advantage to the blue light at the lower power. Since the blue light preponderates at the higher temperatures in all other glowing bodies, the author is forced to the conclusion that the less the power consumed the hotter is the vapour. It is certainly true that the mass of mercury evaporated diminishes as the consumption of power increases. As regards the other lamps, they all shift their maximum of luminosity towards the blue at the higher powers, and the shifting of the luminosity occurs most suddenly in the Nernst lamp. Taking the luminosity of the carbon filament for each wave-length as a standard, the Nernst lamp at ordinary working shows a deficiency both at the red and blue ends, and the tantalum lamp a great preponderance of blue over red.

[P. VAILLANT, *Comptes Rendus*, January 8, 1906.]

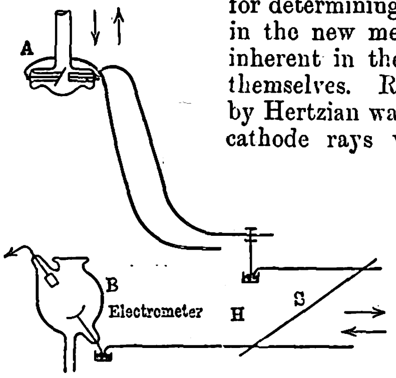
*Electrolytic Preparation of Spongy Tin.*—D. Tommasi describes an industrial method of preparing spongy tin, and gives figures with regard to the efficiency of the method. The electrolytic cell contains two anodes of tin, and the liquid consists of 50 parts water, 10 parts stannous chloride and one part hydrochloric acid. The cathode is a large copper disc capable of rotating in a vertical plane, and fixed for this purpose with its centre to a bronze shaft. The disc is half submerged in the liquid. The upper half passes between two brass scrapers, which scrape off the tin deposit and depolarise the disc. The spongy tin is collected automatically and washed, the liquid being evaporated to the concentration of the bath and used over again. In one experiment, with a disc 30 cm. in diameter, an E.M.F. of 3 volts and a power of 120 watts, the amount of tin deposited per horse-power-hour was 380 grammes, the theoretical amount being 440 grammes. The efficiency is therefore 86 per cent. But there is no reason why discs as large as 3 metres in diameter should not be used. With a disc of that size the amount of tin deposited would be 4,400 grammes per horse-power-hour, or 105 kg. per day of 24 hours.

[D. TOMMASI, *Comptes Rendus*, January 8, 1906.]

*Electrodynamometer Constants.*—G. Lippmann points out that the constant of an absolute electrodynamometer is always determined by calculation, which supposes large solid coils wound with a single turn of wire, whereas the sensitiveness of the apparatus demands light movable coils and many turns of wire. He indicates a method for determining the constant by an induction experiment. In instruments of the "balance" type, the constant sought equals $dP/dx$, where P is the potential of the fixed with respect to the movable system, and $x$ is the displacement. P may be determined by comparison with any induction apparatus whose inductance L is accurately known. Determining this for two positions of the balance, and dividing the difference by the displacement, the above ratio is determined. In electrodynamometers balanced by a moment instead of a direct force, the constant is $dP/da$, where $a$ is the angle of deflection. This constant is determined in a similar manner. Both determinations are based upon a comparison of P and L. This may be done accurately as follows: A battery current is sent through the primary of the induction apparatus and interrupted $n$ times per second. If the induced currents at break are passed through a resistance R, the total quantity of electricity induced per second is $nLI/R$, where I is the maximum intensity of the primary current. Let the latter pass at the same time through the fixed coils of the electrodynamometer, and let the movable coil, which acts as a secondary, be put in circuit with a resistance, R′. Then the induced quantity is $nP/R'$, and if the two induced currents are equal, we have $P/L = R'/R$, an equation which reduces the measurement to a single application of the powerful Wheatstone bridge. The constant L may be accurately determined once for all by building a special apparatus on a large scale designed specially for ease and accuracy of calculation, as by Guillet's method.

[G. LIPPMANN, *Comptes Rendus*, January 6, 1906.]

*Velocity of Röntgen Rays.*—E. Marx has succeeded in measuring the velocity of Röntgen rays by a new and elegant method, and has found it to be the same as the velocity of light. The method is analogous to that of Fizeau's toothed wheels as used for determining the velocity of light, but in the new method the intermittence is inherent in the source and the receiver themselves. Röntgen rays are generated by Hertzian waves. This means that the cathode rays which give rise to the Röntgen rays are only produced during the negative phase of the Hertzian oscillation, hence the intermittence. The receiver is an electrode connected with the same exciting system, and emitting secondary cathode rays under the influence of the incident Röntgen rays, but only when found by them in the negative phase. This represents, therefore, the second toothed wheel. Its action is complicated by the fact that the X-rays themselves produce oscillations in the leads. But the author succeeded in getting over this difficulty by a null method. The arrangement is shown in the diagram, where A is the source and B the receiver, both fed from the same Hertzian oscillating wires H. Successive minima are obtained by shifting the bridge S.



[E. MARX, *Physikalische Zeitschrift*, November 9, 1905.]

*Explosion of Radium Tubes.*—J. Precht reports that a small glass tube with walls 0·5 mm. thick, containing 25 milligrammes of purest radium bromide, exploded after 11 months' use with a loud report. Three minutes before the explosion it had been removed from a bath of liquid air and placed on a wooden table. It had been used several times before. The force of the explosion was such that the glass was shivered into almost microscopic particles which were strewn all over the room, the radium being seen in the dark like a starry sky. The pressure in the tube must have been at least 20 atmospheres, and was no doubt due to the evolution of gaseous decomposition products of radium.

[J. PRECHT, *Physikalische Zeitschrift*, January 15, 1906.]

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## THE ELECTRIC POWER COMPANIES.

A year ago, when we published our annual sheet giving maps and statistics of the electric power companies of the United Kingdom, we were obliged to express our regret at the comparatively small number of these undertakings that had emerged from the stage of operation under temporary conditions. There were then only four power companies which had reached this point; some others were still constructing their works or supplying from temporary plant, and a third group had done very little towards the realisation of the objects for which they had been founded. This year our table displays a very different condition of affairs. Last year the Newcastle, Midland, South Wales and North Metropolitan Companies were the only ones in operation on a permanent basis; this year five more companies may be added. The Lancashire and Yorkshire power companies, whose power houses are built on identical lines, are developing good industrial areas in the North of England, and in Scotland the Clyde Valley, Fife and Scottish Central Companies have made a start. The County of Durham Company is being absorbed into the Newcastle Company, which has thus a wider area for its well-directed efforts. The latter company has displayed the greatest activity of any, and it has done much to popularise the employment of electric power in the Newcastle district. Its connection, aggregating over 30,000 kw., is far greater than any other power company in this country. In fact, the total connections of all the companies in operation may be estimated at between 50,000 and 60,000 kw., so that the Newcastle Company represents about one-half of the total. Of course, this does not mean that the Newcastle Company supplies half the electric power utilised in the United Kingdom, for the private motor connections of the electric lighting stations amount alone to about 250,000 kw., and to this must be added a far larger power supplied for the tramways and electric railways of the country, and a considerable amount representing the self-contained plants which have been erected at many large engineering works. In the same way, the plant-capacity of the power companies—about 70,000 kw. in operation, 9,000 kw. almost completed, and some 7,000 kw. under construction—

is but a small proportion of the aggregate electric power which can be supplied by all the electricity works in the country.

A noticeable feature in the development of the power companies is the increasing number of collieries which buy their power. Many more, it is true, prefer to generate it themselves, but even in this case the more advanced coalowners have discarded their inefficient steam engines and long and wasteful steam pipes, and have substituted one central generating station and electric motors. It is a true sign of the economy of concentration of power generation that the cause should be making good headway at the points where fuel is cheapest. In South Wales and in Scotland the major portion of the power companies' load is supplied for coal mines, and in Durham the Durham Collieries Electric Power Co. will start in a few weeks with a 5,000 kw. plant for supplying a group of collieries in its neighbourhood. Another company which will be starting supply shortly is the North Wales Electric Power & Traction Co., a description of whose undertaking we commence this week. Its chief customers will be slate quarries, which are at present driven by very uneconomical methods, and it is the only electric power company with works driven by water power, and with transmission lines entirely overhead. In Ireland there should be a certain amount of water power available, but the one proposal towards its utilisation on a wholesale basis was the Shannon power scheme, which has now, we are informed, died a natural death. In Scotland no progress has been made in this direction either, if we except the utilisation of the Falls of Foyers by the British Aluminium Co. Within the County of London, the Metropolitan Electric Supply Co. has a large "power" area, and the North Metropolitan Electric Power Supply Co. just dips into London proper at one corner of its district. So far the Metropolitan Electric Supply Co. has only utilised its "bulk" powers in Acton, but the North Metropolitan has Stoke Newington as a consumer within the County of London. It may be mentioned, however, that out of 19 towns in the United Kingdom taking their supply "in bulk," 10 only are customers from power companies, but there are now several agreements in course of negociation, in Yorkshire and Lancashire especially.

There are still, we regret to say, a number of power companies in various parts of the country in an undeveloped condition, and we trust that the success of some of the pioneers will overcome the shyness of capitalists and customers alike, so that the field of the electric power industry may be enlarged to its fullest extent. The 23 maps which we publish on the back of our supplement sheet represent a large portion of the industrial area of the British Isles which should be ready to benefit by the application of electric power.

## ELECTRICITY METERS.*

BY C. H. W. GERHARDI.

*(Concluded from page 518.)*

### METER CLEANING AND REPAIRS.

On the return from the consumers' premises of meters which have been out some time it will often be found that, although in good repair, such meters may be, and probably are, more or less dirty. After making a "test as returned," from which it may be found that the meter is slow at low loads, due to the increased friction caused by dirt, it becomes necessary to overhaul the various parts and thoroughly clean them.

Where the covers are not airtight they can be made more dust proof by applying vaseline at the joint between cover and case; the vaseline catches a lot of the dust which would otherwise enter the meter. Another point which should receive great attention before a meter is sent out on service is the joint between the glass of the window and the cover. These glasses should be bedded on putty, care being taken that no holes are left.

Unless very dirty, there is usually no need to take the instrument entirely to pieces for cleaning. The wheel train is removed and perhaps the main moving part. Then an air blast, preferably from a foot blower, will remove the dust from positions which cannot be got at with brush and duster. The wheel train should be taken to pieces, and all bearing holes in the plates cleaned with peg wood. These should be oiled after cleaning, using a clean pointed piece of peg wood which is just damp with the best clock oil. The slightest film of oil only should be allowed to remain. The pivots should all be cleaned with pith, and the teeth of the wheels brushed with a stiff watch or clock brush. If the teeth are very dirty it may sometimes be necessary to soak the wheels in paraffin before brushing, or it is sometimes sufficient to moisten part of the brush with paraffin and finish off with the dry portion. Peg wood can also be used for the removal of dirt from the teeth, but on no account should they be scraped with a metal instrument, such as a needle or small brooch. If at all burred, it is sometimes possible to file up a tooth, for which a tooth-cutting file, as used by clockmakers should be used. The bearings of the main spindle are cleaned similarly, pith being used for the jewel, which should also be felt with a sharp needle to ascertain if it is rough or cracked. If not found absolutely smooth it should be replaced by a good one, and the pivot or spindle base repolished or replaced.

In many meters the pivot is screwed into or on to the bottom of the main spindle and can be easily removed by means of a key. In such cases there is no need to remove the main spindle, which often means taking the meter to pieces. The practice of using a separate pivot greatly facilitates its examination and repolishing. A polishing head or small motor should be provided with a chuck capable of taking the pivots or spindles, in which case the spindle of the headstock should be hollow. The work necessary to bring the pivot up to the desired polish depends on its state. If at all flat, it should be rounded, using a piece of fine grain Arkansas hone, after which various grades of "blue-black" paper (which is obtainable at any clockmaker's tool warehouse) and a pivot burnisher are used. If finished off with crocus powder and oil a high polish is obtained. A strip of bell metal, oiled, is dipped into the crocus powder, of which a certain amount sticks to the strip, which is then used as a file would be, while the pivot is turned at a high speed. The pivot should be examined in a good light through a magnifying glass. The initial friction and wear depend so largely on the polish of the pivot and jewel that great attention should be paid to these precautions. The most durable point seems to be a spherical one. When a ball takes the place of the pivot, a new ball should be inserted to replace the one which has been running on the damaged jewel.

The footstep jewels are usually sapphires, which rank in hardness next to the diamond. If only rough, and not cracked, they can be repolished at a reasonable cost by workers of precious stones. Those which are cracked are useless and must be replaced by new stones.

In meters having commutators, the condition in which the commutator keeps depends principally on the sparklessness of the brushes. If these spark the commutator soon becomes pitted and rough, whereas if no sparking takes place they will last for years in good condition if precautions are taken to avoid, as far as possible, dust entering the meter. External vibration is probably the chief cause of sparking; it therefore follows that, in order to avoid this source of trouble, the brushes must have as little weight at their free end as possible to prevent pendulum action. With a light brush, also, a weaker spring can be used. It is the author's experience that wire brushes give the least trouble. The point of contact of a circular wire on a cylinder being very small, the number of independent points of contact can be increased without causing the brush friction to be greater than it would be if one or two flat brushes were used, and the more independent points of contact there are the less is the chance of sparking taking place. Wire brushes, moreover, when separated seem to push aside dust particles, thus keeping the commutator clean in the path of each wire. With a view to testing the life of wire brushes, a meter has been run with its cover off in a very dusty situation on a 220 volt supply with a current of 0·05 ampere in the commutator circuit. Its speed has been varied, sometimes exceeding 100 revs. per min., and it has also occasionally been stopped. The brushes are covered with dust, but the commutator has clean lines where each brush touches it and is very dirty at other points. There has never been the slightest visible spark, although the number of revolutions made by the commutator under these abnormal conditions exceeds 25,000,000, an equivalent to over 25 years' working on an average consumer's premises. In this test each brush consisted of four No. 22 standard silver wires, supported in pairs by independent phosphor-bronze strip wound as a spiral spring.

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Commutators which have not been damaged by sparking require only a rub with a piece of linen tape, which should be slightly narrower than the commutator. The tape is passed round the back of the spindle, and slipped between the brushes and commutator. The two ends of the tape (which is about 12 in. to 18 in. long) are held one in each hand in the front, and alternately pulled backwards and forwards, thus turning the commutator and cleaning all the segments. Should the commutator be pitted, narrow strips of "blue-black" paper should first be used in the same way as the tape, always finishing off with the finest ("0000"), after which it is finally polished with tape. When such treatment has to be resorted to, particles of silver dust may become lodged between the commutator bars. These, if not removed, may short circuit sections of the armature; they should, therefore, be blown out by means of bellows, or a piece of peg wood tapered to fit between the commutator bars may be passed down between each segment. The brushes should be removed from the meter and cleaned, if of strip or flat silver, by means of the same materials as used for commutators. Wire brushes require renewing if found to have been sparking.

Wire brushes are easily made out of hard-drawn "Standard" silver wire, which can be obtained in any wire gauge size. This wire is straightened by passing short lengths through a spirit flame, the ends being gripped by pliers. After a little practice it can be straightened in this manner and still retain the requisite spring. Pure silver is too soft for this work.

Other mechanical defects in meters comprise bent spindles, bent discs, broken covers, broken or defective wheel trains, bent hand-carrying spindles, broken or blackened dial plates, broken screws in terminals, broken glasses, &c. Main spindles can often be straightened by tapping with a boxwood mallet, or, if bent near the worm, by pressure until they become true. Discs can also be trued if fitted on a mandril and placed in the lathe. Other mechanical defects are remedied by replacing the parts with new ones, which can generally be obtained from the makers, and of which it is convenient to keep small stocks so that the repairs can be finished off without delay. Glasses for the renewal of the windows should be stocked in larger quantities, as these are easily broken. A meter should never be allowed to remain in stock with a broken glass, for it so soon becomes dusty and would require a further cleaning before being sent out.

In the case of motor-meters containing mercury, it is sometimes advisable to replace the old mercury with new pure mercury. If the old be found dirty the bath should be opened and cleaned before filling with the new mercury.

Electrical defects principally consist of short circuits of main or shunt coils, or resistances, breakages in these circuits, and breakdowns of the insulation to case. Short circuits of the main coils are generally caused by considerable overloads charring the cotton insulation of the wire or strip, and meters which have been sufficiently overloaded to create such short circuits indicate the fact by the outward appearance of the coils. The main coils may sometimes be short-circuited by the metal clips by which they are supported, but this defect is rare, as the clip must have pierced the insulation in two points to produce it. A leak to case caused in this manner is more frequently met with. These defects are easily localised by testing between the various parts with an ohmmeter. Or a detector and battery. Where a leak to case or short circuit of a main coil is caused by the supporting clip the insertion of a piece of mica between clip and coil will remedy the defect, but main coils which have been overloaded sufficiently to char the insulation should be replaced, as they are unreliable, even if apparently unshort-circuited. The author has known cases where such coils, apparently in working condition when cold, have become partially short-circuited when heated by the passage of full-load current for some time. The meter running abnormally slow coupled with a low-voltage drop across the main coils is an indication of short-circuited main coils.

A partial short circuit in the shunt may be indicated by the meter speed being very high, in which case the shunt current will be above the normal. This defect most frequently occurs in meters having non-inductive resistances wound double on bobbins. Where the resistance is wound on more than one bobbin, the faulty bobbin can often be traced by feeling the wire on the several sections after the shunt circuit has been energised a little while. The shorted bobbin will be cold and the sound ones warmer than usual. If no difference in the temperature can be noticed in this manner, it becomes necessary to test the resistance of each section or bobbin, either by the Wheatstone bridge or potentiometer methods. The latter is preferable, as short circuits in these bobbins may be intermittent, only appearing when the coil is hot. Faulty bobbins should be replaced by new ones of the same resistance and the old ones destroyed.

Where meters have wound armatures and commutators, short circuits may occur between adjacent commutator bars, and before an armature is changed it should be ascertained whether the fault is in the commutator or in the armature. Faults of this description can be detected by the unevenness of the speed during a revolution at low loads. They can also be found by measuring the torque for different positions of the armature. Should the torque be zero in any position, it is evident that there is a break on one or the other of the coils connected to one of the bars underneath the brushes.

If a suitable ammeter—*i.e.*, one having a range 0 to 0·05 or 0·1 ampere—be inserted in the shunt circuit, and the armature turned slowly, a jump will be noticed in the reading of the ammeter if the armature or commutator is short-circuited. Owing to the high resistance in series the jump will only be very small, but if the ammeter is connected up in series with the armature on a low voltage sufficient to produce the normal current in the circuit, the jump becomes very marked. It is a good plan to test all new armatures in this manner before they are put into meters.

On a short-circuited armature being found, the spindle and armature complete are removed from the meter and all the leads unsoldered from the commutator bars. The commutator can then be tested between bars for short-circuit. The air space between two shorted bars can be cleaned with a pointed piece of peg wood, which is also pushed down behind the insulating band which holds the bars, and should the short-circuit be due to silver dust this will often remove it. By applying the current for some time (at 100 or 200 volts through a lamp) a fault can sometimes be burnt out without damaging the commutator if the peg wood fails to remove it.

This somewhat crude method of removing faults has often been used with success in locating and burning out leaks from commutator to main spindle, one pole of the supply being connected to the case or spindle.

Owing to the fineness of the wire used in meter armatures and the consequent difficulty of making contact with the ends of the coils, it is convenient to provide for this purpose a pair of spring clips into which the wires from the armature are placed after disconnecting them from the commutator. The clips may be conveniently mounted on a stand and provided with terminals for the testing leads.

A short-circuited coil is rarely found, and usually if any trouble is due to the armature itself it is caused by a break in a coil. Careful examination of the outside of the coils will determine whether any injury has been caused by a blow or the slipping of a screw-driver, in which case several breaks may be found, and it would be cheaper to replace the damaged armature with a new one. It is very difficult to unwind and rewind an armature with the same wire, but one or two coils can be unwound and replaced, and should a break occur in one of the upper coils it can be unwound, repaired and rewound; or new wire can be put on in the place of the old from the point where the fault is found. Breaks are frequently found in the ends of the coils where they are taken up to the commutator bars, and these ends should be carefully examined when detached from the commutator in the first place. The author employs a special chuck for holding armatures of the Duncan, Thomson or Vulcan type when unwinding or rewinding.

The armature to be unwound is soaked in methylated spirit to soften the shellac, and the coil being unwound should be frequently brushed with a camel hair brush dipped in methylated spirit to keep the shellac soft. The speed must be extremely slow and a revolution counter should be fixed to the other end of the lathe head spindle to ascertain the number of turns, in order that the same number may be wound on again.

Another fault in motor meters is that the non-inductive resistances may sometimes break. The faulty section, when found, can be unwound, mended and rewound. It should, however, be ascertained that the wire has not become brittle, in which case the whole resistance should be replaced by a new one.

In induction motor meters breaks may arise in the shunt circuit. When a faulty part of the circuit is found and is replaced by a new one, such as a new coil on the shunt magnet or a new impedance coil, the resistance is of little consequence compared to the self-induction. If, therefore, any coil is rewound the number of turns and the air-gap should be the same as before the repairs.

Repairs to electrolytic meters, such as the Bastian or Wright, are either very simple, or those which can only be done by the makers of the meter. They chiefly consist of replacing broken glass vessels. A new glass vessel means a new scale. In the Aron meter, in addition to breaks in the shunt circuit, there is the liability of the main spring breaking, as also the hair spring which drives the commutator. A main spring is easily replaced and can be done in situ if necessary, as there is no fear of the calibration being affected.

## THE TUNING OF WIRELESS TELEGRAPH APPARATUS.

Prof. Slaby in the fifth [*] of a series of articles appearing at intervals in the *Elektrotechnische Zeitschrift*, describes further experiments with the particular form of variable resonance coil, called by him the "multiply-rod," and used for measuring wave-lengths of electrical oscillations upon wires. The points of principal interest in the article are those dealing with Drude's recent criticism of Slaby's method. It may be remembered (*Electrician*, Vol. LV., p. 117) that Prof. P. Drude found the Slaby multiply-rod to give results about 5 or 6 per cent. too low when measuring wave-lengths. This error was attributed by Prof. Drude to the alteration of the capacity of the multiply-rod when it is approached to the air-wire or to other conductors. Prof. Slaby now admits the error, and describes a number of experiments to show that the error enters through calibrating the multiply-rod by the oscillations on a single long straight insulated wire. It is now shown in fact that the waves on a long straight wire, which was in the original experiments stretched horizontally, are affected both by the proximity of the wire to the earth and by the state of the atmosphere. The capacity effect of the earth is to increase by about 3 per cent. the wave-length of the oscillations on a 60-metre wire held horizontally two metres above the ground; but the increase becomes inappreciable at a height of about 5 metres. On the other hand, the inductive influence—as distinct from the capacity—of neighbouring conductors appears to be about half as important as the above and in the opposite direction. In practice then it may be taken that the quarter-wave-length of the fundamental oscillation on a wire reasonably distant from the earth exceeds the length of the wire by a small percentage. Further, the author claims to show by measurements carried out in a steam-filled scullery, that the hygrometric state of the air, or, at any rate, the presence of a film of water on a wire, may alter to something like 7 per cent. the capacity of the horizontal wire used in these calibrations. The article concludes with some wave-length measurements on variously contorted wire conductors, the results being corrected in accordance with Prof. Drude's criticism.

In a sixth[*] communication, Prof. Slaby considers very briefly the relative amounts of energy supplied to two possible arrangements of the parts of a wireless telegraph sender whose air-wire was coupled directly to the condenser circuit. The rate of supply of energy was measured by wattmeter readings in the primary of the transformer actuating the spark-gap. He found that when the gap was in such a position in the condenser circuit as to be in metallic connection with the air-wire, the energy supply was greater than when the same gap was in a part of the condenser circuit separated from the air-wire by the condenser. This difference he attributes to the direct effect, in the first case, of the capacity of the air-wire itself. He then turns to the consideration of the overtones found in a system consisting of a cable connected to a closed oscillating condenser circuit, and vindicates by some measurements his mode of calculating the fundamental and first overtone. This method does not permit of abstraction. It is sufficient to mention here that two cases are discussed: one in which the condenser is earthed by a short wire, another in which the condenser is earthed by a wire of appreciable inductance.

In a seventh[†] and final article the effect of the coupled transmitter on a distant receiver is examined. Two ways of coupling are considered, both of them being conductive couplings. The one, called direct, has the spark-gap in the length of wire common to the oscillating and radiating circuits; the other, called the indirect method of coupling, has the air-wire connected directly to earth, and the spark-gap in the earth connection of the oscillator circuit. The essential difference between these two modes of coupling appears to be that in the direct mode the earth wire of the system and the air-wire are connected to opposite balls, in the indirect mode to the same ball of the spark-gap in the oscillator circuit. Two kinds of radiator were used in the experiments, and corresponding receivers. One radiator was of the "harp" form, consisting of a frame containing a number of parallel wires; the other was a long covered cable. The receiver in the first case was another harp having in series with it a helix with a sliding contact to give variable inductance. The receiver in the second case was a more or less rectangular loop of wire, containing a condenser and possessing also a variable inductance helix. The experiments were all carried out in a laboratory, but the distances worked over are not stated. Current in the sender was measured by a hot-wire ammeter, and in the receiver by a more delicate instrument of the same type. Since in many of the experiments the capacity of the condensers in the oscillator-circuit were varied, it was necessary to allow for the consequent variability in the rate of sparking. To do this the rate of supply of energy to the transformer was kept uniform, and a curve drawn from preliminary experiments connecting number of sparks per second (measured by a stroboscopic method) and current strength in the radiator. By means of this curve future observations were, when necessary, reduced to a standard spark frequency of 100 per second.

In the oscillator circuit a variety of inductances, five in number, were used so as to permit of wide variations of the capacity in that circuit. For each new capacity the period of the sender was measured and the proper period of the sender adjusted thereto. Since in compound transmitters oscillations of two periods exist, the receiver concerned was tuned in turn to one period and the other, and thus measures were obtained of the efficacy of the separate oscillations. Experiments were made for each wave in each type of sender, with the various capacities and inductances in the oscillator circuit, and for each mode of coupling. For the tables of numerical results and the diagrams exhibiting these results graphically, reference may be made to the original article. It will suffice to record here the author's conclusions :—

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[*] *Elektrotechnische Zeitschrift*, No. 44, 1905.

[*] *Elektrotechnische Zeitschrift*, No. 45, 1905.

[†] *Ibid*, No. 51, 1905.

The tuning of the oscillator circuit to the radiator before coupling, the so-called resonance of the system within itself, is not of overweighing importance either as regards the total energy output of the transmitter or as regards the effect at a distance. It is, on the contrary, harmful, since it divides the energy-output equally between the two wave-lengths existing in the transmitter. Since these two periods are not close enough together to allow of tuning the receiver to a middle value, nor so far apart that the tuning of the receiver to one of them is profitable, the practical importance of the resonance between the parts of the sender has now vanished, or, at least, was over-estimated.

Of the two wave-lengths that have always to be reckoned with, the smaller is not independent of the larger, but must be regarded solely as its overtone. Usually an overtone is feebler than the fundamental. If, nevertheless, it is required to play the principal role in transmission, circumstances must be so arranged that its current loop occupies a more favourable position on the air wire than that of the sender. It is possible to arrange that while the current loop of the fundamental falls in the closed oscillating circuit, that of the overtone lies well up the air wire. Herein lies probably the greatest advantage of the coupled transmitter. Instead of the quarter-wave of Marconi a half-wave with a higher placed current loop is used. The most favourable position for this current loop depends on the spark-gap conductivity—a quantity that depends again on the capacity in the oscillating circuit. Ignoring this, the most favourable position for the current loop would be about 0·3 up the whole length of the air-wire ; but on account of the increase of the conductivity of the spark-gap with increasing capacity the point indicated moves downwards, so that the wave-length is about 20 per cent. greater than the theoretical. By this arrangement the effect of the fundamental at a distance is about 80 per cent. smaller than that of the overtone. Thus, if the receiver is tuned to the overtone, the syntony is practically one-toned.

A perfect monotone is not attainable by the use of the overtone, but is, perhaps, by the use of the fundamental. The experiments show that there is a value for the capacity in the oscillator circuit that gives the best effect when the overtone is employed, while there is no such maximum in the case of the fundamental; and after this value of the capacity is passed the effect of the overtone falls off very rapidly, till, when double that capacity is reached, a receiver tuned to the fundamental will be quite uninfluenced by the overtone. The system oscillates, in effect, in this case, only in the fundamental period, for which again there is a most favourable value of oscillator capacity and spark-gap conductivity. It is possible to choose a capacity that gives a transmission effect greater than that of the overtone, but which, at the same time, is less economical because the current loop is less favourably placed on the air-wire.

A remarkable difference with respect to effect at a distance here appears between the direct and the indirect arrangements. With the fundamental the direct coupling always gives the greater effect, the difference being almost perfectly proportional to the charge on the air-wire, since effect at a distance is proportional to the energy radiated. With the overtone distant effects are greater with the indirect coupling, and depend on the difference between the capacities of the condenser circuit and of the air-wire. With the direct arrangement both capacities are charged to the same potential; with the indirect only the capacity of the condenser circuit is charged. The oscillation energy, which is approximately proportional to the difference, must thus be smaller in the first case. Hence the practical rule that the indirect coupling is employed if the overtone is used, the direct if the fundamental is used. Since in the last case one-tonedness is attained with smaller condensers than by the indirect arrangement, the rate of working is more economical.

Theory ignoring damping indicates that the best effect is obtained if the portion common to the two parts of the transmitter has the smallest practicable self-inductance. If damping is taken into account a certain, though small, common self-inductance must be provided. The experiments show that its most suitable value is related to the capacity of the transmitter. With two very different senders, worked with spark-gaps in air, the experiments give the same value, 6·8, for the ratio capacity : square root of common self-inductance. Finally, the experiments show that the oscillator circuit should have inductance as small as practicable beyond that common to itself and the radiator. In particular, inductance in the earth connection of the oscillator circuit is harmful.

These three articles are now available, published together in pamphlet form.

## TECHNICAL CONSIDERATIONS IN ELECTRIC RAILWAY ENGINEERING.*

BY F. W. CARTER, M.A.

In the course of the Paper the author gave details of the methods employed in investigating the preliminary and exact engineering features of the electrical system, basing his work for the most part on the use of continuous-current railway motors, as applied to suburban service under conditions obtaining in this country. The methods employed were, however, quite general, and applicable to other systems than that particularly considered.

The chief class of service between which it appeared necessary to distinguish for the purpose of the Paper were : (1) urban and suburban, (2) branch line and inter-urban parliamentary, (3) long-distance express, (4) goods. These differ in their requirements chiefly with respect to : (1) rate of acceleration and speed up to which it is necessary to maintain the maximum rate, (2) behaviour on grades, (3) maximum speed attainable on level track. The chief electrical systems available for railway service are: (1) the continuous-current system, (2) the single-phase alternating-current system, (3) the polyphase system employing induction motors. There are, therefore, numerous alternative combinations of service and system, many of which can, however, be disposed of when the general principles have been elucidated.

*General Dynamics.*—The action of a railway motor depends practically on two variables only, and for a motor whose characteristics are known, when the voltage and current are given, the speed and tractive effort at the driving wheels are determined. The effect of the motors on the train depends upon (1) weight of train, (2) inertia of rotating parts, (3) train resistance. The weight of train to be employed in calculating the acceleration due to any force is a certain spurious "effective weight," composed of the true weight and an increment due to the rotation of the wheels and armatures. If W be the weight of a wheel, $r$ its radius at the tread, and $k$ its radius of gyration, the increment of weight due to the rotation of the wheel is $W\left(\frac{k}{r}\right)^2$. In an average steel railway wheel $\left(\frac{k}{r}\right)^2=0{\cdot}6$ approximately. If W′ be the weight of an armature, $r'$ its radius, $k'$ its radius of gyration, and $\gamma$ the ratio of gear reduction, the increment of weight due to the rotation of the armature is $W'\left(\gamma\frac{k'}{r}\right)^2=W'\left(\gamma\frac{k'}{r'}\frac{r'}{r}\right)^2$. For a continuous-current armature $\left(\frac{k'}{r'}\right)^2=0{\cdot}5$ approximately. Thus, if W = 800lb., W′ = 1,600lb., $\gamma=3$, $\frac{r'}{r}=\frac{1}{2}$, the addition for rotary inertia will be approximately 480lb. per wheel and 1,800lb. per armature. In the case of suburban trains operated by continuous-current motors, the amount to be added on account of rotary inertia will usually be some 8 or 10 per cent. of the weight of the train, whilst with single-phase alternating-current motors the increment may amount to double as much, on account of the greater number and weight of armatures and their generally higher peripheral speed.

The forces resisting the motion of the train consist of the positive or negative component due to grade, and the rather uncertain "train resistance," composed of journal and flange friction, air resistance, &c. There is a lack of reliable data on the resistance offered to the motion of electric trains. The classical results of Aspinall† were obtained from measurements made behind a locomotive and tender, and accordingly do not include the head resistance, which is a very important element in the case of electric trains of two or three coaches. The Berlin-Zossen‡ high-speed train resistance tests were made with a single coach of totally different type to those usually employed in this country. Pending the publication of more suitable data, the author has combined the results of the above-mentioned sets of tests to obtain the working curves of Fig. 1, which he has found to agree very fairly with the results of such isolated tests on electric trains as he has been able to make. The variable portion is expressed in terms of the dimensions of the train, rather than of the weight, since it must represent principally air resistance, and therefore at any speed can depend only on the external configuration of the train. The constant portion of the resistance, which is taken from the above-mentioned tests at such low speeds that the static resistance just ceases to be apparent, is probably expressed with sufficient accuracy as proportional to the weight, and appears to be 2½ lb. to 3½ lb. per ton. The total train resistance is therefore the amount deduced from the curves of Fig. 1, increased by 2½ lb. to 3½ lb. per ton.

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* Paper read before the Institution of Electrical Engineers last night. Abstract.

† *Proc.* Institution Civil Engineers, Vol. CXLVII., p. 155.

‡ *Proc.* Institution Electrical Engineers, Vol. XXXIII., p. 894.

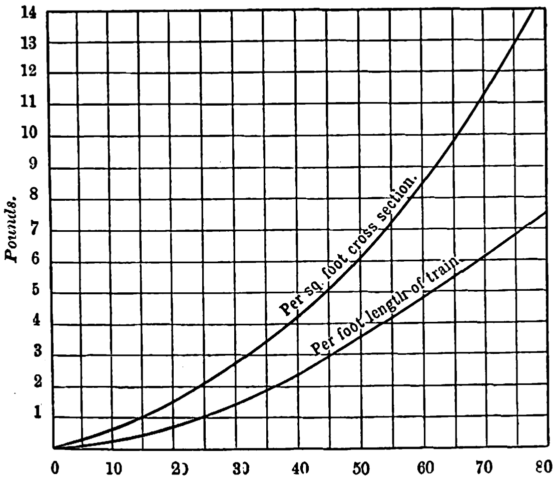

FIG. 1.—TRAIN RESISTANCE CURVES GIVING THE VARIABLE COMPONENT OF TRAIN RESISTANCE.

A light train of given external dimensions will, except at low speeds, meet with almost as great a resistance as a heavier built one of the same dimensions. A long-distance high-speed train should, for efficiency, be composed of many coaches, whilst the weight is a secondary consideration. A frequently stopping low-speed train, on the other hand, should be built light, but whether it is composed of few or many coaches is of small importance as far as efficency is concerned. The resistance due to the friction of brushes, motor journals, and gears, is usually charged to the motors, the tractive effort of which is supposedly measured at the rims of the driving wheels. It accordingly does not affect the train resistance during the time power is being supplied to the motors, but should be included during the time of coasting or drifting.

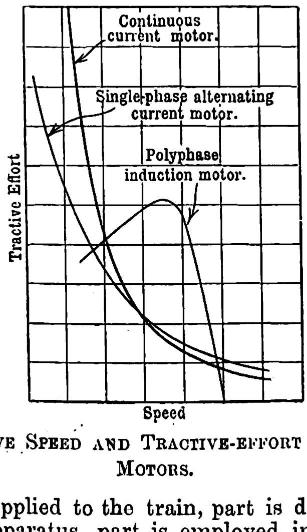

FIG. 2.—COMPARATIVE SPEED AND TRACTIVE-EFFORT CURVES OF RAILWAY MOTORS.

Of the energy supplied to the train, part is dissipated in motors and controlling apparatus, part is employed in overcoming train resistance, whilst the remainder imparts kinetic energy to the train and is dissipated during braking. The proportions of the several components are shown in Fig. 2 for typical suburban service employing continuous-current motors. The energy required to overcome train resistance amounts very nearly to two watt-hours per ton-mile for every pound per ton train resistance. The kinetic energy dissipated during braking varies as the effective weight of the train, and as the square of the speed when brakes are applied. The energy dissipated in motors and gears will be some 10 or 12 per cent, of the input, whilst from 6 to 12 per cent. will usually be dissipated in starting rheostats. In the single-phase system the losses in motors, gears and controlling apparatus will usually be at least as great per ton-mile as in the motors, gears and rheostats of the continuous-current system, chiefly on account of the much lower efficiency of the motors. It will be seen that, in suburban work, a considerable fraction of the energy is dissipated during braking. In order to reduce this, suburban trains should be built as light as practicable, and run at as low a maximum speed as is consistent with the required schedule speed. A high rate of acceleration and a high rate of braking retardation are therefore desirable, since with these given the maximum speed can be kept down without diminution of schedule speed. As a general rule the best gear to employ with the motors is the lowest speed gear that will perform the service with a suitable margin for eventualities, provided, of course, that there is sufficient weight on driving wheels to stand the high accelerating tractive effort of a low-speed gear. It will be seen from Fig. 4 that the energy consumption is considerably affected by the rate of acceleration, particularly when stops are frequent and speeds high.

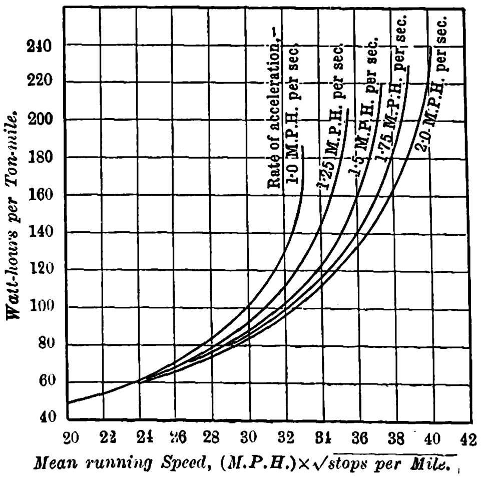

FIG. 3.—ENERGY CONSUMPTION OF TRAINS OPERATED BY CONTINUOUS CURRENT.

The continuous-current railway motor is characterised by the fact that within the limits of practicable and efficient operation it has a large range of torque and a moderate range of speed.

In the polyphase induction motor the efficient range of torque is moderate and the corresponding range of speed very small. Single-phase alternating-current railway motors are of two general types—the compensated series and the repulsion type. The former is characterised by having its range of practicable and efficient operation between synchronous speed and two or two and a-half times as much; whilst the latter operates below and up to synchronous speed, above which the commutation is bad. Both types show the

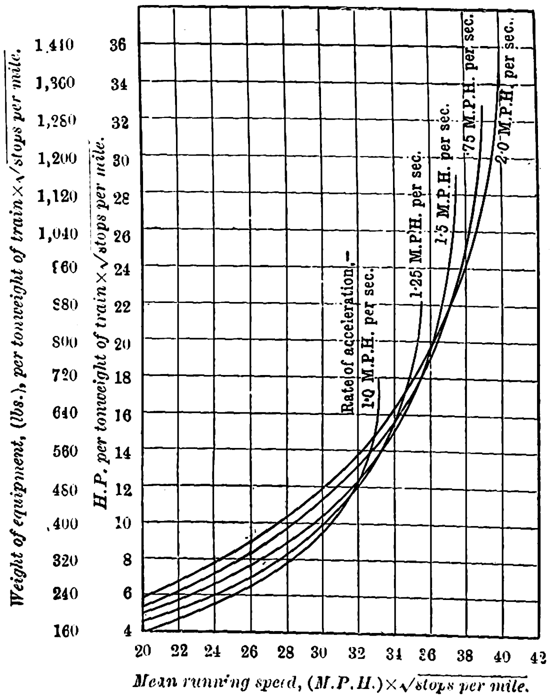

FIG. 4.—POWER AND WEIGHT OF ELECTRICAL EQUIPMENT OF TRAINS OPERATED BY CONTINUOUS CURRENT.

same general speed-torque characteristics—the range of torque being considerably smaller and the range of speed somewhat greater than in the continuous-current railway motor. Fig. 2 shows typical speed and tractive-effort curves for the continuous current, the single-phase alternating current, and the polyphase induction motor. The scale of co-ordinates is arbitrary, and in comparing the several motor types together, the abscissa or ordinate of any curve may be supposed increased or diminished in such proportion as may be desired to render the comparison suited to the class of service considered.

Knowing the train resistance, grade and tractive effort of the motors at any speed, we can deduce the tractive effort available for producing acceleration, whence—from the effective weight of the train—the rate of acceleration. The method of calculation need not be further entered into here, but it may be stated that for an isolated problem—such as the determination of train characteristics corresponding to the average schedule run for any service—by far the best procedure is by the point-to-point method. Where, however, it becomes necessary to make a calculation for an extended run involving stops at irregular intervals, and taking account of grades, curves and other circumstances affecting the running, the point-to-point method becomes exceedingly long and tedious. The author has devised an analytical method* of treating the problem, which is fully as accurate as the point-to-point method and much less laborious in its application to a general case, although involving some preliminary calculations which detract from its advantages if a simple problem only is in hand.

The typical schedule run may be divided into four elements, corresponding respectively to (1) acceleration to the speed curve, (2) speed curve running, (3) coasting, and (4) braking. Since any of these elements can be varied, it follows that a run can be made in many different ways. However, for any particular type of motor, if average values be assumed for the amount of coasting and rate of braking the remaining variables can, for practical purposes, be expressed in a system of curves, from which the particulars and performance of the train can be deduced. Such a system of curves for continuous-current motors as employed in suburban service is shown in Figs. 3 and 4, and these will be found useful and sufficient for preliminary calculations. In obtaining these curves the characteristics of a normal railway motor were taken, and from them was deduced a set of train characteristics corresponding to different rates of acceleration and different ranges of speed-curve running, care being taken that the motor was always employed as it actually would be in normal suburban service. The effective weight of the train was taken as 8 per cent. in excess of the actual weight. Coasting was assumed to occupy $17\frac{1}{2}$ per cent. of the total running time. The average rate of braking was taken at 1·75 miles per hour per second. For train resistance constant figures of 13 lb. per ton while power is on and 15 lb. per ton during coasting were assumed, it being impracticable to allow these figures to vary with the speed, since any point represents a variety of speeds, as explained below.

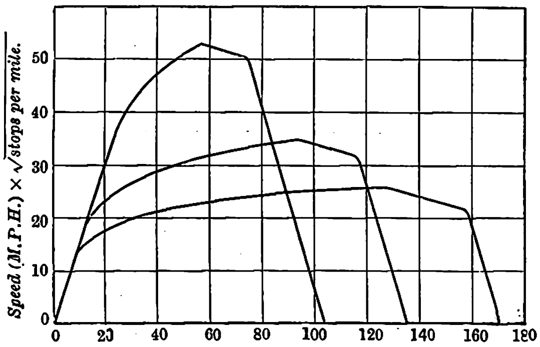

Fig. 5.—Typical Train Characteristics for Trains operated by Continuous Current.

Fig. 6 shows typical train characteristics of this system corresponding to acceleration at 1·5 miles per hour per second. The three curves are of the same area, and the distance represented will be found to be one mile divided by the number of stops per mile, as of course it should be. In order to understand the reason for choosing the co ordinates employed, suppose a particular run is made in $t$ seconds, the distance being $d$ and the number of stops per mile $n$, so that $nd = 1$ mile. Let the speed at any point be $s$.

Next consider a run in which both time and speed are changed in the same proportion, $x$, so that the curve retains its shape but merely varies its linear dimensions in this proportion. The area will vary as $x^2$. We may therefore write :—$t' = xt$, $s' = xs$, $d' = x^2 d$. But $n d = n' d'$.

$$\therefore\ n = x^2 n', \text{ or } x = \sqrt{\frac{n}{n'}} \qquad \therefore\ t' = \sqrt{\frac{n}{n'}}\,t$$

accordingly $t' \sqrt{n'} = t \sqrt{n}$ and $s' \sqrt{n'} = s \sqrt{n}$.

It follows, therefore, that if we take (time × $\sqrt{n}$) as abscissa, and (speed × $\sqrt{n}$) as ordinate in Fig. 5, all speed-time curves having a definite shape will be reduced to a single curve, and all such runs will be represented by a single point on the curves of Figs. 3, 4, and 6. This method of treatment was pointed out to the author by Mr. E. H. Anderson, of the General Electric Co., who has employed it in deducing general curves for his own use, somewhat on the lines of Figs. 3 and 4. Referring again to Fig. 5, and considering a speed-time curve of definite shape, the power required at any point will vary as the speed, and, therefore, inversely as $\sqrt{n}$. The energy consumption per run, varying as the power and as the time, will vary inversely as $n$. The energy consumption per mile, being $n$ times the energy consumption per run, will be independent of $n$, and depend only on the shape of the speed-time curve. Accordingly Fig. 3 gives energy consumption directly in watt-hours per ton-mile.

Fig. 6, showing how the energy input given by one of the curves of Fig. 3 is finally dissipated, practically explains itself. It will be seen that with little speed-curve running the loss in braking predominates, whilst with much speed-curve running the energy is principally employed in overcoming train resistance. In other words, where stops are frequent the total energy consumption depends largely on the weight of the train, and where infrequent on the train resistance. Series-parallel motor control is, of course, always assumed in these curves. The power output of the motors during a run is very variable. It starts at zero and rises with the speed during the period of acceleration on resistance. Then, with the speed still rising, but more slowly, it falls off continually due to decrease of tractive effort. The maximum power will be developed at the instant when all resistance is cut out, with motors in parallel —that is, when the motors are taking the accelerating current at full voltage. This is the power plotted in Fig. 5. With the horsepower reckoned in the above manner, the weight of the electrical equipment is taken as 40 lb. per horse-power, which must, of course, only be treated as a first approximation.

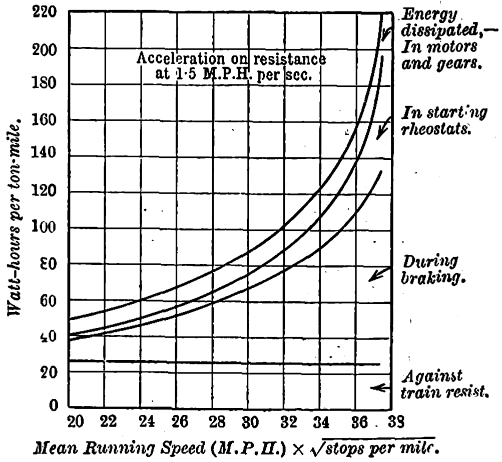

Fig. 6.—Dissipation of Energy in Trains operated by Continuous Current.

We are now in a position to estimate the weight of the train and the total power of the equipment, and to determine the power and number of the motors. A little trial and adjustment may be necessary, as the equipment will be heavier than the above figure (which is based on 150 H.P. to 175 H.P. motors), if many motors of small power are employed, whilst motor trucks are considerably heavier than trailing trucks. Moreover, the weight on driving wheels must be determined before the equipment can be finally settled on, in order to discover whether the adhesion is sufficient to stand the tractive effort of the motors. The accelerating tractive effort should not exceed about 17 per cent. of the weight on driving wheels in the case of trains driven by motor cars, operated by the multiple unit system of train control—wherein it is impracticable to sand the rails in front of all driving wheels in bad weather. Where locomotives are used, however, the average accelerating tractive effort may be allowed to amount to 24 or 25 per cent. of the weight on driving wheels, if efficient provision is made for sanding the rails in case of need.

(*To be concluded.*)

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* *Trans.* American Institution of Electrical Engineers, Vol. XXII., p. 133.

# A NEW METHOD OF AUTOMATIC BOOSTING.*

BY MAX J. E. TILNEY.

The first development in automatic boosters was probably the simple differentially-wound boosters, but these have, I think, in no case been an unqualified success, this want of success being due in early examples to the use of solid cast-steel pole-pieces, and in later examples, with laminated poles, partly to the difficulty of successfully compensating for rise in cell voltage, and partly to magnetic troubles which seem to baffle both manufacturers and users. The Highfield system, I suppose, came next and, except for two reasons, is very successful indeed. The first of these reasons militates against its commercial success, and is, of course, the high price and the fact that it is practically in the hands of one company. The second objection is that, as far as my experience and information go, unless the plant, battery and booster are exactly proportioned to each other and the load, things do not work quite smoothly, and the booster put in will either be to big for the load or grow too small for the load in time.

In 1903 and 1904 we had two new systems brought out by Turnbull & McLeod and Crompton & Co.† I believe both of these give good results, but again the price is high, and means new plant to transform the old station into an auto-boosting station. Then we have the Thury system of auto-regulation, in use, I believe, in Leicester with good results. I have not seen it at work and I do not understand quite how the movement can be quick enough to follow the variations of load, unless the little crankshaft is running at about 1,600 revs. per min., and if it runs at that speed I should expect the wear and tear to be excessive, and this system also means buying a new booster differentially wound. In all these systems the idea is to keep the voltage constant, and as far as I know, except in the case of the T. & M. arrangement, it is not possible to "compound up" to compensate for drop in feeders and line, and this drop may amount to a considerable figure during heavy loads.

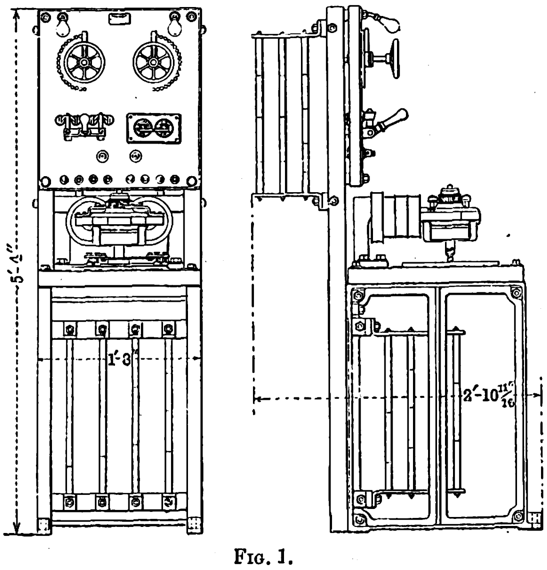

FIG. 1.

The system I am venturing to bring to your notice to-night is one of automatic regulation on the shunt field, and this regulation is automatic, both when the booster is charging and discharging, the apparatus being so arranged as to provide for reversal of the shunt excitation. It is not of much importance whether the pole-pieces are laminated or solid, though a booster with laminated poles naturally gives rather better results due to the flux following variations of shunt current more rapidly.

I propose to deal to-night only with the apparatus as applied to boosters and batteries, but there is no reason why the simple non-reversing regulator should not be used for controlling generators working without a battery on a varying load.

The standard apparatus is shown in Fig. 1, and Fig. 2 is a complete diagram of the arrangement showing booster and battery.

The standard arrangement for tramway systems consists of a multiple way regulating and reversing switch, as shown in Fig. 3, mounted on a kind of table having all the resistances fixed underneath it. The switch-contact blocks are directly connected to the spindle of a small motor armature, which is caused to turn one way or the other from its neutral position by the interaction of the four field coils 1, 2, 3A and 3B. There are two pairs of contact blocks, one pair making contact on rings 1 and 2 and the other pair on rings 3 and 4 in Fig. 3. Fig. 4 shows details of switch gear on a larger scale.

The reversal of the booster excitation and the discharge before reversal is effected by the two contacts marked SS (Fig. 3), the switches, as they pass on to and over these contacts, short-circuiting the booster field windings. This will be easily followed out on the diagram. In practice, no sign of any inductive spark is visible, even with very rapid reversal. As the full boost is never required on discharge, there is a permanent resistance, as shown in the diagram, in series with the regulating resistance on the discharge side. The armature has a small current always passing through it.

Above and behind the table are mounted the terminals for the four field coils and the armature, two small S.P. switches and two small regulating switches with their resistances behind them, also in the standard arrangement two lampholders wired in series with the little motor armature so that this circuit can be put across the 'bus-bar voltage while using a low-resistance armature, this is simply to save the expense of winding such a small armature for the high voltage. One of the two S.P. switches is for this armature circuit, and the other for the circuit of the No. 2 coil, which also has one of the regulators in series with it. The other regulator is a diverter for No. 3A coil.

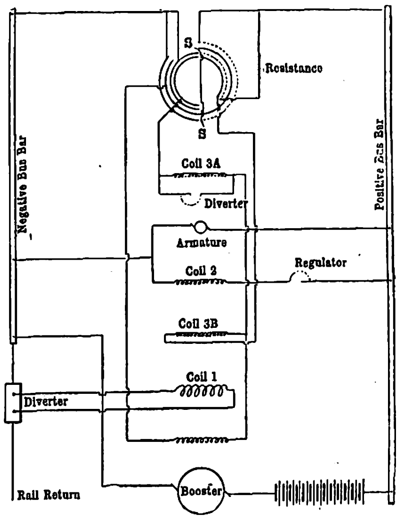

FIG. 2.

The only other piece of apparatus is a main diverter capable of carrying the full output of the station, and this is in a form similar to the shunt of a moving-coil ammeter of large capacity, but of slightly higher resistance. It will be seen that the armature *never makes a complete revolution*, and is therefore quite unlike the motor armature on a Thury regulator, which is always revolving.

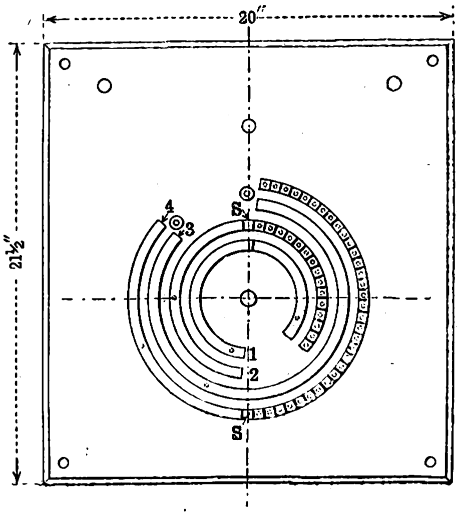

FIG. 3.

The field coils are in four different circuits: No. 1 carries a definite proportion of the outside load diverted through it by the main diverter. No. 2 is set to give a certain number of ampere-turns depending on the output of the machines running in the station, and this value of No. 2 coil only has to be altered when a machine is shut down or put on the 'bus bars. Coil 3A is in the circuit of the booster field when the latter is charging the battery and coil 3B when it is discharging, the change from one to the other being effected by dividing the inside ring of the switch at the point where the booster field is short-circuited before reversal. Coil 3A has connected in parallel with it the small diverter mentioned above and shown in the diagram. This is to compensate for the rise in volts of battery.

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* Abstract of a Paper read before the Birmingham Local Section of the Institution of Electrical Engineers on January 17th.

† See *The Electrician*, Vol. LIII., p. 303, and Vol. LIV., p. 322.

In practice, I find that except when the cells have been considerably run down, or when it is desired to give them a gassing charge, this diverter has not to be touched. I would point out that this diverter will, for practically any booster, never have to be of larger current capacity than, say, 5 amperes, and this takes the place of the costly and, as I find, sometimes dangerous diverters necessary in the case of many automatic boosters, where the main current of the station has to be carried by a variable resistance, whose value may have to be altered with considerable amounts of current passing.

I find, in practice, that it is well to give a regulation of 4 volts per step on the charge side, and 3 volts on the discharge side; and it is very advisable to work out the resistances on each side carefully. The motor armature is designed to carry about 0·5 ampere, and its best figure is somewhere in the neighbourhood of 0·3 ampere.

No. 1 coil on the field is arranged to carry 50 amperes as a maximum at the maximum output of the station, and it has 40 turns, so its maximum value is 2,000 ampere-turns. Coil 2 has 1,000 turns and a current capacity of 2 amperes. The current in this coil is varied by means of the regulator mentioned previously, and its ampere-turns value can be varied from 100 up to 2,000 in the 20 steps provided. These two coils will be the same whether the station in question has a top load of 100 amperes or 5,000; in the former case half the load would be diverted through No. 1 coil, and if the generator output was 50 amperes, the value of coil No. 2 corresponding to it would be 1,000 ampere-turns; and in the second case only one one-hundredth of the output goes through No. 1 coil, and the value of coil No. 2 corresponding to a generator output of, say, 4,000 amperes would be 1,600 ampere-turns.

Coil 3A has 1,000 turns and a current capacity of 2·5 amperes, though this may be altered later if it is found that it is necessary; but I believe diversion would be necessary to correct for rise in cell volts before that value is reached, except in the case, perhaps, of a very large booster. Coil 3B has 2,000 turns and a current capacity of 2 amperes, as I believe it will be found that, except in the case of a very large booster, all the volts required for boosting out will be obtained with lower values of shunt current than this, as the boost-out will not exceed 70 volts within the limits allowed by battery makers, assuming the usual 240 cells on a 500-volt traction system.

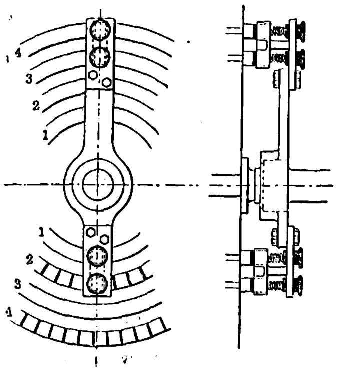

FIG. 4.

The operation of the apparatus is really very simple, and depends on the fact that any movement of the switch not only alters the booster field, but also alters the value of coils 3A or 3B, always tending to produce a resultant zero flux in the small motor field system. Coils 1 and 2 are always producing magnetising effects in opposition to one another. Coil 3A acts in the same sense as coil 1, and therefore the switch tends "on charge" to set itself in such a position that the flux due to coils 1 and 3A is equal to the flux due to coil 2. On discharge, coil 3B comes into action (coil 3A is out of circuit), and coil 3B acts in the same sense as coil 2, and the switch tends to set itself so that the flux due to coils 2 and 3B is equal to that due to coil 1.

Take an example: Assume a maximum possible output of a station 2,000 amperes, and that there are two machines, one 800 and one 400 amperes, the battery being capable of dealing with a discharge of 800 amperes at the one-hour rate and a maximum of 400 amperes on charge. Let us assume that the 800-ampere machine is running with the battery. The diverter will be sending one-fortieth of the main load through No. 1 coil. No. 2 coil would be set at 800 ampere-turns, representing the generator output. If the load on the feeders is 800 amperes it will be clear that coils 1 and 2 will be exactly balanced, and the switch will be in the neutral position, the booster field will be unexcited, and the battery will be floating at about 2·1 volts per cell.

If the cells should be rather low, say, at the beginning of a day's work, it *may* be necessary to set coil 2 a bit below the generator capacity, but this will only have to be done for a very short time, and I have found the apparatus work well with balanced load when the cells were reading anywhere between 1·95 and 2·2. If the cells are high the diverter on coil 3A will have been in use, and the booster will be slightly opposing the cells, as the balance will extend over several steps of the resistance, on the charge side, away from the neutral point. I should say here that the switch operates with a difference of about 50–0–50 ampere-turns, that is, that the limits of variation in the load on such a system as our example, without the switch moving, would be 100 amperes, being 50 ampere-turns on either side of the absolute zero field on the small motor, and a battery of the size taken would deal with such a variation with a drop in volts certainly not exceeding 2 per cent., and probably not exceeding 1 per cent.

Now, returning to our example: Let us assume that an additional load comes on, say, 300 amperes. Coil 1 rises in value to 1,100 ampere turns, being 300 ampere-turns, in excess of coil 2, and the motor now has a strong field, turning the armature and switch round towards the discharge side. Coil 3B comes into operation and adds the necessary 300 ampere turns in the same sense as coil 2. With our standard winding of 2,000 turns this means 0·15 ampere, and with the booster the author has in his mind this will mean about 30 volts boost.

Of course, for boosters with very different magnetisation curves it may be necessary to alter the turns on both coils 3A and 3B, but from particulars I have obtained of a large number of boosters I do not think any alteration in the number of turns is likely to be required, but if it is it will be in the direction of using fewer turns, which will, therefore, not necessitate any alteration to the rest of the apparatus. In most tramway stations the peaks are of short duration, and I do not anticipate any trouble from the use of the diverter in No. 3A coil, because, assuming the battery to be charging and the cells to be at about 2·5 volts, if a discharge, even at a high rate, is taken for a short time, as soon as this goes off the cells will very quickly rise to their previous figure.

If, in our example, the load, after rising to 1,100 amperes, now goes back to 400 amperes, coil 1 will have a value 400 ampere-turns, and coil 2 and coil 3B will greatly overpower it, and the switch will move round towards the charge side until the value of coil 3A is 400 ampere-turns, so that coils 1+3A=coil 2. In our case, with coil 3A undiverted, this would be with a shunt current of 0·4 ampere, giving 55 volts boost; but, of course, if the cells are well up the diverter will have been in circuit, and the boost will amount to whatever value is necessary to charge at 400 amperes.

If it is desired to use the battery and booster without any generating plant running it will be quite clear that, if the S.P. switch controlling No. 2 coil is opened, coils 1 and 3B will try and balance each other, and the boost-out will depend directly on the outside load, any variation making a corresponding variation in the resistance in the booster shunt field, and also in the ampere-turns due to coil 3B. It will be easily seen that the size of the station makes no difference whatever, as the percentage of load variation at which the regulator begins to operate is the same in all cases. I find that with solid cast-steel poles on the booster the switch generally rather overshoots its mark, and then comes back. This is particularly the case with large variations in load, but is an advantage, as it helps to make the excitation follow the shunt current a trifle quicker than it will do with the switch going direct to its proper position.

To overcompound so as to compensate for drop in feeders it is only necessary for the value of coil 2 to be set a little below the capacity of the plant running, and to divert coil 3A by a slightly lower resistance. It will be easily seen that this will, when the booster is charging the battery, still allow it to charge up to its full capacity, or the full capacity of the plant, and when discharging will allow the regulating switch to go a little further round on the boosting-out side, which will raise the volts of the battery and booster in series somewhat higher than is necessary to take its fair proportion of load. This, of course, tends to rob the plant of just so much load as will allow the machine volts to rise to an equal amount, and I have been able to successfully raise the volts on a small system to 520 when the load comes on, and reduce them to 500 when it comes off, so that the cars have been able to keep better time at the busy part of the day than they had previously been able to do.

The next point to consider is the question of efficiency and general running losses.

These latter may be put down as consisting of: (1) Current in small motor armature. (2) Current in No. 2 coil. (3) Volt drop on main diverter and No. 1 coil. (4) Copper loss No. 3A and 3B coils. Of these, No. 4 may be ignored; the resistance of No. 3A is about 5 ohms, and of 3B about 12 ohms. In the latter case it is only 12 ohms moved from the permanent resistance into the coil, and in the former it is only probably half of the rise in the resistance due to the warming up of the machine shunt windings. Loss No. 3 is also quite small, as the resistance of the main diverter is, for a 2,000 ampere station, only about 0·00015 ohm, the series coil resistance being about 0·009 ohm, so that at top load the loss would only be 1,000 watts. Loss No. 2 would at full load in our case be 1·2 × 500 = 600 watts, and loss No. 1 would be 0·3 × 500 = 150 watts, making a total *at maximum load* of 1,750 watts.

The author believes that this system is likely to appeal to many. The total cost for a traction station will not exceed £80 for regulating a booster up to 40 kw. capacity in a station with an output of about 3,000 amperes, as a maximum, and the cost for larger boosters is simply dependent on the regulating resistances required and the capacity of the main diverter for the No. 1 coil.

In the case of a three-wire network with two boosters, two regulators will, of course, be necessary, unless, as is sometimes done, the battery middle wires are taken out and the booster fields are coupled in series, and the armatures also coupled in series, which practically makes the system a two-wire one as far as battery and boosters are concerned, leaving the balancers to deal with any out of balance that may come on.

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After reading his Paper, Mr. Tilney gave some additional information relating to a regulator which was in actual use at the tramway station of the Urban Electric Supply Co., of Glossop. A four-pole shunt-wound booster with laminated pole-pieces was used. The maximum load on the system was about 400 amperes, and the line pressure a full 500 volts. A 45 kw. set and a battery capable of discharging up to 350 amperes had been installed. But in order to keep up the volts to anything like 500 when peak loads came on, it had been found necessary to use an additional set of 90 kw. capacity. By using the regulator they were now able to do the heaviest load with the small set, and there was no necessity to run on for charging purposes except one night a week, when they gave the battery an hour's gassing charge. The practice of the station was to arrange for what he might term over-compounding, by lowering the volts to 500 in the station when there was no load on the line, and by raising them to 520 or higher at the highest peaks. He found that while keeping the load on the machine about constant, it was possible to regulate from 65 amperes charge up to about 180 discharge with an extreme variation of 16 volts. This, he thought, would be improved when the drivers knew the apparatus better.

## DISCUSSION.

Mr. J. S. **HIGHFIELD**, in a written communication, pointed out that his own boosters could be, and, in fact, were used with any make of battery on an entirely uniform price basis. It was not a fact that, as the traction concern grew, a larger battery was necessarily required. In these cases the conditions were different to a lighting load, where the battery should be properly increased as the load increased. In the cases of plants provided with an automatic booster or a similar method of regulation, the battery could be laid out so that it would be sufficient for years, since as the load grew, its load factor improved in nearly every case. In some cases it was not economical to instal a battery equipment to take entire charge of the variation, but was better to lay out the equipment so that part of the variation came on to the generators. In all these cases it was merely a matter of a small degree of regulation, and in his particular design of booster just so much of the load was taken up as was desired.

Mr. R. S. **McLEOD**, in a written communication, referred to Mr. Tilney's suggestion of altering old shunt-wound boosters and using them as automatic reversible ones. In a few cases, perhaps, this might be possible, but there was no heavier work for a booster than a traction load, which varied from 0 to 100 per cent. overload continually. This load had to be carried by the armature, sometimes with a fairly large booster field, and sometimes with no field at all. The commutator conditions were, of course, very difficult, and unless the machine had been specially designed for this class of work it was liable to give a great deal of trouble through sparking. Then, again, laminated fields were practically a necessity if one was going to follow up the peaks of a tramway load quickly enough. It seemed rather a pity to put in an arrangement which necessitated regulating switches being continually moved over their contacts when all necessary regulation could be obtained automatically by current and voltage variations in the system itself.

Mr. **VICTOR BORNAND** said that he was surprised at the title of Mr. Tilney's Paper, as the principle described had been in use for several years in various tramway generating stations in this country. He referred to the system proposed and used by Mr. R. Thury, which consisted of regulating the shunt of a booster by means of an automatically actuated rheostat. The 1/10 H.P. pilot motor of the Thury regulator ran at from 2,000 to 2,500 revs. per min. Such speeds were largely used in fan motors and gave no trouble. This speed resulted in a very quick motion of the gear actuating the field rheostat brush. It was such that with a shunt-wound booster and a sudden variation of load of 50 per cent. or a voltage drop or rise of, say, 25 per cent., only a few seconds would be required to bring the voltage back to its normal value. Where sudden variations of load occurred (as in a tramway system) a compound winding was used ensuring a still quicker regulation. The principal duty of the automatic regulator in such a case was to correct the action of the compounding. In the case of a lighting load it was usual to use a shunt winding only. He pointed out that Mr. Tilney was mistaken in stating that the Thury regulator never automatically reversed the shunt field. This was actually one of its principal duties. He could not agree with the author's statement that the reluctance of the magnetic circuit of the booster generator was unimportant. In order to secure good results, attention should be directed to the shape and form of the armature tooth, and also to the way in which the wires were embedded on the slots. The author had drawn a comparison between the armature of his motor and that of the motor of the Thury regulator. In the latter system the motor was not a necessity, as was the case in the former; in fact, the regulating gear could be driven from any convenient source, from the shaft of the booster, for example. He did not see how the quickness of action which obtained in the Thury regulator (where the amount of iron was reduced to its lowest possible minimum) could be obtained in an electro-magnetic apparatus containing so much iron as that described in the Paper. The author stated that coil No. 2 had to be set at a certain value depending upon the number of machines running in the station, also the diverter of coil 3A had to be altered when the cells were considerably run down. In his opinion, an automatic reversible booster should need no hand regulation. He considered that the losses in Mr. Tilney's regulator were considerable. The small motor of the Thury regulator consumed only 90 watts at all loads.

Mr. **ARMISTEAD** (Wolverhampton) considered Mr. Tilney's system to have several advantages. It gave satisfactory results when used with a simple shunt-wound booster. It was not necessary, as in other systems, to use a machine with under-saturated fields. It enabled the battery to be charged any day, and was fool proof. When switched in or out the voltage across the apparatus was always that of the 'bus bars.

Mr. G. C. **ALLINGHAM** (London) said that Mr. Tilney's system was practically that of the ordinary differential booster worked through a relay, the differential coils being wound on the field magnets of a subsidiary motor. The system had the advantages that the initial cost and the losses in the various coils were reduced. He considered these advantages over the various differential boosters to be gained at the expense of the regulation. In any system the greatest difficulty was the lag of the booster, and he considered that the whole of the field system should be laminated. In an ordinary reversible booster the only lag was that of the machine itself. In the author's system there was, in addition, a lag due to the time required to change the magnetisation of the regulator motor, and to the time required to move the regulator handle.

Dr. D. K. **MORRIS** quoted some figures relating to the Thury reversible booster and regulator recently installed in the electrical laboratory of the University of Birmingham. The booster could deal with 300 amperes, and had cast-steel poles. An immediate change of voltage was, therefore, not possible, even if the regulator worked at any required speed. It was found that when the booster's excitation had to be increased, the automatic regulator, which worked at the rate of two notches per second, operated at one-third to half of the rate at which the booster could build up the voltage; but when the booster volts had to diminish, the regulator was well able to operate as fast as the booster voltage could follow. Under such conditions an automatic regulator more prompt in its action, such as that of Mr. Tilney, was not called for. No doubt, however, under average conditions, especially with a laminated field system, the quicker action of the new regulator would be of great advantage.

Mr. W. **FENNELL** (Wednesbury) considered that the average efficiency of a booster was probably only about 50 per cent. It was important that the whole magnetic circuit of a booster should be laminated, the yoke as well as the pole pieces. Many booster troubles were due to the motor, particularly to variations in the motor speed.

Mr. M. B. **BEYER** said that continental engineers did not favour the use of automatic and reversible boosters, and thought that the boosting devices were as troublesome as the batteries themselves. They added to the initial cost and to the cost for attendance, money which would be more profitably spent in increasing the capacity of the battery.

Mr. S. H. **HOLDEN** referred to Mr. Tilney's statement that the loss in his (Mr. Tilney's) regulator was 1,750 watts at full load and 450 watts at quarter load. But a large portion of the loss seemed to be made up of fixed quantities, and he thought that the loss at quarter load would be about half rather than quarter of the full load losses. The method of reducing the friction by making the pole pieces of the small regulator motor embrace only the upper portion of the armature, thus causing the latter to float, was very interesting. But he thought that the main frictional resistance would occur at the switch contacts, and would like to ask if any wear had been observed at these contacts.

Mr. **TILNEY**, in reply to the discussion, said that the wear on the carbon brushes was inappreciable, and the amount of sparking very small indeed. He was interested in Dr. Morris's remarks, but was afraid that there was a want of appreciation of the fact that in many small tramway stations, it was not possible to keep the cell voltage at a figure to obtain results suggested, not only by Dr. Morris, but by other speakers, as it was quite an ordinary occurrence in these small stations for the cell voltage to rise to 2·5, and it was just the rapid fluctuation of the cell voltage from 2·5 down to 2 volts which had caused most of the trouble in connection with automatic boosting arrangements. Of course, if a booster took such time to reverse its magnetism as mentioned by Dr. Morris, a rapid regulator was useless, but such a booster would be worse than useless on a tramway system with rapidly fluctuating loads. Since the Thury regulator worked on the voltmeter principle he failed to see how it could be done. He agreed that the windings of the small motor on the regulator were somewhat the same as those of the Turnbull and McLeod booster, but the addition of the balancing coil made all the difference. The regulator was, in a way, a differentially wound booster with the difference that it did not boost, but made something else do so. There was no necessity in this regulator, to adjust the series diverter when once it had been fitted up, and the small adjustment necessary to get the right proportion of the outside load diverted through the No. 1 coil was easily made on the job, a few saw cuts in the strip being sufficient to give final adjustment, in the same way as the adjustment of an ammeter shunt was effected. It would be of interest to Mr. McLeod to hear that with the regulator in question, which was in use at Glossop, he was able to keep the load on the generators constant within 10 amperes. All that was required was for the contacts to be wiped over with a rag and methylated spirits, say, twice a week. He was afraid that Mr. Highfield did not quite follow the meaning of the paragraph to which he took exception. He did not intend to convey in any way that a larger battery was necessary as the load grew. Assuming, in the first place, that a generator was in use of 400 amperes capacity, and that the battery would take a charge at 400 amperes, and discharge at, say, 800 amperes, as the system then grew, the maximum discharge would rise to, say, 2,000 amperes. In that case, it would be necessary to use another generator in parallel with the 400 ampere machine and the battery, say, an 800 ampere machine. This would give a total generator output of 1,200 amperes, and supposing the variations below that to be greater than the battery could take as charge (the minimum current being in the nature of 500 amperes), the Highfield booster would attempt to keep the volts level by overloading itself or trying to, and putting more current into the battery in charge than it ought to. If it could do this, there was absolutely no alternative but for the line volts to rise very considerably at these points of minimum current. That was the meaning he wished to convey in the paragraph that Mr. Highfield criticised.

The following additional remarks by the author were sent in later :—

Since reading my Paper I have, with the kind permission of Dr. Morris, been able to time the Thury regulator at the university, which, however, is for fine, not rapid, regulation, and have found that when the load was suddenly altered by hand it took the regulator 5 seconds to correct for a drop of 15 volts, corresponding, say, to 35 volts on a 550 circuit. This may be good enough for some people, but it does not meet with the requirements of central station work. As a matter of fact, in watching the line voltmeter and total current ammeter, as well as an ammeter in circuit with the No. 1 coil, I find that the ammeter in circuit with the No. 1 coil does not appreciably lag in action behind the ammeter of the main circuit, and that though in the event of a very heavy load being thrown on there is a momentary swing on the voltmeter, the needle returns to or approximates to its original position in a second, the little armature of the regulator motor almost moving with the swings of the main ammeter needle.

# CORRESPONDENCE.

## OIL-BREAK SWITCHES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your interesting leading article in this week's *Electrician* on Mr. Patchell's Paper you say on page No. 553, when referring to the oil-break switch, that "the oil-break switch always breaks at the zero point of the curve is proved to be a myth." I was unfortunately not able to be present at the reading of the Paper, but I fail to see how you are able to draw this conclusion from the curves published in your journal. As far as I can judge from the same they seem to me to clearly show that the *current* is broken at, or very near, the zero line. Of course, the voltage curve is not broken at the zero line. It is not possible for a switch to do this. The character of the voltage curve after the break has occurred depends on how the current curve has been interrupted. Providing the current curve is broken at or near the zero line, it is not possible for the voltage curve to assume any dangerous condition.—Yours, &c.,

Charles C. Garrard.

Hollinwood, Lancashire, Jan. 22.

## WATER PIPES AND ELECTROLYSIS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I looked in vain in last week's *Electrician* for any reply to my letter of January 12th on the above subject, so that I am forced to the conclusion that those who so hastily condemned electricity in this case are unable, on reflection, to support their position; and that, instead of electricity being the culprit, it is merely another case of softened water and new lead pipes. I was also hoping that you would have added a few words to counteract the effect produced on several of your non-electrical contemporaries by your publication of the Paper and your original comments thereon.

Referring to your note at the end of my letter, I must confess I fail to see how the fact that there was a resistance of 8 ohms between the earth bar in the engine room and the pipes in the ground could have contributed in any way to electrolysis inside the pipe. The effect of connecting the earth bar by earth plates so as to make a really good earth could only have induced a larger proportion of the current to find its way back along the lead pipe, and therefore to increase any electrolysis there might have been on the outside of the pipe. Having regard to the prominence which has been given to this case, perhaps you would kindly explain to your readers in what way such earthing could have possibly prevented *electrolysis* of the lead pipe in ground ?—Yours, &c.,

Westminster, Jan. 24. A. H. Dykes.

## HOW TO SCREW CONDUIT.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: We have observed the letter written by Mr. Schmahl, of the Armorduct Co., in a recent issue on the above matter. We consider that the manufacturers of steel conduit have adopted a standard size and thread which has met the approval and requirements of the electrical trade for a number of years past, and these sizes and threads are regarded as the standard. We also consider that the standard heavy gauge such as are supplied by this company, and which are identical with those of most of the other makers, are sufficiently heavy to meet all the requirements and contingencies of electrical wiring. Although we find a fairly large demand for screwed conduits of a lighter gauge than the heavy, we do not recommend their use.

We entirely disagree with the conclusion at which Mr. Schmahl has arrived as to the adoption of gas sizes, and we fail to see that any advantage whatever is to be gained by increasing the gauge of the tubes beyond the standard heavy. Why, therefore, should gas sizes be used ? Is it because a few who have lately joined the list of electrical contractors want to utilise their old tools, or is it that Mr. Schmahl is only dealing in gas size tubes.—Yours, &c.,

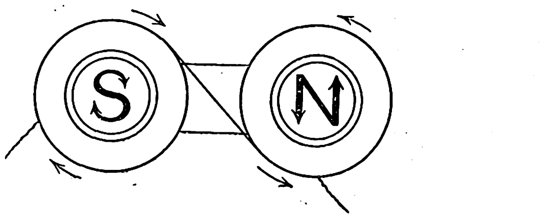
For the Metallic Seamless Tube Co. (Ltd.),

Birmingham, Jan. 23. F. W. Bayliss, Director.

## A NEW SUBSTITUTE FOR AMPÈRE'S RULE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Some ten years ago I had occasion to prepare a lecture diagram showing the end view of an electromagnet with horseshoe core. Having marked the poles S and N, I was proceeding to put in arrows to indicate the direction of the currents in the windings, when I perceived that by a curious coincidence these directions are correctly given by the letters themselves.



For if we imagine each letter pinned by its middle point, the free ends of the S point clockwise—the way a current must flow to produce a south pole—and the free ends of the letter N point counter-clockwise, thus indicating the currents about a north pole.

I have never published this aid to memory, though I have used it in my classes ever since, and my students say it is easier to remember than the corkscrew or the clock face or Ampère's rule. I now send it in the hope that it may interest readers of *The Electrician*.—Yours, &c.,

George J. Burch, F.R.S.

University College, Reading, Jan. 20.

## ARMATURE COILS AND NITRIC ACID.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Referring to Mr. Patchell's reply* to the letter I addressed to you on the above subject in your issue of the 22nd ult., may I be allowed to point out Mr. Patchell is certainly under one misapprehension in this matter—namely, that his criticisms have given rise to ill-feeling. This is certainly not the case as far as we are concerned. As a matter of fact, we regret very much that on account of the manner in which the matter was raised by Mr. Patchell, we had no alternative but to take notice of it, and to give the utmost publicity to the true facts of the case with the help of the technical press.

As for the reply itself, I will leave it to those who have followed this matter to form their own opinion as to whether the interpretation I and others gave to Mr. Patchell's remarks was correct or not, and as to whether there was justification for objecting to those remarks. The whole point of my letter is fully borne out by Mr. Patchell's reply—namely, that without knowing the facts and details of the case, Mr. Patchell advances certain opinions as to the causes of the trouble (which causes, as a matter of fact, have never been in doubt), and that these opinions, if allowed to go uncontradicted, do a grave injustice and injury to the builders of the machines, who, I may take this opportunity of stating, were pioneers in three-phase work, and were building 10,000 volt three-phase plant at least seven years before the Bow plant was thought of.

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* See *The Electrician*, Jan. 19, 1906, p. 542.

In reflecting on this matter, I recall the remarks of a well-known American engineer, made during the discussion on an (American) Institution Paper not long ago. In dealing with an allied subject (A.I.E.E. *Journal*, Vol. 22, p. 369) he stated: "The building and testing of high-tension apparatus, transformers or generators, is an extremely intricate and complicated problem, and no person who has not worked on a design and used such material can have any real appreciation of the difficulties involved." These remarks are certainly applicable to the present case, and I doubt if few outside manufacturing circles really realise what it means to build two-phase plant at what is practically 15,000 volts for climates such as that of London.

I read Mr. Duddell's remarks on the question at issue between Mr. Patchell and myself with great interest—they show a real knowledge of some important considerations which have to be taken into account in connection with the question of the slot insulation of such high-pressure machines. In this connection I would like to point out that the slot insulation in the Willesden alternators never gave the slightest trouble in itself; the whole trouble at Willesden was due to the destruction of the insulation of the individual turns by the formation of nitric acid. And this in spite of the fact that the conductors were heavily braided, and that the pressure between adjacent layers never exceeded 14 volts. Apart from Mr. Highfield, it would appear from the report of the discussion on Mr. Patchell's Paper, that not one of the speakers (the author of the Paper included) properly appreciated this point—namely, that the slot insulation never gave any trouble, and was not acted upon chemically as far as we know, and that the breakdowns which occurred were due solely to the short-circuiting of adjacent turns, with the consequent burning and damage to the slot insulation.—Yours, &c., A. C. EBORALL.

London, Jan. 22.

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Valves and Valve-Gear Mechanisms." By Prof. W. E. Dalby. (London: Edward Arnold.) 21s. net.

"Steam Turbines: Their Development, Styles of Build, Construction and Uses." By Wilhelm Gentsch. Translated from the German by Arthur R. Liddell. (London: Longmans, Green & Co.). 21s. net.

"The Energy Chart: Practical Applications to Reciprocating Steam Engines." By Captain H. Riall Sankey, R.E. (Rugby: Albert Frost & Sons.) 10s. 6d.

"The Management of Accumulators." By Sir David Salomons, Bart. Ninth edition, being a new and revised edition of Vol. I. of "Electric Light Installations and the Management of Accumulators." (London: Whittaker & Co.) 6s. net.

"The Ventilation, Heating and Lighting of Dwellings." By J. W. Thomas. (London: Longmans, Green & Co.) 6s.

"The Science Year Book: with Astronomical, Physical and Chemical Tables, Summaries of Progress in Science, Directory and Diary for 1906." Second year. Edited by Major B. F. S. Baden-Powell. (London: King, Sell & Olding.) 5s.

"The Mechanical Engineering of Collieries." By T. Campbell Futers. Vol. II. Chapter 5. "Winding." (London: The Colliery Guardian Co.) 5s. 8d. net.

"The School Magnetism and Electricity: A Treatise for Use in Secondary Schools and Technical Colleges, Based on Potential and Potential-Gradient." By R. H. Jude. (London: W. B. Clive.) 3s. 6d.

"Whittaker's Electrical Engineer's Pocket Book." Edited by Kenelm Edgcumbe. Second edition. (London: Whittaker & Co.) 3s. 6d. net.

"Proceedings of the American Institute of Electrical Engineers." December, 1905. Vol. XXIV. No. 12. (New York: The Institute.) 50c.

"Die Preisstellung beim Verkaufe Elektrischer Energie." By Gustav Siegel. (Berlin: Julius Springer.) 4m.

"Elektrotechnische Messkunde." By Arthur Linker. (Berlin: Julius Springer). 10m.

## LEGAL INTELLIGENCE.

### Swansea Corporation v. National Telephone Co.

This case came before the Appeal Court on Monday for further consideration of the questions referred to Major Cardew, the referee appointed by the Court. The terms were set out in our last issue.

Mr. DANCKWERTS, on behalf of the company, suggested the following additional question: "Whether, in order to afford all proper facilities for the transmission of telephonic messages between persons using the systems of the Telephone Co. and the Corporation in Swansea, junction wires in sufficient numbers should be laid between all or some and which of the company's and the Corporation's exchanges; and whether they should be one-way wires—that is, one set of wires to be used for calls from the company's subscribers to the Corporation's and another from the Corporation to the company; and whether such junctions should be enclosed in cables in sets or how otherwise."

Mr. BUCKMASTER, K.C., took exception to the form of another question, which seemed to leave it to the referee to decide whether, if the provision of additional wires from the Corporation's central exchange to the company's sub-exchanges was found necessary, it should be made at the expense of the company or of the Corporation.

Lord Justice VAUGHAN WILLIAMS said they had not meant to suggest any such question.

Their Lordships amended this question in the sense desired by Mr. Buckmaster, and admitted the additional question proposed by Mr. Danckwerts.

### Private Wire & Telephone Installation Co. v. Portman & Co.

At Westminster (London) County Court on Monday, judgment was given in the above action. The facts were reported in our issue of Nov. 10. His Honour said that in 1901 a company, called the Consolidated Telephone Construction & Mfg. Co., laid private telephony wires between defendants' offices and certain other premises for which defendants were to pay a rental, and in or about 1902 plaintiffs took over the Consolidated Company's business. He found the laying of the wires by the plaintiffs was in direct contravention of sec. 4 of the Telegraph Act, 1869, no licence having been obtained from the Postmaster-General by plaintiffs' predecessors, and, accordingly, he gave judgment for defendants, with costs.

**Richmond and Portrane Lunatic Asylum Management Committee v. John Edmundson.**—Plaintiffs have commenced proceedings in Dublin for the recovery from defendant of £500 damages for alleged negligence in carrying out electrical work, including telephones and tell-tale clocks, at Portrane Asylum. Last week plaintiffs obtained an order for discovery of certain reports on the subject.

## PARLIAMENTARY INTELLIGENCE.

### STANDING ORDERS COMPLIANCE.

Messrs. Jeune and Campion, the official examiners of standing orders compliance in connection with private bills in Parliament, have sat daily since Thursday, Jan. 18, to examine all the bills deposited for the 1906 session. So far there has been no hitch in connection with those bills of electrical interest which have been considered, and a very large number have been reported for first reading, without being referred to the Standing Orders Committee. All the bills relating to electric power supply in London have gone forward in this way, and there does not appear to be any probability of really serious opposition at this stage to any of the bills with which we are concerned. There have been several postponements, however, among them being the bill of the London United Tramways Co., which seeks a considerable mileage of new lines. The Hammersmith, City & North East London Railway bill, which was thrown out last session by the Standing Orders Committee, has gone forward this year unopposed.

### "ORIGINATION" OF BILLS.

As usual at this period of the year the authorities of the two Houses of Parliament have divided all the private bills into two sections, one of which is to "originate" in the House of Lords and the other in the House of Commons. As mentioned in our Notes columns the London electric power bills, with the exception of the West London Electric Undertakers' Bill, will be dealt with by the House of Commons in the first place; it will be remembered that they originated in the House of Lords last year. The provincial electric power bills do not seem to have been dealt with upon any particular system, for some of them will begin in each House. All the London County Council Bills will originate in the House of Commons and the West London Electric Undertakers' Bill in the House of Lords.

# MUNICIPAL, FOREIGN & GENERAL NOTES.

## APPOINTMENTS VACANT AND FILLED.

The Brush Electrical Engineering Co. invite applications from competent engineers to fill an appointment abroad. Applicants must have good all-round business-engineering experience and be capable of estimating for, negotiating and carrying through engineering schemes, &c. Applications to "A," Brush Co., Belvedere-road, London, S.E.

The Brush Co. also invite applications from engineers competent to act as district representatives. Applications to "J.," Brush Co., Belvedere-road, S.E.

Acton District Council require an improver at their electricity works. Applications to the resident electrical engineer (Mr. J. Martin Blair), Electricity Department, Gothic Villa, Millhill Grove, Acton, W., by noon 30th inst. See an advertisement.

Two junior demonstrators and lecturers are required (to begin work on May 1, 1906) at University College, Nottingham, one for physics and the other for engineering. Applications by Feb. 10 on forms to be obtained from the registrar. See an advertisement.

There is a vacancy for a pupil, without premium, in the central station of a company (suburban). Applications to "County," Moorgate-court, Moorgate-place, London, E.C. See an advertisement.

A professor of physics is required at the East London College in succession to Dr. Lehfeldt. Salary £400 per annum. Applications by Feb. 8.

Hackney (London) Council require an electrical draughtsman. Salary £130 per annum. Applications by 4 p.m. Jan. 29.

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Mr. H. Morris Airey, M.Sc., lecturer and demonstrator in physics at the University of Manchester, has been appointed lecturer in physics at Armstrong College, Newcastle-on-Tyne, in succession to Mr. R. J. Patterson.

Ealing Corporation have appointed Mr. Stowell collector of electric lighting accounts at £150 rising by annual increments of £10 to £200 per annum.

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## EDUCATIONAL NOTICES.

**Technical Education.**—Last week the City of London Court of Common Council appointed the Lord Mayor, six aldermen, the Recorder (Sir Forrest Fulton, K.C.), and 12 members of the Council to serve on the Board of Governors of the Livery Companies for the advancement of technical education, and agreed to the election of four of such members to serve on the Council, and two to serve on the Executive committee of the City and Guilds Institute.

**Technical Education in Ireland.**—An influential deputation waited upon the Chief Secretary for Ireland (Mr. Bryce) at Dublin Castle on Tuesday on the subject of technical education. In reply the Chief Secretary stated that the deputation had made out a good case for more funds if he had them at his disposal, but he had not control of the funds, and all that he could do was to try to get them from the sources which provided them. He was unable without consultation with others, and especially with the Treasury, to make any promise, but the matter would have his careful and sympathetic consideration.

**Working Men's College.**—The opening ceremony of the new college buildings at Crowndale-road, St. Pancras, was performed by Sir Wm. Anson, M.P., on Saturday.

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**Alleged Electric Fire.**—Another case has occurred in which a fire has been hurriedly attributed to electrical causes without ascertaining the facts.

Mr. P. Collinson, electrical engineer, has written to the Editor of the "Yorkshire Daily Observer" in reference to a statement in that paper that the recent fire at Messrs. Lund, Humphries & Co.'s premises was due to the fusing of an electric motor. Mr. Collinson says that electricity could not be responsible for the fire, as it had for some time past been a practice every evening to open the main switches controlling the supply at the point of entry into the building, and this course was followed on the evening of the fire, the switches being opened at about 6:20 p.m.; and, further, there were no traces of the short-circuit which would have been inevitable had the current been left on. Mr. Collinson thinks it desirable to check a growing tendency of the public to make the electricity supply the scapegoat in cases of fire in which the origin is doubtful.

**Argentina.**—The "Review of the River Plate" says the Government has approved the statutes of the Sociedad Belga Argentina de Tramways, which has been formed with 14,000,000 fr. capital, to carry out the concession for electric tramways recently granted by Buenos Ayres Corporation to M. Gaston Roux.

**Ashton-in-Makerfield.**—The Ashton Electric Lighting Order was obtained in 1901, and the Board of Trade are inquiring into the steps taken to put the order into force. The Council have decided to circularise to ascertain the probable demand for electricity.

**Australasia.**—We have received from one of our Australian correspondents the following account of an accident that happened upon the Sydney (N.S.W.) trams on Dec. 6.

Two motor cars in tandem got out of control soon after passing the crest of Brickfields-hill, and rushing down at a great speed crashed into another car standing at the foot of the hill. Most of the passengers escaped with nothing more serious than a few scratches, but several were taken to the hospital, only two being severely injured. The driver, Anderson, although sustaining a broken arm and other injuries, pluckily stuck to his post. The forepart of the runaway car was completely wrecked, while the rear of the other car, which was on the point of starting, was much damaged, traffic on the route being interrupted for an hour. A departmental inquiry is being held, and trials of the various types of car in use have been made. In every case it was found that the drivers had complete control over the car and could stop within a couple of lengths, even at highest speeds and at the steepest part of the selected route. Owing to the severe gradients (maximum 1 in 8½), all the cars are equipped with air brakes of powerful design, which are normally amply sufficient. On the occasion of the accident, however, the lines were slightly wet, the wheels locking and skidding, rendering the wheel brake ineffective. This slippery state of the rails is very unusual in Sydney.

The "Australian Mining Standard" states that Broken Hill Council have purchased Strachan & Mars' electricity works for £12,000.

The Palace lighting station in Pitt-street, Sydney, owned by the trustees of the late George Adams, has now 107 consumers connected with the equivalent of 16,000 8-c.p. lamps. The charge for current for power has recently been reduced to 2d. per unit.

**Barrow.**—The following amended scale of charges for the supply of electricity has been adopted:—

*Lighting:* 6d. per unit for 91 hours maximum demand per quarter and 3d. per unit for all excess. Or option of the following flat rate: Shops, offices, churches and other premises not otherwise specified, 4½d. per unit; hotels, clubs, public houses and dwelling houses, 4d. per unit. Consumers supplied by pre-payment meter, 4½d. per unit. *Motive Power and Heating:* 3d. per unit for 91 hours per quarter and 1d. per unit after. Or option of following flat rate: For first 1,000 units per quarter, 2d. per unit; next 1,000, 1¾d., and all over 2,000 1½d. Works and other premises requiring power and light chiefly during daytime, and guaranteeing not less than 2,000 units per quarter: From midnight to one hour after sunset, 1d. per unit; from sunset until 12 midnight, 6d. per unit.

**Birmingham.**—An inquiry was held on Tuesday into the application of the Corporation for permission to borrow £132,690 further for electricity supply.

The deputy town clerk (Mr. H. A. Pritchard) stated that, in sanctioning the loan applied for in 1904, the Local Government Board eliminated £34,998 for two sub-stations, because the Corporation had not acquired the land. They had since acquired the land for the two sub-stations, but additional expenditure was also rendered necessary by the great development of the tramway system. Two of the tramway leases, affecting 6 or 7 miles, would not fall in until 1911, and provision for power for those lines was not included in the present loan. When the Corporation took over the City tramways there were 33 miles of single track, but in the course of the next 18 months there would be about 64 miles operated by the Corporation. Land had been acquired for a sub-station at Bordesley and for another at Dudley-road, where it was also proposed to build a car depot; while at the Court-road station further plant and extensions (estimated to cost £6,830) were required. The total cost of the extensions of the three sub-stations was £19,500. They also required £19,130 forequipping a sub-station at Saltley. For Summer-lane power station the increased expenditure was £43,270, and they also wanted £16,000 for cables, feeders and distributors, £6,000 of this being for lighting.

The Inspector (Mr. H. Ross Hooper) expressed some doubt as to the right of the Corporation to use for electric lighting purposes capital authorised for tramways.

Mr. Pritchard said they had power under their Act of 1905 to appropriate the expenditure in respect of electric supply undertakings. He submitted that there were not included in this application moneys which were required for tramways. The tramway department would be supplied with electrical energy from the electricity supply department.

**Blackpool.**—An unopposed inquiry was held on Thursday last into the application of the Council to borrow £4,000 for cable extensions.

**Blackrock (co. Dublin).**—The Council are willing to transfer their electric lighting order, which cost about £150, for £300.

**Brighton.**—The Council have decided to pay the British Electric Equipment Co. £160 for extra work under their contract for the overhead equipment of the Old Steine and London-road tramway.

**Cheshunt.**—The North Metropolitan Electric Supply Co. have intimated to the Council that they are not prepared to carry out the lighting of the district under the existing provisional order, but have asked the Council's consent to an application for a new order with a reduced compulsory area. The General Purposes committee propose that the compulsory area should be from the boundary of the district at Enfield through the main road to Mill-lane, and that the maximum charge for current should be 10s. for 20 units or under.

6d. for every additional unit. The committee's recommendation has been adopted.

**Crompton.**—The period of the electric lighting order has been extended for a year.

**Erith.**—The charge for arc lighting has been reduced from £25 to £20 per lamp per annum.

**Exeter.**—The L. & S. W. Railway Co.'s bill, in which powers are sought (inter alia) to supply electricity to any of the company's lessees or tenants, and to run omnibuses, &c., has been considered by the Corporation, who think that these powers might be exercised to the prejudice of the Corporation's electricity supply and tramway undertakings. It has been decided to communicate with the company with a view to obtaining the elimination of these powers, and the co-operation of Devon County Council is to be sought in securing this amendment.

The Tramways Committee recommend that detailed estimates be prepared for laying certain tramway extensions, and that tenders be invited for the work. The rough total of the cost of the extension is put at £9300.

**False Pretences.**—Mr. H. D. Wilkinson writes us concerning a visit he has received from a man giving the name of John Forsyth, Park Hall Farm, Althorpe, Northampton, who called upon him last week, mentioning the names of some of Mr. Wilkinson's clients. He stated that he required his place lighted, at the same time going very circumstantially in details. On leaving, the said John Forsyth asked the best way and the fare to Westminster, and "found he had not enough cash with him." Mr. Wilkinson's note concludes: "In such a case one is placed in a position in which it is impossible not to meet the necessity by a few shillings." Mr. Wilkinson wasted a day going down to Northamptonshire and found that no such address or person of the name existed. We learned by telephone from Mr. Wilkinson yesterday afternoon that the man has since been apprehended on another charge and was sentenced yesterday to six months hard labour.

**Frimley.**—At the last meeting the Council were recommended to oppose the application of the Camberley Electric Supply Co. for a provisional order. The matter was referred back.

**Gosport-Fareham Tramway.**—This new electric line was formally opened on Wednesday. An extension is shortly to be made from Gosport to Lee-on-the-Solent.

**Great Grimsby.** – At last week's meeting of the Public Lighting committee a report submitted from Mr. Vignoles, the borough electrical engineer, stated that, in accordance with the committee's decision of November last, he had carefully considered the question of arc lighting.

Mr. Vignoles considers the streets are well lighted when the arc lamps are working properly. The complaints that the lamps did not always work satisfactorily were occasioned by mechanical defects, faulty trimming or want of attention. For the year ended March, 1905, there were 236,615 hours of burning, and lamps were reported out for 879 hours (=0·37 per cent.), and for the last nine months the percentage was 0·39. He thought these figures were satisfactory, seeing that the lamps were fitted with a mechanism which it was impossible to insure would always work perfectly any more than it was possible to prevent gas mantles deteriorating and breaking. Another cause was the carbons coming too close together or impurities in the carbons. Whatever type of lamp was used the trouble would occur to some extent. It was, of course, possible that if they adopted another type of lamp the number of failures might be reduced, and if flame arc lamps were adopted the amount of light obtained could be very largely increased.

Ultimately it was left to Mr. Vignoles to report further.

**Hackney (London).**—From April 1 next the charges for public lighting will be as follows: 10 ampere arc lamps £13. 10s. per lamp per annum, instead of £18 as at present; 7 ampere lamp £11, instead of £15. 16s. The revised figures do not include charges for interest and sinking fund on lamps and pillars, which are estimated at £2. 10s. per lamp for the 10 ampere and £2 for the 7 ampere lamps per annum.

**Hanley.**—Negotiations are proceeding between the Town Council and Fenton Urban Council in regard to the proposal to supply electricity to Fenton.

**Hardening and Tempering of Steel.**—Mr. R. G. Hodgson, A.M.I.M.E., of Birmingham, recently addressed the Coventry Engineering Society on "The Hardening and Tempering of Steel," and dealt with the obtaining, by means of an electric furnace and other appliances, an actual heating curve of steel so as to find the recalescence points. The lecturer said a curve for any different grade of steel can be obtained by means of an electric furnace, a resistance pyrometer, and a Calendar recorder. Mr. Hodgson gave an interesting description of the electrical furnace and of the appliances used for obtaining the heating curve.

**Hospital Lighting.**—Swindon Hospital Board have decided to adopt electric lighting.

**Italy.**—Authority has been granted to the Roman Tramways & Omnibus Co. to substitute electric for animal traction on a part of their system of tramways.

**Lecture.**—Mr. Charles Bright, F.R.S.E., gave a lecture last Friday at the Brighton Technical College on behalf of the Navy League on the subject of "Submarine Telegraphy."

**Light Railways.**—The Board of Trade have confirmed the Grimsby and District Light Railways Order, 1906, authorising a line from Great Grimsby to Immingham.

On Friday last the Light Railway Commissioners opened an inquiry into the application by Middlesex County Council for an order to authorise a line, 5¼ miles in length, from the termination of the light railways, already authorised, in Harrow-road to a point near the Wembley-Harrow boundary.

The Chairman of the Commissioners said they had previously intimated that an application regarding this line would not be considered unless it formed part of a larger scheme. Mr. Wakelam (engineer to the Council) argued that it did form part of a larger scheme. Mr. Lloyd, who appeared for some objectors, denied this. The promoters agreed to withdraw the application so far as it related to the portion of the line from Swan Inn, Sudbury, to Wembley-Harrow boundary, and Harrow School Governors and others thereupon withdrew their objection. The inquiry is adjourned until Feb. 9.

**London County Council.**—At Tuesday's meeting the Highways committee reported that the construction and equipment of the electric tramways between New Cross and Rushey Green would soon be completed.

The Highways committee also reported that the total traffic receipts from April 1, 1905, to Jan. 13, 1906, were £486,688 from lines worked by electric traction, and £120,072 from lines worked by horse traction, total £606,760. The receipts for the corresponding period in 1904-5 were £421,209, £103,589 and £524,798 respectively. The figures were not exactly comparable owing to the purchase of fresh undertakings from time to time, the extension of lines, and the conversion of routes from horse to electric traction.

It was recommended that expenditure of £12,200 be authorised in respect of the reconstruction (excluding rails) of the existing tramways in Goswell-road for the underground system of electric traction.—Postponed.

On the motion of Mr. Gilbert the following motion was carried: "That it be referred to the Highways committee to confer with the Local Government Committee and report: (1) With regard to the amount which is paid annually by way of rates in each borough in respect of the Council's tramways; (2) with regard to the annual expenditure incurred by the Council on the maintenance of the tramway tracks in each borough; (3) the estimated annual saving in each borough in road maintenance and cleansing since the construction of electric tramways; (4) as to the extent to which the tramway portion of the road is used respectively by the general and by tramway traffic; (5) whether in view of the great alteration which has recently taken place in the character of the general traffic in London, particularly owing to the introduction of motor omnibuses and heavy traction traffic, any changes are, in their opinion, desirable in the law upon the subject; and (6) generally, upon any other aspects of the matter to which they think that attention should be directed."

Mr. Cleland proposed the following motion: "That it be referred to the General Purposes committee to consider and report whether, having regard to the fact that the work included in the references to the Highways, Improvements, Rivers and Bridges committees is intimately connected with the provision of adequate facilities to cope with the traffic problem of London, the time has not arrived when, with a view to coordinate the various methods of dealing with this problem, it is desirable to establish a Traffic committee."—Agreed to.

**London Electric Power Schemes.**—The Remembrancer (Mr. Adrian Pollock) has reported to the City of London Court of Common Council on the various London electric power bills, including those of the City of London Co. and the London County Council, and at the Council meeting last week Mr. Pollock remarked that the electric lighting question in London was a far more important one than was formerly the case. There was, he added, a talk about a Royal Commission being appointed to consider the question.

Westminster City Council are recommended by the Law and Parliamentary committee to oppose the London County Council's electric power bill.

Bethnal Green Borough Council have decided to support the bill.

Stepney Borough Council have appointed a special committee to deal with the promoters of various London Electric Power Bills and to ascertain the terms they would be prepared to concede to the Council if their opposition were withdrawn.

**London United Tramways.**—Col. Yorke, the Board of Trade Inspector appointed to inquire into the complaints as to the noise made by the tramcars on this line, has issued his report.

Col. Yorke visited Ealing on Nov. 29 to ascertain what steps (if any) could be taken for mitigating the nuisance alleged to be caused by the undue noise of the company's tramcars, which was alleged to be due to three causes—viz., (1) some defect in the cars themselves, (2) the condition of the rails, or (3) the condition of the rail joints. On the evening before Col. Yorke's visit the inspector was informed by the town clerk of Ealing that the cars complained of had been removed, and that fresh cars had been put on which were very much less noisy than those which had been running, and gave little cause for complaint. As to No. 1, he visited the car depot at Acton and made himself acquainted with the defect in the cars which, so far as could be ascertained, was one of the causes of the noise complained of. These cars were equipped with the McGuire maximum traction bogie truck, and the defect was said to be in connection with the attachment of the brake gear to the frame of the truck.

This attachment was of such a description that, after being a short time in use, it became loose, and caused a great deal of rattling in the hangers of the brake blocks. It had already been decided by the company to alter that connection in such a way as to prevent its getting loose, and all the cars with that pattern of truck had, he was told, been withdrawn until the alterations could be carried out. One of the cars upon which the alterations had been carried out was running over the route on the day of Col. Yorke's visit, and gave no cause for complaint.

As regards (2) it had been ascertained that in certain places the rails had become corrugated on their upper surface. The corrugations were transverse to the rail, and though not at first serious they tend to increase in depth, and cause an unpleasant rattling while a car is passing over them. The reason of that peculiar condition of the rails was not thoroughly understood. He had seen rails in a similar state on the cable tramway at Handsworth, and he had recently read that the same condition occasionally arose in America. The company had recently equipped an apparatus for grinding the rails where those corrugations existed. That at best was only a partial remedy, as it did not remove the cause (whatever that may be) of that condition of the rails, and the corrugations might, therefore, be expected to reappear sooner or later. Moreover, the apparatus could not be used while the cars were running, so that the grinding operations could only be carried on during a short period of the night. The process, therefore, was slow.

As regards (3), many of the rail joints appeared to be in a faulty condition, the joints being loose and low, and the rails between them hogbacked. When a joint was in this condition each wheel passing over it made matters worse, and caused a violent blow, which was bad for the rails, bad for the cars, unpleasant for the passengers and productive of a great deal of noise. The company were taking steps to repair those joints, but having regard to the fact that the repairs had to be carried on while traffic was running, it did not seem possible to made a good job of such repairs. If the joints were hacked up with concrete the concrete had not time to set before it was disturbed by the weight of a car passing over it. If any other material was used, of a bituminous or plastic description, it did not possess sufficient hardness to hold up the joint for any length of time. The managing director (Sir Clifton Robinson) told Col. Yorke that he would make experiments with the Thermit Welding process, so as to ascertain whether that would be of any use in making good the defective joints. Other repairs were also being carried out with the intention of anchoring the rails down to the concrete, but in view of the continual passing of traffic, and the unfavourable atmospheric conditions under which the work had at present to be carried out, he (Col. Yorke) did not think those repairs would afford more than a temporary improvement. The rails, which were laid in 1901, originally weighed 92½ lb. per yard, and were 45 ft. in length. The cars passing over them were bogie cars, weighing, when empty, about 9½ tons, and when full from 13 to 14 tons. It might perhaps be taken that about 75 per cent. of the total weight of a car, or nearly 10 tons was carried on the driving wheels, which was equivalent to 5 tons per driving axle, or 2½ tons per driving wheel. The wear and tear due to such weights was considerable, and he thought the time would soon come when it would be necessary to relay the line with rails of heavier section.

In view of the fact that efforts are being made to abolish, or at least to mitigate, the excessive noise lately caused by the tramcars passing through Ealing, it did not seem necessary to Col. Yorke to make recommendations at present.

**Metropolitan Asylums.**—On Saturday the Metropolitan Asylums Board sanctioned the introduction of the electric light into the south-western ambulance station to facilitate the repairing and overhauling of motor vehicles after each day's run.

**Milan Exhibition.**—It is announced that among other competitions which will take place at Milan will be an international prize for ploughing machines worked by electricity with a single prize of £80.

**North London Tramways.**—London County Council propose to start work in May on the electrification of the tramways in Gray's Inn-road and Clerkenwell-road.

St. Pancras Borough Council propose to send a deputation urging that the tramway from Holborn to Hampstead should be amongst the first of the lines in the North of London to be electrically equipped.

**Portugal.**—The telephone service of the Anglo-Portuguese Telephone Co., which was established in Lisbon in January, 1882, and in Oporto in March, 1882, now employs 106 males and 51 females, the latter exclusively as operators. The common battery system is in full working in the Central Exchange in Lisbon, all other exchanges being worked magneto. There were at Nov. 30 2,025 subscribers in Lisbon and 1,079 at Oporto. Part of the company's lines are underground, the reconstruction for central battery working and placing of a large portion of the cables underground having been completed in 1904. The area of the company's operations is about 30 km. round Lisbon and 20 km. round Oporto.

**Presentations.**—Early on Sunday morning 21st inst., a number of the Preston tramway staff and employees assembled at the tramway depot in Holmrook-road to make a presentation to Mr. Walter H. Tittensor, who is leaving Preston to take up an appointment in Glasgow. Mr. Tittensor was the recipient of some photographic and scientific apparatus and also a music cabinet for Mr. Tittensor. Mr. Joseph F. Simpson, who is succeeding Mr. Tittensor in Preston, presided. Mr. Tittensor acknowledged the kindly gifts on behalf of Mrs. Tittensor and himself.

The staff of the Midland Railway electrical department, Derby, have made a presentation to Mr. A. D. Crowther, who is taking up an appointment at Umtali, South Africa.

**St. Pancras (London).**—The Council decided on Wednesday to petition against the following bills :—London County Council (Electric Supply), the Administrative County of London & District Electric Power Co., West London Electric Undertakers' Association, Additional Electrical Power Supply (London) and London & Outer Circle Railway.

A meeting of St. Pancras electors recently approved the promotion of a bill by St. Pancras Council to empower them to continue and maintain their electricity works, and by amending their electric lighting order, 1883, to exempt them from the provisions as to nuisance.

**Southwark (London).**—The district auditor's report on the Borough Council's accounts was issued on Tuesday, and referred to several objections raised before him with regard to the correctness of the accounts which show the profit and loss on the electricity undertaking.

In one case he held the objection to be well founded—viz., the absence of any charges on the electricity revenues in respect of the central establishment expenditure. The Borough treasurer had expressed the opinion that £100 per annum would be a fair amount to charge for the services, &c., rendered, and he (the auditor) agreed with that estimate. The Finance committee reported having passed the matter on to the Electric Light committee, with an intimation that the amount named should be placed in the accounts in the future.

**Straits Settlements.**—On behalf of Siemens Bros. & Co., Mr. W. H. Williams is erecting electrical plant on the Pekin Synd. mines and railways, Honan.

**Trade Unionists and Government Contracts.**—The First Lord of the Admiralty (Lord Tweedmouth) and the Postmaster-General (Mr. Sydney Buxton, M.P.) have intimated to the secretary of the Trades' Union Congress (Mr. W. C. Steadman, M.P.) their willingness to receive, soon after the opening of Parliament, a deputation of trades union leaders to consider the alleged placing of Government contracts with firms whose conditions of labour are contrary to the letter and spirit of the Fair Wages Resolution of the House of Commons of 1891.

**Tramcar Roof Covers.**—Halifax Tramways committee are experimenting with a roof cover and are considering the subject of adopting such covers on their cars.

**Walthamstow.**—The equivalent of 56,321 8-c.p. lamps is now connected to the mains, against 50,707 at the same time last year. The electrical engineer (Mr. J. H. Fooks-Bale) has been authorised to buy some electrical instruments, a pump and four motors, and application is to be made for sanction to a loan of £500 for heating the electricity station. The consulting engineers (Messrs. J. and J. S. Enright) are to report as to the alleged nuisance at the works. Mr. Fooks-Bale is also to submit estimates of cost of extending the mains to Higham's Park.

**Watford.**—At Dec. 31 there were 447 consumers connected to the electricity mains, against 377 in 1904. The chairman of the Electric Lighting committee (Mr. R. A. Thorpe) announced at the last meeting of the Council that for the December quarter there was an increase in the units sold of 19,597, while the receipts increased by £294. 2s. 5d., compared with the corresponding quarter of the previous year.

**West Ham.**—On Tuesday the Corporation resolved that :—

Provided the Board of Trade sanction the borrowing of £80,126 for tramway extensions, &c., the Council would not borrow any further sum for such purposes under sec. 73 of the West Ham 1890 Act, beyond the sum already raised—viz., £154,240. When next promoting a bill a provision would be included to repeal the unexercised borrowing powers for tramways conferred by the Council's 1900 Act.

**Willesden.**—Sanctions have been received to the borrowing of £13,678 for mains, £1,382 for services, £3,500 for plant and lamps £1,440 for meters and indicators.

**Dinners, &c.**—The second annual staff dinner of the Anchor Cable Co. (Leigh, Lancs.), took place on Jan 11, Mr. R. H. Harvey, manager, in the chair. A very pleasant evening, to which the members of the staff materially contributed, was spent.

Over 150 employés of the Underground Electric Railways Co. of London met at dinner at Ealing on Saturday, under the presidency of the superintendent of the Mill-hill Park car cheds (Mr. G. G. Porter), who said that in connection with such an undertaking as the Underground Electric Railways Co., which represented a capital expenditure of something like £16,000,000, it was hoped that when the new "Tubes" were opened the pressing problem of London traffic would be partially solved.

The first dinner of Ilford Council electricity department took place on Thursday last. The chief electrical engineer (Mr. Arthur H. Shaw) presided. About 50 members of the staff were present. A very enjoyable evening was spent.

The annual dinner of Maidstone Corporation employees took place on Saturday. Mr. E. E. Hoadley (the borough electrical engineer) replied to the toast of "The Corporation Employees," given by Viscount Castlereagh, M.P.

The staff dinner of the Yarmouth-Gorleston tramways took place on Tuesday, the manager (Mr. F. L. Turner) presiding.

The employees of Hull Corporation tramways department were entertained on Monday and Tuesday evenings to a concert and supper. Amongst those present on Tuesday were the Mayor (Ald. Larard) and Mrs. Larard, Mr. W. J. McCombe (tramways manager) and Mrs. McCombe, Mr. H. A. Bell (city electrical engineer) and Mr. J. Wilkinson (tramways electrical engineer).

Colchester tramway employees were entertained to supper on 17th inst. The general manager (Mr. R. C. Bullough) presided, and amongst others present were the Mayor and Mayoress (Ald. and Mrs. Goody).

**Electro-Harmonic Society.**—A smoking concert will be given this (Friday) evening in the King's Hall, Holborn Restaurant, London, W.C., with Mr. F. E. Gripper in the chair. An excellent and varied programme will be presented.

**Marriage.**—Mr. Orlo Venning Thomas, the electrical engineer responsible for the introduction of electric lighting and tramways in Penang, and a popular member of Penang social circles, was married on Dec. 27 at St. George's Church, Penang, to Tsuma, only daughter of the late Yezo Sakaguchi, of Kumamoto, Japan. The British and Japanese flags and colours formed a conspicuous feature of the event.

## TRADE NOTES AND NOTICES.

### TENDERS INVITED.

*Sunderland* Corporation invite tenders for supply of one boiler feed pump, one wooden cooling tower, one surface condenser with motor-driven pumps, coal bunkers, gantry and other steel work. Specifications from the borough electrical engineer, Mr. John F. C. Snell, M.Inst.C.E. Tenders (addressed to the Chairman of the Electricity and Lighting committee) to the town clerk (Mr. Fras. M. Bowey), Town Hall, Sunderland, by noon March 2. See also an advertisement.

*Sunderland* Corporation also invite tenders by noon March 2 for the extension of Hylton-road electricity station.

Messrs. Preece & Cardew, 8, Queen Anne's-gate, Westminster, S.W., have been instructed by *Shanghai* Municipal Council to invite tenders for the supply and delivery, c.i.f. Shanghai, of one 800 kw. horizontal steam turbo-alternator (single-phase) with condensing plant. Specifications, &c., after Jan. 30, from Messrs. Preece & Cardew, to whom tenders before noon Feb. 22. See also an advertisement.

*Hammersmith* (London) Council invite tenders for stores for 12 months ending March 31, 1907, including arc lamp carbons, &c., brooms, brushes, electrical goods, files, firebricks, &c., gauge glasses, meters, oilman's goods, packing and jointing materials, screws, tools, Welsh smokeless and other steam coal. Tenders to the town clerk (Mr. H. Thompson), by 4 p.m. Feb. 7.

*Barnes* District Council invite tenders for supply, delivery and erection of 300 kw. steam dynamo, together with switchboard panels and connections. Tenders to the Town Clerk, Council House, High-street, Mortlake, S.W., by Feb. 12.

*Blackburn* Electricity and Tramways committee invite tenders by 10 a.m. Feb. 12 for stores for 12 months to March 25, 1907, including incandescent lamps, meters, pipes, cable, fuse-boxes, switches, &c., motors, arc lamp carbons, &c.

*Cardiff* Corporation invite tenders for cooling towers, electrically-driven pumps, pipe work, &c., for Roath power station. Tenders by Feb. 16.

*Bristol* Docks committee want tenders by 10 a.m. 25th inst. for the electric lighting of two sheds and for the maintenance of the work for 12 months.

*Fulham* (London) Council invite tenders for supply and erection of (*a*) steam piping, (*b*) water and exhaust piping. Tenders to the town clerk (Mr. R. M. Prescot), Town Hall, Fulham, by noon Jan. 31.

*Poole* Corporation require tenders by 10 a.m. Feb. 7 for permanent way construction, overhead equipment, feeder cables, &c., of the Parkstone tramway extension.

The Clyde Navigation Trustees, *Glasgow*, want tenders by noon Feb. 12 for the electric cable and conductor installation for Clydebank Dock.

The "Australian Mining Standard" announces that the following contracts are to be placed by Australasian Government departments:—

Postmaster-General, *Melbourne*, for 330 tons copper wire, 32,000 porcelain insulators, 10 cwt. copper binding tape, 2,000 galvanised-iron shackles, with bolts and nuts and porcelain insulators, 8,000 copper tapes and 8,000 binders for 600 lb. per mile copper wire, 7,500 blackwood and 500 iron insulator pins, and 4,000 malleable iron side brackets for the Melbourne–Sydney telephone line. Tenders by Feb. 28.

Postmaster-General, *Melbourne*, for 10 tons copper wire, 1 ton binding wire, 9,000 porcelain insulators, 9,000 copper tapes, and 12,000 copper binders. Tenders by March 7.

Postmaster-General, *Sydney*, for 330 tons of copper wire and 32,000 insulators. Tenders by Feb. 28.

Railway Commissioners, *Sydney*, for one year's supply of incandescent lamps and lubricating oils. Tenders by Feb. 19.

Tenders will be received by the *Norwegian* State Telegraph Department up to noon of Feb. 10 for insulators, hooks, telephone wire, steel cables, &c.

The *Norwegian* Telegraph Administration require tenders by Feb. 3 for supply of paper for the department, including telegraph coils. Samples, &c., from the office of the Technical Section, 3, Hasselgaarden, Christiania; or at the offices of the Telegraph Inspectors at Trondhjem, Bergen, Stavanger and Arendel.

A large quantity of engineering stores and general supplies are required for the *Swedish* State Railway. Tenders are to be in for a portion of these stores by Feb. 10 and the remainder on Feb. 17. Particulars can be obtained from the Central Station, Stockholm. Some documents relating to these tenders can be seen at the office of the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C.

Tenders are invited for supply and erection of 18 electric cranes at *Hamburg*. Tenders will be opened on Feb. 16 by the Financial Administration, Hamburg, where conditions can be obtained, price 3m.

It is announced that tenders will shortly be invited by the *Belgian* State Railways for the installation of the electric light at Esschen station, and also for the apparatus and accessories for the electric lighting of certain trains belonging to the department. Particulars from the Bureaux des Adjudications, Rue des Augustines, Brussels.

### TENDERS RECEIVED AND ACCEPTED.

London County Council have received the following tenders for about 2,300 tons of slot tramway rails:—

| | | | |
|---|---|---|---|
| Steel, Peech & Tozer (*acc.*) | £16,055 | Walter Scott (Ltd.) | £17,550 |
| Bolckow, Vaughan & Co. | 21,000 | Frodingham Iron & Steel Co. | 16,630 |
| P. & W. MacLellan & Co. | 17,780 | E. Le Bas & Co. | 16,113 |

The engineer's estimate was £17,780.

On the recommendation that the tender of Steel, Peech & Tozer should be accepted, Mr. Gaskell remarked that when the Council some time ago bought Belgian rails the specification differed from the present. He understood that they now specified that the rails should be made of acid steel, and without that restriction they could get the goods at 15s. or 20s. a ton cheaper from the Continent. He was glad to see the restriction, as they all wanted to give work to our own people, but he protested against the foreign rails being excluded by a side issue.

Mr. J. Allen Baker, M.P., chairman of the Highways committee, said Mr. Gaskell was wrong in his conclusions. In that particular case it was a matter of indifference whether the rails were of one kind or another. They were quite prepared to accept the lowest tender, if the quality was equal, whether the rails were Belgian or English made.

St. Pancras (London) Council have received the following tenders for arc lamp columns:—

| | | | | | |
|---|---|---|---|---|---|
| Walter Macfarlane & Co. (*accepted*) | £1,128 | 12 | Rowland Carr & Co. | £1,181 | 16 |
| Falkirk Iron Co. | 1,539 | 0 | McDowall, Steven & Co. | 1,178 | 0 |
| Mackenzie & Moncur | 1,520 | 0 | Do. Do. | 1,159 | 0 |
| Pontifex & Co. | 1,364 | 0 | General Electric Co. | 1,121 | 0 |
| D. King & Sons | 1,265 | 8 | Improved Elec. Supply | 1,064 | 0 |
| Rumney & Rumney | 1,245 | 0 | W. Lucy & Co. | 1,045 | 0 |

The Lords Commissioners of the Admiralty have placed with the British Thomson-Houston Co. an order for a large capacity continuous-current type M.P. motor and electrically-operated switch gear to operate a set of hydraulic pumps of the horizontal type capable of supplying a total of 180 gallons of water per minute at a pressure of 650 lb. per square inch to a hydraulic accumulator. The motor will be compound-wound, and is to be started and stopped automatically by the rise and fall of the hydraulic accumulator.

The Admiralty have, for the 20th year in succession, awarded important contracts for the supply of asbestos goods for use in the Royal Navy to the United Asbestos Co. These contracts include "Salamander" rolled cloth and square block packings, corded asbestos fibre, asbestos mattresses and woven asbestos tape; "Victor" asbesto-metallic joints (seamless) and hydraulic joints, and lagging materials of various kinds for boilers and pipes.

Poplar (London) Council has received the following tenders for rewiring the Bromley depot and disinfecting station:—

| | | |
|---|---|---|
| Borough Electrical Engineer (*accepted*) | £100 | 0 |
| H. Pyle & Co. | 115 | 0 |
| W. Palmer | 133 | 4 |

The London Electric Firm, George-street, Croydon, have received an order from Messrs. Foote & Milne for about 200 complete sets of their "one working part" arc lamp lowering gear for Malta Dockyard. The consulting engineers are Messrs. Preece & Cardew.

Brighton Corporation have accepted the tender of the British Westinghouse Co. for wrought-iron protective screens for the switchgear at Southwick and North-road stations at £174 and £72. 10s. respectively.

The Metropolitan Asylums Board have accepted the estimate of Bromley, Batstone & Kirk to wire the gateporter's office at Belmont Asylum, and also to instal electric lights in the nurses' home of the South-Eastern Hospital.

The Commonwealth Postmaster-General has accepted the tender of J. Slater & Co., Melbourne, for 1,200 glass cells, 1,500 inverts and 1,200 inner cells at £88 15s., and that of Webster & Co., Brisbane, for 1,000 iron poles at 33s. each, 1,000 at 45s., and 150 at 47s.

Lewisham (London) Guardians have accepted the tender of the Telephone and Electrical Installation Co , at £125, to provide a new telephonic installation connecting 27 points, with all the necessary accessories.

Southwark (London) Council have accepted the tender of W. Winn, at £59. 17s. 6d., for wiring the stables. The tender of Hammond & Champness was accepted but afterwards withdrawn.

Glasgow Electricity committee reiterate their recommendation to accept the tender of Babcock & Wilcox for 10 boilers for the Port Dundas and St. Andrew's Cross generating stations.

Heckmondwike Council have accepted the tender of the Paterson Engineering Co. for water purification plant for the electricity works.

The Empire Roller Bearings Co. has secured an order for 320 axle boxes to be fitted to 80 heavy goods waggons for Calcutta.

High Wycombe Council have accepted the tender of the local electric lighting company for wiring the public mortuary.

## BUSINESS NOTICES.

Messrs. Marples, Leach & Co. inform us that they have purchased the business formally conducted under the name of the Adnil Electric Co., 6, Victoria-avenue, Bishopsgate-street Without, London, E.C. They have been appointed sole agents for the Bergmann Electrical Works, Berlin, for the whole of their manufactures, comprising all types of alternating and direct current motors, controllers, switches, conduits, holders, fittings and lamps. A complete set of price lists is now ready and can be obtained by the trade.

Mr. Maurice Graham, founder and managing director of Graham, Morton & Co., is commencing business for himself under the title of Graham, Morton & Co., at Pepper-road, Hunslet, Leeds. (The original company of Graham, Morton & Co. is in liquidation.)

Owing to confusion caused by similarity of title to the West Bromwich Corporation electricity department, Messrs. F. W. Richardson and J. D. Carlmark have decided to alter the name of their firm from the West Bromwich Electric Light & Power Co. to Richardson & Carlmark, but there will be no other alteration in the constitution or management of the firm.

Jane and Wm. Caldwell, electrical engineers, &c., trading as Caldwell & Son, 27, South Sherwood-street and Norfolk-place, Nottingham, have dissolved partnership.

We are informed that Mr. P. A. Paris no longer represents the Rhodes Electrical Mfg. Co. in the Manchester district, having severed his connection with the company. All communications for the time being are to be addressed to the head office of the company, Sunbridge-road, Bradford.

The Simplified Underground Conductor Co. (Ltd.) has removed to 180, Crown-street, Liverpool. Telegrams "Simplified Liverpool."

## BANKRUPTCIES, &c.

An application for the discharge of Geo. W. G. Booker, formerly electrical fittings manufacturer, 16, Regent-parade, and 94, Vyse-street, Birmingham, will be heard on Feb. 15 at the Court House, Birmingham.

The trustee in the bankruptcy of J. W. Hunter and Albert Clapham (trading as the Yorkshire Motor Car & Electrical Engineering Co.), 101, Kirkstall-row, Leeds, has been released.

August Richd. Krause, electrical inspector, formerly trading as an electrical engineer under the style of Ashcroft & Co., at Victoria-buildings, Manchester, has been adjudicated bankrupt. First meeting of creditors takes place at O.R.'s, Byrom-street, Manchester, on 31st. inst., and public examination at Court House on Feb. 5.

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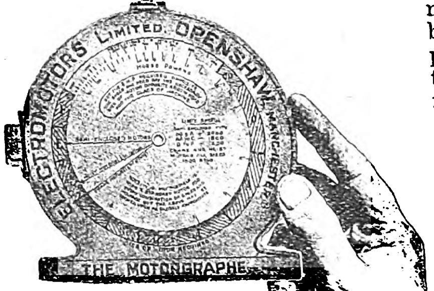
**Sales by Auction.**—Messrs. Wheatley Kirk, Price & Co. will sell by public auction at 11 a.m., Feb. 6, on the works premises, 48 and 49, Britannia-street, City-road, London, N., the whole of the incandescent lamp renovating plant and stock, including motors from $\frac{1}{20}$ H.P. to 10 H.P., switchboards, transformers, electrical instruments, gas engine, tools, and a quantity of new incandescent lamps, &c.). Further particulars from the receiver (Mr. S. Wiltshire), 19, St. Dunstan's-hill, London, E.C.; Messrs. J. J. Edwards & Co., solicitors, 28, Sackville-street, Piccadilly, W.; or of the auctioneers, 46, Watling-street, London, E.C., and Albert-square, Manchester. See also an advertisement.

Messrs. Wheatley Kirk, Price & Co. will also sell by public auction for St. Marylebone (London) Borough Council electricity department, at the Marylebone electric light station (North-street, Marylebone, W.), on Wednesday Jan. 31, at 11 a.m., about 4,500 second-hand meters of various types. Further particulars, catalogues, &c., from the auctioneers, 46, Watling-street, London, E.C., and Albert-square, Manchester. See also an advertisement.

**Factory Sites for Sale or to be Let.**—Messrs. Faraday & Rogers, 77, Chancery-lane, London, W.C., have for sale freehold land in Middlesex (or for letting on lease for 99 years at nominal ground rent) within 7 miles of Liverpool-street station. See an advertisement.

Mr. J. W. Watson, 21, New Station-street, Boar-lane, Leeds, advertises for sale some good factory sites in Leeds, Hull and Tadcaster.

**The "Motorgraphe."**—In our issue for Jan. 12 we gave a brief description of the motorgraphe, an ingenious device introduced by Electromotors (Ltd.), of Openshaw, Manchester, which enables the size of motor required for any given work to be rapidly determined. The accompanying illustration shows how the motorgraphe is operated, but we may repeat our previous reference to this novelty:—Both the fixed and moving portions carry scales of revs. per min. and B.H.P. which form a circular slide rule. To determine the size of motor required the B.H.P. is set opposite the speed and the letter denoting the size of motor is read off opposite one of the arrow heads on the moving disc, according as the machine is to be of the ordinary semi-enclosed type for continuous running or a hoist or crane motor. The limits of speed for each size are printed on the card.



Copyright.

ELECTROMOTORS (LTD.) "MOTORGRAPHE."

**Submarine Electric Lamps.**—The Bristol Electric Safety Lamp Works, 40, Great Smith-street, Westminster, London, S.W., who have been prominently associated with the portable electric lamp branch of the electrical industry for many years, have recently placed upon the market a new type of submarine electric lamp which can be used in diving operations, &c. In Fig. A one of these lamps is shown, and consists of a water-tight gun-metal or aluminium case containing a 10 volt accumulator which energises the small incandescent lamp fitted on one side. The lamp is provided with a reflector and a strong hollow lens protected by a guard as shown. The top of the battery case is firmly screwed down on to rubber packing, making the lamp entirely water-tight at any practicable depth. The accumulator is of sufficient capacity to maintain about 16 c.p. light from four to five hours. In Fig. B another type of submarine lamp is shown, which is provided with a water-proof flexible wire and can be run from a battery. A larger size of this type of lamp is made to order, of similar construction, but giving from 50 c.p to 100 c.p. light. A list can be obtained from the company in which a large variety of portable lamps, accumulators, &c., are illustrated and described.

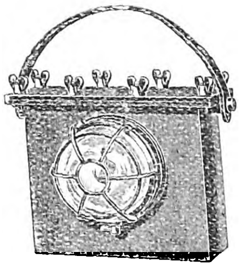


FIG. A.
BRISTOL SUBMARINE LAMP.
(In case.)

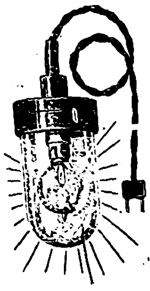


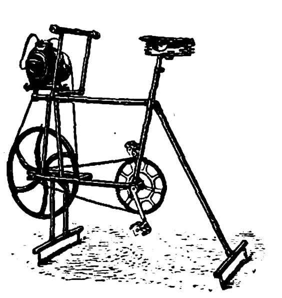
FIG. B.
BRISTOL SUBMARINE LAMP.

**B.T.-H. Automatic Circuit-Breakers**—A pamphlet describes a new line of circuit-breakers which the British Thomson-Houston Co. are introducing. In the new types the magnetic blow-out has been discarded, auxiliary copper and carbon contacts on spring arms being adopted in combination with the edgewise laminated copper main contact worked by a toggle movement in the usual way. In the larger circuit-breakers the overload tripping device is operated by a coil of one turn, the magnetic circuit being connected round one of the current-carrying studs, this doing away with an overload trip coil. The circuit-breakers listed range from 15 to 10,000 amperes continuous and 15 to 300 amperes alternating up to 650 volts. The largest sizes are supplied single pole only, but the smaller types are made for one, two or three poles. If required they can be fitted with "low-voltage" or "reverse-current" devices. The older types of tramway circuit-breakers are described at the end of the pamphlet.

**The Nodon Electric Valve.**—A pamphlet has been issued by Mr. Harry Snowdon, Balfour House, Finsbury Pavement, London, E.C., describing the Nodon patent electric valve for the rectification of alternating currents, and of which he his the sole manufacturer. This apparatus can be used for obtaining continuous currents from three-phase as well as from single-phase circuits. Some results of tests of the apparatus are given, which show an average overall efficiency of about 65 per cent. The current obtained is remarkably steady, and the opinion of one of the storage battery makers is quoted to show that the apparatus proved as suitable as an ordinary dynamo for battery charging.

**Catalogues, &c.**—From Electromotors (Ltd.), Openshaw, Manchester, we have received a copy of their latest catalogue of continuous-current motors and dynamos, comprising, in addition, a good range of standard accessories and specialities. The company have been careful in preparing the catalogue to eliminate, as far as possible, all useless matter. The book is indexed by means of a separate sheet, which is also made to serve the purpose of a trade discount slip. The catalogue is built up on the leaflet principle, and at present contains only a portion of the company's complete catalogue. By the simple process of releasing the clips which hold the sheets in the binder, additional lists can be added until the whole is complete. The company inform us that their well-known type of motor is meeting with great success. Accompanying the catalogue is a good list of electrically-driven propeller fans with a few simple instructions as to the proper method of treating this useful apparatus when once installed.

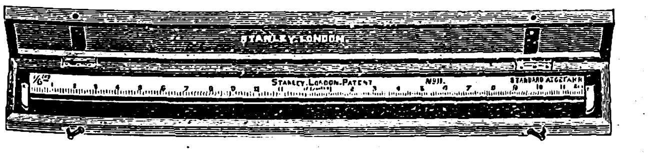
The Crypto Electrical Co., 3, Tyers-gateway, Bermondsey-street, London, S.E., have prepared a new catalogue of "Crypto" specialities, which range from carbon and carbon brushes to alternate and direct current motors, and include a large variety of items for which the general demand is increasing. There is a new Crypto dynamo bicycle driving gear, of which the accompanying illustration gives a view. The arrangement consists of a bicycle frame fitted with a free wheel with brackets near the handle-bar, on which a small dynamo is supported. The frame is so constructed that it will fold up, and only takes up a very small space. The list states that sets of this gear have been supplied with wireless telegraphy and X-ray apparatus, and in the late war in South Africa, during the siege of Ladysmith, one of these sets was found very useful for X-ray apparatus for surgical purposes. The Crypto Co. have established their reputation as manufacturers of small dynamos and motors and other electrical plant and novelties.



"Crypto" Bicycle Driving Gear.

Another excellent price list in the now popular binder is that sent out by Marples, Leach & Co. (the Adnil Electric Co.). The list comprises a very large number of machines, apparatus and appliances manufactured by the Bergmann Electrical Works, Berlin, for whom Marples, Leach & Co. are the sole agents in this country. The list is admirably arranged, and well illustrated and printed.

W. F. Stanley & Co., Great Turnstile, Holborn, London, have ready a pamphlet describing their new patent "Invar" and nickel steel standards. By the introduction of invar and special nickel steels it is claimed that the coefficient of expansion of the metals used in the manufacture of the standards is so small as to be a negligible quantity, excepting for standards for laboratory use. Messrs. Stanley have, therefore, patented and placed upon the market a number of standards of high accuracy, and we illustrate a 2 ft. triple standard with 1 ft. in inches and $\frac{1}{8}$ths and I ft. in inches and $\frac{1}{10}$ths. These standards have an inside standard gauge, an outside standard gauge and a standard scale gauge, all certified by the National Physical Laboratory.



Stanley 2 ft. Triple Standard.

Ernest F. Moy (Ltd.), Camden Town, London, have ready a new price list (No. 10) of distributing boards.

List No. 64 issued by Ferranti Limited, deals with triple-pole single-throw slow-break knife switches for from 25 to 1,000 amperes.

Mr. Jens Orten-Böving, 72, Victoria-street, Westminster, S.W., agent in London for Escher, Wyss & Co., has ready a large sheet illustrating the manufactures of his company. The range of engines, machines, &c., illustrated on the sheet is a varied one.

Sir W. G. Armstrong, Whitworth & Co., Manchester, have ready a new and enlarged illustrated edition of their price list of Whitworth standard thread-screwing apparatus, and call particular attention to their new interchangeable guide screw-stock and dies. Screwing apparatus, working and machine types, &c., are listed, and some excellent illustrations of complete thread-screwing sets are shown.

**Calendar.**—Although late in the field, Johnson & Phillips' excellent desk calendar for 1906 is none the less welcome. A divided panel is utilised to show the complete monthly calendar and an illustration of a cable contract job carried out by the company, so that in the set of 12 calendar cards there are also 12 of these views.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Jan. 17 to Jan. 23, with the ports of destination :—

*Aden.*—£73. *Africa.*—Alexandria, £430 (including £413 telegraph material); Beira, £62; Cape Town, £408 (including £180 telegraph material); Delagoa Bay, £827 (including £220 telegraph cable); Durban, £2,576 (including £1,702 telegraph material); East London, £196 (telegraph cable); Port Elizabeth, £2,421; Port Said, £10,572 (including £10,560 telegraph cable); Suez, £130 (including £96 telegraph material). *Argentina*—Buenos Ayres, £5,593 (including £1,595 telegraph material). *Australasia*—Adelaide, £1,136 (including £1,009 telegraph material); Auckland, £870; Christchurch, £21; Fremantle, £580; Launceston, £8; Lyttelton, £707 (including £500 telegraph cable); Melbourne, £2,528 (including £2,320 telegraph cable); Otago, £169; Perth, £261; Sydney, £675; Wellington, £476 (including £82 telegraph material). *Belgium*—Ostend, £60. *Brazil*—Rio Janeiro, £322. *Canada*—Montreal, £35. *Ceylon*—Colombo, £255 (including £45 telegraph material). *Chili*—Iquique, £55; Valparaiso, £238 (including £55 telegraph material). *China*—Shanghai, £293; Tientsin, £17. *France*—Paris, £155. *Germany*—Bremen, £88 (including £22 telegraph material). *Gibraltar*—£317. *Greece*—Syra, £76 (telegraph material). *Holland*—Amsterdam, £298 (including £133 telegraph cable); Flushing, £16; Rotterdam, £2,000 (telegraph material). *Hong Kong*, £195. *India*—Bombay, £629; Calcutta, £4,665. *Japan*-Kobe, £55; Yokohama, £2,585. *Malta*, £19. *Russia*—Odessa, £149; Reval, £40. *Siam*—Bangkok, £51. *Straits Settlements*—Penang, £21; Singapore, £265 (including £30 telegraph material). *U.S.A.*—New York, £223. *West Indies*—Trinidad, £13. Total, £43,792, against £46,314 in the corresponding week last year (Jan. 18 to 24).

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

Note.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specification. Those marked † are open for inspection* 12 *months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

January 8, 1906.

481 Bruce & Sanger-Shepherd. Devices for measurement of X rays.
514 & 515 B.T.-H. Co. & Holden. Electric measuring apparatus.
516 Benson & Co. & Leaver. Apparatus used in electro-plating.
535 Rotter. Electrical signalling on railways.

January 9, 1906.

550 Jones. Electricity meters.
551 Cowper-Coles. Electrical conductors.
557 Gibbings & Titherley. Ceiling-rose and switch.
569 Garstang. Electric fire-alarm system.
591 Howell. Bridge type fuses and distributing boards.
605 Poring. Dynamos and motors.
615 Borden. Telephone holders. (Date applied for, March 1, 1905.)*†
619 Platte. Suspension of current conductors of electrical railways. (Date applied for, Jan. 10, 1905.)*†
626 Faraday. Electric light fitting.
631 & 632 Duke & Hirst. Incandescent lamps vacuum tubes, &c.

January 10, 1906.

642 Cowper-Coles. Electro-deposition of iron.
646 Cowan. Brush holders and carriers.
689 Fairweather. Plural lamp sockets.*
690 Copsey. Switch for magneto ignition for petrol engines.
706 Hewitt. Controlling means for vapour electric apparatus. (Date applied for, Jan. 20, 1905.)*†
707 Thomas. Alternating-current vapour apparatus. (Date applied for, Jan. 27, 1905.)*†
712 Badmann & Modery. Arm supporters for telephones and the like.
725 B.T.-H. Co. & Sugden. Controlling devices for electric motors.

January 11, 1906.

735 Electric Ignition Co. & Hall. Sparking plugs for internal combustion engines.
756 Williams. Electrical indicators.
773 Wunderlich & Hughes. (London Electric Firm.) Control of air bellows for organs.
774 Ferranti, Field, Garrard & Ferranti Limited. Electrical measuring instruments.
789 Quincey & Harrison. Connecting flexible or solid tubes or conductors to electric fittings.
813 Willans & Robinson & Izod. Turbines.
817 Paterson & Bass. Cables.

## SPECIFICATIONS PUBLISHED.

PUBLISHED January 25, 1906.

1904 Specifications.

21,116 Hanson. Mechanism applicable to a pointer, contact-arm or the like for printing telegraph instruments, automatic telephone switches, &c. (Date applied for, Oct. 1, 1903.)

1905 Specifications.

184 Arnold & La Cour. Compensated single-phase alternating current commutator motor. (Date applied for, Jan. 4, 1904.)
210 Ridings. Arc lamps.
400 Harrison. (Albert & J. M. Anderson Mfg. Co.) Periodically actuating switches, or the like.
839 Boult. (Smith.) Storage battery negative pole plates.
1,968 Bucher. Electric carrying lamp.
2,341 Leitner & Hill. Brush-rocking gear for dynamos.
3,346 Lake. (Helbig.) Method of and apparatus for electrically oxidising atmospheric nitrogen.
3,360 Bentley. Sight magnetic compasses.
3,562 Eckstein & Angold. Arc lamps.
3,899 Köstermann. Motor meters for continuous and alternating electric currents.
4,375 Pohl, Pohl & Phœnix Dynamo Mfg. Co. Dynamo electric machines.
4,967 Scott. Braking arrangements of electric motors.
6,271 Bonnella & Bonnella. Switches.
7,504 Eisemann. Ignition devices for motors.
8,221 Gin. Electro-metallurgical manufacture of metals or alloys free from carbon.
8,991 Cie. Francaise de l'Amiante du Cap. Insulating wires and cables. (Date applied for, May 10, 1904.)
9,347 B.T.-H. Co. (G.E. Co., U.S.) Systems of control for magnetic clutch speed-changing gears.
10,949 Meirowsky. Insulation for commutators.
11,407 Teuber. Electric heating apparatus.
12,205 Veritys Limited & Pipkin. Joining up electric circuit conductors.
15,242 Scotchmer. Sparking plug for electric ignition.
16,079 Davis. Interrupters for making and breaking circuits.
17,881 Roeseke. Electric warning devices for doors and the like.
18,620 Veritys Limited & Gott. Slow-speed operating mechanism for electric motor-starters and like resistance switches.
19,372 Northcott, Townsend & Hoegerstaedt. Electromagnetic valves.
19,719 Ely & Grote. Reflectors for arc lamps.
21,173 Nicholson. Electric igniting for internal combustion engines.

PUBLISHED February 1, 1906.

1904 Specifications.

21,382 Thomson & Thomson-Davis Telephone System. Operating telephonic exchange systems.

1905 Specifications.

310 B.T.-H. Co. & Hopps. Electric power transmission for motor vehicles.
374 Brown, Boveri & Co. Electromotors for single-phase current. (Date applied for, Jan. 8, 1904.)
521 Meusnier & Mounier. Secondary batteries.
540 Maclean. Electrically-heated curling tongs.
1,863 Rosner. Enclosing cables, wires, &c.
2,820 Ward. Tramway or railway permanent way rails.
3,573 Sclater. Electrical starting of prime movers for electric generators and controlling the current.
5,073 Nalder Brothers & Thompson, & Harris. Automatically breaking a circuit in the event of a leakage to earth.
5,820 Electromotors Limited, & Hamilton. Brush-holders.
5,948 Strode & Halsten. Incandescent lamp holders.
6,922 Doyé. Telephone calls.
6,954 Chamberlain & Hookham, & Holden. Prepayment Electricity meters.
7,828 Williams. Electrical signalling device for vehicles.
8,563 Gamble. Arc lamps with multiple electrodes.
9,455 Donohue. Combined curb-stone and electric wire conduit.
9,490 Zelander. Life-guards for tram cars.
10,296 Henley's Telegraph Works Co., & Nicols. Fuse boxes.
10,793 Woodworth. Electric signalling for mines.
10,816 Veritys Limited & Worsley. Clutch mechanism for arc lamp.
11,061 Speirs & Frith. Brush holders.
11,142 Callender's Cable & Construction Co., & Barnard. Insulating tapes.
11,301a Cie Thermo-Electrique (Système Hermite) Soc. Anon. Mounting and heating cylindrical thermo-electric generators. (Date applied for, May 3, 1905.) (Originally in 11,301 of 1905.)
11,921 O'Brien. Apparatus for producing electric sound signals.
14,320 Siemens-Schuckert Werke G.m.b.H. Single-phase alternating-current motors. (Date applied for, Dec. 19, 1904.)
16,484 Siemens Bros. & Co. (Siemens & Halske A.-G.) Call signal apparatus for group-calling in telephone installations.
17,222 Olivetti & Gatta. Transformers for measuring apparatus. (Date applied for, Aug. 25, 1904.)
18,832 Boult (Macquire). Sparking plugs for internal combustion engines.
21,855 Arcioni. Electric power measuring and recording instruments for alternating currents. (Date applied for, Oct. 27, 1904.)

# COMPANIES' MEETINGS AND REPORTS.

## Eastern Telegraph Co. (Ltd.)

The sixty-seventh half-yearly ordinary general meeting of this Company was held on Wednesday at Electra House, Finsbury-pavement, London, under the presidency of Sir John Wolfe Barry, K.C.B.

The SECRETARY (Mr. A. R. Hardie) read the notice calling the meeting and the report of the auditors. The report of the Directors was taken as read.

The CHAIRMAN then said: I think I may congratulate the shareholders on meeting them in this hall instead of going to the other side of the square (hear, hear). We find it very convenient to set apart one of these rooms for this purpose, and I think our meeting here will be convenient not only to the Board of Directors, but also to the shareholders, as the more they are brought into touch with those who administer their affairs the better. Before entering upon the formal business of this meeting I desire to express our great regret at the death on Nov. 30 last of our valued colleague, Sir Henry Fischer. He had been associated with us for a comparatively short time, having been appointed to a seat at the Board in 1898; but his connection with telegraphy, as a public servant, extended over a great number of years previous to that date. He was a capable and conscientious director, and well acquainted with the business of submarine telegraphy. In order to fill the vacancy caused by the death of Sir Henry Fischer, the Board have nominated the Right Hon. W. J. Pirrie to a seat on the Board, and I have reason to believe that he will not only desire to occupy this position, but that he will also be able to give us very valuable assistance as a Director. The matter is not absolutely completed, because he has to go through certain formalities, but I wished to make the earliest announcement I could to the shareholders when they were assembled. The accounts which are now submitted to you show no variation of an abnormal nature, either as regards income or expenditure, when compared with those for the corresponding period of 1904, but as there is an increase of about £17,000 in the balance available, after providing for all expenses and fixed charges, I think the result of the working for the half-year under review will be considered satisfactory. Before, however, finally moving the adoption of the report and accounts, I will, in accordance with the usual custom, offer a few remarks on the various items of receipts and expenditure. The gross revenue amounted, in round figures, to £607,700, as compared with, for the half-year to September, 1904, £589,400, or an increase of £18,300. This increase mainly arises from traffic with Egypt, Turkey, Greece, Spain, Portugal and the Red Sea ports. With regard to the Egyptian traffic, however, it must be borne in mind that, in accordance with the arrangements referred to in our last report, a considerable reduction in the tariff became operative from August 1 last. There are, therefore, only two out of the six months' accounts which are affected by this reduced rate, and it will have a larger effect, perhaps, in the following year. Although there has been an increase in the number of words carried to and from Egypt since August 1, when the rate was reduced about 30 per cent., there has been, as we anticipated, a diminution of receipts from that date. We hope, however, that this loss will gradually disappear as the business of that resourceful country expands under its present beneficial management and control; but we by no means always find that a diminution of tariff produces a development of traffic which recoups us for the reduction, and of this I shall give a little later a notable instance among other cases of which we have had a rather sad experience. Several other branches of traffic show an improvement while others have produced less revenue, the most important falling off taking place in the receipts from traffic with India, Aden and South Africa. With regard to the decrease in the receipts from Indian traffic, this is partly caused by the reduction in the tariff from 2s. 6d. to 2s. per word, which came into force on Aug. 1 last, in accordance with our agreement with the Secretary of State for India, under which a standard revenue was guaranteed. It is noteworthy that, notwithstanding this reduced rate, the actual number of words transmitted also shows a decrease. As I explained at the last meeting, the Indian Government also contributes towards any loss in the event of the receipts not reaching the stipulated standard figure. Although, as I have previously stated, a reduction of rates frequently does not of itself bring a corresponding increase in the volume of traffic, our policy has been to reduce rates whenever circumstances justify this action. We fully recognise that, as servants of the public, it is our duty not only to provide a quick, trustworthy and efficient service, but also a service as cheap as possible, with due regard to the stability of the Company. Whilst fulfilling our duty to the public, I think the satisfactory accounts presented to-day bear witness that the interests of the proprietors have at the same time been safeguarded. All reductions in rates, therefore, more especially in the future, can only be effected after the most careful consideration of the interests of all concerned.

We fully anticipated that the reduction in the Indian rate would result in a loss of revenue for some time to come, but we hardly expected that there would be an actual falling off in the number of words transmitted, but such has been the case, and similar results were observable when other reductions have been made, very notably in Australia. These facts point to the conclusion that the principal factor in stimulating the growth of telegraphic traffic, apart from financial reasons affecting the trade of various countries, is efficiency, both in speed and accuracy, and to this end we are constantly striving. These are the benefits which are the most highly appreciated by merchants and others interested in the expansion of international commerce. Coding has now been carried to such a state of perfection that the cost per word to the merchant is only a fraction of our published rate, and the merchants, as a matter of fact, obtain their telegrams extremely cheaply. To put the general public on the same advantageous basis we instituted the "Via Eastern" Social Code, which is slowly making its way. We look forward to being recouped for the present loss of revenue resulting from the reduction of the Indian tariff, by the gradual development of trade and the increasing prosperity of the Indian Empire, but the recoupment will not, I think, be in leaps and bounds. The decrease in the traffic between Aden and Great Britain is caused partly by the reduction of tariffs, but principally through the cessation of military operations in Somaliland.

Turning now to the other side of the account, it will be seen that the total expenses for the half-year, exclusive of income tax payable in England, and interest on loan and debentures, amounted to £231,200, as against, for the corresponding period of 1904, £220,100, or an increase of £11,100. The expenses in London are £935 less, while the working expenses at stations are £3,300 more than in the corresponding half-year. The items of expenditure must necessarily vary each half-year, some showing increases and some decreases. The principal increases on this occasion are in salaries and wages, expenses of land lines, and our contribution to other companies for joint station expenses. The expenses attending maintenance of cables show an increase of £6,500. Two of our ships have received special overhaul this half-year, which, of course, very materially added to the expenses under this head, but as the charge for this special overhaul included the cost of, and expenses incidental to, new boilers, we have allocated £10,000 from the Maintenance Ships Fund, as a contribution to this exceptional expenditure. Income tax payable abroad has increased to the extent of about £900, which is principally due to this Company's liability under an act recently introduced into Cape Colony, and to which I referred at the last meeting of the shareholders. During the half-year we have been able to repay the balance of the loan we received from the Eastern & South African Telegraph Co., the charge for interest appearing in these accounts being £1,500, against, for the corresponding period, £9,200, or a reduction of £7,700. Income tax payable in England also shows a reduction to the extent of £3,200, while interest on 4 per cent. mortgage debenture stock has increased to the extent of about £1,100. These are the details of the principal increases and decreases in the expenditure, but if the whole of the expenses and other charges against revenue are summarised, it will be found that the net increase is only £1,400, whereas, as I have already stated, the gross revenue is about £18,300 more than in the corresponding period of 1904, and thus the increase of net revenue is about £17,000.

You may have noticed an item which appears this half-year for the first time in the revenue account. I allude to a charge of £1,205 for supplementary retiring allowances. When the Staff Pension Fund scheme was submitted to the shareholders some 14 years ago it was agreed that in the case of some of the older members of the staff the pension which would accrue to them on their retiring from the Company's service, and which would, of course, depend upon the annual amount set aside by the Company, and to a certain extent upon the amount contributed by the staff from their salaries, would be inadequate to provide a suitable allowance in all cases. It has, therefore, been found necessary from time to time to supplement, in special and deserving cases, the amount of retiring allowances due to these older members of the staff from the established funds, and I feel sure that the proprietors will approve of this being done. The amounts have been distributed over the various departments and sections to which the individuals were attached. As, however, these supplementary amounts have now reached a considerable sum, it has been thought expedient to show them as a separate item in the revenue account. This charge may for some time to come be increased as it unfortunately becomes necessary for some of our old employes to retire from the service of the Company, but as time goes on it is anticipated that the Pension Fund will in itself provide a sufficient allowance, so that the supplemental charge to which I have referred, though growing for a time, will afterwards be gradually reduced and eventually disappear. In continuance of the operations which have been fully explained at previous meetings, we have charged against the General Reserve Fund £140,000 in respect of the cables laid between 1899 and 1903, and the balance of this account, as will be seen by reference to the balance-sheet now stands at £115,000 which will be entirely written off during the current half-year.

There is only one little matter I now want to allude to—that is, to inform you that the Board have made a contribution of £105 to the Indian Earthquake Fund, in response to a very urgent appeal of the Viceroy, to alleviate the suffering caused by the sad catastrophe which overwhelmed Dharmsala in April last. The Associated Companies have also contributed the sum of £250 to the Queen's Fund for the Unemployed. We feel assured that these payments will meet with the approval of the stockholders. (Hear, hear). I now move—

"That the report and accounts of the Directors to Sept. 30, 1905, submitted to this meeting, be, and the same are hereby received and adopted." When that has been seconded we shall be able to deal to the best of our ability with any questions which any stockholder may desire to address to us.

The VICE-CHAIRMAN and MANAGING DIRECTOR (Sir John Denison-Pender, K.C.M.G.) briefly expressed his pleasure at seconding the motion.

No shareholder rising to address the meeting,

The CHAIRMAN put the resolution in the usual manner, and declared it carried unanimously.

On the motion of the VICE-CHAIRMAN and MANAGING DIRECTOR, seconded by the Marquess of TWEEDDALE, K.T., Sir John Wolfe Barry and Mr. Francis Alexander Johnston, the retiring Directors, were re-elected.

Messrs. Deloitte, Plender, Griffiths & Co., and Messrs. Welton, Jones & Co., were afterwards elected auditors for the ensuing year, on the motion of Mr. ADLARD, seconded by Mr. BAINES.

Mr. BAINES then proposed a vote of thanks to the Chairman and Directors for their highly successful administration of the company's affairs in the past half-year.

Mr. JOHN NEWTON, in seconding the motion, expressed great satisfaction that the meeting was being held at Electra House instead of at another place. The shareholders, he continued, could not be too thankful at the knowledge that the wise administration of the Company's affairs for so many years by the Directors was gradually putting their telegraph undertakings on as solid a basis as the railways. This point was not yet reached, but the time was fast approaching when it would do so.

The motion was carried unanimously.

The CHAIRMAN: On behalf of the Board and myself, and I think I may also say of the Staff, we thank you very sincerely for this vote of thanks. I very much agree with what Mr. Newton has said as to the stability of the telegraph companies owing to the wise policy—I will not say of the Board so much as of the shareholders, who supported the Board in putting away a sufficient sum to provide for eventualities when they occurred. The stability of telegraph companies is, I think, in a very satisfactory condition (cheers).

The proceedings then terminated.

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**ANGLO-AMERICAN TELEGRAPH CO. (LTD.)**—The total receipts from the 1st July to 31st Dec., 1905 (including £1,252. 18s. 4d. from last account) amounted to £204,953. 0s. 5d. The traffic receipts show an increase of £14,675 compared with the corresponding half-year in 1904. The working expenses of the half-year, including those of s.s. "Minia," pensions account, &c., amounted to £97,106. 4s. 5d., an increase of £2,799. 19s. 4d. The directors have set apart £5,000 to renewal fund, leaving £126,846. 16s. Quarterly interim dividends of 15s. per cent. on ordinary stock, and £1. 10s. per cent. on the preferred stock, were paid on Nov. 1 (absorbing £52,500), leaving £74,346. 16s., out of which the directors recommend final dividends of £1. 1s. per cent. on the ordinary stock, £1. 12s. per cent. on the preferred stock, and 10s. per cent. on the deferred stock (payable on 3rd February), amounting to £73,500, making a total distribution for 1905 of £3. 5s. per cent. on the ordinary stock, £6. per cent. on the preferred stock, and 10s. per cent. on the deferred stock. The balance (£846. 16s.) will be carried forward.

**CENTRAL LONDON RAILWAY CO.**—The directors have declared a dividend at the rate of 4 per cent. per annum for the half-year ended Dec. 31 on the ordinary and preference stocks, and at the rate of 4 per cent. per annum for the whole year on the deferred stock. £10,000 has been added to reserve and £25,394 carried forward.

**CITY OF LONDON ELECTRIC LIGHTING CO. (LTD)**—An extraordinary meeting was held on Wednesday, when a resolution approving the bill proposed to be introduced to Parliament for further powers was adopted.

**CITY & SOUTH LONDON RAILWAY CO.**—For the half-year ended Dec. 31 the accounts show a balance, after providing for debenture interest, dividend on preference stocks and transferring £1,500 to renewal fund, sufficient to allow of a dividend on the consolidated ordinary stock at rate of $1\frac{3}{4}$ per cent. per annum, carrying forward £1,366. This is the same rate of dividend as last year, and the sum carried forward £1,449.

**DIRECT UNITED STATES CABLE CO. (LTD.)**—The report of the directors for the six months to Dec. 31 states that the half-year's revenue, after deducting out-payments, amounted to £56,353. 2s. 1d., compared with £51,029. 12s. 10d. for the corresponding period of 1904, an improvement of £5,323. 9s. 3d. Working and other expenses, including income tax, amounted to £23,299. 5s. 8d., leaving £33,053. 16s. 5d. as net profit, or, with £2,525. 15s. 10d. brought forward, £35,579. 12s. 3d. For the corresponding period of 1904, working expenses and other payments amounted to £22,108. 6s. 1d. Interim dividends of 3s. per share for the quarter ended Sept. 30 and of 3s. 6d. per share for the quarter ended Dec. 31, payable Jan. 31, together absorbed £19,730. 15s., and after setting aside £10,000 to reserve, the balance of £5,848. 17s. 3d. has been carried forward. The reserve fund, after been credited with interest on investments and amount set aside from revenue, now amounts to £500,700. 16s. 11d., taking the investments at cost price.

**EAST LONDON RAILWAY CO.**—On Wednesday Lord Claud Hamilton told the shareholders that if their line was electrified up to New Cross it would no doubt add materially to their traffic receipts. He was not at all convinced that the third-rail system was the best or most economical and profitable manner of working a railway. His opinion had been rather confirmed by the unsatisfactory working of the Metropolitan and District Railways since they were electrified. Judging from the report of the Metropolitan Co., it appeared to him that there was no question that it was a very costly way of electrifying and working a railway. The only mode of electrifying their line would be either to do it themselves or by means of the District or Metropolitan Railway, or by the leasing companies as a whole. One of the leasing companies was so convinced that the third rail was not the best that it had just let a contract for the overhead system from London Bridge to Victoria Station, and it was calculated that the electrification could be carried out at two-thirds of the cost of the third-rail system. In face of that, and until the experiment had been tried, they might be certain the Brighton Co. would be no party to electrifying their line on the third-rail system, and, therefore, he was afraid that the electrification must be postponed until it was proved which of the two modes was the more efficacious and economical.

**LONDON, BRIGHTON & SOUTH COAST RAILWAY CO.**—In the report for the December half-year it is stated that several difficult and unexpected problems had to be solved before the work of equipping the South London line for electric traction could be commenced, but the directors hoped these difficulties will shortly be overcome and the work put in hand. They propose to equip the whole of the South London line from London Bridge to Victoria. The directors have established motor car services on the coast lines with very satisfactory results, and these services would be extended as occasion might arise. Powers are being sought by the company to work and use road motor vehicles wherever it may be thought desirable, but no further capital powers are needed.

**METROPOLITAN RAILWAY CO.**—During the half-year ended Dec. 31 the services of electric trains were considerably extended, and the Inner Circle service is now being worked entirely by the new power, in addition to the local service between Baker-street and Harrow and between Harrow and Uxbridge. Several of the electric locomotives ordered have been delivered and tested and are working traffic on the Harrow line. The work undertaken by the G.W. Railway Co. of electrifying the Hammersmith and City line is proceeding, and the new rolling stock for that service is being built. Until that has been delivered and the equipment of the line completed it will be impossible to dispense altogether with steam locomotives or to obtain the full advantage of the accelerated service which the electric trains are able to provide.

At the meeting yesterday, the Chairman (Sir Chas. McLaren) stated that additional capital had been raised and spent on electrification works during the half-year, and that for various reasons they were not in a position to reap the full benefits of the new mode of working. He hoped they were within a few months of the time when steam would disappear entirely from the tunnels, and they would be able both to increase the service of trains and give their customers greater comfort. The expenses chargeable to the new electric working had been considerably greater than the saving they had been able to effect in locomotive power. Two things stood in the way of complete withdrawal of steam trains, the first being that the conversion of the Hammersmith & City Railway had not been completed, and the second that they had not got all their electric locomotives. All the electric rolling stock had been ordered from British firms, and he believed that in no instance had they paid more than if the orders had been placed abroad.

**SOUTH AMERICAN LIGHT & POWER CO. (LTD).**—In the report for the year ended Sept. 30 last, it is stated that Mr. Thursby had paid off his debt to the company, and the money had been applied towards paying for the new plant, the whole cost of which, including erection, was £12,948. The trading profit from sale of current rent of meters and private installations in the Argentine (£4,896) showed an increase on the preceding year of 45 per cent. Another 240 kw. gas engine and alternator had been ordered, so that the company would be in a position to meet the increasing demands for light and power during next winter in Bahia Blanca.

**SOUTH-EASTERN & LONDON, CHATHAM & DOVER RAILWAY CO.'S.**—The report of the Managing committee of the boards of these companies for the half-year ended Dec. 31, attributes the large decrease in short-journey suburban traffic mainly to the increasing competition with the electric tramway services. It was proposed to re-open Charing Cross station in a few weeks. In the meantime the committee had granted permission to the Charing Cross, Euston & Hampstead Railway Co. to open the forecourt temporarily, for the purpose of facilitating the construction of their underground station, which would be in direct communication with the committee's terminus.

## NEW COMPANIES, STATUTORY RETURNS. MORTGAGES AND CHARGES.

### NEW COMPANIES.

**LANCASHIRE ELECTRIC SUPPLY CO. (LTD.)** (87,265.)—Reg. Jan. 18, capital £5,000 in £1 shares, to acquire business carried on by Lancashire Electric & General Supply Co., and to carry on the business of manufacturers of electric appliances, fittings, machinery, &c. Reg. office, 27A, Blackfriars-street, Manchester.

**PERFECTA SEAMLESS STEEL TUBE & CONDUIT CO. (LTD.)** (87,287.)—Reg. Jan. 19, with capital of £40,000 in £1 shares, to carry on the business of ironfounders, mechanical and hydraulic engineers, tube and conduit manufacturers, &c., and to adopt agreements with the Perfecta Seamless Steel Tube Co. and its liquidator (R. A. Felton).

### STATUTORY RETURNS.

**ABERDARE ELECTRIC LIGHTING CO. (LTD.)**—Return to Dec. 30 gives capital as £2,000 in £1 shares, of which 340 have been taken up. No calls have been made. Mortgages and charges, nil.

**BARSI LIGHT RAILWAY CO. (LTD.)**—In return to Jan. 1 capital is £300,000 in 30,000 shares of £10 each, of which 16,000 have been taken up. £10 per share has been called up on 7,500 and £2. 10s. per share on 8,500 shares, and £134,057. 10s. has been received, including £37,807. 10s. paid in advance of calls. Mortgages and charges, £140,000 debenture stock.

**BRITISH TRAMWAYS & GENERAL CONSTRUCTION CO. (LTD.)**—In return to Dec. 28 capital is £300,000 in £1 shares, of which 241,000 have been taken up and paid for in full. Mortgages and charges, nil.

**BULLERS LIMITED.**—In return to Dec. 22 capital is £400,000 in 20,000 ordinary and 20,000 preference shares of £10 each, of which 15,000 ordinary and 15,000 preference shares have been taken up. £10 per share has been called up on 7 ordinary and 15,000 preference, and £150,070 has been received. £149,930 is considered as paid on 14,993 ordinary. Mortgages and charges, nil.

**ELECTROMOBILE CO. (LTD.)**—Return to Dec. 14 gives capital as £50,000 in 45,000 ordinary and 5,000 deferred shares of £1 each, of which 35,924 ordinary and 5,000 deferred have been taken up. £1 per share has been called up on 29,000 ordinary and £29,000 has been received. 6,924 ordinary and 5,000 deferred shares are considered as fully paid. Mortgages and charges, £3,483.

**LIGHT RAILWAYS CO. OF SICILY (LTD.)**—Statutory report (dated Jan. 12) shows that 607 shares have been taken up out of a nominal capital of £12,000 in £1 shares. £600 has been paid, and £7 remains in arrears. No mortgages or charges.

**POROUS ACCUMULATOR CO. (LTD.)**—According to return to Dec. 18 capital is £3,000 in £1 shares, all of which have been taken up. £1 per share has been called up and paid on 1,007 shares and 1,993 are considered as fully paid. Mortgages and charges, £16,000.

**SIEMENS ELECTRIC APPLIANCES (LTD).**—Return to Dec. 19 gives capital as £25,000 in 250 shares of £100 each, all of which have been taken up. £100 per share has been called up on 7, and £30 per share on 243 shares and £7,990 has been received. Mortgages and charges, nil.

**WALSALL ELECTRICAL CO. (LTD.)**—According to return to Jan. 4 capital is £25,000 in £1 shares (sub-division not stated), of which 12,000 ordinary and 4,380 preference have been taken up. £1 per share has been called up on 10,000 ordinary and 4,380 preference, and £14,380 has been received. 2,000 ordinary are considered as fully paid. Mortgages and charges, £3,000.

### MORTGAGES AND CHARGES.

**CHLORIDE ELECTRICAL STORAGE CO. (LTD.)**—This company has paid off its £20,000 first mortgage debentures as at the end of 1905, and there are now no debentures of any kind.

**CONSOLIDATED SUPPLY CO. (LTD.)**—Issue on Jan. 1 of a £500 5 per cent. debentures, part of series created Sept. 22, 1905, to secure £5,000, charged on company's undertaking and property, present and future, including uncalled capital. Holders, Consolidated Electrical Co., Ltd., Broad-street House, E.C. No trustees. Previously issued of same series, £2,500.

**FRINTON-ON-SEA & DISTRICT ELECTRIC LIGHT & POWER CO. (LTD.)**—Issue on Dec. 29 of £1,100 debentures, part of series created Oct. 26, 1905, to secure £3,000 and 5 per cent. interest, charged on company's undertaking and property, present and future, including uncalled capital, subject to £3,000 first mortgage debentures. Holders, W. Webster and Miss A. A. Mackay. No trustees. No previous issue of same series.

**PERTH ELECTRIC TRAMWAYS (LTD.)**—Issue on Jan. 3 of £6,000, part of series created Dec. 22, 1903, to secure £50,000, charged on benefit of certain agreements, deposit, provisional order and Acts of Parliament, tramways, plant, &c., in Perth, Western Australia. Trustees, Lord Arthur Butler and J. S. Austen. Previously issued of same series, £39,600.

**PRIVATE WIRE & TELEPHONE INSTALLATION CO. (LTD.)**—A memorandum of satisfaction in full of debentures dated April 27, 1903, securing £2,000, has been filed.

**SUNDERLAND DISTRICT ELECTRIC TRAMWAYS (LTD.)**—A charge dated Dec. 29, 1905, to secure £2,500 and 6 per cent. interest, has been registered. Property charged, company's undertaking and property, present and future (subject to trust deed dated Dec. 8, 1903, and £160,000 debentures issued thereunder), ranking pari passu with a charge for a like amount given to Bruce Peebles & Co. Holder, Electric Conversion Synd.

**UXBRIDGE & DISTRICT ELECTRIC SUPPLY CO. (LTD.)**—Issue on Jan. 9 of £400 5 per cent. debentures, part of series created July 14, 1904, to secure £35,000, charged on company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series £33,000.

**VERITYS LIMITED.**—£40,000 6 per cent. debentures, created and dated Jan. 9, 1906, have been registered. Property charged, the company's undertaking and assets, present and future. No trustees.

## CITY NOTES.

**MEMORANDA** (Jan. 25).—Bank rate 4 per cent. since (Sept. 28, 1905). Price of silver $30\frac{1}{8}$d. per oz. Consols $89\frac{3}{4}$—$89\frac{7}{8}$ for money, $89\frac{13}{16}$—89 for account; $2\frac{1}{2}$ per cent. annuities $89\frac{5}{8}$—$89\frac{7}{8}$. Consols Pay Day, Feb. 1. Stocks and Shares Continuation Day, Feb. 6; Ticket Day, Feb. 7. Pay Day, Feb. 8; Mining Share Carry-over Day, Feb. 5.

**CASTNER-KELLNER ALKALI CO. (LTD.)**—The Right Hon. Gerald W. Balfour has been elected to a seat on the board of this company.

**LIVERPOOL OVERHEAD RAILWAY CO.**—The accounts for the past half-year show an available balance of £7,460. 4s. 4d. The 5 per cent. preference dividend will absorb £3,675. 17s., the balance forward being £3,784. 7s. 4d.

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. | | |
|---|---|---|---|---|---|---|
| | | | | No. of weeks. | Amount. | Inc. or Dec. (a) |
| | | £ | £ | | £ | £ |
| **Aberdeen Corporation** | Jan. 20 | 1,119 | + 47 | 34 | 47,623 | - 1,029 |
| **Airdrie** | ,, 12 | 199 | + 23 | 2 | 421 | + 45 |
| Anglo-Argentine | ,, 21 | 14,490 | + 1,640 | 8 | 44,583 | + 3,740 |
| **Ayr Corporation** | ,, 20 | 170 | + 6 | 35 | 11,119 | - 1[illegible]9 |
| **Barnsley** | ,, 12 | 139 | - 7 | 2 | 234 | - 9 |
| **Barrow** | ,, 12 | 187 | + 7 | 2 | 318 | + 20 |
| **Bath Electric Trams, Ltd.** | ,, 17 | 684 | + 183 | 8 | 1,987 | + 320 |
| Birkenhead Corporation | ,, 21 | 987 | + 121 | 3 | 3,410 | + 85 |
| **Birmingham Corporation** | ,, 20 | 412 | + 102 | 42 | 15,624 | + 2,0 0 |
| ***Birmingham & Mid.** | ,, 12 | 1,307 | - 320 | 2 | 2,265 | - 653 |
| **Blackpool Corporation** | ,, 18 | 300 | + 44 | 3 | 46,313 | + 1,916 |
| **Blackpool and Fleetwood** | ,, 20 | 141 | - 10 | 3 | 465 | - 84 |
| **Bolton Corporation** | ,, 21 | 1,734 | + 232 | 43 | 82,626 | + 3,968 |
| **Bournemouth Corporation** | ,, 18 | 1,414 | + 583 | †42 | 59,722 | + 13,418 |
| **Bradford Corporation** | ,, 20 | 8,815 | + 255 | 42 | 184,386 | - 3,513 |
| **Brighton Corporation** | ,, 21 | 766 | + 68 | 43 | 43,127 | + 591 |
| **Bristol Trams & Carriage** | ,, 19 | 4,913 | + 612 | 23 | 77,415 | + 1,942 |
| **Buenos Ayres & Belgrano** | ,, 21 | 3,509 | + 476 | 3 | 10,903 | + 1,000 |
| Buenos Ayres Elec. Trams | Dec. 23 | 1,448 | ... | 3 | 61,149 | ... |
| **Burnley Corporation** | Jan. 20 | 1,036 | + 154 | 42 | 57,009 | + 3,182 |
| **Burton Corporation** | ,, 21 | 271 | + 16 | §44 | 13,104 | - 1,475 |
| **Bury Corporation** | ,, 14 | 229 | ... | §41 | 31,120 | ... |
| **Calcutta Tramways Co.** | ,, 20 | R43,486 | + R2,391 | 3 | R154,925 | + R10,880 |
| **Camborne-Redruth** | ,, 20 | 104 | + 6 | 12 | 1,301 | - 1 |
| **Carlisle Tramways Co.** | ,, 20 | 162 | + 20 | 3 | 499 | + 26 |
| Cavehill | ,, 12 | 27 | - 3 | 2 | 45 | - 9 |
| **Central London Railway** | ,, 20 | 7,020 | - 395 | 3 | 21,025 | - 777 |
| **Chatham & Dist. Lt. Rys.** | ,, 18 | 643 | + 91 | †3 | 1,608 | + 60 |
| ***City of Birm'gh'm Tram Co.** | ,, 12 | 5,099 | - 236 | 2 | 8,894 | - 264 |
| **City & South London Rly.** | ,, 21 | 3,059 | - 85 | 3 | 9,232 | - 158 |
| **Colchester Corporation** | ,, 18 | 169 | + 26 | 25 | 4,712 | - 1,500 |
| **Cork Electric Trams Co.** | ,, 18 | 411 | + 14 | †3 | 1,111 | ... |
| **Devonport & Dist. Trams** | ,, 12 | 411 | - 49 | 2 | 737 | - 67 |
| **Dover Corporation** | ,, 20 | 185 | + 30 | ‡42 | 9,585 | + 29 |
| **Dublin & Lucan Railway** | ,, 19 | 20 | - 6 | §3 | 239 | - 32 |
| **Dublin United** | ,, 19 | 4,556 | + 265 | ‡3 | 12,779 | + 630 |
| **Dudley—Stourbridge** | ,, 12 | 742 | + 22 | 2 | 1,243 | + 25 |
| **Dundee Corporation** | ,, 17 | 956 | + 172 | §35 | 32,926 | + 2,490 |
| **East Ham Council** | ,, 20 | 8[illegible]2 | + 231 | 42 | 34,958 | + 4,747 |
| **Gateshead & Dist. Trams** | ,, 12 | 872 | + 35 | 2 | 1,556 | + 28 |
| **Glasgow Corporation** | ,, 20 | 14,843 | + 1,465 | 34 | 516,889 | + 32,416 |
| Glossop | ,, 20 | 120 | + 19 | 3 | 361 | + 58 |
| Gloucester Corporation | ,, 17 | 249 | + 46 | 42 | 12,359 | ... |
| **Gravesend—Northfleet** | ,, 12 | 210 | + 13 | 2 | 337 | + 20 |
| **Gt. Northern & City Rly.** | ,, 20 | 1,798 | + 13 | 3 | 5,431 | + 98 |
| **Greenock & Port Glasgow** | ,, 12 | 529 | + 60 | 2 | 1,024 | + 81 |
| **Halifax Corporation** | ,, 17 | 1,343 | + 249 | 42 | 66,257 | + 4,714 |
| **Hartlepool Tramways** | ,, 12 | 235 | + 5 | 2 | 426 | + 3 |
| Hastings Elec. Trams Co. | ,, 18 | 399 | ... | 3 | 1,163 | ... |
| **Huddersfield** | ,, 20 | 1,358 | + 225 | 42 | 57,602 | + 3,093 |
| **Hull Corporation** | ,, 20 | 2,262 | + 304 | 42 | 94,193 | + 1,678 |
| Ilford Dist. Coun. | ,, 20 | 416 | + 98 | 41 | 19,912 | + 828 |
| **Ipswich Corporation** | ,, 20 | 330 | + 30 | 42 | 18,199 | - 1,885 |
| **Isle of Thanet Co.** | ,, 20 | 220 | + 26 | 16 | 4,290 | - 449 |
| **Kidderminster & District** | ,, 12 | 89 | - 4 | 2 | 150 | - 3 |
| Kilmarnock Corporation | ,, 20 | 133 | - 4 | 36 | 5,691 | ... |
| **Kirkcaldy Corporation** | ,, 17 | 192 | + 12 | 20 | 4,147 | - 82 |
| **Lanarkshire Trams Co.** | ,, 18 | 773 | + 200 | †3 | 2,479 | + 524 |
| Leamington | ,, 12 | 142 | + 43 | 2 | 250 | + 82 |
| **Leeds Corporation** | ,, 19 | 5,510 | + 585 | 42 | 253,711 | + 7,843 |
| **Leicester Corporation** | ,, 20 | 2,013 | + 895 | 3 | 5,855 | + 1,086 |
| Leith Corporation | ,, 13 | 412 | + 221 | 34 | 12,321 | + 9,632 |
| **Liverpool Overhead Rly.** | ,, 21 | 1,379 | - 72 | 3 | 4,239 | - 197 |
| Liverpool Corporation | ,, 13 | 10,410 | + 479 | 3 | 20,054 | + 720 |
| ***London County Council** | ,, 6 | 13,872 | + 1,183 | 41 | 616,760 | + 81,963 |
| | ,, 13 | 13,987 | + 1,387 | | | |
| **Lowestoft** | ,, 20 | 120 | + 7 | 16 | 2,355 | - 16 |
| **Maidstone Corporation** | ,, 18 | 97 | + 11 | 42 | 5,202 | ... |
| **Manchester Corporation** | ,, 20 | 12,053 | + 1,247 | 42 | 512,514 | + 26,961 |
| **Mersey Railway** | ... | ... | ... | ... | ... | ... |
| **Merthyr** | ,, 12 | 167 | - 6 | 2 | 285 | - 4 |
| Metropolitan Dist. Railway | ,, 21 | 8,151 | + 403 | 3 | 24,548 | + 1,533 |
| ***Metropolitan Elec. Trams** | ,, 12 | 2,767 | + 779 | 2 | 4,622 | + 1,350 |
| **Middleton** | ,, 12 | 279 | + 27 | 2 | 473 | + 57 |
| **Musselburgh** | ,, 11 | 156 | ... | 56 | 11,925 | ... |
| **Nelson Corporation** | ,, 20 | 128 | + 31 | 43 | 5,650 | + 611 |
| **Newcastle-on-Tyne Corp.** | ,, 20 | 3,787 | + 320 | 42 | 160,468 | + 4,117 |
| **Newport (Mon.)** | ,, 20 | 567 | + 93 | 16 | 8,800 | + 654 |
| Northampton Corporation | ,, 19 | 882 | + 71 | 41 | 17,866 | + 6,059 |
| **Oldham, Ashton & Hyde** | ,, 12 | 500 | + 22 | 2 | 840 | + 87 |
| **Oldham Corporation** | ,, 21 | 1,522 | + 216 | 43 | 70,446 | + 16,929 |
| **Perth (W. A.) Elec. Trams** | ,, 19 | 1,691 | + 182 | ‡3 | 4,529 | + 212 |
| **Peterborough** | ,, 12 | 99 | - 9 | 2 | 163 | - 12 |
| Pontypridd Dist. Council | ,, 20 | 137 | ... | 42 | 6,793 | ... |
| Portsmouth Corporation | ,, 20 | 1,685 | + 224 | 42 | 83,313 | + 1 585 |
| **Potteries** | ,, 12 | 1,749 | + 62 | 2 | 2,897 | + 86 |
| Preston Corporation | ,, 17 | 620 | ... | 2 | 1,219 | ... |
| **Reading Corporation** | ,, 13 | 603 | + 66 | 3 | 1,774 | + 74 |
| **Rotherham Corporation** | ,, 13 | 417 | + 61 | 42 | 12,228 | - 312 |
| **Rothesay** | ,, 12 | 47 | + 8 | 2 | 132 | + 21 |
| **Salford Corporation** | ,, 12 | 4,012 | + 229 | 43 | 183,622 | + 10,982 |
| **Sheerness** | ,, 10 | 52 | - 5 | 2 | 72 | - 9 |
| **Sheffield Corporation** | ,, 21 | 4,787 | + 608 | 43 | 212,739 | + 12,017 |
| **Southampton Corporation.** | ,, 17 | 940 | + 136 | 15 | 13,645 | - 92 |
| **Southend Corporation** | ,, 17 | 248 | + 37 | 42 | 16,023 | + 953 |
| **Southport Tramways** | ,, 12 | 231 | + 6 | 2 | 431 | + 5 |
| **S. Staffordshire Trams.** | ,, 12 | 773 | + 131 | 2 | 1,286 | + 212 |
| **Stockport Corporation** | ,, 19 | 787 | + 352 | 42 | 32,683 | + 8,664 |
| Sunderland Corpn. | ,, 21 | 1,174 | + 155 | 42 | 55,984 | + 2,387 |
| **Swansea Trams** | ,, 12 | 714 | + 261 | 2 | 1,283 | + 467 |
| Swindon Corporation | ... | ... | ... | ... | ... | ... |
| Taunton | ,, 12 | 46 | + 5 | 2 | 82 | + 12 |
| **Tynemouth and District** | ,, 12 | 157 | - 7 | 2 | 280 | - 18 |
| **Tyneside Trams Co.** | ,, 10 | 320 | + 4 | ¶1 | 475 | - 50 |
| **Wallasey District Council** | ,, 10 | 709 | + 148 | 42 | 32,901 | + 1,338 |
| **Walsall** | ,, 20 | 485 | + 96 | 3 | 1,374 | + 111 |
| **Warrington Corporation** | ,, 18 | 316 | + 61 | 42 | 14,389 | + 826 |
| **West Ham Corporation** | ,, 18 | 2,035 | + 1067 | 41 | 77,045 | + 33,157 |
| **Weston-super-Mare** | ,, 10 | 25 | - 4 | 2 | 36 | - 4 |
| Wolverhampton Corpn. | ,, 17 | 833 | ... | 2 | 1,583 | ... |
| **Wolverhampton District** | ,, 12 | 873 | + 48 | 2 | 580 | + 8 |
| ***Worcester** | ,, 12 | 202 | - 11 | 2 | 428 | - 19 |
| **Wrexham** | ,, 12 | 87 | - 4 | 2 | 124 | - 7 |
| Yorkshire W.R. Trams | ,, 21 | 674 | + 248 | 3 | 2,058 | + 625 |
| **Yorkshire Woollen District** | ,, 12 | 816 | + 274 | 2 | 1,814 | + 579 |

(a) These comparisons are with the corresponding period last year. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days. ¶ Minus 3 days. * Partly electrical.

**RANGOON ELECTRIC TRAMWAY AND SUPPLY CO. (LTD.)**—The subscription list for the issue of first mortgage debenture stock and cumulative preference shares of this company, advertised in our last issue, closed yesterday (Thursday).

**ST JAMES' & PALL MALL ELECTRIC LIGHT CO. (LTD.)**—The directors recommend a dividend for the half-year ended Dec. 31 of 7s. 6d. per share on the ordinary shares, making a total distribution of 12½ per cent. for the year.

**SOUTH LONDON ELECTRIC SUPPLY CORPN. (LTD.)**—During the quarter ended Christmas 2,757,087 units were sold, realising £21,725, against 2,546,868 units and £21,760 for the same period last year.

**STOCK EXCHANGE NOTICES.**—The Stock Exchange Committee have appointed Jan. 31 a special settling day in 90,000 £5 fully-paid ordinary shares of the *National Telephone Co. (Ltd.)*, and have granted quotations to a further issue of £164,824 sterling 500-year 4 per cent. redeemable debenture stock of the *Commercial Cable Co.*, and to 20,000 £10 (£9 paid) and 10,000 £10 (£5 paid) shares of the *Newcastle & District Electric Lighting Co. (Ltd.)*. The committee have been asked to appoint a special settling day in and grant a quotation to £150,000 4½ per cent. first mortgage debenture stock of *W. T. Henley's Telegraph Works Co. (Ltd.)* and also to grant quotations to 60,000 £10 6 per cent. cumulative preference shares and £600,000 4½ per cent. debenture stock of the *Bombay Electric Supply and Tramways Co. (Ltd.)*, and a further issue of 3,128 £5, fully paid, and 50,000 £5, £1 paid, 4½ per cent. cumulative preference shares of the *Westminster Electric Supply Corpn. (Ltd.)*.

**WATERLOO & CITY RAILWAY CO.**—A dividend at the rate of 3¼ per cent. per annum (the same as in 1904) for the half-year ended December has been declared, £380 being carried forward.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Jan. 24. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Jan. 24. | |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | £ s. d. | | Highest. | Lowest. |
| 5 | 3/0 | Anglo-Argentine Ord. Shares | 8⅝—8⅞ | 4 11 0 | Ap, Oct | [illegible] | [illegible] |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞—6⅛ | 4 8 0 | — | 6 | [illegible] |
| St. | 6% | Do. Permanent 6% Deb. Stock | 140 —143 | 4 3 6 | — | .. | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 104 —106 | 4 14 3 | — | 105 | 104½ |
| 5 | .. | Brisbane Electric Trams. Invest Ord. | 1 —1½ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 1⅞—4½ | 6 1 4 | — | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 93 —96 | 4 13 9 | — | 96½ | 95 |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 120 —123 | 4 17 6 | — | 122½ | 121¼ |
| St. | 5% | † Do. Pref. Ord. Stk | 110 —113 | 4 8 4 | — | .. | .. |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock | 108 —111 | 4 10 0 | — | [illegible] | — |
| 40 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%—105% | 4 5 9 | — | .. | — |
| 100 | 4½% | † Do. Vancouver Power Debs. | 101 —104 | 4 6 6 | — | .. | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | 4⅝—4⅞ | 5 3 0 | — | [illegible] | [illegible] |
| 5 | 3/0 | Do. 6 per Cent. "A" Cm. Pref | 5¾— 6 | 5 0 0 | — | 6 | .. |
| 5 | 3/0 | Do. "B" | 5¼—5¾ | 5 4 0 | — | [illegible] | [illegible] |
| St. | 5% | Do. 5 per Cent. Debs. | 105 —107 | 4 13 6 | — | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 101 —104 | 4 15 0 | — | .. | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 96 —98 | 5 2 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 100 —104 | 5 5 9 | .. | .. | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 100 —104 | 5 17 0 | .. | .. | .. |
| 5 | 5/6 | Calcutta Tramways (Nos. 1 to 105) | 9½—10 | 4 5 0 | — | [illegible] | .. |
| 5 | 2/6 | Do. Nos. 105,001 to 137,610 | 8¾—9¼ | .. | .. | — | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 104 —106 | 4 5 0 | — | .. | .. |
| 1 | 0/6 | Cape Electric Tram Shares | ⅞—1⅛ | 4 8 10 | — | [illegible] | — |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 102 —104 | 4 16 0 | — | .. | .. |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 97 —99% | .. | .. | .. | .. |
| 1 | .. | Lisbon Elec. Trams Ord. | [illegible] | .. | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛—1⅜ | 4 7 4 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 100 —103 | 4 17 0 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 101 —103 | 4 17 0 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 102 —105 | 4 15 0 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 104 —106 | 4 5 6 | — | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 104 —107 | 4 13 6 | .. | [illegible] | .. |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 146 —148 | 5 8 0 | .. | .. | .. |
| .. | 5% | Do. 5% 1st Mt. $500 Dbs. | 98%—100% | 5 0 0 | .. | [illegible] | 93 |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | — | Adelaide Elec. S'ply Co. 6% Cu.Pr. | 4¾—5¼ | — | .. | .. | .. |
| 5 | 3/8 | Calcutta Elec. (1-50,000) | 8¾ 9¼ | 4 9 0 | — | [illegible] | 8⅞ |
| 10 | 5% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbr. | 50 —52 | 4 16 0 | .. | [illegible] | .. |
| .. | 5% | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 94 —96 | 5 4 0 | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½— 3 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Debs. | 85 —90 | 5 10 0 | — | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | 8½—8¾ | — | — | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92 —94 | 5 6 8 | .. | — | .. |
| St. | 10/2 | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. | 108 —110 | 5 10 0 | .. | .. | .. |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞—1 | 6 0 0 | — | [illegible] | [illegible] |
| 1 | 1/0 | Band Electric | 1¼—1⅜ | .. | — | .. | — |
| 1 | .. | River Plate Electricity Co. Ord. | [illegible] | .. | .. | .. | .. |
| 1 | 1/2⅝ | Do. 6% Non. Cum. Pref. | [illegible]— 1 1/16 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Deb. Stock | 101 —103 | 4 17 0 | .. | 103 | 102¼ |
| 5 | 5/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5¼—5¾ | 5 4 4 | .. | .. | — |
| 5 | 9·3d | Do. (12,001-20,000) | 5 —5½ | 3 8 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100 —103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 5% | Shawinigan Water and Power 5% Bds., Scrip | 101 —103 | 4 17 0 | .. | 102 | .. |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

### ELECTRIC RAILWAYS, TRAMWAYS, &c.

| Share. | Last Dividend | Name. | Price Wed. Jan. 24. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business, Week to Jan. 24. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| 1 | .. | Bath Elec. Trams Pref. Ord. | 15/16—1 | .. | .. | 31/32 | 15/16 |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1 1/32—1 1/16 | 4 14 9 | .. | 1 1/32 | 1 1/16 |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 103½—105½ | 4 5 0 | .. | 104⅛ | 104 |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 101—103 | 4 7 9 | .. | 101¾ | .. |
| 10 | 9% | Bristol Tramways and Carriage Ord. | 17—17½ | 5 2 11 | Feb, Aug | .. | .. |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10—10¼ | 3 18 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Debs. | 104—106 | 3 15 6 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 8⅜—8⅝ | 6 19 8 | .. | 8⅝ | 8 7/16 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 10¾—11 | 5 8 0 | Feb, Aug | 11 1/16 | 10 15/16 |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 119—121 | 4 2 8 | .. | 119½ | 119 |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 98—100 | 4 10 0 | .. | .. | .. |
| St. | 4% | Central London Ordinary Stock | 95—97 | 4 2 6 | June, Dec | 96½ | 95½ |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 104—106 | 3 15 4 | .. | 105 | .. |
| St. | 4% | Do. Deferred Stock | 86—89 | 4 10 0 | .. | .. | .. |
| 100 | 4% | † Do. 4 per Cent. Debs. | 110—112 | 3 11 3 | .. | 111¾ | 110½ |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 4⅞—5⅛ | 4 17 6 | .. | – | – |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 101—104 | 3 17 0 | .. | .. | .. |
| St. | 2% | City and South London Rly. Con. Ord. | 43—45 | 4 8 3 | Feb, Aug | 44¾ | 44 |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 120—123 | 4 1 4 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 117—120 | 4 8 4 | .. | .. | .. |
| St. | 5% | Do. (1901) | 115—118 | 4 4 8 | – | .. | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 106—109 | 3 13 4 | May, Nov | 108½ | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13½—14½ | 4 2 8 | .. | 14⅜ | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½—15½ | 3 17 3 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5½—5¾ | 6 19 0 | .. | 5⅝ | .. |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8—9 | 4 8 11 | – | 8¾ | 8 11/16 |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 101—103 | 4 7 6 | .. | 102½ | 102 |
| 10 | 9% | ‡ Imperial Tramways Ord | 17—18 | 5 0 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 18¼—18¾ | 4 7 8 | Mar, Sept | – | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 110—112 | 4 0 4 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2½—2¾ | 9 8 6 | – | 2 19/32 | 2½ |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 82—87 | 4 12 0 | – | – | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8 1/16—8 3/16 | 3 13 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾—10¼ | 4 15 3 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99—102 | 3 19 3 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9¼—9¾ | 5 2 6 | – | .. | .. |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 97—100 | 4 0 0 | – | 98¼ | .. |
| St. | .. | Mersey Con. Ord. Stock | 7—9 | – | – | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8—11 | – | – | – | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32—9/32 | .. | – | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1—1 1/16 | 4 14 1 | – | 1 | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104—106 | 4 5 0 | – | 105 | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½—1½ | .. | May | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾—9¼ | 5 5 8 | .. | .. | – |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9¾—10¼ | 4 17 6 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103—106 | 4 5 0 | – | – | – |
| 100 | 5% | Sunderland Dist. Elec. Trams. 5% 1st Mort. Debs. | 92—97 | 5 3 0 | .. | 93½ | 93¼ |
| .. | 5% | Underground Elec. Rys. Co. of London | 98—99 | 5 1 0 | .. | .. | .. |
| St. | 3% | Waterloo and City Ord. | 94—97 | 3 2 0 | June, Dec | 94 | .. |
| St. | 4½% | Yorkshire W.R. El. Trs. Co. 4½% 1st Debs. | 95½—96½ | 4 12 9 | .. | .. | .. |

### TELEGRAPHS.

| Share. | Last Dividend | Name. | Price Wed. Jan. 24. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business, Week to Jan. 24. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| 100 | 4% | *African Direct Tel. 4% Mrt. Deb. (red.) | 98½—101½ | 3 18 6 | Jan, July | – | .. |
| 10 | – | Amazon Telegraph | 3¾—4¼ | .. | Jn, Dec | 2⅜ | .. |
| 100 | 5% | Do. 5% Debs. (red.) | 83—88 | 5 18 6 | .. | 85½ | 85½ |
| St. | 15/0 | Anglo-American | 65—67 | 4 9 8 | F,My,Ag,N | 66 | .. |
| St. | 30/0 | Do. Preferred | 114—115 | 5 0 0 | F,My,Ag,N | 114½ | 113 |
| St. | 2/0 | Do. Deferred | 18—18¼ | .. | F,My Ag,N | 18⅜ | 16½ |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 97½—99½ | 4 0 6 | Jn.Ap,Jy,O | 98 | .. |
| 10 | 5/0 | Cuba Submarine Ord. | 8½—9 | 5 11 0 | Feb, Aug | 8½ | .. |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17—18 | 5 11 2 | Feb, Aug | 17 | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜—3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 8½—8¾ | 5 14 0 | April, Oct | .. | .. |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 99%—102% | 4 8 0 | Jan, July | .. | .. |
| 20 | 3/0 | Direct United States Cable | 14½—15½ | 4 4 6 | Ja,Ap,Jy,O | 15 3/16 | 15 |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 99—101 | 4 9 0 | Jn, Dec | .. | .. |
| St. | 25/0 | †Eastern Ordinary | 148—151 | 4 12 8 | Ja,Ap,Jy,O | 150 | 147 |
| St. | 17/6 | † Do. 3½ per Cent. Pref. Stock | 92—94 | 3 14 6 | Ja Ap,Jy,O | 93⅜ | 92½ |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 109—110½ | 3 13 0 | May, Nov | 108½ | .. |
| 10 | 2/6 | †Eastern Extension | 14½—15 | 4 13 4 | Ja,Ap,Jy,O | 14¾ | 14½ |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 107—109 | 3 13 4 | Feb, Aug | .. | .. |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb. 1909 | 101—103 | 3 18 3 | Feb, Aug | 101 | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101%—103% | 3 18 3 | May, Nov | 102⅜ | .. |
| 10 | 5/0 | G. N. (of Copenhagen) with coupon 65 | 37½—39½ | 6 1 6 | Jan, July | .. | .. |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 99—101 | 4 7 6 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57—59 | 5 10 0 | May, Nov | .. | .. |
| 100 | $1 | Mackay Companies Common | 64 5/16 | 3 2 3 | Jan, July | – | .. |
| 100 | 4% | Do. Preference | 76⅞ | 5 4 0 | Ja,Ap,Jy,O | .. | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1⅛—1¼ | .. | .. | .. | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 99—102 | 3 18 6 | June, Dec | .. | .. |
| 10 | 4/0 | West African Telegraph Shares | 9½—10 | 5 0 0 | .. | .. | .. |
| 2½ | – | West Coast of America | 9/16—11/16 | .. | – | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 99½—101½ | 3 18 9 | Jan, July | .. | .. |
| 10 | – | West India and Panama | ⅜—⅝ | .. | May, Nov | ½ | .. |
| 10 | 6/0 | Do. 6% 1st Pref. | 8¼—8¾ | 6 6 8 | May, Nov | 8⅝ | .. |
| 10 | – | Do. 6 per Cent. 2nd Pref. | 6¾—7½ | .. | May, Nov | .. | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 100—103 | 4 17 0 | Jan, July | – | .. |
| 10 | 3/0 | Western Telegraph | 14½—14¾ | 4 17 0 | Mr,Jn,O,D | 14⅝ | 14 7/16 |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 100—102 | 4 18 0 | June, Dec | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 102—104 | 3 16 10 | .. | 103⅜ | 103 |

### TELEPHONES.

| Share. | Last Dividend | Name. | Price Wed. Jan. 24. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business, Week to Jan. 24. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 102—104 | .. | .. | .. | .. |
| 5 | 3/0 | †Chili Telephone (fully paid) | 7⅞—8⅛ | 4 18 6 | August | .. | .. |
| 1 | 0/9⅗ | Monte Video Telephone Ord. | ⅞—1 | 4 0 0 | – | .. | .. |
| 1 | 1/0 | Do. 5% Pref. | ⅞—1 | 5 0 0 | .. | .. | .. |
| St. | 6% | National Co. Pref. Stock | 113—114 | 5 5 2 | – | 113½ | 113⅜ |
| St. | 5% | Do. Def. Stock | 110—112 | 4 8 8 | .. | 111½ | 110¾ |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13—15 | 4 0 0 | Feb, Aug | 14¼ | 14½ |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 11—13 | 4 12 4 | Feb, Aug | 12¼ | 12⅛ |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅝—5⅞ | 4 5 2 | Feb, Aug | 5⅝ | .. |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 98½—101½ | 3 9 0 | June, Dec | 100 | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 104—106 | 3 15 6 | – | 104½ | 104 |
| 1 | 0/7⅕ | Oriental | 1 5/16—1 7/16 | 4 11 0 | April, Oct | 1⅜ | .. |
| 1 | 0/7⅕ | Do. 6 per Cent. Cum. Pref. | 1¼—1⅜ | 4 7 0 | – | .. | .. |
| St. | 24/7⅔ | Do. 4% Red. Deb. Stock | 96—98 | 4 1 6 | .. | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 101—104 | 4 6 6 | .. | 102 | .. |
| 5 | 3/0 | United River Plate | 7¼—7½ | 5 6 8 | July | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5½—5¾ | 4 7 0 | June, Dec | 5⅝ | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 110—112 | 4 9 8 | June, Dec | 110⅝ | .. |

### FINANCIAL, INVESTMENT, &c.

| Share. | Last Dividend | Name. | Price Wed. Jan. 24. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business, Week to Jan. 24. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 5—5½ | 5 9 0 | .. | 5 1/16 | .. |
| 10 | 2/0 | Globe Telegraph and Trust | 11¼—11½ | 4 15 0 | Ja,Ap,Jy,O | 11½ | 11¼ |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14⅝—14⅞ | 4 0 6 | Ja,Ap,Jy,O | 14 13/16 | 14¾ |
| 10 | 6% | Submarine Cables Trust (Cert.) | 126—129 | 4 13 0 | April, Oct | .. | – |

### ELECTRICITY SUPPLY.

| Share. | Last Dividend | Name | Price Wed. Jan. 24. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Week to Jan. 24. Highest. | Lowest |
|---|---|---|---|---|---|---|---|
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12⅝—12⅞ | 5 9 6 | .. | 12⅝ | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10¼—10¾ | 4 8 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11¾—12¼ | 4 18 0 | .. | 12 1/16 | – |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 105—107 | 4 4 0 | .. | 106½ | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 102—105 | 4 5 9 | – | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 8½—9½ | 5 5 0 | – | 8¾ | 8½ |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 8½—9½ | 3 14 5 | Mar, Sept | – | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 102—105 | 3 16 3 | – | .. | .. |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 5¾—6¼ | 5 13 0 | Feb, Aug | 6 1/16 | .. |
| 5 | 2/8 | Do. 4½ per Cent. Pref. | 5¼—5¾ | 3 18 8 | Feb, Aug | 5½ | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 101—103 | 3 17 6 | – | 102½ | 102⅜ |
| 5 | 2/8 | Do. City Undertaking 4½% Cm. Pref. | 4⅝—4⅞ | 4 12 6 | – | .. | .. |
| 5 | 2/8 | Do. Do. (1903) | 4⅝—4⅞ | 4 12 6 | .. | .. | .. |
| 5 | 2/8 | Chelsea Electric Supply Ord. | 5—6 | 5 0 0 | March | 5⅞ | 5 1/16 |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 108—110 | 4 1 6 | Jn, Dec | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 11—12 | 5 0 0 | Feb, Aug | 11½ | 11 1/16 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13¾—14¼ | 4 4 2 | Jan, July | 13½ | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 122—126 | 3 10 4 | Jn, Dec | .. | – |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 100—102 | 4 8 8 | .. | 101½ | .. |
| 5 | .. | County of Durham Elec. P.D. Ord. £2 pd. | 2 1/16—2 3/32 | .. | April, Oct | 2 1/16 | 2 1/32 |
| 5 | 5% | Do. Do. 5% non cum. pref. | 5¼—5⅜ | 4 13 0 | April, Oct | 5¼ | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 8½—9½ | 4 6 6 | – | 9 | 8⅞ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12½—13 | 4 12 3 | Mar, Sept | 13 | 12½ |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 109—112 | 4 0 4 | .. | 110½ | 110 |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 101—103 | 4 7 6 | .. | 101½ | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5—5½ | 4 11 9 | .. | – | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 102—105 | 4 5 6 | – | – | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8¼—8¾ | 4 17 2 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100—103 | 4 7 5 | – | .. | – |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 10½—11½ | 5 4 0 | .. | 10½ | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½—7 | 4 5 9 | Jan, July | – | – |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98—101 | 3 19 2 | .. | .. | – |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101—103 | 3 17 8 | .. | .. | .. |
| 3 | 1/9⅜ | London Electric Supply Ord. | 1¾—2¼ | 4 0 0 | .. | 1 15/32 | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 4¾—5¼ | 5 14 0 | .. | 4⅝ | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 98—101 | 3 19 2 | Mr,Jn,S,D | .. | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 8¾—9¼ | 5 2 6 | April, Oct | 9⅝ | 9⅜ |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5¼—5½ | 3 18 0 | Jan. July | 5 15/32 | 5 5/16 |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 107—111 | 4 1 0 | Jn, Dec | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 95—97 | 3 12 3 | – | .. | .. |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 100—102% | 4 8 0 | – | 101 | 100½ |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 12—12¼ | 5 11 1 | Feb, Aug | .. | .. |
| 100 | 4½% | † Do. 4½% Deb. | 101½—102½ | 4 7 8 | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8 1/16—8 3/16 | 4 18 6 | Feb, Aug | 8 3/16 | 8⅛ |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6¼—6⅝ | 3 19 4 | Feb, Aug | 6⅜ | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99—101 | 3 19 7 | Jan, July | .. | .. |
| 1 | 3% | Northern Counties Elec. Sup. | 15/16—31/32 | 3 2 6 | Mar, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 101—102 | 4 7 6 | Jan, July | – | – |
| 10 | 6/0 | Notting Hill Electric Ord. | 13½—14½ | 4 16 8 | March | 13¾ | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98—100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅜—6⅞ | 5 1 6 | March | – | – |
| St. | 4% | † Do. 4% Deb. Stock | 99—101 | 3 19 0 | – | .. | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 11½—12½ | 6 0 0 | Feb, Aug | 12⅜ | 11⅝ |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 7—8 | 4 7 0 | Feb, Aug | 7½ | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 97—99 | 3 10 9 | – | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2—2½ | 8 0 0 | .. | 2 5/16 | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76—80 | 5 0 0 | – | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 3—3½ | 5 10 0 | .. | .. | .. |
| 1 | – | South Metrop'n Elec. Lt. & Power Ord. | ¾—⅞ | .. | .. | .. | .. |
| 1 | 0/8⅖ | Do. 7% Cum. Pref. | 1 5/16—1 7/16 | 4 17 2 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105—108 | 4 8 8 | – | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4⅝—4⅞ | 5 2 6 | – | 4 23/32 | |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5—5¼ | 4 15 8 | – | 5 3/32 | |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 104—106 | 4 5 0 | .. | 105 | |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 10½—11½ | 6 1 0 | Mar, Sept | 11¼ | |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝—5⅞ | 4 9 0 | .. | 5 25/32 | |

### ELECTRIC MANUFACTURING, &c.

| Share. | Last Dividend | Name | Price Wed. Jan. 24. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Week to Jan. 24. Highest. | Lowest |
|---|---|---|---|---|---|---|---|
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝—⅞ | 5 6 6 | – | – | |
| 1 | 10½d. | Aron El. Met. 6% Cm. Pf. | ½—⅝ | .. | .. | .. | |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3¾—4 | 5 0 0 | .. | .. | |
| 1 | 7½d. | Do. Pref | 1 7/16—1 9/16 | 3 16 10 | .. | 1⅛ | |
| 5 | 4/0 | British Insulated & Helsby Cables Ord. | 7—7½ | 5 6 8 | July, Feb | .. | |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 6—6⅛ | 4 12 8 | Jan, July | 6 1/16 | |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103—106 | 4 4 11 | .. | 104½ | |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98—100 | 4 10 0 | .. | .. | |
| 5 | .. | British Westinghouse 6% Pref. | 1⅞—2¼ | .. | .. | 2⅛ | |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 77—82 | 4 17 6 | .. | .. | |
| 2 | – | Brush Electrical Engineering | ⅜—⅝ | .. | March | .. | |
| 2 | 2/4⅘ | Do. 6 per Cent. Pref. Non-Cum. | 1¼—1¾ | 6 17 0 | Mar, Sept | 1 7/16 | |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 99—101 | 4 9 0 | Mar, Sept | 99½ | |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 82—84 | 5 7 4 | Jan, July | .. | |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11—12 | 5 0 0 | Jan, July | – | |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅜—5⅞ | 4 5 0 | Jan, July | .. | |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 108—110 | 4 1 6 | Nov, May | 110 | |
| 1 | 4⅘d. | Castner-Kellner Alkali Co. | 1 1/16—1 3/16 | 5 1 0 | .. | 1 5/32 | |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 97—102 | 4 8 8 | – | .. | |
| 1 | 9⅗d. | Chadburn's (Ship) Telegraph Ord. | 1—1¼ | 8 0 0 | .. | .. | |
| 1 | 7⅕d. | Do. 6% Cum. Pref. | 1 1/16—1 3/16 | 5 2 7 | .. | .. | |
| 3 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 1⅞—2⅛ | 3 10 6 | Jan, July | 2 | |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 97%—99% | 5 2 0 | Jan, July | 97½ | |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8½—9 | 5 11 1 | Sept | .. | |
| 5 | 3/0 | Do. 6% Cum. Pref. | 5¾—6¼ | 4 18 0 | Sept | .. | |
| St. | 4½% | Do. 4½% Deb. Stock | 104—106 | 4 5 0 | .. | .. | |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅜—1⅝ | – | Feb, Aug | 1 9/16 | 1 17/32 |
| 5 | 2/6 | Do. (£5 paid) | 2¼—2¾ | .. | Feb, Aug | 2 9/16 | 2 7/16 |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 86—88 | 4 11 0 | June, Dec | – | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92—97 | 5 8 1 | .. | .. | .. |
| 5 | 2/6 | †Edmundson's Elec. Corp. Ord. | 5—5½ | 6 7 0 | H'lf-yearly | 5 5/16 | 5 1/16 |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5—5½ | 5 9 0 | .. | 5½ | 5 1/16 |
| St. | 4½% | † Do. 4½ per Cent. 1st Mort. Deb. (red.) | 104—106 | 4 5 0 | – | 105 | 104 |
| 2 | 1/7½ | Electric Construction Co. | ½—¾ | 9 6 0 | July | .. | .. |
| 2 | 2/9⅗ | Do. 7 per Cent. Cum. Pref | 1⅞—2⅜ | 5 18 8 | July | .. | .. |
| St. | 4% | † Do. 4 per Cent. 1st Mort. Deb. (red.) | 90—93 | 4 6 0 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9—9½ | 5 5 0 | .. | .. | – |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96—100 | 4 0 0 | .. | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 12⅜—12½ | 5 11 1 | Feb, Aug | 12½ | 12⅜ |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼—5½ | 4 2 0 | Feb, Aug | 5 5/16 | .. |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | – | 4 1 1 | Feb, Aug | .. | .. |
| 10 | 15/0 | India Rubber, Gutta Percha, &c., Wrks. | 18¼—18½ | 2 10 6 | Feb, Aug | 18 13/16 | 18½ |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99—102 | 3 18 5 | Mar, Sept | .. | – |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¾—12¼ | 4 1 8 | Mar, Sept | .. | – |
| 12 | 12/0 | Telegraph Construction & Mainten'ce. | 84—86 | 4 18 6 | Mar, July | 85 | .. |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 100—102 | 3 18 6 | Jan, July | 100½ | .. |
| 5 | – | Willans and Robinson Ord. | 2—2½ | – | Apr, Oct | 2 1/16 | 2⅛ |
| 5 | – | Do. 6 per Cent. Cum. Pref. | 4—4½ | – | Apr, Oct | 4¼ | 4⅛ |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 82—87 | 4 12 0 | May Nov | 85¾ | .. |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

AN
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**ANCHOR**
**CABLE CO.,**
TELEPHONE: **LTD.,** 1911 HOLBORN.

TRADE MARK.

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VICTORIA EMBANKMENT.

Works:
LEIGH,
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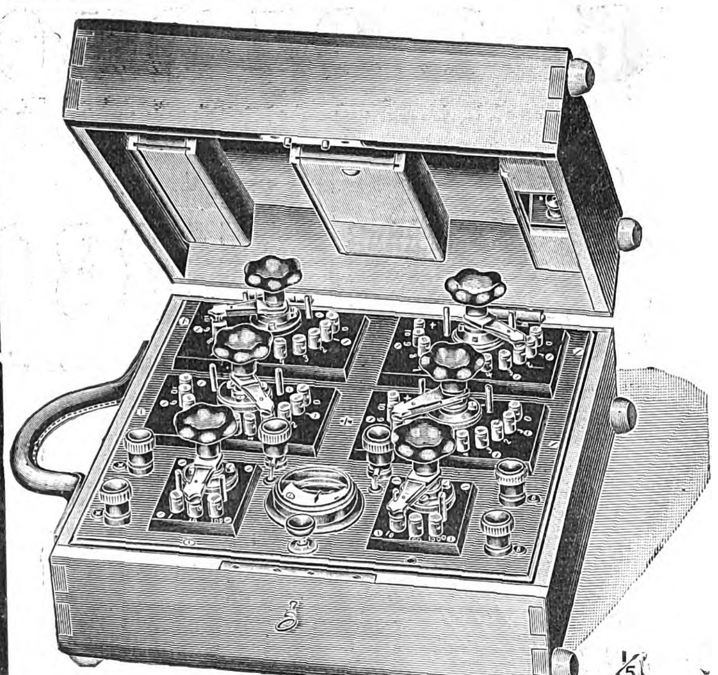
*MANUFACTURERS OF*
**CABLES, INSULATING MATS, INSULATED SPANNERS, JOINTERS GLOVES, &c., &c.**



TESTING APPARATUS FOR ALL WORK OF THE MOST ACCURATE KIND.

**Union Electric Co. Ltd.**
151, QUEEN VICTORIA STREET,
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*Telegraphic Addresses:*
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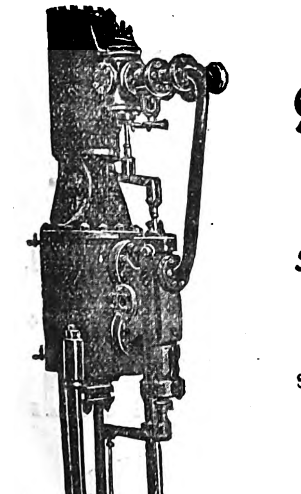
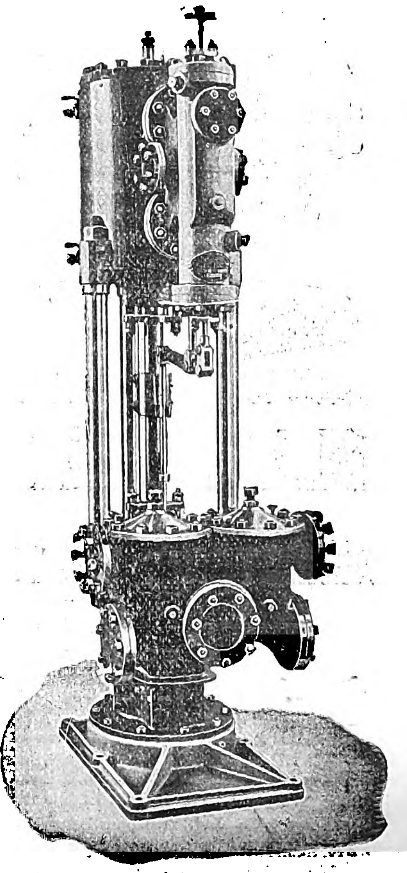
**CLARKE, CHAPMAN & CO., LTD.**
GATESHEAD-ON-TYNE,
General and Electrical Engineers.

MANUFACTURERS OF
SLOW SPEED, INDEPENDENT
**.. FEED PUMPS ..**
SIMPLE & COMPOUND. *(WOODESON'S PATENT.)*

**SURFACE CONDENSERS**
MOUNTED OVER COMBINED AIR & CIRCULATING PUMPS.
*(WOODESON'S PATENT.)*


Tandem Compound Type.

Surface Condenser.


Standard Slow Speed Independent Feed Pump (Woodeson's Patent).

# C. A. PARSONS & Co.

**Heaton Works, NEWCASTLE-UPON-TYNE.**

TELEGRAPHIC ADDRESSES—
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SILENTLY LONDON.
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SMOOTHLY GLASGOW.

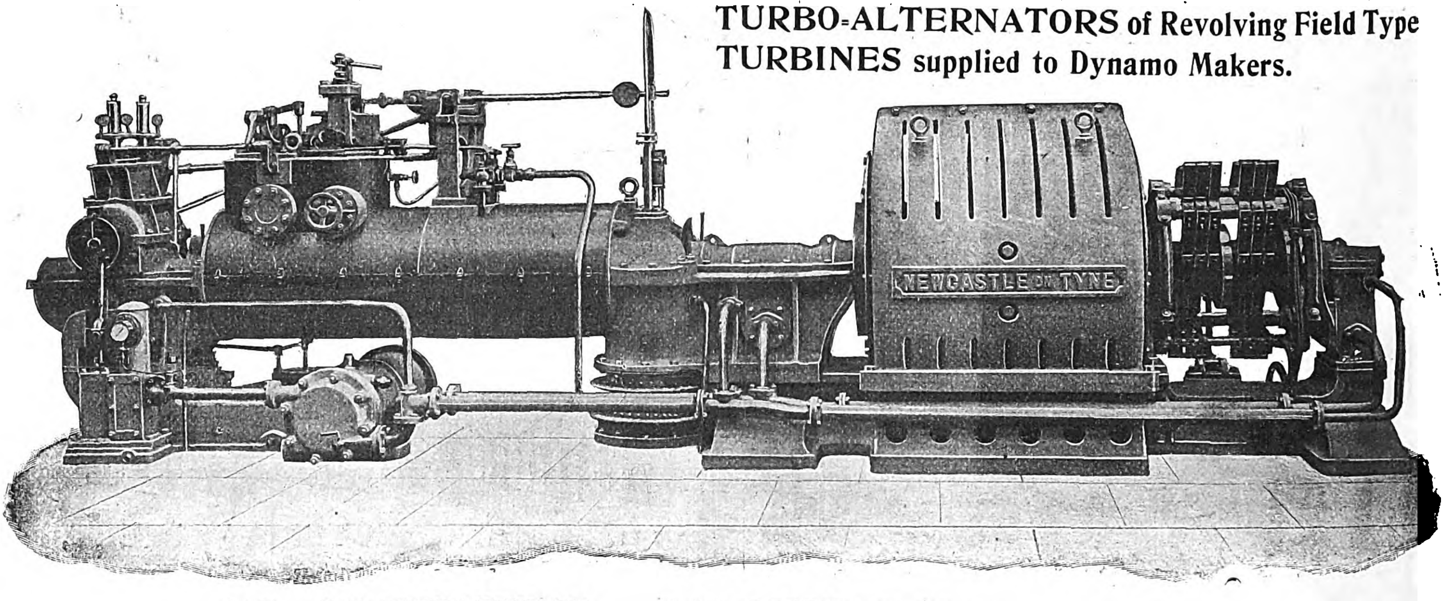
66, Victoria Street, London, S.W. 13, Peacocks Buildings, Leeds. 99, Great Clyde Street, Glasgow

## STEAM TURBO-DYNAMOS

. . FOR . . CONTINUOUS CURRENT.

SPARKLESS COMMUTATION GUARANTEED.

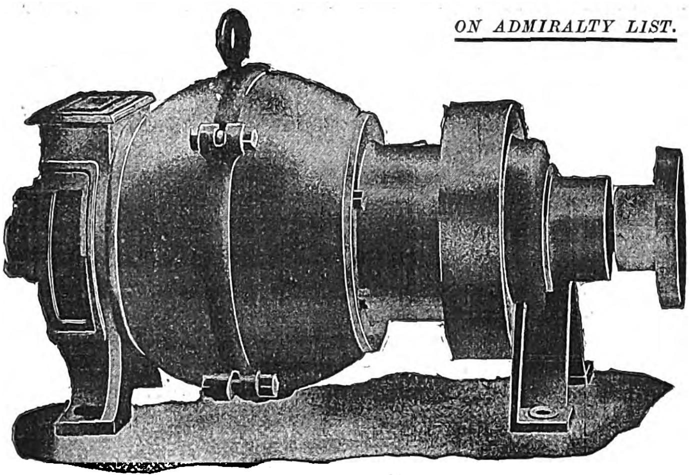
TURBO-ALTERNATORS of Revolving Field Type
TURBINES supplied to Dynamo Makers.



300kw. C. C. TURBO-DYNAMO supplied to DERBY CORPORATION for TRAMWAYS.

◆ ◆ ◆

ON ADMIRALTY LIST.



For PORTABLE ELECTRIC HOIST—*See next advertisement.*

## SPEED REDUCING GEAR FOR MOTORS.

**SIMPLE.**
**COMPACT.**
**EFFICIENT.**

*For full particulars apply to—*

**HUMPAGE, JACQUES and PEDERSEN, Limited,**
ASHTON GATE, BRISTOL.

◆ ◆ ◆

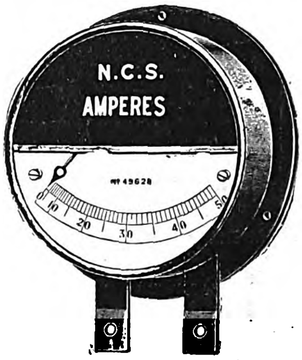
# NALDER BROS. & THOMPSON, Ltd.

MANAGING DIRECTOR: F. H. NALDER.

**AMMETERS, VOLTMETERS, RECORDERS, CIRCUIT BREAKERS & SWITCHBOARDS.**

GOLD MEDAL, ST. LOUIS EXHIBITION, 1904.

## DEAD-BEAT MOTOR GAUGES



From **23s.** (list).

**34, Queen St., Cheapside, LONDON, E.C.**

Telegrams: OCCLUDE LONDON. Telephone Nos. 124 & 161 BANK.

AGENTS.

Marsh, Son & Co., Ltd., 11, Upper Priory, Birmingham.
Wm. McGeoch & Co., Ltd., 108, Argyle Street, Glasgow.
Berry, Skinner & Co., 65, King Street, Manchester.
Robert Bowran & Co., 3, St. Nicholas Bldgs., Newcastle-on-Tyne.
Frampton, Paine & Jackson, 29, Old Queen Street, London, S.W. (London, Southern, Western and Eastern Counties.)
Oswald Haes, 56, Margaret Street, Sydney.
Balmer, Lawrie & Co., Calcutta.
Studio Elettrotecnico Industriale, Lugano and Milan (for Switzerland and Italy).
Hammar & Co., Konigstrasse 7, Hamburg.
W. A. Brinck, Amersfoort, Holland.

## WHEATLEY KIRK, PRICE & CO.

*(Established 1850.)*

ELECTRICAL AND MECHANICAL VALUERS, ARBITRATORS AND AUCTIONEERS.

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Periodical Valuations, Stock-takings and Reports for DEPRECIATION, RENEWALS, &c., in conformity with the Acts.

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Telephones { 5077 Bank London. 3218 Central Manchester.
Telegraph Addresses { Indices London. Indicator Manchester.

## SALES BY AUCTION.

In the High Court of Justice, 1905. E. 395.
Chancery Division,
Mr. JUSTICE JOYCE.

*In the matter of* BELL *v.* THE ELECTRIC LAMP RENOVATING CO., LTD.

**TO ELECTRICIANS, ENGINEERS, LAMP MAKERS AND OTHERS.**

TUESDAY, 6th February, 1906.

WHEATLEY KIRK, PRICE & CO. have received instructions from the Receiver, Sydney Wiltshire, Esq., to SELL BY PUBLIC AUCTION, on the WORKS PREMISES, 48 & 49, BRITANNIA STREET, CITY ROAD, HOXTON, LONDON, N., commencing at 11 o'clock prompt, on TUESDAY, February 6th, 1906, the whole of the

**INCANDESCENT LAMP RENOVATING PLANT AND STOCK**

comprising 1-20th to 10 H.P. Motors, Main and Branch Switchboards, 600 volt Alternator, Transformers, Wattmeters, Photometers, Exhausting Benches, Vertical and Horizontal Duplex Exhausting Pumps, 10 B.H.P. Gas Engine, Root's Blower, Glass Blowing Benches, Flashing Tables, Resistances, Volt Regulators, New and Regenerated Electric Lamps; also Automatic Mechanical Advertising Cabinets driven by Motor, and other Effects.

Admission by Catalogue only, which may be obtained from the Receiver, SYDNEY WILTSHIRE, Esq., of Messrs. Wright & Wiltshire, Incorporated Accountants, 19, St. Dunstan's Hill, Great Tower-street, London, E.C ; J. J. EDWARDS & CO., Solicitors, 28, Sackville-street, Piccadilly, London, W.; or the AUCTIONEERS, 46, Watling-street, London, E.C., and Albert-square, Manchester. Telegrams: Indices London; Indicator Manchester. Telephones: 5077 Bank; 3218 Manchester.

## MISCELLANEOUS PLANT, &c., WANTED.

WANTED, TWO SERIES of FLAME ARC LAMPS and ACCESSORIES.—For particulars apply to H. FARADAY PROCTOR, City Electrical Engineer, Temple Back, Bristol.

WANTED, LAMP TOPS, with Platinum, Scrap Platinum, &c.—EDEY & Co., 29, Ludgate-hill, London, E.C.

## MISCELLANEOUS PLANT, &c., FOR SALE.

DYNAMO, 4-pole, well-known make, about 400 light, 110-135 volts, 1,000 revs., with slide rails and shunt regulator, flywheel and pulley, compound or shunt wound, being removed to replace a larger machine. Can be seen running by appointment. Could be used as motor.—C. T. B., *Electrician* Offices, Salisbury-court, Fleet-street, London.

DYNAMO, 2-pole, well-known make, with shunt regulator, flywheel and pulley, about 50 amperes, 110-140 volts, 1,200 revs. compound or shunt wound. Could be used as motor.—C. T. C., *Electrician* Offices, Salisbury-court, Fleet-street, London.

FOR SALE or HIRE, high-class Dynamos, Motors, Alternators, Cable and Electrical Apparatus.—PERCY HUDDLESTON & Co., 72, Finsbury Pavement, London, E.C.

CHEAP LAMPS, 200 volts, 16 c.p. and 8 c.p., 5s. per doz. DULWICH LIGHTING Co., Lordship-lane, East Dulwich, London, S.E.

THE PROPRIETORS of an OIL SEPARATOR desire to meet with a Firm of Engineers to acquire the PATENTS, or to take up the Manufactureon Royalty.—6010, *Electrician* Offices, Salisbury-court, Fleet-street, London.

GAS LIGHTING BY ELECTRICITY.—The ENGLISH and AMERICAN PATENTS for new improvements on apparatus for lighting gas by electricity FOR SALE. Price £500. Specimen, description and copy of letters patent on application.—KARL ABEL, Austria, Vienna, IX Lichtensteinstr 12.

"The Electric Accumulator." No. 1, Vol. I.

**The ONLY Storage Battery Paper.** Jan. '06.

*Particulars:*—8, St. Ann's Road,
Telegrams: ELECTROLYT. WANDSWORTH, LONDON, S.W.

---

Telegrams: Turnstile London. **STANLEY** GOLD MEDAL, St. Louis, 1904.

**SURVEYING & DRAWING INSTRUMENTS.**

*NOTICE OF REMOVAL OF THE RETAIL DEPARTMENT*
from GREAT TURNSTILE to
**286, HIGH HOLBORN, LONDON, W.C.** Price List post free.

**CAUTION.**

### ELECTRIC TRAM CARS.

**RADIAL TRUCKS.**

AN ACTION has been commenced in the High Court of Justice, Chancery Division, by Messrs. LYCETT & CONATY, against Messrs. MOUNTAIN & GIBSON, LIMITED, to restrain them from infringing certain Letters Patent (15970 and 23948 of 1903) by Manufacturing and Selling Electrically Driven Tramcars in which the motors which drive the axles are so mounted as to have the same radial movement as the axles themselves.

TAKE NOTICE that all other persons infringing the said Letters Patent are liable to have proceedings taken against them also and to pay damages.

Dated this 31st day of January, 1906.

SYDNEY MORSE,
37, Norfolk-street, Strand, London, W.C.,
Solicitor for Messrs. Lycett & Conaty.

## TENDERS INVITED.

### COUNTY BOROUGH OF WEST HAM.

**TO ELECTRICAL ENGINEERS AND OTHERS.**

The Council hereby invite TENDERS for:

(1) ONE 1,500-2,000 K.W. TWO-PHASE TURBO-GENERATOR;
(2) ONE 500 K.W. MOTOR GENERATOR, 500-550 volts direct current to 2,100 volts alternating current, Two-Phase; and
(3) SWITCHGEAR for above.

Specification, Form of Tender, and further particulars may be obtained from the Borough Electrical Engineer, A. Hugh Seabrook, Tucker-street, Canning Town, West Ham, on and after Friday, the 2nd February, on the deposit of a £5 Bank of England note, which will be returned on receipt of a bona-fide tender.

Tenders, endorsed "Tender for Turbine Generator, etc., to be sent to my office not later than 4 o'clock on FRIDAY, the 16th February, 1906.

The Council does not bind itself to accept the lowest or any tender.

The Contractor will be required to enter into a bond with two sureties for the due performance of the Contract, and no work will be ordered under the Contract until such bond has been duly executed.

The Contractor whose tender is accepted, and with whom a Contract is entered into, will be required to pay all workmen employed by him in or about the Contract such rates of pay, and observe such hours of labour as are embodied in the schedule which will be part of the Contract. In the event of any breach of such agreement the Council will enforce the penalty clause in its entirety.

A Tender will not be accepted unless it is stated by the Contractor in the Tender, and proved to the satisfaction of the Council, that the Contractor, at the date of the Tender, pays to the whole of his workmen such rates of wages, and observes such hours of labour as are recognized by the Workmen's Trade Unions in the several localities where his work is done. If, after the Contract is signed, it shall be proved that the said statements of the Contractor in the Tender are contrary to fact, the Council shall be entitled to rescind the Contract, or at its option to recover from the Contractor as liquidated damages, and not as a penalty, the sum of £50.

By order of the Council,
FRED. E. HILLEARY, Town Clerk.

Town Hall, West Ham, January 1906.

TENDERS INVITED continued on next page.

**GAMBRELL BROS.** MANUFACTURERS of ELECTRICAL TESTING INSTRUMENTS.
Durham House, North Side,
Clapham Common, London, S.W.
CATALOGUE ON APPLICATION.

**Royal Doulton Potteries.**

**INSULATORS**

AND ALL KINDS OF

**POTTERY FOR ELECTRICAL PURPOSES.**

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LIMITED,
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**EVERSHED & VIGNOLES, LIMITED.**

Our New List of AMMETERS and VOLTMETERS will be forwarded post free on application.

*Makers of all kinds of ELECTRICAL INSTRUMENTS,*

**Acton Lane Works, CHISWICK, LONDON, W.**

◆ ◆ ◆

## TENDERS INVITED—*continued.*

### LEYTON URBAN DISTRICT COUNCIL.

**UNDERGROUND ELECTRICAL FEEDERS FOR TRAMWAYS.**

The Leyton Urban District Council is prepared to receive TENDERS for the Underground Electrical Feeders on the solid system for their tramways.

A Specification with schedules and form of tender can be obtained by the deposit of £2 2s. from the undersigned at the Electric Light and Power Works, Cathall-road, Leytonstone, where the plans can be inspected by tenderers between 10 a.m. and 4 p.m., and between 10 a.m. and noon on Saturdays.

Tenders on the forms attached to the specifications are to be delivered to the meeting of the Electric Lighting Committee to be held at the Town Hall, Leyton, on THURSDAY, the 15th February, 1906, at 7.30 p.m.

Duplicate copies of the specification can be obtained by the deposit of £1 1s. each.

Deposits are returnable one month after the receipt of a bona fide tender and return of specification in respect of which deposits have been made.

The Council does not bind its.lf to accept the lowest or any Tender.

F. HARMAN LEWIS,
Electrical Engineer to the Council.

The Electric Light and Power Works,
Cathall-road, Leytonstone, February, 1st, 1906.

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### METROPOLITAN BOROUGH OF SHOREDITCH.

**ANNUAL CONTRACTS.**

The Council of the Metropolitan Borough of Shoreditch are prepared to receive PROPOSALS and to contract with any person or persons for the following ARTICLES and WORKS for one year from the 1st day of April next to the 31st day of March, 1907 (inclusive), viz.:—

1. Highways Works Department.—For paving, repairing and relaying the footway and carriageway pavements within the said Borough, and the supply of Materials. (A £10 Bank of England Note to be enclosed with Tender.)
2. For supplying and laying patent or manufactured Stone, or other paving material.
3. Asphalting.
4. Broken Granite.
5. Plumbers' Work.
6. Smiths' Work.
7. Drain Pipes, Junctions, Bends, &c.
8. Drain Rods, Pails, Ropes, &c.
9. Timber.
10. Sewer Ironwork and Street Posts.
11. Gas Fittings, &c., for the Public Lighting of the Borough.
12. Lime, Cement, &c.
13. General Cartage. (A £10 Bank of England Note to be enclosed with Tender.)
14. Street Name Plates, Notice Boards, Writers' Work, &c.
15. Ballast, Hoggin, Shingle, and Sand.

Samples of the above Articles can be seen at the depot, Flemming-street, Kingsland-road, N.

16. Scavenging and Other Departments.—Iron, Ironmongery, Coach Ironmongery, Coal and Coke, Basket Work, and Miscellaneous Indiarubber Work, Brooms, Brushes, Harness Sundries, Loin Cloths and Sail Cloth Covers.

Samples of the Articles required for these Departments may be seen, and Forms of Tender obtained, at the Town Hall, Old-street, E.C.

17. Electricity Works Department.—(A) Electric Cables and Sundries; (B) Gas Pipe and Fittings; and (C) Engineers' Stores.

Samples may be seen at the Electric Lighting Station, Coronet-street, Hoxton, N.

Forms of Tender for all the above-mentioned articles can be obtained on application to the undersigned.

Tenders must be sent properly endorsed to the Town Clerk, at his Offices as under, before 3 o'clock on TUESDAY, the 13th day of March, 1906, after which time no Tenders can be received.

Contractors must agree to pay the trade union rate of wages observed at the date of the Contract, and to observe the usual hours of labour recognised by the trade, and not to sublet the Contract, and Contractors or their Agents tendering in respect of items 13 and 14 only must attend at the Council Meeting at the Town Hall, Old-street, on Tuesday, the 13th March, 1906, at 6:30 p.m.

The Council does not pledge itself to accept the lowest or any Tender, and none but Tenders on the official printed Forms will be received, which, with any further information, may be obtained from the various Departments of the Council, or from

H. MANSFIELD ROBINSON, Town Clerk.

Shoreditch Town Hall, Old-street, E.C.,
February, 1906.

---

## FACTORIES & WAREHOUSES TO LET & WANTED.

TO ENGINEERS AND OTHERS.

OFFER is made of a SITE, free of cost, of from two to 10 Acres, to engineers or manufacturers contemplating erection of works Site is FREEHOLD, and alongside main line of two of largest railways.—Address, for further particulars, OWEN B. THOMAS, Solicitor, 59, Chancery-lane, London.

GOSWELL ROAD.—FACTORY and STABLING, near the Angel. Large two-floor building, with chimney shaft, hitherto used for stabling on first floor, and vehicles beneath, but suitable for any manufacturing purposes.—Detailed particulars of P. BARNETT, 56, Moorgate-street, London, E.C.

FREEHOLD FACTORY to be LET or SOLD. Substantial modern building, 51 ft. frontage, main Harrow-road. Good light, back and front.—For particulars apply to HOLLAND & HOLLAND, LIMITED, Gunmakers, 98, New Bond-street, London, W.

SITES FOR WORKS.—FACTORY SITES FOR SALE, very choice positions in Leeds, Hull and Tadcaster. Many of these sites have railway frontages, and some have railway sidings, good water supply, and the price is very low.—For plans and particulars apply J. W. WATSON, Estate Offices, 21, New Station-street, Boar-lane, Leeds.

FACTORIES AND WAREHOUSES TO LET continued on p. xvi.

### THE BOURNEMOUTH AND POOLE ELECTRICITY SUPPLY COMPANY, LIMITED.

NOTICE is Hereby Given that the TRANSFER BOOKS and REGISTER of MEMBERS will be CLOSED from the 6th to the 14th FEBRUARY, 1906, both days inclusive, preparatory to the payment of the Dividends due on the 4½ per cent. Preference and 6 per cent. Second Preference Shares of the Company for the half-year ended 31st December, 1905.

By order,
H. B. RENWICK, Secretary.

Moorgate Court. Moorgate-place,
London, E.C., 30th January, 1906.

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**ELECTRICAL WORKERS.**

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# THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,446. [No. 16. Vol. LVI.] FRIDAY, FEBRUARY 2, 1906. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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## NOTES.

◆

WE close this week our series of Tables of Electric Supply and Traction Undertakings of the United Kingdom with a supplement sheet containing details with regard to the electric railways and tramways. This sheet is divided into three tables. The first (Table IV. of the series) relates to the 114 tramways which are supplied from combined lighting and traction stations; the second (Table V.) to the smaller number, 47, with their own power houses; and the third (Table VI.) to electric railways, of which there are now 10 in operation and 5 more under construction. The tramways and light railways under construction number 9, and particulars of these are also given on the sheet, as well as the schemes still in the "projected" stage and a reference table giving the names of the tramways serving various towns. The tendency of supplying tramways and lighting from one works still continues to find favour, for, while Table IV. is increased by 11 entries. There are only two additions to Table V. The 114 "combined" stations supply 1,190 miles of route (1,860 miles of single track), and the 47 tramways of the latter class have a mileage of 780 miles of route, equivalent to 1,180 miles of single track. The former tramways possess 5,060 cars and the latter 4,360. To conclude this note, a comparison of the total mileages with last year will doubtless be found interesting. On January 1, 1905, there were 1,770 route-miles of tramways in the country, equivalent to 2,740 miles of single track. On January 1, 1906, there were 1,970 route-miles, equivalent to 3,040 miles of single track,—an increase of about 11 per cent. in each case. Last year there were 106 route-miles of electrically-equipped railway, equivalent to 212 miles of track; this year 150 route-miles, or 285 miles of single track, an increase of 41 and 34 per cent. respectively.

◆

Mr. FELL'S Paper on brakes attracted the best attendance that has been seen at a meeting of the Tramways and Light Railways Association since the memorable fiscal discussion. The Paper was well worthy, not only of that mark of distinction and the practical and useful discussion which we report in this issue, but of much more careful study than could have been devoted to it by either hearers or speakers. Its chief value lies in the tables of tests of various brakes, and of the same brakes under varying conditions upon a particular length of track. The provision of good recording instruments on the cars eliminated as nearly as may be the errors due to personal equation, and the results may therefore be compared with considerable confidence. Such discrepancies as present themselves are probably due to those differences of rail surface, which vary with the weather and cannot be standardised for experiments necessarily limited to a few hours in each week. At present the records stand as the best available data on the performance of tramway brakes. In view of the importance of reliable brakes, especially under London conditions, in the prevention of accidents, and the reduction of lost time, the expenditure on these tests was well warranted, and Mr. FELL must be thanked for taking the trouble to publish the results to his colleagues.

◆

THE most striking result is the superiority of the magnetic track brake of the new pattern. Provided that sufficient pressure can be applied to it, a track brake of any pattern has a greater range than wheel brakes, which are limited by the adhesion. As soon as the retarding force exceeds adhesion, skidding occurs and the retardation immediately falls. As the adhesion available depends upon the surface condition of the rail, it follows that wheel brakes are variable and uncertain in action—the loss of braking effect by skidding is the common cause of runaway car accidents, and of most collisions between tramcars and other vehicles.

◆

THE effect of the track brake is only limited by the pressure that can be applied and the coefficient of friction available. Mechanical track brakes may theoretically carry any pressure up to the full weight of the car, but such a limit is never approached because of the risk of derailment, and the loss of wheel-brake power. Whatever weight is taken by the slippers is taken from the wheels. The magnetic brake has the peculiarity that it does not take weight off the wheels, as the pressure is entirely due to magnetic pull. It may thus conceivably exceed the car weight, but the full weight is in any case available for wheel braking. It is here that the magnetic brake scores over the mechanical as regards available retarding power. Rapidity of application is another important advantage. The hand-applied track brake is, in effect, a jack, by which the driver raises the car more or less, and is for that reason slow in application. It is in fact only fit for keeping car speeds under control on the descent of long inclines, but for that purpose is an excellent and reliable device. Theory and practice were both represented in the oral discussion following the delivery of the Paper, and the whole report merits careful study by the engineers and managers of tramways.

◆

NOISY tramcars have disturbed the peace of Ealing, and the Board of Trade, attending to the Town Council's complaint, investigated the matter in the person of Col. YORKE, as reported in our last issue. Loose and rattling brake gear account for part of the trouble, an example of oversight in inspection of a rather too common kind. Such things as gear cases and dust guards make a noise altogether disproportionate to their importance if allowed any chance of rattling, and are overlooked in the shed from the cars being examined at rest only or from heedlessness. The irritation produced by these janglings is not realised by the average shed foreman, but he can be taught. Loose and low rail joints are more difficult to remedy. The elimination of joints by one of the welding processes seems the most hopeful resource. The corrugation trouble is the most persistent of the noise producers, and its cure the most tedious and expensive. Exact and frequent attention to the wheel gauge of cars may delay the onset of the disease and retard its spread, but prevention will probably be achieved only by a modification in the composition and quality of the rails. The tramcar kept in good order, on a well-laid and maintained track, is a quieter vehicle than any other of equal capacity, hence the gong. It must not lose its character by slackness of management.

◆

SINCE that pioneer in electric traction, Mr. FRANK J. SPRAGUE, broke a lance in favour of high-tension continuous-current traction for railway work some weeks ago in an open letter addressed to the electrical press of America, a wordy warfare has been, and is still being waged between the advocates of continuous-current and alternating-current traction. Side by side with the mutual personal attacks into which the open correspondence between the various groups of vested interests has degenerated of late, there is to be found some valuable comparative information which helps to draw the line of demarcation between the fields best suited to either system. Such an article was recently contributed to the *Street Railway Journal* by Mr. B. G. LAMME, and from it we have culled the interesting passages relating to the limitations of high-tension continuous-current traction. This abstract will be found on p. 637 of this issue. Few are able to speak more authoritatively on the subject, for Mr. LAMME, though now best known as the Westinghouse Company's expert for single-phase traction, has in the past been closely associated with continuous-current work. The greatest hindrance to the introduction of high-tension continuous-current traction is stated to be the increased liability to flashing at the motors and at the rotary converters at the sub-stations. Since, however, the author generously describes means for overcoming these difficulties we do not think that he has proved his contention—viz., that 1,500-volt traction motors are at present out of question. We might recall here the tests made by Messrs. J. J. Rieter & Co. on some 90 H.P. traction motors which were run successfully at voltages up to 1,700 volts (see *The Electrician*, November 17, 1905, p. 188). True, the tests were carried out in the test shop, but the mere fact that a considerable number of these motors are now being built for the Bellinzona-Mesocca electric railway, with a pressure of from 1,500 to 1,600 volts between trolley wire and earth, inspires confidence in their success under working conditions.

**Personal.**—Mr. H. A. Wilson, D.Sc., M.A. (Cambridge) has been appointed Professor of Physics at King's College, London, in succession to Prof. W. Adams.

**Congress of Scientific Societies.**—The 44th Congrès de Sociétés Savantes will be opened at the Sorbonne on Tuesday, April 17th, at 2 p.m. It will be held till the Friday, and on the Saturday it will be concluded by a meeting in the great Amphitheatre of the Sorbonne, presided over by the Minister of Public Instruction and the Fine Arts.

**Cable Interruptions and Repairs.**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Tarifa—Tangier | Jan. 18, 1904 | — |
| Jamaica—Colon | Jan. 10, 1905 | — |
| Cadiz—Teneriffe | July 20, 1905 | — |
| Puerto Plata—Martinique | Dec. 15, 1905 | — |
| St. Thomas—St. Kitts | Dec. 29, 1905 | Jan. 30, 1906 |
| Bolama—Bissao | Jan. 19, 1906 | — |

**Private Bills in Parliament.**—No proceedings of importance have taken place before the Examiners of Standing Orders in Parliament during the week. A number of electrical bills have been passed and reported for first reading. It may be mentioned that when the London and Brighton Motorway bill was called yesterday no appearance in support of it was made, and the bill will accordingly not be proceeded with this session.

**The Simplon Tunnel.**—In view of the statements which have appeared in some of the daily papers that the Simplon Tunnel had been opened for traffic, we think it well to point out that, according to the statement of the London agent of the Swiss Federal Railways, the passenger traffic will not be commenced until the electrical installation is completed in the spring.

**New West Coast of South America Cable.**—The first section of a new cable to serve the west coast of South America has just been successfully laid. The c.s. "Faraday" recently arrived at Iquique from Valparaiso after completing this work The cable will be continued from Iquique to Churrillos (Peru), making the total length 1,681 nauts. The section just completed is 911 nauts long.

**The Tramway Accident in Liverpool.**—Referring to our note in last week's issue on the recent accident on the Liverpool tramway system, we understand that, following on the request of Sir Charles Petrie, the chairman of the Liverpool Tramway committee, Colonel von Donop visited Liverpool yesterday for the purpose of holding a Board of Trade inquiry.

**Students' Section of the Institution of Electrical Engineers.**—The second visit of the students' section of the Institution of Electrical Engineers to the Post Office Central Telephone Exchange has been postponed from February 10th until March 3rd. The students' meeting arranged for February 14th has been postponed, and the annual students' dinner will be held on February 15th at the Holborn Restaurant, at 7 p.m. for 7:30 p.m.

**Junior Institution of Engineers.**—On Friday, January 26th, Prof. J. D. Cormack delivered the honorary member's lecture before the Institution of Junior Engineers at Westminster Palace Hotel, taking for his subject "Notes on Boiler Trials." After pointing out the objects and uses of such trials he set forth the requisite balance-sheet, and indicated the measurements, &c., necessary, and the chief statements to be made. Reference was also made to the system of conducting boiler trials recommended by the committee of the Institution of Civil Engineers. On the following afternoon, Saturday, January 27th, a visit was paid to the engineering laboratories of the University College, Gower-street, where Prof. Cormack demonstrated the methods of conducting a boiler trial, one being in progress at the time. The Pender electrical laboratory was also open to inspection, through the kindness of Prof. J. A. Fleming, F.R.S. About 100 visitors were present.

**Wireless Telegraph Notes.**—In a communication with a typewritten signature, the American De Forest Wireless Telegraph Co. informs us that on January 3rd the De Forest long-distance station at Manhattan Beach sent a message which was correctly received by the operator in charge of their installation at the naval station in Colon, Isthmus of Panama. This distance is 2,150 miles, and, the company states, established a new record for long distance wireless work that has been officially authenticated. The confirmation in this case, the communication continues, comes from Admiral Manney, chief of the bureau of equipment of the navy at Washington, and leaves no room for doubt that this distance has been successfully negotiated. The letter concludes with the remark that it is significant to note that the distance from New York to the west coast of Ireland is but very little greater than to Colon.

According to the *Manchester Guardian*, the wireless telegraph system which has been established between Sörvaagen and Röst in the Lofoten district of Norway will be formally opened in a few days' time.

**Iron and Steel Institute.**—The annual general meeting of the Iron and Steel Institute will be held at the Institution of Civil Engineers, 25, Great George-street, Westminster, London, on Thursday and Friday, May 10th and 11th next. The council will shortly proceed to award Carnegie Research Scholarships, and candidates must apply before February 28th. The awards will be announced at the general meeting. In place of the ordinary autumn meeting, a joint meeting of the American Institute of Mining Engineers and of the Iron and Steel Institute will be held in London on July 23rd-29th. The Lord Mayor of London has kindly consented to act as chairman of the London Reception Committee, and will give a conversazione at the Mansion House on the evening of July 24th. The annual dinner will be held in the Grand Hall of the Hotel Cecil on Friday, July 27th. A full programme will be issued later. Members are invited to take part in the Sixth International Congress of Applied Chemistry to be held in Rome from April 25th to May 3rd. One of the sections of the Congress is devoted to metallurgy, and among the excursions will be one to the ironworks of the Island of Elba. The subscription to the Congress is 16s.

**Electricity Supply in Paris.**—In our issue of December 8th last we reviewed the present position of electricity supply in Paris. It will be remembered that the companies supplying there hold concessions which will expire shortly, some on April 8, 1907, and others at different dates up to December 11, 1908. It is therefore necessary that arrangements should be made to ensure continuity of service after these dates. After prolonged deliberation and the consideration of tenders and offers from the present companies and others, a report was submitted by the Prefect of the Seine (M. de Selves) recommending the acceptance of an offer made by the Société pour l'Exploitation de l'Energie Electrique à Paris (a syndicate formed by the two large electrical companies, Schneider & Co. and Mildé & Co.) to take over the whole supply under agreement with the companies now working. Apparently this recommendation has not been accepted, for the last issue of the *Industrie Electrique* contains an announcement to the effect that the Paris Municipal Council invites "offers or propositions" relative to the organisation of the future electricity supply service in Paris, either including a service of a temporary nature for the first few years, utilising possibly the plant of the present companies, or on the basis of the future service independent of any "transitional" period. Offers are to reach M. de Pontich, Directeur Administratif des Travaux de Paris, at the Hôtel de Ville, on or before March 1st next.

**City & South London Railway.**—Sensational accounts have appeared in some sections of the daily press with regard to a slight mishap on the City & South London Railway on Thursday night last week, and we are glad to be able to state that the incident was of a comparatively unimportant nature. The real circumstances were as follows: The driver had a difficulty in keeping his automatic circuit breaker in when running in full parallel, and so came back a few steps on the parallel resistance, in which position he ran between a few stations. Between the Oval and Stockwell this resistance, which is not designed for constant running, got so hot that the solder in the terminals became soft and caused some arcing just below the switch. This led to short circuiting between the resistance and cables and necessitated cutting the current off the locomotive. The emergency tunnel lights were switched on within a few moments of the time the current was cut off from the train, and another locomotive was sent from the Oval which pushed the train into Stockwell Station. Unfortunately, the driver became a little excited, and but for this the passengers or public would not have been aware that anything out of the ordinary had happened. The City & South London Railway system is one particularly free from danger from tunnel fires. The use of separate locomotives renders the transmission of fire to the train almost impossible, and the small amount of combustible material limits any fire on the locomotive to infinitesimal proportions. Another advantage of the arrangement is the promptitude with which a spare locomotive can be on the spot to remove a disabled train. The emergency lights in the tunnels are also valuable in allaying any tendency to panic.

**Obituary.**—We regret to record the death of Monsieur Jules Despecher, which took place in Paris on the 27th instant, in his 84th year. In his early life M. Despecher was engaged in connection with wine growing in California, and afterwards promoted a company which chartered the "Great Eastern" to bring passengers from New York to the Paris Exhibition of 1868, in connection with which undertaking he made the acquaintance of the late Sir James Anderson, who was then in command of that vessel. He became later the representative in Paris, to the French Government, of the Telegraph Construction & Maintenance, the Eastern Telegraph, Anglo-American Telegraph and other cable companies. In the early days of these enterprises he took a very important part in negotiating concessions for various submarine lines, and was well known in most European capitals, which he frequently visited in the course of his duties as Continental agent. M. Despecher attended, as delegate of Cable Companies, all the International Telegraph Conferences held since that of Vienna in 1868, including the last conference held in London in 1903. He had practised as a civil engineer, and was Chevalier of the Royal Order of the Crown of Italy, Commander of the Military Order of our Lady of the Conception of Villa Viçoza, besides holding several other foreign orders. M. Despecher was a diplomatist of the first order, and was well known and cordially regarded by a wide circle of friends in various parts of the world. Some years ago he retired to a considerable extent from active service. The funeral took place in Paris on 30th ult., and was attended by a large number of relatives, friends, and representatives of submarine telegraph cable interests.

**Single-Phase Traction in the Sarnia Tunnel.**—The Sarnia tunnel of the St. Clair Tunnel Co. passes under the St. Clair river and connects the divisions of the Grand Trunk Railway system which terminate at Port Huron, Mich. (U.S.A.) and Sarnia, Ont. (Canada). The tunnel proper is 6,032 ft. long. A single track leads through the tunnel, but the approaches are double track to a point about 300 ft. from each portal. From terminal to terminal, a distance of 19,348 ft., the line is to be equipped with the Westinghouse system of single-phase traction in accordance with plans and specifications prepared by Mr. Bion J. Arnold, of Chicago. At the present time passenger and freight trains arriving from either direction are hauled through the tunnel by steam locomotives. Almost all of the freight trains must be divided on arrival, as they are too heavy for a single locomotive. The equipment includes a complete power station with steam turbines, bridge and pole lines for catenary trolley construction, overhead work, transformers for power and light, motor-driven pumps, drainage and sewer systems for buildings and yards, electric locomotives, &c. Each of the six locomotives to be supplied will exert a drawbar pull of 25,000 lb. at a speed of 10 miles per hour. The locomotives may be operated from either end, and two or more may be coupled together and controlled in multiple from a single unit. These locomotives are of the rigid frame type, with driving axle boxes and draft gear mounted on the same frame. Each unit will have three pairs of 62 in. driving wheels with a motor on each axle connected with a gear reduction of 18 to 95. It will weigh approximately 62 tons. Equaliser beams similar to those used in standard steam locomotive practice will distribute the weight among the six drivers. The frames will be made of cast steel and will be placed outside the wheels. The power equipment of each unit is to comprise three 250 H.P. single-phase series motors. Pneumatically-operated trolleys of the pantagraph type will collect the current from the overhead trolley line outside the tunnel. Alternating current at 3,000 volts 25 ∿ per sec. will be delivered to the locomotives. Outside the tunnel the current will be fed through a No. 0000 grooved trolley wire hung by a catenary suspension from steel towers which span the track or from bracket arms mounted on lattice-work poles of steel.

**The Association of Technical Institutions.**—At the 13th annual meeting of the Association of Technical Institutions, held at the Fishmongers' Hall on Friday last, Sir William Anson (late Parliamentary Secretary to the Board of Education) delivered his Presidential Address, after having been introduced by the retiring president, Sir Philip Magnus. In the course of the address the speaker expressed the wish that the educational authorities would realise that education did not consist of libraries, laboratories and a curriculum, but had mainly to do with teachers and students, and that this wanted, above all things, teachers who could so teach as to show the students how to learn. He urged the importance of the study of languages, disagreeing with the view that languages, dealing with words and not things, trained the memory and not the intelligence. He also referred to the usefulness of the recent report issued by the Association on the co-operation of employers with technical institutions (see *The Electrician*, December 15th, p 335). This subject was further considered at the continuation of the meeting on Saturday, when a Paper by Prof. W. Ripper was read containing some comments on the report suggested by his own experience, fully urging the importance of an *entente cordiale* between employers and technical institutions. An interesting appendix followed on the best method of arranging the period of college and workshop training for technical day students. Prof. Ripper's view was that the answer to the question of whether the college training should, precede or follow the workshop experience depended very much upon the circumstances and conditions of the student himself, so that either method might be the best in any particular case. He was, however, strongly inclined to favour the third method, much approved in the Glasgow district, of attendance at works and college concurrently. In the discussion which followed, Mr. Alexander Siemens, after objecting to employers being treated as if they did not know their own interests, expressed his preference for the student having his technical training before he entered the works, and for a proper training he recommended the young man to devote himself to day training. Another Paper, on "Systematisation of Homework in the Evening Classes of a Technical Institute," was read by Mr. F. C. Forth, of Belfast, and the proceedings terminated with a vote of thanks to the Fishmongers' Company for the use of their hall.

**Recent Progress with Electrical Automobiles.**—The recent "Automobile" number of *Scientific American*, although dealing chiefly with petrol cars, contains an interesting article on the electrical automobile. Considerable improvements have been lately made with both batteries and motors, and it is now said to be possible to construct pleasure vehicles to consume only 50 watt-hours per ton-mile at 15 miles per hour, or about one-third of that required a few years ago, and batteries are now obtainable giving 15 to 18 watt-hours per pound, as against 8 or 9 watt-hours formerly the usual limit. Cars are now on the market with a guaranteed mileage of 85 on one charge, but for exhibition purposes as much as 130 miles has been accomplished. It is stated that a year of service can now be assured before replacement of positive plates becomes necessary and a set of negative plates will usually outlast two sets of positives. With regard to batteries other than the lead type there has been no great advance. The lead-zinc battery, if ever perfected, would show some advantages owing to its high voltage (2·5 volts per cell) and its light weight (25 watt-hours per pound). The Edison battery has shown some promise, but suffers seriously from loss of capacity under the action of cold. Chains are replacing spur gearing for transmission, two motors being employed for all but the very smallest vehicles. The batteries are, wherever possible, connected permanently in series to avoid inequality in the discharge of different cells, and the general tendency is to employ lower voltage batteries than were formerly usual, such as 12 to 24 cells. Mention is made of the increase of business and commercial vehicles for town use, which is, however, more noticeable in America than in this country. In connection with this subject some figures quoted by *Electricity* of New York for the cost of running an electric waggon of 2.000 lb. carrying capacity, averaging 30 miles per day for 288 working days in the year, are of interest. The particular type of waggon would cost about $2,500 with a set of 3½ in. solid rubber tyres. The following costs per annum are given for battery maintenance: New positive plates, $155; new negative plates, $84; new wood separators, $26.1; rubber separators, $4.55; rubber jars, $21.70; labour in connection with battery, $65; supplies and other expenses, $48.5; total, $404.85. To show what proportion this would form of the total expenses, the following figures are given: Battery maintenance, $404.85; tyre maintenance, $180; cost of charging current, $122.7; general repairs, $73.1; depreciation, $182.7; interest on investments, $125. This gives a total of $1,088.35, or $3.78 per day.

**The Automobile Exhibition at the Crystal Palace.**—Some representatives of the Press and other friends were entertained to lunch on Friday last by the promoters of the Crystal Palace Automobile Exhibition, Mr. Ernest Schenk, the chairman of the Crystal Palace Co., presiding. The Sydenham building has some advantages for displaying the merits of motor vehicles to intending purchasers, notwithstanding the poorness of the railway service. Following so soon on the show at Olympia, however, it was impossible for the exhibition to be anything like so large as it was a few years ago, when the principal display of the year was held at the Crystal Palace. A slight increase in the number of exhibits over last year is apparent, but the show cannot in any sense of the word be described as representative. It seems a pity that these minor exhibitions should continue to be held when the automobile trade as a body has so unmistakably declared itself in favour of only one London exhibition in each season. The only jusification of several shows in the year would appear to be a division of the commercial, private vehicle and motor boat sections rather than the multiplication of shows containing all three branches. Of the electrical features of the exhibition, the Kriéger Electric Carriage Syndicate have a stand of their well-known carriages, with their patent system of front drive, but they are not showing the combination petro-electric vehicle alluded to in our columns in connection with the Paris show. The capacity of their four-seated cars on one charge is stated to be about 45 miles. With regard to electric ignition systems, opinion seems to be about equally divided between the high-tension and low-tension magneto systems, and we are pleased to see makers beginning to show greater confidence in the magneto by discarding the auxiliary battery and coil, until lately usually carried as a stand-by and used with separate plugs. Magnetos are placed in more accessible positions than formerly, and are now almost universally driven by enclosed gearing instead of chains, as was sometimes done in the past. Various small electrical accessories, such as lamps and push-button indicators for communication with the driver are shown, but no striking novelty is apparent. The catalogue contains an alphabetical list of exhibitors, but, in common with most publications of this kind, is not provided with a subject index, so that a visitor desiring to inspect any particular kind of car or accessory cannot see at a glance which stands will be of interest to him.

**High-Speed Electrical Machinery.**—The second Howard Lecture delivered at the Society of Arts on January 25th by Prof. Silvanus P. Thompson was devoted to questions affecting the design of turbo-dynamos for continuous currents. He commenced by pointing out that the crux of the whole problem in all high-speed continuous-current generators was satisfactory commutation except in the case of the "homopolar," or, as it is often incorrectly termed, "unipolar" type. The lecturer reviewed the difficulties attending the determination of the reactance of current-carrying armature coils embedded in slots in a characteristically clear manner, and pointed out how one of the chief factors determining the absence of sparking was the duration of the period of commutation. It was shown how the introduction of the carbon brush had made all the difference between success and failure in this direction, for "natural commutation" was only made possible within wide limits of working by the peculiar properties of the contact resistance of carbon and copper, and a full set of curves showing the variation in its value with current density and speed were thrown upon the screen. The lecturer was emphatic in his condemnation of the method sometimes proposed of putting resistance in the connections between armature coils and commutator, which was clearly proved to have no effect on sparking. He amused the audience, however, by likening the effect of reactance to the pure ideal of conservatism, which, according to his statement, opposed all change. A number of the formulæ used by past and present designers, with more or less success, as a criterion of the sparking limit, were given, special reference being made to Prof. E. Arnold's work in this direction. The subject of forced commutation, although of greater importance in high-speed machines, was not so fully dealt with, the lecturer passing on to slides of actual machines with only a very brief mention of the way in which the commutation difficulties at high peripheral speeds had been overcome by providing auxiliary poles, which produced an opposing flux at the right moment to accelerate the reversal in the armature coil. A number of Parsons continuous-current turbo sets were shown, both of the earlier and more recent types. It was mentioned how the introduction of auxiliary commutation poles had improved these machines, but no reference was made to the remarkably ingenious system used by Parsons until comparatively recently, when he caused the brushes to be shifted at different loads by variations in the initial steam pressure. Special mention was made of the work of C. E. L. Brown, and a number of photographs of the Brown-Boveri turbo machines with their slotted stators were shown. All these machines used metal brushes, but the Siemens-Schuckert Company, some of whose high-speed sets were illustrated, had introduced a combination system of copper and carbon brushes which was very satisfactory in working. Slides were also shown of De Laval sets and Allgemeine sets with Reidler-Stumpf turbines, and diagrams were given of Oerlikon, Brush and other makes. The British Thomson-Houston Company had built a few continuous-current machines in this country for driving by Curtis vertical turbines. Messrs. Siemens Bros. had also done good work in this direction, although not much of it, at their works at Stafford, and he regretted not being able to show slides of their machines. Referring to the possibility of using carbon brushes alone up to peripheral speeds of 7,000 ft. to 9,000 ft. per minute, the lecturer described the new Morganite brush, which not only had different resistance in the longitudinal and transverse directions, but had a higher resistance at the trailing than at the leading portion. There was, however, another method of dealing with the question, and that was the use of "homopolar" machines, in which there was no commutation at all. The early difficulties of obtaining practicable voltages had been got over by Noeggerath at Schenectady by employing a number of slip rings at each end of the armature, by which the conductors were placed in series (*The Electrician*, Vol. LV., p. 59). Illustrations of a machine of this type driven by a Curtis turbine were shown, and another remarkable homopolar or "acyclic" turbo-dynamo recently made by the British Westinghouse Company from designs of Mr. Miles Walker.

## ARRANGEMENTS FOR THE WEEK.

**(To-day) FRIDAY, February 2nd.**

NORTHAMPTON INSTITUTE ENGINEERING SOCIETY.

*5:45 p.m.* Meeting at the Institute, St. John-street-road, Clerkenwell. Paper to be read: "Electric Traction Controllers and Control Systems," by E. U. Pannell.

JUNIOR INSTITUTION OF ENGINEERS.

*8 p.m.* Meeting at the Westminster Palace Hotel. Paper to be read: "Some Recent Electrical Engineering Measuring Instruments," by Kenelm Edgcumbe.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse by Prof. Silvanus P. Thompson, F.R.S., on "The Electric Production of Nitrates from the Atmosphere."

**SATURDAY, February 3rd.**

INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.

*10 a.m.* Visit to the Great Western Railway Lighting Installation, Paddington. Meet under clock, No. 1 platform, Paddington.

INSTITUTION OF ELECTRICAL ENGINEERS: GLASGOW LOCAL SECTION.

*7:30 p.m.* Annual Smoking Concert in the Banqueting Hall of "The Grosvenor," Gordon-street, Glasgow.

**MONDAY, February 5th.**

SOCIETY OF ENGINEERS.

*7:30 p.m.* Meeting at the Royal United Service Institution, Whitehall, London. Mr. Nicholas J. West will deliver his Presidential Address.

INSTITUTION OF ELECTRICAL ENGINEERS: NEWCASTLE LOCAL SECTION.

*8 p.m.* Meeting at the Armstrong College of Science. Papers to be read: (1) "The Electric Wiring of Small Buildings during Course of Erection," by R. E. Robson; (2) "Electric Ignition for Motor Cars," by Frank Little.

**WEDNESDAY, February 7th.**

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. Paper to be read: "Progress in Electric Lighting," by Leon Gaster.

**THURSDAY, February 8th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Ordinary General Meeting. Paper to be further discussed: "Technical Considerations in Electric Railway Engineering," by F. W. Carter. The following Paper will also be read: "Crane Motors and Controllers," by Claude W. Hill.

INSTITUTION OF ELECTRICAL ENGINEERS: DUBLIN LOCAL SECTION.

*8 p.m.* Meeting at the RoyalCollege of Science, Dublin.

**FRIDAY, February 9th.**

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER STUDENTS' SECTION.

*7:30 p.m.* Meeting in the Municipal School of Technology, Sackville-street, Manchester. Paper to be read: "Electrical Instruments," by H. A. Carney.

INSTITUTION OF CIVIL ENGINEERS: STUDENTS' SECTION.

*8 p.m.* Meeting at 25, Great George-street, Westminster. Paper to be read: "Electric Driving at the Locomotive Works of the North London Railway," by R. H. Mackie.

**SATURDAY, February 10th.**

JUNIOR INSTITUTION OF ENGINEERS.

*6:30 for 7 p.m.* Twenty-second Anniversary Dinner at the Hotel Cecil.

## THE KINGSWAY SHALLOW-TUNNEL TRAMWAY.

As our readers will be aware from recent notes in this journal, the electric subway tramway, extending at present for nearly three-quarters of a mile along Kingsway and Aldwych, has already passed the usual Board of Trade inspection, and a regular tram service between the Kingsway station (near the Strand) and the Theobald's-road end of the northern portion of the London County Council's electric tramway system will be commenced as soon as the cars, now due, arrive from the makers.

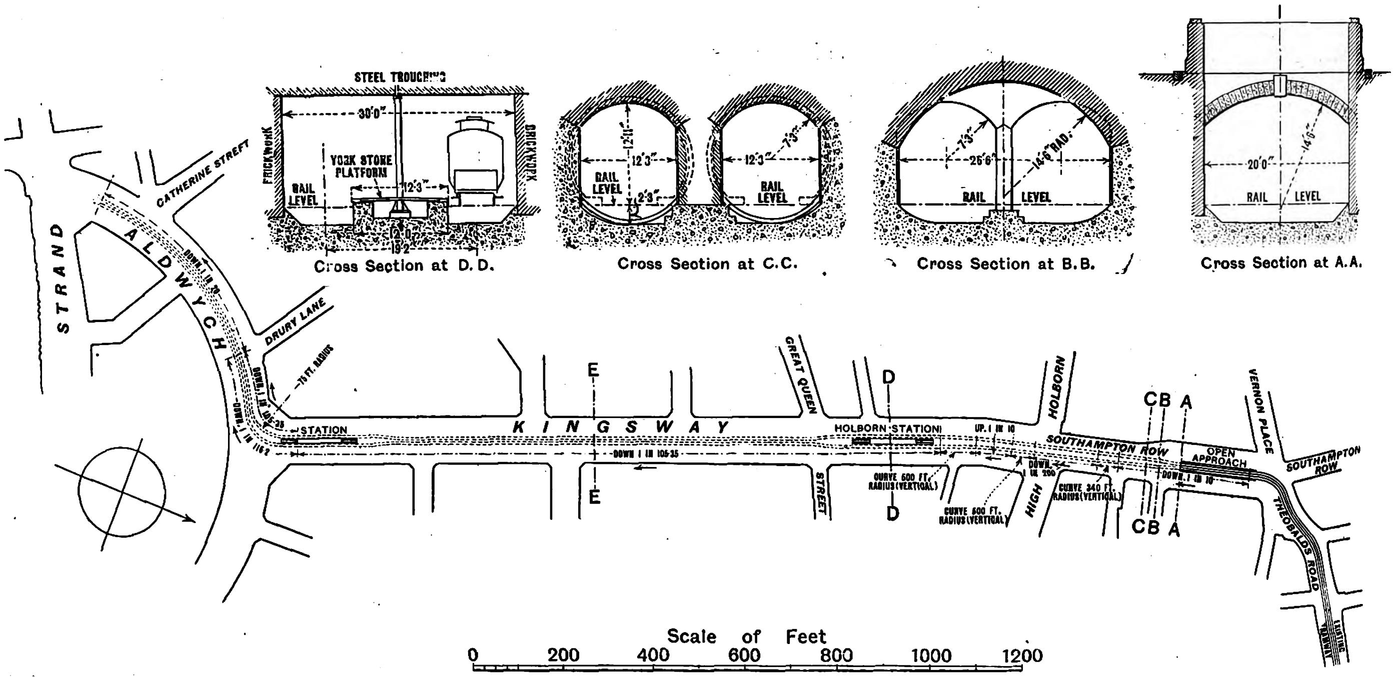
STEEL TROUGHING
30'0"
BRICKWORK
YORK STONE PLATFORM
RAIL LEVEL
12'3"
12'0"
19'2"
Cross Section at D.D.
12'11"
12'3"
7'3"
2'3"
RAIL LEVEL
Cross Section at C.C.
7'3"
25'6"
14'6" RAD.
RAIL LEVEL
Cross Section at B.B.
20'0"
14'6"
RAIL LEVEL
Cross Section at A.A.
STRAND
CATHERINE STREET
ALDWYCH
DRURY LANE
75 FT. RADIUS
STATION
KINGSWAY
E
E
GREAT QUEEN STREET
D
D
HOLBORN STATION
UP. 1 IN 10
DOWN 1 IN 105·35
CURVE 600 FT. RADIUS (VERTICAL)
CURVE 340 FT. RADIUS (VERTICAL)
HIGH HOLBORN
SOUTHAMPTON ROW
VERNON PLACE
OPEN APPROACH
DOWN 1 IN 10
C B A
C B A
THEOBALDS ROAD
EXISTING TRAMWAY
Scale of Feet
0 200 400 600 800 1000 1200

Fig. 1.—Plan of Kingsway, showing Route of Shallow-tunnel Tramway and various Sections though Tunnel.

The subway, which is the first of its kind in this country, will ultimately be extended beyond its present southern end, near the Strand, to the Thames Embankment.

In brief, the history of the subway is this: The idea of constructing a subway originated at the time the new thoroughfare between the Stand and Holborn was decided on, it being recognised that the difficulties attending the construction under an entirely new road would be comparatively small. A deputation, including Mr. J. Allen Baker, M.P. (the present chairman of the Highways committee), Mr. Alfred Baker (the predecessor of Mr. A. L. C. Fell) and Mr. John Rider (electrical tramway engineer) was then sent to America to report upon the subways in New York and Boston. As a result, the London County Council (upon the recommendation of the Highways committee, of which Mr. J. W. Benn was then chairman) applied to Parliament in 1902 for powers to construct a subway from the Thames Embankment to Theobald's-road, and also—in order to complete the scheme—for powers to connect the Blackfriars and Westminster termini of the southern tramways by a new line over the bridges and along the Embankment. The opposition, however, to the second part of the scheme proved insurmountable, and the curtailed bill, as passed in 1902, conferred powers only for constructing the proposed subway and for running electric trams in it between the Strand and Theobald's-road. The subway under Kingsway and Aldwych was constructed at the same time as the new thoroughfare, but it may be remarked that the portion between the Strand and the Embankment yet remains to be built.

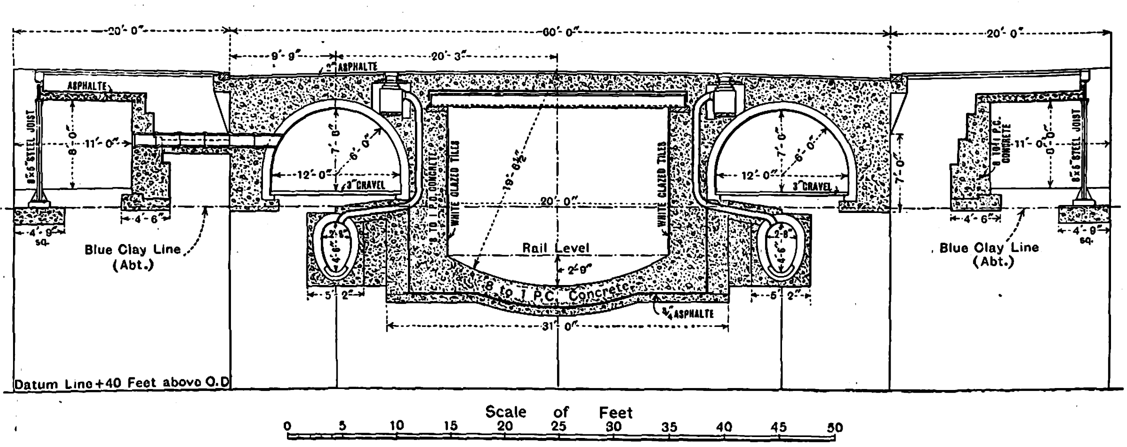
20'0"
60'0"
20'0"
9'9"
20'3"
2" ASPHALTE
ASPHALTE
8"×6" STEEL JOIST
8'0"
11'0"
7'6"
6'0"
12'0"
3" CRAVEL
8 TO 1 P.C. CONCRETE
WHITE GLAZED TILES
19'6½"
20'0"
7'0"
4'6"
4'9" sq.
Blue Clay Line (Abt.)
2'8"
4'6"
5'2"
Rail Level
2'9"
8 to 1 P.C. Concrete
¾" ASPHALTE
31'0"
Datum Line + 40 Feet above O.D
Scale of Feet
0 5 10 15 20 25 30 35 40 45 50

Fig. 2.—Cross-section through Subway and Side Tunnels at E E (Fig. 1.).

The tramway and subway were designed by Mr. Maurice Fitzmaurice, C.M.G., the Council's chief engineer, and were built under his supervision by the Council's works department, of which Mr. G. W. Humphreys is manager. After rising to the surface at Theobald's-road, the cars will proceed along the new route through Rosebery-avenue to Islington.

Fig. 1 is a general plan of the subway. It will be noted that there are two stations, one at the Strand end of Kingsway, the other near High Holborn. At both these stations the platform is only 16 ft. below the street level, and access is easily gained by a flight of stairs at either end of the station. Since the tramcars are to run at frequent intervals, there will be no time left for crowds to gather on the platforms. It will never be necessary to break up Kingsway for the purpose of laying pipes, &c., as ample room for pipes, electric cables and so forth is provided in the pipe subways at both sides of the tramway tunnel (Fig. 2). These pipe subways are connected at intervals by cross subways. At a considerable depth below the subway, the Great Northern, Piccadilly & Brompton tube railway is being built. In constructing the subway between Great Queen-street and Southampton-row, special precautions were taken not to disturb any of the fine buildings, such as the Holborn Restaurant, along the route. Great care was also required to prevent damage to the large sewer running along Holborn, the bottom of which is immediately over the top of the subway.

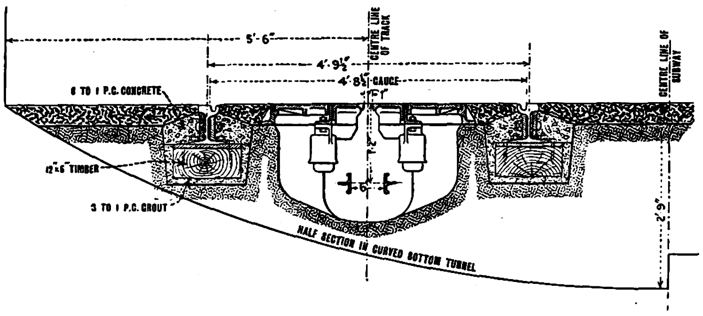

Fig. 3.—Cross-section of Track at Insulator Boxes.

The following general data are of interest:—

| | |
|---|---|
| Length of Kingsway and Aldwych | 1,800 ft. and 1,500 ft. |
| Width of Kingsway and Aldwych | 100 ft. |
| Material excavated in forming the new road and subways | 300,000 cubic yds. |
| Average number of workmen engaged daily upon the work | 250 |
| Amount of concrete used | 83,000 cubic yds. |
| Number of bricks used | 6,300,000 |
| Quantity of granite used | 1,500 tons |
| Quantity of cement used | 15,000 tons |
| Quantity of ballast used | 90,000 tons |
| Quantity of steelwork used | 2,000 tons |
| Quantity of cast iron used | 1,300 tons |

After thus outlining the general scheme, we will proceed to a more detailed description of the subway and its electrical equipment: Cars coming from Islington dip into the subway at the junction of Theobald's-road and Southampton-row through an open cutting in the centre of the street, the gradient here being 1 in 10. This gradient is about 350 ft. long, and is succeeded by a gentler slope of 1 in 200 of about 200 ft. length. Then follows a short rise of 1 in 10, after which the track falls easily (gradient 1 in 105·35) to the Kingsway station. From here to the Strand the gradient is about 1 in 20, and the track turns into Aldwych through a curve of 75 ft. radius, this being the sharpest curve in the subway. Under Holborn and the Strand the subway attains a depth of 31 ft. and 34 ft. respectively below the surface of the road, this being necessary to avoid existing sewers. The greater portion of the subway is close to the surface of the street, however, but in the short length of less than 1 mile between Theobald's-road and the Strand there are several kinds of construction, as indicated by the diverse cross-sections of the subway shown in Figs. 1 and 2. Cast-iron tubes in duplicate are used, for instance, in the deep level portions of the subway, while concrete, brickwork and girder constructions are used in the remainder. Along Kingsway, the depth from the surface of the street to the top of the subway is only 3 ft. In the stations the walls are lined with glazed brick.

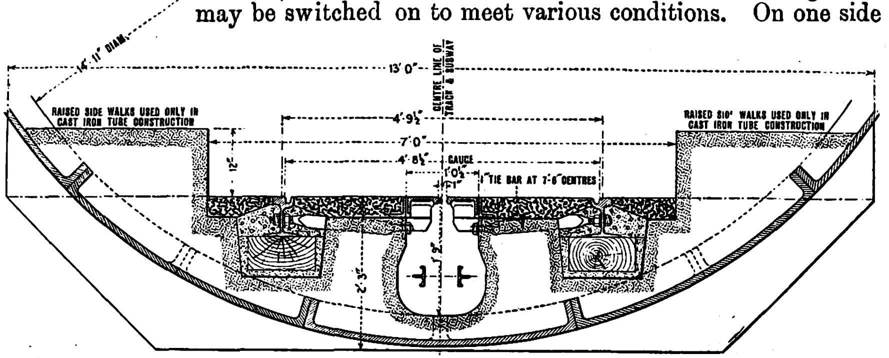
4'-0" DIAM.
13'-0"
CENTRE LINE OF TRACK & SUBWAY
RAISED SIDE WALKS USED ONLY IN CAST IRON TUBE CONSTRUCTION
RAISED SIDE WALKS USED ONLY IN CAST IRON TUBE CONSTRUCTION
4'-9½"
7'-0"
4'-8½" GAUGE
1'-0½"
TIE BAR AT 7'-6" CENTRES
2'-3"

Fig. 4.—Cross-section of Track in Single Tunnel.

Turning to the electrical equipment of the line, it may be mentioned that a somewhat modified form of the conduit system is adopted, which is familiar in connection with the Council's surface tramways. The chief objects in view in designing this modified system were to provide improved means of access to the conduits and their conductors, and, incidentally, to reduce the cost of construction where practicable, these two objects being rendered possible by the absence of vehicular traffic. A full and illustrated description of the L.C.C. tramway system will be found in *The Electrician*, Vol. LI., pp. 9, 112, 159 and 241. The **T** rails in the conduit for conveying the current to the cars are the same as in the surface tramways, but the outer casings of the insulators which support the rails are slightly altered. As will be seen from Figs. 3 and 4, the conduit is formed entirely of concrete, the heavy cast-iron yokes employed in the surface system being dispensed with. The conduit is covered from end to end by steel bulb angles, 7 ft. 6 in. long. These covers can be readily removed by two men by means of suitable keys inserted into holes provided at either end of each cover. To support these covers, channel irons (of a section 6 in. by 2½ in. by $\frac{7}{16}$ in. and about 1 ft. 4 in. long) are embedded in the concrete at right angles to the track. That end of the channel iron furthest from the conduit is anchored by a substantial rag bolt, while the other end protrudes a few inches into the conduit. Cast-iron angle supports are bolted to the protruding ends of the channel irons, and the steel covers themselves are carried on these supports. The arrangement is such that while the covers can readily be removed if required, the slot width is maintained constant throughout. It will be noticed from Fig. 4 that the track rails are secured to gauge by tie bars to a washer plate 6 in. by 4 in. by ½ in. let into the concrete in the inside of the conduit. The width of slot is 1 in., the same as on the northern portion of the conduit tramways.

The track rails are laid on longitudinal wooden sleepers, 12 in. by 6 in. in section of pitch pine, the sleepers themselves being embedded in 3 to 1 p.c. grout. On top of the 5 to 1 concrete forming the conduit and the foundation of the track, there is a 4 in. layer of ballast which is finished off with a layer of 4 to 1 cement. Fish plates of the usual type and sole plates 2 ft. by 1 ft. by $\frac{5}{8}$ in. are used for joining the rails, the spaces between and outside the rails over the 5 to 1 concrete foundation being filled up with 8 to 1 concrete after the rails have been laid and properly joined up. All special track construction was supplied by the Hadfield's Steel Foundry Co. (Ltd.), of Sheffield.

As regards the artificial lighting of the subway, it may be mentioned that each station is lighted by four Davy enclosed arc lamps connected in series across the 500 volt tramway supply in addition to eight three-light fittings containing lamps of 16 c.p. In the tunnels, 16 c.p. incandescent lamps are provided at either side. Each side has its own circuit (controlled from two switchboards at each of the two subway stations) so that one or the other side alone, or both together, may be switched on to meet various conditions. On one side the 16 c.p. lamps are placed at intervals of 90 ft., while on the other side the lamps are nearer together, but are not distributed in a uniform manner. A number of wall plugs have also been fixed at various places in the tunnels. The wiring is in stout galvanised barrel throughout, and all the lamp fittings too are galvanised and of a simple and artistic design.

In order to remove any accumulation of water, electrically-driven pumps are installed at the lowest levels. The pumps are of the centrifugal type with vertical spindles, driven by electric motors of about 5 H.P. each. The motors are put in and out of operation automatically by means of floats which close or open the local circuits, thus causing the controlling apparatus at the subway station to supply current to the pump motors or to switch them out of circuit.

Until the London County Council's own generating station at Greenwich is complete, current for working the subway tramway and for lighting will be supplied by the Metropolitan Electric Supply Co.

*(To be concluded.)*

## ELECTRIC POWER DISTRIBUTION IN NORTH WALES.

(*Continued from page 580.*)

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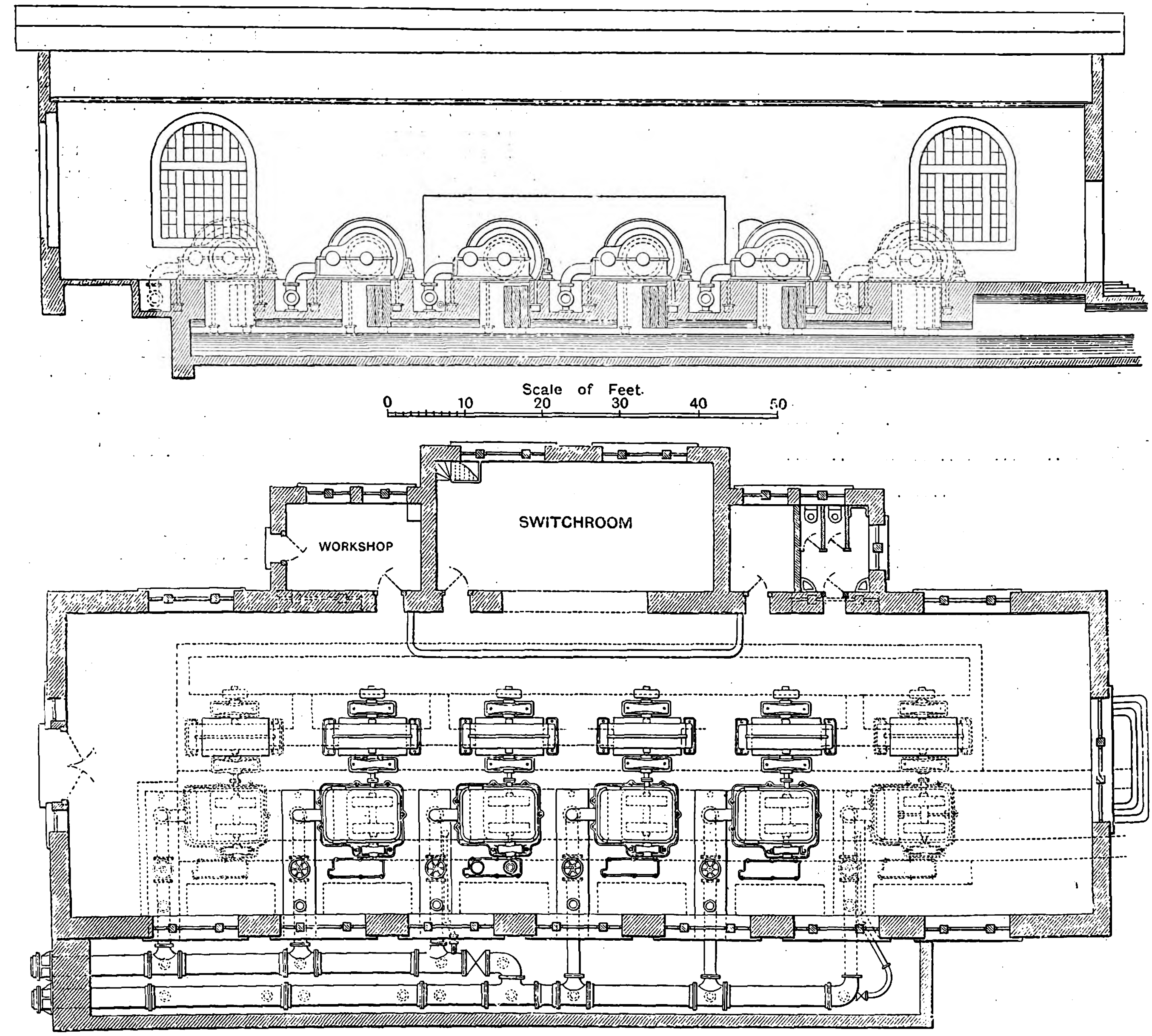


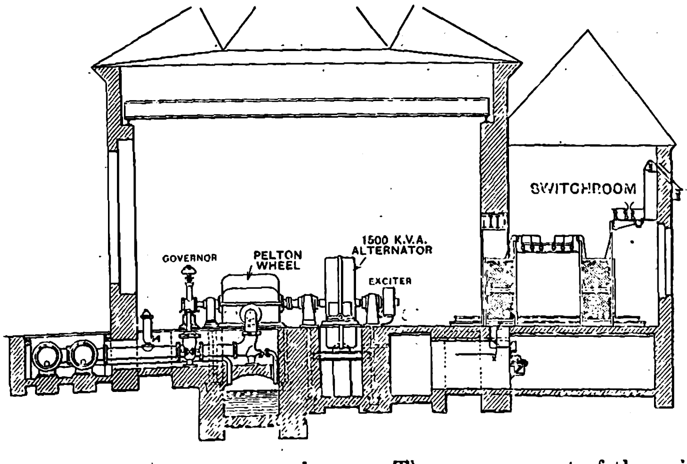


Fig. 8.—Plan, Elevation and Cross Section of Power House.

At the bottom of the pipe line the two pipes are joined, through 27 in. valves, to a double line of pipes in the pipe trench outside the power-house. The arrangement of these is seen in the plan of Fig. 8. Four turbines have been erected, and there is space for two more, shown dotted in the plan. Each pipe will supply three turbines, but there is a valve by means of which the two sides can be connected. The valve of each Pelton turbine is within the power-house, and before this is reached a branch is taken off to the governor. The power-house is a compact building, constructed of local stone, and exceedingly well lighted. Fig. 8 is a general arrangement, and Fig. 9 shows the construction of the turbines. These are Pelton wheels, and have been made by Messrs. Ganz. The shape of the buckets is also shown in Fig. 13, and the nozzles are seen to the left of this illustration. As is seen in Figs. 9 and 13, each turbine contains two bucket wheels, and the supply of water is regulated by screwing the needle of the nozzle up or down, and so enlarging or diminishing the aperture. The nozzles are mounted on trunnions, and are deflected more or less to one side by the action of the governor, when the speed increases above the fixed normal speed, so that some of the water flows directly into the tail race without impinging on the buckets. The governor itself is of the centrifugal type, and when the weights rise a simple lever motion lets water into a hydraulic cylinder, the plunger of which is connected in its turn through levers to the nozzles. The mechanical arrangement is fairly clear from Fig. 9. This hydraulic cylinder is supplied with water from the pipe line, the head of which is, of course, amply sufficient to work it.

Each of the four turbines is directly connected to a 1,500 k.v.a. three-phase generator, and there is an exciter on the main shaft in each case. Owing to the comparatively high speed of the Pelton wheels, 500 revs. per min., the machines are of small size for their output. Each has 12 poles on the revolving field magnet (which serves at the same time as flywheel), so that the frequency is 50 ∿ per second. The exciter voltage is 45, and the field coils of the alternators are of strip wound on edge. It may be noted that there is no switch either in the excitation circuit or in the field of the exciter. Regulation is by a rheostat in the field circuit of the exciter. The alternator voltage is 10,000.

The switchboard has been supplied by Messrs. Ferranti Limited. The switches are of this firm's new oil-break pattern, with handles only in front of the board. They are controlled directly from the hand levers. There are no tripping coils on the generator switches, and of course no fuses, but the feeder switches are fitted with overload release. The feeder and generator boards are back to back, with a

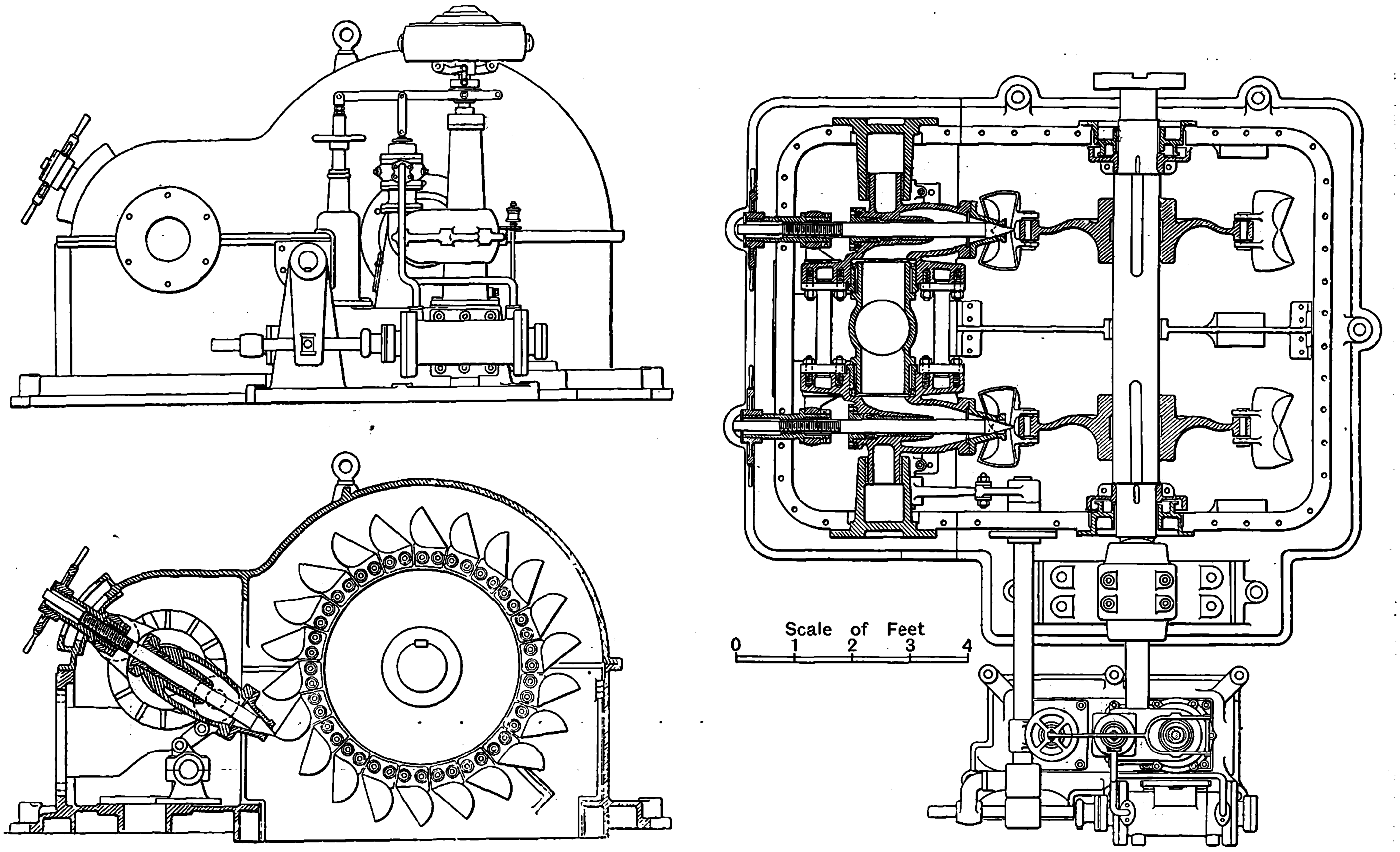
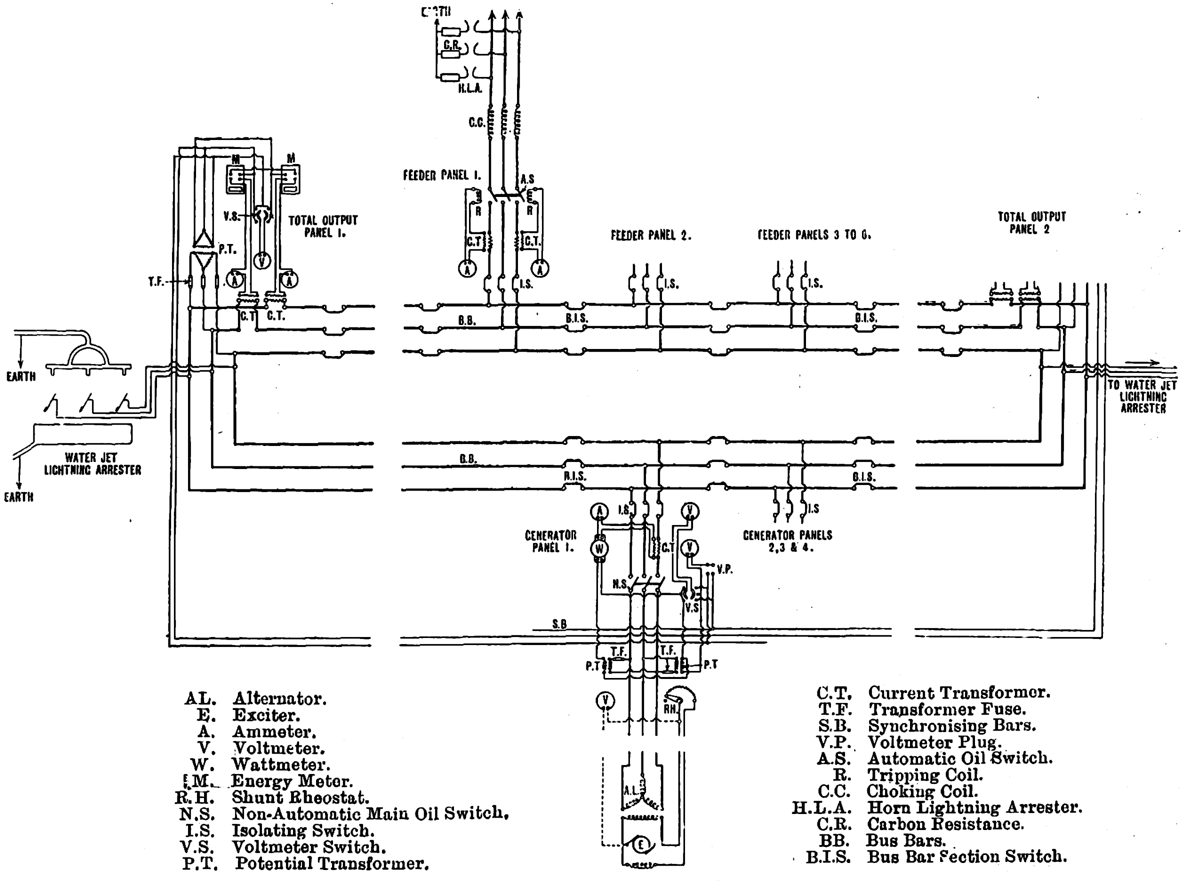

Scale of Feet
0 1 2 3 4

Fig. 9.—General Arrangement of the Pelton Wheel.
Scale 1 : 40.


EARTH
G.R.
H.L.A.
C.C.
FEEDER PANEL 1.
A.S
R
C.T
A
I.S.
M
V.S.
TOTAL OUTPUT PANEL 1.
P.T.
T.F.
C.T.
FEEDER PANEL 2.
FEEDER PANELS 3 TO 6.
TOTAL OUTPUT PANEL 2
B.B.
B.I.S.
EARTH
TO WATER JET LIGHTNING ARRESTER
WATER JET LIGHTNING ARRESTER
EARTH
GENERATOR PANEL 1.
GENERATOR PANELS 2,3 & 4.
V.P.
N.S
V.S
S.B
RH
A.L.
E

| | |
|---|---|
| AL. | Alternator. |
| E. | Exciter. |
| A. | Ammeter. |
| V. | Voltmeter. |
| W. | Wattmeter. |
| E.M. | Energy Meter. |
| R.H. | Shunt Rheostat. |
| N.S. | Non-Automatic Main Oil Switch. |
| I.S. | Isolating Switch. |
| V.S. | Voltmeter Switch. |
| P.T. | Potential Transformer. |
| C.T. | Current Transformer. |
| T.F. | Transformer Fuse. |
| S.B. | Synchronising Bars. |
| V.P. | Voltmeter Plug. |
| A.S. | Automatic Oil Switch. |
| R. | Tripping Coil. |
| C.C. | Choking Coil. |
| H.L.A. | Horn Lightning Arrester. |
| C.R. | Carbon Resistance. |
| BB. | Bus Bars. |
| B.I.S. | Bus Bar Section Switch. |

Fig. 10.—Diagram of Switchboard Connections.

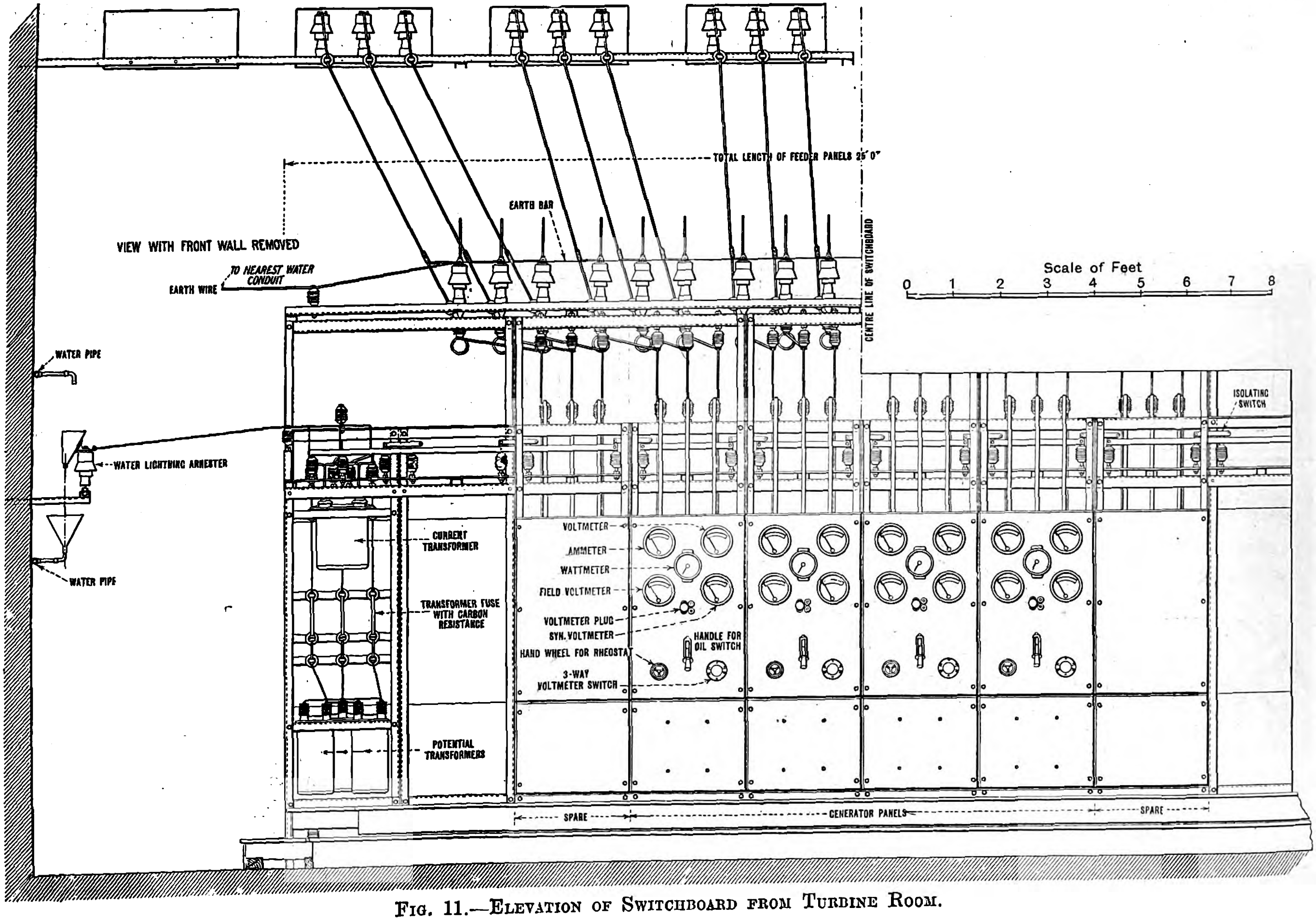

TOTAL LENGTH OF FEEDER PANELS 25' 0"
EARTH BAR
VIEW WITH FRONT WALL REMOVED
TO NEAREST WATER CONDUIT
EARTH WIRE
CENTRE LINE OF SWITCHBOARD
Scale of Feet
0
1
2
3
4
5
6
7
8
ISOLATING SWITCH
WATER PIPE
WATER LIGHTNING ARRESTER
WATER PIPE
CURRENT TRANSFORMER
TRANSFORMER FUSE WITH CARBON RESISTANCE
POTENTIAL TRANSFORMERS
VOLTMETER
AMMETER
WATTMETER
FIELD VOLTMETER
VOLTMETER PLUG
SYN. VOLTMETER
HAND WHEEL FOR RHEOSTAT
3-WAY VOLTMETER SWITCH
HANDLE FOR OIL SWITCH
SPARE
GENERATOR PANELS
SPARE

FIG. 11.—ELEVATION OF SWITCHBOARD FROM TURBINE ROOM.
Scale ¼ in. = 1 ft.

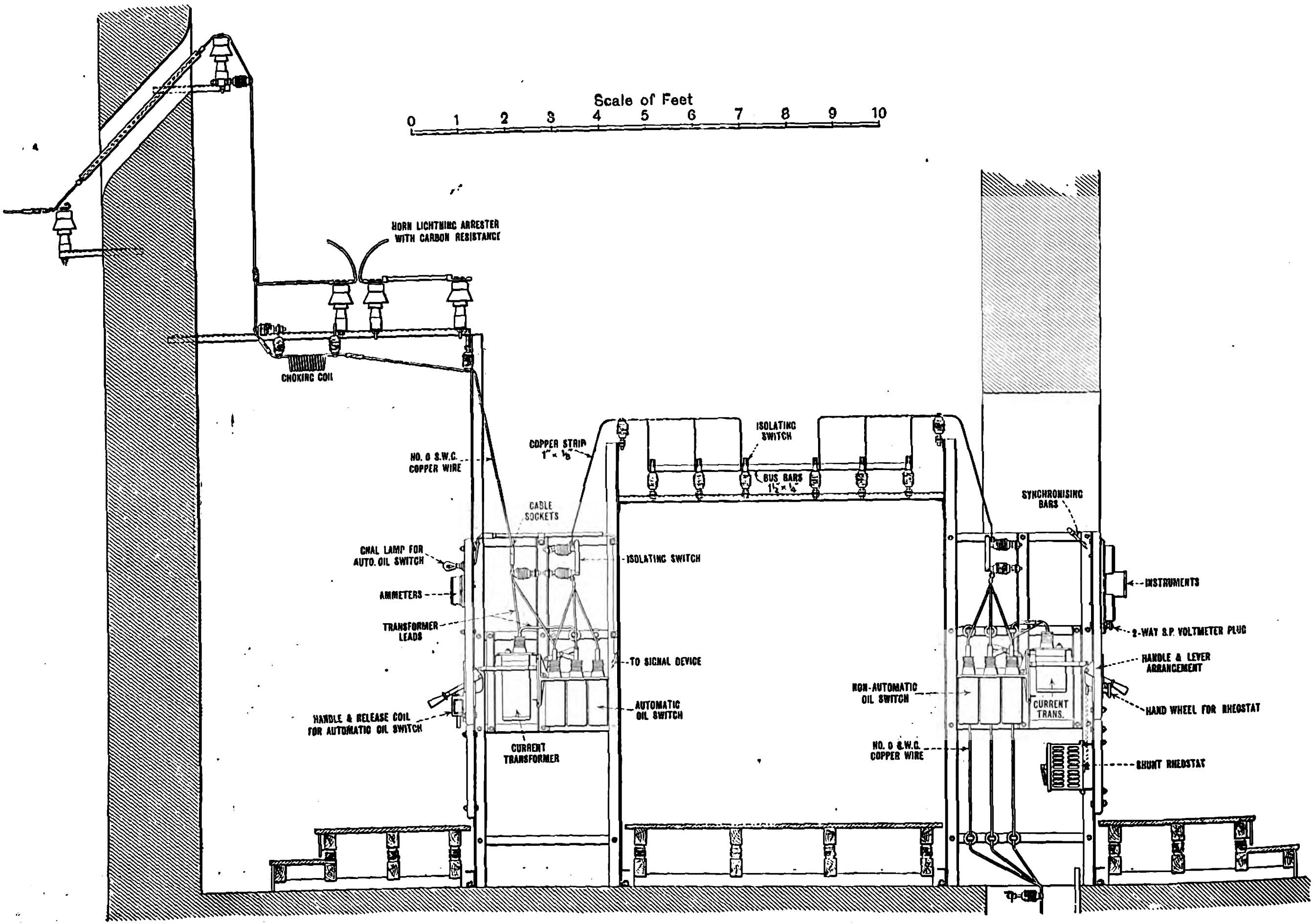

Scale of Feet
0
1
2
3
4
5
6
7
8
9
10
HORN LIGHTNING ARRESTER WITH CARBON RESISTANCE
CHOKING COIL
NO. 0 S.W.G. COPPER WIRE
COPPER STRIP 1" × ⅛"
ISOLATING SWITCH
BUS BARS 1½" × ¼"
SYNCHRONISING BARS
CABLE SOCKETS
SIGNAL LAMP FOR AUTO. OIL SWITCH
AMMETERS
TRANSFORMER LEADS
ISOLATING SWITCH
TO SIGNAL DEVICE
AUTOMATIC OIL SWITCH
HANDLE & RELEASE COIL FOR AUTOMATIC OIL SWITCH
CURRENT TRANSFORMER
INSTRUMENTS
2-WAY S.P. VOLTMETER PLUG
HANDLE & LEVER ARRANGEMENT
NON-AUTOMATIC OIL SWITCH
CURRENT TRANS.
HAND WHEEL FOR RHEOSTAT
NO. 0 S.W.G. COPPER WIRE
SHUNT RHEOSTAT

FIG. 12.—CROSS SECTION OF SWITCHBOARD.
Scale ¼ in. = 1 ft.

space between for the switches, as is clearly seen in Fig. 12, and the generator panels face the turbine room. These are seen in elevation in Fig. 11, and this figure, taken together with Fig. 12, gives a clear idea of the connection to the overhead lines. All the connections between the generators and switchboard are of bare copper wire supported on insulators, with the exception of the cables from the measuring instrument transformers, which are lead covered. The wires from the generators are carried through a subway beneath the floor of the turbine room and switchboard room, and the instrument transformers are also in this basement as seen in the cross-section in Fig. 8. Fig. 10 is a diagram of the switchboard connections, and is self-explanatory. In it only one generator panel and one feeder panel and one total output panel are shown, so as to leave the diagram as clear as possible, but the positions and connections to the remainder are clearly indicated. The 'bus bars form a ring, at each end of which are the total output panels, and the ring can be divided up as desired.

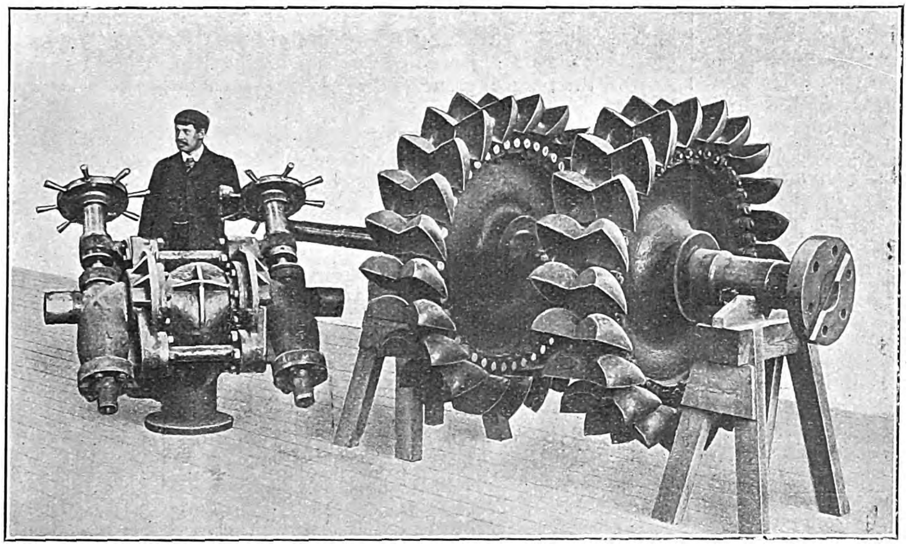
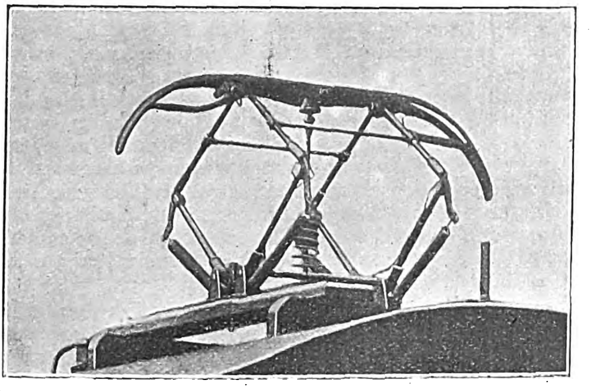


Fig. 13.—Buckets and Nozzles of Pelton Wheel.

(*To be concluded.*)

## A NEW FORM OF PANTAGRAPH TROLLEY BOW.

It will be remembered that the North-Eastern Railway, when "electrifying" the portion of their line between Newcastle and Tynemouth, decided to use locomotives for working their goods traffic on the Quayside branch of the railway. The locomotives were supplied by the British Thomson-Houston Co., the trucks and bodies having been built by the Brush Company. As originally constructed, the locomotives were provided with sliding bow trolleys mounted on the inclined portion at the end of the locomotive. An illustrated description will be found in *The Electrician*, Vol. LIV., p. 47. We understand that the working of these was not all that could be desired, so the engineers of the contracting company determined that to meet the conditions and overcome the faults of the bow trolley, it would be advisable to design a special form of scissors or pantagraph trolley. This type of collector was first applied to overhead wire electric railways by C. J. Van der Pool, in the early days of American electric traction, and was also to be seen on the locomotives of the Baltimore & Ohio Railway, when this line was worked on the overhead system. The special form of collector now employed is illustrated in the accompanying figure. The chief cause which led to the adoption of the pantagraph type of collector in preference to that previously designed for this particular line was the great variation in the height of the trolley wire in different parts of the line, which amounts to as much as 1 ft. 6 in. The new collector readily accommodates itself to this difference in height, and we are informed that it has worked so far with perfect freedom and entire success.



The Pantagraph Trolley Bow on North-Eastern Railway Locomotives.

## A COMPACTLY-ARRANGED STREET PHOTOMETER.

The discussion on Mr. Haydn T. Harrison's recent Paper on "Street Lighting," read before the Manchester Local Section of the Institution of Electrical Engineers, centred very largely around the question of the best form of photometer which was suitable for making street measurements and could give reliable information as to the merits and demerits of different systems of public lighting. The Paper and discussion were fully reported in the numbers of *The Electrician* for December 15th, 22nd and 29th (see pages 351, 388 and 436). It will be remembered that Mr. Harrison finally came to the conclusion that, for most purposes, an illumination measurement is the most satisfactory, provided that this is taken in one direction only, and that the angle of the screen is so chosen that the illumination measurements can be readily converted into candle-power should this be required. He selected an angle of 45 deg. for the screen for various reasons, one of which was that this angle formed a convenient compromise between the horizontal and the vertical, and probably represented more nearly than any other the angle at which the majority of objects to be examined were found.

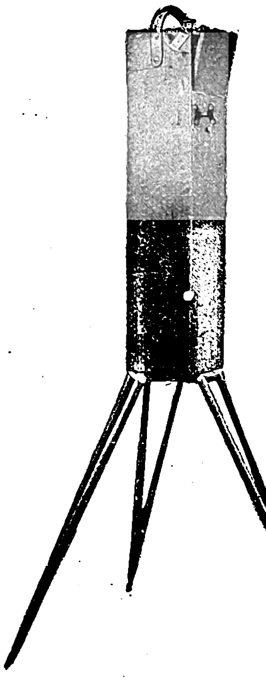


Fig. 1.—Photometer complete.

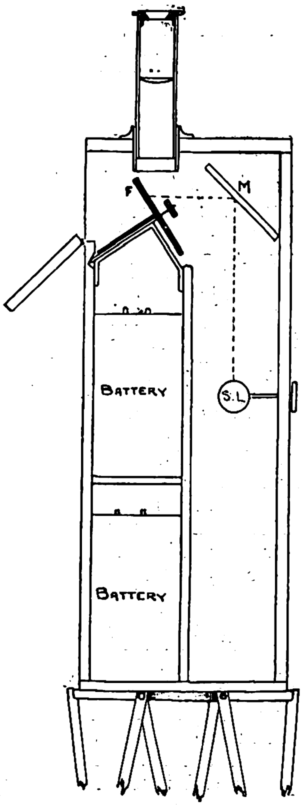


Fig. 2.—Diagrammatic Section.

The present struggle between those interested in gas and electricity for the public lighting of the City of London has also drawn, considerable attention to questions of reliable street photometry and a description of the form which the Harrison street photometer has taken in the hands of Messrs. Everett, Edgcumbe & Co., who are putting the instrument on the market, will be of interest.

The appearance of the instrument is shown in Fig. 1, and Fig. 2 represents diagrammatically the method of working. SL is the standard lamp, which can be moved vertically up and down the case until a balance is obtained. The mirror M reflects the light from this lamp on to the rotating screen F of the photometer proper. This is of the "Flicker" pattern, which facilitates measurements with illuminants of different colours. The screen which receives the illumination to be measured is inclined, as will be seen, at an angle of 45 deg., and the two illuminated surfaces are alternately presented to the eye of the observer through an eye-piece in the usual way. The battery feeding the standard lamp consists of four accumulator cells in non-spillable cases, contained in two compartments of the box, and permanently connected through a small press key to the lamp. When required the range of the instrument can be increased by the employment of two standard glow lamps of different candle-powers. A small voltmeter can be provided when required, in order that a check may be kept on the constancy of the lamp voltage; but, as a matter of fact, the cells are of such ample size that it is found that there is practically no variation whatever in the voltage, and the candle-power remains constant during many hours' continuous use after the cells have been charged. A levelling arrangement enables the photometer screen to be set at an angle of exactly 45 deg. with the horizontal, and a lens and scale show at a glance the angle at which the rays from the source of light fall upon the screen. From a reading taken in this way, representing the illumination on a surface inclined at 45 deg., either the horizontal or vertical illumination can be at once calculated, or, if required, the actual candle-power of the lamp in question. The whole apparatus is, as will be gathered from the figures, absolutely self-contained, and, for carrying about, the tripod stand folds over flat against the sides of the case, and need never be removed from the photometer. The size of the apparatus, when closed, is only 27 in. by 6 in. by 6 in.

In view of the doubt that has existed as to the accuracy of street measurements, it is interesting to note that the makers claim that the results obtained with this photometer can be safely relied upon to within 3 to 5 per cent., according to the brightness of the illumination.

## TECHNICAL CONSIDERATIONS IN ELECTRIC RAILWAY ENGINEERING.*

BY F. W. CARTER, M.A.

(*Concluded from page 598*).

*Service Capacity of Motors.*—In the preceding section we have shown how, from the requirements of the service, the dynamical characteristics of the motors necessary for driving the train may be deduced. It does not follow, however, that any motor having the required characteristics and capable of giving the required power without injurious sparking, would be capable of standing the service continuously without overheating.

There does not at present appear to be a general agreement as to how railway motors should be rated. The most generally-followed rule is that of the Committee of Standardisation of the American Institution of Electrical Engineers,† according to which "the commercial rating of a railway motor should be the horse-power output, giving 75°C. rise of temperature above a room temperature of 25°C. after one hour's continuous run at 500 volts terminal pressure, on a stand, with the motor covers removed." The rule is, however, by no means universally followed in this country. The rule was devised to suit the needs of continuous-current tramway motors, and whilst satisfactory for the purpose of comparing such motors with one another and useful in providing for a good running test at heavy load, which subjects the motor to a considerably higher temperature than would be aimed at in use, it furnishes no criterion as to whether the motor will suit a given service. Moreover, it lacks flexibility in specifying a test at 500 volts, which may differ considerably from the voltage for which the motor is designed, and at which it is intended to be operated. There is no practicable and simple method of rating a railway motor competent to express its real service capacity, and it is only by experience in actual service tests that the sufficiency of a motor for its duty can be determined.

According to the practice of the General Electric Co. of New York, the runs are made as far as practicable at constant voltage, constant mean accelerating current, constant time with power on, constant total time between starts and constant distance run. Records of current and voltage are obtained by means of recording instruments. Temperatures of armature and field coils by resistance, and of field coils and frame by thermometer are noted hourly, whilst final temperatures of armature core and commutator are ascertained immediately on finishing the run. In expressing the results it is assumed that the temperature rise will be proportional to the energy loss in the motor, and that otherwise it will depend chiefly on the manner in which the energy loss is distributed between armature and field coils. Accordingly from the ammeter and voltmeter records the best possible estimate is obtained of the average energy loss in the armature and the field coils—the armature-core loss having been previously obtained from stand tests. Curves are plotted from the tests having as abscissa the ratio of armature loss to field-coil loss (the so-called ratio of distribution), and as ordinate the temperature rise per watt loss, one curve being plotted for the armature and another for the field coils. The appearance of the resulting curves for a large railway motor is shown in Fig. 7.

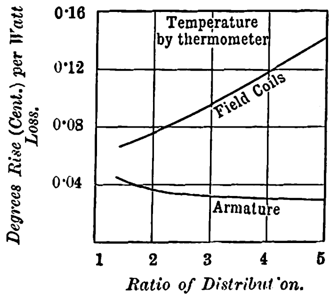


FIG. 7.—SERVICE THERMAL CHARACTERISTICS OF RAILWAY MOTOR.

The design of the motors should be such that for a service involving frequent stops—where they take the accelerating current for a considerable fraction of the time that power is on—the field coil temperature is the higher, whilst in a service involving much free running the armature temperature should be the limiting feature.

Fig. 8 is deduced from Fig. 7, and expresses the thermal characteristics of the motor in a different manner. It shows the total electrical loss which causes a limiting temperature rise in field coils or armature of 60°C. There is not a very large variation in energy loss for different classes of service, and as a first approximation one might affirm that, with a given frame and a definite arrangement of perforated covers or other heat-dissipating devices, the permissible electrical losses are definite. A motor dynamically capable of a given service will, therefore, be suitable for continuous use on that service, provided the permissible electrical losses are not exceeded. These losses in a continuous-current railway motor of good design and considerable power usually amount to between 6 and 7 per cent. of the input.

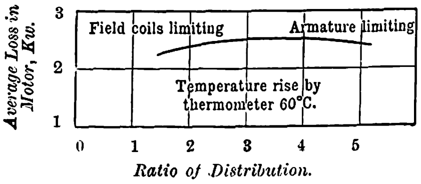


FIG. 8.—SERVICE THERMAL CHARACTERISTICS OF RAILWAY MOTOR.

*Traffic.*—Having finally settled upon the driving equipment and determined the maximum and average power taken by a train, it becomes necessary to make the best possible estimate of the amount of electrically operated traffic upon all parts of the system at all times, in order that the generating and distributing systems may be devised to suit the duty to be imposed upon them. In the case of an entirely new railway, the estimate must be based on knowledge derived from similar ventures elsewhere, modified according to the local circumstances. Where, however, it is in connection with an existing steam-operated system that electrification is contemplated, great assistance can usually be derived from a study of the time-tables of the system.

*Distributing System.*—In a system of any size there will usually be certain junctions from which several lines radiate, and which accordingly form natural distributing points, where one would locate substations if otherwise practicable. One must also locate a substation near each of the ends of a line, since, with the usual arrangement of low-tension feeders, the distance that one can feed to a dead end with a given drop in potential is only about one-third of the distance between adjacent substations on the line. In the case of a completely insulated line equipment, such as that employed on the Metropolitan and Metropolitan District Railways, the waste of energy limits the mean voltage drop, whilst the necessity of efficient train lighting at all times limits the maximum. With a rail return, however, there is the additional restrictions imposed by the Board of Trade on the voltage drop in uninsulated conductors.

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* Paper read before the Institution of Electrical Engineers, Jan. 25th. Abstract.

† *Trans.* American Institution Electrical Engineers, Vol. XIX., p. 1,083.

In the case of rotary converter substations, the total capacity of the installed machinery will usually be some 40 or 60 per cent. greater than that installed in the generating station for supplying power to the trains. The excess is chiefly required on account of the exceedingly bad load factor of a substation, which necessitates an installation far greater than the mean load would indicate. In this respect the transformer substations of a purely alternating-current system show to great advantage. Transformers can be designed to stand five or six times the rated load for short periods without injury or excessive voltage drop, and two or three times for an hour or two without excessive heating. In a continuous-current system the all-day efficiency of distribution from generating station 'bus bars to trains, is usually in the neighbourhood of 78 per cent. In a well-designed alternating-current system this efficiency would probably approximate to 87 per cent.

*Generating Plant.*—The location of the generating station for a suburban system will be chosen principally from considerations of available sites, suitable subsoil and facilities for obtaining water and coal. Only after these have been taken account of will the high-tension feeder system become the predominant consideration, and then mainly in reference to the question of cost.

By means of a traffic curve combined with estimates of the maximum probable traffic under electrical operation, the power required per train and the efficiency of distribution, a fair estimate may be made of the power required at all times of the day. The size of the units—which should be similar—will be largely governed by the load at times of light traffic, whilst the number of units will be determined by the mean power required during the highest peak of the load.

*Alternating-Current Working.*—The most valuable features of alternating-current operation are consequent upon the possibility of supplying power to the trains at high potential. This makes practicable the use of much lighter line conductors than can be employed under continuous-current operation, and also requires fewer sub-stations for a given loss in the line-conductor network.

The use of the track or other insulated return circuit for the current requires consideration. The author has no information as to what amount of electrolytic corrosion is to be expected from alternating earth currents as compared with continuous, or what regulations are likely to be imposed to prevent damage by such currents. It is not, however, desirable to impose a limit to the difference of potential between points on the uninsulated return unless the method of measuring the voltage is very precisely set out. If the volt-meter be joined to two points in the conductor by pilot wires lying very close to the conductor, the voltage indicated will be little more than the CR drop. The alternating flux due to the current in the conductor will for the most part cut the pilot wire and produce an E.M.F. practically neutralising the reactance drop; thus the indication of the voltmeter will be the difference of potential diminished by this E.M.F. In order to indicate the true difference of potential between points on the conductor, the pilot wire should lie on the surface separating the lines of force which close about the trolley wire from those about the return conductor. This is practically the horizontal plane at a height from the ground equal to half the height of the trolley wire.

In the case of a rail return, where the conductor is of magnetic material, the varying lines of force in the iron itself will tend to confine the current to the outside layers of the conductor, and the CR drop will be several times as much for alternating as for continuous current. Altogether, if earth currents are to be reduced to the same order as is found under continuous-current operation, and it is desired to place the sub-stations as far apart, it will be necessary—taking account of the lower power-factor and heavier trains incidental to alternating-current working, in addition to the foregoing considerations—to adopt a line pressure of at least 6,000 volts, or else to instal frequent track boosters to take care of the voltage drop in the earthed conductors. If advantage is to be taken of the high pressure to considerably reduce the number of sub-stations, it becomes necessary either to adopt a completely insulated line conductor system, which much increases the difficulty of installation and working at complicated junctions, or to instal track boosters, which adds to the expense. The best arrangement of boosters is probably that of the Oerlikon Company,* in which the track current is transferred by the boosters to a common return conductor running between sub-stations. It is possible, however, to do without the return conductor by connecting the secondaries of the boosters across insulated joints in the track and introducing a small equalising wire as shown diagrammatically in Fig. 9. With this arrangement the track rails are employed as return conductors. The boosters must, however, be closer together near the sub-stations than in the Oerlikon system, and a greater number are accordingly required.

The weak feature of the single-phase system, as applied to this class of work, lies in the driving-motor. This has a much smaller range of power than the continuous-current motor, whilst its electrical efficiency is considerably lower. The compensated series type of motor has a somewhat higher efficiency than the repulsion type—mainly on account of its lower rotor losses. Its efficiency is, however, necessarily lower when operated as an alternating-current motor than when operated as a continuous-current motor, and this again is lower than it would be if the motor were specially designed for continuous-current operation. In suburban service, as we understand it in this country, a single-phase railway motor with a given outside shell has little more than half the service capacity of the continuous-current motor having a similar shell, which in such service is liable to be employed to its utmost capacity. This, we have seen, is equivalent to saying that the electrical losses in the motor are nearly twice as great, as compared with the input, as obtain in the continuous-current system.

The result of the above is that the alternating-current equipment is considerably heavier than the corresponding continuous-current equipment, the increased weight of the train itself requiring more motors. If we charge to equipment-weight not only the weight of the motors, transformers and controlling apparatus, but also the excess of weight of the motor trucks over trailing trucks, and of the heavier underframe required to carry the transformers, &c., it is not too much to say that the single-phase system has an equipment weight per ton from 2¼ to 2½ times as great as the continuous-current system, whilst an equipped and loaded train of given capacity will be some 30 or 40 per cent. heavier on the former than on the latter system. In the foregoing we refer particularly to the somewhat severe conditions of English suburban service. The objection, however, is more general than this, as will be seen by reference to the published weights of some single-phase cars. On the Indianapolis and Cincinnati Traction Company's single-phase line the cars, equipped but not loaded, weigh 96,700 lb.* each. These are large corridor cars 55 ft. long and seating 54 passengers each. They are of the type usually employed on American inter-urban lines, which, when designed for continuous-current operation, weigh from 60,000 lb. to 70,000 lb. each complete with equipment. Again, the car on the Ballston Line of the Schenectady Street Railway, which seats 44 passengers, weighs, when fully equipped, 60,800 lb.,† although the underframe and trucks were not intended to carry such an equipment and are rather light for the purposes. If furnished with an equivalent continuous-current equipment, however, the weight would not exceed 50,000 lb.

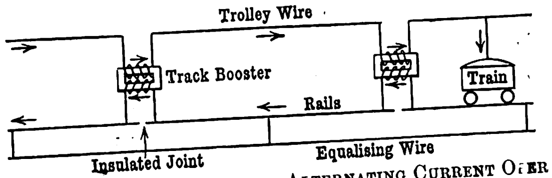

FIG. 9.—TRACK BOOSTER SYSTEM FOR ALTERNATING CURRENT OPERATION.

We can now see why, under suburban conditions, the single-phase system compares very unfavourably with the continuous-current system. A properly-installed overhead conductor system, insulated for high potential, will be at least as costly as a third rail, whilst the single-phase train equipments will be two or three times as expensive as the continuous-current equipments for corresponding trains. In fact, taking account of all circumstances, the single-phase system, when compared with the continuous-current system on the basis of equal traffic capacity, costs considerably more to instal and considerably more to operate in the class of service under discussion.

The speed-torque characteristic of the single-phase motor is more suitable for high-speed service with few stops than for suburban service. A low rate of acceleration would here be no disadvantage, whilst the smaller range of power output would avoid the large drain of power which the continuous-current system would show when starting a train in such service. Moreover, the energy consumption would depend principally on the train resistance, which would not be increased greatly on account of an increased weight of train. It would probably be necessary, however, to concentrate the equipment on a locomotive, where the motors might be artificially cooled—a course hardly practicable when they are carried on the axles of the coaches. Some of the disabilities of the single-phase system disappear at low speeds, where the equipment weight is in any case a smaller fraction of the train weight, and its increase, therefore, of less importance. Again, a service involving infrequent stops and moderate speeds, where the input per ton is small and the motor losses can accordingly be kept within reasonable limits, may often prove quite suitable for operation by the single-phase system. In short, this system shows promise of having extensive, but by no means universal, application to railway work.

The polyphase system, employing induction motors, has the disadvantage of requiring two or more overhead conductors, which complicates matters considerably at junctions, although it is not so serious an objection on continuous track. It is not well suited for suburban or other service in which stops are frequent and a high rate of acceleration necessary.

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* *Elektrotechnische Zeitschrift*, Vol. XXV., p. 313.

* See *Street Railway Journal*, Vol. XXV., p. 173.

† See *Engineering*, Vol. LXXVIII., p. 775.

The polyphase system is practically confined to trains drawn by a single locomotive or motor coach. A small difference in the size of the driving wheels would result in a considerable inequality in the loading of the motors, and if some of the wheels are new and others old—as would be sure to be the case at times with multiple-unit trains—some of the motors would do all the work and might even drive others as generators. The difference in size of the wheels is almost without effect in the continuous-current and single-phase systems.

Since the motor runs at nearly constant speed, the power output is practically proportional to the torque. Thus the variations of the load on the generators, due to acceleration and grade resistance, is much greater for this class of motor than for continuous-current motors, and is accentuated by the return of power to the line on down grades. This return of power must nevertheless be reckoned as one of the advantages of the system. The strong feature in the polyphase motor, as compared with that of other systems, lies in the absence of a commutator, whereby the most frequent source of trouble is avoided. The motor is a good mechanical apparatus, with nothing particular to get out of order, and one could afford to sacrifice many advantages for the sake of employing such a motor for train driving. The weakest feature lies in the small air-gap necessary, which requires exceedingly good and well-designed bearings. These, however, can be provided without difficulty. In fairly level country, goods or other service, in which stops are infrequent, and the acceleration therefore of small importance, might very well be operated by the polyphase system. High-speed long-distance service is particularly suitable, the high train resistance making the grade resistance of relatively smaller importance, so that during free running the motors can be arranged to operate near the load of highest efficiency.

*Conclusion.*—The chief immediate developments in the direction of railway electrification are to be looked for in urban and suburban districts, where the increased schedule speed and the greater capacity of an electrically-operated railway could be relied upon to develop the necessary traffic. It is these considerations rather than the possible saving in operating expenses which constitute the case for the electrification of suburban lines. If it desired merely to handle electrically the traffic at present handled by steam, the saving in operating expenses would not pay 1 per cent. on the capital sunk in conversion. Taking all things into consideration the continuous-current system appears by far the most suitable for suburban service in this country, and there are no present indications that it is likely to be superseded for this class of service. Our suburban trains usually make good schedule speeds in spite of the frequent stops, but we must expect to improve on the speeds under electrical operation. The Liverpool-Southport service, in which the schedule speed is 30 miles per hour, with stops less than 1¼ mile apart, could hardly be effectively and efficiently operated otherwise than by the continuous-current system. In one respect the London suburban service on such systems as the Great Eastern Railway will afford an engineering problem differing considerably from those with which we are familiar—the trains at times of dense traffic will be considerably heavier than has been usual in electrical suburban service. If an increased number of passengers have to be carried it will hardly be practicable to diminish the length of the trains, which is only limited by the length of the station platforms. The use of excessively heavy trains is fraught with consequences likely to lead to a radical departure from the present standard practice. The coaches will probably be of the present compartment type, on account of their greater seating capacity as compared with the corridor type, and, in fact, the present coaches could be largely employed in making up the trains. The chief disadvantage of the compartment type is that when trains are well filled time is lost by intending passengers in seeking a compartment, so that longer station stops are necessary than when the corridor type of coach is employed.

The objections to the continuous-current system when heavy trains are to be employed arise for the most part from the necessity for using a third rail. This being accessible constitutes a source of danger, whilst it is exceedingly difficult to instal at complicated junctions. Moreover, the system is hardly the most suitable for long-distance service, so that objection has been made to it on the ground that it cannot be generally extended throughout a railway system. This last objection, however, is of little weight, as electricity cannot compete with steam for general railway work in this country, so that universal electrical operation may be ruled out of account. The danger to workmen and others arising from the presence on the line of an accessible conductor at dangerous potential is patent, and can only be obviated by rendering accidental contact with the conductor impossible. An efficient wooden protection for this purpose will add perhaps 5 per cent. for the total cost of electrification, so that the question of additional danger is not a very effective argument against the continuous-current system. The third-rail protection, moreover, by preventing short circuits with track tools, is a valuable security against shut down. It is worthy of note in this connection that the New York Central and Hudson River Railroad have adopted a completely protected third rail within their New York City electrical zone.*

The difficulty of installing line conductors amongst the intricate switch work and signal rods of a large terminus or junction is serious, and is increased fourfold, as far as a great portion of the London district is concerned, by the action of the underground railways in adopting an insulated return conductor instead of employing the track rails as return. Where the track work is not too complicated, a single conductor can usually be installed, so that contact is never lost by the collector shoes, whilst even at the most intricate junctions it can always be located overhead. With a second insulated conductor, however, it is at such places practically impossible to secure continuous contact for both sets of collector shoes within the length of a locomotive or motor coach, and sometimes even of a long train. The chief argument in favour of an insulated return is that it enables the track rails to be used for signalling purposes.

A class of traffic for which electrical operation might be expected to show to advantage is interurban passenger traffic, handled on the same lines as on the American interurban railways—*i.e.*, with single cars or small trains running at fairly high speeds and at frequent intervals. There are many districts in this country where such a system could hardly fail to attract considerable traffic. Where stations are fairly close together the continuous-current system will probably be found most suitable for this class of work, especially if the system forms a compact network. In case none but small trains are to be electrically operated, the track conductors may be located overhead in the form of a trolley wire, otherwise a third rail will be necessary. At the present standard voltages, the weight of train that can be fed from a single overhead trolley wire is limited to perhaps 50 tons. There is, however, no real engineering necessity for restricting the operation to present standard voltages. If the mean speed desired is not very high—considering the distance between stops—it may often happen that alternating-current operation would furnish the most satisfactory means of attaining the end in view. Where stations are not less than 2 or 3 miles apart and the electrically-operated lines do not form a too complicated system, a strong case could in many instances be made for the polyphase system. In general, however, it is probable that the single-phase system would be found the more advantageous for such work. Another class of service for which electrical operation might well prove desirable is that on branch lines, where in many cases the traffic is not in itself sufficient to pay expenses, but is necessary to put country towns in communication with the main lines. These should be run as interurban tramways, operating a fairly frequent service of single cars or trains of two or three coaches and employing overhead line conductors. Such a system could be installed at moderate capital outlay, whilst a considerable saving in operating expenses would ensue on account of plant and operatives being more uniformly employed. The more frequent service would be expected to result in considerably increased traffic between towns and villages.

In a few places, such as between Liverpool and Manchester and between Leeds and Bradford, it might be possible to inaugurate a very high-speed service on the lines indicated by the Marienfelde-Zossen tests, although it is a little doubtful whether the saving of time possible in these comparatively short distances would form sufficient inducement to create a paying traffic. Such lines running from London to Birmingham, Manchester and Liverpool, might attract considerable traffic, but could hardly be constructed against the opposition of existing companies, and as they would be largely special and reserved for the one class of traffic, it is improbable that they could be made to pay at present. Altogether there does not appear to be much prospect for such exceedingly high-speed lines in this country for some time to come.

The operation of our main-line trains would not be sensibly improved by electrification; certainly no such improvement would be anticipated as would justify the necessary great outlay of capital. Where conditions are different, however, considerations which do not apply in this country may render general electrical operation desirable. In Sweden, for instance, where the locomotive coal is imported, whilst there are extensive peat beds and much water power, it is possible that general electrification may be justified. Here, however, the coal bill is not a very great item in the operating expenses, and we could not expect to save on it. Electrical operation is, therefore, economically feasible only for those classes of traffic in which some service advantage results. No particular advantage would in general accrue from the electrical operation of goods traffic. At docks, goods-yards, and like places, however, where there is much shunting, if there is an existing generating plant for supplying power to cranes, capstans, &c., it would undoubtedly be advantageous to employ electric locomotives in place of steam. The latter are very inefficiently employed in such service on account of the large amount of standing and starting necessary. With electric locomotives designed suitable for such work, the efficiency of the system would be much improved at trifling extra cost, whilst an improvement would also be expected in the load factor of the generating plant, so that the cost of additional power would be small. In some such localities the use of overhead wires would be objected to, and some form of surface-contact system would probably be found necessary.

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* *Street Railway Journal*, Vol. XXVI., p. 336.

Although, for reasons above stated, no general electrical operation of our railways is to be expected, we may yet look forward to many developments in railway work within the next few years. There is at present a little natural conservatism amongst railway managers, and a disinclination on the part of directorates to sanction the outlay of a large amount of capital when the best system of operation appears to the superficial observer still a matter of speculation. It is hoped that the present paper will serve in a measure to delimit the spheres of usefulness of the several systems of electrical operation, or at least to prove that the most suitable system can be determined in any particular case.

The author wishes to add that the views expressed in this Paper are entirely the results of his own study of the subject, and should not in any way be taken as representing the attitude of the Company with which he is connected.

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The following is an abstract of the discussion which took place in connection with the Paper on January 25th :—

Mr. PHILIP DAWSON, of Messrs. Kincaid, Waller, Manville & Dawson, and consulting electrical engineer to the London, Brighton & South Coast Railway, said he would only discuss the Paper from the point of view of the particular problem he had in hand at the present moment, and if he differed from the conclusions in the Paper it was not to be taken as any reflection upon the results arrived at by Mr. Carter. The author had compared the amounts which had to be added to the weight of the train, in calculating the acceleration, to allow for the inertia of revolving masses, and had given this as from 8 to 10 per cent. in the case of continuous-current traction, and double this for single-phase. But in the case of the single-phase motors which he (the speaker) was investigating at the present moment, the utmost which they had to add was 13 per cent., or only 3 per cent. more than the maximum stated in the Paper for continuous-current motors. The Paper further stated that "the energy dissipated in motors and gears will be some 10 or 12 per cent. of the input, whilst from 6 to 12 per cent. will usually be dissipated in starting rheostats. In the single-phase system the losses in motors, gears and controlling apparatus will usually be at least as great per ton-mile as in the motors, gears and rheostats of the continuous-current system, chiefly on account of the much lower efficiency of the motors." Some work which he had had carried out, however, gave figures which did not agree with these conclusions. Although the single-phase motor, as at present constructed, was usually of lower efficiency than the continuous-current motor, the difference was only about 4 per cent. as compared with the very best continuous-current motor constructed; but if they took account of the gain by controlling, &c., with voltage variation by transformers, instead of by losses in resistances, there was certainly a very much smaller loss with alternating current than continuous-current motors. He also disagreed with the author's comparison of speeds and tractive efforts of alternating and continous-current motors. In the very short time at his disposal since receiving the Paper, he had plotted out some results which he himself had obtained with alternating-current motors, and the curve practically coincided with the curve given in the Paper for the continuous-current motor. He presumed, therefore, that the author referred to a different alternating-current motor than the one which he had experimented with, and which would be used on the London, Brighton & South Coast Railway. The over-all efficiency of distribution from the generating station 'bus bars to the trains was given by the author as 78 per cent. for continuous current, but he himself had made some most careful calculations, and could not get a higher figure than 74 or 75 per cent., although he thoroughly agreed with the author that the efficiency of an alternating-current system was 87 per cent., which could even be raised with a properly-designed system. The author called attention to the very important property of the single-phase system—viz., the very much higher voltage which could be used in the conductors, as compared with continuous current. This pressure at the present moment was standardised at about 6,000 or 6,500 volts, which about carried out the suggestion made later in the Paper that to get equal drops the line pressure would have to be raised about 10 times. But as far as he could see at present, he knew of no reason why the pressure should not be greatly increased. At the present moment, in Switzerland, there was a line 15 miles long where 15,000 volts were used, and no difficulty had been encountered either in transmitting or collecting. He thought the reference in the Paper to the low power-factor of the single-phase system must have been made under a misapprehension, because when one took the power-factor of a continuous-current installation using direct-current motors, but supplied by polyphase generators through sub-stations, there was practically no difference between the average power-factor obtained on a single-phase system and that for a continuous-current system. The author made a very hard statement when he said that the single-phase system showed no prospect whatever of being rendered satisfactory for the urban and suburban railway work likely to be required in this country. There were a great many members present that evening who remembered the time—not many years ago—when the mere possibility of a satisfactory single-phase motor being produced for traction purposes was considered ridiculous; at the present moment he was sure there was not one who would suggest that such a motor was not a perfectly workmanlike object and gave satisfactory results. He did not agree with the author that the single-phase motor in its present development was unsuited for such work, but in any case it was rather hard to say that the future would not enable a satisfactory single-phase motor to be produced. It was true that, up to the present moment, single-phase motors were slightly heavier than continuous-current motors—and, as far as could be seen at present, this could not be very much improved upon—but he thought the disabilities of single-phase motors had been brought out rather too prominently by the author. To justify this assertion he had some figures, which he had personally verified, and it was seen that the weight of a 150 H.P. motor rated on the American principle was 2·7 tons, and the weight of a 115 H.P. motor rated exactly on the same basis was 2·4 tons; the weight of two motor trucks, including trucks equipped with four 115 H.P. motors compared with a similar motor gear of 150 H.P. continuous-current motors would be 27 tons, as against 26 tons for the latter. It was very important to bear in mind, however, that there were other portions of a train which must be taken into consideration besides the weights of either the motor equipment or the trucks. As the author rightly said, the introduction of electric traction on railways was a commercial proposition as to how far it would increase the carrying capacity and the receipts. This would largely depend upon the accommodation given to the passengers, and this, again, would depend upon the car body construction, and from personal knowledge he knew that there was no railway manager in Great Britain who would hesitate for one moment to employ car bodies weighing 15 tons if he could give better accommodation as compared with a car body weighing 10 tons. At the same time, there were different types of trucks, varying in weights, and the difference in weight, taking the mean, would be 3 tons per car, and the total difference in weight between one type of car body and truck and another, leaving outside altogether the question of the weight of the motor equipment, would be 8 tons per car, or with a three-car train—which would be the normal train—there would be a difference of nearly 24 tons due to car bodies and trucks alone, which was a great deal more than any difference which could exist between different motor equipments. He did not exactly understand the author's remarks on the multiple-unit system, as this was perfectly applicable to single-phase equipments, and, in fact, practically the same apparatus used in conjunction with continuous currents for multiple-unit control was used for single-phase, the only difference being that the latter was very much simpler, and the parts very much fewer, than with continuous current. Taking all these things into consideration, he could not agree with the statement of the author that the single-phase system compared unfavourably with the continuous-current system as regards suburban traffic, or that the current consumption of single-phase motors must necessarily be greater than direct-current motors. He had some figures from experimental results, which he himself was acquainted with, for a run over a distance of a level 2,583 ft. The train consisted of two motor coaches, having eight motors, and three trailer coaches. The coaches and trucks were exactly the same for both the continuous-current test and for the single-phase. The time taken with the continuous-current equipment was 91·46 seconds, and with the alternating 92·25 seconds. The average efficiencies were 73·6 per cent. and 74·2 per cent.; the watt-hours consumed per ton-mile for hauling and braking, including the amount required for operating the air compressors were 68 and 63 respectively; the acceleration was very much more favourable to the single-phase. The continuous-current train required 37 seconds to attain a speed of 25½ miles per hour, whilst the alternating-current train attained 25 miles per hour in 22½ seconds. Also the rate of acceleration was very much more favourable to the single phase. He had recently had the opportunity of making a number of very interesting tests, with some apparatus designed by Mr. A. P. Trotter, of the acceleration obtained under actual running conditions with single-phase and continuous-current trains, and the results were practically these: Whilst the continuous-current trains gave a very high average rate of acceleration, this was due to the fact that a very high rate of acceleration was gained at the beginning—viz., 2 ft. 6 in. or 3 ft. per second per second, but it fell away to 1 ft. 6 in. per second per second. With the alternating-current train it was exactly the reverse. It started at 9 in. per second per second for the first 100 ft. or 200 ft., then rose to nearly 2 ft. and remained stationary during the whole period of acceleration at 2 ft. per second per second, and he suggested that the curve would be very much more satisfactory for suburban service than the continuous current. In discussing this question one point ought not to be lost sight of. They must be able to prove to the existing railway authorities that the electrification of railways was advantageous, and that it would not bring in its train very serious disadvantages. From the very careful and prolonged investigation that he had made, he had come to the conclusion that the unanimous consensus of opinion amongst railway men, both over the whole of Europe and in America, was that if electricity was to take the place of steam for running ordinary suburban trains, this would never be the case so long as the third rail existed. Under these circumstances, it was perfectly evident that the continuous-current system must be out of court, and he believed that the very satisfactory results that had been obtained with single-phase motors during the past few years were due to the big electrical houses thoroughly realising that the main line railways would not adopt electric traction unless the third and fourth rails could be dispensed with. He felt sure that suburban railways would adopt single-phase traction for handling their trains.

Mr. A. P. TROTTER, electrical adviser to the Board of Trade, who desired it to be understood that he spoke in his private capacity and not officially on behalf of the Board, said there were one or two points upon which he could give some information. He agreed with Mr. Dawson about the coming of alternating current. He could not remember for the moment whether the pressure was to be 3,000 or 6,000 volts on the London Brighton & South Coast line, but it did not matter much, as if it could be made safe for the one pressure it could for the other, or even for 10,000 or 15,000 volts. Some information had been asked for on the question of alternate-current electrolysis. There was such a thing as alternate-current electrolysis, and he had made many experiments; it might be about half that of continuous current. But on the particular railway to which he had given his attention the rails were on chairs, the chairs on sleepers, the sleepers on ballast, and the ballast had high brick arches or embankments. They were a long way from the pipes, and in these circumstances he did not see any objection to 20 volts drop. But how was it to be measured? He had considered this with some little care. The author had given the case of a single trolley wire and a single rail to show that in ordinary circumstances the pilot wire ought to be between the two. This followed from simple mathematics, but what was going to be the case in practice, with two trolley wires and four rails, and about three feeders from the power house to the sub-stations, a feeder probably from the sub-station to points upon the track, and a track return into which the current was boosted from the rails. He was glad he had not got to calculate where the pilot had to be. But he would propose to borrow a telephone wire forming a loop from the point at which the pressure was to be measured, about a mile or two right out in the country, and back to the rails in such a way that it could not be influenced by the railway current. Then he would have the pilot wire placed anywhere at side of the track in the most convenient position, and compare the two voltmeter readings so as to calibrate the instrument connected on the pilot wire to show the true voltage drop; 20 volts was a pressure that could be measured electrostatically. The question of earth currents need not be troubled about, because modern telephones all had double circuits; but there was one point which he had suggested to the engineers of the Brighton line—viz., that with the periodicity which they proposed to use and a Wheatstone instrument working at 400 words per minute (as a matter of fact, he did not think there were any south of the Thames) might happen to synchronise. Political speeches were transmitted by the Wheatstone instruments, and it would be awkward if there was recorded a succession of dot, dot, dot, which he believed would mean "I, I, I." The impedance of the rails on the Spindlersfeld line was only ½ ohm per kilometer, which was better than some of the Swiss lines. With regard to the type of carriage, electrical engineers were hardly concerned with the seating of the passengers, unless they wished to get to business themselves, but he might mention an interesting type of carriage used for the suburban traffic in Berlin, and which had commended itself to some railway engineers. The carriages seated five a side with the ordinary partition at the back of the passengers, but they had sacrificed one seat by cutting away 18 in. of seat and partition, making a sort of corridor train, so that the passengers got in anywhere and sorted themselves through the 18 in. The arrangement worked very well, and there were just as many doors as with the ordinary rolling stock.

The discussion was then adjourned until Thursday, February 8.

## A SELF-REGULATING LOAD FOR TESTING METERS.

In a recent article in the *Elektrotechnische Zeitschrift*, Dr. Martin Kallmann refers to the difficulty of keeping the artificial load on meters constant during tests on consumer's premises, and describes an arrangement by means of which the load is kept practically constant in spite of considerable fluctuations in the supply voltage. The errors which may arise from the use of a resistance having a negligible temperature coefficient (such as constantan, for instance) are shown best by an example: Assume this resistance to be 44 ohms. When connected across a 220-volt supply it will pass exactly 5 amperes, and the power consumed is 1,100 watts. Should the voltage drop or rise only 2 per cent. from the normal, however, the power consumed would fall to 1,056 watts ($215.6^2/44$) or rise to 1,144 watts ($224.4^2/44$), the error being ± 4·4 per cent. from the normal. Dr. Kallmann gets over this difficulty by connecting in series with the ordinary resistance, another resistance having a pronounced temperature coefficient. Such resistances, as is well known, are used in Nernst lamps for steadying the current. They consist of thin iron wire in a sealed glass tube filled with hydrogen at a certain pressure. Since the current through this resistance is practically constant for considerable fluctuations in the supply pressure, it follows that the voltage across the ordinary resistance is also practically constant. Hence the watts consumed by the ordinary resistance with negligible temperature coefficient are likewise constant. Any desired load may be obtained by connecting two or more "units" in series or parallel. Experiments went to show that the power consumed in the ordinary resistance did not vary appreciably when the supply voltage fluctuated between 213 and 227 volts, and the error only reached ± 1 per cent. when the voltage dropped to 210 volts or rose to 230 volts respectively. The connections for a meter test are as follows: The ballast resistance is inserted in one of the supply conductors behind the meter, while the ordinary resistance is connected across the mains in front of the meter, but behind the consumer's main switch, which is opened. A practically constant current now flows through the ballast resistance to one of the main terminals of the meter. Here it divides, a small current flowing through the shunt coil of the meter to the other main, but the bulk flowing through the main coil of the meter and the ordinary resistance to the other main supply conductor where it units with the shunt current. Since there is a drop of from about 10 to 20 volts in the ballast resistance, it is clear that the meter is tested at a somewhat lower pressure than that for which it is normally intended, but Dr. Kallmann states that this does not appreciably affect the calibration curve of the continuous-current meters in general use. The author's arrangement is also applicable, of course, for testing alternating-current meters.

## ELECTRIC CRANES, HOISTS AND TRAVELLERS.*

BY J. RITCHIE.

Crane makers began to turn their attention to electric driving soon after the advent of the practical electrical motor. The author's first electrically-driven crane was built in 1887, and consisted of an ordinary derrick crane with a reversible series motor, which simply replaced the steam engine; this is practically the design of the small electric derricks of to-day. With regard to crane controllers, the type adopted must be strong and simple: two forms are in general use—(1) the liquid controller, and (2) the tramway controller, both of which are satisfactory. Even where separate motors are used for different motions of the crane, the author prefers separate controllers for each as simpler than a combined "universal type" controller.

In connection with small derrick cranes for general work, crane-makers are often required to give figures as to cost of running as compared with steam. Take the ordinary two-ton builders' crane; this, if steam driven, will use about 4 cwt. of coal per day, at a cost of, say, 20s. per week. Such a crane electrically driven might be expected to raise 1 ton 40 ft. every five minutes, taking 3 H.P., with an additional 50 per cent. for frictional and other losses, say 0·056 unit for one minute lift, and two minutes at half this for slewing and derricking, or 0·112 units every five minutes, which is equivalent to 12 units per day, or 8s. 4d. per week (with electricity at 1¼d. per unit) for 600 tons raised 40 ft. In actual practice, a builder's crane at work in Edinburgh was found to cost 4s. per week for current (at 1¼d. per unit). A crane in a builder's yard cost 20s. per week for current, and did the work of two steam cranes which would cost 40s. for coal and 30s. for the driver. An actual trial at another place gave the following results:—Three loads of 10 tons each raised 30 ft., slewed and lowered at a cost of 2s. 8d. per load, and six loads of 5 tons each raised 30 ft. slewed and lowered at a cost of 1s. 6d. per load, an extremely low cost compared to cost of same work by steam crane. The usual speed of lift for a 10-ton shop crane was 10 ft. to 15 ft. per minute for full load, and 20 ft. per minute for 5-ton loads. The motor would be of 18 to 20 B.H.P., and capable of working at 50 per cent. overload. The author's practice in fixing the power of the motor was to take the theoretical horse-power required to lift the load at the required speed, add 50 per cent. for losses, and specify the motor to do 100 per cent. overload for three minutes. For small cranes, whose different motions are worked from a single motor, the author used bevelled friction gear, one bevel wheel being of compressed paper. For overhead traveller work electric driving was superior to the older methods, both as regards economy and handiness. The all-day loss in driving endless ropes and square shafts was a serious matter, amounting in an actual case to 7 B.H.P. for a 50 ft. length of square shafting. The various motions of the traveller could either be derived from the one motor—in which case the bevel friction gears were used to connect and disconnect the various shafts used—or a separate motor could be provided for each motion—the latter was more economical in working and better suited for high or varied speeds. In long span travellers the travelling shaft should be driven from the centre, even when one motor only controlled all motions. In large power cranes and travellers, dealing generally with weights much below the maximum, it led to economy in working if separate motors and separate gears were provided for light and heavy weights.

English practice in crane work differed from American and Continental in three important matters: (1) In all cranes above 10 tons the side plates are of steel in British practice and not cast iron. (2) Toothed gearing and low speed motors (about 500 revs. per min.) are preferred by most British makers to worm gearing and high-speed motors. (3) Steel ropes are in general preferred to chains in this country.

Motors for crane work should be totally enclosed, ready access should be provided to all parts, and the field magnets should preferably be split so as to allow of quick removal of the armature.

For the transmission of the materials for building the bridge across the Zambesi Gorge (650 ft. span and 400 ft. deep), it was decided to adopt telpherage, a method of working originally proposed by the late Prof. Fleeming Jenkin, and the author was consulted as to the mechanism and design. The carrying cable was of plough steel $2\frac{9}{16}$ in. diameter fastened at one end to a fixed tower and at the other end to the top of a jib pivoted at its foot, inclined 45 deg. and weighted at its tip with 40 tons so as to keep a pratically constant tension on the cable. This cable carried the 10 ton telpher, which the author described in detail in the Paper.

Reference was made to some comparative tests of electrical and hydraulic cranes carried out in 1904 by the North-Eastern Railway Co. at Middlesboro' Docks (*Engineering*, January 24, 1904). These tests showed 25 per cent. in favour of the electric cranes on a load factor of 7·3 against a load factor of 14·0 for the hydraulic cranes. With equal load factors the saving would have been 60 per cent., and for ease of shifting from place to place the electric cranes were much superior.

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* Paper read before the Dublin Section of the Institution of Electrical Engineers on January 18th. Abstract.

The Paper was illustrated by a fine series of slides, showing a number of cranes, hoists, travellers and conveyers, mostly built by the firm of Carrick & Ritchie.

### DISCUSSION.

Mr. C. STEWART referred to his experience of warping in a traveller in which the travelling motion was driven from one end. He had had considerable experience in electrical cranes and considered them much superior to other types.

Mr. A. E. PORTE congratulated Mr. Richie on his Paper, which, like all the author's work, was done well. He was surprised at the success of the bevel friction gearing, as his own experience of it had not been satisfactory. He alluded to the fact that he had carried out experiments for the late Prof. Fleeming Jenkin in connection with telpherage.

Mr. T. TOMLINSON considered the most important point to them was that electric driving was proving itself economical in the humbler work of the contractor and builder, and not merely in the equipment of factories and docks. He pointed out in this connection, however, that the hypothetical calculation in the beginning of the Paper showed a duty of 24,000 foot-tons for 8s. 4d., while the actual tests on the 3–10 loads, given later on, only gave a duty of 900 foot-tons for 8s. He had been engaged on the first experimental telpherage line at Stevenage, and gave an account of the difficulties met with.

Mr. MASSEY said that three electrical cranes had been installed on the Glasgow & South-Western Railway. One had only just been put down, but the two others—each 10 tons with three independent motors—had been in for some time, and had been thoroughly satisfactory, only requiring occasional renewal of brake blocks and brushes. One had replaced an hydraulic crane in a position where absolute steadiness of suspension was required and had given it: the hydraulic crane had not done this on account of slight leakage past the cup leathers. His experience of cone friction clutches had not been altogether satisfactory, depending a good deal on the dampness of the weather. He appreciated the point of the central driving of the traveller shaft in big spans; but asked why the motor was not put in the centre.

Mr. A. T. KINSEY wished to know what was the average life of a steel rope on crane work, and whether any lubricant was necessary.

Mr. J. RITCHIE, in reply, stated that he had used friction bevel gearing for 15 years. The difficulty was getting suitable paper. He had only found one mill in the United Kingdom where it was made satisfactorily. At Wolverhampton such gears had been in use since the works were first started. The great practical point was that the shaft must be absolutely rigidly and a bearing provided close up to every cone pulley. In reply to Mr. Massey, the motor could not in general be put in the centre of a traveller, because of the tendency to cross-warp the traveller beam by its weight. In reply to Mr. Tomlinson: The difference in cost alluded to arose from the fact that, in the second case, the firm were producing the electricity themselves, and apparently at an excessive cost. In reply to Mr. Kinsey: Eight to ten years would be a fair life for a steel rope. Outdoors a mixture of blacklead and tallow was used as a lubricant.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. FOURNIER D'ALBE.]

*Constitution of Chlorine.*—R. Fabinyi describes some suggestive experiments with regard to the properties of chlorine prepared from the same ingredients, but in different succession. In one experiment chlorine is prepared by adding sulphuric acid to a mixture of potassium perchromate and sodium chloride, and the chlorine so obtained is called variety I. In another experiment potassium perchromate is mixed with sulphuric acid, and sodium chloride solution is added drop by drop. The chlorine then obtained is called variety II. Both varieties were tested for all the usual impurities, and found to be free from them. But I was bright greenish-yellow, both by itself and in aqueous solution, whereas II was much darker, and in saturated solution had a dark green colour. Another well-marked difference between the two varieties is the rate at which the aqueous solution is transformed into hydrochloric acid under the influence of light. Variety II is transformed more rapidly, the difference amounting to about 10 per cent. with exposure to an Auer flame. The author suspects that the variation of mass action in the two experiments has some effect upon the intimate structure of the chlorine atom, and that the latter may vary in stability in a manner suggested by the behaviour of the radioactive bodies.

[R. FABINYI, *Physikalische Zeitschrift*, January 15, 1906.]

*Gravitational Energy.*—The radiation resulting from the acceleration of electrons implies a degradation of energy, and V. Crémieu puts the question as to whether a corresponding degradation of energy can be traced in connection with the generation or destruction of gravitational energy. If it cannot, then gravitational energy is the only form of entirely reversible energy hitherto known. He has endeavoured to approach this question experimentally along several different lines of investigation. One of them consists in determining the gravitational constant in liquids, where it should be the same as in air in accordance with hitherto accepted opinions. He succeeded in determining the constant in water under favourable conditions, but could not obtain any decided indication of an effect of the medium. He also endeavoured to detect some effect of the abrupt acceleration by free fall of the attracting body, arguing that by Lenz's law the energy liberated would produce a motion in the attracted object tending to oppose the relative motion. He looked for an impulse of the attracted object in the direction of the fall, but failed to find it. In another experiment he formed in a bath of olive oil several drops of a mixture of alcohol and water of the same specific gravity as the oil, and found that they were apparently attracted towards each other, although neither capillarity nor ordinary gravitational attraction could be alleged as the cause of the attraction.

[V. CRÉMIEU, *Journal de Physique*, January, 1906.]

*Sparking through Condensed Gases.*—C. and H. Guye have examined the dielectric strength of gases compressed in a Cailletet tube under pressures up to 80 atmospheres. They find that up to about 10 atmospheres the spark potential increases linearly with the pressure. At higher pressures than that the spark potential increases more slowly than the pressure. The potential and pressure curves take the form of a parabola. Nitrogen shows a peculiarity in the shape of a maximum which coincides with the maximum compressibility and the minimum *pv* of the gas. In air, the results also show a slight elevation of the curve near the highest pressure used. But no such behaviour was found in either hydrogen or oxygen, no doubt owing to the fact that the minimum *pv* is beyond the range of pressures used. The authors also made a few experiments on carbonic acid near its critical point, and found indications of a diminution of the spark potential as the critical point was approached; but the partial decomposition of the gas produced by the spark makes the interpretation of the results somewhat uncertain. The values of the potentials recorded for $CO_2$ range from 10 to 60 electrostatic units at 18 deg., and from 10 to 54 units at 33 deg., the distance being 0·2 mm. The authors also tried the effect of X rays and of radium rays, but could not detect any perceptible difference produced by them.

[C. and H. GUYE, *Physikalische Zeitschrift*, January 15, 1906.]

*N-rays.*—Prof. Mascart has, in conjunction with Blondlot, Virtz, and Gutton, repeated Blondlot's experiment on the refraction of N-rays by an aluminium prism. The "spectrum" shows a series of maxima, and each of the observers located these by means of a sulphide screen and a dividing machine, and the readings were noted independently by another observer. They were taken in two directions, both going and returning. The consistency between the readings was found to vary with the training of the observer, that of Blondlot being greatest, his maximum error being less than 0·5 per cent. The other observers' errors sometimes amounted to 1 per cent., but they were never sufficient to confuse successive maxima. The mean deviation was 30 degrees, and readings were taken within 2 minutes.

[MASCART, *Comptes Rendus*, January 15, 1906.]

*N-ray Photographs.*—C. Gutton has investigated the alleged effect of N-rays upon a Hertzian oscillator by means of photographic records. Blondlot maintained that when N-rays fall upon the spark in the primary circuit, the brightness of the secondary spark decreases. This decrease is very difficult to observe on account of the general unsteadiness of the spark. The difficulty was overcome by the author by using brass terminals, which, being more volatile than platinum, gave a steadier spark, and which also, on account of the zinc they contain, are rich in photographic rays. The N-rays were derived from a Nernst lamp surrounded by sheet-iron, and were filtered through wood, paper, and aluminium. The photographs show the effect described by Blondlot quite clearly.

[C. GUTTON, *Comptes Rendus*, January 15, 1906.]

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## RAILWAY ELECTRIFICATION.

The considerable increase in the mileage of electrically-driven railways during the last year has not tended to produce any sense of finality amongst electrical railway engineers. Rather it has shown up somewhat forcibly the economic limitations of what may be called the "standard" third-rail system. It is too soon to say anything of the commercial results on the London underground lines that have been converted from steam working. A great increase of traffic has manifestly occurred, and is the main reason of the public complaints about the service; whether that increase will justify the expenditure remains to be seen. These particular instances will not help much towards solving the problems of daylight lines of any kind. What to do with suburban railways and how electrical working can be justified on such lines is the immediate question engaging attention, and its satisfactory solution is of particular interest to electrical engineers.

The resolution of the London, Brighton & South Coast Railway to equip the South London line with a single-phase overhead system will give results capable of application to a very considerable mileage of railways, not only around London, but also in the suburbs of the other great towns, and in the closely-populated industrial districts. The North-Eastern Tyneside lines are of this class. Whilst electrification has made a vast improvement in the service and increased the traffic, there is an impression in railway circles that the return is hardly encouraging enough to justify the conversion of similar lines on the same system. It is abundantly clear that the heavy capitalisation necessary limits the low-tension third-rail system to lines with a good "load factor." Between such railways and the main lines there exists a large and increasing mileage which could be worked electrically with much advantage if only the cost of equipment could be kept down.

Railway managers are showing signs that they have come to some sense of the advantages of electrification, and they will be more ready to consider schemes that promise to be generally applicable to suburban traffic than those which are evidently only remunerative on the most heavily-worked lengths, generally extending only 5 to 10 miles around populous centres.

We conclude in this issue our abstract of Mr. F. W. CARTER'S Paper, read before the Institution of Electrical Engineers last week, and publish our report on the first day's discussion upon it. The debate has come at an opportune moment, and will enable us to put on record the opinions of the best available authorities upon this important question. Mr. CARTER'S figures and deductions indicate in an admirably clear manner the commercial limitations of what we have called the standard system, because he treats chiefly of that system and shows the main considerations governing the details of its application to any given case. It is true that no money values are given, but the principles expounded have the financial result as their chief aim. The author's treatment of the single-phase system is much less full and somewhat deprecatory, although he allows it a certain field, but it seems likely that he intended to provoke some reply on this part of the subject. He certainly succeeded in drawing from Mr. PHILIP DAWSON a well-reasoned statement of the case for single-phase working which will go far to convince many doubters that the Brighton Company has chosen something that will work and that will cost considerably less to instal than the continuous-current system. Whilst single-phase motors are somewhat less efficient than continuous-current motors, there is an improvement in the distribution efficiency, which may bring matters even. Perhaps the most important and encouraging feature of the single-phase system is that it lends itself to extension to interurban and possibly main-line working. The continuous-current system, on the contrary, shows no prospect of such wide application, and this fact has done a good deal to retard the electrification of suburban lines: railway men naturally object to condemn themselves to the vexations of a break of system. The electrification of main-line traffic is not a problem pressing for immediate consideration, but it has to be kept in sight. It is quite likely that the results of suburban electric working may stimulate the more enterprising railways to make the experiment of a frequent service of short trains on a main-line section —and not impossible that they may then find that "facilities increase traffic" is an axiom not limited by a suburban 20-mile radius.

## REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign book).

**A Practical Treatise on the Steam-Engine Indicator, and Indicator Diagrams.** With Notes on Engine Performances, the Expansion of Steam, Behaviour of Steam in Steam-engine Cylinders, and on Gas and Oil-engine Diagrams. By W. WORBY BEAUMONT, M.Inst.C.E. 2nd edition, revised and enlarged. (London: "The Electrician" Printing & Publishing Co., Ltd.) 1906. 6s.

The author has aimed at producing a book which will be of practical use to those who have to deal with the indicator and indicator diagrams, and has undoubtedly succeeded. He has made three divisions of the subject: In the first the indicators themselves, their attachment to engine cylinders and the methods of driving the drum are considered. In the second division a large number of actual indicator diagrams are given and compared with theoretical diagrams, and in the third gas and oil-engine diagrams are discussed.

The book is divided into 16 parts, and in Part I., after a few preliminary remarks as to the meaning of indicator diagrams and what they show, the calculation of horse-power, &c., a description of Watt's indicator is given. This indicator is not only of great historic interest, but it also serves to illustrate the principles on which all indicators should be designed. The diagram was drawn on a small board having a to-and-fro motion, and a weight was used instead of the spring, which gives the return motion to the drum of the modern indicator. Such an arrangement was obviously only suitable for very slow speeds, owing to the great inertia of the parts, and it is interesting to note that the reduction of inertia has been one of the principal difficulties with which designers of indicators have had to contend. The author rightly lays great stress on this point, and is careful to emphasise it in the descriptions he gives of various well-known indicators such as Richards', Krafts', Darke's, Crosby's, MacInnes-Dobbie's, & Tabor's, and he points out that attempts have been made to avoid still further the effects of inertia by using a beam of reflected light. Various matters of detail in connection with each of the above indicators are considered at some length.

The attachment of the indicator to a cylinder and the apparatus for actuating the motion of the drum are considered in Part II. The indicator cock is shown with a cylindrical thread and is screwed up to a shoulder. A better arrangement, giving more readily a steam tight joint, is to make this end of the cock slightly conical. The usual actuating arrangements are given, and a circular form of reducing gear is described which obviates the usual angular error.

In Parts III. and IV. indicator diagrams from simple engines are discussed, and an interesting diagram from a Smeaton atmospheric engine is given. The diagram was taken by the author in 1889, and shows a mean pressure of 8·17 lb.; it looks excellent, and, as the author points out, it would not reveal the fact that the steam consumption of this engine was no less than 300 lb. per indicated horse-power hour (the steam consumption for the corresponding Rankine engine is 34 lb. per hour). The theoretical diagram of comparison chosen by the author is one with an hyberbolic expansion. No doubt this is usual, but the only merit seems to be the ease with which hyberbolic expansion lines can be drawn. Adiabatic expansion, however, is also discussed, and figures are given to enable this curve to be drawn. The usual method of calculating the steam shown by the indicator is given.

Parts V., VI., and VII., deal with a variety of compound engines and the indicator diagrams to be expected from them are given. The method of "combining" the high-pressure and low-pressure diagrams of a compound engine is discussed at some length. Parts VIII. to XI. give a number of reproductions of actual indicator diagrams taken from simple, compound, triple and quadruple expansion engines working under various conditions of admission and exhaust pressure, speed and load. Many of these diagrams are good, others are bad and the defects are pointed out. In several cases the effect of altering the admission valves is given, and some interesting results are shown. This collection of indicator diagrams is quite representative and will prove, when combined with the explanation given in the text, of great assistance in detecting defects in engines. A variety of locomotive diagrams, both simple and compound, are given in Part XII., and a series of 10 taken from a goods engine of the L.B. & S.C.R. (designed by the late Mr. W. Stroudley) when running at various speeds but with the same load, are most instructive and will well repay careful study.

Part XIII. deals very shortly with gas and oil engine diagrams, and this part would bear enlargement. The indicator diagrams to be expected from different cycles are given. There is a description of a special indicator for use with gas and oil engines, fitted with a differential spring—that is, there are two springs, one light and the other heavy; the former deals with the suction part of the diagram and the release, whereas the latter comes into action during compression, explosion and expansion periods. By this means a "bottom loop" card can be taken simultaneously with the ordinary card.

In Part XIV. will be found certain other applications of the indicator, such as a method of obtaining the valve diagram, or the stress in the valve rod of a locomotive at different points of the stroke. There is also a description of Mathot's indicator for very high-speed engines. Part XV. gives a few examples of faulty diagrams due to defects in the engine, with a few hints helping to infer the defect from the shape of the diagram. This part might have been much enlarged with advantage.

The book concludes with a few words on the measurement of indicator diagrams. H. Riall Sankey.

**Practical Electric Wiring for Lighting Installations.** By C. C. Metcalfe. (London: Harper Bros.) 1905. 5s.

Every man engaged in house wiring work will find much that is useful in Mr. Metcalfe's book. It tells the reader in considerable detail how to fix casing, how to run the wires in it, and how to arrange and fix the fittings, and it is evidently written by a man with considerable practical experience. Those parts of the book which deal with casing are particularly complete, and we do not know any other publication in which this class of work is described in such detail. "Interior conduit" and gas-barrel wiring has been displacing casing work for some considerable time, however, and it is to be regretted that this part of the subject is not treated quite so fully; still many valuable hints are given both with regard to tube wiring and of a general nature, and the book will serve as an excellent guide to those who are learning housewiring, while even the fully-qualified wireman might profit by a perusal of it.

The only serious fault we have to find with the book is a want of system in its arrangement. The information which is given has apparently been written in the order it happened to occur to the author, and has then been sifted out in accordance with some rough method. For instance, in the chapter on "Tools," the author on p. 60 advises the workman to carry a stick of Chatterton's compound in his tool box (by the way, he should warn him that "Chatterton" costs 4s. 6d. per pound), and he adds: "Its use has been fully dealt with in the chapter on Flexible Conductors"—a chapter which commences 40 pages later. The reader is given some practical hints as to the handling of conduit, the disposal of joints in it and with regard to inspection bends and slack on pp. 19 and 20, but it is not until p. 83 that he is told what the conduit system is. Again, in the opening chapter there is a page on "Pressure Drop." After vainly trying to understand from it how he is to calculate the fall of pressure in a circuit, the reader will receive fresh encouragement when he comes to the last sentence, in which it is stated that "the bulk of wiring installations are carried out by the use of tables . . . and a few necessary tables will be found at the end of the book." There is, however, only one short table at the end of the book, which is quite insufficient to enable the reader who possesses only the limited knowledge acquired from the former page, and the reader will have to seek his tables elsewhere.

Other parts of the book in which the design of the wiring system is treated have also their defects; but it is as a book of practical instruction in the execution of the work that we prefer to consider the volume, and as this it may be recommended.

**The Alternating-current Circuit and Motor.** By W. Perren Maycock. 2nd edition. (London: Whittaker & Co.) 4s. 6d.

In addition to the subject matter contained in the first edition, which has been revised in various directions, this second edition includes much new matter concerning single-phase and polyphase motors. It is an elementary book, intended to initiate the non-mathematical reader into the nature, peculiarities and properties of alternating currents, and alternating-current machinery. This object has been attained by clear explanations, by citing numerous mechanical and hydraulic analogies and by many simple diagrams and curves. The first part of the book is principally devoted to theory, while the second portion contains chiefly desciptions and illustrations of single-phase and polyphase motors and transformers, together with discussions on the relative merits of various types. A good deal is said by the author about switches, and a number of ordinary switches are illustrated, but we failed to find any mention of oil switches, although this is the type used exclusively for high-tension alternating-current work on a large scale. Another notable omission relates to the compensated repulsion motor which has been, and is, at least as successful in single-phase traction work as the single-phase series motor and the repulsion motor, both of which have been dealt with at some length by the author. The use of the synonymous terms mono-phase, single-phase and 1-phase in a book of less than 250 pages is not to be encouraged. But these few omissions do not seriously detract from the value of the book for the class of readers for which it is intended.

**Physikalische Grundlagen der Gleich- und Wechselstromtechnik.** By A. Königswerther. (Hanover: Dr. Max Jänecke.) 1905. 2.60m.

We have here the first volume of a new series to be known collectively under the name "Repetitorien der Elektrotechnik," and intended to cover practically the whole ground of applied electrical knowledge. In this first volume Herr A. Königswerther has endeavoured to summarise clearly and concisely the principles, fundamental laws and general formulæ relating to electric science and practice, so that the reader, after having digested the contents of this volume, should have no difficulty in thoroughly understanding the more practical volumes to come. In this task the author has succeeded well, and the volume may be recommended to those who desire to "polish up" and extend their knowledge of electrical principles or require a book of reference in which to find general formulæ and handy rules without having to wade through much extraneous matter.

**Traité Pratique D'Électrochemie.** Par Richard Lorenz. Refondu, d'après l'édition allemande par Georges Hostelet. 1905. (Paris: Gauthier-Villars.) 9 fr.

This book, which is the French translation of Prof. Lorenz's well-known book in German, is one which will undoubtedly be found of great use to students of electro-chemistry in France. The book is a very free translation, and contains much new information not included in the German edition. For example, on p. 35 we find the latest information about the silver coulombmeter. In some cases also the translator has altered the arrangement of the experiments and has introduced new diagrams. Thus, while the ammeter shown in the German edition is from a German firm, that in the French edition is by a French firm.

The first part of the book deals with the laws governing the theory and practice of electro-chemistry, and is partially theoretical and partially practical. That is to say, where possible the theoretical parts are experimentally illustrated, the student of course being expected to carry out the experiments. Section 2 of Part I. is devoted mainly to preparations. Thus we find the preparation of potassium from fused caustic potash. The electrolysis of sodium chloride with and without a diaphragm, the preparation of iodoform, &c. The author might with advantage have given a larger selection to organic preparations.

The actual theory of electrolysis is left to the second part, and is divided up into two parts which deal with the theory of solution and with E.M.F. and polarisation tension. The third part treats of electro-chemical analysis in a manner which is too brief to be of much value, and of applied electro-chemistry. Throughout the book theory and practice are well correlated, and we certainly think that the student who carefully reads and works through this book will finish with a good knowledge of the subject.

Why will not French authors index their books? A table of contents is of very little value, and one is often exasperated in trying to discover whether a certain thing is to be found in a book or not.

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Electrical Power; What It Is, and What It Can Do: A Simple Explanation of the Subject for Business Men and Householders." By Alfred W. Marshall. (London: Marshall & Co.) 3d.

"L'Année Électrique: Électrothérapique et Radiographique: Revue Annuelle des Progrès Électriques en 1905." By Dr. Foveau de Courmelles. 6th edition. (Paris: Ch. Béranger.) 3fr. 50.

"Die Leitungen, Schalt- und Sicherheitsapparate für elektrische Starkstromanlagen." Part II., Schaltanlagen, Montage der Leitungen und Kabel. By H. Pohl. Part III., Berechnung von Leitungsnetzen. By B. Soschinski. (Leipzig: S. Hirzel.) 28m.

"Elektrische Centralen." By K. Wilkens. (Leipzig: S. Hirzel.) 22m.

## BRAKES.

The following is an abstract of the discussion which took place at the Tramways and Light Railways Association on January 10th, in connection with Mr. A. L. C. Fell's Paper on the above subject. A report of the Paper itself will be found in our last two issues, pp. 543 and 586.

### DISCUSSION.

Sir **WILLIAM PREECE** reminded his hearers that he was something of a pioneer in tramway work, having been consulting engineer to the first electric tramways in this country, opened in 1885 at Blackpool. On his recent visit to South Africa with the British Association he had noticed that electromagnetic brakes were used with success in Port Elizabeth, where gradients as steep as 1 in 7½ were met with. He would like to know from Mr. Fell what was the time interval between the movement of the motorman to apply his brake and the actual going on of the brake itself, as this seemed to him a very important point.

Mr. **E. M. LACEY** said his attention had been attracted to the curves showing the performance of the two types of brake which the author considered the most serviceable, at any rate for London conditions, these being the A and B types of magnetic brake. The difference in the performance of these two types was shown by curve sheets I D to IV D and I A to IV A. It was difficult to reconcile the apparently enormous differences with the conclusions of the author to the effect that there appeared to be comparatively little to choose between them. In dealing with the rheostatic brake the author said that, owing to the shorter life of the motors, the maintenance was heavy, Mr. Fell's experience apparently being that at the present time series motors were chosen for accelerating and running the car, and that they very rarely had sufficient reserve capacity to perform much extra work without excessive heating. But in dealing with the magnetic brake, although one of these appeared to do its work with but little call upon the reserve capacity of the motors, while the other apparently required some 10 times the amount, the author did not appear to attach much weight to this point. Perhaps he had found that there was but little difference in heating effects under actual service conditions, and it would be interesting to know if the temperatures of the motors had been taken after a day's run with both types of brake. He personally had found that what many tramway managers desired, particularly in localities where there were heavy and dangerous gradients, was an emergency brake which could be operated by the same handle as was used for running purposes, this brake being used under regular service conditions at all times, so that the motorman in times of emergency went through exactly the same motions as when applying the brake for service stops. It would be interesting to know whether the author had found that these new pattern brakes had fulfilled these conditions.

Mr. **O. H. BALDWIN** had been interested in the subject of electromagnetic brakes for some months. He had analysed the results of the tests to ascertain as far as possible what was the division of the work of retardation among the parts of the equipment of the car—more particularly in regard to the "B" type of brake with new magnets. The author had referred to the superior results obtained by this brake on greasy rails as compared with the corresponding results obtained on dry rails, and had concluded that in all probability the brakes were manipulated more skilfully in the latter tests. He would like to ask if the brakes were not manipulated by the same man in both cases, and also if the rail on the night of the "dry-rail" test, although perfectly dry, was dirty and uneven in patches, while on the night when the tests were made on the "greasy rail," the surface of the rail, while wet and covered with more or less slime, was uniform. If so, this divergence in the track conditions might easily account for the superior results obtained in the case of the so-called "greasy-rail" test. Another disputable statement was that the wear between the pinion and gear wheels was one of the items which had to be taken into consideration as affecting the maintenance of the A and B types of brake. It was a curious fact that the amount of current generated in the armatures to actuate the B type of brake (new magnets), expressed in kilowatt-seconds, was almost identical with the kinetic energy of the two revolving armatures expressed in foot-pounds. In other words, if at the moment of applying the brake the armature were disconnected from the gear and allowed to revolve freely, then the stored-up energy in the armature would be sufficient to stop the car. Therefore, during the period of application of the brake there was practically no wear between pinion and gear. In this respect type B brake (new magnet) was easier on the gears and pinions than the hand-brake, since with the hand-brake it is necessary to check through the gears the stored-up energy of the armatures, which by calculation amounted to nearly 7 per cent. of the total kinetic energy of the moving car. To ascertain the proportion among the various parts of the equipment in the work of retardation (B type with new magnets) the following had been partly taken from ascertained facts and partly assumed: (1) Total weight of car, 12 tons; (2) Number of magnets, four; (3) Maximum pull of each magnet on rails, approximately 4,500 lb.; (4) Assumed that the coefficient of friction between magnet shoes and rail was the some as between brake block and wheel; (5) Assumed that the lever arms between magnets and wheel brakes were so designed as to divide the work beoween the magnet shoes and wheel blocks in proportion to the pressure exerted at their respective-points of application; (6) Assumed that this ratio between the wheel brake and track brake is a constant at all rates of retardation. (7) These assumptions were probably correct for a wide range of conditions, but all of the factors (and there were a large number) were variables, and certain of the ratios also varied, so that the following division of the work of retardation was subject to modification.

| | |
|---|---|
| Work done between brake blocks and wheels | 54 per cent. |
| „ „ „ magnets and track | 35 „ |
| Loss in rheostats | 5 „ |
| Car friction | 3 „ |
| Motor friction | 1½ „ |
| Electrical loss in motor | 1½ „ |

It was evident, when apportioning the work done between the two types, that to obtain the same braking effect, type A brake must throw 60 per cent. of the total work of retarding the car on the motors through armature reaction. Curves IIIA and IVA in particular showed this great difference in the current required to actuate the two types of brakes, and if we considered that the heating effect on the motors was proportional to the square of the currents, the relative difference of temperatures of the motors operating the cars equipped with these two types of brake would be very considerable. Regarding the cost of maintenance of the type B brake, the connecting levers between the magnets and the brake blocks were, generally speaking, of the same materials and general construction as the brake rods and levers which were to be found on all tramcars, and the wear and tear of these parts were not difficult to estimate. Beyond the adjustment from time to time to allow for wear, there could be no great expense, and there was no reason why this part of the equipment should not last as long as any other part of the car.

Mr. **H. N. SPORBORG** had been specially interested in the remarks of Mr. Baldwin, who had made mention of certain divisions of braking effect calculated from these tests. He stated that 55 per cent. of the total energy was dissipated in the wheel shoes, and 35 per cent. in the track shoes. It was difficult to understand this. If these figures were considered in connection with curves I and II, A and D, it was rather difficult to understand why the A and B types of brake with the old magnets showed practically the same results. He should like to hear the explanation of this point.

Mr. **J. S. RAWORTH** would have liked to have had more information about the ordinary track brake. He thought the rheostatic brake was not quite as bad as had been painted, and he instanced a personal experience on the L.C.C. tramways in which a smash was avoided by this brake.

Mr. **W. WORBY BEAUMONT** agreed with the author that the ordinary track brake could not be considered for congested streets and high speeds. It was a pity the author had carried his tests only up to speeds of 15 miles an hour. It was interesting to hear that most of the accidents occurred at low speeds.

Prof. **W. E. AYRTON** asked for more exact information as to the surface of the rails during the tests.

Mr. **H. M. SAYERS** said that brake tests carried out on railways were not directly applicable to tramways, because the rails in the former case were always clean, never being covered with road slime. He had devised hand-operated slipper brakes some eight years ago for heavy cars and stiff gradients, and found them to be satisfactory. Wooden blocks were by far the most effective. They were less variable than metallic blocks, and this he attributed to the fact that a fresh surface was constantly offered to the rail. Pneumatic brakes were expensive both in first cost and in maintenance. He believed that corrugations on tramway rails were frequently started by cars skidding.

Mr. **A. H. POTT** asked for further information concerning the weight, &c., of the cars used and the exact condition of the rails during the tests. Tests on greasy rails which were sanded would also be of interest. He had found that oak blocks cut across the grain wore the longest and gave the best results generally. In some rough tests of his own he had found that both the magnetic brake and the rheostatic brake acted better for watered than for dry rails. When the rails were rendered greasy by the application of axle grease the magnetic brake showed up better than the rheostatic brake. He did not agree with Mr. Fell's remark that for cars driven at high speeds, within reasonable limits, the total cost of power was not materially increased. When he changed the gear on some of his cars from 1 in 4·6 to 1 in 3·9 from 10 to 15 per cent. more power was taken by the car.

Mr. **W. CLOUGH** was of the opinion that the first cost of the brake equipment ought not to be the prime consideration, as a good brake might effect a large saving in life and reduce the damage done to cars. On his system at Bury he had 14 maximum traction truck cars fitted with the B type of electromagnetic brake, and had found during two years that the "B" type had not cost 1s. more in repairs than the "A" type of brake.

## SINGLE-PHASE RAILWAY ON LONG ISLAND.*

The urban railway which has recently been installed by the Long Island Railroad Co. at Glen Cove, L.I., is intended to convey passengers from Sea Cliff and Glen Cove stations on the Long Island Railway to the neighbouring steamboat landings on Long Island Sound. It is only 5 miles long. Power is transmitted from the generating station at Long Island City, 27 miles distant, at 11,000 volts over two No. 1 bare copper wires placed on a wooden pole line to a transforming sub-station adjacent to the passenger station of the Long Island Railway at Glen Cove. The transforming substation equipment consists of two 200 kw., oil-cooled, 11,000 to 2,200 volt, 25 cycle transformers, and the necessary switching and protecting devices. The high-potential lines enter through the centre of double-glass windows, and, passing through spiral choking coils, terminate in oil switches in the primary circuit of the transformers. These switches are enclosed in separate cement compartments, being operated by a system of levers, the handles for which are placed on a separate panel adjacent to the 2,200-volt switchboard. A bank of low-equivalent lightning arresters serves to protect each line entering the building.

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* From the *Street Railway Journal*.

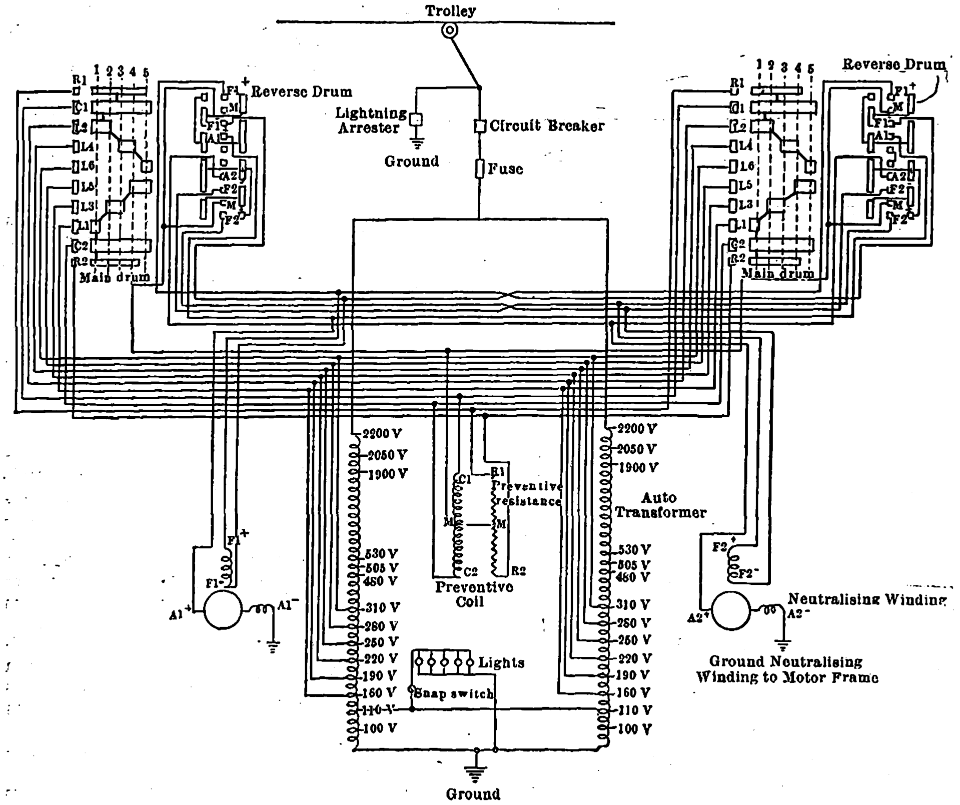
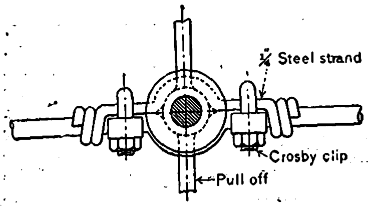

Trolley
Lightning Arrester
Ground
Circuit Breaker
Fuse
R1
C1
L2
L4
L6
L5
L3
L1
C2
R2
1 2 3 4 5
Main drum
Reverse Drum
F1
M
A1
A2
F2
2200 V
2050 V
1900 V
530 V
505 V
480 V
310 V
280 V
250 V
220 V
190 V
160 V
110 V
100 V
C1
R1
Preventive resistance
M
C2
R2
Preventive Coil
Auto Transformer
Lights
Snap switch
Ground
Neutralising Winding
Ground Neutralising Winding to Motor Frame

FIG. 1.—DIAGRAM OF CIRCUITS OF EQUIPMENT USING TWO-PART AUTO-TRANSFORMERS.

No attendants are required at the sub-station. In the event of the primary switches being opened from any cause, an electric bell in the adjacent passenger station is caused to ring. Although only one of the phases of the three-phase generating system supplies power to the railway at present, the sub-station equipment is designed for three-phase operation. All switches, lightning arresters and switchboards are of the three-phase type, two-thirds of the equipment being used at present. With future extensions, a third transmission wire will be erected and a third transformer will be installed, so that power can be obtained from all three of the phases.


¼ Steel strand
Crosby clip
Pull off

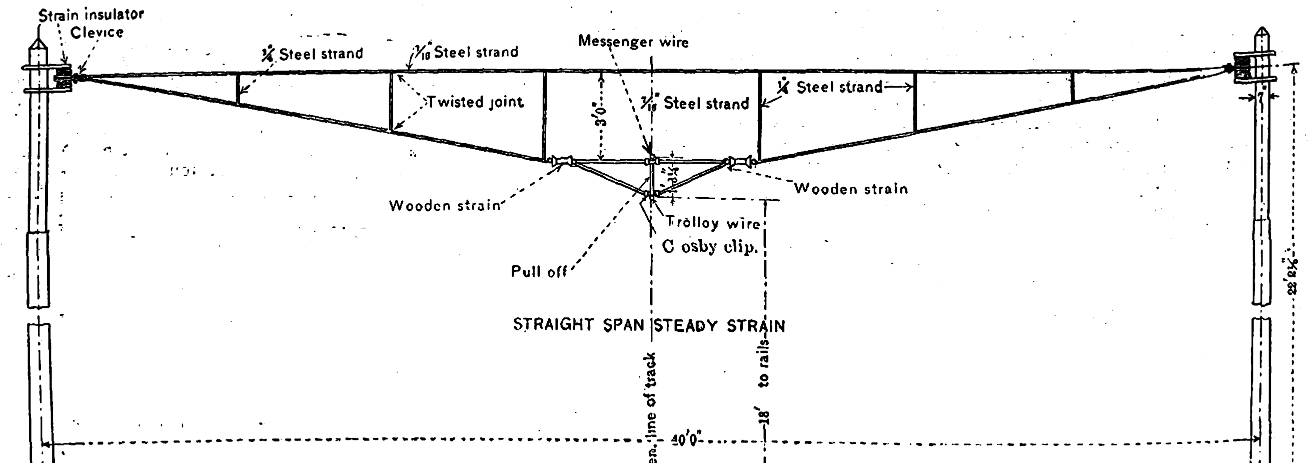

Strain insulator
Clevice
¼ Steel strand
7/16 Steel strand
Messenger wire
Twisted joint
3'0"
⁵⁄₁₆ Steel strand
¼ Steel strand
Wooden strain
Wooden strain
Trolley wire
Crosby clip.
Pull off
STRAIGHT SPAN
STEADY STRAIN
Cen. line of track
18' to rails
40'0"
23'8½"

FIG. 2.—DOUBLE CATENARY WIRE TROLLEY SUSPENSION USING IRON SIDE POLES.

At the present time four cars have been equipped. Two are of the single-truck type, and each weighs 14 tons; while each of the other cars is supplied with double trucks, and weighs 17 tons. The single-truck cars are of the semi-convertible type. One of the double-truck cars is also of the semi-convertible type, while the other is of the open type. The driving equipment of each car consists of two 50 H.P. 300-volt, 25-cycle Westinghouse single-phase, compensated series motors, connected permanently in parallel and regulated by potential control (Fig 1.) Very little sparking is stated to be produced, even under the severest starting conditions. The four brush studs are mounted on an annular ring, which is arranged to be rotated through 360 deg. when desirable, so that all brushes can be inspected from the top opening in the frame of the motor. The brush studs are connected in two pairs to two copper 'bus rings, which are joined to flexible leads, which pass through the frame by way of substantial insulating bushings, after the compensating stator winding has been included in the armature circuit. All bearings are lubricated with waste dipping in heavy machine oil. Each car is provided with a variable ratio auto-transformer. Six of the intermediate taps, giving effective voltages of 160, 190, 220, 250, 288 and 310 volts respectively, are for use in connection with the motors. There are on the controller, however, only five running points, corresponding to 175, 205, 235, 265 and 295 volts respectively. It will be observed that the E.M.F. impressed upon the motor circuits is in each case intermediate between the voltages available at the transformer taps. This intermediate voltage is obtained through the use of so-called preventive resistance and preventive reactance, the prime object of which is to eliminate sparking at the controller. The motor circuits receive current from the middle points of the preventive reactance coil and the preventive resistance. When the controller is on any one of the first four accelerating points, both of the coil and the resistance are subjected to an E.M.F. of 30 volts. This voltage forces a certain current through the preventive resistance independent of the operation of the motors, and it causes a certain exciting current to flow through the preventive coil. In addition to its exciting current, there flows through each half of the preventive coil one-half of the current to the motor circuits, the two components of the motor current flowing in opposite directions in the two sections of the coil. In changing the controller from a running position to the one next higher in voltage, the lower E.M.F. terminals of the preventive coil and resistance are disconnected from the corresponding tap on the auto-transformer and transferred to another tap 60 volts higher in E.M.F. At the intermediate position of the controller, only the necessary exciting current flows through the preventive coil, while one-half of the preventive resistance carries the whole of the current to the motor circuit. It is evident, therefore, that the windings on the transformer are never short-circuited and the circuit to the motors is never opened during the accelerating period. When the controller is placed on the running position giving the highest voltage, the preventive resistance is excluded from the circuit and only the preventive coil is in use, thus eliminating that loss in the preventive resistance due to the 30 volts across its terminals. Experience shows that there is no perceptible arcing at the contacts when the controller is changed from one running position to another, and that when the controller is thrown to the "off" position the arcing is very slight.

The auto-transformer of each of the double-truck cars is rated at 50 kw., and is of the air-cooled type. Each single-truck car is provided with two 25 kw. auto-transformers, which are electrically so interconnected as to form virtually a single 50 kw. transformer. The object in thus dividing the transformer was to allow of a proper distribution of the weight, since sufficient space was not available for placing it under the centre of the car, and it was not considered advisable to concentrate the weight at one end. The lamps of the car, including those for the two headlights, are connected in parallel and receive current from the 110 volt tap of the main auto-transformer. From the same tap is taken current for operating the rheostatic heaters of the car. Each car is provided with a plain mechanical hand brake. The trolley pole differs in no wise from the standard construction used in street car work, and is provided with the usual grooved wheel. Its socket is rigidly attached to a special platform which is mounted on four substantial porcelain insulators immediately over the centre of the car. The conducting circuit from the pole passes across a Wurts lightning arrester equipment suspended beneath the special platform, and is then led through grounded protecting tubing to an oil circuit-breaker and switch placed in the canopy of the vestibule. All metallic parts of the car are thoroughly grounded, even the lower end of the trolley rope being joined to the framework. Two wooden strain insulators are inserted in the trolley rope for the purpose of preventing the passage of leakage current when the rope is damp.

The trolley wire has an area equivalent to a B & S No. 000. It is of a grooved section, and is held in place by means of clamping ears, which are suspended from a $\frac{7}{16}$ in. steel cable catenary. The method of supporting the catenary varies with the curvature of the track and the nature of the locality. Since very little of the road length is laid on tangents, and the route covers village streets, country roads and steam road beds, almost all types of suspension are in use. Along the track, which is laid on the bed of the steam road—that is, for the distance of $\frac{1}{2}$ mile, and along a portion of the country roads, the catenary is held in place by means of a bracket-arm construction employing wooden poles spaced 120 ft. apart. Along the route of the old direct-current railway the original side brackets were used without alteration. Each bracket-arm is an iron pipe 2 in. in diameter, which serves to hold the trolley wire about 21 ft. above the rails. Along the line adjacent to the steam road the brackets are made of substantial T-irons. Within the towns the catenary is held in place by means of side-pole and double span-wire construction. In the town of Glen Cove the side poles are built up of iron piping of three sizes, having diameters of 6 in., 7 in. and 8 in. respectively (see Fig. 2). Each pole is 30 ft. in length and is set 6 ft. in the ground on a bed of concrete, the hole being filled with concrete to the level of the ground. The span wires, which are made of $\frac{7}{16}$ in. steel cable, are supported and insulated from the iron poles by means of substantial porcelain sleeves. Each sleeve is cemented around a short length of iron piping, the two ends of which are secured to the iron pole by clamps and retaining bolts. The span wires are fastened to a malleable iron collar, which surrounds the porcelain sleeve, a separating lead collar serving to insure that the mechanical pressure of the iron collar is properly distributed over the porcelain sleeve. In all cases, the major insulation of the line is provided by these porcelain sleeves. The catenary is connected directly to a centre porcelain sleeve insulator which is supported from the lower of two span wires. This lower span wire is itself supported from the upper span wire, and in it are inserted two hickory strain insulators, one on each side of the centre porcelain sleeve. Owing to the fact that the trolley collector is of the wheel type, guard loops are provided for those porcelain sleeves from which the catenary is directly suspended, in order to protect the insulator in event of the trolley wheel leaving the wire.

Over certain sections of the railway, where electric light and telephone wires are numerous, guard wires have been erected in order to prevent fallen wires from coming in contact with the catenary or the trolley wire. For this purpose, 30 in. above the central trolley wire and catenary have been placed two galvanised iron wires, which are separated from each other by 18 in. These guard wires are thoroughly insulated from, and supported by, a system of span wires, which are grounded to the side poles. The two wires are transposed at frequent intervals, and it is expected that they can be utilised as a telephone circuit in spite of their proximity to the trolley wire carrying alternating current.

In the town of Glen Cove the track is formed of 130 lb. girder rails, electrically connected by protected ribbon bonds. The terminals of these bonds are placed in holes freshly drilled in the rails, and conductivity is assured by the use of a wedge-shaped steel core, which is driven in a hole in the terminal, and forces the copper of the terminal into intimate contact with the unoxidised surface of the iron web. The bond is then covered by the fish-plate. The track, which is laid parallel to the steam road and on the same road-bed, is formed of 70 lb. T-rails, which were previously used on the steam road. These rails are interconnected by means of protected ribbon bonds, similar to those used on the girder rails.

## HIGH TENSION CONTINUOUS-CURRENT TRACTION.

In an interesting article on continuous-current *versus* single-phase traction, appearing in a recent issue of the *Street Railway Journal* of New York, Mr. B. G. Lamme makes the following remarks on the limitations of H.-T. continuous-current traction: The present direct-current traction system has accomplished wonderful results, but there are limits to its application. If the present direct current system with its transforming sub-stations is to be retained, then the future development must lie in the direction of increasing the direct-current voltage on the trolley and car system. About 15 years ago, 500 volts was usual, while at the present time 650 volts is rarely exceeded in regular service. It has been stated that the present 500 or 600 volt system is an arbitrary standard, and that there is no particular reason for retaining such a standard when occasion calls for higher voltage. However, as it has taken about 15 years to obtain an increase of about 150 volts, while there has been good reason for years for going much higher, it is evident that something more than the mere adherence to a standard has prevented the use of higher direct-current voltages.

As 1,500 volt direct-current equipments have been talked about to a considerable extent in the past year or two, it would probably be of interest to many to know what difficulties could be expected with such a relatively large jump above our present practice. I will, therefore, mention some of the troubles which have been encountered in increasing from 500 to 650 volts, and this will furnish an indication as to what designers would expect if very much higher voltages are used. There have been isolated instances where high direct-current voltages have been used on car equipments, but in general it has been found that 600 to 700 volts represents the practical limit with present designs of apparatus. The difficulties in designing direct-current railway apparatus for higher voltage are not due to lack of ability to construct a railway motor which can be wound for 1,500 volts, but largely to certain operating conditions found principally in railway service.

In the direct-current railway motor, one of the most difficult conditions to be met is the tendency to occasional flashing. This is particularly found in the larger motors for heavy, high-speed service. On a small motor a flash may not be very destructive, but the larger the motor the more serious the difficulty becomes, as a flash may put the motor out of service. In fact, in most cases it is only the efficiency of the control system and circuit-opening devices which saves the motors. It would undoubtedly be much more serious on higher-voltage motors. On 500 volts it is seldom noted, but on 600 or 700 volts it appears to be much more frequent, even though such higher voltage motors are designed with a proportionately larger number of commutotor bars, larger size of commutator, &c. This flashing is liable to occur when the circuit of the motor is opened momentarily and then closed again with the motor remaining connected across the circuit. If the magnetism of the motor has an opportunity to die down during the period that the current is off, then the first rush of current when the circuit is again closed will not build up the field as quickly as the armature. The result is an enormous rush of current until the armature counter E.M.F. rises, this current rush being accompanied by great field distortion, with consequent change of lead. This in itself is sufficient to account for many cases of flashing. In late designs of motors it is common practice to remove, as far as possible, all secondary or closed circuits around the field, in order that the field magnetism may build up more quickly. However, the solid yoke of the usual type of direct-current motor forms, to some extent, a secondary circuit retarding the rise in field magnetism, and also the armature coils immediately under the brushes form secondary circuits which may have enormous currents momentarily set up in them. These secondary circuits may cause momentary "spitting" or "blazing" at the brushes, and this latter action may also assist in starting a flash. Experience has shown that, with all possible damping effects removed from the field of the ordinary direct-current motor, there still exists a tendency to flash under certain conditions, particularly when the cars are operated on a trolley system which has considerable inductance, such as one with circuits largely of iron, conveying very heavy currents. In such a system, any sudden reduction in the current is liable to produce momentary voltage rises which may bring any motors connected across the system up to the flashing point, and this action has apparently been responsible for certain troubles in large systems. If, however, the normal voltage is raised to 1,500 across the motors, experience tends to show that the above difficulties would practically prohibit their use if the present types of construction are retained.

There are certain ways in which this flashing tendency in high-voltage motors could be suppressed, but these involve very radical changes in the design. For example, they could be made entirely with laminated magnetic circuits with no closed secondary paths and no low-resistance secondary circuits in the armature winding. The field would be provided with neutralising or so-called "compensating" windings, which practically neutralise the magnetising effect of the armature. In such a motor the field magnetism would rise almost instantly when the circuit was closed and the rush of current would be relatively small. Also, such current as did flow would produce practically no distorting effect on the field and but little change in lead. The armature coils, short-circuited at the brushes, having no low-resistance path, would have no heavy secondary current set up in them, and consequently there would be no particular tendency to undue sparking at the first current rush. Such a motor, when running at high speed, could be thrown directly across a high-voltage circuit without resistance in circuit, or could even be reversed without resistance, with no injurious effects as regards flashing. Such a motor would, therefore, form an ideal one for direct-current service. However, it would be relatively expensive to construct, and if wound for high voltage would require a comparatively large number of turns on the armature and compensating windings. The field winding, however, could have comparatively few turns, as a stiff field is not required to prevent distortion.

Another feature of the high-voltage direct-current system which should be considered, is the question of the control system. I have no doubt whatever but that a 1,500 volt control system will be more costly than one for 600 volts, and it will also be more liable to break-downs. While its construction is not impossible, yet I believe that a 1,500 volt direct-current control will be much more troublesome to operate than a 600-volt control.

Passing next to the sub-stations or power house required with a high-voltage direct-current system, we find that it is necessary to use high-voltage direct-current generators or rotary converters. A 1,500 volt direct-current generator may represent a permissible design and it may not be unduly expensive. However, a high-voltage rotary converter presents some problems which are not found to the same extent in the present low-voltage machines. A good non-hunting rotary converter possesses an inherent tendency to flash under certain conditions. It is found that on certain conditions a short circuit, momentary or otherwise, on the direct-current system, sufficient to open the circuit-breaker at the rotary station, may cause the rotary converters to flash at the commutators. This effect appears to be dependent largely upon the alternating-current transmission system back of the rotaries. For instance, the direct-current short-circuit may produce a momentary drop in voltage on the alternating-current system supplying the rotary. The moment the direct-current circuit-breaker opens and the short-circuit is removed, the alternating-current voltage at once tends to rise to normal value. The rotary, however, has had its counter E.M.F. lowered by the short circuit, and there is, therefore, a tendency to produce a momentary rush of current when the alternating-current voltage rises. This rush of current momentarily changes the lead and may cause a flash at the commutator, which again produces a drop in the alternating-current system, tending to reduce or stop the flashing. The result may be a series of flashes following each other quickly, and in some cases this is only stopped by cutting the machine out of circuit. It has been the practice in some cases to instal automatic circuit breakers in the alternating side to get the machine out of circuit when this flashing occurs. However, the time required to synchronise is generally considered such an objection that the risk of flashing is considered the lesser evil and the alternating-current breakers are omitted. Cases have been noted where several rotaries were connected to the same system, some operating without load, when a short circuit across one of the loaded rotaries has caused the empty ones to flash, indicating clearly that this effect comes through the alternating system.

Experience has shown that this possibility of flashing increases rapidly with increase in voltage. It usually is not troublesome in city and suburban plants where the alternating-current transmission drops are comparatively small and where the loads are comparatively steady. The trouble increases in those cases where the line drop is liable to be rather large, and where the service is rather infrequent and the load fluctuates over a wide range. On account of this difficulty, it is generally not feasible to instal rotary converter capacity in the sub-stations corresponding only to the average load, but it must be more nearly comparable with the maximum load, in those cases where the service is very infrequent and the load fluctuates violently. With voltages of 1,000 and 1,500 on rotary converters, this flashing tendency would be enormously increased and might even prohibit the use of this class of machinery. It has been noted that it seems to be, to a great extent, independent of the frequency, the number of commutator bars, size of commutator, &c., just as the flashing in a railway motor seems to be, to a certain extent, independent of the number of commutator bars and the size of commutator.

As to the construction of 1,500 volt generators for constant potential service, while this may not be entirely impracticable, yet it is not a particularly easy problem to design them for railway service. It has been stated a number of times in the past four months that the construction of high voltage direct-current generators is not a difficult problem, as instanced by the 3,000-voltage generators of the Thury constant-current system. However, it should be borne in mind that a 3,000 volt constant-current machine represents a much easier condition as regards operation than a 1,500 volt constant potential machine, such as would be required for railway service. In this country 6,000 volt direct-current constant-current machines have been common practice for years, yet the builders of such machines are well aware of the fact that the constant-current feature is a very important condition in their construction and operation. A flash on a constant-current machine is not especially destructive, as the current does not rise to a dangerous point. On a constant-potential machine, however, the current may rise to an enormous value and its destructive effect may increase rapidly with increase in voltage, as the energy expended in the arc will be greater. Experience has shown that on 650-volt machines a flash is more vicious than on 500 volt machines. The tendency to flash will also undoubtedly increase with increase in voltage. Further, it is not fair to compare a railway machine with one terminal grounded with a high-voltage machine in which both terminals are insulated. In railway service, any momentary flash which reaches to any of the neighbouring parts of the frame would short-circuit the machine unless the frame and parts are entirely insulated from the earth, while this would not be true in the case of a generator with insulated circuits. Taking all things into account, the design of a first-class 1,500 volt direct-current railway generator with one terminal grounded presents such possibilities for trouble that those designers most able to construct such a machine are the ones who would raise the greatest objection to doing so.

The present third-rail system, while it has operated admirably on 600 and 700 volts, would present serious objections on 1,500 volts, and it is the opinion of many that if such voltage were to be used, then the overhead trolley system would also be used. A 1,000 or 1,500 volt overhead trolley system, while it is operative under many conditions, is far from being adequate for the general problems of traction which are to be met at some future time.

## THE MEASUREMENT OF HIGH FREQUENCY CURRENTS AND ELECTRIC WAVES.*

BY PROF. J. A. FLEMING, M.A., D.SC., F.R.S.

(*Continued from page 558*).

### LECTURE II.—MEASUREMENT OF HIGH-FREQUENCY CURRENT AND VOLTAGE.

If a condenser of any kind, such as a Leyden jar, is discharged through a low resistance, it is a familiar fact that the discharge does not consist in a single movement of electricity in one direction, but in a rapidly decreasing to-and-fro movement, called a train of electrical oscillations. We can have this operation represented to the eye optically or photographically by means of a Duddell oscillograph, provided that we employ a capacity and inductance which are not too small.

The oscillograph is a kind of mirror galvanometer adapted to measure very rapidly changing currents. It consists of one or two loops of fine wire which carry a mirror, these loops being placed in a strong magnetic field (see Fig. 14). When an alternating current is passed through the wire it causes the mirror to vibrate to and fro, and a ray of light reflected from this mirror is also reflected from another mirror with axis at right angles, which is vibrating in tune with the first. The ray of light is then reflected either on to a ground-glass screen or a sensitive photographic plate. In order to render the instrument available for recording non-periodic phenomena, I have adopted the following plan:—On the shaft of an alternator having a frequency of about 80, is fixed a disc on non-conducting material having brass sectors let into it. Against this disc three brass wire brushes press in such a fashion that, as the alternator revolves, the middle brush is alternately connected, first to one and then to the other of the outside brushes for a time, equal to half a period of the alternator. If a condenser, C, a battery of secondary cells, B, and the oscillograph circuit O are connected up, as shown in diagram in Fig. 15, we can then employ the current from the alternator to drive the mirror of the oscillograph, and at the same time use the alternator shaft to drive the commutator which alternately charges the condenser from the battery and discharges it through the oscillograph.* The result of this is we get on the screen of the oscillograph curves representing the oscillatory discharge of the condenser as seen in Figs. 16-18. These curves indicate that when the condenser discharges, the electricity rushes to and fro in the discharge circuit with a gradually decreasing amplitude, the oscillations decreasing in geometrical progression as the time increases in arithmetical progression. The capacity, inductance, and resistance in the circuit used are marked in each case on the diagram. The time interval between two successive zero points is called the semi-period of the oscillation, and the complete period is denoted by the letter T. The frequency, denoted by the letter $n$, is the number of periods per second. It can be shown by analysing these curves that two successive maxima in opposite directions bear the same ratio to one another. In other words, if we can call $I_1$ $I_2$ $I_3$, &c., the successive maximum values of the currents, the ratio of $I_1/I_2$, $I_2/I_3$, &c., is constant. The logarithm of this ratio taken to the Napierian base is called the logarithmic decrement, and denoted by the letter $\delta$. If the amplitude of the oscillations dies away quickly, the oscillation is said to be highly damped, and if very slowly they are said to be slightly damped. If R is the total resistance of the circuit including the oscillograph, and L is the inductance, the ratio R/2L is called the damping factor, and denoted by the letter $a$. If C is the capacity of the condenser reckoned in microfarads, and L the inductance of the circuit in centimeters, then the quantity $\sqrt{CL}$ is called the oscillation constant of the circuit. It can be then shown that these quantities are connected by the following equations—

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* Cantor lectures delivered at the Society of Arts, Nov. and Dec., 1905.

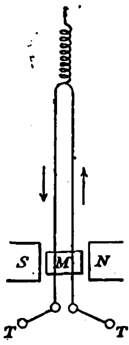

Fig. 14.—Diagram of Duddell Oscillograph.

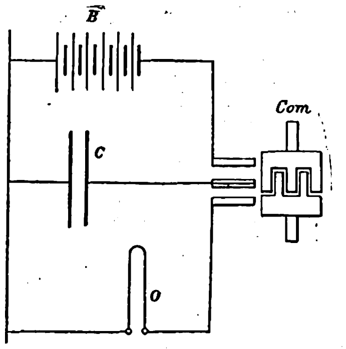

Fig. 15.—Arrangement for Delineating Condenser Discharge Curve.

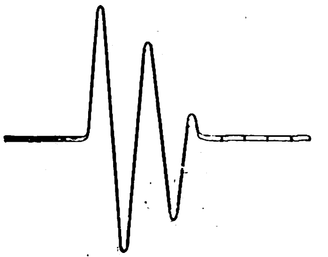

Fig. 16.

Oscillatory Discharge.—Capacity=7 mfds. Inductance (L.F.)=31·5 m.h. Inductance (H.F.)=... Total Resistance=7 ohms. Frequency=339. T calculated =29·53×10⁻⁴ secs.

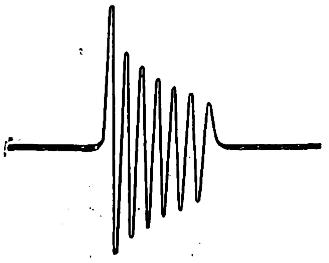

Fig. 17.

Oscillatory Discharge. — Capacity=0·75 mfds. Inductance (L.F.)=31·5 m.h. Inductance (H.F.)=... Total Resistance =7ohms. Frequency=1017. T measured= 9·83×10⁻⁴ secs. T calculated=9·68×10⁻⁴ secs.

$$T=\frac{1}{n}\;p=2\pi n=6{\cdot}28n$$

$$\delta=\log\frac{I_1}{I_2}=\log_\epsilon\frac{I_2}{I_3}=\&c.$$

$$\epsilon^\delta=I_1/I_2=I_2/I_3=\&c., \text{ where } \epsilon=2{\cdot}718$$

$$a=R/2L=2n\delta$$

$$T=\frac{2\pi}{\sqrt{\frac{1}{CL}-a^2}} \text{ or } n=\frac{1}{2\pi\sqrt{CL}}.$$

In making quantitative measurements we must measure capacity in microfarads and inductance in centimetres, and then the formula for the frequency becomes—

$$n=\frac{5\times10^6}{\sqrt{C(\text{in mfds})\times L(\text{in cms})}},$$

and the expression for the oscillation constant O becomes— $O=\sqrt{CL}=5\times10^6/n$. Also it can be shown that there is a certain relation between the first maximum ordinate $I_1$ of current, and the capacity of the condenser C the voltage V, to which it is charged and the frequency, which is expressed by the following formula—

$$I_1=CVp10^{-6}.$$

Where C is the capacity of the condenser in microfarads, V the voltage of the battery charging the condenser, and $I_1$ the first maximum value of the discharge current in amperes. The three important quantities in which we are concerned in considering the oscillatory discharge of the condenser are first, the frequency, $n$; secondly, the decrement, $\delta$; and thirdly, the maximum amplitude, $I_1$. Again, we have to fix conventionally some limit beyond which we may consider the oscillations to be extinguished.

For all practical purposes we may consider the oscillations to be over when they are reduced to 1 per cent. of their initial value. It is then easy to show that the number of complete oscillations, M, in the group or train is given by the formula—

$$M=\frac{4{\cdot}60\;6+\delta}{2\delta}.$$

Suppose $\delta$ has any such a value of 0·1, which means that each oscillation is about 90 per cent. of the preceding one. This means that in 23 or 24 oscillations, the discharge is finished. If, however, $\delta$ equals ·01, then there will be 230 to 240 complete oscillations in the train. In the case of oscillatory circuits as used in wireless telegraphy, in some cases there may not be half-a-dozen oscillations, in other cases as many as a thousand. As the operations of wireless telegraphy are greatly dependent upon the number of oscillations in a train, the measurement of the decrement is very important. We are now in a position to analyse completely the events which take place when a Leyden jar is attached to the secondary terminals of an induction coil, and has a spark-gap and inductance placed in series with it, forming an oscillatory circuit with the spark-gap.

We are concerned with the following five quantities: First, the capacity C of the jar or condenser; second, the inductance L of the circuit; third, the maximum voltage V to which the jar is charged; fourth, the number of discharges per second, N; and fifth, with the mean square value of the current in the oscillatory circuit $J^2$. In order to explain the meaning of this last term, consider the oscillations in one single train to be sent through a fine wire, they would create a certain amount of heat in that wire, and if N groups of oscillations were sent through the wire in one second they would create N times as much heat in the wire. Supposing, then, that we pass through the wire continuous current having a certain value, J, such that it would produce in that wire in one second the same quantity of heat as the N groups of the oscillations. The current J is called the R.M.S. value of oscillations. We can, therefore, find the value of J or the R.M.S. value of any train of oscillations by passing it through a hot-wire ammeter, provided this has a suitable form. In order that such an instrument may be available for making the above measurement, the wire which is heated must consist of either one fine wire not exceeding No. 36 in size or else a group of such wires in parallel, any suitable arrangement being made for measuring the expansion of the wire by heat, and, therefore, for graduating the instrument by means of a continuous current. I exhibit to you an instrument designed on these lines which I have had made. (See Fig. 19.)

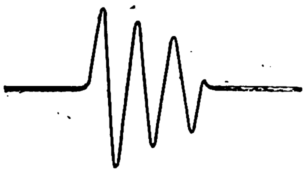

Fig. 18.

Oscillatory Discharge.—T measured=22·85×10⁻⁴ secs. T calculated=22·24 ×10⁻⁴ secs. Capacity=4 mfds. Inductance (L.F.)=31·5 m.h. Inductance (H.F.)=.... Total Resistance=7 ohms. Frequency=438.

German investigators have made a good deal of use of a form of hot-wire ammeter, which is described in old books of electricity under the name of the Reiss Electrical Thermometer. This instrument was, in fact, invented by our countryman, Sir W. Snow Harris, and was described by him in 1827 in the *Philosophical Transactions* of the Royal Society. In this instrument a fine wire or strand of fine wires is included in the bulb of an air thermometer, consisting of a U-tube attached to a bulb, the bend of the tube being filled with some liquid (see Fig. 20). When a current is sent through the wire it heats the air and forces the liquid up in one leg of the U-tube until a stationary position is reached depending on the current. Such an instrument may be used for measuring the R.M.S. value of a train of oscillations, but my own experience is that it is not so useful or quick in operation as a hot-wire ammeter made with a bundle of fine platinoid wires, the expansion of these wires being measured by means of the sag produced in them.

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* In the actual experiments made in the Pender Electrical Laboratory, the time during which the condenser was in connection with the oscillograph was $\frac{66}{10000}$ of a second, and the times of charge and discharge were not quite equal.

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It is not difficult to show that there is a definite relation between the R.M.S. value of a train of oscillations, the maximum value I of the first oscillation, the logarithmic decrement $\delta$, and the frequency $n$, which is expressed by the following formula:—

$$J^2 = NI_1^2/4a = NI_1^2L/2R = NI_1^2/4n\delta.$$

Returning, then, to the Leyden-jar discharge, we place a hot-wire ammeter in the discharge circuit, and also a spark counter, and make use of a discharger, consisting of two spark balls of steel, each ball being about 2 cm. in diameter, the distance between the balls being adjustable and measurable by means of a micrometer screw.

**Table IV.**—*Showing the Spark Voltage between Brass Balls, 2 cm. in Diameter, for various Spark Lengths.*

| Spark length in cms. | Spark voltage. | Spark length in cms. | Spark voltage. | Spark length in cms. | Spark voltage. |
|---|---|---|---|---|---|
| 0·1 | 4,700 | 1·8 | 44,700 | 3 5 | 61,100 |
| 0·2 | 8,100 | 1·9 | 46,100 | 3·6 | 61,800 |
| 0·3 | 11,400 | 2·0 | 47,400 | 3·7 | 62,400 |
| 0·4 | 14,500 | 2·1 | 48,600 | 3·8 | 63,000 |
| 0·5 | 77,500 | 2·2 | 49,800 | 3·9 | 63,600 |
| 0·6 | 20,400 | 2·3 | 51,000 | 4·0 | 64,200 |
| 0·7 | 23,250 | 2·4 | 52,000 | 4·1 | 64,800 |
| 0·8 | 26,100 | 2·5 | 53,000 | 4 2 | 61,500 |
| 0·9 | 28,800 | 2·6 | 54,000 | 4·3 | 66,000 |
| 1·0 | 31,300 | 2·7 | 54,900 | 4·4 | 66,600 |
| 1·1 | 33,300 | 2·8 | 55,800 | 4·5 | 67,200 |
| 1·2 | 35,500 | 2·9 | 56,700 | 4·6 | 67,800 |
| 1·3 | 37,200 | 3·0 | 57,500 | 4·7 | 68,300 |
| 1·4 | 38,700 | 3·1 | 58,300 | 4·8 | 68,800 |
| 1·5 | 40,300 | 3·2 | 59,000 | 4·9 | 69,300 |
| 1·6 | 41,300 | 3·3 | 59,700 | 5·0 | 69,800 |
| 1·7 | 43,200 | 3·4 | 60,400 | 5·1 | 70,300 |

There is a definite relation between the voltage required to give a spark of any length in air at the normal pressure and the size of the spark balls, which is given in Table IV. below, mostly taken from Heydweiller's observations of spark potential.* (See Fig. 21.)

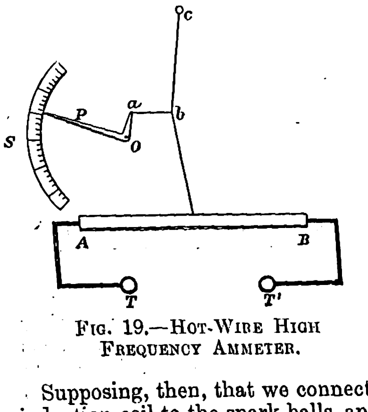

FIG. 19.—HOT-WIRE HIGH FREQUENCY AMMETER.

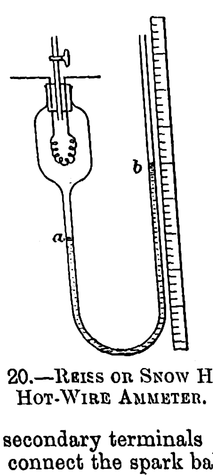

FIG. 20.—REISS OR SNOW HARRIS HOT-WIRE AMMETER.

Supposing, then, that we connect the secondary terminals of an induction coil to the spark balls, and also connect the spark balls by means of an oscillatory circuit consisting of an inductance coil, a condenser or Leyden jar, and an ammeter suitable for measuring high-frequency currents made as described; also let us suppose that a strip of paper tape is drawn between the spark balls, as already described, so as to count the number of sparks per second, and let it be assumed also that we have already measured, as described, the capacity of the Leyden jar and the inductance of the circuit, we have then the means of measuring the above five mentioned quantities, C, L, V, J, R, and from these measured quantities we can deduce the value of others—viz., the frequency $n$, the decrement $\delta$, the resistance of the circuit R in ohms, and the number of oscillations per train, N, by the following formula:—

$$I_1 = \frac{C}{10^6}Vp = V\frac{\sqrt{C/10^6}}{\sqrt{L/10^9}} = V\sqrt{\frac{1{,}000C}{L}}.$$

$$R = \frac{NLI_1^2}{2\times10^9J^2} \quad \delta = \frac{R10^9}{4nL} \quad M = \frac{4{,}606\times\delta}{2\delta}.$$

Where C the capacity is measured in microfarads, V the charging voltage in volts, L the inductance in centimetres, J the R.M.S. current in amperes, and the resistance R is given in ohms.

Let us apply this to the case of the Leyden jar before us. The jar has a capacity of $\frac{1}{1000}$th mfd., hence $C = \frac{1}{1000}$th mfd., the inductance L of the circuit = 2,000 cm., the spark-length = about 3 mm., hence the voltage V = 12,000 volts, the number of sparks per second N = 50, and the R.M.S. value of the discharge current = J = 1·5 amperes. We then find that the frequency $n = 2{\cdot}25\times10^6$ and the maximum current I = 390 amperes. The spark resistance R = 3.5 ohms and the decrement $\delta = 0{\cdot}2$ and the number of oscillations per train M = 24.

Nothing is more astonishing than the large currents which can be given out by condensers of quite moderate size. At one instant during its discharge this Leyden jar before you is furnishing a current of nearly 400 amperes, but of course that current lasts only for an infinitely small time. Supposing we desire to make a diagram to a scale representing what is taking place during one second when this Leyden jar is creating an oscillatory discharge, let us suppose that we take a scale of time on which one foot represents one millionth of a second, then a time of one second would be represented by a length of 200 miles. Again, let us suppose that we take a scale of current on which 1 mm. represents 1 ampere, then we desire to represent a curve delineating the oscillations taking place in one second when this jar is discharged, we should have to draw a series of diagrams, each of which will resemble the one in Fig. 19, which would have to be placed 4 miles apart. Each train of 24 oscillations would be 4 ft. 6 in. long, and the maximum ordinate, representing a current of 390 amperes, would be 15½ in., whilst the ordinate representing the R.M.S. current 7 would only be $\frac{1}{5}$ mm. You will notice, then, that the 50 groups of the oscillations taking place in one second only occupy in all one thousandth of a second, hence for 999 thousandths of a second nothing is happening, and this explains how it is that the maximum current is so enormously greater than the R.M.S. current.

We must next consider some facts connected with the decay of oscillations in a train. The reason for this decay is evidently the dissipation of energy from some cause or causes. This dissipation may arise from any or all of the following causes: 1. The resistance of the inductive circuit. 2. The resistance of the spark. 3. Magnetic hysteresis in the metal of the circuit. 4. Dielectric hysteresis or brush discharge or conduction in the condenser. 5. Radiation of energy from the circuit.

This last cause is generally the most important. In closed or nearly closed oscillatory circuits containing a spark-gap, the decay of the oscillations is chiefly due to spark resistance, and, generally speaking, the resistance of the metallic part of a circuit is negligible compared with that of the spark. The decrement per semi-period may be of the order of 0·01 or 0·001. On the other hand, in open oscillatory circuit, such as an Hertzian radiator or Marconi telegraphic aerial, it is found that the decrement per semi-period is much larger and may have the value 0·1 or 0·2, and this decay is not due to spark resistance, far less resistance of the wire, but chiefly to the energy dissipated in the form of the electric waves.

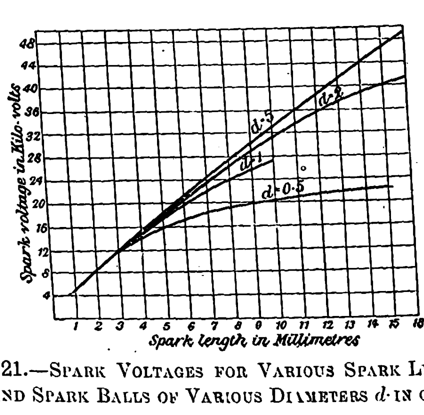

FIG. 21.—SPARK VOLTAGES FOR VARIOUS SPARK LENGTHS AND SPARK BALLS OF VARIOUS DIAMETERS *d* IN CMS.

There are several methods by which this decrement may be determined, and it is essential to distinguish between that part of the decrement which is due to resistance, which is called the resistance decrement, and that part due to radiation, which is called the radiation decrement. Rutherford, Bjerknes and Drude have all devised methods for determining the decrement of electrical oscillations in a circuit. Rutherford's method depends on the principle that if a small bundle of soft iron wires, very fine and short, is magnetised to saturation, and then placed near an oscillatory circuit, it will be demagnetised proportionately to the strength of the first oscillation, which is in the right direction. Since the oscillations alternately magnetise and demagnetise the steel, and since the sum of a geometrical progression is proportionally to its first term, the integral effect is proportional to the magnitude of the first oscillation. Rutherford, therefore, arranged an apparatus, as follows: Near the oscillatory circuit he placed a very small bundle of steel wires magnetised to saturation, and thereby caused to deflect a magnetometer. He permitted the discharge to pass first in one direction, and then in another, by charging the condenser alternately in opposite directions, and noticed in each case the loss in magnetism of the small magnet. The ratio of these readings gives us the ratio of the first and second oscillations, and a Naperian logarithm of this ratio gives us the value of the decrement $\delta$. When there is no radiation it can be shown that the decrement $\delta$ is equal to the quotient R/2 L, where R is the resistance of the spark and circuit, and if the resistance of the metallic part of the circuit is small we obtain the value of the spark resistance. Rutherford used this method to measure spark resistance, and also to prove that electrical oscillations are confined to the surface of a conductor. If the metallic part of the oscillatory circuit is made of iron wire the value of the decrement is largely increased by reason of the hysteresis of the iron, but Rutherford found that the thinnest possible deposit of electrolytic copper put on the iron wire brings the decrement back to the same value as if the wire was solid copper.

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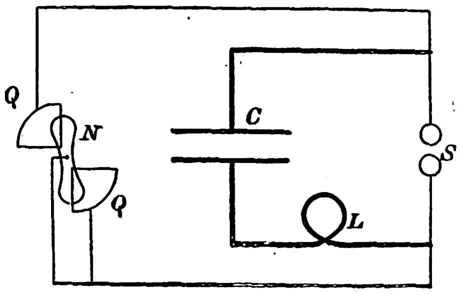
* See A. Heydweiller "On Spark Potentials." *Ann. der Physik*, Vol. XLVIII., p. 235 (1898).

Rutherford's experiments have been more recently repeated by Miss Brooks, and, amongst other things, she has been able to show that the light and the heat of the spark must be chiefly due to the impact of electrons against air molecules. Since the charge consists of a movement of electrons across the gap, and since we know the quantity of electrons moved, we know the number of electrons.



$$U = \frac{V}{8n\,\delta} \qquad n = \frac{1}{2\pi\sqrt{CL}}$$

Fig. 22.—Bjerknes' Use of Quadrant Electrometer to Measure R.M.S. Value of High Frequency Voltage.

Miss Brooks has given a proof that more electrons are created by the spark than are necessary to carry the current across. This is no doubt due to the ionisation of the air molecules by electronic impact, and it is to the recombination of these ions that the heat and light of the spark are due.

The second method of obtaining the decrement is due to the Norwegian physicist, Bjerknes. If we connect to the terminals of a condenser an electrostatic voltmeter, the readings of this voltmeter gave us the R M.S. value of the alternating voltage (see Fig. 22). If we measure the spark length, and determine from that the maximum voltage to which the condenser is charged, we can determine the ratio of this last quantity V to the R.M.S. value of the potential, U, and it can easily be shown that the ratio V/V = 4a = R/L. Hence from this ratio and the known value of the inductance of the circuit spark resistance can be determined. A third method, due to both Bjerknes and Drude, is based upon the use of what is called a resonance curve (see Fig. 23). It will be necessary to defer until the next lecture a full consideration of the nature and mode of delineation of such a curve, but it affords a means of determining with great accuracy the decrement of a circuit, and hence the spark resistance if that circuit contains the spark-gap. By the employment of this method Drude showed that for every condenser circuit containing a spark-gap there is a certain length of spark which gives minimum of damping, and also that zinc spark balls give less damping than iron or brass.

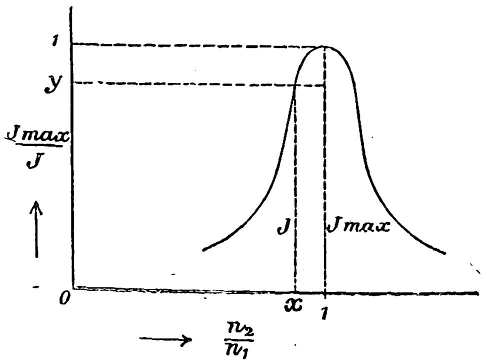


Fig. 23.—Resonance Curve.

Another very important matter is the damping of a Hertzian radiator or Marconi aerial wire by radiation. Hertz gave a well-known formula by which this radiation decrement can be determined, and this can be applied to a wireless telegraph antenna of height $h$ and diameter $d$. It is as follows :—

$$\delta r = \frac{\pi^3}{24 \log_\epsilon \frac{2h}{d}} = \frac{0{\cdot}54}{\log_{10} \frac{4h}{d}}.$$

Thus, if the height of an aerial is 50 metres, and diameter $\frac{1}{10}$th of an inch, we find that the decrement has a value 0·12. This implies that there cannot be much more than a dozen complete oscillations in the case of the ordinary form of the plain aerial.

Another important practical measurement is the determination of the ratio of the energy dissipated in the spark of the energy radiated. When a plain Marconi aerial wire, having a spark gap at the bottom, is charged and discharged, part of the energy is radiated as electric waves and part is expended in the spark. The efficiency of the antenna as radiator may be expressed as a percentage of the total energy. It can be shown that the energy radiated is to the energy expended of the spark in the ratio of the radiation decrement to the resistance decrement.

Taking a spark gap, say of 5 mm. in length for an ordinary plain aerial, the ratio of the radiation to the resistance decrement is about ten to one, and hence the radiation efficiency of the antenna is about 90 per cent. Supposing such an antenna has the capacity, say, of $\frac{1}{5000}$th of a microfarad and is charged to 15,000 volts, corresponding to a 5 mm. spark gap 50 times per second, the power given to the aerial is only 1·25 watts and 90 per cent., and this is about 1 watt. Such an aerial can affect a suitable receiver 100 miles away. On the other hand, to supply such an aerial would involve the use of an induction coil taking, say, amperes at 16 volts, and therefore, although the efficiency of the antenna per is comparatively high, there is a considerable loss of energy somewhere else. This loss of energy takes place in the induction coil, and in the arc discharge which accompanies the spark of the induction coil, hence the moral is that the improvement of the efficiency of a wireless telegraph plant is to be looked for in an improvement in the efficiency of a spark-producing device.

*(To be continued.)*

## IRON-CORED ALTERNATE-CURRENT INSTRUMENTS.*

BY W. E. SUMPNER, D.SC.

Alternate-current instruments of the induction or eddy-current type have been in use for some years, and in these instruments iron cores are employed. They have proved useful and convenient in practice, and much skill has been expended in constructing and developing them. But it cannot be maintained that such instruments obey any known and precise law. The mathematical theory of an eddy-current problem can only be worked out in a few simple cases, while the structure of an actual instrument of this type involves conditions so complex that satisfactory mathematical treatment is out of the question. It is thus only possible to develop working theories of a rough approximate kind for the action of these instruments, and their readings can only be relied on when the exact conditions of testing are reproduced.

During the last year I have devoted much attention to the problem of constructing accurate electromagnet instruments for alternate-current working. The model selected for imitation has been the permanent-magnet moving-coil instrument for direct-current circuits. Of course, the permanent magnet has been replaced by an electromagnet. It has been found possible to construct iron-cored instruments for use as ammeters, voltmeters, wattmeters, &c., such that their scales can be determined from tests in which only direct-current measurements are involved and such that their readings are independent of frequency and wave form.

The instruments are all characterised by having a moving-coil circuit and a fixed electromagnet. Instruments of this kind are novel in alternate-current working. A little consideration will soon show that difficulties in regard to their accurate working are most likely to arise from the action of the electromagnet. As regards the moving coil, this will be turning in a field the strength of which can easily be made as strong as, and even far stronger than, that of a permanent magnet instrument, so that only a minute current and but few turns will be needed. It is thus possible to use a large non-inductive resistance in series with the coil, so as to render quite negligible any effects due to self or mutual induction. The question of accuracy, therefore, entirely turns upon the behaviour of the electromagnet.

Now, there are many causes at work tending to prevent an electromagnet excited by an alternating current from acting in the exact way wanted; but the errors which arise are easily grouped under two heads. The magnetism produced may differ from what is required either in its amount, or in its phase and wave form. We may thus class the errors of the magnet as either magnitude errors or phase errors. Experience soon shows that the latter are far the more important.

It does not necessarily follow that an error in the magnet will cause an error in the instrument readings. Thus for an ammeter it is not necessary for the magnetism of the field to be proportional to the magnetising current. All that is needed is that the flux density at a given part of the gap must always be the same for the particular current which deflects the coil to that position in the gap. For an ammeter the coil is not needed in the same position for two different currents, so that variation in the reluctance of the magnetic circuit will only affect the calibration of the scale, just as variation of the gap length at different deflections will affect such calibration. For a wattmeter this is not the case, since, owing to variations in voltage or power-factor, a given deflection may be required for currents of very different magnitude. In such an instrument it is necessary for the flux density at each position in the gap to be proportional to the magnetising current for all working values of the latter. The resulting instrument error is, however, not of a serious character, for if the greatest variation from proportionality is 2 per cent., the greatest error of the wattmeter due to this cause will only be 2 per cent., and will be an error independent of the power-factor of the circuit and affected only by the magnitude of the current.

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* Abstract by the Author of an Original Communication which has been accepted for publication in the *Journal* of the Institution of Electrical Engineers.

Now as regards errors of magnitude, there are only two causes which tend effectively to vary the reluctance of the magnet. These are eddy currents and changes in the permeability of iron. The effect of eddy currents at ordinary frequencies can easily be made negligible by suitable lamination, and the influence of the air-gap is very great in steadying the reluctance of the magnetic circuit. With ordinary dimensions of instruments the reluctance of even a narrow air-gap will be very large compared with that of the iron path, so that a large change in the permeability of the iron will be needed to affect appreciably the reluctance of the whole circuit. But a great change in permeability is not likely to occur. In the first place, a high induction density is not needed. The field in the best permanent magnet moving-coil instruments rarely exceeds 700 lines per square centimetre, and it is not necessary to have it greater in alternate current instruments. Moreover, a high density across an air gap of as little as $\frac{1}{8}$ in. needs an undesirable number of ampere turns in the field coil. Hence the flux density in the iron will only reach moderate values, for which the permeability of the iron will be fairly constant, and the reluctance of the whole magnetic circuit will not vary appreciably if the air gap is short, and practically all the lines cross this gap by a short path. I find, however, that if the air gap is large magnetic leakage effects become serious, not so much because the waste field is large, but because the leakage factor varies with the current. If this leakage factor is constant, that is to say, if the mode of distribution of the lines remains the same, there is a definite meaning to the reluctance of the magnetic circuit, and this reluctance will be more and more constant for different currents the greater the gap used. But if, owing to changes in permeability of the core, the mode of distribution of the lines alters, the same effect is produced as if the gap itself varied for different currents. Now, with a large air gap the leakage factor is in general large and appreciably dependent on the strength of the current, the result being that the flux density at a given part of the gap is not sufficiently proportional to the total flux in the iron.

For an ammeter none of these effects matter. Only the calibration of the scale can be affected, and a narrow air-gap may be used, so that a sensitive instrument can be produced. With a wattmeter the case is far otherwise if the magnet is excited by the current. For although, if a narrow air-gap is used, magnitude errors become comparatively unimportant, the phase-error due to hysteresis under these circumstances is, I find, so large that the instrument becomes hopelessly inaccurate. Nor does there appear any prospect of making satisfactory iron-cored wattmeters with a series exciting coil. The hysteresis error can only be reduced by using a large air-gap, causing serious trouble owing to magnetic leakage, and practically throwing away all the advantages in the way of sensitiveness associated with iron-cored instruments.

There remains for consideration the second and much more serious source of error in these instruments—viz., phase errors. Before studying these, reference may be made to Figs. 1 to 4 which show how the instrument may be connected to the circuit for the various purposes of an ammeter, a wattmeter or a voltmeter. The instrument has two circuits, each of which may be connected with the mains in series or in shunt. There are thus four cases to consider. Figs. 1 and 2 represent the ammeter and wattmeter each with a series-wound electromagnet. Figs. 3 and 4 represent shunt magnet instruments, the former denoting a voltmeter, and the latter a wattmeter. In Fig. 3 the moving coil C is put across the mains in series with a condenser, K. In Fig. 4 the moving coil C forms part of a circuit including a large non-inductive resistance, R, and the secondary, S, of a small transformer whose primary, P, is traversed by the main current. This transformer must have a magnetic circuit of constant reluctance.

In both these cases the moving coil current is in quadrature with the electrical quantity producing it. Thus in Fig. 3 it is proportional to the rate of change of the voltage, while in Fig. 4 it is proportional to the rate of change of the current. The reason for securing this quadrature relationship is to be found in the action of the electromagnet when excited by the voltage of the mains. With a magnet of good design the induced voltage in the windings due to the changing magnetism in the iron will be so large compared with the copper drop that the former will not appreciably differ from the voltage of the mains. The magnet flux F and the line voltage V will be in quadrature, since V will be proportional to the rate of change of F. The moving-coil current, C, will be caused by Q, the second electrical quantity affecting the instrument. In Fig. 3 Q is the line voltage V, while in Fig. 4 Q is the load current A. Thus the average product of VQ is either the square of the voltage for Fig. 3 or the power in watts for Fig. 4. The deflection of the instrument is dependent on the average product of CF. Now, it can be proved mathematically that whatever the frequency or wave form, the mean value of VQ is proportional to the mean value of CF, provided exact quadrature relationships are obtained—that is, if V varies as the rate of change of F, and if C varies as the rate of change of Q. Under these circumstances the deflection of the instrument will measure either the voltage or the watts if the instrument connections are those of Fig. 3 or of Fig. 4 respectively.

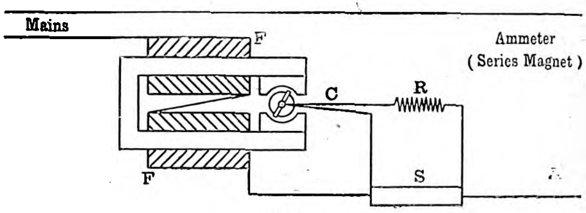

Fig. 1.

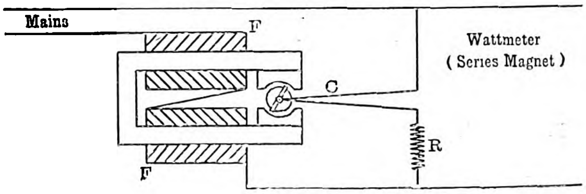

Fig. 2.

Small phase errors must occur in actual instruments, but they can be so reduced that the resulting instrument errors become negligible in practice.

The shunt magnet has a striking property most valuable for instrument purposes. Its magnetism is determined by the voltage, and variations in the permeability of the core do not alter the ratio between the two. If the voltage doubles the magnetism must also double, *whether the permeability varies or remains constant.*

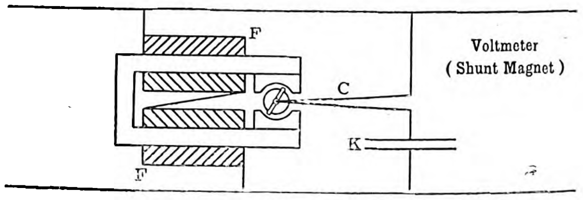

Fig. 3.

This statement is mathematically accurate if the resistance of the winding is zero. The coil must, of course, have some resistance, and a phase error is therefore introduced owing to the copper drop; but experience with a number of new instruments has proved that it is easily possible to design the electromagnet so that for all ordinary frequencies the copper drop is negligible compared with the applied voltage. It is thus true, for practical purposes, that shunt magnets can be made such that the flux of magnetism is accurately proportional to the applied voltage, even when the induction density ranges from very low to very high values. Of course, the magnetism is not in phase, but in quadrature, with the voltage. This at first sight appears to render the instrument problem difficult. As a matter of fact, it makes it much easier of solution

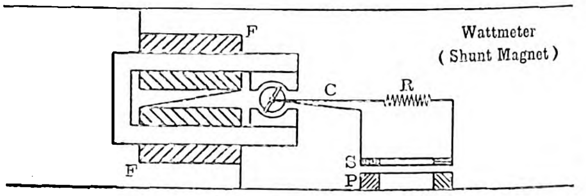

Fig. 4.

The characteristics of the electromagnet when excited by a series or shunt winding form a striking contrast. With the series magnet, the variation of the ratio of magnetism to current, or in their phase relation, is entirely caused by the properties of the core. With the shunt magnet any change in the ratio of magnetism to voltage, or in their phase relationship, is entirely due to the resistance of the winding. There is another point of contrast which, though not so apparent, is quite as important. With the series magnet the chief source of error is the phase difference between magnetism and current, due to hysteresis. For ammeters this is not important, as a fairly large phase error is allowable without introducing appreciable error into the instrument readings; but for wattmeters it is vitally important to make this phase error small, and the only way of doing this is to use a large air-gap. Thus, with the series magnet, the condition for accuracy is opposite to the condition for sensitiveness. With the shunt magnet, on the contrary, the shorter the air-gap the more sensitive, and also the more accurate, the instrument becomes, since the copper drop diminishes with the gap. For these reasons voltmeters and wattmeters should be constructed with shunt magnets. For an ammeter a series magnet must be used, but in this case the errors due to hysteresis and varying permeability can be made negligible even when the gap is small.

A thorough investigation shows that the electromagnet, whether it is to be used in series or in shunt, must be so designed as to secure the same condition of construction. This condition is that the copper drop in the winding must be made sufficiently small, but not too small, in comparison with the total voltage absorbed by the winding. For a given number of turns in this winding it is always advantageous to reduce the resistance as much as possible, and the impedance must always be made large, but there is no advantage in making it larger than is necessary to sufficiently diminish the phase error, and to produce a strong magnet. The copper drop reckoned as a percentage of the coil voltage may be much larger for ammeters and voltmeters than for wattmeters, and it is in consequence easier to design the former instruments than the latter, but in nearly all respects the suitability of the electromagnet is directly determinable from the copper drop.

For a detailed proof of all these statements I must refer the reader to a long theoretical and experimental investigation just printed, in the form of an original communication, by the Institution of Electrical Engineers. It is needless to point out the advantages of iron-cored instruments. These advantages are universally acknowledged. Everything turns upon the accuracy of such instruments, and this can only be established by a careful and thorough investigation of their errors. This has been done both mathematically and experimentally in the communication referred to. The errors found are shown to be in strict accordance with the theory. It is also shown that the magnitude of these errors is reducible to a negligible amount. This is particularly the case with ammeters and voltmeters, the frequency error of which is reducible to less than one-tenth of one per cent. for a range of frequency of three to one, while errors due to varying wave form are non existent. High accuracy in wattmeters, just like high-efficiency in transformers, can easily be obtained if sufficient iron and copper are used in their construction. For designs equally economical in material, and such as to secure the same degree of accuracy, the weight of the wattmeter must be greater for circuits of low-frequency or low-power factor, than for circuits of high-frequency or high-power factor; but experience proves that there is no difficulty in constructing a wattmeter suitable for any ordinary working conditions, such that its weight does not exceed that of an ordinary permanent magnet instrument. Ammeters and voltmeters are essentially the same as wattmeters used on circuits of unity power factor, hence their weight can be much reduced in comparison with that of wattmeters, and it is unnecessary to pay much attention to economy of material in their design.

Instruments of this kind have the characteristics of those of the dynamometer type, and may be used as ammeters, voltmeters, or wattmeters, in accordance with the way the two windings are connected with the circuit. Several of the instruments made have, in fact, been used in all three ways. The markings of the scale have been determined from direct-current measurements, and the scale reading has proved proportional to the watts when the instrument has been used as a wattmeter, and also a measure of the square of the amperes or of the square of the volts when the same instrument has been used in either of the other two ways.

Present limitations of space prevent more than a brief reference to the nature and extent of the instrument errors due to incorrect phase relations. Each of the instruments has two windings, and each of these windings is subject to the influence of one of the electrical conditions (voltage or current) of the circuit. If $\phi$ is the phase difference of these two electrical conditions, and if $\phi+\theta$ is the phase difference between the magnet field and the moving-coil current, $\theta$ is the *phase error*, and the torque, instead of being proportional to $\cos\phi$, is proportional to $\cos(\phi+\theta)$. The true reading of the instrument will bear to the actual reading the ratio of the cosines of these angles. If $\phi$ and $\theta$ are both fixed, the ratio of the above quantities will also be fixed, and there will be *no* instrument error, since only the constant to be used with all parts of the scale will be affected; but if either $\phi$ or $\theta$ varies, the instrument error is measured by the greatest change in the above ratio under working conditions. Now, with an ammeter or voltmeter $\phi$ is not only fixed, but it is zero, since for these instruments the two electrical conditions affecting the windings are the same, being both the main current, or both the main voltage respectively. The error in these instruments is thus measured by the greatest *change* in the value of $\cos\theta$.

For an ammeter, $\theta$ is the phase error due to hysteresis. It is independent of frequency, and, although not small in amount when a narrow air gap is used, it only varies very slightly with the current, so that $\cos\theta$, which is always very close to unity, is essentially constant, and, as a matter of fact, the instrument error can be made inappreciable in practice.

For a voltmeter it can be shown that the error-factor is

$$1-\tfrac{1}{2}\theta_r(\theta_r+\theta_i+\theta)$$

where $\theta_r$ is the copper drop, which I find can be reduced to 0·5 per cent on circuits of 50 cycles; $\theta_i$ is the hysteresis phase error, which for narrow air gaps may be 10 or 15 per cent.; and $\theta_k$ is the power-factor of the condenser, which can be taken as about 2 per cent.; so that the error-factor need never differ from unity by as much as 1 part in 3,000, its variation is utterly negligible, and the instrument error can be made far too minute to be detected.

For the wattmeter a totally different state of things holds good. $\phi$ is no longer constant, since $\cos\phi$ is the power-factor of the load, and the percentage error, in taking $\cos(\phi+\theta)$ as a measure of $\cos\phi$, can be shown to be $\theta\tan\phi$, where $\theta$ is measured as a percentage of a radian. Taking as a representative load one of power-factor 0·707, for which $\tan\phi$ is unity, it appears that $\theta$ must be reduced to 1 per cent. of a radian if the instrument is to measure accurately to 1 per cent. on circuits of such power-factor. For the wattmeter $\theta$ is the sum of three phase errors,

$$\theta=\theta_r+\theta_s+\theta_i$$

where $\theta_r$ is the copper drop, which on 50-cycle circuits can be reduced to 0·5 per cent. and even less; $\theta_s$ is the self induction error of the moving coil circuit, which with air-core transformers can be reduced to 0·2 per cent. or less; while $\theta_i$ is the hysteresis phase error of the current transformer, if this has an iron core or shield. $\theta_i$ is zero for an air core transformer, and is very small if the transformer is merely shielded from extraneous fields by laminated iron. The magnetic circuit of a current transformer, having an iron core through its coil, must contain a large air-gap, or the phase-error will be too great, just as in the case of series electromagnets; but there is no difficulty, even in this case, in reducing $\theta_i$ to less than 1 per cent. with a suitable design. The total phase-error of the wattmeter can without difficulty be reduced to 1 per cent., corresponding with a 1 per cent. error in the readings on loads of power factor 0·7, as compared with non-inductive loads.

# CORRESPONDENCE.

## AUTOMATIC BOOSTING.

### TO THE EDITOR OF THE ELECTRICIAN.

SIR: I fear that the report of the discussion on my Paper in this week's issue may give those who were not present the impression that I did not reply to Mr. Bornand's remarks, which are reported at some length. As a matter of fact, I think that those who were there will agree that I did answer them very fully, and as those answers have been "abstracted" I must ask your leave to reply to those of his criticisms which are published.

As regards the speed of operation of the Thury regulator, to which I referred in the Paper, I was not speaking of the speed of the motor but of the ratchet arrangement, and when Mr. Bornand speaks of "a few seconds" he forgets that much may happen on a tramway system in a few or even in one second.

As regards reversal of the field, when I made inquiries first from Mr. Bornand for a Thury regulator to deal with the load for which my system was first thought out, I suggested to him whether it was possible to make his regulator reverse, and he said *no*. I do not complain of his making progress and adopting my suggestion, but I *do* complain of his saying that it is one of the principal duties of the Thury system, when it was obviously not thought of at the time of which I am speaking.

The curves of volts and amperes included in the full Paper are, I think, a fairly good answer to the remarks as to the design of the boosters that can be used with this arrangement, as they were taken with a machine with solid cast-steel poles. The remarks I added, and which were published, are a sufficient comment on the subject of quickness of action.

Dealing with the question of hand regulation, the amount of attention the regulator requires is limited to one setting when the plant is started up, which has also to be done in the case of the Thury regulator, in which the voltage switch has to be set, and an alteration to the No. 3 diverter which corresponds to making an alteration in the shunt excitation of the main machine, which would almost certainly have to be done to enable a Thury regulator to charge the battery when the cells get up in the region of 2·5 volts per cell, which is usually only done once a week when the gassing charge readings are being taken, and so is unimportant in either case.—Yours, &c., MAX. J. E. TILNEY.

London, S.W., Jan. 27.

## WIRELESS TELEGRAPH DETECTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: May I be permitted to qualify somewhat the sentence with which you conclude your description in last week's *Electrician* of my new call-relay for long distance wireless telegraphy. In that sentence you state that I am a firm believer in the advantages of the electrolytic coherer over other detectors. Might I point out that so far I have been able to experiment only with the "electrolytic" type of coherer in connection with the new call-relay described by you, and I have no actual experience of the various other long distance and ingenious detectors now before the public. I can, however, see no reason why the new instrument should not work equally well with any current-operated coherer or detector of the same degree of sensibility as the particular coherer to which my experiments have hitherto been confined. The same remark applies to the other pieces of apparatus which I have designed for use in connection with the new call-relay.—Yours, &c., H. W. SULLIVAN.

London, E.C., Jan. 31.

## BENHAM & FROUD (LIMITED).

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has only to-day been drawn to the fact that the name of my company appears in your issue of January 5th in a list headed "Public Companies Wound Up, Dissolved, &c., in 1905"; and as this announcement is calculated to seriously injure the business of my company I venture to ask for space for a few words of explanation. In the first place, I would like to say that our company has never been a "public" one, but unfortunately it is a fact that about six months ago, owing to protracted bad trade, we found it necessary to consent to a debenture holders' action for the appointment of a "receiver and manager," and, for the complete protection of all interests, our shareholders passed a resolution for voluntary liquidation, with the same gentleman as liquidator. The business has, however, been carried on as usual from that date, and is still "in being," and it is hoped that some scheme of reconstruction or amalgamation will be carried out. In the meantime, it is obvious that our chief desideratum is *more business*, so that it is *very* important to us that your readers should not think we are either "wound up" or "dissolved," but should understand that in our new and extensive works we have every facility for carrying out orders for art metal work on any scale.—Yours, &c., H. A. BENHAM.

London, W.C., Feb. 1.

# LEGAL INTELLIGENCE.

### Attorney-General (ex. rel. Sutton & Co.) v. Manchester Corporation.

This action, which was heard by Mr. Justice Farwell on Monday and Tuesday, was brought for a declaration that the defendant Corporation have no power to carry, collect or deliver for reward any goods or parcels otherwise than by their tramways, and that it is unlawful for them to expend any part of the city fund or the receipts of the tramway undertaking for any such purpose.

Mr. UPJOHN, K.C., for plaintiff, sketched the powers obtained by the Corporation to work their tramways, and said the Corporation had also established a complete business of common carriers and collecting agents. They had founded, quite independently of their tramways, a chief office and a chief depot. They had a large number of other depots, at which they received goods, and they had a large number of agents scattered all over the district to receive parcels. The Corporation had spent £3,185 in connection with the hiring of a chief depot and making a single line of tramway into it, and they spent on vans and other vehicles £1,600, harness and so forth and stabling £800, horses £3,200, and there must have been a great deal more expenditure. It was admitted that the payments had been made out of the tramway fund. They actually took away a good many of Messrs. Sutton's men and a good many of their agents, and so must have been aware that they were starting a competitive business. A sub-committee expended £116 on travelling expenses to Ireland to buy horses, and paid £60 to the dealer they were compelled to employ, besides fees to a veterinary surgeon. Of the horses they purchased nine died before they got to Manchester or a day or two afterwards. The Corporation had given notice to introduce a bill next session to give them powers to do what he now complained of their doing, but at the statutory meeting of the ratepayers that bill was unanimously rejected. The carrier business had not been particularly successful financially.

Mr. BALFOUR BROWNE, K.C., on behalf of defendants, claimed that they had the right to act as they had acted under their Tramway acts. All they had done was incidental to or consequential upon powers to carry goods or parcels by tramway.

His LORDSHIP asked if the Corporation claimed to have power to act as common carriers.

Mr. BALFOUR BROWNE said they might have powers to do things that the statute had not given them powers to do, because they were a chartered corporation as well as a statutory body.

Mr. MACMORRAN, K.C., who followed for defendants, put in the charter of the Corporation of Manchester, bearing date Oct. 23, 1838. He called Mr. William Thomas Pullen to prove the service of the statutory notices from sundry local authorities, by virtue of which the Corporation claim statutory powers for what they have done in regard to the construction and working of some of the tramways. Witness produced a bundle of notices, but said he had not got the relative copies of the "London Gazette."

His LORDSHIP held that the service of these notices must be strictly proved.

WITNESS said that the notices were served on him by the solicitors of the local authorities. His firm's offices were the offices of the Southern Tramways Co., but there was neither a secretary nor a board of directors of that company.

Mr. MACMORRAN said he based the Corporation's right to act as they had first upon defendant's statutory powers as a Corporation, secondly on powers derived from various statutes, and lastly on powers as a chartered Corporation. Under secs. 14 to 19 of the schedule of the Manchester Corporation Act, 1878, they obtained power to carry passengers, goods, minerals, animals and parcels, and to take tolls and other charges for so doing, and by the Manchester Corporation Tramways Act, 1899, these powers were made applicable to all tramways belong to or on lease to the Corporation, or over which they had running powers. Such provisions had been incorporated in the Corporation's Act of 1903, which also included special powers authorising the carriage of parcels. He contended that it was necessary to the proper carrying on of their tramways undertaking in connection with the carriage of parcels that they should provide means of collecting, sorting, dispatching and delivering those parcels and performing the usual services incidental to such a business. He cited a number of decided cases in support of his contentions.

His LORDSHIP said he intended to put his judgment into writing because it was a most important case. He agreed that there must be accommodation at each end for goods, and as at present advised he thought the Corporation might distribute, but where he found a difficulty was in the contention that the Corporation could go from the extreme north to places altogether outside their bounds. He understood that the Corporation claimed that if their vans were at Rochdale they had the right to collect parcels at Rochdale and deliver them at Heywood.

Mr. MACMORRAN said the Corporation claimed that, as their tramways went beyond the city as far as the Middleton depot, they had the right to distribute from that depot, and that the vans which were employed for the delivery of goods might also be employed for collecting other goods.

His LORDSHIP: But you also claim the right to collect at Rochdale and distribute at Heywood, which is not near your depot.

Mr. MACMORRAN said that if they carried parcels otherwise than as stated they still claimed that that was within their powers as a chartered corporation, and involved no charge on the city rates, but was, on the contrary, a source of profit, because it increased the receipts without substantially, if at all, increasing the expenditure necessary to carry on a parcels carrying business, for which they had obtained statutory powers.

Mr. UPJOHN replied on the whole case, and contended that they had no right to take the goods beyond the depot at the end of their line.

His LORDSHIP was disposed to think that when the statute gave power to convey it meant also to give power to deliver to the consignee.

Judgment was reserved.

### Buchanan v. Glasgow Corporation.

The Corporation were recently sued by plaintiff for £500 as damages for personal injuries sustained on March 15 last while travelling in one of defenders' electric cars. The motorman, it was alleged, brought the car suddenly to a stop; the passengers in the car were thrown violently forward, and one of them fell against the glass door with such force as to break the glass. In addition to shock, pursuer said he was injured by the glass, a piece of which was embedded in his knee. He maintained that defenders were liable for the negligence of the conductor in allowing passengers to stand on the floor of the car, which was thereby overcrowded. Defenders denied negligence, and pleaded that the motorman stopped the car with the hand brake because the lifeguard in front of the car had fallen, and it was his duty to replace it. Defenders have, however, paid pursuer £150 and expenses in settlement of his claim.

### Satow v. Melling.

This action came before Mr. Justice Kennedy and a special jury on Wednesday, and was brought to recover damages for libel. Plaintiff is a director of the Manufacturing Electric Co. (Ltd.), and complained of a letter sent by defendant to Mr. A. Slatter (a co-director) and to Mr. J. D. F. Andrews (managing director of the company). The letter stated that defendant had obtained sworn information that "you and your co-directors joined your managing director in a conspiracy to create a bogus receivership in order to deprive me of my account, and I have decided to take criminal proceedings unless the account which you guaranteed along with Mr. Satow is paid me within seven days of this date. I am giving the same notice to Mr. Satow and also to Mr. Andrews." Defendant denied that the words imputed a criminal offence to plaintiff, and pleaded that they were published on a privileged occasion, and that in their ordinary and natural sense they were true.

PLAINTIFF said he was not a debenture holder, and that he had nothing to do with the appointment of receiver.

Mr. Justice KENNEDY held that, as regards the publication to co-directors, it was privileged; but the question was whether the terms of the letter showed that there was express malice on the part of defendant. There seemed to be hardly a shred of evidence in support of the plea of justification.

The jury found that there was express malice in publishing the letter to Mr. Slatter, and returned a verdict for plaintiff for £75 damages, for which his LORDSHIP gave judgment with costs.

In a further action, Slatter *v.* Melling, Mr. Slatter, chairman of the above-named company, complained of the publication of the same letter. Defendant now withdrew his plea of justification as regarded Mr. Slatter, and admitted that he had no case against the plaintiff. He wished to make a full and frank apology, and consented to pay costs as between solicitor and client.

### Vinecombe v. Underground Electric Railways Co. of London (Ltd.)

At Brompton County Court recently Sir Wm. Selfe heard an action in which plaintiff sued for damages for injury to one of his eyes. Plaintiff was working for defendants at their Acton works on Sept. 2, when a particle of metal flew into his eye from an emery wheel. It was contended that the emery-grinding machine was insufficiently guarded, and that plaintiff should have been provided with goggles. For the defence, it was urged that the machine was guarded, and that it was not necessary to provide men with goggles in ordinary circumstances.

The jury awarded plaintiff £225.

### Andrew v. National Electric Construction Co.

In the Court of Session, Edinburgh, last week Matilda Andrew sued defendants for £2,000 damages for the death of her husband, William Andrew, a retired police-inspector, who was struck and killed by an electric car which had left the rails at Musselburgh on June 5 last. The jury returned a verdict for applicant for £650.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT AND FILLED.

The council of Armstrong College, Newcastle-on-Tyne, will shortly appoint a professor of electrical engineering. Stipend £500 per annum and one-third of fees until £750 in all is reached. Applications to the secretary (Mr. F. H. Pruen) by March 1. See an advertisement.

Two junior demonstrators and lecturers are required (to begin work on May 1, 1906) at University College, Nottingham, one for physics and the other for engineering. Applications by Feb. 10 on forms to be obtained from the registrar. See an advertisement.

The North Wales Power & Traction Co. (Ltd.) require a station superintendent to take charge of power station (water-driven, E.H.T.), near Snowdon. Salary £200 per annum, with free residence. Applications to the General Manager, Llanberis, North Wales, by Feb. 9. See an advertisement.

There is a vacancy for a pupil in a central electric generating station (water-driven, E.H.T.) in the Snowdon district. Apply to General Manager, North Wales Power & Traction Co., Llanberis, North Wales. See an advertisement.

A third-class engineer is wanted in the lines department of the National Telephone Co. Applications to Engineer-in-chief, Telephone House, London, E.C. See advertisement.

The Brush Electrical Engineering Co. invite applications from competent engineers to fill an appointment abroad. Applicants must have good all-round business-engineering experience and be capable of estimating for, negotiating and carrying through engineering schemes, &c. Applications to "A," Brush Co., Belvedere-road, London, S.E.

The Brush Co. also invite applications from engineers competent to act as district representatives. Applications to "J.," Brush Co., Belvedere-road, S.E.

A professor of physics is required at the East London College in succession to Dr. Lehfeldt. Salary £400 per annum. Applications by Feb. 8.

The lectureship in electrical engineering at the City of Bradford Technical College is vacant. Salary £200 per annum. Particulars from Prof. G. F. Charnock. Applications to the secretary (Mr. T. Garbutt) by 17th inst.

Mr. Louis Toft, B.Sc. (Vict.), lecturer in mathematics and engineering at the Municipal College, Grimsby, has been appointed assistant lecturer in mechanical engineering at the Royal Technical Institute, Salford.

Gloucester Council have appointed Mr. Stephens as tramway traffic superintendent.

Mr. W. A. Thain, assistant lecturer and demonstrator in engineering at University College, Cardiff, has been appointed professor of engineering at the Royal College of Agriculture, Cirencester.

**Personal.**—Major F. Bayley, instructor in electricity at the School of Military Engineering, Chatham, has, on the completion of his period of appointment, been ordered to proceed on a tour of duty in India.

### EDUCATIONAL NOTICES.

**Battersea Polytechnic.**—Pending the appointment of a successor to Mr. A. G. Cooke, the former head of the electrical engineering department, Mr. Frank Broadbent, M.I.E.E., has accepted the invitation to conduct the evening classes in electrical engineering for the remainder of the present session.

**University of Sheffield.**—We have received a copy of the souvenir of the opening of the new engineering and metallurgical laboratories, which took place in Sept., 1905. In addition to giving a good historical sketch of the development of Sheffield University, the pamphlet gives many good illustrations of the laboratories and their equipment, &c.

**Aberdeen.**—For the position of tramway manager the Tramways committee have selected the following short list of seven out of the 72 applicants:—

Messrs. D. Caird (interim manager at Aberdeen), John C. Couper (traffic superintendent, Halifax), Thomas Hartley (traffic manager, Huddersfield), E. Lafferty (traffic manager, Preston), Joseph Lawrence (works manager W. Lucy & Co.), R.S. Pilcher (traffic manager, Burton-on-Trent), and George Webster (traffic and general manager, Rochdale). The salary offered is £300 a year, and the gentleman appointed will have control of the tramway undertaking, including the rolling stock, but exclusive of the electrical and mechanical equipment.

**Anti-Seasickness Device.**—It is stated that the Hamburg-American Steamship Co. have installed a new chair on board their vessels to prevent seasickness. The apparatus consists of a small electric motor which keeps the seats of the specially-made chairs in constant motion. They are said to have been a remarkable success.

**Barking.**—On the recommendation of their electrical engineer (Mr. Henley Howard) the Council have decided to discontinue the wiring of consumers' premises and the supply of fittings. Regulations for wiring by contractors are to be drawn up.

The Council have decided, on the suggestion of the electrical engineer (Mr. H. L. Howard), to make (as an experiment) the following charges for the electric lighting of artizan's buildings in King Edward-street: One block of dwellings containing two lights, 4d. per week; and one block containing four lights, 6d. per week.

The Council have decided to petition against the Administrative County of London Electric Power Bill, and the clerk (Mr. H. Hargreaves) has been instructed to communicate with the promoters of the bill as to the amendment of their offer for street lighting, price of current to private consumers, and power to apply to the Board of Trade for revision of prices.

**Berlin.**—The Municipal Council have decided, after consultation with the authorities of eight suburban towns, to take the initial step towards acquiring the undertaking of the Berlin Tramway Co., which has a capital of 100,000,000m.

**Brazil.**—As only one tender was submitted on a recent invitation for offers to provide public electric lighting for the town of Floreanopolis (Santa Catarina), and for the construction of electric tramway, it is announced that further tenders are to be invited.

**Callender's Hospital and Distress Fund.**—We have received a copy of the third annual report and balance-sheet of this fund, which was unanimously adopted at a meeting of the subscribers held at Callender's Erith works on Jan. 20, Mr. T. O. Callender presiding.

The following brief review of the report and accounts will interest our readers, and may be the means of encouraging others to organise similar funds. Great interest is taken in the fund and in the work of the fund by the employees at Callender's works. No less than 130 hospital letters were issued last year, including 8 in-patients and 87 letters for surgical appliances, 7 members were assisted to convalescent homes and £57. 10s. was granted to members in distress. The subscriptions (1d. per week) realised £247. 9s. 10d. Donations during the year (including £50 from Callender's Co.) amounted to £76. Annual grants to hospitals, dispensaries, &c., were voted to the amount of £233. 15s., against £211 in the previous year. After making these liberal grants the fund had at Dec. 31 £204. 14s. 4d. at the bank and in hand. Altogether a very creditable year's work in the sacred causes of charity and self-help.

**Canadian Trade Inquiry.**—The Commercial Intelligence Branch of the Board of Trade inform us that a firm of manufacturers' agents in Montreal desire to be placed in communication with a British house manufacturing electric cotton threads for electrical purposes, as they are in a position to open up considerable trade in this direction. Further information from the Canadian Trade Inquiry Office, 73, Basinghall-street, London, E.C.

**Colchester.**—The extension of the tramways from Magdalen-street to the recreation ground has been opened for traffic this week.

**Croydon.**—On Monday the Corporation reiterated their determination to municipalise the electric tramways, and a further offer of the British Electric Traction Co. for leasing the lines was rejected.

**Cuba.**—The value of electrical machinery imported into Cuba from the United Kingdom in 1904 was nil, compared with £1,698 in 1903. From the United States the value of these imports was £9,707.

**Customs Decisions.**—The Customs authorities of the Argentine Republic have decided that imported arc lamp carbons shall bear a duty of 35 per cent. ad val. Wires and cables of more than 5 mm. diameter for electrical uses, "implements" for the installation of underground cables, and machinery and conduits for the installation of public lighting are to bear a 5 per cent. ad val. duty.

**Dartford.**—The electric tramways (about 8 miles of single track) which have cost about £100,000, and are to connect up with the Bexley Council tramways, are nearly completed and trial trips are being made this week.

**Dundee.**—The Electricity committee have considered the alternative schemes of the city electrical engineer (Mr. H. Richardson) to deal with the increasing demand for electric energy—(1) to extend the Dudhope-crescent station, or (2) to erect a new generating station at Stannergate, at an estimated cost of £75,000. The committee think it is impossible to extend the existing station with economy, and, therefore, recommend the Council to adopt scheme No. (2).

**East Ham.**—Notice has been served upon the North Metropolitan Tramways Co. requiring them to sell to the municipality their undertaking in East Ham.

**Exeter.**—An application is to be made for sanction to a further loan of £8,500 for electric lighting extensions.

**Fenton.**—On Tuesday the Council decided to invite Hanley and Stoke on-Trent Corporations to state the terms upon which they would give a supply of electricity in bulk in Fenton.

**Fraud on Electrical Engineers.**—At Eccles on Jan. 22 an electrician named Frank Taylor was sentenced to six months' imprisonment for fraud. By representing that he was engaged by a Manchester firm of electrical engineers he obtained a quantity of lamps from Mr. Pennington, of Patricroft, and these he sold as mercury vapour lamps, subsequently removing them on the plea that they were the wrong lamps, reselling them to other persons.

**Gellygaer.**—In the event of the Council succeeding in their application for a provisional order they will enter into negotiations with the Powell-Duffryn Co. to arrange terms for the supply of electricity by the company for street lighting at Bargoed.

**Grimsby.**—An inquiry was held on Thursday last into the application of the Council to borrow £18,000 for electric lighting extensions.

The borough electrical engineer (Mr. W. A. Vignoles) supplied technical details and said that the present capacity of the station plant was 900 kw., without allowing any spare. In December the load reached 705 kw., and he estimated that next winter an additional 50 kw. of plant would be required to supply ordinary customers, and in addition to that the Corporation had undertaken to supply the railway company with electric energy, the maximum power required for that being estimated at 230 kw. Each year the undertaking had shown an improvement financially, there being a surplus last year of £895, and he estimated that at the end of the present financial year there would be a surplus of not less than £1,500 after paying interest and sinking fund. The deficits resulting from the first three years' working were made good out of the rates. The present loan (£18,000) was divided as follows: £9,500 for extensions of plant, buildings, &c., £8,500 for additional main feeders, mains, &c. They were putting in coal-handling plant and were erecting a store for meters, cables and general stores.

The inspector (Mr. H. Ross Hooper) suggested that, as it would probably be found that the amount actually required would be less than £18,000, the Corporation would probably amend the application.

The deputy town clerk (Dr. Grange) asked whether it would be better to at once amend it and make it £17,500.

The Inspector did not think so; he would rather give them the opportunity of submitting the matter to the committee. He suggested that the committee should have a reserve fund. There was not a station in the country having no reserve fund which would not be very thankful if they could only have one. Committees allocated the profits to other purposes, but there came a time when machinery reached the limit of its revenue-earning capacity, sometimes whilst there was a debt remaining on it. A reserve was the salvation of many undertakings.

There was no opposition.

**Hertford.**—The Shire Hall is to be wired and fitted for electric lighting at a cost of £330, current being taken from the North Metropolitan Electrical Power Distribution Co.

**High-pressure Fire Risks.**—At the Insurance Institute of Ireland, Dublin, Mr. Kenneth J. Tarrant, electrical inspector of the Sun Fire Office, lectured on "The Use of High Pressures in Electric Light and Power, and its attendant Fire Risk."

Mr. Tarrant said applied electricity had advanced at an enormous rate, and one of the most difficult tasks was to keep pace with the developments constantly occurring in the application of electricity for power and lighting work. The address dealt in detail with the problems which were occupying electrical engineers with a view of minimising or obviating risks of fire from electric installations.

**Ilford.**—Sanction to a further loan of £5,000 for electric lighting extensions has been received by the Council.

**Lancashire Power Bill.**—Representatives of the urban district councils affected by the Lancashire Electric Power Bill met at Manchester on Tuesday to consider the attitude to be adopted towards the bill.

It was stated that the promoters were seeking such powers as would enable them to supply electric power within the area of any authority having an electric lighting order, with the consent of such authority; but this consent would be deemed unreasonably withheld, and consequently to be dispensed with, in all cases where the authority was unable or unwilling to offer terms to consumers at least as favourable as those offered by the promoters of the bill. Where a council had not obtained an order the company proposed to take power to supply electricity within the area of that council without consent.

The meeting also considered the South Lancashire Tramways Bill.

**Lancaster.**—It was decided by the Council on Wednesday, after a long discussion, to supply electricity to the L. & N.W. Railway Co. for power at 1½d. per unit.

**Light Railways.**—The Board of Trade have confirmed the Newark and District Light Railways Order, 1906, and the Bideford, Clovelly and Hartland Light Railways Order, 1906.

Cheshire County, Northwich Urban, Runcorn and Northwich Rural Councils and the Weaver Trust are opposing the application of the promoters of the Warrington & Northwich Light Railway for an extension of time, and a local inquiry is to be held by the Light Railway Commissioners.

An inquiry was held at Bath last week into the application of the Bath Electric Tramways Co. (Ltd.) for an order authorising them to extend their system from Newton St. Lo to Saltford, and the Commissioners decided to report in favour of granting the order.

**Llandudno.**—The Council are considering an offer by Bruce Peebles & Co. to take over and complete a light railway between Llandudno and Colwyn Bay, provided the Council authorise the running of tramcars on Sunday. It has been decided to take a poll of the ratepayers.

**London County Council.**—At Tuesday's meeting it was decided to proceed with the reconstruction of the tramways in Goswell-road at an estimated cost of £12,200.

*Opposition to Bills.*—It was agreed to lodge petitions in Parliament against the whole of the electric supply and power bills affecting London, against the whole of the underground railway bills, and against the Pneumatic Despatch Co.'s bill.

*L.C.C. Electric Power Bill.*—The Council agreed, as required by sec. 4 of the Municipal Corporations (Borough Funds) Act, 1872, to confirm the resolutions passed on Nov. 24, 1905, with regard to the promotion of the L.C.C. (Electric Supply) Bill, 1906.

*Fire Brigade Department.*—The Theatres and Music Halls committee brought up recommendations to the effect that from April 1 the chief officer of the fire brigade should be responsible to the Council for the inspection of the electric lighting installations and heating and other mechanical arrangements of theatres and other places of public entertainment licensed by the Council, and that for the purpose an electrical and mechanical engineer, at a salary of £400 a year, and an electrical engineer, at a salary of £200 a year, be appointed to the brigade.

**London County Council Tramways.**—The extension of the electric tramways from New Cross to Lewisham was opened to the public on Tuesday. Through cars are now running between Westminster and Lewisham.

**London United (Surrey) Tramways.**—A trial run was made on Wednesday on two sections of the tramways connecting Kingston, Surbiton and Malden. These lines will eventually form part of a route from the company's tramways in Middlesex over Kingston Bridge, through Raynes Park and Wimbledon to a junction with the L.C.C. tramways at Tooting.

**Manchester.**—As the Corporation's omnibus bill for further tramway powers, &c., has been rejected by the ratepayers' meeting a poll will be taken on Feb. 8.

**Marylebone (London).**—The Electric Supply committee reported on Tuesday on the financial position of the undertaking as at Dec. 31.

It was stated that capital expenditure might be divided under two heads. With regard to the first (the sum required to pay the Metropolitan Electric Supply Co. the amount of their award, &c., and the expenses in connection therewith) the consulting engineer (Mr. Wright) had estimated this at £1,378,692. The total net estimated expenditure was now, however, £1,415,876, so that Mr. Wright's estimate had been exceeded by £37,184. Mr. Wright's first estimate was made before the long delays occurred, which rendered it a matter of impossibility to prevent the Metropolitan Co. expending large sums which had (the report states) been of little value to the borough. The second main division of expenditure was for erecting a generating station and changing over the supply from 100 to 240 volts. This Mr. Wright estimated at £540,600, but the actual expenditure was now estimated at £587,662, an increase of £47,062. This was caused chiefly (£41,000) by the increase in cost of changing pressure. Another cause (£6,552) was the probable bonus which will be earned by the turbine contractors (Messrs. C. A. Parsons & Co.) owing to the greater efficiency of their plant. The advance in the price of copper at the time of the acceptance of the feeder contracts further accounts for the increase in the estimate, as did also the cost of providing special mains to take over a large area in bulk instead of in small sections, as originally intended. The total estimates had been exceeded by £84,246, making, with £38,500 for site, £122,746. It will, therefore, be necessary to increase the capital charges as given in Mr. Wright's table by a charge of £7,110, and also to add 1½ per cent. depreciation charge on new plant (£47,062) of £705 per annum, or £7,815 more than Mr. Wright estimated. On the other hand, there was no doubt that the Council will save at least ½d. per unit in the cost of generation, which will amount to a saving on Mr. Wright's estimates of £15,200 a year; the committee had also avoided the large estimated loss in 1905, and no credit had been taken for the sale of old plant or of properties not necessary for the purposes of the undertaking. Sanction would be required from the L.C.C. for £151,162 to complete the scheme. The expenditure will be distributed over the next 2½ years.

The Finance Committee, in a report upon the foregoing. state they are confident the Electric Supply committee have thoroughly gone into the matter and given the true facts; also that their estimates had been framed on cautious lines.

The Electric Supply committee also reported that they have entered into a provisional arrangement with Hampstead Borough Council for the exchange of electric lighting areas so as to make the areas conterminous with the boundaries of the respective boroughs.

**Menai Straits Power Scheme.**—A meeting under the presidency of Mr. H. Bulkeley Price recently passed a resolution in favour of the promotion of a scheme for the utilisation of water power to be obtained from the river Briant, which falls 100 ft. into the Straits, in order to use this power to generate electrical energy for lighting the villages of Menai Bridge and Llanfair and certain mansions, including Plas Newydd, the seat of the Marquis of Anglesey, for pumping water for Llanfair, and for supplying current for two search lights for the Straits.

**Mexico.**—The company La Electra, of Guadalajara (Mexico), have under construction an electric railway 58 kilometres in length (single track) built to 4 ft. 8½ in. gauge. Water-power will be employed in the generation of current, and the equipment of the power house will comprise three 400 kw., two 60 kw. and two 75 kw. motor generators. 40 motor cars and 16 trailers will be operated at the start, and it is expected that the line will be in working order about January, 1907. It is estimated that 15,000 H.P. of water-power is available and this power is owned by La Electra Co., which owns the supply of current for electric lighting and power started about 10 years ago in the City of Guadalajara, which has a population of 200,000. The company's present station has a total plant capacity of about 3,000 H.P. The new plant, which, as above mentioned, is to be installed at the power house for operating the railway, will supersede the 3,000 H.P. plant now running, and will generate current for lighting and power for Guadalajara, Aguas Calientes, Lagos, &c., and also for energy for working the electric railways and tramways owned by the company in different towns in Mexico.

**Middlesex.**—At the meeting of the County Council last week the Parliamentary committee reported on several electric lighting orders for various districts in the county. As the draft orders sufficiently protect the Council's interests no opposition will be offered.

The Edgware electric lighting order is not to be proceeded with.

The County Council have decided to petition against the Additional Electric Power Supply (London), the L.C.C. Electric Power and the Metropolitan Electric Supply and Twickenham & Teddington Electric Supply Co.'s bills, in order to obtain protective clauses.

**Munich.**—The Munich electric tramway will, at June 30 next, pass into the hands of the Municipal Council for the final payment of £35,660. At present the undertaking is not a flourishing one, there having been a deficit of £6,500 in 1904-5. The municipality purchased the tramways from a private company under a condition to pay 11 per cent. dividend until June 30, 1906, when this drain upon the resources of the undertaking will cease.

The largest electrical manufacturing company in Bavaria, which paid no dividend in 1903-4, was, owing to the improved trading conditions, enabled to pay 4 per cent. in 1904-5.

Only Bavarian firms are allowed to tender for Bavarian Government requirements, and it is stated that the Prussian Government authorities retaliate by excluding Bavarian tenders. There is some friction between the two States on this account.

Since July, 1905, the Munich postal authorities have employed the electric tramways for the transport of letters and parcels between the central and branch postal offices. The owners of the tramway provided two cars, costing £600 each, and the drivers and conductors of these cars were officials of the Post Office. The platforms of the cars are closed, and the interior, which is lighted electrically, is divided into two compartments, the large for ordinary and the smaller for registered postal matter. The windows of the cars are protected by strong iron gratings and iron doors are provided. The Post Office authorities pay the company an average of 2½d. per kilometre run of the cars, 4 per cent. for expenses incurred and 6 per cent. amortisation.

Munich occupies the distinguished position of being third on the list of largest cities of the world in regard to the number of telephones per head of the population.

**Municipalisation in the United States.**—Mayor Dunne has signed an ordinance directing that Chicago Municipality take over the street railways of the city. The question is not yet finally settled, for the citizens of Chicago will, in the spring, decide by ballot whether the ordinance shall be carried out.

**Newcastle-on-Tyne.**—Mr. J. M. McElroy, manager of Manchester Corporation tramways, has been appointed to act as arbitrator in a dispute between the tramway employés and the Corporation regarding certain alleged grievances.

**Northamptonshire.**—Wellingborough Rural Council and Earl's Barton and Ecton Parish Councils have assented to the County of Northampton Electric Light & Power Co.'s application for a provisional order.

**Nottingham.**—The County Council have decided to oppose the Notts. & Derbyshire Tramways and the Derbyshire & Notts. Electric Power Bills and the Mansfield & District Light Railway Order, with a view to obtaining protective clauses.

**Oxford.**—The result of the poll as to the promotion of the Corporation Tramways Bill was as follows: 5,092 against, 1,117 for.

**Penang.**—A highly successful official trial of the municipal electric tramways at Penang took place on Dec. 23, when the contractors and several members of the Commission, &c., travelled on one of the new cars, which was in charge of Mr. O. V. Thomas and Mr. E. S. Haslam, the former representing Messrs. Preece & Cardew, the consulting engineers for the work. At the close of the run an adjournment was made to the Town Club, where Mr. J. W. Hallifax proposed the success of the undertaking, coupling with the toast the name of Mr. O. V. Thomas, the electrical engineer who had carried out the work. Messrs. Dick, Kerr & Co. supplied the permanent way material, bonding and overhead equipment; the British Thomson-Houston Co. the motors and controllers; and the Brush Company the cars. The permanent way construction was carried out by Mr. R. Young, M.Inst.M.E., and the overhead construction was supervised on Messrs. Dick, Kerr & Co.'s behalf by Mr. T. S. Allen.

**Private Bill Legislation.**—Leyton Council have decided to invite other councils to co-operate in calling the attention of the Government to the unnecessary expense imposed upon local authorities by reason of the omission to insert in companies' private bills the necessary protection clauses. It is suggested that power should be given to charge companies which neglect to insert these clauses with the expenses entailed by their omission.

**Provisional Order Transfer.**—Notice is given of intention to transfer to the North Metropolitan Electric Power Supply Co. the powers conferred upon Edmonton District Council by their 1902 provisional electric lighting order. The consideration for the transfer is £2,800. Objections to Board of Trade before Feb. 26.

**Salford.**—The Tramways Committee have been asked to grant an increased rate of pay to employés in the committee's service,

so as to make the rates equal to those in Manchester, where drivers are paid a minimum of 5¾d. and a maximum of 7d. per hour, while in Salford a minimum of 6d. and a maximum of 6¾d. prevails. The minimum for conductors in Manchester is 5½d. and the maximum 6¾d.; in Salford 5½d. and 6¼d. In Manchester ticket inspectors receive 35s. weekly, and in Salford the minimum is 30s. and maximum 35s. Manchester timekeepers get 32s. 6d. per week of six days, and in Salford the minimum is 30s., maximum 35s. per week of seven days. Manchester shedmen get 5½d. per hour for 54 hours in six nights weekly and an annual week's holiday with payment; Salford shedmen get 5½d. per hour for 52 hours in six and a-half nights weekly.

**Shipley.**—The Council will apply for a further loan of £650 for extending the public electric lighting.

**Southampton.**—The borough electrical engineer (Mr. H. F. Street) has submitted a report on the increased output of the electricity works during the winter, and recommends that immediate steps be taken to provide additional plant to meet next winter's load.

During the heaviest period of load this winter all the engines were running at both stations, with two exceptions; in each case the smallest engines were not at work. At neither of the stations was there adequate reserve plant. It was necessary to have a reserve equal to the largest unit in use; and an extension of the lighting battery was also required. The cost of the extension is put at £1,600. Should the committee decide in favour of reciprocating engines (the report continues) he (Mr. Street) would recommend a 500 kw. set similar to those now at work. The cost of an engine and a generator, with piping, &c., would be £7,000. If a turbo-generator were adopted, he would recommend that a 1,000 kw. set be obtained, at a total cost of £10,200. Of the two sets the horizontal engine would be the more efficient as regards coal consumption, and he thought the horizontal engine and generator were the best when considered from an engineering point of view, though the turbine had many points in its favour. The makers of the existing plant had agreed to supply similar plant to that ordered in 1902.

The Electricity Committee recommended that application be made for sanction to borrow £2,000, being £1,600 for the storage battery extension and £400 for extending the switchboard.

The report and recommendations have been adopted.

**Southend.**—A special meeting of the Council was held on Friday to consider a recommendation to apply for an order authorising the extension of the tramway system to Shoeburyness, but as the confirming resolution was only carried by 11 votes to 7 there was not the requisite two-thirds majority.

**Spain.**—Application for a concession for the construction and working of an electric tramway in Barcelona has been made by the Barcelona & San Andres Tramway Co. The concession is open to competition, but the present applicants will receive preferential treatment over other tenderers at the same rate. The "Madrid Gazette" of Jan. 25 contains further particulars.

**Stoke-on-Trent.**—The Council have decided to supply electricity, and to fix prepayment meters in the municipal cottage property.

**Stourbridge.**—The Board of Trade have deferred for six months the question of revoking the Council's electric lighting order.

**Switzerland.**—A concession has been granted to a syndicate headed by Mr. J. E. Dunand, of Geneva, for the construction and working of an electric tramway between Versoiz and Divonne les-Bains, via Nyon, Prangins and Coppet, at an estimated cost of about £38,000.

**Theft.**—At the Westminster (London) Police court on Friday, Henry Taylor, 47, whose face was disfigured, was charged before Mr. Curtis Bennett with stealing electric cable, the property of the Underground Electric Railways Co., of London. On Jan. 8 prisoner was found at Brompton Station with his face much cut, and insensible from loss of blood and shock. Near him were three heavy pieces of cable, a saw which had been used to cut through the cable, and a candle which had slipped from his hand. Prisoner had been employed as a labourer on the line. He had sawn through the cable on a drum at Gloucester-road and walked through the tunnel to the station at Brompton, where he overbalanced on a plank and fell headlong 40 feet.

Detective-inspector Ward said in some instances drums of cable had been entirely spoilt by such thieves as the prisoner, who cut through the metal at any part.

Prisoner was sentenced to be detained for 21 days in the prison infirmary.

**The Great Electrical Frauds.**—A sequel to the recent criminal proceedings against William Leslie, electrical engineer, George Webber and Alice F. Cheeseman was the appearance of Leslie in the Bankruptcy Court at Wandsworth (London), last week.

It will be remembered that the above-named conspirators were engaged in a series of fraudulent transactions by which a number of electrical supply houses were defrauded of sums amounting in the aggregate to between £30,000 and £40,000. Leslie was employed as an electrical engineer at the Grand Theatre, Fulham, and now stated that his income averaged from £350 to £400 a year. He said that when he was arrested at Aberystwyth he had money and jewels in his possession valued at about £10,000, but which would have been worth much more if he had had himself the opportunity of realising their value. He missed amongst the jewellery found some very valuable items. One ring in particular which he had not seen had cost him £750. If he made a full disclosure of all the matters connected with the fraudulent transactions in which he had been engaged it would bring other people into the business. There would come a time, however, when he would have a good deal more to say with regard to the whole matter, as he would like the whole truth to be known. He was worth between £2,500 and £3,500 when he went to the Fulham Theatre.

After Leslie's examination the proceedings were adjourned, and he and his companions were marched back to prison.

**Tramway Bye-Laws.**—The new regulations of the Imperial Tramways Co. for their Middlesbrough lines provide that in inclement weather, on Sundays, public holidays, race days and Saturday afternoons, or on special occasions (with the consent of the Corporation), such additional passengers as the conductor may permit shall be carried. Middlesbrough Council have decided to object to the proposed regulations.

**Walsall.**—The total receipts of the electricity department for the year ended Dec. 31 were £11,819. 1s. 1d., including £4,029. 13s. 2d. for traction. Total expenditure was £7,274. 2s. 11d., leaving £4,544. 18s. 2d. After paying interest, sinking fund, &c., there is a deficit of £184. 2s. 8d., which is accounted for by charging to repairs and maintenance the cost of altering two substations in order to increase their capacity, by a considerable decline in the traction demand since 1904, and by the average prices obtained for all classes of supply being lower than in 1904.

**Wireless Telegraph Installations.**—As evidence of the progress being made in connection with the adoption and application of wireless telegraph installations to the class of communication to which this system has already become or is becoming adapted, we have received particulars of the installations now supplied by the Gesellschaft für Drahtlose Telegraphie of Berlin. This list comprises a total of 518 stations made up as follows: Germany, 169; Russia, 112; United States, 65; Austria Hungary and Sweden, 24 each; Holland, 23; Denmark, 14; Norway, 12; Spain and Portugal together, 10; Argentina, Brazil, China, 9 each; Netherlands India, 7; Switzerland, 6; Mexico, 4; Bosnia, Cuba, England, Finland, France, India, Peru, Siam, Tonkin and Turkey, 2 each; Uruguay, 1.

**Dinners.**—The annual staff dinner of W. T. Glover & Co., was held at the Trafford Park Works on 25th ult., and a smoking concert followed. Mr. E. A. Claremont, managing director, was in the chair, and over 200 members of the staff attended.

On Saturday over 50 of the staff at the Arc Works, Chelmsford, dined together, Mr. A. J. Hodgson, the general manager, presiding.

The toast of "Continued Success to Messrs. Crompton & Co." was proposed by Mr. P. G. Cheverton, who mentioned that he had just entered upon his 21st year with the firm. He hoped the past success of the company would continue under their new general, Mr. Hodgson.

Mr. Hodgson, in reply, said meetings of this kind brought them more closely together, and were for the ultimate good of both employer and employed. For some while the company had had a rather hard time. Competition had been very keen, and prices had been cut, which made it difficult to make both ends meet. If they all pulled together, however, they could still hold their own.

**Concert and Dance.**—Under the auspices of the London branch of the Electrical Trades Union a concert and dance will be given at Battersea Town Hall on Saturday, Feb. 10.

## TRADE NOTES AND NOTICES.

### TENDERS INVITED.

*West Ham* Corporation invite tenders for one 1,500 kw. to 2,000 kw. two-phase turbo-alternator, one 500 kw. motor-generator and switch gear. Specifications, &c., from the borough electrical engineer (Mr. A. Hugh Seabrook), Tucker-street, Canning Town, West Ham. Tenders to the town clerk (Dr. Fred. E. Hilleary), Town Hall, West Ham, by 4 p.m. Feb. 16. Further particulars are given in an advertisement.

*Shoreditch* (London) Borough Council invite tenders for stores for one year ending March 31, 1907, including electric cables and sundries, gas pipe and fittings, and engineers' stores. Samples may be seen at the electric lighting station, Coronet-street, Hoxton, N. Further particulars are given in an advertisement. Forms of tender from the town clerk (Dr. H. Mansfield Robinson), Town Hall, Old street, E.C., to whom tenders by 3 p.m. March 13.

*Leyton* Urban District Council invite tenders for underground electric feeders on the solid system for their tramways. Specifications, &c., from the electrical engineer (Mr. F. Harman Lewis), Cathall-road, Leytonstone. Tenders to be delivered at the meeting of the Electric Lighting committee at the Town Hall, Leyton, on Feb. 15 at 7:30 p.m. See also an advertisement.

*Sunderland* Corporation invite tenders for supply of one boiler feed pump, one wooden cooling tower, one surface condenser with motor-driven pumps, coal bunkers, gantry and other steel work; also for extension of Hylton-road station. Tenders (addressed to the Chairman of the Electricity and Lighting committee) to the town clerk (Mr. Fras. M. Bowey), Town Hall, Sunderland, by noon March 2.

*Hammersmith* (London) Council invite tenders for stores for 12 months ending March 31, 1907, including arc lamp carbons, &c., brooms, brushes, electrical goods, files, firebricks, &c., gauge glasses, meters, oilman's goods, packing and jointing materials, screws, tools, Welsh smokeless and other steam coal. Tenders to the town clerk (Mr. H. Thompson), by 4 p.m. Feb. 7.

*Salford* Electricity committee require tenders for stores for 12 months, including cables, meters, house fuse boxes, castings, tubes and fittings, carbons, electric lamps, switches and fittings, electric motors and motor starters, ammeters, oil and engine room stores, &c. Tenders by Feb. 17.

*Salford* Tramways committee require tenders by 3 p.m. Feb. 12, for 12 months' supply of various materials, including electrical and mechanical car accessories, wire, oils, lubricants, &c.

*Barnes* District Council invite tenders for supply, delivery and erection of 300 kw. steam dynamo, together with switchboard panels and connections. Tenders to the Clerk, Council House, High-street, Mortlake, S.W., by Feb. 12.

*Blackburn* Electricity and Tramways committee invite tenders by 10 a.m. Feb. 12 for stores for 12 months to March 25, 1907, including incandescent lamps, meters, pipes, cable, fuse-boxes, switches, &c., motors, arc lamp carbons, &c.

*Cardiff* Corporation invite tenders for cooling towers, electrically-driven pumps, pipe work, &c., for Roath power station. Tenders by Feb. 16.

The Midland Railway Co. Northern Counties committee, *Belfast*, want tenders by Feb. 8 for 12 months' supply of stores, including telegraph ironwork, batteries, signal wire, tubing, ironmongery, &c.

*Dover* Corporation want tenders by Feb. 12 for a 350 kw. combined steam generator set for traction.

*Wakefield* Corporation invite tenders for a water-softening and purification plant. Tenders by Feb. 17.

Messrs. Preece & Cardew, 8, Queen Anne's-gate, Westminster, S.W., have been instructed by *Shanghai* Municipal Council to invite tenders for the supply and delivery, c.i.f. Shanghai, of one 800 kw. horizontal steam turbo-alternator (single-phase) with condensing plant. Specifications, &c., after Jan. 30, from Messrs. Preece & Cardew, to whom tenders before noon Feb. 22.

The Deputy Postmaster-General of the Commonwealth, *Brisbane*, requires tenders for 50 telephone wall sets, of which specifications and forms of tender can be obtained at the General Post Offices of Sydney, Melbourne, Brisbane and Adelaide. Tenders have to be in at Brisbane by noon Feb. 19.

The Postal Telegraph Authorities, *Madrid*, will open tenders on Feb. 9 for 10,000 telegraph posts impregnated with sulphate of copper on the Boucherie system. The "Madrid Gazette" of Jan. 13 gives further particulars.

Tenders will be opened on Feb. 20 at the Chief Telegraph Office, 10, Corretas, *Madrid*, for the supply of 55 tons of galvanised wire (4 mm. diameter), 15 tons of bronze wire (3 mm. diameter) and 5 tons of bronze wire (2 mm. diameter). The "Madrid Gazette" of Jan. 21 gives further particulars.

The Spanish Telegraph Administration, *Madrid*, invite tenders by Feb. 26 for the supply of 60,000 No. 2 porcelain insulators (Spanish telegraph type) to be delivered in five equal lots at Madrid, Barcelona, Cordoba, Valladolid and Zaragona. See also "Madrid Gazette" for Jan. 27.

*Paris* Municipal Council invite "offers or propositions" relative to the organisation of the future electricity supply service in Paris, either including a service of a temporary nature for the first few years, utilising possibly the plant of existing companies, or on the basis of the future service independent of any "transitional" period. Offers to M. de Pontich, Directeur Administratif des Travaux de Paris, Hôtel de Ville, by March 1. Some further information is given in our Notes columns.

The State Telegraph Department of *Chili* invite tenders for supply of 26,500 quintals of telegraph wire, 25,500 insulators, 20,000 coils of Morse paper, and other telegraphic supplies. Tenders will be opened on March 15.

The Municipality of *Giurgevo* (Roumania) are about to invite tenders for the construction and working of an electric lighting system in that town at an estimated cost of about £40,000.

The Commercial Intelligence Branch of the Board of Trade have received from the Acting British Consul-General at *Christiania* notification that tenders are invited for the supply of telegraph and telephone materials (including battery zincs, insulators, sal ammoniac, retort carbon, &c.) for the Norwegian State Railways. Tenders from British firms should be lodged, by their properly-accredited agents, at the offices of the State Railway Authorities in Christiania by 3 p.m. Feb. 9. A copy (in Norwegian) of each of the specifications and conditions, together with drawing of insulator, may be seen at 73, Basinghall-street, London, E.C. Apart from the usual Custom duties, a preference of from 10 to 15 per cent. is given to Norwegian manufacturers. It is important to observe that in all cases of Norwegian Government contracts it is obligatory that a resident agent should act for tenderers not residing in Norway, and be responsible to the Government, but it is not necessary for the agent to be a Norwegian firm.

## TENDERS RECEIVED AND ACCEPTED.

Marylebone (London) Council have accepted the following tenders for 12 months' supply of stores for the electricity department: W. H. Willcox & Co., rags, axes, brooms, brushes, soldering irons, &c.; Croager Bros., tape, rope, &c.; Geo. Hatch and F. Bird & Co., ironmongery; C. F. Chesterman, timber; W. McGeoch (Ltd.) and Edison & Swan Co., electrical fittings; W. Lucy & Co., service boxes; G. Johnston & Co., oils, gauge glasses, packing, &c.; R. H. Vincent, oils, candles, soap, enamel, &c.; H. Sabey & Co., cement and bricks; Charrington, Sells, Dale (Ltd.), coke; Krupka & Jacoby, carbon brushes, &c.; Pryke & Palmer, iron and lead piping; G. Schultz & Co, mica; Piggott Bros. & Co., jointer's tents (£3. 16s. 6s. each); Stephen Carter, jointers' trucks (£6. 10s. each); Siemens Bros. & Co., cable trollies (£42 each); J. Smith & Co., tarpaulins.

Leyton Council have received the following tenders for two dynamos:—

| | | | | | |
|---|---|---|---|---|---|
| Mather & Platt (*accepted*) | **£1,185** | 0 | General Electric Co. | £1,405 | 0 |
| Lahmeyer Electrical Co. | 1,803 | 0 | Vickers, Sons & Maxim | 1,393 | 0 |
| Dick, Kerr & Co. | 1,684 | 0 | British Westinghouse Co. | 1,390 | 0 |
| Electrical Co. | 1,640 | 0 | Crompton & Co. | 1,380 | 0 |
| Bruce Peebles & Co. | 1,630 | 0 | Siemens Bros. & Co. | 1,330 | 0 |
| British Thomson-Houston Co. | 1,574 | 0 | Lancashire Dynamo & Motor Co. | 1,281 | 0 |
| Brit. Electric Plant Co. | 1,530 | 0 | John Fowler & Co. | 1,270 | 0 |
| Electric Construction Co. | 1,502 | 0 | Johnson & Phillips | 1,215 | 16 |
| International Elec. Co. | 1,480 | 0 | Greenwood & Batley | 1,210 | 0 |
| Brush Co | 1,406 | 0 | T. Parker (Ltd.) | 1,119 | 0 |

L.C.C. have received the following tenders for roadwork and platelaying in connection with the construction of their southern tramways:

| | | | |
|---|---|---|---|
| R. W. Blackwell & Co. (*accepted*) | **£82,620** | **11** | **11** |
| Wm. Griffiths & Co. | 92,894 | 14 | 5 |
| J. G. White & Co. | 92,460 | 2 | 4 |
| Muirhead, Greig & Matthews | 89,992 | 10 | 10 |
| Dick, Kerr & Co. | 89,663 | 3 | 3 |
| J. Mowlem & Co. | 86,548 | 0 | 0 |
| A. Krauss & Son | 84,078 | 7 | 0 |

The contractors will be allowed to sublet as follows:—(1) To Hadfield Steel Foundry Co., the manufacture of special work (consisting of points, crossings, &c.); (2) to Anderston Foundry Co., the manufacture of yokes and castings; (3) to Messrs. Bayliss, Jones & Bayliss, the manufacture of tie-bars, &c.; and to the Associated Portland Cement Mfg. Co., the supply of cement.

Leyton Council have received the following tenders for tramway overhead electrical equipment, and have referred them to the electrical engineer (Mr. F. Harman Lewis) and the Highways committee with power to act:—

| | | | |
|---|---|---|---|
| Macartney, McElroy & Co. | £14,069 | 9 | 6 |
| J. G. White & Co. | 12,917 | 1 | 11 |
| R. W. Blackwell & Co. ........£11,535. 4s. 6d. & | 12,093 | 11 | 9 |
| Dick, Kerr & Co. | 12,049 | 17 | 3 |
| Brush Co. | 11,671 | 0 | 0 |
| British Electrical Equipment Co. | 11,404 | 7 | 0 |

The following tenders were received for a telephone installation (central battery system), fire alarms and tell-tales for the new Cardiff Asylum:—

| | | | |
|---|---|---|---|
| J. B. Saunders & Co. (*accepted*) | **£1,291** | **18** | **0** |
| Cox-Walkers | 1,454 | 0 | 0 |
| National Telephone Co. | 1,329 | 17 | 0 |
| Gent & Co. | 1,320 | 0 | 0 |

Shoreditch Borough Council Electricity department has placed an order with the Stirling Boiler Co., which stipulates for the supply by Ed. Bennis & Co., Little Hulton, Bolton, of eight patent chain grate stokers, Bennis-Miller-Bennett type, fitted with the "Bennis" patent light load damper, the necessary shafting, gearing and accessories. The stokers are to be used in connection with both Stirling and Babcock & Wilcox water-tube boilers.

For an overhead crane Leyton Council have accepted the tender of Herbert Morris & Bastert at £119. 12s. There were 11 tenders, ranging from £119. 12s. to £280.

Stepney (London) Council have accepted the tender of Babcock & Wilcox for 72 boiler tubes at £81. 4s. Stewarts & Lloyds tendered at £108 and the British Mannesmann Tube Co. at £81, plus carriage. The tender of the South Metropolitan Gas Co. has been accepted for 50 tons of moulded pitch at 39s. 6d. per ton.

Leyton Council have accepted the tender of the Bell Punch Co. for hammer ticket punches at 15s. each, and for tickets at 3d. per 1,000.

Islington (London) Council have accepted, at £255. 10s. 2d., the tender of the British Thomson-Houston Co. for six electric motors for the Caledonian-road baths.

For roof trusses, &c., for power station extension the tender of Goddard, Massey & Warner at £161 has been accepted by Leyton Council. Seven tenders varying from £161 to £323 were received for this work.

Marylebone (London) Council have accepted the tender of H. F. Higgs at £1,980. 12s. for levelling a site adjoining the generating station.

Staffordshire Education committee have placed an order with the Walsall Electrical Co. for wiring the new schools at Darlaston at £125. 10s.

City of London Corporation has accepted the following tenders: British Thomson-Houston Co., 1,000 electric glow lamps, £40; V. G. Middleton wiring underground convenience, £25.

Barnstaple Council have accepted the tender of Newtons Limited for a 3 H.P. motor for blowing the organ at the Albert Hall at £21. 9s.

**Chimney Building Record.**—A chimney shaft 120 ft. high from foundation has been completed at Dundee electric tramways station, Monifieth, N.B., within 25 working days by the Ferbeck Chimney Construction Co. (Finsbury Pavement House, London, E.C.) for Messrs. J. G. White & Co. (Ltd.).

## BUSINESS NOTICES.

Mr. Richd. Vivian has retired from the partnership hitherto existing between himself and Andrew P. and Reginald W. Whaley, under the style of the Victoria Electric Co., at 47, Victoria-street, London, S.W.

Wm. Turnbull Gray and Thos. Bogle (trading as the United Electric Co.), 38, South Castle-street and Benns-gardens, Liverpool, have dissolved partnership. Debts by Mr. Bogle.

## BANKRUPTCIES, &c.

The trustees have been released in the bankruptcies of Hy. Geo. Ellis and Geo. Linzell Bastin (trading as the Electrical Contracting & Maintenance Co.); Alex. Holland (trading as the Electrical & Mechanical Engineering Co.), 13, Bridgewater-street, Farnworth, Lancs.; and Thos. Williams, electrical engineer, 54, Bridge-street, Llandaff.

The public examination of Henry J. C. Somerville, 109, Victoria-street, London, S.W., took place on Tuesday. Total liabilities £4,875 (unsecured £4,190), assets valued at £1,201.

Debtor started business in 1887 at Birmingham as a commission agent, and came to London in 1890. From 1892 to 1900 he was concerned in the promotion of a number of companies, and among them the Otto Electrical Mfg. Co. (1905), (Ltd.) ....

Claims against the Otto Electrical Mfg. Co. (1905), Ltd., to Mr. E. H. Fletcher, 14, George-street, Mansion House, London, E.C., by March 17.

A meeting will be held on March 6 at 14, George-street, Mansion House, London, E.C., to receive an account of the winding up of the Apostoloff Automatic Telephone Parent Synd. (Ltd.).

**Winding-up Petition.**—A petition for the winding-up of the Webster Electrical Engineering Co. (Ltd.), has been presented by the Midland Electric Wire Co. (incorporated with Gent & Co., Ltd.), and will be heard on Feb. 13 at the Court House, Bradford.

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**Sales by Auction.**—Messrs. Wheatley Kirk, Price & Co. will sell by public auction at 11 a.m., on Tuesday next Feb. 6, at 48 and 49, Britannia-street, City-road, London, N., the whole of the incandescent lamp renovating plant and stock, including motors from $\frac{1}{20}$ H.P. to 10 H.P., switchboards, transformers, electrical instruments, gas engine, tools, and a quantity of new incandescent lamps, &c. Further particulars from the receiver (Mr. S. Wiltshire), 19, St. Dunstan's-hill, London, E.C.; Messrs. J. J. Edwards & Co., solicitors, 28, Sackville-street, Piccadilly, W.; or of the auctioneers, 46, Watling-street, London, E.C., and Albert-square, Manchester. See also an advertisement.

**Patent for Sale.**—Herr Karl Abel, 12, Lichtensteinstrasse, Vienna, IX., Austria, advertises for sale English and American patents for "Improvements in apparatus for lighting gas by electricity.

**Arc Lamps Wanted.**—Some "flame" arc lamps and accessories are wanted by the city electrical engineer (Mr. H. Faraday Proctor), Temple Back, Bristol. See an advertisement.

**Factory Sites Offered.**—An offer is made of a freehold site of from 2 to 10 acres, free of cost, to engineers or manufacturers contemplating the erection of works. Particulars from Mr. O. B. Thomas, solicitor, 59, Chancery-lane, London, W.C. See also an advertisement.

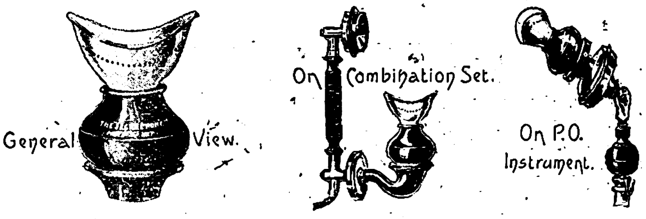
Mr. P. Barnett, 56, Moorgate-street, London, E.C., advertises to let a factory and stabling in Goswell-road, near the "Angel," suitable for manufacturing purposes.

Messrs. Holland & Holland (Ltd.), 98, New Bond-street, London, W., have for letting or for sale a freehold factory in the Harrow (main) road, W.

**Patent Litigation.**—Notice is given in an advertisement that an action has been commenced by Messrs. Lycett & Conaty against Messrs. Mountain & Gibson (Ltd.) to restrain the latter "from infringing Letters Patent 15,970 and 23,948 of 1903 by manufacturing and selling electrically-driven tramcars, in which the motors which drive the axles are so mounted as to have the same radial movement as the axles themselves."

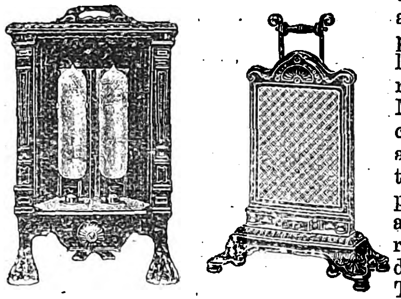
**"Juno" Flame Arc Lamp.**—Messrs. Johnson & Phillips (Ltd.) are placing upon the market the Juno flame arc lamp, and particulars of this lamp are given in a circular just issued. The company claim that the lamp is the outcome of a series of experiments and trials over an extended period, and is a marvel of simplicity and neat design. There are only three moving parts, no shunt coils, wheels, sliding rods, clockwork, dashpots, brakes, clutches or other mechanism likely to get out of order. Any number of lamps can be run in series on either alternating or direct current circuits, each lamp taking about 48-50 volts. The highest claims for economy in running are made on behalf of this lamp. The weight of the lamp is 19lb., length over all 29½ inches, and length of carbons 18 inches.

**The Secrephone.**—We have been afforded an opportunity of testing the merits of an appliance, which has been called "The Secrephone," and is designed to secure immediate privacy on all telephones. The accompanying illustrations show this device as applied to different instruments, and also a general view. The chief merit of the Secrephone is that it can be applied to the transmitter or mouthpiece of any telephone by skilled or unskilled persons in a few seconds. Its weight is under 4 oz., and it cannot be thrown out of adjustment. Our own tests of this device enabled us to conduct a telephonic communication in an undertone between Coleman-street, E.C., and Salisbury-court, E.C., without anyone in the room at the former address being able to hear the message, while the conversation was clearly audible to the person at the other end. The Secrephone is claimed by its exploiters, the Secrephone Co., 10, Coleman-street, London, E.C., to have other merits, amongst which is that of making clear and loud communication through the telephone when, from one cause or another, the conversation is conducted with difficulty owing to induction or cross circuits. The Secrephone is portable, and can be carried about for the exclusive use of the holder on any telephone instrument, say at call offices, &c., or in places where noise interferes with ordinary telephonic conversation. It is of course necessary to speak close into the metal mouthpiece of the Secrephone, and, to provide for the natural condensation of the breath, antiseptic paper linings, made to exactly fit the mouthpiece, are supplied in quantity for a very small sum. We learn that more than one of the municipal telephone undertakings in Great Britain are considering the introduction of the Secrephone to their subscribers' instruments. The same company's Autopad, an ear device, is well-known and has a large and increasing sale.


General View.
On Combination Set.
On P.O. Instrument.

THE SECREPHONE TELEPHONE DEVICE.

**Catalogues.**—A new list of electric radiators is issued by the General Electric Co., and contractors for this class of apparatus are informed that the company have been able to considerably reduce prices with a view to popularising the use of the electric radiator as a heating factor. Many new patterns have recently been introduced of attractive design, and one of these is shown in the accompanying illustration, which is an example of the "Phœbus" radiator suitable for offices or drawing and dining rooms. This radiator has a flush front, is well and substantially made, and is supplied with plain black stove enamel finish relieved with gold lines. The "Diaper" type of non luminous radiator is shown in the second figure, this being wired on the enamel system.



The "Phœbus." The "Diaper."

GENERAL ELECTRIC CO'S. RADIATORS.

A neat list (which can be carried in the pocket) has been issued by Chas. Macintosh & Co., Cambridge-street, Manchester, which gives tabulated details of a wide range of electrical conductors, showing dimensions, capacity, resistances and weight, and giving particulars of cables heavily braided with asbestos yarn and compounded with fireproof composition; cables with pure and vulcanised rubber, taped and braided, and covered with preservative compound; cables insulated with pure and vulcanised rubber, taped and lead covered; double vulcanised and special thin insulation flexible cords, telephone wires and cables, paraffined line wires, &c., which are manufactured by the company. A sheet list is also issued of "W.R." dry batteries, which are supplied either round or rectangular in wooden boxes or india rubber covers, for motor cars and motor bicycle sets, as well as for intermittent lighting and telephone work.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Jan. 24 to Jan. 30, with the ports of destination:—

*Aden*—£36. *Africa*—Alexandria, £1,646 (including £236 telegraph material); Beira, £68; Cape Town, £120; Durban, £3,566 (including £2,326 telegraph material); East London, £252 (telegraph material);

Mombasa, £25 (telegraph material); Port Elizabeth, £96. *Argentina*—Buenos Ayres, £143 (including £105 telegraph material); Rosario, £260 (telegraph material). *Australasia*—Adelaide, £50; Lyttelton, £900 (telegraph material); Melbourne, £1,554 (including £1,412 telegraph material); Perth, £346; Sydney, £923; Wanganui, £45. *Belgium*—Ostend, £56. *Brazil*—Rio Janeiro, £1,638 (telegraph material). *Ceylon*—Colombo, £17. *Chili*—Valparaiso, £266. *China*—Canton, £142; Shanghai, £18. *Cuba*—£1,000. *France*—Dunkirk, £135; Marseilles, £72 (including £53 telegraph material). *Germany*—Cologne, £37. *Gibraltar*—£23. *Greece*—Piræus, £21 (telegraph material). *Holland*—Amsterdam, £266 (including £60 telegraph cable); Rotterdam, £38 (telegraph material). *Hong Kong*, £305 (including £270 telegraph material). *India*—Bombay, £295 (including £29 telegraph material); Calcutta, £2,705 (including £205 telegraph material); Karachi, £110. *Japan*—Kobe, £632 (telegraph material); Moji, £117; Tokyo, £770; Yokohama, £813. *Malta*, £9. *Mauritius*, £1,049. *Philippines*, £165,000 (telegraph material). *Russia*—Reval, £14; St. Petersburg, £55. *Siam*—Bangkok, £285. *Straits Settlements*—Singapore, £344 (including £190 (telegraph material). *U.S.A.*—New York, £18. *Uruguay*—Monte Video, £13. *Zanzibar*, £36 (telegraph material. Total, £186,329, against £9,930 in the corresponding week last year (Jan. 25 to 31).

# COMPANIES' MEETINGS AND REPORTS.

◆

## Direct United States Cable Co. (Ltd.)

The fifty-seventh ordinary general meeting was held on Tuesday, Mr. E. M. Underdown, K.C., presiding.

The GENERAL MANAGER and SECRETARY (Mr. T. Finnis) read the notice convening the meeting, and the auditors' report. The directors report was taken as read.

The CHAIRMAN, in moving the adoption of the report, said: The half-year's revenue, after deducting out-payments, amounted in round figures to £56,353, while the working and other expenses, including income tax, absorbed £23,299, leaving a balance of £33,054 as net profit. With £2,526 brought forward from the previous half-year, that makes a total of £35,580. This has been appropriated as follows: An interim dividend of 3s. per share up to Sept. 30 was paid, absorbing £9,107. We propose now an interim dividend of 3s. 6d. per share to Dec. 31, requiring £10,624. We set aside to the reserve fund £10,000 and carry forward £5,849, making a total of £35,580, equal to that on the other side. Now the revenue, as compared with that of the corresponding period of 1904, shows an increase of £5,323, due to the continued improvement of the traffic. As I have often told you, we are a sort of barometer as to the state of the business between this country and the rest of the world, but principally the United States. When commercial relations are active the cables feel it, because they have a larger amount of matter to receive and to transmit. The working expenditure does not require much remark, because in London it is practically unaltered, and at the stations the small increase is owing to the increased amount of traffic handled. The remaining expenditure entered on the debit side of the revenue account consists mostly of items of a fixed character. We have altogether a total of £23,299, showing an increase of £1,190, but the shareholders will remember that this total now includes provision for the staff pension fund, which was approved by them in January of last year. The before-mentioned increase of £5,323 in the revenue has been earned with an additional outlay of only £1,190, leaving a balance of £4,233 secured as net profit. Now, during some considerable period you have had no charge against the reserve fund. We have been singularly fortunate in escaping large expenditure for repairs, and we have gone on, according to the very prudent plan we inaugurated many years since, continually adding to our reserve fund and making use of the interest accrued upon the investments in that fund for the purpose of bringing it up to a sum which will be regarded as equivalent to our possible requirements, taken reasonably. We have credited this account with the interest, £7,753, and £10,000 from the revenue account, and now I have the satisfaction of informing you that we have reached the sum that we have been for a long time ambitious to obtain in the shape of reserve. The reserve fund now exceeds £500,000 sterling—strictly speaking, £500,700. That is at cost, whereas the value of our investments is slightly in excess of that amount (applause). I think that we may take credit to ourselves for the prudence with which we have made use of our powers to invest the reserve fund. After all the troubles we have had, after the great fall in Consols which we fortunately got out of without any loss, our investments are now worth what they stand at in our books at cost. That brings me to another point. Hitherto, you have noticed that in every half-year we have set aside a considerable sum to the reserve, sometimes £10,000, sometimes more, sometimes less, and we have, as I said before, added the interest to that reserve fund. Having reached the point we have now attained, the Board feels that it may, with justice and prudence, give the shareholders the advantage of having, if not all, a very substantial amount of the whole net profit of the earnings. Of course, I do not mean to state that we are going to allow that reserve fund to be depleted. It may be that if it is decreased by any amount, we shall have to replace that sum, but, on the whole, you may take it, if our experience in the future is as our experience in the past, the interest of the accumulated fund will cover our ordinary repairs. In the December quarter of the past half-year we have been able to give you half per cent. more. We trust all conditions are favourable, as our lines are in excellent order. In fact, all the cables of ourselves and our friends in the pool are now working well, which, of course, tends to the prosperity of everyone connected with the pool. Our share out of the pool is a satisfactory one. It is always not only more satisfactory that our earnings are greater, but, inasmuch as we have a fixed payment to make, that fixed payment becomes of less consequence when we have very good traffic. Now the question of the future appears to me to be a simple one. I hope we can count on the continued prosperity that we now enjoy. There are not, perhaps, too many cables, but business is such that during business hours nearly all the cables are occupied. That business we are able to cope with, and I think that our position is a very satisfactory one. I observe to-day in the paper the announcement of the death, at the age of 83, of a gentleman connected with telegraphy a great number of years, M. Despecher, who had a great deal to do with the arrangements of telegraphic communication between this country, the United States and France, and in other ways. One regrets that one more of the landmarks of telegraphy has disappeared. I do not think I need trouble you with any further remarks, and I simply move the resolution.

Sir JAMES PENDER seconded the resolution, which was unanimously adopted.

Mr. HOLMES moved a vote of thanks to the Chairman and Directors, and congratulated them on the satisfactory nature of the report. He said that the Company had a great deal to be thankful for, because their cables lay on a nice bottom, whereas if they had rocks and coral to deal with it would be very different. He desired also to couple with the motion a vote of thanks to the staff, upon whom a great deal depended, and he thought it would be satisfactory to them that the shareholders recognised their services.

Mr. JULIUS EBEL seconded the motion, which was carried unanimously.

The CHAIRMAN: I am very pleased that you have coupled the staff with our names. We are not only carrying on the business efficiently, but we have taken into consideration, so far as is prudent and possible, all things relating to the comfort and well-being of the staff, and I trust they are a contented body in every respect.

The proceedings then terminated.

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**CENTRAL LONDON RAILWAY CO.**—The directors' report for the half-year ended Dec. 31 states that capital expenditure was £4,729. 11s. 3d., receipts amounted to £174,521. 3s. 11d. (a decrease of £1,760. 4s. 2d.), and working expenses to £94,667. 13s. 7d. (a decrease of £1,269 18s. 8d.) compared with the corresponding period of last year, leaving £79,853. 10s. 4d. 21,694,066 passengers were carried, against 21,906,150 in the corresponding period of 1904, the total for 1905 being 44,731,501, against 44,875,547 in 1904. The average receipt per passenger for the half-year was 1·85d. compared with 1·86d. in the corresponding period of 1904. After providing for interest and other payments (including £2,049. 1s. 11d. for opposing competing bills in Parliament), the balance is £106,000. 3s. 7d. The directors recommend dividends at rate of 4 per cent. per annum on the undivided and preferred ordinary stock for the half-year and on the deferred ordinary stock for the whole year. Of the unappropriated balance (£35,393. 17s. 2d.) the directors recommend that £10,000 be transferred to reserve (making that fund up to £73,438), the balance of £25,393. 17s. 2d. being carried forward. In view of the report of the Royal Commission on London Traffic and the public announcement by the Board of Trade of the preparation of a Bill relating thereto, and providing for the establishment of a traffic board as recommended in that report, the directors did not think it advisable to incur the expense of re-depositing the bill for the proposed extension of their line, via Hammersmith, to the City. A bill has, however, been deposited by other promoters for a line from Hammersmith to Southgate, via Piccadilly, the Strand and the City, with various branches, which it will be necessary for the company to oppose. Several electrical power supply and other bills have also been deposited which may affect the company's railway. The subways for the exchange of passengers with the Charing Cross, Euston & Hampstead Railway at Tottenham Court-road station, and with the Baker-street & Waterloo Railway at Oxford Circus station, are in course of construction, satisfactory arrangements having been concluded with the companies concerned. It is expected that the connection at Oxford Circus station with the Baker-street & Waterloo Railway will be available for use when that line is opened for traffic.

**CHATHAM & DISTRICT LIGHT RAILWAYS CO.**—For the half-year ended Dec. 31 the receipts were £17,505. 0s. 7d. and the expenses £12,800. 8s. 5d., leaving £5,704. 12s. 2d., which, with balance from June half-year (£2,568. 11s. 3d.) and less debenture interest (£1,000) leaves £7,273. 3s. 5d. Of this sum, £2,000 has been transferred to reserve for depreciation, £387. 1s. written off, and the directors recommend that the balance be disposed of by paying the dividend on the 5 per cent. preference shares, and a dividend at the rate of 3 per cent. on the ordinary shares, carrying forward £699. 6s. Rochester Corporation are proceeding with the construction of an extension line to Delce Grange, which will be leased to the company.

**CITY & SOUTH LONDON RAILWAY CO.**—The total receipts for the half-year ended Dec. 31 amounted to £74,713. 14s. 4d., and the cost of working to £34,848. 7s. 9d., leaving a profit of £39,865. 6s. 7d. Inclusive of balance forward from June 30, the total is £41,399. 17s. 6d. After making provision for interest and the transfer to renewal fund of £1,500, the balance available for dividend is £28,674. 18s. 8d., out of which the directors recommend the full dividend of 5 per cent. on the preference stocks and a dividend at the rate of 1¾ per cent. per annum on the consolidated ordinary stock for the half-year, leaving £1,366. 16s. 2d. to be carried forward. Exclusive of season-ticket holders, 8,607,486 passengers were carried, compared with 8,662,588 and 8,401,846 in the two preceding half-years, and the receipts (including season tickets) were £70,103. 14s. 4d., £71,802. 7s. 8d. and £70,705. 10s. 11d. respectively. The directors record with regret the death of Mr. Charles Grey Mott, and express their warm appreciation of his valuable services and unfailing devotion to the interests of the company. They have elected the Right Hon. C. B. Stuart-Wortley, K.C., M.P., to fill the vacancy on the board, and have elected him chairman of the company. Satisfactory progress is being made with the construction of the extension to Euston. An agreement has been made with the L. & N.W. and the Charing Cross, Euston & Hampstead Railway Companies as to the interchange station and connecting subways with the former company's platforms at Euston Station. The contract for the works and lifts and the contract for the joint subway connecting the City & South London Co.'s platforms with those of the Charing Cross, Euston & Hampstead Railway have been entered into. At the Elephant and Castle station subway communication between the company's platforms and those of the Baker-street & Waterloo Railway is nearing completion.

**DUBLIN & LUCAN ELECTRIC RAILWAY CO.**—The receipts for the half-year ended Dec. 31 were £3,327. 16s., a decrease of £8. 1s. compared with the corresponding period of 1904, while the expenditure was £1,784.12s.7d., an increase of £88. 14s. 7d. After providing for interest the available balance is £1,304. 13s. 2d., and the directors recommend payment of the half-year's preference dividend and £500 to the contractors on account of sum due to them for electrical equipment, leaving £329. 13s. 2d. to be carried forward.

**DUBLIN UNITED TRAMWAYS CO. (1896) (LTD.)**—For the half-year ended Dec. 31 the amount available for division is £49,707. 6s. 3d., and it is recommended that dividends be paid on the preference shares and at the rate of 6 per cent., tax free, on the ordinary shares. £4,000 is put to reserve, £1,000 to accident insurance, and £2,500 towards maintenance. These items will absorb £42,600, leaving £7,107. 6s. 3d. to be carried forward.

**GIANT'S CAUSEWAY, PORTRUSH & BUSH VALLEY ELECTRIC TRAMWAY CO. (LTD.)**—At the meeting on Monday, Dr. Anthony Traill, J.P., moved the adoption of the report, which states that the receipts of the past year amounted to £3.934. 5s. 5d., against £3,616. 12s. 1d. in 1904, and £3,376. 17s. 1d. in 1903. The company had carried 128,546 passengers, against 119,876 in 1904. The net profit was £1,783. 2s., against £1,479. 1s. 9d. The number of miles run was 29,347, against 28,489. The engineer's report was of a satisfactory nature.

**KENT COLLIERIES (LTD.)**—At the meeting on Friday last this company's electric power bill was approved.

**LIVERPOOL OVERHEAD RAILWAY CO.**—For the half-year to Dec. 31 gross receipts were £39,638. 9s. 8d., and working expenses £32,186. 11s. 7d. The number of passengers carried were 5,617,672, against 5,558,113 in the June half-year, and 5,613,752 in the corresponding period of 1904. The slight increase in the number of passengers carried during the past half-year has been entirely in cheap workmen's tickets, there having been a falling-off both in first and third-class traffic. The directors have introduced a system of differential fares with the view of meeting the competition of the tramways. Their average receipts per passenger amount to 1·78d. compared with 1·90d. last year. The Seaforth extension was opened in July, but the through train service to Southport has not yet been inaugurated owing to the delay in completing the necessary rolling stock by the L. & Y. railway. The Seaforth extension has increased the working expenses without so far producing any corresponding increase in earnings. After paying debenture interest, the balance available for dividend is £7,460. 4s. 4d., out of which the directors recommend payment of the preference dividend (less tax), leaving £3,784. 7s. 4d. to be carried forward.

**LONDON, BRIGHTON & SOUTH COAST RAILWAY CO.**—At the meeting on Wednesday Lord Cottesloe said the directors had hoped that the work of electrifying a portion of the railway would have been commenced some time during the course of the past financial year, but difficulties had been met with, which it had taken a good deal of time and lengthened negotiations to surmount. The delay had brought with it some advantages, however. In the first place, Victoria Station, though progressing favourably, was still in a transition stage, and if the electrification of the South London line had been taken in hand a year ago, it would certainly have been impossible to provide the electrical equipment in that station or on the lines leading to it. A year's delay had therefore brought much nearer the time when it would be possible to fix apparatus for electric working in that station. A second reason why the delay had been advantageous was that the system fixed upon has had a longer trial and had been improved in several details, with the result that the board were now so satisfied with its reliability that, instead of equipping only a short section of the South London line as a preliminary experiment, they felt justified in dealing with the whole of that line from London Bridge to Victoria. The company was in active negotiation for a contract with the Allgemeine Elektricitäts Gesellschaft of Berlin, and in the arrangements with that company it was proposed to require that, with the single exception of the motors for the first set of eight trains, the whole of the plant should be of British manufacture.

**LONDON, TILBURY & SOUTHEND RAILWAY CO.**—Mr. A. L. Stride stated at the meeting yesterday that so far they had found the cost of electric traction had been considerably in excess of steam, but the line was not being worked at a normal cost. The men were new to the work, the stock was new, and there had been a considerable waste of current in the working of the electric trains; but every week showed a great improvement, both in cost and in smooth working. There was, in fact, no case in the experience of railway men where so great and radical a change had been made in the working of a system with so little inconvenience to the public. At one time they feared they would have to shut up the line for at least a week during the conversion. As they knew, the line had not been closed, but to keep faith with the public had cost a great deal of money. As it was they did not even then know how much they would have to pay the District for the current they had used, but they had set aside a sum that would cover any possible demand upon them.

**NATIONAL TELEPHONE CO. (LTD.)**—The directors, after declaring a dividend at the rate of 6 per cent. per annum on the preferred stock, announce a distribution on the deferred stock at the rate of 5 per cent. per annum, and £125,000 to reserve, carrying forward about £10,000. A year ago the dividend was the same, £115,000 was added to reserve, and £10,000 carried forward.

**SOUTH EASTERN RAILWAY CO.**—At the meeting on Tuesday, Mr. H. Cosmo Bonsor said that within the metropolitan area there was again a loss, due, no doubt, to the competition of electric tramways and motor omnibuses.

**WESTMINSTER ELECTRIC SUPPLY CORPN. (LTD.)**—The directors recommend, subject to the audit, payment of a dividend at rate of 13 per cent. per annum (less tax) for the half-year ended Dec. 31, making 13 per cent. for the year.

At an extraordinary meeting on Wednesday the shareholders confirmed the resolution passed on Jan. 9 approving of the company participating in the promotion of a bill to authorise the association of electric supply undertakers in the west of London.

## NEW COMPANIES, STATUTORY RETURNS. MORTGAGES AND CHARGES, LIENS, &c.

### NEW COMPANIES.

**COMMERCIAL ELECTRO-CHEMICAL ANALYSIS CO. (LTD.)** (87,306.)—Reg. Jan 22, capital £2,000 in £1 shares, to take over the business of an electro-chemical analyst carried on by E. B. Vaughan, with the journal called the "Electric Accumulator" published by him, and the laboratory and other property appertaining to the said business.

**CURATIVE ELECTRICITY CO.** (87,347.)—Reg. Jan. 24 as an unlimited company, with a capital of £100 in £1 shares, to manufacture and sell an appliance known as the "curative electricity coil," &c. The first directors are R. Pittman and C. Pittman. Reg. office, 6, Guildhall-chambers, London, E.C.

**HANKON LIGHT & POWER CO. (LTD.)** (87,331.)—Reg. Jan. 27, capital £20,100 in 2,000 ordinary shares of £10 each and 2,000 deferred shares of 1s. each, to carry on the business of electrical, mechanical and chemical engineers, electricians, suppliers of electricity, &c. Reg. office, 23, College-hill, London, E.C.

**HEADINGLEY MOTOR & ENGINEERING CO. (LTD.)** (87,390.)—Reg. Jan. 26, capital £1,000 in £1 shares, to acquire the business of electricians, electrical engineers, suppliers of electricity, manufacturers of and dealers in motors, cycles, &c. No initial public issue. First directors are J. J. Nicholson and J. S. Savile. Reg. office, 18, St. Michael's-lane, Headingley, Leeds.

**HUNSLET ELECTRICAL POTTERY CO. (LTD.)** (87,353.)—Reg. Jan. 24, capital £3,000 in £1 shares, to carry on the business of manufacturers of and dealers in earthenware pottery in connection with electrical fittings of all kinds. First directors are W. A. Ibbitson, J. Hepworth, jun., A. D. Brighouse and E. D. Ibbitson. Reg. office, Balm-road Mills, Hunslet, Leeds.

**ILFORD ACCUMULATORS (LTD.)** (87,316.)—Reg. Jan. 22, capital £12,500 in 11,500 preference shares of £1 each and 20,000 founders' shares of 1s. each, to adopt an agreement and to carry on the business of manufacturers of electrical apparatus, scientific instruments, electric and steam motors, motor cars, dynamos, storage and primary batteries, accumulators, &c. Reg. office, 13, Borough High-street, London, S.E.

**MADRAS ELECTRIC SUPPLY CORPN. (LTD.)** (87,409.)—Reg. Jan. 27, capital £400,000 in £5 shares, to carry on, in India or elsewhere, the business of an electric light and power company, and that of electrical engineers, electricians, contractors, manufacturers of and dealers in cables, wires, lines, accumulators, lamps and electrical appliances, &c., and to acquire concessions or licences granted by and enter into contracts with the Indian Government or other authority. The subscribers are A. M. H. Walrond, Sir W. J. Cuningham, T. E. Ivens. A M.Inst.C.E., Sir Ralph D. R. Moor, J. G. B. Stone, F. R. Reeves (engineer), and F. Medcalf. First directors: A. M. H. Walrond, Sir Wm. J. Cunningham, K.C.S.I., T. E. Ivens, Sir Ralph D. R. Moor and J. G. B. Stone. Reg. office, Salisbury House, London Wall, London, E.C.

### MORTGAGES AND CHARGES.

**PRIVATE WIRE & TELEPHONE INSTALLATION CO. (LTD.)**—£4,500 5 per cent. debentures, created Jan. 4 and dated Jan. 6, 1906, charged on company's undertaking and property, present and future, including uncalled capital, have been registered. No trustees. Holders, Consolidated Electrical Co. and Mrs. E. L. Russ.

**POWER PLANT CO. (LTD.)**—A debenture dated Jan. 8, 1906, to secure £5,000, charged on factory and works at Yiewsley, West Drayton, and company's undertaking and other assets, has been registered. Holders, E. M. Hall and E. D. Vaisey.

## CITY NOTES.

**MEMORANDA** (Feb. 1).—Bank rate 4 per cent. (since Sept. 28, 1905). Price of silver $30\frac{1}{8}$d. per oz. Consols $90\frac{3}{16}$—$90\frac{5}{16}$ for money, $90\frac{7}{16}$—$90\frac{9}{16}$ for account; $2\frac{1}{2}$ per cent. annuities $89\frac{1}{8}$—$89\frac{3}{8}$. Consols Pay Day, March 1. Stocks and Shares Continuation Days, Feb. 6 and 20; Ticket Days, Feb. 7 and 21. Pay Days, Feb. 8 and 22; Mining Share Carry-over Day, Feb. 5.

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. No. of weeks | Aggregate. Amount. | Aggregate. Inc. or Dec. (a) |
|---|---|---|---|---|---|---|
| | | £ | £ | | £ | £ |
| **Aberdeen Corporation** | Jan. 27 | 1,141 | + 49 | 35 | 48,767 | − 980 |
| **Airdrie** | ,, 10 | 223 | + 43 | 3 | 644 | + 68 |
| Anglo-Argentine | ,, 28 | 13,864 | + 1,311 | 4 | 58,457 | + 5,081 |
| **Ayr Corporation** | ,, 27 | 175 | + 11 | 35 | 11,119 | − 179 |
| **Barnsley** | ,, 10 | 151 | + 12 | 3 | 385 | + 3 |
| **Barrow** | ,, 19 | 202 | + 34 | 3 | 520 | + 54 |
| **Bath Electric Trams, Ltd.** | ,, 24 | 628 | + 146 | 4 | 2,616 | + 476 |
| Birkenhead Corporation | ,, 28 | 945 | + 16 | 4 | 4,355 | + 101 |
| **Birmingham Corporation** | ,, 27 | 389 | + 59 | 43 | 16,018 | + 2,069 |
| ***Birmingham & Mid.** | ,, 19 | 1,372 | − 79 | 3 | 3,657 | − 732 |
| **Blackpool Corporation** | ,, 25 | 305 | + 55 | 4 | 46,618 | + 1,970 |
| **Blackpool and Fleetwood** | ,, 27 | 181 | − 2 | 4 | 615 | − 37 |
| **Bolton Corporation** | ,, 28 | 1,766 | + 133 | 41 | 84,892 | + 4,101 |
| **Bournemouth Corporation** | ,, 24 | 1,238 | + 469 | †43 | 60,960 | + 13,887 |
| **Bradford Corporation** | ,, 27 | 8,870 | + 285 | 43 | 188,257 | − 3,227 |
| **Brighton Corporation** | ,, 28 | 708 | + 31 | 44 | 43,835 | + 560 |
| **Bristol Trams & Carriage** | ,, 26 | 4,438 | + 144 | 24 | 81,858 | + 2,086 |
| **Buenos Ayres & Belgrano** | ,, 28 | 3,352 | + 854 | 4 | 12,817 | + 1,438 |
| Buenos Ayres Elec. Trams | Dec. 20 | 1,417 | ... | 52 | 62,596 | ... |
| **Burnley Corporation** | Jan. 27 | 1,056 | + 116 | 43 | 58,125 | + 3,398 |
| **Burton Corporation** | ,, 28 | 259 | − 10 | §45 | 18,363 | − 1,485 |
| **Bury Corporation** | ,, 21 | 786 | ... | §42 | 31,906 | ... |
| **Calcutta Tramways Co.** | ,, 27 | R42,691 | + R4,668 | 4 | R197,616 | + R25,648 |
| **Camborne-Redruth** | ,, 27 | 120 | + 25 | 13 | 1,421 | + 24 |
| Cardiff | ,, 10 | 2,018 | + 240 | 42 | 86,397 | + 60 |
| **Carlisle Tramways Co.** | ,, 29 | 164 | + 29 | 4 | 653 | + 55 |
| Cavehill | ,, 19 | 18 | − 8 | 3 | 73 | − 17 |
| **Central London Railway** | ,, 27 | 6,850 | − 350 | 4 | 27,875 | − 1,127 |
| **Chatham & Dist. Lt. Rys.** | ,, 25 | 549 | − 4 | †4 | 2,157 | + 56 |
| ***City of Birm'gh'm Tram Co.** | ,, 19 | 5,258 | + 658 | 3 | 14,152 | + 289 |
| **City & South London Rly.** | ,, 29 | 2,978 | − 16 | 4 | 12,210 | − 169 |
| **Colchester Corporation** | ,, 25 | 139 | − 2 | 26 | 4,851 | − 1,502 |
| **Cork Electric Trams Co.** | ,, 25 | 398 | + 6 | †4 | 1,508 | + 6 |
| **Devonport & Dist. Trams** | ,, 19 | 431 | + 7 | 3 | 1,168 | − 60 |
| **Dover Corporation** | ,, 27 | 166 | + 5 | ‡43 | 9,752 | + 85 |
| **Dublin & Lucan Railway** | ,, 26 | 90 | + 1 | §4 | 329 | − 32 |
| **Dublin United** | ,, 26 | 4,553 | + 297 | ‡4 | 17,832 | + 252 |
| **Dudley—Stourbridge** | ,, 19 | 766 | + 170 | 3 | 2,009 | + 225 |
| **Dundee Corporation** | ,, 24 | 931 | + 165 | §26 | 33,927 | + 2,656 |
| **East Ham Council** | ... | ... | ... | ... | ... | ... |
| **Gateshead & Dist. Trams** | ,, 19 | 933 | + 178 | 3 | 2,489 | + 187 |
| **Glasgow Corporation** | ,, 27 | 15,160 | + 1,526 | 25 | 532,049 | + 33,942 |
| Glossop | ,, 27 | 129 | + 24 | 4 | 491 | + 82 |
| Gloucester Corporation | ,, 24 | 209 | + 16 | 43 | 12,568 | + 1,145 |
| **Gravesend—Northfleet** | ,, 19 | 203 | + 28 | 3 | 540 | + 48 |
| **Gt. Northern & City Rly.** | ,, 27 | 1,793 | + 29 | 4 | 7,224 | + 127 |
| **Greenock & Port Glasgow** | ,, 19 | 567 | + 87 | 3 | 1,591 | + 168 |
| **Halifax Corporation** | ,, 24 | 1,227 | + 125 | 43 | 67,510 | + 4,852 |
| **Hartlepool Tramways** | ,, 19 | 250 | + 31 | 3 | 676 | + 24 |
| Hastings Elec. Trams Co. | ,, 25 | 339 | ... | 4 | 1,502 | ... |
| **Huddersfield** | ,, 27 | 1,259 | + 157 | 43 | 58,860 | + 3,200 |
| **Hull Corporation** | ,, 27 | 2,115 | + 144 | 43 | 96,389 | + 1,817 |
| Ilford Dist. Coun. | ,, 27 | 391 | + 63 | 43 | 20,203 | + 892 |
| **Ipswich Corporation** | ,, 27 | 302 | + 2 | 43 | 18,503 | − 1,827 |
| **Isle of Thanet Co.** | ,, 24 | 240 | + 23 | 17 | 4,580 | − 426 |
| **Kidderminster & District** | ,, 19 | 97 | + 9 | 3 | 247 | + 6 |
| Kilmarnock Corporation | ,, 27 | 144 | + 10 | 37 | 5,835 | ... |
| **Kirkcaldy Corporation** | ,, 24 | 178 | + 7 | 21 | 4,325 | − 15 |
| **Lanarkshire Trams Co.** | ,, 25 | 790 | + 212 | †4 | 3,169 | + 785 |
| Leamington | ,, 19 | 133 | + 57 | 3 | 383 | + 140 |
| **Leeds Corporation** | ,, 27 | 5,478 | + 385 | 43 | 259,189 | + 8,279 |
| **Leicester Corporation** | ,, 27 | 1,909 | + 236 | 4 | 7,764 | + 1,361 |
| Leith Corporation | ,, 20 | 436 | + 234 | 35 | 12,757 | + 9,866 |
| **Liverpool Overhead Rly.** | ,, 28 | 1,399 | − 62 | 4 | 5,638 | − 259 |
| Liverpool Corporation | ,, 20 | 10,214 | + 186 | 4 | 30,268 | + 1,657 |
| ***London County Council** | ... | ... | ... | ... | ... | ... |
| **Lowestoft** | ,, 27 | 125 | + 15 | 17 | 2,480 | − 2 |
| **Maidstone Corporation** | ,, 26 | 80 | − 3 | 43 | 5,282 | ... |
| **Manchester Corporation** | ,, 27 | 12,066 | + 799 | 43 | 554,880 | + 28,050 |
| **Mersey Railway** | ... | ... | ... | ... | ... | ... |
| **Merthyr** | ,, 19 | 178 | + 26 | 3 | 464 | + 23 |
| Metropolitan Dist. Railway | ,, 28 | 8,018 | + 518 | 4 | 32,561 | + 2,051 |
| ***Metropolitan Elec. Trams** | ,, 19 | 2,841 | + 1,111 | 3 | 7,463 | + 2,461 |
| **Middleton** | ,, 19 | 285 | + 45 | 3 | 758 | + 102 |
| **Nelson Corporation** | ,, 27 | 119 | + 21 | 44 | 5,770 | + 684 |
| **Newcastle-on-Tyne Corp.** | ,, 27 | 3,628 | + 75 | 43 | 164,197 | + 4,429 |
| **Newport (Mon.)** | ,, 27 | 523 | + 40 | 17 | 9,329 | + 695 |
| Northampton Corporation | ,, 26 | 888 | + 25 | 42 | 17,704 | + 5,084 |
| **Oldham, Ashton & Hyde** | ,, 19 | 516 | + 55 | 3 | 1,857 | + 92 |
| **Oldham Corporation** | ,, 28 | 1,556 | + 196 | 44 | 72,002 | + 17,126 |
| **Perth (W. A.) Elec. Trams** | ,, 26 | 1,518 | + 11 | ‡4 | 6,017 | + 233 |
| **Peterborough** | ,, 19 | 108 | + 14 | 3 | 270 | + 2 |
| **Pontypridd Dist. Council** | ,, 27 | 140 | ... | 43 | 6,934 | ... |
| Portsmouth Corporation | ,, 27 | 1,263 | + 69 | 43 | 84,676 | + 1,654 |
| **Potteries** | ,, 19 | 1,819 | + 814 | 3 | 2,716 | + 401 |
| Preston Corporation | ,, 24 | 556 | ... | 3 | 1,775 | ... |
| **Reading Corporation** | ... | ... | ... | ... | ... | ... |
| **Rotherham Corporation** | ,, 25 | 415 | + 54 | 43 | 19,689 | − 258 |
| **Rothesay** | ,, 19 | 40 | + 7 | 3 | 172 | + 81 |
| **Salford Corporation** | ,, 29 | 4,030 | + 230 | 44 | 187,652 | + 11,162 |
| **Sheerness** | ,, 17 | 52 | ... | 3 | 122 | − 9 |
| **Sheffield Corporation** | ,, 28 | 4,945 | + 551 | 44 | 217,684 | + 12,068 |
| **Southampton Corporation** | ,, 24 | 808 | − 7 | 16 | 14,453 | − 100 |
| **Southend Corporation** | ,, 24 | 246 | + 48 | 43 | 16,268 | + 1,000 |
| **Southport Tramways** | ,, 19 | 217 | + 31 | 3 | 662 | + 26 |
| **S. Staffordshire Trams.** | ,, 19 | 744 | + 173 | 3 | 2,031 | + 391 |
| **Stockport Corporation** | ... | ... | ... | ... | ... | ... |
| Sunderland Corpn. | ,, 28 | 1,225 | + 118 | 43 | 57,219 | + 2,006 |
| **Swansea Trams** | ,, 19 | 740 | + 320 | 3 | 1,972 | + 787 |
| Swindon Corporation | ,, 17 | 163 | + 21 | 43 | 8,875 | ... |
| | ,, 24 | 158 | ... | | | |
| Taunton | ,, 19 | 47 | + 5 | 3 | 180 | + 17 |
| **Tynemouth and District** | ,, 19 | 167 | + 17 | 3 | 446 | − 2 |
| **Tyneside Trams Co.** | ,, 17 | 314 | + 44 | ¶2 | 819 | − 6 |
| **Wallasey District Council** | ,, 27 | 672 | + 63 | 43 | 33,578 | + 1,401 |
| **Walsall** | ,, 27 | 467 | + 40 | 4 | 1,841 | + 151 |
| **Warrington Corporation** | ,, 25 | 329 | + 36 | 43 | 14,719 | + 928 |
| **West Ham Corporation** | ,, 25 | 1,814 | + 786 | 42 | 78,860 | + 33,954 |
| **Weston-super-Mare** | ,, 17 | 28 | − 3 | 3 | 64 | − 7 |
| Wolverhampton Corpn. | ,, 24 | 699 | ... | 3 | 2,282 | ... |
| **Wolverhampton District** | ,, 19 | 371 | + 85 | 3 | 951 | + 93 |
| ***Worcester** | ,, 19 | 255 | + 43 | 3 | 633 | + 55 |
| **Wrexham** | ,, 19 | 90 | + 10 | 3 | 235 | + 3 |
| Yorkshire W.R. Trams | ,, 28 | 722 | + 214 | 4 | 2,273 | + 839 |
| Yorkshire Woollen District | ,, 19 | 833 | + 316 | 3 | 2,147 | + 895 |

(a) These comparisons are with the corresponding period last year. † Minus 8 days. ‡ Minus 2 days. § Plus 2 days. ¶ Plus 8 days. * Partly electrical.

**BLACKPOOL & FLEETWOOD TRAMROAD CO.**—The directors recommend a dividend for the half-year ended Dec. 31 at the rate of 9 per cent. per annum; £150 is to be placed to depreciation reserve, £250 to general reserve, and £1,798 carried forward.

**BOURNEMOUTH & POOLE ELECTRICITY SUPPLY CO. (LTD.)**—The transfer books will be closed from Feb. 6 to 14 inclusive, preparatory to payment of dividends due on the 4½ per cent. preference and the 6 per cent. second preference shares for the half-year ended Dec. 31.

**BRITISH INSULATED & HELSBY CABLES (LTD.)**—Warrants for interest to Dec. 31 on the 6 per cent. cumulative preference shares have been posted.

**CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)**—During the five weeks ended Dec. 29, 1905, 291,367 units were delivered to consumers, compared with 225,932 units in the corresponding five weeks of the preceding year.

**CHARING CROSS, WEST END & CITY ELECTRICITY SUPPLY CO. (LTD.)**—At an extraordinary general meeting on Wednesday the company's electric power bill was approved.

**METROPOLITAN DISTRICT RAILWAY CO.**—The profit for the past half-year admits of a distribution on the 4 per cent. guaranteed stock at the rate of £1. 2s. 6d. per cent. per annum.

**SOUTH LONDON ELECTRIC SUPPLY CORPN. (LTD.)**—Subject to final audit, the directors recommend a dividend on the ordinary shares of 4 per cent. for the past year, with an increased carry forward.

**STOCK EXCHANGE NOTICES.**—The Stock Exchange Committee have appointed Feb. 7 a special settling day in 60,000 £10 (£4 paid) 6 per cent. cumulative preference shares and £600,000 4½ per cent. debenture stock of the *Bombay Electric Supply & Tramways Co. (Ltd.)*, and have ordered 15,000 £10 (fully paid) 6 per cent. cumulative preference shares of *J. G. White & Co. (Ltd.)* to be quoted.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Jan. 31. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Jan. 31. Highest. | Business, Week to Jan. 31. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | £ s. d. | | | |
| 5 | 3/0 | Anglo-Argentine Ord. Shares | 8⅝–8⅞ | 4 11 0 | Ap, Oct | 8¾ | .. |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5 13/16–6 1/16 | 4 9 0 | — | 6 | 5 15/16 |
| St. | 6% | Do. Permanent 6% Deb. Stock | 140 –143 | 4 3 6 | — | .. | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 104 –106 | 4 14 3 | — | .. | — |
| 5 | .. | Brisbane Electric Trams. Invest Ord. | 1 –1½ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 3⅞–4⅛ | 6 1 4 | — | 4 3/32 | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 103 –106 | 4 13 9 | — | .. | — |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 120 –123 | 4 17 6 | — | .. | .. |
| St. | 5% | Do. Pref. Ord. Stk | 110 –113 | 4 8 4 | — | 111¼ | 111 |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock | 108 –111 | 4 10 0 | — | .. | — |
| 40 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%–105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 101 –104 | 4 6 6 | — | .. | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | 1⅝–1⅞ | 5 3 0 | — | 1 11/16 | 1¾ |
| 5 | 3/0 | Do. 6 per Cent. "A" Cm. Pref | 5¾–6 | 5 0 0 | — | .. | .. |
| 5 | 3/0 | Do. "B" | 5¼–5¾ | 5 4 0 | — | .. | .. |
| St. | 5% | Do. 5 per Cent. Debs. | 105 –107 | 4 13 6 | — | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 101 –104 | 4 11 0 | — | .. | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 96 –98 | 5 2 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 100 –104 | 5 5 9 | .. | .. | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 100 –104 | 5 17 0 | .. | .. | .. |
| 5 | 8/6 | Calcutta Tramways (Nos. 1 to 105) | 9½–10 | 4 5 0 | — | 9⅞ | 9¾ |
| 5 | 7/6 | Do. Nos. 105,001 to 137,610 | 9 –9½ | .. | .. | 9 7/16 | 9 |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 104 –106 | 4 5 0 | — | 103¾ | .. |
| 1 | 0/6 | Cape Electric Tram Shares | ⅞–1⅛ | 4 8 10 | — | .. | — |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 102 –104 | 4 16 0 | — | .. | .. |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 97 –99% | .. | .. | — | .. |
| 1 | .. | Lisbon Elec. Trams Ord. | 1 7/16–1 9/16 | .. | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛–1⅜ | 4 7 4 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 100 –103 | 4 17 0 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 101 –103 | 4 17 0 | Ja, Jul | 102⅜ | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 102 –105 | 4 15 0 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 104 –106 | 4 5 6 | — | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 104 –107 | 4 13 6 | .. | .. | .. |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 146 –148 | 5 8 0 | .. | .. | .. |
| .. | 5% | Do. 5% 1st Mt. $100 Dbs. | 98%–100% | 5 0 0 | .. | 99¾ | 99½ |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 1 | — | Adelaide Elec. S'ply Co. 6% Cu. Pr. | 4¾–5¼ | — | .. | .. | .. |
| 5 | 3/3 | Calcutta Elec. (1-50,000) | 8¾–9¼ | 4 9 0 | — | 9 | 8⅞ |
| 10 | 1% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50 –52 | 4 16 0 | .. | 51¼ | .. |
| .. | 5% | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 94 –96 | 5 4 0 | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½–3 | .. | .. | .. | ... |
| St. | 5% | Do. 5% Debs. | 85 –90 | 5 10 0 | .. | .. | — |
| 10 | .. | Havana Electricity Co. Shares | 8½–9½ | .. | — | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92 –94 | 5 6 8 | — | .. | .. |
| St. | 26/2 | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. | 108 –110 | 5 10 0 | .. | — | .. |
| 1 | 5 3⅜d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞–1 | 6 0 0 | .. | .. | .. |
| 1 | 1/0 | Rand Electric | 1¼–1⅜ | .. | — | 1⅜ | 1⅜ |
| 1 | .. | River Plate Electricity Co. Ord. | [illegible] | .. | — | — | — |
| 1 | 1/2⅞ | Do. 6% Non. Cum. Pref | 1 1/16–1⅛ | .. | .. | 3/32 | .. |
| St. | 5% | Do. 5% Deb. Stock | 101 –103 | 4 17 0 | .. | .. | .. |
| 5 | 3/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5¼–5¾ | 5 4 4 | .. | .. | .. |
| 5 | 8 3d | Do. (12,001-20,000) | 5 –5½ | 8 8 0 | .. | .. | — |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100 –103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 5% | Shawinigan Water and Power 5% Bds., Scrip | 101 –103 | 4 17 0 | .. | 102½ | 102⅛ |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Shre. | Last Dividend | Name. | Price Wed., Jan. 31. | Rate % Yielded. £ s. d. | Dividend Due. | Business, Week to Jan. 31. Highest | Lowest |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12⅜–12⅞ | 5 9 6 | .. | .. | .. |
| 10 | 4/3 | Do. 4½ per Cent. Cum. Pref | 10¼–10¾ | 4 8 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11¼–12¼ | 4 18 0 | .. | – | – |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 105–107 | 4 4 0 | .. | .. | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼–5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 102–105 | 4 5 9 | – | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 8½–9½ | 5 5 0 | – | .. | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 8½–9½ | 3 14 5 | Mar, Sept | – | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 102–105 | 3 16 3 | – | 102½ | .. |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 5¾–6½ | 5 13 0 | Feb, Aug | .. | .. |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼–5¾ | 3 18 8 | Feb, Aug | 5 5/16 | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 101–103 | 3 17 6 | – | 101½ | .. |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4⅝–4⅞ | 4 12 6 | – | .. | .. |
| 5 | 2/3 | Do. Do. (1908) | 4⅝–4⅞ | 4 12 6 | .. | 4 21/32 | .. |
| 5 | 2/3 | Chelsea Electric Supply Ord. | 5–6 | 5 0 0 | March .. | 5 11/16 | 5 9/16 |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 108–110 | 4 1 6 | Jn, Dec .. | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 11–12 | 5 0 0 | Feb, Aug | 11⅝ | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13¼–14¼ | 4 4 2 | Jan, July | 13½ | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 122–126 | 3 19 4 | Jn, Dec .. | .. | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 100–102 | 4 8 3 | .. | 102 | 101 |
| 5 | .. | County of Durham Elec. P.D. Ord. £2pd. | 2 1/16–2 3/32 | .. | April, Oct | .. | .. |
| 5 | 5% | Do. Do. 5% non cum. pref. | 5¼–5 11/16 | 4 13 0 | April, Oct | .. | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 8½–9½ | 4 6 6 | – | 9 | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12½–13 | 4 12 3 | Mar, Sept | 12¾ | .. |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 109–112 | 4 0 4 | .. | .. | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 101–103 | 4 7 6 | .. | .. | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼–5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5–5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | † Do. 4½ 1st Deb. Stock (red.) | 101–104 | 4 6 6 | – | .. | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8¼–8¾ | 4 17 2 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100–103 | 4 7 5 | – | .. | – |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 1[illegible]½–1[illegible]½ | 5 4 0 | .. | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½–7 | 4 5 9 | Jan, July | – | – |
| St | 4% | † Do. 4 per Cent. Deb. Stock (red.) | 98–101 | 3 19 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101–103 | 3 17 8 | .. | .. | .. |
| 3 | 1/9⅜ | London Electric Supply Ord. | 1¾–2¼ | 4 0 0 | .. | 1⅞ | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 4¾–5¼ | 5 14 0 | – | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 98–101 | 3 19 2 | Mr, Jn, S, D | 100 | 99¾ |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 8¾–9¼ | 5 2 6 | April, Oct | 9½ | 9 |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5¼–5½ | 3 18 0 | Jan. July | 5 5/16 | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 107–111 | 4 1 0 | Jn, Dec .. | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 95–97 | 3 12 3 | – | .. | .. |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 100–102% | 4 8 0 | – | .. | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 11¾–12 | 5 13 8 | Feb, Aug | .. | .. |
| 100 | 4½% | † Do. 4½% Deb. | 101½–102½ | 4 7 8 | Jan, July | – | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8 1/16–8 3/16 | 4 18 6 | Feb, Aug | .. | .. |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6¼–6⅜ | 3 19 4 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99–101 | 3 19 7 | Jan, July | .. | .. |
| 1 | 3% | Northern Counties Elec. Sup. | 15/16–31/32 | 3 2 6 | Mar, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 101–102 | 4 7 6 | Jan, July | – | – |
| 10 | 6/0 | Notting Hill Electric Ord. | 13½–14½ | 4 16 8 | March .. | 14 | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98–100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅜–6⅞ | 5 1 6 | March .. | .. | .. |
| St. | 4% | Do. 4% Deb. Stock | 99–101 | 3 19 0 | – | .. | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 11¼–12¼ | 6 2 6 | Feb, Aug | 11⅝ | 11½ |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 7–8 | 4 7 0 | Feb, Aug | 7¼ | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 97–99 | 3 10 9 | – | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2–2½ | 8 0 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76–80 | 5 0 0 | – | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 3–3½ | 5 10 0 | .. | 3½ | .. |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | ¾–⅞ | – | .. | .. | .. |
| 1 | 0/8¾ | Do. 7% Cum. Pref. | 1 5/16–1 7/16 | 4 17 2 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105–108 | 4 3 3 | – | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4⅝–4⅞ | 5 2 6 | – | 4 13/16 | 4⅝ |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5–5¼ | 4 15 8 | – | 5 3/16 | .. |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 104–106 | 4 5 0 | .. | 104¾ | 104 |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 10½–11¼ | 6 1 0 | Mar, Sept | 11⅛ | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅜–5⅝ | 4 9 0 | .. | 5½ | .. |
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| 1 | – | Bath Elec. Trams Pref. Ord. | 15/16–1 | .. | .. | 15/16 | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16–1 1/16 | 4 14 9 | .. | 1 | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 103½–105½ | 4 5 0 | .. | – | .. |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 101–103 | 4 7 9 | .. | 102½ | .. |
| 10 | 9% | Bristol Tramways and Carriage Ord. | 17–17½ | 5 2 11 | Feb, Aug | – | .. |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10–10¼ | 3 18 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Debs. | 104–106 | 3 15 6 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 8⅛–8⅝ | 6 11 8 | – | 8 7/16 | 8⅛ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 10½–11 | 5 8 0 | Feb, Aug | 10¾ | 10 19/32 |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 119–121 | 4 2 8 | .. | 119⅞ | .. |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 98–100 | 4 10 0 | .. | 99½ | .. |
| St. | 4% | Central London Ordinary Stock | 95–97 | 4 2 6 | June, Dec | 96½ | 95 |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 104–106 | 3 15 4 | .. | 105 | 104½ |
| St. | 4% | Do. Deferred Stock | 86–89 | 4 10 0 | .. | 88½ | 88¼ |
| 100 | 4% | Do. 4 per Cent. Debs. | 110–112 | 3 11 3 | .. | .. | .. |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 5–5¼ | 4 16 0 | .. | 5¼ | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 101–104 | 3 17 0 | .. | .. | .. |
| St. | 2% | City and South London Rly. Con. Ord. | 42–44 | 4 5 3 | Feb, Aug | 43⅝ | 43 |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 120–123 | 4 1 4 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 117–120 | 4 3 4 | .. | .. | .. |
| St. | 5% | Do. (1901) | 115–118 | 4 4 8 | – | .. | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 106–109 | 3 13 4 | May, Nov | .. | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13¾–14¾ | 4 1 6 | .. | 14⅜ | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½–15½ | 3 17 3 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5–5½ | 7 5 6 | .. | 5 7/16 | .. |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8–9 | 4 8 11 | – | .. | .. |
| St. | 4½% | Hastings & Dist. Elec. Tram. Co. 4½ Db. St. | 102–104 | 4 6 6 | .. | .. | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 17–18 | 5 0 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 13¼–13¾ | 4 7 3 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 110–112 | 4 0 4 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼–2¾ | 9 8 6 | – | – | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 82–87 | 4 12 0 | – | – | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8¼–8¾ | 3 13 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾–10¼ | 4 15 3 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99–102 | 3 19 3 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 8¾–9¼ | 5 8 0 | – | .. | .. |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 97–100 | 4 0 0 | – | .. | .. |
| St. | .. | Mersey Con. Ord. Stock | 7–9 | – | – | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8–11 | – | – | .. | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32–9/32 | .. | – | ¼ | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1–1 1/16 | 4 14 1 | – | 1 | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104–106 | 4 5 0 | – | .. | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½–1½ | .. | May .. | – | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾–9¼ | 5 5 3 | .. | .. | .. |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9¾–10¼ | 4 17 6 | Feb, Aug | 9 3/16 | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103–106 | 4 5 0 | – | .. | .. |
| 100 | 5% | Sunderland Dst. Elc. Trms. 5% 1st Mt. Db. | 92–95 | 5 5 0 | .. | .. | .. |
| .. | 5% | Underground Elec. Rys. Co. of London | 98–99 | 5 1 0 | .. | 98¾ | .. |
| St. | 3% | Waterloo and City Ord. | 96–99 | 3 0 6 | June, Dec | 97 | .. |
| St. | 4½% | Yorkshire W.R. El. Trs. Co. 4½% 1st Debs. | 95–97 | 4 13 0 | .. | 96 | .. |

| Shre. | Last Dividend | Name. | Price Wed., Jan. 31. | Rate % Yielded. £ s. d. | Dividend Due. | Business, Week to Jan. 31. Highest | Lowest |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝–⅞ | 5 6 6 | – | .. | .. |
| 1 | 10⅛d. | Aron El. Met. 6% Cm. Pf. | ½–⅝ | .. | .. | .. | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 8¾–9 | 5 0 0 | .. | 8 13/16 | 8 11/16 |
| 1 | 7½d. | Do. Pref | 1 7/16–1 9/16 | 3 16 10 | .. | .. | .. |
| 5 | 4/0 | British Insulated & Helsby Cables Ord | 7–7½ | 5 6 8 | July, Feb | 7¼ | .. |
| 5 | 3/0 | † Do. 6 per Cent. Pref. | 5¾–6¼ | 4 16 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103–106 | 4 4 11 | .. | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98–100 | 4 10 0 | .. | .. | .. |
| 1 | .. | British Westinghouse 6% Pref. | 1¾–2¼ | .. | .. | 2⅛ | 2 3/32 |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 77–82 | 4 17 6 | .. | 80 | 79½ |
| 2 | .. | Brush Electrical Engineering | ⅜–⅝ | .. | March .. | .. | .. |
| 2 | 3/4½ | Do. 6 per Cent. Pref. Non-Cum. | 1¼–1¾ | 6 17 0 | Mar, Sept | 1 7/16 | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 99–101 | 4 9 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 82–84 | 5 7 4 | Jan, July | 83 | .. |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11–12 | 5 0 0 | Jan, July | 11 | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝–5⅞ | 4 5 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 108½–110½ | 4 1 3 | Nov, May | .. | .. |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1 1/16–1 3/16 | 5 1 0 | .. | .. | .. |
| St. | 4½% | † Do. 4½% 1st Mort. Deb. (red.) | 95–100 | 4 10 0 | – | .. | .. |
| 1 | 9⅜d. | Chadburn's (Ship) Telegraph Ord. | 1–1¼ | 8 0 0 | .. | .. | .. |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1 1/16–1 3/16 | 5 2 7 | .. | .. | .. |
| 3 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 1 13/16–2 1/16 | 3 9 6 | Jan, July | 2⅛ | 2 1/16 |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 96%–98% | 5 2 0 | Jan, July | .. | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8½–9 | 5 11 1 | Sept .. | .. | .. |
| 5 | 3/0 | Do. 6% Cum. Pref. | 5¾–6¼ | 4 18 0 | Sept .. | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104–106 | 4 5 0 | .. | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅜–1⅝ | – | Feb, Aug | 1 7/16 | 1 7/16 |
| 5 | 2/6 | Do. (£5 paid) | 2¼–2¾ | – | Feb, Aug | 2⅜ | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 86–88 | 4 11 0 | June, Dec | – | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92–97 | 5 3 1 | .. | .. | .. |
| 5 | 2/6 | Edmundson's Elec. Corp. Ord. | 4¾–5¼ | 6 13 4 | H'lf-yearly | 5 3/16 | 5 |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5⅛–5 5/16 | 5 16 6 | .. | 5 3/16 | 5 3/32 |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 104–106 | 4 5 0 | .. | 105¼ | 105 |
| 2 | 1/7½ | Electric Construction Co. | ½–¾ | 9 6 0 | July .. | – | .. |
| 2 | 2/9⅜ | Do. 7 per Cent. Cum. Pref | 2–2½ | 5 12 0 | July .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 90–93 | 4 6 0 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9¼–9¾ | 5 4 6 | .. | 9½ | 9 7/16 |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96–100 | 4 0 0 | .. | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 13–14 | 5 7 0 | Feb, Aug | 13 11/16 | 13½ |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼–5½ | 4 2 0 | Feb, Aug | 5⅜ | 5 5/16 |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | – | 4 1 1 | Feb, Aug | .. | .. |
| 10 | 15/0 | India Rubber, Gutta Percha, &c., Wrks. | 18½–19½ | 2 10 6 | Feb, Aug | 19 | 18½ |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99–102 | 3 18 5 | Mar, Sept | – | – |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¾–12¼ | 4 1 8 | Mar, Sept | .. | – |
| 1 | 1/3⅜ | Richardsons, Westgarth & Co., Ltd. Ord. | 31/32–1 1/32 | 5 17 0 | .. | 1 1/16 | .. |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1–1⅛ | 5 7 6 | .. | .. | .. |
| St. | 4½% | Do. 4½% Perp. Deb. Stock | 100–102 | 4 8 3 | .. | 101½ | 101¼ |
| 12 | 12/0 | Telegraph Construction & Mainten'ce. | 34½–36½ | 4 18 9 | Mar, July | 36 | 35 |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds. 1909 | 100–102 | 3 18 6 | Jan, July | .. | .. |
| 1 | 1/0 | Vickers, Sons & Maxim, Ltd., Ord. | 2⅝–2⅞ | 4 9 6 | .. | 2¾ | 2 11/16 |
| 1 | 6d. | Do. 5% Non-Cum. Preference | 1 3/16–1 5/16 | 3 16 0 | .. | 1 9/32 | .. |
| St. | 5% | Do. 5% Non-Cum. Preferred | 121–124 | 4 0 8 | – | .. | .. |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock Red. | 104–106 | 3 15 6 | .. | 105½ | 104½ |
| 100 | 4½% | Do. 4½% 2nd Mort. Debs., Red | 104–106 | 4 5 0 | – | .. | .. |
| 5 | – | Willans and Robinson Ord. | 2–2½ | – | Apr, Oct | .. | .. |
| 5 | – | Do. 6 per Cent. Cum. Pref. | 4–4½ | – | Apr, Oct | – | .. |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 82–87 | 4 12 0 | May Nov | .. | .. |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | *African Direct Tel. 4% Mrt. Deb. (red.) | 98½–101½ | 3 18 6 | Jan, July | – | .. |
| 10 | – | Amazon Telegraph | 3¾–4¼ | .. | Jn, Dec .. | .. | .. |
| 100 | 5% | Do. 5% Debs. (red.) | 83–88 | 5 18 6 | .. | .. | .. |
| St. | 15/0 | Anglo-American | 65–67 | 4 9 8 | F, My, Ag, N | 66½ | 65½ |
| St. | 30/0 | Do. Preferred | 114–115 | 5 0 0 | F, My, Ag, N | 114½ | 113½ |
| St. | 2/0 | Do. Deferred | 18¼–18½ | .. | F, My Ag, N | 18 7/16 | 17⅞ |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 97–99 | 4 1 0 | Jn Ap, Jy, O | 98¼ | 98 |
| 10 | 5/0 | Cuba Submarine Ord. | 8½–9 | 5 11 0 | Feb, Aug | 8 13/16 | 8¾ |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17–18 | 5 11 2 | Feb, Aug | 17¼ | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜–3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 9¼–9¾ | 5 14 0 | April, Oct | .. | .. |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 99%–102% | 4 8 0 | Jan, July | .. | .. |
| 20 | 8/6 | †Direct United States Cable. | 15–16 | 4 1 0 | Ja, Ap, Jy, O | 16⅜ | 15 |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 99–101 | 4 9 0 | Jn, Dec .. | .. | .. |
| St. | 25/0 | Eastern Ordinary | 148–151 | 4 12 8 | Ja, Ap, Jy, O | 150½ | 149 |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 91½–92½ | 3 15 0 | Ja, Ap, Jy, O | 91¾ | 92 |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 107½–109½ | 3 13 0 | May, Nov | 109 | 107 |
| 10 | 2/6 | Eastern Extension | 14½–15 | 4 13 4 | Ja, Ap, Jy, O | 14⅜ | 14 |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 107–109 | 3 13 4 | Feb, Aug | .. | .. |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb. 1909 | 101–103 | 3 18 3 | Feb, Aug | .. | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101%–103% | 3 18 3 | May, Nov | .. | .. |
| 10 | 5/0 | G. N. (of Copenhagen) with coupon 65 | 57½–59½ | 6 1 6 | Jan, July | 57⅞ | .. |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 99–101 | 4 7 6 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57–59 | 5 10 0 | May, Nov | 58½ | .. |
| 100 | $1 | Mackay Companies Common | 69 15/32 | 3 6 3 | Jan, July | – | .. |
| 100 | 4% | Do. Preference | 74 13/32 | 5 7 0 | Ja, Ap, Jy, O | .. | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1 7/16–1 9/16 | .. | .. | 1½ | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 99–102 | 3 18 6 | June, Dec | .. | .. |
| 10 | 4/0 | West African Telegraph Shares | 9½–10 | 5 0 0 | .. | .. | .. |
| 10 | – | West Coast of America | 9/16–11/16 | .. | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 99½–101½ | 3 18 9 | Jan, July | .. | .. |
| 10 | – | West India and Panama | ⅜–⅝ | .. | May, Nov | .. | .. |
| 10 | 6/0 | Do. 6% 1st Pref. | 8¼–8¾ | 6 6 8 | May, Nov | 8½ | .. |
| 10 | – | Do. 6 per Cent. 2nd Pref. | 6½–7½ | .. | May, Nov | .. | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 100–103 | 4 17 0 | Jan, July | .. | .. |
| 10 | 8/0 | Western Telegraph | 14¼–14¾ | 4 17 0 | Mr, Jn, O, D | 14⅝ | .. |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 100–102 | 4 18 0 | June, Dec | 102¼ | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 102–104 | 3 16 10 | .. | .. | .. |
| | | **TELEPHONES.** | | | | | |
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 102–104 | .. | .. | – | – |
| 5 | 3/0 | Chili Telephone (fully paid) | 7⅞–8⅛ | 4 18 6 | August .. | 8⅛ | 8 1/16 |
| 1 | 0/9⅜ | Monte Video Telephone Ord. | ⅞–1 | 4 0 0 | – | 15/16 | .. |
| 1 | 1/0 | Do. 6% Pref. | ⅞–1 | 5 0 0 | .. | .. | .. |
| St. | 6% | National Co. Pref. Stock | 113–114 | 5 5 2 | – | 113¾ | 113½ |
| St. | 5% | Do. Def. Stock | 110–112 | 4 8 8 | – | 111¼ | 111 |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13–15 | 4 0 0 | Feb, Aug | 13⅜ | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 11–13 | 4 12 4 | Feb, Aug | 12 3/16 | 12 |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅝–5⅞ | 4 5 2 | Feb, Aug | .. | .. |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 99½–101½ | 3 9 0 | June, Dec | 100½ | 99⅝ |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 104–106 | 3 15 6 | – | 104¾ | 104 |
| 1 | 0/7½ | Oriental | 1 5/16–1 7/16 | 4 11 0 | April, Oct | 1⅜ | .. |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1¼–1⅜ | 4 7 0 | – | – | .. |
| St. | 24/7⅔ | Do. 4% Red. Deb. Stock | 97–99 | 4 1 0 | .. | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 102–105 | 4 5 9 | .. | 103 | .. |
| 5 | 3/0 | United River Plate | 7¼–7½ | 5 6 8 | July .. | 7¼ | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5½–5¾ | 4 7 0 | June, Dec | .. | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 110–112 | 4 9 3 | June, Dec | .. | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 5–5½ | 5 9 0 | .. | .. | .. |
| 10 | 3/0 | †Globe Telegraph and Trust | 11⅛–11⅝ | 4 16 6 | Ja, Ap, Jy, O | 11⅜ | 11¼ |
| 10 | 3/0 | † Do. 6 per Cent. Pref | 14⅜–14⅞ | 4 0 6 | Ja, Ap, Jy, O | 14 11/16 | 14⅝ |
| 10 | 6% | Submarine Cables Trust (Cert.) | 127–130 | 4 12 0 | April, Oct | 127½ | – |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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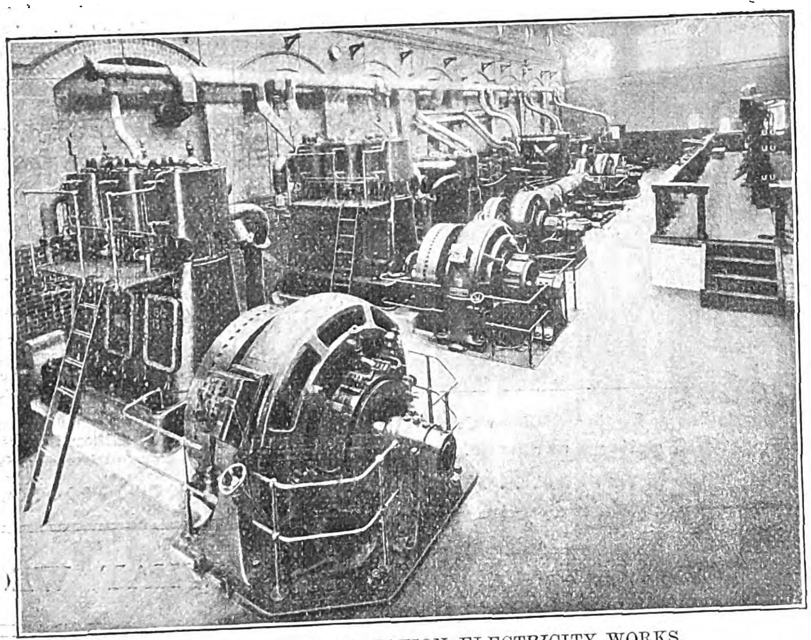

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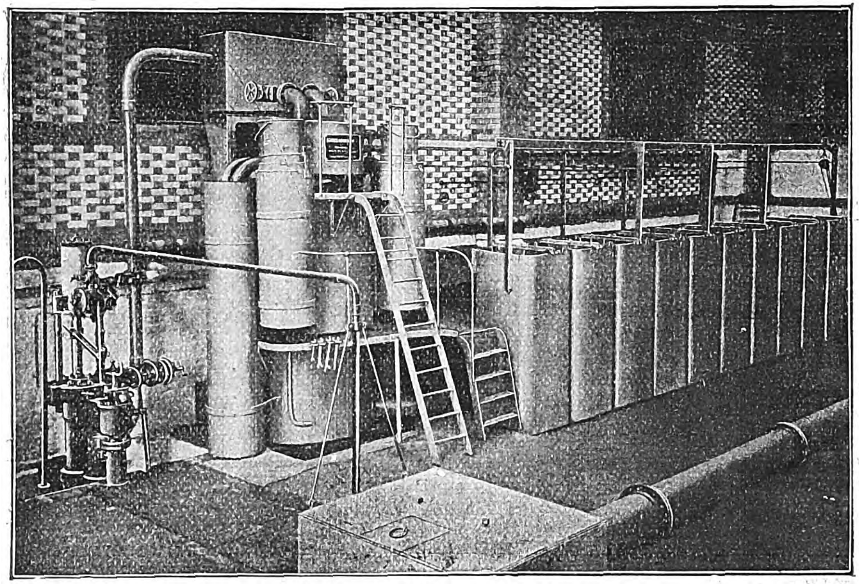
# No More COLLAPSED FURNACES or BUCKLED TUBES

## THROUGH GREASE
## IF YOU PURIFY THE CONDENSED WATER
## WITH THE "HARRIS-ANDERSON" PURIFIER.



" Harris-Anderson " Purifier, Pinkston Power Station, Glasgow Corporation Tramways.
Capacity, 22,000 gallons per hour.

Grease Absolutely Removed.
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Automatic and Simple Action.
Minimum Waste of Water.
Numerous Plants now at work in Electric Light and Power Stations, &c.

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**HARRIS PATENT FEED WATER FILTER, LTD.,**

82, Victoria St., Westminster; LONDON, S.W.
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Nat. Tel.: 876 WESTMINSTER.

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Telegrams: WINDTIGHT SUNDERLAND. Telephone 569

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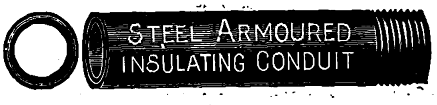
Telegrams: WINDTIGHT GREENOCK. Telephone 127.

◆ ◆ ◆

# NO MORE FIRES
## From Electric Wires.

Important to Electrical Engineers.

# IMPROVED ELECTRIC WIRING



**The only SAFE SYSTEM.**

ABSOLUTELY PREVENTS ALL DANGERS
Arising from the Fusing of Wires.

***FIRES FROM THIS SYSTEM HAVE NEVER OCCURRED.***

**In use at Car Sheds of British Tramways, Portsmouth Tramways, London United Tramways, Dublin Tramways, and Municipal Buildings at Glasgow, Newport, Cardiff, Brighton, &c.; also at Arundel Castle, British Museum, Eaton Hall, Woburn Abbey, &c.**

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WE DO NOT KNOW if it is the CHEAPEST, but you can easily ascertain this for yourself.

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## SALE BY AUCTION.

MESSRS. HORNE & CO., 8, Delahay-street, Storey's Gate, Westminster, S.W., will SELL by PUBLIC AUCTION, at the Royal Arsenal, Woolwich, on WEDNESDAY, 21st February, 1906, by order of the Secretary of State for War, at Eleven o'clock in the forenoon precisely, the following **UNSERVICEABLE and OBSOLETE STORES**, viz.:—2 tons Ashes (Founders'): 421 tons Iron, Wrought, Cast and Steel; 100 tons Brass (C.M.G., Miscellaneous, &c.): 6 tons Gunmetal; 5 tons Mixed Metal; 5 tons Lead; 28 cwts. Aluminium; 1½ tons Phosphor Bronze, Cupro Nickel and Lead, 32 tons Zinc Cylinders, &c.; 2 cwts. Tin, Pewter, Whitemetal; 80 Anchors; 450 Axletrees; 1,500 Cast Iron Fenders; Tinplate and Terneplate; 14 Lathes, Screw-cutting and Turning; 170 Scale Boards; Electrical Appliances; Telegraph Instruments; 10 Diving Helmets; 5,320 Glass Measures; Lamps and Lanterns; Varnish; Cork; Rope; Oakum; Jute; Horsehair; Dowlas; Canvas; 72 Canvas Hosepipes, 2 in. (New); Paper; Waterproof Sheeting and Bags; Webbing; Leather (Bands, Cuttings, Cases, Straps, Miscellaneous, &c.); 27 Bullion Bags; 10 Horse Drugs; 1 Truck Railway, B.G.; 61 Pairs Shafts; 200 Swingletrees; Boxes; Cases; Chests; Wood, &c., &c. The Lots may be viewed at the Royal Arsenal, Woolwich, from 10 to 1 o'clock and from 2 to 4:30 o'clock on the Monday and Tuesday previous to, and on the morning of the Sale. Catalogues may be obtained at the War Office, Pall Mall; at the Ordnance Office, Tower; and at the Ordnance Office, Royal Arsenal, Woolwich.

## SALE BY TENDER.

*Re* WILLIAM LESLIE In Bankruptcy.

**TO ELECTRICIANS, ELECTRICAL ENGINEERS, AND MOTOR MANUFACTURERS,**

FOR SALE BY TENDER, the well-assorted STOCK-IN-TRADE of ELECTRICAL and MOTOR FITTINGS, comprising Electric Lamps, Carbons, Cable, Pognon and "A D" Sparking Plugs, Telephones, Four Electric Motors, 40 and 60 amp. Accumulators, Tumbler and other Switches, Lampholders and Adapters, Rubber Strip, Insulating Tape, Large Motor Lamps and Generators, Electroliers, One Megger Testing Set, Flexible Wire, One "Pittlers" Lathe, Hand Shaping Machine, &c. On view February 12th, 1906, and following days. Forms of Tender, with an Inventory of the Goods and Order to View can be obtained of Messrs. HENRY W. FIGG & SON, Metal Trade and Machinery Valuers and Auctioneers, 128A, Queen Victoria-st., London, E.C.

## PLANT FOR SALE.

FOR SALE.

MORDEY-VICTORIA ALTERNATOR A 12. 75 kw. Rev. per minute 500. Complete with Direct-coupled Exciters. Groved pulley for eight ropes. Hand E.M.F. regulator. Spare armature coils, &c. Guaranteed in perfect working condition.

BRUSH SERIES DYNAMO, suitable for five 10 ampere lamps in series.

BRUSH SERIES DYNAMO, suitable for sixteen 10 ampere lamps in series.

ONE BRUSH-GEIPEL AUTOMATIC REGULATOR suitable for above.

ONE STATIC VOLTMETER reading to 1,500 volts.

EIGHTEEN 10 ampere BRUSH SERIES ARC LAMPS.

A QUANTITY of OLD CABLE. Hard Drawn Wire, &c.

For very low prices and full particulars of above apply to JOHN S. BROWN, Electrical Engineer, Swansea.

For MISCELLANEOUS PLANT, &c., FOR SALE see next page

Telegrams: Turnstile London.

**STANLEY**

GOLD MEDAL St. Louis, 1904.

**SURVEYING & DRAWING INSTRUMENTS.**

*NOTICE OF REMOVAL OF THE RETAIL DEPARTMENT*
from GREAT TURNSTILE to
**286, HIGH HOLBORN, LONDON, W.C.** Price List post free.

## CAUTION.

## ELECTRIC TRAM CARS.

### RADIAL TRUCKS.

AN ACTION has been commenced in the High Court of Justice, Chancery Division, by Messrs. LYCETT & CONATY, against Messrs. MOUNTAIN & GIBSON, LIMITED, to restrain them from infringing certain Letters Patent (15970 and 23948 of 1903) by Manufacturing and Selling Electrically Driven Tramcars in which the motors which drive the axles are so mounted as to have the same radial movement as the axles themselves.

TAKE NOTICE that all other persons infringing the said Letters Patent are liable to have proceedings taken against them also and to pay damages.

Dated this 31st day of January, 1906.

SYDNEY MORSE,
37, Norfolk-street, Strand, London, W.C.,
Solicitor for Messrs. Lycett & Conaty.

## NOTICE.

## ELECTRIC TRAM CARS.

### RADIAL TRUCKS.

WE HEREBY GIVE NOTICE that if any ACTION should be brought against any PURCHASER of our Radial Trucks by Messrs. Lycett & Conaty for alleged infringement of Letters Patent, we are prepared at our own expense to defend such action on the conduct thereof being handed over to us forthwith on the writ being issued,

MOUNTAIN & GIBSON, LIMITED,
Elton Fold Works, Bury, Lancs.

## TENDERS INVITED.

## MUNICIPAL COUNCIL OF SYDNEY, N.S.W.

ELECTRICITY DEPARTMENT.

The Council is prepared to receive TENDERS for the Supply and Erection of

A.—**BOILERS, AUTOMATIC STOKERS, PIPEWORK, &c.**

B.—**TURBO-ALTERNATOR, SUB-STATION MACHINERY, SWITCHBOARDS, &c.**

Specifications, plans and Form of Tender may be obtained on application to Mr. T. Rooke at the offices of Messrs. Preece & Cardew, 8, Queen Anne's-gate, Westminster, on and after Monday, 12th February. A deposit of Five Guineas will be required on application, which will be refunded on receipt of a bona fide Tender, as directed, and a cash deposit or marked cheque for the sum of £1,000 will be required when the Tender is sent in.

Sealed Tenders, endorsed "Tender for Electric Lighting Plant," are to be addressed to the Town Clerk, Town Hall, Sydney, and must be delivered at the Town Hall on or before 4 p.m. MONDAY, 7th May, 1906.

The Council does not bind itself to accept the lowest or any Tender.

(Signed) THOMAS H. NESBITT, Town Clerk.

TENDERS INVITED continued on next page.

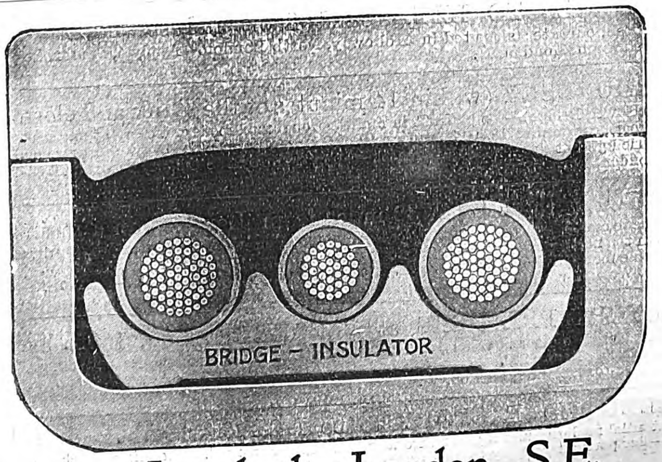
**GAMBRELL BROS.**
Durham House, North Side,
Clapham Common, London, S.W.

MANUFACTURERS of ELECTRICAL TESTING INSTRUMENTS.
CATALOGUE ON APPLICATION.

## DOULTON TROUGHING

AND BRIDGE-INSULATORS

**For SOLID SYSTEM CABLES.**



**This troughing is made of strong, hard-burnt glazed stoneware, with socket joints, in a variety of sizes, to take one or several cables.**

**The bridges are of a special admixture of clay, fired and enamelled at a high temperature, and not dependent upon the glaze for insulation.**

*FURTHER PARTICULARS & QUOTATIONS ON APPLICATION.*

Royal Doulton Potteries Lambeth, London, S.E.

# EVERSHED & VIGNOLES, LIMITED.

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*Makers of all kinds of ELECTRICAL INSTRUMENTS,*

**Acton Lane Works, CHISWICK, LONDON, W.**

## TENDERS INVITED—*continued.*

### COUNTY BOROUGH OF CROYDON.

CROYDON CORPORATION ELECTRIC TRAMWAYS.

**CAR-BODIES, TRUCKS, AND ELECTRICAL EQUIPMENT.**

NOTICE is hereby given that the Council are prepared to receive Alternative TENDERS for the Supply of FIFTEEN DOUBLE-DECK, DOUBLE and SINGLE-TRUCK CARS respectively, equipped complete with MOTORS, &c., for Overhead Trolley System.

Specifications, General Conditions of Contract, and Form of Tender can be obtained at the office of the Borough Electrical Engineer, Factory Lane, Croydon, upon payment of a deposit of two guineas, which will be returned on receipt of a bona fide Tender.

Sealed Tenders, addressed to me, must be delivered at my Office, at the Town Hall, Croydon, not later than 11 o'clock in the forenoon of MONDAY, the 19th day of February, 1906, endorsed "Tender for Electric Motor Cars."

Tenders will only be received subject to the draft Contract, and to the terms of the Specification and General and Special Conditions which have been deposited at my Office and may be inspected during office hours.

The Council will not be bound to accept the lowest or any Tender.

F. C. LLOYD, Town Clerk.

Town Hall, Croydon, February 8th, 1906.

### COUNTY BOROUGH OF LONDONDERRY.

The Council invite TENDERS for the Supply of the undermentioned **MATERIALS** for the Electric Supply Department for one year from 1st APRIL, 1906.

1. CARBONS.
2. METERS and DEMAND INDICATORS.
3. BITUMEN and BOX COMPOUND.
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Specifications and Tender Forms may be obtained from R. V. Macrory, Electrical Engineer, Strand-road, Londonderry.

Sealed and endorsed Tenders to be lodged with me not later than Noon on SATURDAY, the 3rd MARCH, 1906.

F. HENRY MILLER, Town Clerk.

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OFFER is made of a SITE, free of cost, of from two to 10 Acres, to engineers or manufacturers contemplating erection of works Site is FREEHOLD, and alongside main line of two of largest railways.—Address, for further particulars, OWEN B. THOMAS, Solicitor, 59, Chancery-lane, London.

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By order,
F. J. WALKER, General Manager and Secretary.

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## PATENTS, DESIGNS AND TRADE MARKS ACTS,

1883 TO 1902.

NOTICE is Hereby Given that FRANK MICHAEL LEWIS, of 11, Buckingham-road (formerly of 2, Prestonville-terrace), Brighton, in the County of Sussex, Electrical Engineer, seeks LEAVE to FURTHER AMEND the SPECIFICATION of LETTERS PATENT No. 4557 of 1903 granted to him for "IMPROVEMENTS IN OR CONNECTED WITH ELECTRIC ARC LAMPS."

Particulars of the proposed amendment were set forth in the *Illustrated Official Journal* (Patents), issued on the 31st January, 1906.

Any person, or persons, may give Notice of Opposition to the Amendment (on Form G), at the Patent Office, 25, Southampton-buildings, London, W.C., within one calendar month from the date of the said Journal.

(Signed) C. N. DALTON, Comptroller-General.

Address for service, care of J. C. Lorrain, Chartered Patent Agent, Norfolk House, Norfolk-street, London, W.C.

## APPOINTMENT VACANT.

### ARMSTRONG COLLEGE, NEWCASTLE-UPON-TYNE.

The Council will shortly proceed to the appointment of a **PROFESSOR OF ELECTRICAL ENGINEERING**. Stipend, £500 per annum and one-third of fees until £750 in all is reached. Candidates must send in four copies of their application and testimonials, not later than MARCH 1st, to the undersigned, from whom further particulars may be obtained.

F. H. PRUEN, Secretary.

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DEPARTMENT OF ENGINEERING.

The **LECTURESHIP IN ELECTRICAL ENGINEERING** is vacant; commencing salary £200 per annum. Full particulars of the duties of the appointment and Form of Application, may be obtained from Prof. G. F. Charnock at the College.

Applications to be sent in not later than 17th inst.

THO. GARBUTT, Secretary,
Bradford Education Committee.

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WANTED, by large electrical firm in the North, first-class ELECTRICAL DESIGNER. Must be fully conversant with latest practice for continuous-current and multiphase machinery. State full particulars and salary expected. Applications treated confidentially.—Reply, C. T. M., *Electrician* Offices, Salisbury-court, Fleet-street, London.

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SITUATIONS VACANT, &c., continued on next page.

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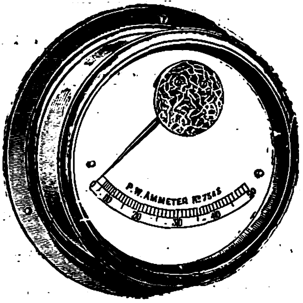

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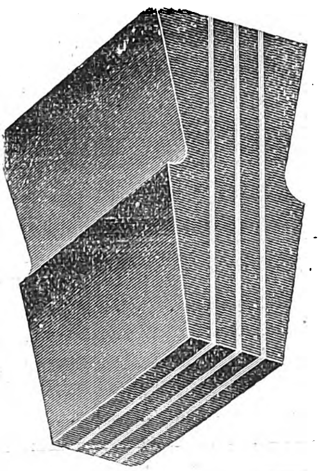

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# THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,447. [No. 17. Vol. LVI.] FRIDAY, FEBRUARY 9, 1906. PRICE SIXPENCE (by post, 6½d.), *Abroad 9d., or 18 cents, or 90c., or 80pf.*

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## NOTES.

◆

PROF. SILVANUS P. THOMPSON delivered an interesting Friday evening discourse at the Royal Institution last week, and demonstrated by an experiment on a large scale the ingenious process for the "fixation" of nitrogen devised by Prof. BIRKELAND and developed by him with the assistance of Herr EYDE. When this method was originally described at the St. Louis Congress, we expressed a desire for some figures of cost before publishing our opinion upon it as a commercial process, and these are now supplied by Prof. THOMPSON. There can now be little doubt that the Birkeland and Eyde system has now become of considerable industrial importance, and that if Sir WILLIAM CROOKES' gloomy prophesies are correct, these energetic workers in Norway will have done much to delay the bread famine with which our veteran chemist has threatened our descendants.

WE publish on another page a series of tests which have been sent us by those interested in a new metallic-filament incandescent lamp due to Dr. HANS KUZEL, of Vienna. These results, which report an efficiency in the neighbourhood of 1 watt per candle for a life of 1,000 hours and more, are certainly worth recording. So far, makers of other metallic-filament lamps have not claimed such a good efficiency as this; the low-voltage osmium lamp is rated at about 1½ watts per candle and the 100 volt tantalum lamp at about 1¾. Still, no comparisons or definite conclusions can be drawn from the limited information now furnished to us, as important data have been omitted. We are not told whether the candle-powers are mean spherical or mean hemispherical candle-powers or are merely measured in the direction of their maxima. If the tests were made under the last-mentioned condition they are of little value without a curve showing the distribution of the light, as nothing is told us of the shape of the lamp or the form of the filament. As in other metallic-filament lamps, a difficulty has been experienced in making filaments of sufficiently high resistance to suit them for the distribution voltages now in vogue in this country; it is announced, however, that 110 volt lamps can be obtained, although the tests relate to lower voltages. The progress of the lamp will be watched with interest, and if the additional data, when it is furnished, is of a satisfactory nature there is no doubt that Dr. KUZEL'S invention has a future before it. These additional data must be forthcoming, however, before any definite opinion can be expressed as to the merits of the new lamp.

◆

THE method of manufacturing the filament of the new lamp is presumably that described in Dr. H. KUZEL'S English patent No. 28,154 of 1904. It is stated in the patent that the process is applicable to refractible metals, such as platinum, chromium, manganese, molybdenum, uranium, tungsten, vanadium, tantalum, niobium, &c. Briefly, it is as follows: The metal is reduced to a colloidal state by a process such as that of BREDIG, in which an electric arc is produced under water between a pair of rough electrodes of the metal in question. Dr. KUZEL recovers this finely-divided metal and forms filaments by forcing it through a die. The filaments are dried at a temperature of 60°C. to 80°C. for 5 or 10 minutes, when they become conductive, but they lose their conductivity again on cooling. To restore the conductivity they are placed in vessels which have either been evacuated or contain only inert gases such as hydrogen, and are first heated to 60°C. or 80°C. to render them conductive and then raised to white heat by an electric current. This, it is stated, restores them to a crystalline state and at the same time diminishes their diameter as well as their specific resistance, and the filaments are then ready for use.

THE keen and interesting discussion which took place in connection with Mr. P. ROSLING'S recent Paper on the "Rectification of Alternating Currents," an abstract of which appears on p. 677 of this issue, is an indication that there is a real demand for a rectifier without moving parts, provided such a device be reasonably reliable and efficient. In this respect considerable progress seems to have been made in the three years that have elapsed since the test of an electrolytic rectifier referred to by Mr. WILKINSON. Even then the efficiency was as high as 60 per cent., which is about the order of the efficiency of the small motor-generators frequently employed for charging motor-car cells. Mr. CHURTON, it is true, averred that a ½ kw. motor generator set which he had tested had an efficiency of nearly 70 per cent.—69·5 per cent., to be exact—but we agree with Mr. ROSLING that this is quite an exceptional efficiency for so small a set. Mr. WILKINSON'S failure appears to have been mainly due to his attempt to work the rectifier continuously. The electrolytic rectifier could not stand this owing to the excessive increase in temperature, but we believe that water cooling has been successfully tried to keep the temperature down.

THE mercury-vapour rectifier is, however, the more promising of the two types. It has no acids to be replenished, is lighter, and can be designed for very high voltages—indeed, its efficiency increases with the pressure, and amounted to 90 per cent. in an actual case when it was supplying 4 amperes continuous current at 4,260 volts. But it also gives good results on moderate and low pressures. Mr. ROSLING mentions an efficiency of 75 per cent. for a rectifier giving 30 amperes at 80 volts continuous when fed with alternating current at 220 volts. Unfortunately, this type of rectifier has not yet been made for higher currents than 30 amperes, owing to considerations of temperature, but there are numerous cases in which a larger current than that named is not required. It is noteworthy that the price of the mercury rectifier depends almost entirely on the current and not on the voltage, so that its price per kilowatt practically varies inversely as the voltage used. A 30-ampere rectifier when supplying current at 100 volts, for instance, would cost between £16 and £17 per kilowatt, but if used to give current at 200 volts the capital cost per kilowatt would be little more than £8 per kilowatt. If the voltage is low the rectifier may cost a little more than a motor-generator of the same output, but for higher voltages it is cheaper.

AN important decision was given by Mr. Justice FARWELL on Monday with regard to an action brought against the Manchester Corporation by the Attorney-General at the instance of a firm of carriers. The Manchester Corporation have powers to carry parcels on their tramways, and the contention was that they were exceeding their powers in this respect by collecting and delivering parcels by means of road vans and by undertaking to convey parcels from Manchester to all parts of the United Kingdom and abroad, and to act as agents for all railway companies. The judgment is of a highly legal-technical nature, but, briefly, it may be said to limit the extent of this business to collecting and delivering parcels (by road vans if necessary) for conveyance by the tramways. It is laid down that to collect and deliver parcels outside the radius of the trams and without any connection with the trams is not incidental to the authorised tramway business, while on the other hand such collection and delivery for the tramway is incidental. If the general delivery service and the general railway agency involves additional expense it is *ultra vires*. Finally, the judge is of the opinion that the action was "properly brought," and the Manchester Corporation have to pay half the plaintiff's costs in addition to their own. We report the judgment at length in another column.

**Electric Furnaces at the Krupp Works.**—It is stated by the *Elektrotechnischer Anzeiger* that the Friedrich Krupp Company at Essen has decided to introduce the Kjellin type of electric furnace for producing, during daytime, considerable quantities of ordinary and special steel. A description of the Kjellin type of furnace will be found in *The Electrician*, Vol. LIV., p. 877.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| **Tarifa—Tangier** | **Jan. 18, 1904** |
| **Jamaica—Colon** | **Jan. 10, 1905** |
| **Cadiz—Teneriffe** | **July 20, 1905** |
| **Puerto Plata—Martinique** | **Dec. 15, 1905** |
| **Bolama—Bissao** | **Jan. 19, 1906** |
| **Vladivostock—Nagasaki** | **Feb. 7, 1906** |

**Personal.**—Sir Alexander B. W. Kennedy, F.R.S., has been elected a member of the Athenæum Club under the provisions of the rule which empowers the committee to elect in each year three persons "of distinguished eminence in science, literature, the arts or for public services."

On Tuesday Mr. John C. Denison-Pender, elder son of Sir John Denison-Pender, K.C.M.G., was married to Miss Irene de la Rue, only daughter of Mr. Ernest de la Rue.

**The Measurement of High-frequency Currents and Electric Waves.**—Prof. Fleming sends us the following corrections which he desires to make in his second Cantor lecture published in our last issue: P. 640, left-hand column, under Fig. 20, *for* Reiss *read* Riess. Same column, tenth line from bottom, *for* $M = \frac{4,606 \times \delta}{2\delta}$ *read* $M = \frac{4{\cdot}606 \times \delta}{2\delta}$. P. 640, right-hand column, line 1, *for* 390 amperes, *read* 420 amperes. Same column, line 3, *for* $M = 24$, *read* $M = 12$. P. 641, right-hand column, line 21, *for* —amperes, *read* 10 amperes. P. 639, left-hand column, *for* $\epsilon\delta = I_1/I_2$, *read* $\epsilon^\delta = I_1/I_2 =$ &c.

**Artificial Graphite.**—It is announced that a great increase has taken place in the manufacture of artificial graphite by the International Acheson Graphite Co. at Niagara. In 1897 the quantity manufactured was 81 tons, in 1900 400 tons, and in 1904 1,333 tons. The quantity enquired for was, however, 1,625 tons, and as a consequence the company have fitted up a new 1,500 kw. plant, so that they are now in a position to manufacture 2,666 tons in the year. Artificial graphite finds ready employment in the manufacture of dry batteries and as a lubricant; also, owing to its splendid conductivity, which is higher than that of natural graphite, and to its resistance to oxidation employment as electrodes.

**Private Bills in Parliament.**—No private bills have been examined for compliance with Standing Orders during the week, but a number of postponements have been made in respect of some opposed measures. The consideration of these has been fixed for February 15th and subsequent dates, and specially interesting proceedings, it is expected, will take place in connection with the memorials against the two bills by companies proposing the construction of electric tramways in Folkestone, Sandgate and Hythe. It will be remembered that one of these bills is promoted by the British Electric Traction Co. and the other by the National Electric Construction Co., and we had something to say in reference to this matter in the Editorial Notes in our issue for January 5th.

**Improvement in Conduit Tramways for Narrow Streets.**—In the English patent No. 3,009 of 1905, Messrs. A. L. C. Fell and J. H. Rider describe arrangements of laying a conduit tramway system in narrow streets with interlaced tracks, so as to avoid movable points in both track and slot rails, as well as all discontinuities in the conductor bars. The inner track rail serves also as a slot rail, and the arrangement is such that the plough of the up-car travels in the slot rail which forms the running rail of the down track, and vice versa. Claim 1 reads as follows: "In electric tramways constructed on the conduit system, interlacing the track and slot rails in such a manner that the slot rail used by the plough of a car passing in either direction is used as the track rail for a car passing in the other direction. . . ."

**Dinner.**—On Saturday last the 12th annual dinner and smoking concert attended by a large section of the submarine cable companies' London staffs was held. On this occasion the arrangements had been left in the hands of the Direct United States Cable Co.'s Mark-lane staff, who received the cordial support of the other leading companies. Mr. F. J. Williams (Direct United States) occupied the chair, and Mr. G. J. Hodson (Commercial) was in the vice-chair, over 100 guests being present. An interesting feature of the evening was the receipt of a number of congratulatory messages from colleagues scattered over various parts of the world, including Japan, Siberia, China, United States, Canada and France, and from friends nearer home at cable stations in the United Kingdom. A proposal brought forward at last year's gathering advocating the formation of a cable companies' literary, social and sports club was again referred to, and it is probable that a practical move in that direction will shortly be made.

**Map of Metropolitan Improvements.**—Stanford's new map of metropolitan railways, tramways and miscellaneous improvements has just been issued. The raison d'être of this map is to show in a graphic form all the proposals for the coming Parliamentary session in so far as they relate to railways, tramways, electric supply and other improvements, and in this Mr. Stanford has succeeded admirably. The dividing up of the map into two sheets, found necessary last year owing to the increasing number of tramways, tube railways, &c., has been adhered to, the scale being 3 in. to the mile. With regard to the electric power supply bills for the 1906 session, the map does not indicate the areas of each, but only the lands scheduled by the various promoters, and in the case of the Additional Electric Power Supply Bill the routes of its proposed overhead mains alongside the Lea Navigation and the Regent's Canal. In addition, of course, borough boundaries are shown, as well as railways and tramways in operation and sanctioned, &c. The sheets each measure 60 in. by 40 in., and the price of the two is 10s. 6d.

**Extension of the German Telephone System.**—According to the *Elektrotechnishe Zeitschrift*, 20 new local telephone exchange systems are to be erected by the German postal authorities during 1906 and connected up to the general long-distance network. Considerable extensions of the trunk lines are also to be carried out, not merely to connect these new exchanges to the trunk system of the country, but also in order to provide new routes and to relieve the congestion on some of the existing trunk lines. The number of new trunk circuits is to be 1,198 (627 overhead and 571 underground), and the total length of new wire will be 40,200 miles. Some 1,450 miles of conductor is to have a diameter of 5 mm. (0·197 in.), about 5,220 miles, a diameter of 4·5 mm. (0·177 in.), about 11,700 miles a diameter of 4 mm. (0·157 in.), about 17,720 miles of wire a diameter of 3 mm. (0·118 in.) and some 4,070 miles, finally, a diameter of 2 mm. (0·079 in.). A few of the lines will be of hard-drawn copper, but by far the larger portion is of bronze. In the budget for 1906 £12,500 are set down for the 20 new exchange systems and £750,000 on the trunk system.

**New Shallow-tunnel Railway in Berlin.**—According to *Elektrotechnischer Anzeiger*, a company has received from the Berlin authorities a concession (which will expire on November 5, 1987) to construct and work a new combined underground and overhead railway in the German capital. The first portion of the railway, which must be completed by 1907, is to extend underground from the Potsdamerplatz, and via the Leipzigerplatz, Wilhelmsplatz and Gendarmenmarkt to the Spittelmarkt. The continuation from this point under the River Spree to the Alexanderplatz is to be built by the end of 1912. From Alexanderplatz the railway is to be underground as far as the Fransecki-strasse, and will then, rising above ground, be continued to the boundary of Berlin (near the Stolpeschestrasse) as an overhead line. This third section is to be ready for service by 1915. At one point this third section will have to cross above the existing Ringbahn. The company has to pay to the city of Berlin 2 per cent. of the gross receipts as long as these do not exceed one million marks per route-kilometre (£80,600 per route-mile), and 2¼ per cent. if the gross receipts range from 1 to 1½ million marks per route-kilometre (£80,600 to £121,000 per route-mile), and more, according to an agreed scale, when the gross receipts exceed 1½ million marks per route-kilometre. In addition, half of the net profit of the overhead section beyond 6 per cent. of the capital expenditure is to be paid to the city.

**Automatic Starting Resistance for Motors.**—According to the *Western Electrician*, Mr. Charles P. Steinmetz has patented an automatic rheostat, which embodies in its construction the use of a material which has high initial resistance, but becomes more and more conductive as the temperature is increased, the resistance finally becoming so small as to enable the material to pass the full current to the motor with a practically negligible ohmic drop through the resistance. Among the various substances which are conductive at ordinary temperatures, and become more conductive as the temperature increases, Mr. Steinmetz has found that the tetroxide of iron or magnetite is especially suitable for the purpose, or a mixture of magnetite and chromite of iron, the latter having a higher initial resistance than the former, but being equally conductive at high temperatures, may be used. These substances are chemically stable and structurally solid even at a red heat, while the resistance of magnetite is about 100 times less at red heat than at ordinary temperatures. By mixing with it the chromite of iron the initial resistance can be made even higher. The self-reducing resistance is simply a stick of magnetite or other material having the characteristics above specified suitably mounted in series with the armature of the motor. The length of time required to reach this point depends upon the size of the stick and the voltage to which it is subjected.

**Electric Train Lighting in India.**—A recent number of *Indian Engineering* contains some comments on a report issued a few months ago by Mr. Shadbolt, the director of railway construction in India, on electric train lighting on some of the Indian railways. The report only deals with the Stone system as used on the Jodhpur–Bikanir Railway, and with the Independent Storage system as used on the Rajputana–Malwa Railway. Our contemporary points out, however, that these records only refer to 270 out of the 485 coaches to which electric lighting has been applied on the railways of India. The narrow (metre) gauge of the Jodhpur–Bikanir Railway necessitates some modifications in the Stone system as usually employed in England. Only two dynamos are provided on the train instead of each coach being treated as a complete independent unit. Even with the reduction in the number of belts, however, about 9 per cent. of the cost of working is due to belt renewals, owing to the action of the compensating slip of the belts. Of the other costs of working, amounting to some 900Rs. per train with 46 5 c.p. lamps, about one-half is devoted to the inspection and running staff, for a lighting inspector is carried on each train. The total cost per lamp-hour is, however, considerably less than for the oil lamps previously employed. The other system described in which the batteries are removed and charged at special stations, has given satisfaction since the adoption of open-type cells with removable vulcanite lids in place of hermetically-sealed batteries, notwithstanding the usual difficulties due to vibration, but the figures show a higher cost per lamp-hour than the Stone system.

**Society of Engineers.**—At the first ordinary meeting of the Society of Engineers for the present year, held on February 5th at the Royal United Service Institution, Whitehall, Mr. N. J. West, the president for 1905, first distributed the premiums awarded for Papers read during 1905, and then introduced the president for the present year, Mr. Maurice Wilson. The new president then delivered his inaugural address. After referring to the healthy state of the society in all connections, he passed in review some of the notable engineering achievements of 1905, alluding to the bridge over the Victoria Falls in Rhodesia, the boring of the Simplon Tunnel, the new and enormous dock at Salford in connection with the Manchester Ship Canal, and concluded this part of his address with a reference to the electrification of the Metropolitan & District Railway. Mr. Wilson then dwelt at length upon the question of education, laying much stress upon a sound and common-sense mathematical training of students combined with a practical training, so that the would-be engineer learned to appreciate the value of, and take an interest in, his mathematical studies. The speaker was of the opinion that masters had at present too many pupils to look after, and he suggested that no master should have more than 15 to 20 boys to teach at a time. The Institution of Civil Engineers was moving in the matter, and this movement should be cordially supported by all engineers. The president concluded his address with a reference to Mr. George Burt's resignation of the office of hon. secretary and treasurer to the society. He was pleased to be able to state that Mr. D. B. Butler, a past president of the society, had been unanimously elected as the new hon. secretary and treasurer.

**Progress in Electric Lighting.**—A Paper on this subject was read by Mr. Leon Gaster before the Society of Arts last Wednesday evening, Sir William Preece, K.C.B., F.R.S., in the chair. After a brief introduction, the author described a modern lamp factory, illustrating his remarks with photographs of the Robertson works thrown on the screen. The importance of a constant supply voltage to consumers was then dwelt upon at length, and supply undertakers were recommended to calculate the most economical efficiency, taking into account the life of the lamps and the cost of electrical energy, and then to give free lamp renewals, and so sell light rather than current. The speaker advocated the adoption of a standard specification, as is already proposed by the Engineering Standards Committee, and referred to the need of a new standard unit of light with reliable and convenient secondary standards. In the second part of his Paper he described the structure, peculiarities and possibilities of a large number of electric incandescent lamps, arc lamps and vapour lamps, and he had on view a representative collection. These exhibits, most of which were shown in operation, included two novelties not yet on the British market—viz., a 110 volt osmium lamp and a zirconium lamp. The latter is claimed to consume only 1 watt per candle-power, and is at present designed for 37 volts. In the discussion which followed the Paper, Dr. R. T. Glazebrook mentioned that he had been engaged for the last two months in considering a standard specification for incandescent lamps, and hoped that the result would be made public before very long. The 10 c.p. pentane lamp was a good standard of light for laboratory work, but was not well suited to ordinary use. Researches in the direction of evolving a satisfactory secondary standard were now being made, however, at the National Physical Laboratory. After a few words by Sir William Preece, who pointed out that the reduction in the price of electric energy had gone hand in hand with the increase in lamp efficiency, the meeting terminated.

**The Recent Tramway Accident at Liverpool.**—A Board of Trade inquiry was held by Col. von Donop on February 1st to investigate the causes of the accident on the Liverpool electric tramway system on January 22nd. Evidence was given by the driver of the car, who stated that he started to descend the slope as usual by switching off the line current and using the electric brake. He had tested the electric brake on leaving the car shed and found it satisfactory. Some surprise was caused by his assertion that the circuit-breaker on the car came out, even after he had cut off the line current which passed through it, and when he was on the second brake notch of the controller. As the electric brake failed to check the progress of the car after he had got about 10 yds. down the hill, he was unable to pull up at the "compulsory" stopping place about the middle of the slope. He also tried putting the canopy switch in again and reversing the controller, but this also failed, so he tightened the hand brake as much as possible to steady the car. In rounding the curve, however, it left the rails and overturned, having reached a speed of about 15 or 17 miles per hour. The rails were in good condition, and he applied sand constantly while descending the hill. According to his statement, the same car had failed in a similar way about six weeks previously. The conductor expressed the opinion that if the passengers had kept their seats the car would not have overturned. Further evidence was given by the assistant engineer to the tramways department, who stated that he had examined the car after it fell and found the hand brake hard on, but the gear was not in position for reversing and the electric brake was not in position. The chief motor inspector at the depot to which the car was removed after the accident said that, when he had tried the electric brake, it had worked very effectively. Other evidence was also given to the effect that the car was in perfect condition after the accident. In the course of the inquiry Col. von Donop pointed out that drivers had been descending this gradient continually since 1900 without difficulty, and that there were many far worse hills constantly traversed by tramcars in different parts of the country. The official report of the inquiry will be published in due course.

**Electric Winding.**—Mr. W. C. Mountain read a Paper on "Electric Winding, considered Practically and Commercially," before the Manchester Section of the Institution of Electrical Engineers on January 16th. The first part of the Paper contained detailed descriptions of the three-phase installation at the "Preussen" colliery near Dortmund, which was equipped by the Allgemeine Elektricitäts-Gesellschaft, and of a continuous-current plant installed by the Siemens & Halske Co. at "Zollern II." colliery, also in Germany. A description of the former will be found in *The Electrician*, Vol. LIV., p. 582. In the second part of his Paper, Mr. Mountain discussed electric versus steam winding from the economical point of view. A number of tables were given containing the actual costs—under various headings—relating to steam-operated winding plant, and further tables were given in which the estimated figures concerning electrically-equipped collieries for different outputs were tabulated. In all cases the total costs (including capital costs) were higher for electric than for steam operation. Mention was made here of the actual working costs obtaining at the Grand Hornu New Mine, Belgium (see *The Electrician*, Vol. LV., pp. 666 and 712), but since the capital costs were not available in this case, the total costs had again to be estimated. The conclusions, so far, referred to collieries only which generate their own current, and Mr. Mountain remarked that, in the case of electric power being bought from a company, there was a possibility of electricity competing successfully with steam for winding purposes. Whether the author's conclusions are all correct or not we do not intend to discuss here, but we willingly endorse his last remark, especially when applied to collieries in which current is also put to other uses below and above pit surface. We may here recall the case of the Cambrian Collieries, who effected an annual saving of no less than £1,900 by giving up their steam-driven plant and replacing it by electrical machinery supplied with current from the mains of the South Wales Electrical Power Distribution Co. (*The Electrician*, Vol. LIV., p. 263):—

In opening the discussion, Mr. S. L. Pearce, who occupied the chair, hoped that the colliery managers and engineers present might be able to put electrical winding in a more favourable light. Mr. T. L. Hiller, after referring to the saving which could be effected by working a Rateau turbine with the exhaust steam from the main engine, remarked that there was something to be said in favour of centralisation where a number of small collieries were concerned. Mr. Braun, of the British Westinghouse Co., explained the technical details of the converter-equaliser made by his firm for smoothing out the peaks of the load curve. He defended the friction (Koepe) pulley, and stated that in Germany the ropes were tested every two years by Government officials, and that frequently no deterioration could be detected. There was no danger of smashing the pit-head gear through overwinding. Mr. J. H. Chiicote Brooking said that if electrical engineers had taken such a pessimistic view of electric lighting in its early days as the author had done with regard to electric winding the electric industry would not be in the proud position it was to-day. Mr. F. Walker was in favour of doing away with the heavy winding drum, and suggested a rack up the pit shaft and a motor within the cage itself. Mr. Mountain, replying to the discussion, said that storage batteries had not proved a solution of the problem, being worn out in less than nine months. A balance rope was economical. He did not believe in the friction pulley, for if the rope broke both cages fell. He had never come across a colliery manager in this country who would allow a friction pulley.

**High-speed Electrical Machinery.**—Professor Silvanus P. Thompson concluded his series of Howard lectures on the above subject on Thursday, February 1st, at the Society of Arts, and dealt with the design of alternators for steam turbine driving. The main point where "turbo" alternators differed from the slower speed type was the much higher peripheral velocity necessitated by the impossibility of sufficiently keeping down the rotor diameter. This causes the pole pitch to be greater than in the slow machines, and entails various modifications in design, such as a considerable increase of stator core depth. The most important differences, however, are due to the enormous figures attained by the centrifugal force, which render special methods of construction necessary to obtain the required strength and avoid all possibility of shifting of parts, which might upset the balance of the rotating mass. The greater pole pitch also lengthens the end bends of the stator windings, which have to be arranged in special ways, additional precautions being required on account of the greater stray field due to the increased air-gap, which is apt to cause idle currents in the end bends; thus the end bends have to be bent well out of the way, and are usually securely clamped in place. Fine windings cannot be used on the rotor coils, so that low excitation voltages down to 10 or even 5 volts become in some cases necessary. After referring to these and other points of difference between the conditions of high-speed and low-speed practice, the lecturer threw on the screen a fine series of illustrations of actual machines and parts of machines, commenting on the different methods adopted by the various designers to overcome the difficulties which he had indicated. Starting off for the sake of comparison with some views of large slow-speed machines, including the 5,000 kw. alternator at Manhattan, the lecturer remarked how the difficulties of paralleling, which used to occur with slow-speed machines, had entirely disappeared with the advent of the steam turbine. He then showed some of the early revolving armature turbo-machines of Parsons. This arrangement soon, however, gave place to the now universal revolving field type, a fine example of which was found in the 5,000 kw. Parsons turbo-alternators in the Carville power house of the Newcastle Power Co. A number of Brown Boveri machines, varying in size up to 6,000 kw., illustrate the manner in which the field windings are embedded in slots cut in the periphery of the solid steel forging forming the rotor. Great care was taken with these machines in the clamping of the armature end bends and, in most cases baffle plates are employed to direct the course of the incoming air for ventilation with a "chimney" at the top for the outgoing air. Another type in which the field windings were contained in slots cut in a solid steel rotor was the Westinghouse turbo-alternator, although the slots in this case were arranged in the sides of the pole-pieces instead of entirely on the periphery. This type is a development of the early designs of Lamme. Ventilating ducts are also milled out of the solid rotor. Reference was made to the vertical shaft machines of the General Electric Co. (U.S.A.) and British Thomson-Houston Co. for coupling to Curtis turbines, and it was pointed out that the ventilation current of air was in the opposite direction from most machines, being directed downwards in order to prevent the entry of steam due to any slight leakage, as the generator is situated directly above the turbine. A full description of these machines will be found in Mr. Meyer's recent article in our columns (*The Electrician*, January 12, 1906, p. 498). Further illustrations were given of the Oerlikon Companies machines, in which the pole pieces are dovetailed in, the American Bullock machine, very similar to the European types, and some machines of the Allgemeine Elektricitäts Gesellschaft, in which the outer housing is almost absent, the back of the core itself being exposed for cooling. The turbo-alternators of the Siemens-Schuckert Co. were of the type identified with the latest Continental practice, but in this country Messrs. Dick, Kerr & Co. still retain the arrangement of a built-up stator with separate pole pieces (*The Electrician*, Nov. 24, 1905, p. 218), and have not adopted the chimney form of ventilation. After giving his opinion as to the great future to be expected from steam turbine driving, in spite of the fact that the net gain in steam consumption was but small over the best types of reciprocating engine, Prof. Thompson concluded by expressing his thanks to many manufacturers who had so kindly put details of their machines at his disposal.

## ARRANGEMENTS FOR THE WEEK.

**To-day) FRIDAY, February 9th.**

Institution of Electrical Engineers: Manchester Students' Section.

*7:30 p.m.* Meeting in the Municipal School of Technology, Sackville-street, Manchester. Paper to be read: "Electrical Instruments," by H. A. Carney.

Institution of Civil Engineers: Students' Section.

*8 p.m.* Meeting at 25, Great George-street, Westminster. Paper to be read: "Electric Driving at the Locomotive Works of the North London Railway," by R. H. Mackie.

**SATURDAY, February 10th.**

Junior Institution of Engineers.

*6:30 for 7 p.m.* Twenty-second Anniversary Dinner at the Hotel Cecil.

**MONDAY, February 12th.**

Institution of Mechanical Engineers: Graduates' Section.

*8 p.m.* Meeting at Storey's Gate, St. James' Park, Westminster, when Prof. W. C. Unwin, F.R.S., will deliver a special lecture on "The Niagara Power Stations."

**TUESDAY, February 13th.**

Tramways and Light Railways Association.

*2:30 p.m.* Visit to the Baker Street & Waterloo Railway. Meet at Baker Street Station.

Liverpool University Engineering Society.

*5:30 p.m.* Meeting at the University. Paper to be read: "Labour-saving Appliances used in the Carbonisation of Coal," by H. E. Bloor.

Institution of Electrical Engineers: Manchester Local Section.

*7:30 p.m.* Meeting at the University. Paper to be read: "Idle Currents," by M. B. Field.

Institution of Electrical Engineers: Glasgow Local Section.

*8 p.m.* Ordinary Meeting at 207, Bath-street, Glasgow. The adjourned discussion on the following paper will be taken: "The Maintenance of Underground Mains," by G. L. Black.

**WEDNESDAY, February 14th.**

"Dynamicables."

7 for *7:30 p.m.* Dinner at the new Gaiety Restaurant ("Adam" Chamber). Prof. Perry will preside.

Institution of Electrical Engineers: Birmingham Local Section.

*7:30 p.m.* Meeting at the University. Paper to be read: "Notes on the Construction and Maintenance of Overhead Equipment." By R. N. Tweedy and H. Dudgeon.

Society of Arts.

*8 p.m.* Ordinary Meeting. Paper to be read: "The Horseless Carriage, 1885-1905," by Claude Johnson.

Rugby Engineering Society.

*8 p.m.* Meeting in the Benn Building, High-street, Rugby. Paper to be read: "Lubrication," by W. J. Parish.

**THURSDAY, February 15th.**

Institution of Electrical Engineers: Students' Section.

7 for *7:30 p.m.* Annual Dinner at the Holborn Restaurant.

Institution of Electrical Engineers: Leeds Local Section.

*7:15 p.m.* Meeting at the University. Paper to be read: "Waste in Incandescent Electric Lighting, and Some Suggested Remedies," by G. Wilkinson.

**FRIDAY, February 16th.**

Royal Institution.

*9 p.m.* Evening Discourse on "The Passage of Electricity through Liquids," by W. C. Dampier Whetham, F.R.S.

**SATURDAY, February 17th.**

Glasgow Technical College Scientific Society.

*7:30 p.m.* Meeting at the Glasgow and West of Scotland Technical College, George-street, Glasgow. Paper to be read: "The Inglis Patent Boiler," by G. Inglis.

## ELECTRIC POWER DISTRIBUTION IN NORTH WALES.

*(Concluded from page 625.)*

Four sets of feeders leave the power house. One runs directly to the Oakeley quarries at Blaenau Festiniog, a distance of $7\frac{1}{4}$ miles. Two go to the quarries at Nantlle, by way of the Llanberis Pass, being led across the western base of Snowdon from Llanberis to Quellyn lake and thence along the valley to Nantlle, a total distance of $13\frac{5}{8}$ miles. The fourth will supply the Dinorwic and the Glyn Rhonwy quarries; it runs on the same poles as the Nantlle lines to Llanberis, and branches are taken to the two quarries which are 6 and $7\frac{1}{2}$ miles respectively from the power house. All these lines are shown diagrammatically in Fig. 14. The light railways from Portmadoc to Carnarvon will be fed from the Nantlle transmission lines. The actual route followed by the transmission lines is shown in the map (Fig. 3) published on p. 579 of our issue of January 26th. 9 mm. wire is used on the Nantlle route, 8 mm. on the Festiniog route and 6 mm. on the Dinorwic line.

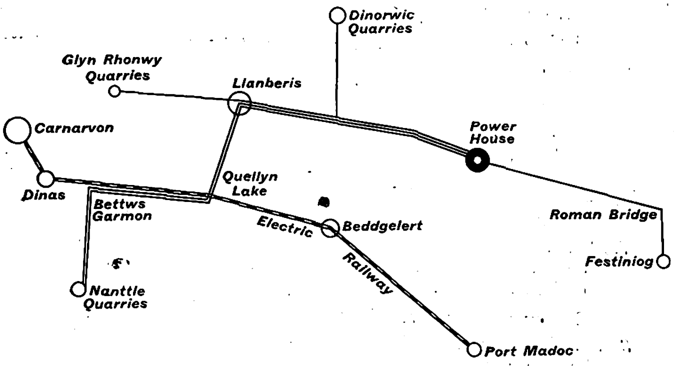

Dinorwic Quarries
Glyn Rhonwy Quarries
Llanberis
Carnarvon
Power House
Dinas
Quellyn Lake
Bettws Garmon
Electric
Railway
Beddgelert
Roman Bridge
Festiniog
Nanttle Quarries
Port Madoc

FIG. 14.—DIAGRAMMATIC SKETCH SHOWING ROUTE OF TRANSMISSION LINES.

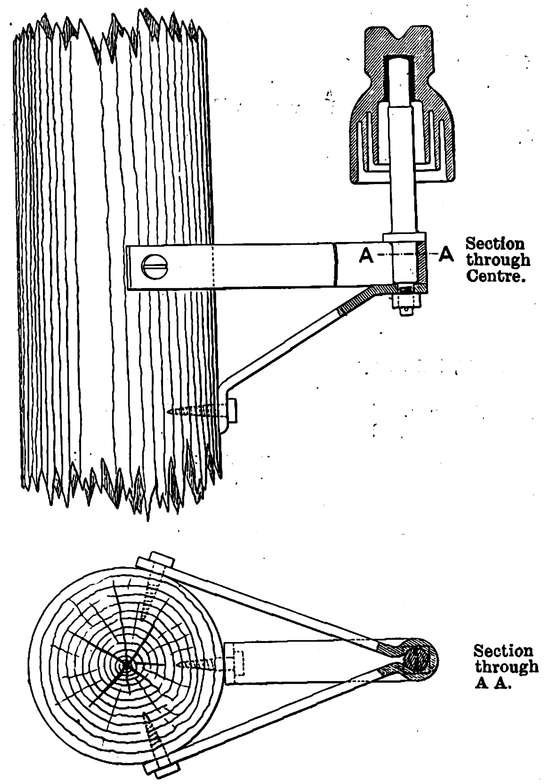

A
A
Section through Centre.
Section through A A.

FIG. 15.—INSULATOR AND METHOD OF ATTACHMENT. Scale, ½ Full Size.

On all the routes the poles are spaced 120 ft. apart on the straight runs, and the average distance apart (including curves) is about 100 ft. Most of the poles are wooden, but in some parts a light iron lattice-work construction has been preferred to resist the wind and falling rocks. The poles are well creosoted and are set in concrete. Plain wooden bracket arms are employed, and the three lines for the three phases are set one above the other. The telephone wires, which are carried on the same poles, are of course revolved. Fig. 15 shows the type of insulator employed and the method of fixing it on the poles which only carry three wires. It is of white porcelain with an iron pin. Fig. 16 gives the design of these single poles, Fig. 17 shows the nine-wire poles employed on the Llanberis route (similar construction is used for the six-wire route from Llanberis to Nantlle), and Fig. 19 is the iron lattice-work pole.

All the poles on a roadway or footway have a ring of galvanised iron with sharp points about 12 ft. 6 in. from the ground, and a danger board (Fig. 18) bearing an inscription both in English and Welsh is fixed to them. In such positions also a guard net is provided. A simple piece of channel iron, shaped as shown in Fig. 20 is fixed to each pole with a clip, and six galvanised mild steel wires 5 mm. in diameter are strung from pole to pole, being fastened to the eye-bolts. The net thus formed is completed by 3 mm. cross-wires bound on to the six longitudinal wires about every 1 ft. 9 in. This guard net is earthed, the iron lattice poles are also earthed by a copper earth plate 5 ft. square every fifth pole, and a 6 mm. copper wire runs from pole to pole above ground, so that each is effectively earthed.

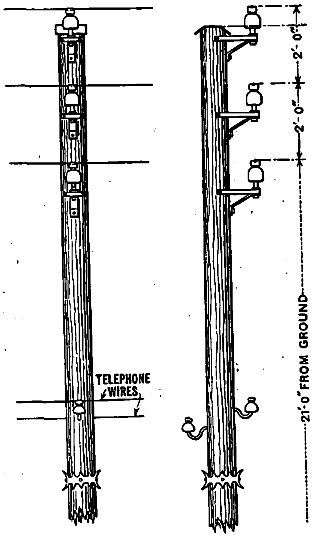

2'-0"
2'-0"
TELEPHONE WIRES
21'-0" FROM GROUND

FIG. 16.—POLE FOR THE FESTINIOG TRANSMISSION LINE. Scale 1:60.

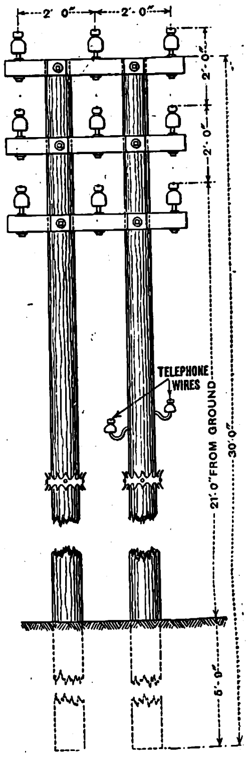

2'-0"
2'-0"
2'-0"
2'-0"
TELEPHONE WIRES
21'-0" FROM GROUND
30'-0"
6'-0"

FIG. 17.—POLE FOR THE LLANBERIS AND NANTLLE TRANSMISSION LINE. Scale 1:60.

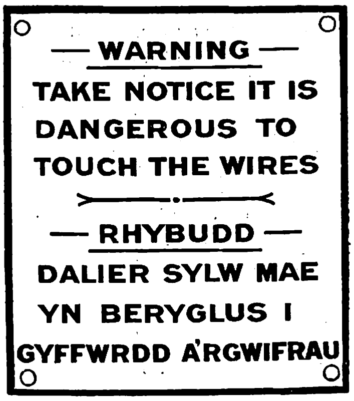

WARNING
TAKE NOTICE IT IS
DANGEROUS TO
TOUCH THE WIRES
RHYBUDD
DALIER SYLW MAE
YN BERYGLUS I
GYFFWRDD A'RGWIFRAU

FIG. 18.—DANGER BOARD. Scale, ¼ Full Size.

As a protection against lightning, lightning-arresters of the British Thomson-Houston Co.'s pattern are provided on all routes every 3 miles. These resemble the arresters employed on the Lancashire power scheme. They consist (Fig. 21) of three groups of five short metal cylinders, each group constituting a series of air gaps. In series with each set is a pair of horizontal carbon pencils forming a non-inductive resistance sufficient to prevent a large current from the line from following the lightning discharge. Above this group of elements is a single-blade switch to enable the arrester to be disconnected from the line when the spark-gaps are being cleaned. In addition to these, each line is furnished with a set of three horn lightning arresters in the power house, and a set of water-jet lightning arresters is connected to each side of the feeder 'bus bars. Both of these were shown in the drawings and diagram of the switchboard in our last issue, but we now illustrate them to a larger scale (Figs. 22 and 23). The horn lightning arrester constitutes a spark-gap with horn-shaped terminals between the station end of the feeder and earth; a carbon resistance is inserted in the earth circuit of the one horn to limit the current from the generator which follows the path of the lightning spark, and a choking coil, formed of a short spiral of bare copper wire, is connected in the line to the station side of the point where the arrester is attached to protect the generators, &c. The water-jet arrester, on the other hand, constitutes a permanent leak of high resistance between each 'bus bar and earth. Each 'bus bar is connected to a hopper-shaped trough mounted on an insulator; and a stream of water flows from this to an earthed funnel 1 ft. below the bottom of the nozzle in this trough, and thence to the waste pipe. The troughs are kept filled by pipes leading from the water service and terminating 1 ft. above the top of the troughs. The terminals and other details of both forms of arrester are

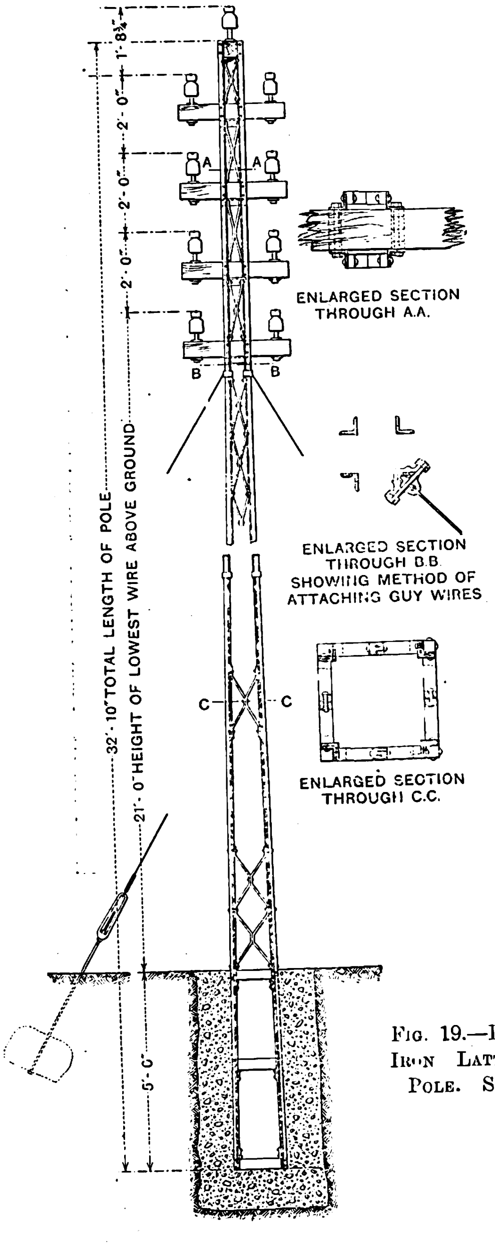

1'-8¾"
2'-0"
2'-0"
2'-0"
2'-0"
A
A
B
B
C
C
32'-10" TOTAL LENGTH OF POLE
21'-0" HEIGHT OF LOWEST WIRE ABOVE GROUND
5'-0"
ENLARGED SECTION THROUGH A.A.
ENLARGED SECTION THROUGH B.B. SHOWING METHOD OF ATTACHING GUY WIRES
ENLARGED SECTION THROUGH C.C.

Fig. 19.—Details of Iron Lattice-work Pole. Scale, 1:60.

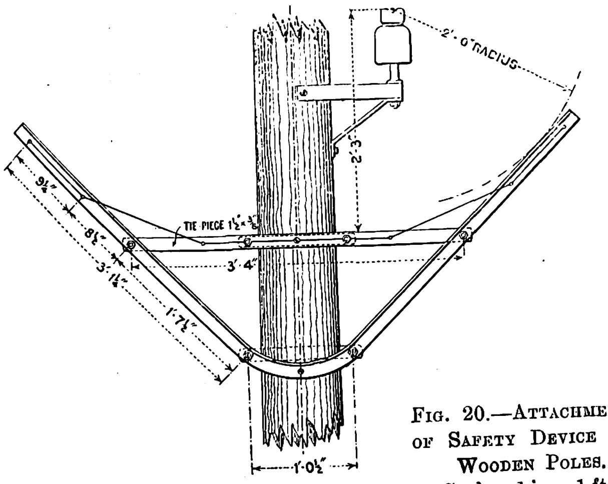
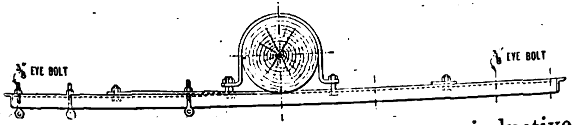

2'-0" RADIUS
2'-3"
TIE PIECE 1½"×⅜"
9¼"
8½"
3'-1¼"
3'-4"
1'-7½"
1'-0½"

Fig. 20.—Attachment of Safety Device to Wooden Poles. Scale: ½ in.=1 ft.


⅜" EYE BOLT
⅜" EYE BOLT

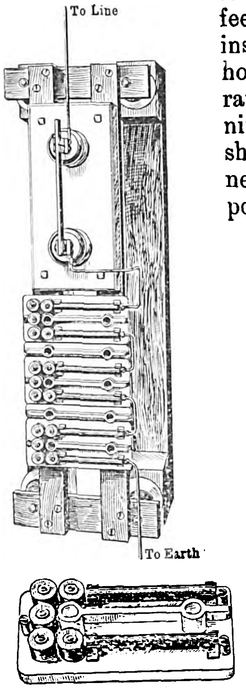

To Line
To Earth

Fig. 21.—B.T.-H. Lightning Arrester.

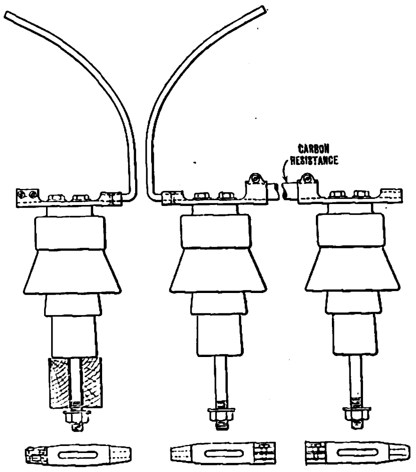

CARBON RESISTANCE

Fig. 22.—Details of Horn Lightning Arrester. Scale, 1 in.=1 ft.

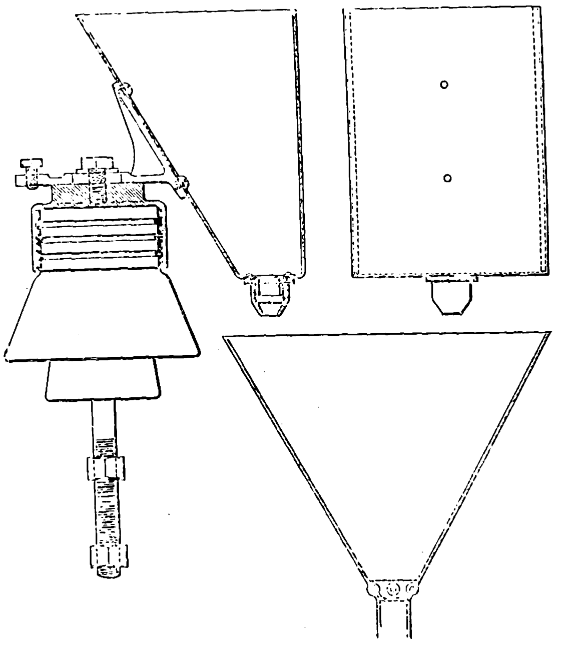


Fig. 23.—Details of Water Jet Lightning Arrester. Scale: 1 in.=1 ft.

clearly shown in the illustrations. Messrs. Ferranti supplied them to Messrs. Bruce Peebles & Co. as part of the switchboard sub-contract.

Owing to the nature of the country and the weather conditions, it need hardly be said that the contractors experienced unusual difficulties in carrying out the work which has been continued without intermission through this winter. Those who know the rainy climate in the Snowdon district and the keen winds that prevail there in the winter will appreciate this. All the material had to be brought by road from Portmadoc, Carnarvon, Rhyddu or Llanberis—that is to say, at least 8 miles to the power house—and the transmission lines from there are almost entirely across country. Fig. 24 is a typical view on the Llanberis pole-line, but it represents by no means the steepest of the gradients. In the transport of the line material traction engines were of course used as much as possible, and when the line was far from the roads and extended across country, light rails were placed down temporarily, and the material was conveyed on trolleys. In the case of high hills, a winding engine was used to draw up the poles, &c. Fig. 25 shows this in use on a steep hill facing the power house, but this photograph, again, was taken in a comparatively easy place. The workmen had to camp out frequently, under canvas, for several days at a time, and each man was furnished with a waterproof suit as part of his equipment. The contractors were fortunate enough to secure the late Sir Edward Watkin's châlet, which is only a short distance from the power house, and it has proved invaluable to them as a dwelling house and offices for their engineer-in-charge, in which

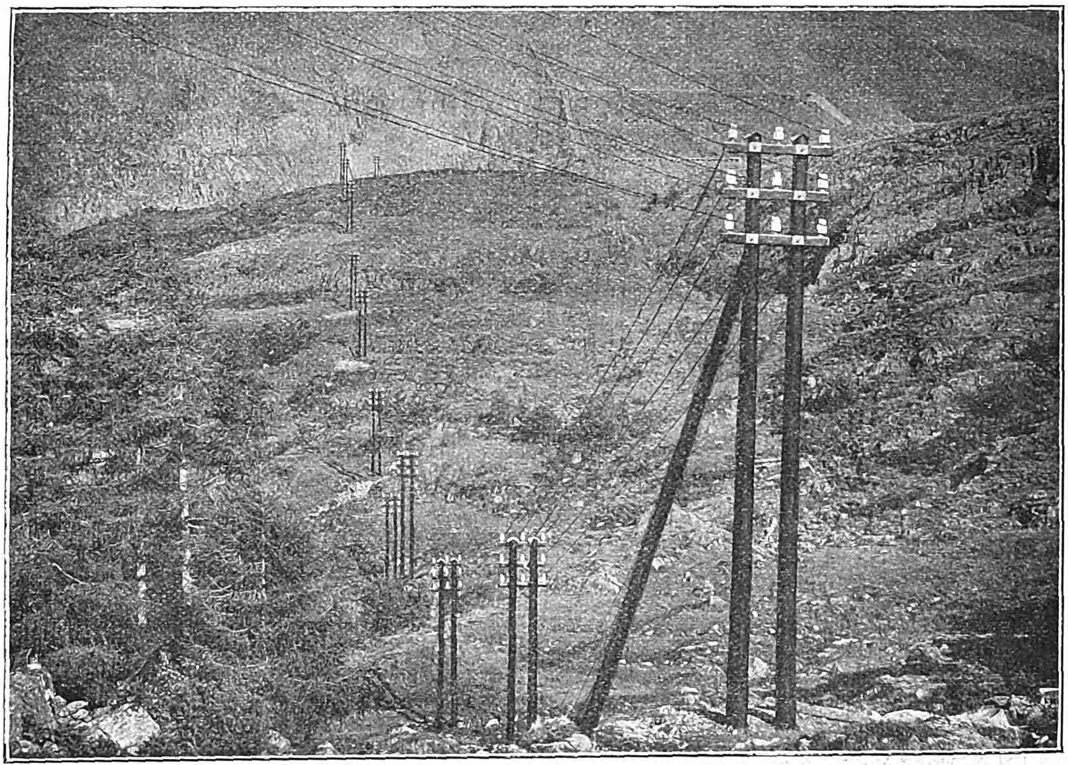


Fig. 24.—View on the Nantlle Pole Line.

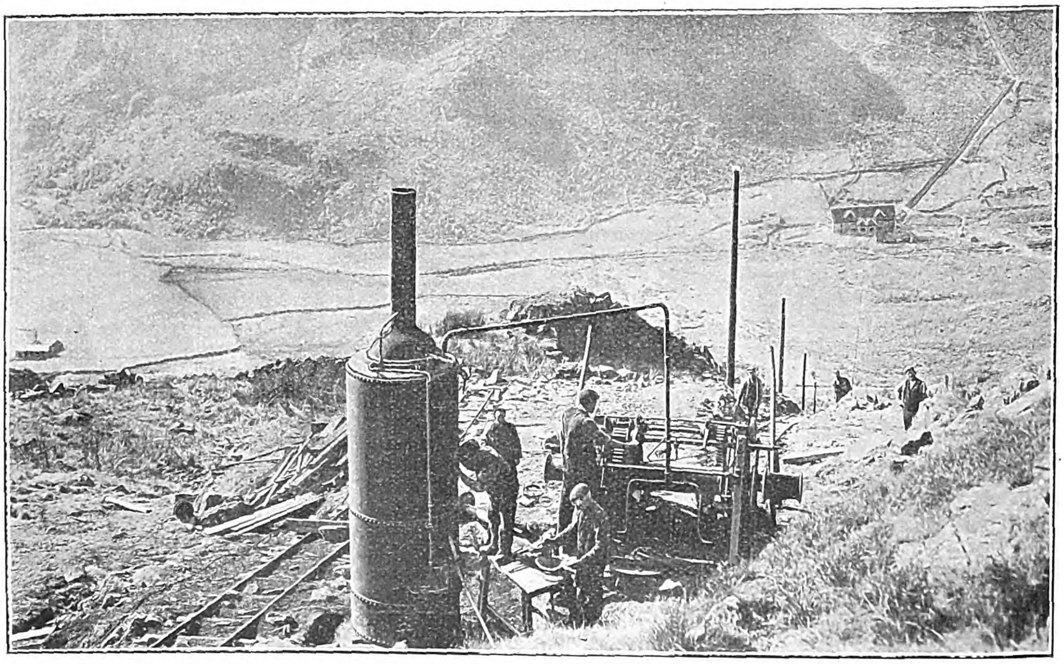


Fig. 25.—Winding Engine drawing Line Material up the Sides of a Steep Hill.

also engineers who had to visit the work occasionally could be put up. We were most grateful for this hospitality after a long day's journey and an inspection of the work in inclement weather. In addition to our thanks to the contractors and their representative, Mr. W. V. Waite, we wish to express our indebtedness to Messrs. Harper Bros., the consulting engineers (particularly to Mr. L. P. Szilagyi, who had charge of the electrical part of the design in London, and Mr. L. D. Taylor, their engineer on the work), and to Mr. E. W. Beutell, chief engineer to the North Wales Power & Traction Co., who came over from Llanberis on purpose to meet our representative. Without the assistance of these gentlemen, who placed all information, drawings and photographs at our disposal, we should have been unable to give our readers so complete an account of this interesting power-transmission scheme.

The North Wales Power and Traction Co.'s office is at Llanberis, which is the headquarters of the general manager, Mr. G. C. Aitcheson, and of Mr. Beutell. The price charged for power will vary from ⅞d. to 1½d. per unit according to the load factor. A second power-house will be erected a few miles to the south of Conway, in which power will be obtained from Llyn Eigiau in much the same way as from Llyn Llydaw in the present case. The pipe line will be shorter, however, and the head about the same. Out of a total capacity of 6,000kw., 4,000kw. will be taken by an industrial company with a 24-hour load factor, which will establish works there for the purpose. A further 1,000 H.P. has also been applied for.

## CRANE MOTORS AND CONTROLLERS.*

BY CLAUDE W. HILL.

There is at present considerable diversity of practice in determining the size and rating of motors for crane work, the object in all cases being to obtain a size of motor such that in the ordinary working of the crane its temperature rise shall not exceed what is usually considered to be a safe figure, this in English practice being generally 75°F. If the temperature rise is less than this the motor is larger and more expensive than is necessary, while if the rise is higher there is the possibility of injury to the motor. In the case of cranes for a specified duty going through a known cycle of operations all day long the work of the motor is known beforehand, and the most convenient method of specifying and testing is to specify that the motor, when run continuously at a given horse-power, shall in a stated time attain a temperature rise which shall correspond with that which it will attain when driving the crane all day long in the usual way. The point to be determined here is the method of calculation by which we can ascertain the load and time which shall produce a rise of temperature equal to that produced in the usual way of working. This is one of the points with which it is proposed to deal in this Paper.

It is sometimes desired by purchasers that the motor shall be tested by running it intermittently at its stated horse-power for a sufficient time for its temperature to become steady. This is an unnecessarily expensive way of testing, and is, moreover, useless, because we cannot introduce the same starting conditions as to friction of repose and inertia load as will be encountered in actual work. In the general run of crane work we do not know beforehand what the average work of the crane will be, so that the size of the motor has to be a more or less fortunate guess. It is owing to this uncertainty that the diversity of practice already mentioned has grown up. Some of the more common methods of specifying are as follows:—

(1) The horse-power required to lift or move the load, plus gearing losses, is taken as the brake horse-power of the motor. The motor is specified to be of this power, with a load factor of 20 per cent., 25 per cent., &c. (as the case may be), with continuous runs not exceeding, say, five minutes and temperature rise of 75°F. Thus a motor of 10 B.H.P. with 20 per cent. load factor, if worked intermittently at 10 B.H.P. with periods of rest four times as long as the periods of working, the latter in no case exceeding five minutes, would have a final mean temperature of 75°F. above the atmosphere. (2) The horse-power required to lift or move the load, exclusive of gearing losses, is taken as the brake horse-power of the motor. The motor is specified to be of this power and to be capable of exerting double power for a few minutes. (3) The horse-power required to lift or move the load, plus gearing losses, is taken as the brake horse-power of the motor. It is specified to maintain this power on a continuous run of one hour with a rise of 75°F., and to maintain half this power for four hours with the same rise of temperature (4) The horse-power required to lift or move the load, plus gearing losses, is taken as the brake horse-power of the motor. It is specified to maintain this power on a continuous run of ¼, ½ or 1 hour, as the case may be, with a rise of temperature of 75°F.

In cases where the work of the crane cannot be exactly ascertained beforehand, the author considers that the last method of specifying and testing is most convenient both to the purchaser and the maker. The decision as to whether a ¼, ½ or 1-hour motor is most suitable in such cases cannot be settled by calculation, but is a matter for judgment based on previous experience. An examination into the characteristics of ¼, ½ and 1-hour motors is, however, of assistance in forming a decision, and is another point with which it is proposed to deal in the present Paper.

*Rise of Temperature.*—For the calculations relating to the rise of temperature, the author has availed himself of Goldschmidt's Paper, *Journal* of Proceedings, Vol. XXXIV., p. 660,* and has used the formula given by Prof. Silvanus Thompson in the discussion—

$$C_t = M \times (1 - 2{\cdot}718^{-\frac{t}{T}}), \quad . \quad . \quad . \quad . \quad (1)$$

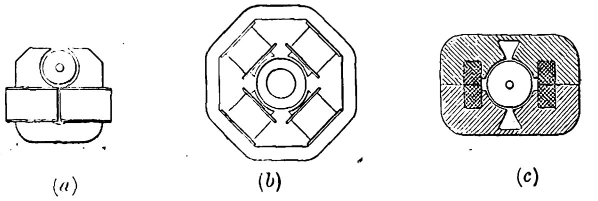
in which M is the final rise of temperature of the motor when running continuously, $C_t$ the rise of temperature at any time $t$ from commencement of run, and T the time in which the rise of temperature M would be attained if there were no loss of heat, time being taken in minutes.

The value of M is found by formula No. 2 which was first given by Mr. W. B. Esson† in his Paper at this Institution in 1888—

$$M = CW/S, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

in which C represents the rise of temperature for an energy loss of 1 watt per square inch of radiating surface, W the watts, and S the surface in square inches.

| Type of machine. | Peripheral speed of armature. Ft. per min. | Armature C. | Magnet. | |
|---|---|---|---|---|
| | | | C taking outer surface. | C taking whole surface |
| 1. Bipolar open-type drum with armature overhead (Type *a*) .. | 2,914 | 20·5 | 50·25 | 119 |
| 2. Same machine ............... | 1,850 | 27·4 | 59·36 | 140 |
| 3. Do. do. ............... | 925 | 47·0 | 69·8 | 164 |
| 4. Four-pole open-type drum armature, having end connections which were very open and set up a strong draught (Type *b*) .... | 1,734 | 12·0 | 27·0 | .. |
| 5. Totally enclosed bipolar drum with toothed armature (Type *c*) | 1,507 | 62 5 | .. | 142 |



(*a*) (*b*) (*c*)

FIG. 1.

For purposes of comparison some values of C, taken from machines of widely different design, are given in the Table above and Fig. 1. In Fig. 2 two curves are given, taken from the first machine in Fig. 1, showing how the value of C, both for the armature and magnets, varies with the speed.‡ The temperatures were in all cases taken by thermometer, and on six-hour runs. In the case of a machine running intermittently, in order to determine its ultimate mean temperature we require to know the rate at which its temperature rises when working and the rate at which it cools when stopped. By taking the differences of rise and fall over the successive periods of work and rest and summing them, we obtain a curve which ultimately becomes flat.

*The Heating Curve.*—In order to determine the value of T in formula No. 1 we require to know the specific heat and volume of that portion of the machine to which the formula is being applied. For an insulated coil we require to know the mean specific heat, which we can derive from the respective specific heats of copper and cotton insulation. The specific heat of such a coil will vary with the space factor, and, taking copper at 0·095 and cotton insulation at 0·38, the curve, Fig. 3, has been prepared showing the relation. A further curve, Fig. 4, has been prepared from this, showing the relation between the space factor and the watts per cubic inch which would raise the temperature of the coil at the rate of 1°C. per second if there were no losses.

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* Paper read before the Institution of Electrical Engineers yesterday.

* An abstract of Mr. Goldschmidt's Paper appeared in *The Electrician*, Vol. LIV., p. 878.

† *Journal* Institution of Electrical Engineers, Vol. XIX., p. 148.

‡ Similar curves are given in Parshall and Hobart's "Electric Generators," and Prof. Thompson's "Dynamo Electric Machinery."

From the known dimensions of the coil the value of T can be found from formula No. 3—

$$T = MW/60w_1, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

in which $w_1$ are the watts per cubic inch of coil and W the watts per cubic inch (taken from Fig. 4), which would cause the temperature of the coil to rise at the rate of 1°C. per second. In the case of open machines a curve based upon the above value of T seems to agree very well with the curve found by experiment, as may be seen in Mr. Goldschmidt's Paper, and the curve in Fig. 5. With enclosed motors, in determining T it appears to be necessary to include something more than the dimensions of the coil, as some portion of the machine carcase in proximity to the coil is heated to practically the same temperature. Thus, if we base T on the dimensions of the coil only, we get a curve which is considerably to the left of the observed one; while, if we base T upon the specific heat and volume of the entire machine, we get a curve which slopes away very much to the right of that found by experiment. Thus, in finding the watts per cubic inch, upon which the value of T depends, we must add to the volume of the coil some portion of the volume of the machine carcase; but as the amount of this additional volume is indeterminate, we may instead multiply T (taken from the known dimensions of the coil) by a constant, K, found by experiment from the nearest parallel case. The value of K is given by the formula No. 4—

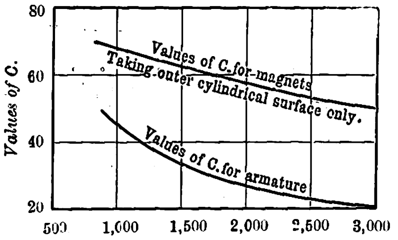

FIG. 2.

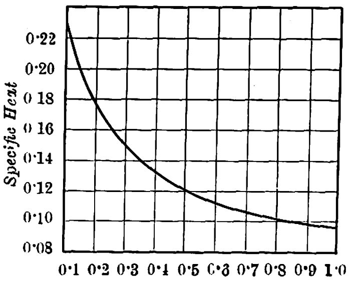

FIG. 3.

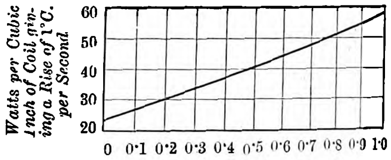

FIG. 4.

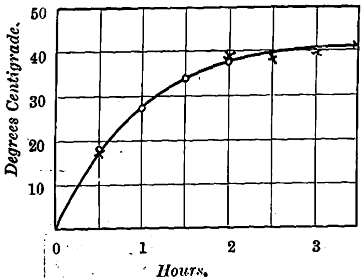

FIG. 5.

Space factor, 0·38.
Watts per cubic inch, 0·457.
Watts per 1°C. per sec., 36·75.
M=43. T=58.
Observed points ×.
Calculated points ○

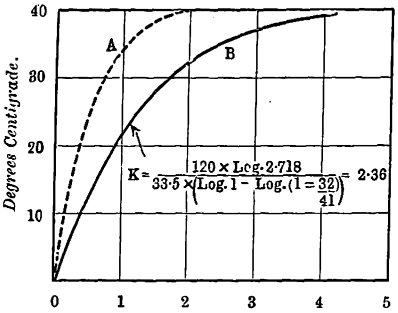

FIG. 6.

*Curve A (Calculated).*
Space Factor, 0·28.
Watts per cubic inch, 0·675.
Watts per 1°C. per second, 3?.
M=41. T=33·5.
*Curve B (Observed).*
T=33·5×2·36=79·1.

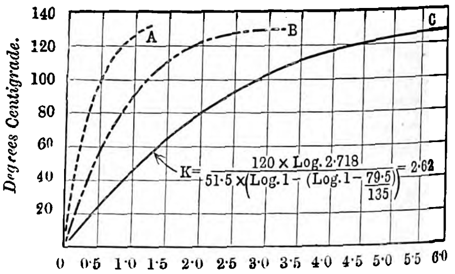

FIG. 7.

*Curve A (Calculated for Armature Coils only).*
Space Factor, 0·34.
Watts per cubic inch, 3·66.
Watts per 1°C. per second, 35·2.
M=135. T=21·6.

*Curve B (Calculated for whole Armature).*
Specific Heat of whole Armature, 0·117.
Watts per 1°C. per sec., 40·5.
Watts per cubic. inch (iron and copper losses), 1·78.
M=135. T=51·5.

*Curve C (Observed).*
T=51·5×2·62=135.

$$K = \frac{t \times \text{Log } 2{\cdot}718}{T \times \left(\text{Log } 1 - \text{Log}\left(1 - \frac{C_t}{M}\right)\right)} \quad . \quad . \quad . \quad (4)$$

in which $t$ is the time from the commencement of the run at which a temperature is taken, $C_t$ the temperature at that time, and M, as before, the final temperature to which the coil rises. Examples are given in Figs. 6 and 7, taken from the totally-enclosed machine shown in Fig. 1 This machine was of somewhat special design for a special purpose, and possibly the discrepancies between the various curves would not be so great with a machine of more ordinary type. Also it should be mentioned that the armature test was made with a current 2·25 times the normal, and that it was not run up to the final temperature of 135°C., this being calculated from the constant 62·5 found from a six-hours' run at normal load, in which, unfortunately, no intermediate readings were taken.

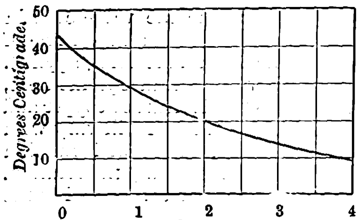

FIG. 8.

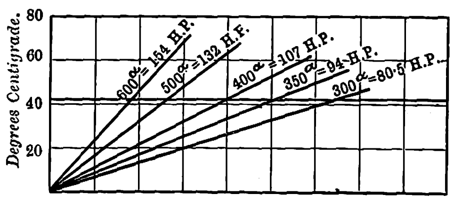

FIG. 9.

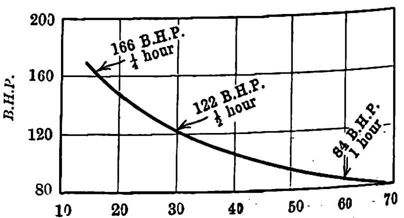

FIG. 10.

*The Cooling Curve.*—An example of a cooling curve, taken off a coil of similar dimensions to that of which the heating curve is given in Fig 5, is given in Fig. 8. This curve may be calculated by reversing formula No. 1, but multiplying T by a constant K′, which must be found by experiment, as it will be found that, although all machines cool down at a slower rate than they heat up, the rate of cooling varies with the design of machine.

*Machines of ¼, ½ and 1 Hour Ratings.*—In Table I. the temperature data have been worked out for three sizes of machine—A, B and C. For each machine a series of temperature curves, such as those shown in Fig. 9, have been calculated, and from these curves, such as Fig. 10, have been prepared, showing the relation between length of run and horse-power for a temperature rise of 41·5°C. (75°F.). For each machine the load has been worked out for a temperature rise of 41·5°C. on a run of ¼, ½ and 1 hour, the winding being the same for each rating. It will be noted that notwithstanding the heavy loads the reactance voltages, even at the ¼-hour ratings, are not excessive. If, however the machines were wound for a circuit of double the voltage (*i.e.*, 440 instead of 220), these reactance voltages would also be doubled, and it would then be desirable to use commutating poles.

The armature data have been worked out for each machine, but magnet data have only been got out for machine C. These figures show that as T has not the same value for both armature and magnet, their respective rises of temperature, if the windings remain the same, will not be the same at the different ratings Thus in the example given the armature and magnet rises practically correspond to the ½-hour rating, while for the ¼-hour the magnet rise is greater, and for the 1 hour less, than the armature. It has been generally noted among crane makers that ¼-hour rated motors have a habit of burning out with a facility which has been somewhat surprising to them. If, however, we look into the matter we find that it is not so surprising that this class of machine should fail with quite moderate overloads. A sudden evolution of heat such as would be caused by an overload does not immediately spread throughout the armature. Being localised, it heats a smaller volume, so increasing the rate of rise, while at the same time the amount of heat generated is proportional to the square of the current.

On the above assumption some figures of a rough character have been worked out, and are given in the lower part of Table II. These show how very rapidly the rate of increase of temperature increases with the overload on short-rated machines. From the figures in Table I. we may conclude that the ¼-hour motor has a very limited field of application, while the ½-hour motor is suitable for the generality of cranes having low load factors,* and the 1-hour motor is suitable for cranes which are worked moderately hard.

*Motors working on a known Cycle.*—Taking the simplest case of a motor working at a given horse-power for a stated time and then standing for a stated time, the final mean temperature above the atmosphere will be attained when the rate of heating × the time of working equals the rate of cooling × the time of standing. This has been worked out for the machines A and C, and in Figs. 11 and 12 curves are given showing the relation between load factor and final temperature when the machines are run at the same horse-power as would result in a rise of temperature of 41·5°C. in one hour's continuous run. We note that for the same rise of temperature the load factor of the small machine is greater than that of the large one. This illustrates the point that for a given load factor and rise of temperature the larger the machine the longer must its time rating be.

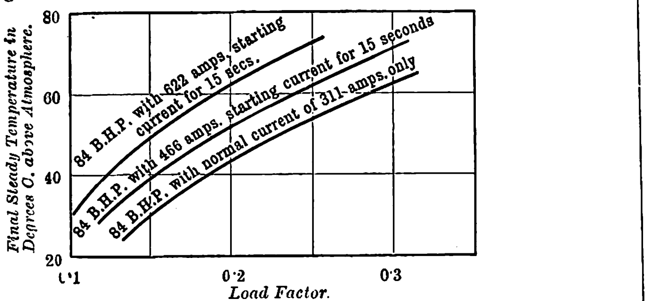

FIG. 11.

Working period one minute in each case.

MACHINE C.—84 B.H.P., 440 revs. per min., 220 volts, 311 amperes.

Rise of Temperature in continuous run of 1 hour at 84 B.H.P.=41·5°C.

$$\text{Load Factor} = \frac{\text{Time of working}}{\text{Time of working} + \text{time of stopping.}}$$

A point which has to be taken into consideration is that each time the motor is started its current, for a time, exceeds the normal to a greater or less extent, and we ought, therefore, in our calculations, to take the mean current during the working period, and not merely the current after the motor has settled to its steady speed. If the working period is short, we may for practical purposes take the equivalent current during the period to be as given in formula No. 5—

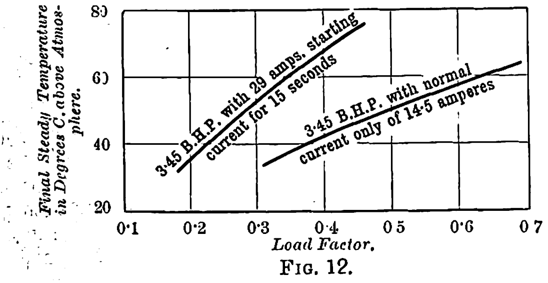

FIG. 12.

Working period one minute in each case.

MACHINE A.—3·45 B.H.P., 490 revs. per min., 220 volts, 14·5 amperes.

Rise of Temperature in continuous run of 1 hour at 3·45 B.H.P. = 41·5°C.

$$\text{Load Factor} = \frac{\text{Time of working}}{\text{Time of working} + \text{time of stopping}}.$$

$$\sqrt{\frac{C^2_s t_1 + C^2_n t_2}{t_1 + t_2}}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (5)$$

in which $C_s$ is the mean starting current, $t_1$ the starting period, $C_n$ the normal running current and $t_2$ the normal running period. In Fig. 11 for machine C three curves are given, one in which no account is taken of the starting current, a second in which the mean starting current is taken at 1·5 times the normal and a third in which it is taken at twice the normal.

In Fig. 12, for machine A a curve is given for normal current only, and a second in which the mean starting current is twice the normal. In all these cases the starting current is taken as being on for 15 seconds out of a working period of one minute. An examination of these curves shows how very necessary it is to take into account the starting currents when the working periods are short.

(*To be concluded.*)

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* Mr. Hill has made use of the expression "power factor" throughout his Paper, but we have taken the liberty of altering it to "load factor," as power factor has a different significance to our readers, and Mr. Hill's definition approaches more nearly to the accepted definition of load factor.

## THE ROMAPAC SYSTEM OF TRAMWAY PERMANENT WAY CONSTRUCTION.

This system of tramway rail construction was designed with the object of enabling tram lines to be repaired when badly worn at a minimum of cost and inconvenience. The Romapac rail itself is constructed in two parts, the lower portion of which is a permanent fixture laid in the usual way, the upper part, or about 41 per cent. of the whole being renewable without disturbing the lower portion. The advantages of such a system are obvious; not only is a very much smaller amount of steel discarded on renewals than with ordinary rails, but the removal of the wearing portion of the rail only necessitates taking up about 9 in. of the roadway on each side of the metals, and the labour of laying the lower portion of the rail does not have to be repeated. In addition to this, it is possible to arrange the joints in the top portions of the rail so that they are intermediate to the joints in the lower part giving a very smooth running joint. A section of the rail is shown in Fig. 1. The lower section has grooves at the sides over which the flanges of the upper section are fixed so as to grip the head of the girder.

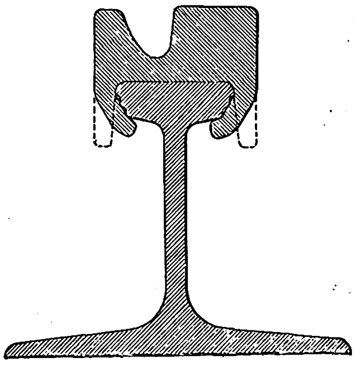

FIG. 1.

The use of a compound rail such as this is not entirely new, but the novelty lies in the special machinery employed to effectively combine the two sections, and to afterwards cut them apart when worn so that a new upper section can be fixed. The plant comprises a rolling-on machine, which rolls the depending flanges of the upper grooved section inwards, so as to clasp round the head of the under permanent T-section. The action of this cold rolling on is so powerful that at a test made by the Sheffield Test Works, the adhesion of the top section to the bottom section in a length of only 1 ft. was found to be 23 tons. The details of the fixing machine are shown in Fig. 2, the rollers being clearly seen on each side of the rail. The whole machine with its driving engine is shown in Fig. 3. The equipment for removing worn rails consists of a cutting machine which cuts a groove into one of the depending flanges of the rail to a depth of one-third to one-half the thickness of the metal and a breaking-off machine (see Fig. 4), which, when applied

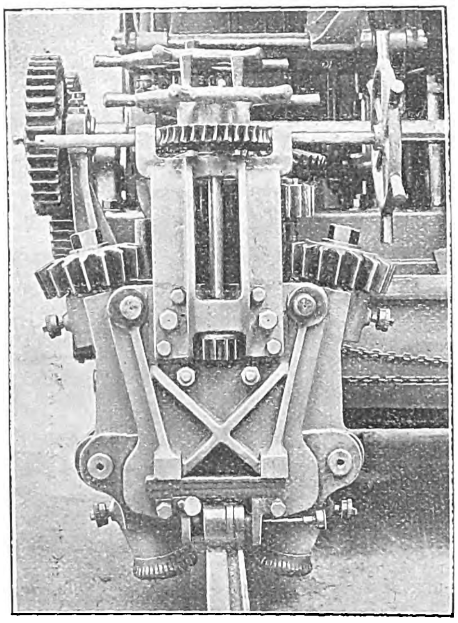

FIG. 2.—ROLLING-ON MACHINE.

to the two sections, breaks off the partly cut flange, thereby releasing the head rail. These two operations do not in any way injure or disturb the under section.

In the construction of new lines, the rolling-on machine only is required. The lower girders being fixed in their place, fished and tied to gauge, the top section is laid on the under girder and the machine travels along the rail gripping the two parts firmly together. The capacity of the machine for rolling on the top section exceeds 10 ft. per minute. In the repair of lines the cutting and breaking machines travel along the rail followed by the fixing machine which rolls on the new head rail. In this operation, there is no interference with the permanent way beyond the removal of the setts immediately adjoining the line. Favourable reports have been made on the mechanical properties of the compound rail by Mr. J. H. Wicksteed. We understand that the Romapac Tramway Construction Co. have already carried out a contract on this system for the Leeds Corporation, so that the method may be said to have already passed beyond the experimental stage. The machines will work not only on the straight portions of the line, but also round such curves as occur in practice. A report of Mr. J. B. Hamilton, the general manager of the Leeds City Tramways, estimates the saving in cost by the adoption of this system at 53¾ per cent. compared with the cost of the old system of entirely relaying the track. He also calls attention to the rapidity with which a length of rail can be relaid at the least possible inconvenience to the general public, and the lessening of rail movement through loosening at the joints, owing to the joint at the top section and the joint of the under portion being staggered.

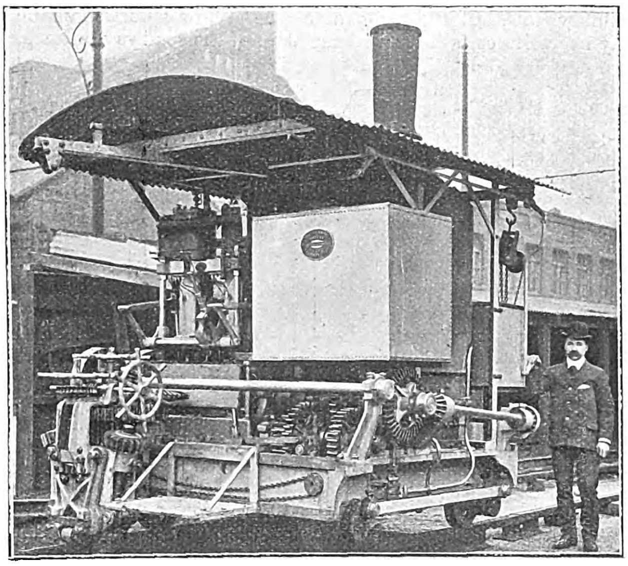

FIG. 3.—COMPLETE MACHINE WITH STEAM ENGINE

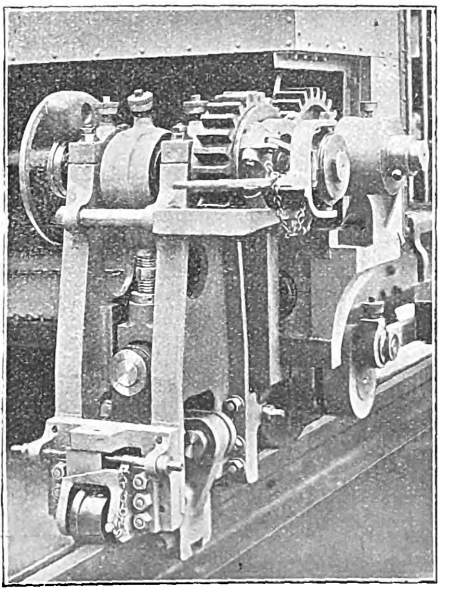

FIG. 4.—BREAKING-OFF MACHINE.

## THE ELECTRIC PRODUCTION OF NITRATES FROM THE ATMOSPHERE.*

BY PROF. SILVANUS P. THOMPSON, D.SC., F.R.S.

There are rare occasions when a scientific man, after a careful and impartial survey of gradually accumulated facts and of the tendencies they reveal, points out the inevitable conclusions to which they lead, and by pointing out those conclusions seizes the ear of the public and awakens it from its habitual attitude of indifference. Such an occasion arose in the autumn of 1898, when Sir William Crookes, in his Address as President of the British Association, reviewed the food problem, and pointed to the narrow margin of safety which for the white races of the globe stood—and stands—between demand and supply, and to the serious menace of an impending famine of bread. This was an absolute certainty within the measurable distance of less than half a century, unless the scientific chemist should step in to stave it off.

His argument may be concisely stated as follows: The cumulative experience of mankind shows that for the brain-working and muscle-using people of the world, the appropriate staple food is wheat. Wheat can be grown only in the temperate regions, and on certain soils; its present acreage is known, and the maximum possible acreage can be estimated, being defined by ascertainable geological and meteorological conditions. The number of wheat-eating individuals in the world is growing at a greater rate than the acreage devoted to wheat. Under this increasing demand for wheat the land still available for wheat-growing is being rapidly taken up, and at the present rate of increase will be entirely taken up before the middle of the twentieth century. Of the possible new wheat lands within the temperate zones, though much has come into (wheat) cultivation during the last 25 years, particularly in Manitoba, Dakota, Queensland, New Zealand and Argentina, some so brought under cultivation is already being devoted to other uses, and as towns grow up in these regions the available acreage in each begins to contract. As an illustration of this tendency, it may be noted that in Ontario from 1880 to 1893 the acreage under wheat cultivation decreased by 54 per cent. India needs all the wheat she can grow for her own starving millions. Strange as it may seem, the United States will soon reach the position of having to import supplies.

Looking ahead for some 30 or 40 years, we are, therefore, within measureable distance of a time when the last available acre will be occupied.

If and when that time comes, the only chance of averting famine lies in increasing the output per acre.

Such was Sir Wm Crookes' argument, statistically demonstrated.

Now, all crops require some special manurial agent—some need nitrogen, some potash, some phosphates. Wheat requires nitrogen, not "free" as it exists in the air, but chemically "fixed," either in the form of ammonia or in that of nitrates. Nitrogen is indeed acquired from the atmosphere by vegetation, and "fixed" slowly and with difficulty by processes which cannot be either accelerated or augmented. It is in particular assimilated through bacterial agency by clover and other leguminous plants. Fixed nitrogen is also supplied by natural manures, but in the vast wheat fields of the world these manures must necessarily be other than those furnished by existing animals. In defiance of the warnings of Liebig half a century ago, we in England still throw away as worthless the sewage and drainage of our cities. The ancient deposits of the guano beds are all but exhausted. Sulphate of ammonia, a bye-product of our gasworks, is an artificial fertiliser of high value, but its total is scarce a twentieth of the future demand, and any great increase in its production is problematical. The great fertiliser available and used in ever-increasing quantities is nitrate of soda, known as Chili saltpetre. Beds of this substance, the product of ages, occur as a native product in a narrow tract between the Andes and the lower hills near the coast. To every part of the world Chili saltpetre is exported from these mines, and the vast output has made colossal fortunes. In 1894 just over 1,000,000 tons were exported; in 1898, at the date of Sir William Crookes' address, the yearly export was 1,250,000, and this had risen in 1905 to 1,559,000 tons per annum, the increase being about 39,000 tons per annum, or some 4 per cent. per year. It is said by one of the best authorities that the supply will last for 50 years at 1,000,000 tons a year. Dr. Vergara puts 1923 as the date of exhausion at present rates. Of all the nitrate of soda produced, about one-fifth is used for the manufacture of nitric acid; of the rest a certain fraction goes for fertilising the beetroot crop for sugar, but the bulk is used as a manure for *wheat*.

But wheat eaters are increasing; and if the possible wheat acreage cannot much increase, then the only alternative is to increase the output per acre by dressing with fertilizers. The average crop per acre all over the world is only 12·7 bushels; but in Denmark, Great Britain, New Zealand, Norway, Germany, Belgium and

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* A discourse delivered at the Royal Institution on Friday last. Slightly abridged.

Holland, the yield is over 20 bushels, and in France, Hungary and Roumania nearly 20 bushels per acre. In the United States it is 12; in Australasia, India and Russia it is under 10. To bring the average of the world up from 12·7 to 20 bushels per acre will require the use of 1½ cwt of nitrate of soda (or its equivalent) per acre. The price (at Liverpool) has varied between £7. 7s. 6d. to £10. It is now £10. 15s. to £11 per ton. During the years 1891-95 the mean number of acres growing wheat was 159,000,000; and according to the careful estimate of Sir William Crookes this cannot be increased beyond 259,000,000 or, say, in round numbers, 260,000,000.

Now 25 years hence—in 1931—there will be 746,100,000 bread eaters, demanding 4·5 bushels per head (including an allowance of 0·6 bushel per head for seed sowing), or requiring a crop of 3,357,000,000 bushels. At the present average crop of 12·7 bushels per acre, this requires 264,000,000 acres—slightly in excess of the maximum available area. Any increase in the white populations of the world beyond this point will bring about a wheat famine, unless the average output per acre can be raised. Assuming that it can be raised to 20 bushels, this will stave off the impending famine for 35 or 40 years only. But to achieve this, there is involved a consumption of at least 1½ cwt. of nitrate of soda, on the average, for each of the 260,000,000 available acres. This is, broadly, 12,000,000 tons per annum more than at present. But if at the rate of 1,000,000 tons per annum the Chili nitrate beds will only last for 50 years, then at the rate of 12,000,000 tons per annum they would be exhausted in little more than four years. Suppose that the extent of the Chili deposits has been underestimated, and that the experts are 100 per cent. wrong; even then eight or nine years of such a tremendous demand will exhaust them. What then?

The resources of civilisation are, however, unlike the Chili beds, in that science knows no finality; and the possibilities of invention cannot be limited. Sir William Crookes himself gave the clue in the words: "*Starvation may be averted through the laboratory.*"

Now, consider the immense quantity of nitrogen that exists in the free state in the air—four-fifths of the whole atmosphere. If available it would be practically an inexhaustible supply. Over the whole earth there exist about 4 trillion tons. The quantity hanging over London alone, and pressing down with a weight of about 7 tons on every square yard, is several times greater than the entire quantity stored up in all the beds of Chili. There is some 4 tons in this theatre—worth nearly £240 if it were but "fixed" as combined nitrogen in 22 tons of nitrate of soda, but, being uncombined and free, it is absolutely worthless.

We can make nitrogen burn with oxygen, but only by pumping electric energy into it to keep up the combination; for while in ordinary combustion, as when carbon combines with oxygen, heat is given out, the formation of nitric oxide is an endothermic reaction absorbing heat. To the celebrated Cavendish we owe the observation in 1781 that when hydrogen is burned with air the product is not pure water, but contains some nitric acid, so that to a certain extent nitrogen is combustible. And five years later he demonstrated that by passing electric sparks through air, the whole of the nitrogen could be removed by giving sufficient additional oxygen, and supplying energy enough in the form of a sufficient quantity of electric sparks. Now, this experiment has been known for 120 years, and there has, therefore, been a prima facie case for thinking that the fixation of atmospheric nitrogen by electric means might be one day realised as an industrial process. Doubtless Nature in her laboratory does, by means of lightning flashes, actually produce this very combination, but in minute quantities.

The electric arc, which Davy first showed in this historic theatre in 1804, is a flame, less hot, it is true, than the hottest sparks that can be produced, yet at the enormous temperature of some 3,800 absolute degrees. To Professor (now Sir James) Dewar, who gave a Friday night discourse on the subject in 1880, we owe the discovery that both nitrites and cyanogen compounds are formed in the arc; and in particular he investigated the yield of nitrites, using Siemens' machines and lamps, and also using Jablochkoff candles with the alternating current of a De Meritens generator. With the Siemens' machines the highest yield was with the lamp adjusted to burn with a long arc, when he obtained 804 milligrammes per hour. The amount of electric power absorbed is not known—it must have been about a kilowatt. With the De Meritens current at its highest intensity 1,257 milligrams of nitrous acid per hour was the greatest output. Sir James Dewar concluded that nitric peroxide is formed in the arc but subsequently reduced to nitrous anhydride by contact with the red-hot carbon electrodes or other reducing products.

Later, in 1892, Sir William Crookes showed at a soirée of the Royal Society an experiment on the flame of burning nitrogen, in which a strong induction current being passed between terminals the air burns with a powerful flame producing nitrous and nitric acids. Almost at the same time Lord Rayleigh in the course of the classical experiments which led to the discovery of argon, fitted up apparatus for performing the operation on a larger scale. His figures yield the result that it would require 1 kw.-hour to form 74 grammes of nitrate of soda.

Commenting on the state of investigation in 1898 Sir William Crookes foresaw in these experiments the possible development of a mighty industry destined to solve the food problem. He reminded his audience that though electricity generated by coal and steam-engines might be too costly for industrial purposes, water power as at Niagara furnished a far cheaper source, and calculated on the basis of Lord Rayleigh's experiments, that if electric energy could be furnished at one-seventeenth of a penny per kilowatt-hour, nitrate of soda could be manufactured at £5 per ton, the current price of Chili nitrate being then £7. 10s.

Seven years have passed away, and I stand before you to-night to describe to you a development which has attained to commercial proportions, and shows a new industry in the making. The particular process which I have to elucidate does not stand alone, but it is, I believe, the only one that can claim to produce nitrates commercially by artificial means. It is but fair to mention, however, that in Scotland the Cyanide Company is turning out 20 tons a week of electrically-manufactured cyanide of soda. In Berlin, also, cyanamide of lime is being made according to the process of Prof. Frank by first separating nitrogen from the air and then passing it over pulverised carbide of calcium at a temperature of 800°C. The cyanamide when treated with water produces carbonate of lime and ammonia. So far this is only in the experimental stage, though a factory is being erected in Italy to work the process.

In the United States, taking advantage of the cheap electric energy generated by water power at Niagara, Messrs. Bradley and Lovejoy have attempted to obtain nitrates by the persisted electrification of air by continuous current at a potential of 10,000 volts, under the auspices of the Atmospheric Products Company. Owing to difficulties in keeping discharges at such voltages in continuous operation they have employed a slowly rotating framework with projecting platinum electrodes, the approach of which, during revolution, to other projecting platinum rods provoked discharges, which were immediately interrupted. But unfortunately their process has not proved commercial, and though they have produced nitrate of soda in fairly large quantities by absorbing the gaseous products in caustic soda the synthetic product was found to be more costly than the imported Chili saltpetre.

The production of nitrates has also been essayed in Geneva by M. Alois Naville, and in Freibourg by MM. Kowalski and Moscicki. Of the results obtained by M. Naville I have no information. In the Kowalski process alternating electric currents at a potential of 50,000 volts have been employed; their operations were carried on in a fairly large research establishment. But for some cause, I know not what, they have been discontinued.

Amongst others who have laboured at the problem one ought also to mention the names of Messrs. Muthmann and Hofer, who have sought to find the scientific bases of the operation, irrespective of industrial ends, and the name of Prof. Nernst, of Göttingen, who has likewise investigated the nature of the reactions involved.

Let us devote a moment to one point of theory, but of more than merely theoretical interest. The nineteenth century witnessed the growth of a new science—that of *thermo-chemistry*—in which we are taught to look at chemical reactions as questions of energy-transfer. We have learned to deal with chemical combinations as actions between the *ions*, and to consider the questions of temperature as entering in as a determining factor as to what changes in chemical combination can or cannot occur. The phenomena of dissociation and the reversibility of chemical actions are now understood far better than they were 30 years ago.

At temperatures such as those of the electric spark and of the arc the biatomic molecules of free nitrogen and free oxygen are more or less completely ionised or dissociated; a reaction which may be stated thus: $N_2=2N$; $O_2=2O$. But if these dissociations occur in air a more or less complete recombination takes place; some of the atoms now recombining as nitric oxide, $N+O=NO$, or as some chemists would write it, $2N+2O=2NO$. But the action is always incomplete, limited, because of the circumstance that a precisely converse operation can occur to the molecules of nitric oxide. In fact, if we were to begin with pure NO and subject it to the electric spark or arc, we should have $2NO=2N+2O$, and some of these free atoms of nitrogen and oxygen would recombine amongst themselves, giving us $N_2$ and $O_2$. Hence we cannot expect in passing a spark through air that more than a limited proportion of the molecules will be found to emerge from the operation as nitric oxide, for however long we continue the sparking, presently there will be reached the limit of the reaction.

But there is always another action simultaneously going on, because there is always some free oxygen present, and NO (which is a colourless gas) has, to use the old chemical language, an affinity for oxygen, and takes to itself spontaneously another atom of oxygen and becomes $NO_2$ (or $N_2O_4$), nitric tetroxide, known at once by its orange-coloured fumes.

Now mark how the question of temperature comes in. At low temperatures the limit of the reaction—that is, the point at which the gain of NO by association is balanced by the loss of NO by dissociation—is reached when a very small percentage has been formed.

At higher temperatures a higher percentage is formed before the limit is reached. According to Nernst, the following are the values :—

| Temperature Centigrade. | Temperature Absolute. | Percentage NO in volume. |
|---|---|---|
| 1,538° | 1,811 | 0·37 |
| 1,760° | 2,033 | 0·64 |
| 1,922° | 2,195 | 0·97 |
| 2,927° | 3,200 | 5·00 |

Further, the times in which the limit is reached is shorter the higher the temperature, as follows, the last figure being obtained by extrapolation :—

| Temperature Centigrade. | Temperature Absolute. | Number of seconds. |
|---|---|---|
| 1,267° | 1,540 | 100·0 |
| 1,454° | 1,737 | 3·5 |
| 1,650° | 1,923 | 0·1 |

Could a still higher temperature be applied, the time required for the transformation to reach its limit would be higher, and the actual percentage of transformation would also be higher. Now the local temperature of the spark and of the arc are much higher. Hence we may conclude that in the actual space occupied by the spark while it lasts there is a more complete formation of nitric oxide. The arc has to heat up the molecules in its path, and in thus giving up its energy to them it effects the desired combination. According to the calculations of M. Haber, one kilowatt year ought to yield, theoretically, 819 kg. of $HNO_3$ if the temperature is 3,200°C. (=3,473 absolute degrees); or 1,850 kg. of $HNO_3$ if the temperature is 4,300°C. (=4,573 abs.).

Now these numbers cannot be attained because of the tendency to dissociation which has already been mentioned. Unless the associated product can be instantaneously cooled down it will begin to dissociate ; and, in fact, it ought to be cooled down as rapidly as possible below 700°C. if the percentage of NO in the air that has been treated is not to fall off. All this points to the necessity of some device for passing the air that is to be treated through the arc very quickly in order that, whatever the percentage of useful association, it may be retained before dissociation has had time to reduce it much.

We are now ready to turn to the process which has already established itself in the industrial sense, and to see how the conflicting conditions have been met. For the solution of the problem I invite you to turn to Norway, and to hear how in that beautiful land of forests, lakes and mountain torrents there has arisen the germ of a new and important industry. The process which I have to describe to you is the invention of Messrs. Birkeland and Eyde, and it has been at work on a sufficiently-large scale and for a sufficiently-extended time to enable a fair estimate to be made of its value in the practical sense. The inventors are not unknown persons. Prof. Christian Birkeland is Professor of Physics in the University of Christiania, and Mr. Samuel Eyde is a well-known engineer in the same city. They have been associated together since 1903 in developing the electric furnace in which the nitrogen of the air is burned, in the large-scale researches in their experimental laboratory at Arendal, and in the creation of the saltpetre factory at Notodden in the Hitterdal, under the auspices of a society which they have created under the name of "det Norske Kvaelstof Compagnie."

If an arc formed between electrodes by an alternating current of high potential is subjected to the influence of a transversely applied magnetic field it is blown out laterally into a series of curvilinear streams which spring from the electrodes both above and below, and enlarge themselves into a veritable disc of flame, such as is shown diagrammatically in Fig. 1. The action of a magnet on an arc is not an unknown thing. It has been used over and over again in arc lamps, in electric blow-pipes, and in magnetic blow-out devices. But it does not seem to have occurred to anyone before Birkeland to utilise the peculiar disc of flame characteristic of the high-voltage alternating arc. If, using a transformer to give us the necessary high voltage, we let such an arc play between two horizontal electrodes, we have a phenomenon totally different from that of the arc such as we have in arc lamps. There there is a single, short, stationary, almost invisible flame of enormous heat, raising to white incandescence the tips of a pair of carbon rods. The potential between the electrodes is only some 40 to 80 volts, and the flame is silent. In Birkeland's flame we have a series of discharges, alternately above and below the electrodes, which discharges are approximately semicircles that, beginning with a radius of, say, ¼ in., enlarge themselves with great rapidity under the influence of the magnet, moving outwards like the ripples on a pond, and enlarging until—in the actual furnaces used—they attain a radius of some 3 ft. This new kind of arc is best formed when the potential is from 3,000 to 4,000 volts; the temperature is probably higher even than that of the carbon arc, and it roars tumultuously.

Though there is nothing here that a physicist would not recognise as exactly what might be expected from the given conditions, the Birkeland flame constitutes an absolute novelty as a weapon for attacking the fixation of atmospheric nitrogen, and kindred problems. It was recognised as such by Prof. Birkeland, who forthwith called into association and partnership Mr. Eyde whose engineering training and experience, no less than his genius for organisation, led to the industrial development of the idea. They constructed electric furnaces, small at first, larger as experience guided them. They surrounded themselves with a staff of capable young men, highly trained chemists from the Technical High School of Charlottenburg, electrical engineers from the Polytechnikum of Darmstadt, engineers and physicists from the University of Christiania, and agricultural chemists from the Royal Agricultural School of Aas in Norway.

But before I speak further of the Birkeland and Eyde furnace and of the saltpetre factory at Notodden, let me point out how particularly suitable this flame is for the purpose in hand. We have seen how the very essential of the process is that the molecules of the air should be subjected to a very high temperature and removed as rapidly as possible. Now all inventors in this field have sought to attain this mechanically by blowing the air through the region where the electric sparks were produced. The velocities attainable are limited by the pressure at which the air is blown. But it does not seem to have occurred to any previous inventor to move the arc or flame across the air. The movement of the arc itself under the influence of the magnetic field may, however, attain a much greater velocity than could be conveniently given to the air. This circumstance gives a prima facie reason for the efficiency of this particular process.

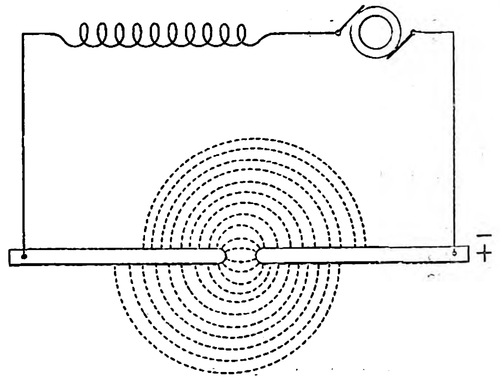

FIG. 1.

The furnace in its practical form is extremely simple (Fig. 2). On each side of the roaring disc of flame there are fire-clay cheeks pierced with holes for the inlet of air, which is driven into the central region under a gentle pressure by a Roots blower, and passing radially arrives at a peripheral channel whence it is conducted away. The whole is enclosed in an external copper case, into which, on either side, there enter the poles of a large electromagnet. The horizontal electrodes are of copper. They approach one another to within about ⅓ in. and are hollow, to permit of their being cooled by a water circulation that keeps them from fusing. They are not consumed, and need only to be replaced at intervals of a few weeks when they have become slightly eroded or roughened on the surface.

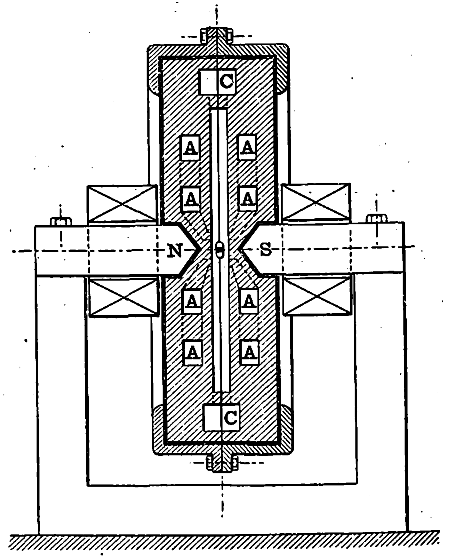

FIG. 2.

The first experimental work, in July, 1903, was made in a factory in Christiania with a small furnace taking 3 kw. to 4 kw. of power (4 H.P. to 6 H.P.) which was shortly increased to 20 kw. In three months a small research establishment was set up at Ankerlokken just outside Christiania, next to the electric supply station, and a larger plant of 120 kw. was constructed, with appliances for collecting the nitric fumes and converting them into nitric acid. In September, 1904, the work was removed to the extreme south of Norway, where, at Vasmoen, about 20 miles from Arendal, an experimental factory was erected on a spot where electric power to the extent of 500 kw. could be obtained from a waterfall. Six resident engineers and chemists and 20 workmen constituted an adequate staff. By this time the possibilities of the process had been sufficiently proved, and no time was lost in erecting the first commercial factory. A cheap electrical supply was the first consideration, but no less important was the question of convenience of shipping the products. The place chosen was Notodden in the Hittersdal, on the shores of the Hittersdal lake, whence there was water-communication through the canal to Skien, and thence either to Christiania or to Hamburg. The factory at Notodden, which is conceived on a scale competent in the first instance to turn out from 3,000 to 5,000 tons of product per annum, with ample room for extension, and a prospect of ample power from the neighbouring waterfalls, rose with surprising rapidity, and began regular operations in May, 1905.

But now it is necessary to speak of the products of the process. Nitric oxide fumes, as already mentioned, at once absorb a further quantity of oxygen from the unconsumed part of the air and turn to nitric peroxide, and this when treated with water combines to form nitric acid. But nitric acid, valuable though it is, is a most undesirable substance for transportation. It is obviously easy to absorb the acid in caustic alkali, and to produce nitrate of soda. But here two difficulties present themselves. Caustic soda is not a natural product in Norway and would require to be imported for the purpose; and the liquid formed by treating the nitric oxide with water contains nitrous acid as well as nitric acid, so that the product would be a nitrate of soda containing a considerable proportion of nitrite of soda. For some purposes the presence of nitrite would be objectionable, though, as recent experiments of Prof. Schloessing show, the prejudice against nitrite as a manure is largely unfounded. It was therefore decided to employ lime as the basic agent; and as a very pure limestone can be procured in any quantity in the neighbourhood, it is easy by merely leading the crude acid into vats containing limestone to produce nitrate of lime. The nitrite present can be eliminated by a further addition of nitric acid, the nitrous gases evolved being led back into the absorbing chambers and mixed with fresh gases from the furnaces and absorbed afresh. So it comes about that the product which the Nitrogen Company of Norway is putting on the market is neither nitric acid nor nitrate of soda, but nitrate of lime. This substance, which is not found anywhere native, though it undoubtedly occurs in small quantities in the economy of nature in calcareous soils, where plants are assimilating nitrates from ammonia, can be produced in several different states. It forms clear crystals containing four molecules of water of crystallisation. Secondly, if the liquor is concentrated by evaporation beyond this point a nearly anhydrous nitrate of lime is produced containing about 13 per cent. of nitrogen. Thirdly, by the further addition of caustic lime a basic nitrate of lime is produced which is quite anhydrous. The suggestion of this basic nitrate is due to Dr. Rudolph Messel of London. As will be presently shown, the nitrate of lime is, in proportion to the amount of nitric acid it contains, the equivalent as a fertiliser to nitrate of soda; and for certain kinds of soil the circumstance that lime, not soda, is its basic constituent is a positive advantage. Pure calcic nitrate, moreover, commands a market of its own in preference to nitrate of soda for certain uses in the chemical industry in the manufacture of colouring matters.

Very wisely, therefore, the Nitrogen Company determined, in starting their factory at Notodden, that they would confine its operations to the sole production of Norwegian saltpetre—that is, of nitrate of lime.

The research laboratory at Vasmoen, near Arendal, merits more than passing mention. There are here several kinds of furnace, including one of a new vertical pattern, of 250 kw. to 300 kw., and several others of different sizes. The laboratory is, in fact, a small factory equipped with every device for precision of measurement. Electrical measuring instruments are, of course, installed—voltmeters, amperemeters, wattmeters; also an oscillograph for study of the alternating currents. An electrical pyrometer measures the temperature of the air. Air meters and pressure gauges control the air supply. In the chemical laboratory daily records are kept of the titrations of samples drawn from the furnaces and from the liquors in the absorbing towers. It would be difficult to imagine a more thoroughly scientific equipment. It is not hampered by commercial routine, and has already undertaken the investigation of several other new chemical processes of kindred nature.

On the other hand, there is nothing experimental about the factory at Notodden. Though so recently erected, it bears the aspect of a regular industrial routine. The workmen go about their duties as if they had been brought up to them from boyhood; the hum of the furnaces resounds night and day. Boats come to the quay laden with limestone or depart charged with a cargo of sealed canisters of Norwegian saltpetre, en route for Skien.

Notodden was selected as the site for the first factory because of its advantageous situation for water-carriage and cheap electric power. There are three furnaces of 500 kw. each. Air is supplied by blowers at about 50 litres per minute per kilowatt. The hot gases first pass through a steam boiler where they give up part of their heat to raise some steam, then they enter two large oxidation chambers, through which they pass slowly and emerge at a temperature of some 50°C. to enter the absorption towers, about 50 ft. high, built of granite slabs and filled with lumps of quartz over which water trickles. The first tower yields a 50 per cent. nitric acid, the second about 25 per cent., the third 15 per cent., the fourth 5 per cent. The liquids from the fourth tower are raised by compressed air to the top of the third, those from the third to the second, those from the second to the first, thus gradually increasing in concentration up to 50 per cent., at which density it is drawn off. The gases then pass through a fifth tower in which they are treated with milk of caustic lime, and finally through a wooden tower over beds of dry quick lime. The 50 per cent. acid is treated with limestone to form nitrate of lime, which is concentrated as previously described, and poured molten into iron canisters ready for shipment. The number of workmen is surprisingly small, most of the processes being automatic. One single assistant engineer attends the three furnaces; and his principal duty is to enter in the log book every quarter-hour the readings of the electrical measuring instruments.

Though I am not at liberty to state the results of the tests made during my visit to the factory in August last, I may observe that Prof. Otto Witt, who was a member of the visiting experts, has publicly stated that, according to his observations, the yield was between 500 kg. and 600 kg. of anhydrous nitric acid per kilowatt-year, and that not infrequently higher yields were observed under varying conditions. If we take the lowest figure of 500 kg. per kilowatt-year, and assume the cost of electric power at 0·1d. per unit, this would make the cost of the pure nitric acid (so far as electric power is concerned) £7. 6s. per ton, and the nitrate of lime, containing 13 per cent. nitrogen, would cost (in power alone) £4. 10s. per ton. To this, of course, would have to be added the additional costs in labour and supervision, together with interest on capital outlay, rents, and the inevitable standing charges. But power, as obtained from the waterfalls of Norway, does not cost anything like 0.1d. per unit. At about half a mile from Notodden is the waterfall called Tinnfos, where the river Tinne or Tinnelf drops in a fall of some 40 ft. Here, some years ago, turbines were erected to take some 6,000 H.P., which was applied at first to a pulp factory. The engineering conditions were so favourable that the capital expenditure was under £5. 10s. per horse-power, and the cost of production per unit only about 10 kroners per horse-power-year, which is about $\frac{1}{40}$d. per unit. The owners of the pulp factory sell part of this power to the saltpetre factory at 23 kroners per horse-power-year, or at about £1. 14s. 4d. per kilowatt-year, or 0·047d. per unit, yielding them a handsome profit.

So, then, the manufacture of the Norwegian saltpetre calls for nothing, save the machinery, that is not found ready to hand: air, water, limestone and electric energy.

The whole output of the present factory being readily absorbed either for the local needs of agriculture or by the buyers at Hamburg, enlargement is already begun. The present works will accommodate five more furnaces, and Tinnfos has still some spare power. But within a few months a new factory, more than double the size of the present one, will be erected alongside, and the power for this must be brought from another source.

Three miles up the gorge of the Tinnelf is another waterfall, the Svaelgfos, which has some 29,000 H.P. of which 26,500 will be available. A barrage must be erected, sluices made and a canal cut for some 50 yds. down to the site of the power house. Already some 300 navvies are at work on the needful construction. When completed, in about 12 months' time, this power will be transmitted to Notodden, The cost of power from this fall, as delivered at the factory, will be under 8s. per horse-power per year—that is to say, less than 11s. per kilowatt-year, or 0·0151, that is $\frac{1}{66}$d., per unit.

But the projects of the Nitrogen Company of Norway do not stop with the enlarged factory at Notodden. They have acquired powers for the utilisation of three other waterfalls—Boilfos, near Arendal, with about 25,000 gross horse-power; Wamma, on the river Glommen on the Swedish border, with about 40,000 gross horse-power; and a still larger fall in Telemarken, the Rjukanfos. This fall is on the same stream as Tinnfos and Svaelgfos, but above the Tinnsjoe. In the heart of the mountains, behind Gausta, lies the lake Mjosvand, from which the river issues, and, after a course of about 3 miles, plunges down the Rjukan in a succession of falls, which give an available height of over 1,500 ft. Here there is about 300,000 H.P. at the maximum, of which a steady minimum can be utilised amounting to at least 220,000 E.H.P. In the lower valley a still larger factory will be built, now that the fall and its possibilities have been favourably reported on by Mr. Turrettini, the highest authority on water-power in Europe. In fact, nowhere else in

Europe is there a water supply which presents so favourable a field for the enterprising engineer.

Experiments have been made at the agricultural station at Aas by Messrs. Sebelien and Bastian Larsen to test the cultural value of the nitrate of lime. The fertilising properties of nitrate of lime appear to be, for equal amounts of nitrogen content, scarcely distinguishable from those of nitrate of soda. The Norwegian saltpetre appears to stimulate a slightly higher yield of grain, the Chili saltpetre a slightly higher yield of straw. In some tests on oats the Norwegian product gave a higher yield of both grain and straw. Prof. Schloessing of Marseilles has lately investigated the use of the Norwegian nitrate, as well as of the nitrites of soda and of lime. For maize the nitrate showed itself the equal of Chili saltpetre to within less than ½ of 1 per cent., and the nitrites showed themselves to be, for equal amounts of nitrogen content, slightly superior to the nitrates.

Let us return to the bearing of this development upon the wheat problem. If it is clear that not even all the waterfall power of Scandinavia, if devoted solely to the manufacture of nitrates, could yield an output equal to that demanded by agriculture it is at least clear that with the approaching exhaustion of the Chili nitrate beds the value of synthetic nitrates, which already can be produced in concurrence for the markets of Europe, will be of increasing value every year, and will at least help to preserve for the white races a few added years of relief from the impending crisis.

For us in Great Britain, though our coal does not furnish us with cheap sources of electric power which can be put into consideration beside those of Norway, the question is more vital than for any other nation. For Great Britain stands in a position differing from that of every other nation of the world, differing from that of any of her colonies, in that she alone, in order to support her population, must necessarily import four-fifths of her foodstuffs. This puts her economic condition into a unique case, and forces her to adopt an economic policy different from that of every other nation and colony.

This is pre-eminently a matter to be withdrawn from the region of passion and prejudice.

In the name of science, and for the dignity of deliberate reason, I protest against the thought that questions such as that of the food supply should be treated as pawns in the ignoble game of party politics.

The author has gratefully to acknowledge the courtesy of the Norwegian Nitrate Company in sending the model electric furnace used at this lecture for the demonstration of the Birkeland and Eyde process. He also returns his thanks to Mr. Bonnevie, assistant engineer of the Nitrate Company, for personally undertaking its transport and erection. His thanks are also due to the London Electric Supply Co. for the use of special appliances and cables installed for the supply of alternating current to the furnace in the lecture theatre, and to the British Electric Transformer Co. (Hayes, Middlesex) for the loan of the special step-up transformer needed to procure the required high voltage.

## THE MEASUREMENT OF HIGH FREQUENCY CURRENTS AND ELECTRIC WAVES.*

BY PROF. J. A. FLEMING, M.A., D.SC., F.R.S.

(*Continued from page 641.*)

### LECTURE III.—MEASUREMENT OF FREQUENCY AND RESONANCE.

We have seen in previous lectures that every electrical circuit containing a condenser and inductance when charged and discharged executes electrical oscillations with a certain definite period depending on the capacity and inductance. The circuit may therefore be compared to a pendulum which has a periodic time depending on its length. Suppose that we have two such oscillatory circuits placed near to each other in the right position; oscillations set up in one circuit will induce oscillations in the other circuit, and the circuits are said to be inductively coupled. They exercise a mutual action and reaction, and may be compared to two pendulums coupled together mechanically. Thus, for instance, suppose we have two pendulums of equal length hanging from a loose cross string, and that we set one pendulum swinging, it imparts little jerks to the cross string, and if the other pendulum has the same time period, this last will gradually be set in motion. But since action and reaction are equal and opposite, the driving pendulum must retard itself just as much as it accelerates its colleague, and therefore the energy is passed backwards and forwards, hence the pendulum that was started in motion is gradually brought to rest and the other one that was at rest is gradually set in motion. These states of rest and motion alternate for each pendulum. Two such coupled pendulums are called syntonic pendulums when they have the same time period or when one pendulum has a period which is the harmonic of the other. The same experiment may be shown with two pendulums, one of which is double the length of the other. It will not succeed, however, unless the natural time periods of the two pendulums are either equal or in some integer ratio. Similarly two electric circuits when inductively coupled act and react on each other if their time periods are equal or in integer ratio.

Returning to the pendulums, let us suppose that we take a trace of the motion of the bob of each pendulum, by causing it to mark its vibrations on a strip of paper which is moved uniformly across its motion. We should obtain a curve for each, similar to that in Fig. 24, waxing and waning as the amplitude of the pendulum motion is increased and decreased.

It is a well-known fact that such a curve as that shown in Fig. 24 is the resultant of two simple harmonic motions of slightly different period, and it is the graphic representation of the audible effect called beats in music, due to the simultaneous action of two sources of sound, say two organ pipes slightly out of tune with each other. Hence we may resolve the waxing and waning motion of each of the coupled pendulums into the sum of two simple harmonic motions of different period. Therefore the effect of coupling two pendulums of equal time period is to generate in each of them by their mutual re-action a compound oscillation, composed of two vibrations of different periods. The same thing holds good in the case of two electric oscillatory circuits or a pair of coupled circuits constituting an oscillation transformer. These are said to be closely or loosely coupled according as their mutual induction is large or small, the coefficient of coupling denoted by the letter $k$ being equal to $M/\sqrt{LN}$, where M is the mutual inductance of the two circuits, and L and N are the inductances of the two separate circuits.

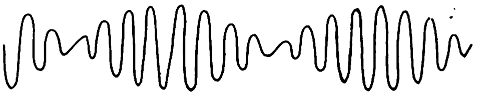

FIG. 24.—CURVE COMPOUNDED OF TWO SIMPLE PERIODIC CURVES OF SLIGHTLY DIFFERENT WAVE LENGTHS.

Suppose then we have two such circuits inductively coupled, and electric oscillations are set up in one of these circuits by introducing a spark gap into it and charging the primary condenser by means of an induction coil. We may so adjust the inductance and capacity of the other circuit that it has the same time period, and the circuits are then said to be syntonised or tuned. If we introduce into the secondary circuit a hot wire ammeter, and measure the effective value of the current in the secondary circuit, we find that in proportion as the secondary circuit is brought into tune with the primary circuit, so does this secondary current increase up to a maximum value which is called the resonance value. We can plot a curve called a resonance curve, ordinates of which represent the ratio of the maximum or resonance current to any other current and corresponding abscissæ represent the ratio of the natural frequencies of the two circuits (see Fig. 25). The form of this resonance curve will depend upon the nature of the coupling. If the coupling is very weak, then the resonance curve has one maximum value. If the coupling is stronger, then it has two maxima like the hump of a dromedary camel. When the tuning of the two circuits is not quite exact, theory shows that there are two sets of superimposed oscillations in the circuit. The resultant oscillation is the sum of these two. When the two circuits are not strongly coupled and are tuned to the same period $n_0$, then it can be shown that the frequencies $n_1$ and $n_2$ of the two resultant oscillations in the secondary circuit are given by the formulæ

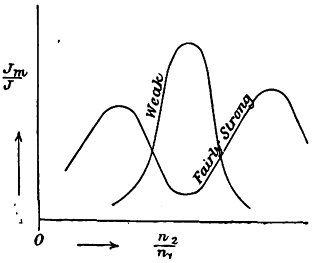

FIG. 25.—RESONANCE CURVES.

$$n_1=n_0\frac{1}{\sqrt{1-k}} \text{ and } n_2=n_0\frac{1}{\sqrt{1+k}}, \text{ where } k=M/\sqrt{LN}$$

and accordingly we have $n_1^2+n_2^2=2n_0^2$, $k=\frac{n_1^2+n_2^2}{n_1^2-n_2^2}$.

To illustrate and investigate these facts I have devised an instrument called the cymometer, which has proved itself to be exceedingly useful in connection with high-frequency measurements.*

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* Cantor lectures delivered at the Society of Arts, Nov. and Dec., 1905.

* Since this instrument and its applications were fully described and illustrated in *The Electrician*, Vol. LV., p. 1040, and in a number of recent notes, we give here only an abstract of the description given in the lecture.—ED. *E.*

The cymometer can be used for determining the frequency of oscillations in any circuit, or the capacity of a Leyden jar or the inductance of a coil of wire. A variety of other measurements can be made with the cymometer, which will suggest themselves if it is remembered that when the cymometer bar is placed parallel and near to any circuit in which oscillations are taking place, the scale reading when the vacuum tube glows most brightly, taken on the scale marked "oscillation constant," gives the square root of the product of the capacity reckoned in microfarads, and the inductance reckoned in centimetres of the circuit being tested.

The cymometer is most valuable as a teaching instrument to illustrate to a class or audience the laws of electrical resonance and the phenomena connected with the inductive production of electrical oscillations. It is in fact as useful in connection with high frequency oscillations as a Wheatstone bridge or potentiometer is in relation to the measurement of continuous electrical currents. The cymometer is contained in a strong wooden box fitted with handles. In the lid of this box the standard inductance is fixed. The over-all dimensions of the instrument are:—Length, 4 ft. 6 in. = 136 cm.; width, 1 ft. = 30 cm.; depth (with handle unscrewed), 6 in. = 15 cm.

We may employ this cymometer to prove the statement just made that in the case of two coupled circuits, oscillations of two frequencies are set up if they have the same natural time period. I have before me two rectangular circuits, each of which contains a Leyden jar. The two circuits have the same inductance and the same capacity; one of these circuits contains a spark-gap and we set up oscillations in it in the usual manner by an induction coil. When this is done, if we apply the cymometer to both these circuits, putting the bar of the cymometer first parallel to the secondary circuit and then parallel to the primary circuit, we find that in each of these circuits there are two oscillations, and that the vacuum tube of the cymometer illuminates itself for two positions of the handle of the cymometer. We can determime the natural period of vibration of each of the circuits by removing the secondary circuit and employing the cymometer in the above-described manner to measure the oscillations of one single frequency, then occurring in the primary circuit. We then find that the frequency of these two oscillations and also that of the natural oscillation are different, and comply with the formula given above; one of these oscillations in the coupled circuits has a greater value and the other has a lesser value than the natural frequency of both the circuits taken separately.

We can also employ this cymometer to determime the oscillations in a wireless telegraph antenna, as follows:—Place the cymometer with its copper bar parallel to the lower portion of the aerial wire and a few inches from it, then set the transmitter coil in action and move the handle of the cymometer until the vacuum tube glows most brightly. The reading on the scale will give the wave length both in feet and metres. It will in general be found that there are two positions of the handle in which the tube glows. These correspond to the two wave lengths sent out from the aerial. In making this experiment, and in fact in all cases in which the cymometer is used as above described, the copper bar should be placed as far from the circuit being tested as possible. If it is placed too far away, however, the vacuum tube will not glow under any circumstances, but if it is just brought near enough, a position will be found with a very sharp scale reading, in which the vacuum tube just glows.

In the previous courses of lectures I have explained the mode in which the oscillations in such an antenna throw off electric waves of definite wave-length. The relation between the wave-length $\lambda$ of the radiated wave measured in centimetres, and the frequency $n$ is given by the formula

$$3\times 10^{10}=n\lambda.$$

The frequency itself is expressed by the formula

$$n=\frac{5\times 10^6}{\sqrt{CL}}=\frac{5\times 10^6}{O},$$

where O is the oscillation constant $=\sqrt{CL}$. Accordingly we can determine the length of the radiated wave when we know the oscillation constant of the antenna. This can be at once determined by placing the cymometer near to it, and moving the handle of the cymometer so as to adjust its capacity and inductance until the neon tube shines most brightly. When this is the case, the scale reading of the cymometer shows its oscillation constant, and, therefore, also that of the antenna. The wave-length of the radiated wave is, therefore, given by the following formulæ:—

$$\lambda=\frac{3\times 10^{10}}{n},\quad n=\frac{5\times 10^6}{O}$$

$$\therefore\quad \lambda=\frac{3}{5}10^4 O,$$

or, $\lambda=6{,}000\times O$ cm. $=60\times O$ metres $=200\times O$ ft.

Accordingly the cymometer enables us to measure the wave-length of the radiated wave and hence its name from the Greek word κυμα = a wave.

In those cases in which we are using an antenna coupled to a closed syntonic circuit, waves of two wave-lengths will be thrown off from the antenna in accordance with the principles just explained. These waves have wave-lengths given by the formula

$$\lambda_1=\lambda_0\sqrt{1+k},\quad \lambda_2=\lambda_0\sqrt{1-k},\quad \text{where } \lambda_0=\frac{3\times 10^{10}}{n_0},$$

$n_0$ being the natural frequency of the antenna taken alone.

In such a case the cymometer shows us not only that there are waves of two wave-lengths thrown off from the antenna, but that these waves are of unequal intensity and damping. The wave which has the greatest wave-length has the least damping and the greatest energy. The wave lengths of these two waves are connected with the natural wave-length of the antenna taken alone by the formula

$$\lambda_1^2+\lambda_2^2=2\lambda_0^2,$$

and the coefficient of coupling of the oscillation transformer can be shown to be given by the formula*

$$k=\frac{\lambda_2^2-\lambda_1^2}{\lambda_2^2+\lambda_1^2}.$$

For certain reasons it can be shown that the best results are obtained in the case of inductively coupled antennæ when the coupling coefficient $k$ has such a value that one of these radiated waves has three times the wave-length of the other.

The damping of the two radiated waves of different wave-lengths is, as already observed, different, but the decrements of the two waves are related to the decrements of the primary and secondary circuits when taken separately, and this relation has been determined by a formula, due to Drude. If $\delta_1$ is the decrement of the primary or condenser circuit with the spark-gap when taken alone, and if $\delta_2$ is that of the antenna taken alone, then Drude has established the following relations:—

$$D_1=\frac{\delta_1+\delta_2}{2}\,\frac{n_1}{n_0},\qquad D_2=\frac{\delta_1+\delta_2}{2}\,\frac{n_2}{n_0},$$

where $D_1$ and $D_2$ are the decrements of the two waves of wave-length $\lambda_1$ and $\lambda_2$ thrown off by the antenna. We see from the above formula that if we make $k$ nearly unity or employ a very strong coupling, we can make one of the waves radiated from the antenna have much less damping than would be the case for a plain antenna alone. This establishes the importance of the inductive coupling of an antenna with a condenser circuit.

We can make use of the cymometer to show that high-frequency oscillations are confined entirely to the surface of conductors. If we construct two circular loops of wire, one of copper and one of iron, of exactly the same size, then we find on attempting to measure the inductance of these loops with a cymometer, as above described, that the iron loop damps out the oscillations and that it is difficult to obtain a reading with the iron wire. The cymometer has to be brought much closer to the primary circuit to cause the neon tube to glow. If, however, we employ a galvanised iron wire of the same diameter and length as the iron wire, or if we deposit electrochemically on the plain iron wire a thin coating of copper, we find that the inductance is the same as that of a copper wire and that the damping of the oscillations as shown by the behaviour of the neon tube is the same as if the wire were zinc or copper.

We can also use the cymometer most advantageously to compare dielectric constants, or if we measure the capacity of a plate condenser formed of two thin plates of metal close together in air, and then insert a sheet of glass or ebonite between the two and measure the capacity again, the ratio of these capacities gives us the dielectric constant of the insulator. It is not difficult to show by experiments of this kind that the dielectric constant of glass becomes reduced if the frequency is increased.

A simple formula for the capacity of an air condenser formed by two parallel plates is as follows:—Capacity in microfarads = area of plate in square centimetres divided by thickness of air space in centimetres multiplied by 11,060,000. I have found this formula useful in connection with experiments on high-frequency circuits.

(*To be concluded.*)

**The Royal Society.**—Among the Papers down for reading yesterday were the following:—"Polarisation in Secondary Röntgen Radiation," by Dr. C. G. Barkla, communicated by Prof. J. J. Thomson, F.R.S.; "Ionic Size in Relation to the Physical Properties of Aqueous Solutions," by W. R. Bousfield, K.C., communicated by Prof. J. Larmor, F.R.S.; "On Periodicities in Sunspots," by Prof. A. Schuster, F.R.S.

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* For the proof of this and other formulæ given in this lecture the reader is referred to the author's treatise on "The Principles of Electric Wave Telegraphy" (Longmans & Co.), or to the German work, Dr. J. Zenneck, "Elektro-magnetische Schwingungen and Drahtlose Telegraphie."

## PHYSICAL SOCIETY.

At a meeting of the Physical Society on January 26th, Prof. J. H. Poynting, F.R.S., President, in the chair, a Paper on

### "The Use of Chilled Cast Iron for Permanent Magnets"

was read by Mr. A. Campbell. The experiments described were undertaken with a view to corroborating and extending the results already obtained by other experimenters. A good many years ago Mr. J. R. Ashworth showed that rods of chilled cast iron could be made into very fair permanent magnets, and last year Mr. B. O. Peirce, of Harvard University, published an interesting research on the subject, going considerably farther and describing the practical utility of chilled cast iron for magnets of moving-coil galvanometers and other instruments. His tests, although conclusive in many ways, did not in general give any absolute values (for permeability, &c.). The present investigation was made on rings in addition to rods of the standard dimensions usual in testing magnet steels. All the specimens were heated to 1,000°C. and then chilled in cold water, care being taken to support them during the process, as cast iron is very brittle at such a high temperature. The rods were tested for maximum remanent B and coercivity by Madame Curie's method, the magnetised bar being placed in a long solenoid producing a demagnetising field which was gradually increased until a search coil slipped along the bar showed that the demagnetisation was complete. The results showed the chilled cast iron to be not very inferior to ordinary magnet-steel. By ballistic tests on the two rings their permeability curves were obtained, and these indicated that the simple process of chilling used was quite satisfactory even for a tolerably massive ring of 6 sq. cm. cross-section. The cheapness and ease of working cast iron should encourage instrument makers to test its capabilities in various instruments.

Mr. W. H. PRETTY asked the author what kind of cast iron he had used in his experiments. The physical properties of cast iron varied with the chemical composition, and it was important that the kind of iron used in the experiments should be stated.

Mr. CAMPBELL, in reply to Mr. Pretty, said the iron used was grey commercial cast iron, but Mr. Ashworth had tested several kinds, and found very little difference in their magnetic properties.

A Paper by Prof. Lyle and Mr. Baldwin,

### "On Experiments on the Propagation of Longitudinal Waves of Magnetic Flux along Iron Wires and Rods,"

was read by Prof. F. T. Trouton. The experiments described in the Paper were undertaken with the object of determining if there is a definite rate of propagation of magnetism in iron. The method adopted was to produce magnetisation at a particular point on a bar by means of a coil through which an alternating current was passed and then to observe the magnetic flux at various distances from the coil by means of a small secondary coil, free to be moved to various places on the bar. By the use of Prof. Lyle's wave-tracer the magnetic flux at various points along the bar was thus obtainable. The wave curve was then analysed by Fourier's series. Various curves given in the Paper show the value of the constants in Fourier's series and of the lag in the magnetisation as the coil was moved along the bar. Contrary to what had been observed in previous researches, the authors found that the phase lag, instead of continuously increasing along the bar, reached a maximum value and then diminished, proving the absence of true wave propagation.

Prof. TROUTON read a letter from Mr. A. W. Porter pointing out that the occurrence of a maximum in the phase lag was exactly what was to be expected on any theory which made the lag depend upon a direct power of both permeability and distance.

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Modern Turbine Practice and Water Power Plants." By John Wolf Thurso. (London: Constable & Co., Ltd.) 16s.

"The Seven Follies of Science." By John Phin. (London: Archibald Constable & Co., Ltd.) 5s. net.

"Radiography and the 'X' Rays." By S. R. Bottone. 2nd edition. (London: Whittaker & Co.) 3s. 6d. net.

"Lehrbuch der Physik." Edited by Leop. Pfaundler. 2nd edition. Vol. I., Part 2. (Brunswick: Friedrich Vieweg und Sohn.) 3·50m.

"Central Station Electricity Supply." By Albert Gay and C. H. Yeaman. 2nd edition. (London: Whittaker & Co.) 10s. net.

"Matriculation Directory." (Cambridge and London: University Tutorial Press Ltd.), 1s.

"Proceedings of the Royal Society." Series B. Vol. LXXVII. No. B. 516 Biological Sciences. (London: Harrison & Sons.) 3s. 6d.

"Les Procédés de Commande à Distance au moyen de l'Électricité." By Régis Frilley. (Paris: Gauthier-Villars.) 3f. 50

## FARADAY SOCIETY.

At the meeting of the Faraday Society held on Tuesday, January 30th, 1906, Prof. A. K. Huntington in the chair, an abstract of a Paper on

### "The Electric Furnace: Its Origin, Transformations and Applications" (Part III.)

by M. Adolphe Minet was read. The previous sections of the Paper, which was of a classificatory and historical character, dealt with the first or laboratory period of the development of the electric furnace. The second period, inaugurated by the researches of the brothers Cowles and Héroult (1886-1887), saw the birth of industrial furnaces and the beginnings of three new industries—the electro-metallurgy of aluminium, the electro-metallurgy of sodium, and the preparation of refractory materials. The present Paper dealt almost entirely with the first of these industries. The methods for the manufacture of aluminium were divided into two principal groups—electrothermic methods, which produce the metal alloyed with copper or iron or combined with carbon, and electrolytic methods, which yield pure aluminium. The furnaces of Cowles, Borchers, and Willson, the early types of the Héroult furnace, and the Minet "mixed" furnace were described, among others, under the former heading. The principal electrolytic furnaces dealt with were those of Héroult, Minet and Hall, and finally some of the more recent suggested improvements in the electrometallurgy of aluminium were briefly outlined.

Mr. E. RISTORI added some interesting details in connection with the early work of Héroult and others. Kleiner, in 1885, had unknowingly decomposed bauxite and produced small quantities of aluminium.

Mr. W. M. MORRISON pointed out that Héroult's invention was actually made in 1885, although his patents only dated from 1887.

Dr. O. J. STEINHART referred to recent patents of Hall for purifying bauxite electrolytically, and of Bett for depositing pure aluminium from an impure electrolyte.

Mr. BERTRAM BLOUNT said that, although the purification of the bauxite was the whole crux of the aluminium problem, yet now there might be found uses for impure aluminium in connection with "thermit" welding. He discussed some of the developments that had taken place in the general design of electric furnaces.

Mr. F. W. HARBORD, in reply to a question, said that calcium might, if it could be made cheaper, replace aluminium for getting rid of over-oxidation in steel, but it had not yet been really tried.

Dr. J. A. Harker then gave a demonstration of a solid electrolyte tube furnace. The furnace was designed for uses in which the presence of hydrocarbons or other reducing gases, inseparable from a carbon tube furnace, was undesirable. It had, in particular, been used for calibrating thermo-couples and determining the melting point of platinum, which the author gave as 1,703°C.-1,713°C. The furnace was practically an overgrown Nernst lamp, consisting of a tube made of a mixture of zirconia and 10 per cent. yttria, which was squirted through a die and then baked. The small type shown in operation was $2\frac{1}{2}$ in. long between the contacts. When taking 1 ampere at about 120 volts a temperature of 1,600° C. was attained. The tube was made conducting either by heating direct, or else by surrounding it with an external nickel heating coil, separated from it by a layer of pure zirconia, the combination forming a "cascade" type of furnace. Special attention had to be paid to the contact of the platinum leading-in wires and the tube. With regard to the mechanism of conduction through Nernst conductors, the author thought that a comprehensive and satisfactory theory was at present lacking. It was, however, certain that the conduction was electrolytic, because by pumping away the atmosphere surrounding a Nernst glower, to prevent recombination, a metallic filament could ultimately be obtained.

Mr. BERTRAM BLOUNT thought that no special mechanism was needed to explain solid electrolysis. Ordinary transference of ions would take place in a semi-plastic mass.

Dr. T. M. LOWRY referred the author to the dissertation by Reynolds. The conduction was similar to that which occurred in hot glass.

A Paper entitled

### "Note on the Production of Ozone by Electrolysis of Alkaline Fluorides"

was communicated by Mr. E. B. R. Prideaux. When a concentrated aqueous solution of hydrofluoric acid or of a fluoride was electrolysed, the action of nascent fluorine on the water produced ozone in considerable quantities, and this might, conceivably, have commercial importance. The electrolysis of potassium fluoride was more promising than that of hydrofluoric acid; with dilute solutions of the latter only 0·23 per cent of ozone was easily obtained by the author. The largest yield obtained with the former, however, was only 0·65 per cent. of ozone in 20 minutes. Variations of C.D. did not much affect the yield, but this fell off as the duration of the experiment was increased. The experiments were made in a U tube of thin glass coated inside with paraffin and vaseline and immersed in ice-water. The cathode was of copper, and the anode of plantinum.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

*Mariner's Compass.*—E. Kohlschütter discusses the present position of the fluid compass in comparison with the needle-point compass on shipboard. It appears that the needle-point or dry compass is the more easily compensated of the two. The compensations are carried out by the methods indicated by Lord Kelvin and by Hechelmann. But in the German Navy the fluid compass alone is used. It was found that the dry compass suffered from long-lasting vibrations and tremblings, induced by mechanical and magnetic deflections due to shooting and the turning of the gun towers. By vertical shocks the needle and cap were rapidly worn out, and as soon as they suffered the least damage the compass became unreliable or failed entirely. The chief disadvantage of the fluid compass is that, in spite of high magnetic moments, it does not rotate easily and is carried round when the vessel is rapidly turned. This the author proposes to rectify by using electromagnetic needles instead of permanent magnets. The sextantal and octantal deviations can be got rid of by a suitable placing of the needles. If two needles are used, the lines joining their opposite poles should include an angle of 60 deg. If four needles, the angles should be 30 and 90 deg. Slight faults in the placing lead to serious deviations.

[E. Kohlschütter, *Deutsche Mechanikerzeitung*, January 15, 1906.]

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*Heating Effect of Röntgen Rays.*—H. A. Bumstead concludes a lengthy Paper by the following somewhat startling conclusions: "The present experiments indicate that when Röntgen rays are equally absorbed in lead and in zinc, approximately twice as much heat is generated in the lead as in the zinc. It does not appear possible to attribute this result to errors in the measurements or in the theory underlying the experimental method. To account for this effect the writer has been able to think of only one hypothesis which is not in more or less direct conflict with experimental facts. This hypothesis is that by means of Röntgen rays the atoms of certain elements may be artificially broken up, and that the energy thus liberated forms a part (and perhaps the greater part) of the energy which appears when the rays are absorbed by matter." The only metals hitherto compared were lead and zinc. The author used a strip of lead 0·30 mm. thick and a stip of zinc 0·82 mm. thick, and they gave about the same absorption of $\alpha$-rays. They were mounted on an ebonite disc close to a radiometer with transparent vanes and opaque walls, used for measuring the temperature. The experiments were carried out at the Cavendish laboratory. The strips were both covered with aluminium leaf so as to have the same emissivity. The amount of heat steadily generated in lead under the influence of Röntgen rays is 1·93 times the amount generated in zinc.

[H. A. Bumstead, *Philosophical Magazine*, February, 1906.]

*Theory of Magnetism.*—Since, on the modern view of the constitution of matter, solids are supposed to be aggregates of crystalline groups, any theory of magnetism must be founded upon the magnetic behaviour of crystals, and more especially of the cubic system to which the magnetic metals belong. With the material accumulated by Weiss, W. Peddie investigates the constitution of the molecular magnets in iron, and finds that the absolute value of the magnetic susceptibility of a molecule containing three atoms of iron is $5 \times 10^{-26}$, as deduced from observations on dissolved salts of iron. This may have to be increased some 20 times, as it implies a molecular size as many times smaller than that found by means of the kinetic theory. Speaking generally, the theory of molecular magnetism, when applied to magnetic crystals of the cubic class, leads to results which are in good general agreement with observation. Wallerant's formula is correct in mathematical form, but should be interpreted with reference to internal force instead of magnetisation. It is possible that parallel investigations of the properties of other assemblages having cubic symmetry may shed some light on the actual arrangement of the molecules. It is evident that the Boscovichian theory of the constitution of matter is capable of being applied to magnetic properties.

[W. Peddie, *Proceedings*, Royal Society of Edinburgh, 25, 12, 1905.]

*Radio active Transformations.*—The theory of the transmutation of the chemical atom, upon which Rutherford and Soddy have based their explanation of radio-active phenomena, is capable of accounting for very many of them, and of reconciling them with the principles of the conservation of matter and of energy. But P. Gruner points out several particulars in which the mathematical theory of transmutation may be improved. It may be assumed that radio-activity is a manifestation of the spontaneous transmutation of atoms. Each successive transmutation takes place according to a simple exponential law with invariable constants. It may further be assumed that the intensity of the radio-active effects is proportional to the rate of disintegration of the atoms. If $N_1, N_2 \ldots$ are the numbers of transmutable atoms of successive kinds in the substance, the law of transmutation may be expressed mathematically in the form: $-\frac{dN_1}{dt} = \lambda_1 N_1$; $-\frac{dN_2}{dt} = \lambda_2 N_2 - v_2 \lambda_1 N_1$, &c. The author integrates these equations for some simple cases, and proves that the constant governing the third transformation of radium is a little more than one-tenth of the constant governing the fourth transformation. This would mean that, contrary to Rutherford's assumption, the transformation of radium B into radium C cannot take place entirely without the radiation of electrons. The author finally warns physicists against the surreptitious introduction of auxiliary hypotheses into radio-active theory.

[P. Gruner, *Annalen der Physik*, No. 1, 1906.]

*Terrestrial Magnetism.*—W. Maunder studies the connection between sun spots and magnetic disturbances. The former may be regarded as minor symptoms of solar eruptions. The streams of erupted matter have an angular diameter of not more than 20 deg. That in spite of this thinness and the earth's smallness so many of the streams influence the earth may be accounted for by supposing that they need not impinge upon the earth, but may act by induction. Perhaps the sudden magnetic storms are due to streams impinging upon the earth, and the more gradual ones due to induction. The streams do not necessarily emerge normally to the sun's surface.

[W. Maunder, *Astrophysical Journal*, 21, 1905.]

*Radiant Matter from the Sun.*—That the aurora and magnetic disturbances are due to streams of matter radiated by the sun is sometimes doubted on the ground of a lack of periodicity. But J. M. Schaeberle shows that a periodicity cannot be expected unless it is assumed that all such streams have the same initial velocity, which is improbable. An initial velocity of 376 miles per second would enable the streams to just touch the earth's orbit and then fall back. An initial velocity of 382 miles per second would send the matter out to infinity. At intermediate velocities the streams would cut the earth's orbit the second time after 27 to 65 days. Such streams, encountered by comets, may account for fluctuations in their luminosity.

[J. M. Schaeberle, *Astronomische Nachrichten*, 169, 1905.]

*Interstellar Atmosphere.*—A. Schmidt seconds Mendelejeff's bold attempt to determine the physical and chemical properties of the substance filling all space. He attempts to calculate the molecular weight of the substance, and finds it to coincide with that of the electrons. The data available for the calculation are the gravitational potentials at the surface of the atmospheres of the earth and the sun, and the temperatures of those regions. The velocity of a body after falling from infinity into the sun would be 608,000 metres per second, and at the earth's surface it would be 43,000 metres per second. The average velocity of a hydrogen molecule at freezing point is 1,840 metres per second. Hence the equation for the molecular weight,

$$\mu/2 = \frac{1{,}840^2}{273(608{,}000^2 - 43{,}000^2)}(T_2 - T_1),$$

where $T_2$ is the absolute temperature of the sun's surface, and $T_1$ that of the upper atmosphere of the earth. The former is probably 7,000 deg. absolute, and the latter 200 deg. absolute. These figures would give $\mu = 0{\cdot}00047$, or $\frac{1}{2000}$ that of the hydrogen molecule. This is very close to the value assigned by Wiechert to the electrons, so that these may constitute the attenuated atmosphere of interstellar space.

[A. Schmidt, *Physikalische Zeitschrift*, February 1, 1906.]

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The success or failure of the project as regards the achievement of the high ideal in view, depends entirely on the choice of the right men as exponents of the subjects to be taught. Not only must the information imparted be theoretically sound, but it must also embody the very latest knowledge and developments arising from experience in each branch of applied science dealt with. This can only be secured by the employment as teachers of men who are themselves acknowledged experts and leaders in the industries they represent, at salaries commensurate with their skill as specialists. For the higher technical education that is to be given at this new college,—an engineering education which is to reach a far more advanced point than that attained at any of our existing institutions—it is the expert who has done the work himself who is required rather than the professional teacher. Remarkable as his power of imparting ideas to others may be, the experienced professor can never have had the opportunities of himself obtaining that knowledge of the subtleties of the inner workings of the advanced portions of his subject possessed by the specialist. It must not be thought that we are urging an unduly utilitarian point of view, for no one could be more opposed than we are to the mere presentation to the student of a multitude of facts and methods of practice without a solid and scientific foundation. We take it that, in this case, however, the students who will be catered for by the proposed institution will have already acquired the scientific habit of mind and not be youths who have yet to be taught how to learn. It is only by restricting the class of student to those who will really benefit by instruction in the most advanced portions of the subject that a continued repetition of elementary matters can be avoided which only too frequently renders the treatment of the higher parts of the subject in technical institutions too brief through lack of time.

Passing on to the question of the relations of the new institution to the University of London, the Report sets forth opinions both for and against control by the University, and takes up a non-committal attitude on the matter. In our opinion the question of University or independent control is one which can well wait to be settled until after the scheme is under weigh. Provided efficient men are chosen to direct affairs, it matters little what are the exact relations with the University of London. The appointment of a Royal Commission may eventually take place to settle this open question, but the final decision of this comparatively minor point must not be allowed to delay the foundation of the new Imperial Technical College. The object of the college will be, not to teach students to pass examinations, but to enable them to commence their career fully imbued with a knowledge of the exact scientific and engineering aspects of their profession, and ready to apply their talents to the improvement of the industries of the Empire.

## REVIEWS.

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**Motive Power and Gearing for Electrical Machinery:** A Treatise on the Theory and Practice of the Mechanical Equipment of Power Stations for Electricity Supply. By the late E. Tremlett Carter. 2nd edition. Revised in part by G. Thomas-Davies. (London: "The Electrician" Printing & Publishing Co.) 12s. 6d.

This is a really valuable text book for engineering students and engineers generally. The author has taken pains to write clearly and concisely, not using the higher mathematics more freely than is absolutely necessary, and the book is planned and classified so as to make its various sections harmonise and lead up to conclusions in a specially useful manner. All the fundamental principles and useful applications of every known class of motive power are given. The revised edition shows evidence of great care to include all the most recent applications. One has referred to the index for details rarely given in such text books, only to find in almost every case one's search rewarded and the details thoroughly explained.

Part I. contains lucid definitions of the fundamental principles and their relations to the fundamental units, with the usual equations; gives an excellent and graphic description of "load factor" and influence of capital cost upon working costs. An interpretation of the economic law of design may be especially recommended to the reader. The author deals with the various methods of measuring power, and one would prefer to see a description of Froude's dynamometer, for example, given here (with the other instruments described) rather than later in the book. The same remark applies to the steam indicator. One hardly agrees that "it is often necessary . . . to have the engine and dynamo at a considerable distance apart" in these days, or that it is correct to include "electric current" under "kinetic energy." A slight slip also occurs on p. 7, where wave engines are included under "Wind Power," which obviously come under the category of "Water Power." The term "electric current" is frequently used where the term "electric energy" might be adopted with greater accuracy. On p. 7 also the area of a rectangle is given as "OHHJ" where it is obviously "OHJT." Part I ends with a clear explanation of the principles and economies involved in the storage of energy.

Chapter II. is especially admirable, and to be recommended to the electrical engineering student, as it deals comprehensively with the economic principles involved in central station design and management. The influences of plant and general load factors are clearly explained, and are such as one has not met with in a text book before. The author states that the average load factor of English electric lighting stations "is not more than 10 to 12 per cent." This statement requires modification, and a reference to diversity factor and its economical influence would have been useful.

Part II. is devoted to a treatise on fuels and the economical values of various coals, and the physical properties of combustion, which are given in a very practical way. Chapter IV. deals with thermodynamic principles in a concise and readable manner, and in itself is a complete and useful physical treatise on this subject. Not only does the author deal with the scientific aspects, but with the more practical details of the influences of changes of temperature on cylinder walls, piston speeds, and concludes this section with a clear explanation of the $\theta\phi$ diagram. Chapter V. deals with the physical properties of steam, and also such practical points as the flow of steam in pipes, and the influences of wire drawing, &c. The author then naturally deals with the various types of boilers and furnaces—forced and induced draught—chimney design and mechanical stokers. An unusual but useful table is given of the floor spaces required by various types of boiler, and is one of the details included in this book which emphasise in particular its value to the central station engineer. Feed pumps and economisers are dealt with, but one misses any practical reference to boiler or steam pipe coverings, or, in the feed-water section, to softening or the extraction of oil. The book covers so wide an area that it is easy to omit some of these details, and one hopes they may be included in future editions. The drawings of power stations given as types, represent somewhat out-of-date practice, and more modern examples might be given with advantage, and also a tabulated statement of the economies of superheated steam, which is, however, dealt with more fully in a later chapter.

Chapter VII. is devoted to the theory and practice of steam engines; deals with the losses arising from steam leakage and cylinder condensation, and so forth; and the physical principles involved in engine regulation from valve settings, governors and flywheels. Willans' law and its relation to station economies is, of course, given. The author then proceeds to deal with engine details and descriptions of valve gears as are usually found in steam engine text books, but a special reference is made to condensers and water-cooling arrangements. One notices the omission of the barometric condenser. Chapter IX. is a description of typical steam engines, but cannot be said to be quite up to date, and the steam turbines given are practically limited to one type. One would suggest some amplification in this respect. The testing of steam engines, their application to the driving of electrical generators and the practical details involved, more particularly in alternator running, are very clearly dealt with.

Part III. deals with gas and oil engines, and describes the various gas producers and gas storage, followed by a description of the several types of gas engine, and their application as prime movers to electricity, and naturally includes methods of testing.

The book is so catholic that it contains a treatise even on hydraulics, not only dealing with the fundamental equations, but with the practical data involved in their practical application. Even the civil engineering side, such as construction of reservoirs and *barrages*, is dealt with. The various forms of water turbines and wheels are, of course, included.

Part V. almost appears to be unnecessary, dealing with various kinds of gearing, such as belts, chains, worm gearing, and so forth; pulleys, ropes, clutches—indeed, what is there not to be found? This chapter requires some revision, as it speaks of Manchester as still having belt-driven generators at one of its power stations, which is not the case. This section is presumably necessary to make the book complete, though it appears to be somewhat redundant and antique when applied to electrical driving.

The book concludes with descriptions of some really modern and admirable examples of power stations, and some appendices of the latest developments, such as thermal storage, Diesel oil engine, suction and pressure gas producers. The keynote of this work is its thoroughness and completeness, and yet the descriptions are given with clearness and lucidity, and an enormous amount of information is compressed within its 600 odd pages. Any subject almost which one requires to look up in connection with prime movers as applied to electricity is to be found in it, and it is bound to be a useful addition to an electrical engineer's library.

JOHN F. C. SNELL.

**Mica: its Occurrence, Exploitation and Uses.** By FRITZ CIRKEL. (Ottawa: Mines Branch Department of the Interior.)

Acting under instructions from the Mining Department of the Dominion of Canada, the author has brought together a valuable and exhaustive collection of data and information respecting his subject, especially as regards the Canadian mica industry. In view of the very general use of mica as an insulator, this monograph is of considerable interest to the electrical engineer. Of the group of crystalline minerals which can be split into thin transparent sheets included in the term mica in its broader sense, three only are of commercial importance—muscovite or potash mica, ranging in colour from pale yellow to ruby; phlogopite, the amber-brown magnesia-alumina mica found principally in Canada; and the black magnesia-iron mica known as biotite. Details of the crystalline form and hardness are given, and it is stated that the softer specimens are the best fitted for electrical purposes. The author is of opinion that, although some chemists have synthetically produced small artificial mica crystals, it is not likely that crystals of the size required in commerce will ever be produced artificially. All the three varieties of the mineral are found in Canada, but muscovite is also worked in India and the United States.

After some geological notes on mica deposits, an account is given of the methods of mining employed in Canada, accompanied by descriptions of all the prominent Canadian mines. The systems seem somewhat crude compared with the mining of other materials, but it must be remembered that the peculiar location of the crystals and the care required to extract them without damaging the sheets render the quicker mechanical methods of other kinds of mining generally inapplicable. Hand drilling, therefore, is usual when blasting is to take place near the deposits, and the holes are only lightly loaded, the object being just to loosen the rock preparatory to taking it down with the mica by picking, or, in the case of very valuable crystals, with hammer and chisel. Some idea of the percentage of mica obtainable from the rock may be gathered from the fact that on the average at least 750 lb. of "thumb-trimmed" mica must be extracted from every 100 tons of rock to make a mine a paying concern. Over 80 per cent. of the output of a mica mine results in sheets of a less size than 2 in. by 3 in., and a very small proportion is over 4 in. by 6in. Some 10 or 12 years ago only the sizes of 2 in. by 4 in. and upwards were in demand; anything smaller was hardly saleable. To-day, owing to the introduction of micanite, built up of thin layers of mica fixed together by a special shellac cement, the demand is chiefly for the smaller sizes.

The crystals when removed from the mine are split up into sheets about $\frac{1}{16}$ in. thick, to remove damaged films and inclusions of foreign matter. The sheets are then sorted and packed, and sent to the trimming works, one of the largest of which is owned by the General Electric Co. at Ottawa. Much of the scrap and waste is used for the manufacture of ground mica of which a quantity is required for various purposes. The increase in the mica trade in Canada has been considerable during the last 10 years, and the prospects seem at present bright. The applications of mica for other than electrical purposes are numerous, ranging from windows and screens of various kinds to paints, lubricants and coverings for steam pipes and boilers. The qualities best for electrical purposes must split easily, and be flexible, smooth and soft. Colour does not seriously affect its insulating power, but the presence of magnetite inclusions renders it useless for this purpose. The insulating properties of micanite are quite as good as those of sheet mica; it can be obtained in sheets of any size and can be moulded to any form.

It is not, we think, so generally recognised as it should be that the insulating properties of mica are greatly impaired by contact with oil. The results of experiments are quoted by the author to show that in some cases a light coating of oil will cause a piece of mica to break down with only half the voltage which it would previously withstand.

In comparison with East Indian mica, the Canadian product seems not only to hold its own, but to be in some respects even superior. India, however, ranks foremost among the mica-producing countries of the world. It employs more persons in the industry than any other country, and the area covered by mica deposits is the largest so far known. The method of obtaining the mineral in India is entirely different from that employed in the Canadian mines. No explosives of any kind are used, but fires are kindled against the face of the lode, and when the walls are sufficiently heated, water is thrown on them, which causes the rock to crack. Wedges of soft iron are then driven into the cracks and in this way large boulders are detached, from which the crystals are chiselled out. After giving figures of the output of mica in various parts of the world, the book concludes with a bibliography followed by a well-arranged index.

**Landolt-Bornstein Physikalisch-chemische Tabellen.** 3rd edition, revised and enlarged. By Dr. RICHARD BORNSTEIN and Dr. WILHELM MEYERHOFFER. (Berlin: Julius Springer. London and Oxford: Williams & Norgate.) 36s. net.

The long-expected third edition of this admirable work comes none too soon for the large number of physicists and chemists who found the previous editions indispensable, but who were anxious for an up-to-date collection of tables containing the results of the latest physical and chemical measurements. The greatly enlarged scope of the new edition somewhat delayed the completion of the work, so that the literature could not be embodied further than the end of 1901 for the earlier parts of the work, comprising the mechanical properties of bodies. But the practice of giving the authorities for all figures, and of placing each table under the care of a specialist who signs his name to it, has been retained, and will do much to preserve and enhance the confidence of the scientific public in this monumental compilation. Among the tables which have been newly added are those on thermoelectric force, spark potentials, magnetic properties, physical dimensions, E.M.F.s and terrestrial constants. But, useful as these new tables are, they are far from being as complete in their way as, for instance, those on viscosity, capillary constants or specific heats. This may be due to the necessity of respecting the claims of chemistry and chemical physics, and if purely physical constants were similarly elaborated it would become impossible to confine the material within two moleskin covers as at present. The printing is well done and curves have been added where desirable. The proof-reading appears to have been done very carefully, and even minor typographical errors, as on page 427, line 11, and page 466, line 16, are conspicuous by their rarity. We have no hesitation in commending this great work as an indispensable adjunct to the laboratory, and a treasure-house for physical research.

## THE RECTIFICATION OF ALTERNATING CURRENTS.*

BY P. ROSLING.

Neither the motor-generator nor rotary converter are in the immediate future likely to be superseded for the conversion of large powers at comparatively low potentials from alternating to continuous current, but for smaller powers there are now two systems of rectification in commercial operation, both of them having the supreme advantage of having no moving parts—viz., the electrolytic rectifier and the mercury arc rectifier.

*The Electrolytic Rectifier*† consists of plates of an alloy mainly composed of aluminium, acting as cathode, suspended in a solution of borate or phosphate of ammonium or other salt capable of rapidly altering the condition of the polarising layer or film formed on the passage of an alternating current, such as salts of tartaric, oxalic, acetic, or gallic acids; the electrolyte may be contained in lead cells which would then form the anode.

When a single-phase alternating current is switched on to such a combination, if the direction is positive from the lead to the aluminium, it passes on through the circuit; if, however, the direction is positive from the aluminium to the lead, a polarising insulating film is immediately formed on the lead, which offers a high resistance and opposes the passage of the current. When the polarity reverses and the current flows from the lead to the aluminium plate, the film undergoes alteration and the current passes readily. If only one semi-phase is required, a single cell is sufficient, giving an interrupted unidirectional current of as many pulsations as the periodicity of the alternating-current circuit. In usual practice both semi-phases are used, either by grouping four cells, as in the Leo Gratz method, so that they allow the current to pass through two cells in series, turn and turn about, as shown in Fig. 1, or as in the Churcher method, where one platinum or lead plate and two aluminium plates are suspended in one cell, the current coming through the working circuit from the middle point of a reactance coil (Fig. 2).

In Fig. 1 the path of the current during one semi-cycle is shown by the arrows. It passes through cell V″, the accumulator and V‴, the insulating film forming on V′, the aluminium to lead path, preventing the current short-circuiting across to the other side of the A.C. circuit; on the reversal of the polarity the current flows through V′, the accumulator and V″″, V″ now forming the "closed door." The current thus passes in the same direction through the accumulator in pulsations of twice the periodicity of the alternating-current circuit. Fig. 2 shows the Churcher arrangement. The path during one semi-cycle is shown by arrows—from the middle point of the reactance coil current passes through the accumulators and the rectifier cell V. On reversal of polarity, the current flows through the other half of the reactance coil, the accumulators and the other half of the cell V.

In both systems the reactance coil can be arranged with multiple tappings so that the correct E.M.F. for the work to be done can be efficiently obtained, the pressure across the direct-current circuit being approximately 90 per cent. of the pressure between the tapping and the terminal end of the reactance coil. Rectifiers of this description may be used on 50 to 100 cycle circuits where the A.C. pressure does not exceed 140 to 150 volts, and where the temperature of the electrolyte can be kept below 120°F.; above this temperature the efficiency falls off very rapidly.

In a test made by Mr. Horace Boot of an electrolytic rectifier arranged as in Fig. 1, and known as the Nodon valve, an overall efficiency of 65 per cent. was obtained on apparatus charging cells (50 amperes and 118 volts), the efficiency being the ratio of the alternating current watts taken from the mains to the direct-current watts put into the cells as measured by recording wattmeters. This result compares favourably with a motor generator of similar capacity, which, over the whole run, would not give more than about 55 per cent. efficiency.

It is usual to insert a resistance between an electrolytic rectifier and the alternating-current circuit; otherwise it sometimes happens that there is a large rush of current on first starting, especially if the plates have been left in the electrolyte. This resistance can be short circuited when the apparatus has started working. The loss in an electrolytic rectifier is principally leakage current, which does not pass through the direct current or load circuit, but is expended on heating the electrolyte, and is dependent upon the electrode potential at the film, the quality of the aluminium electrode, and the particular electrolyte used; and as the losses increase enormously if the temperature of the electrolyte exceeds 120° F. it is necessary to provide some means, such as cooling tubes or forced ventilation, to keep the apparatus below that temperature. In the above test there was a drop of 8 volts on the cells, or 4 volts per cell, and a loss of 22 amperes out of 72 in the four cells. With two and three phases in use, the current flowing through the working circuit would be pulsating, but to a much less degree than with single phase.

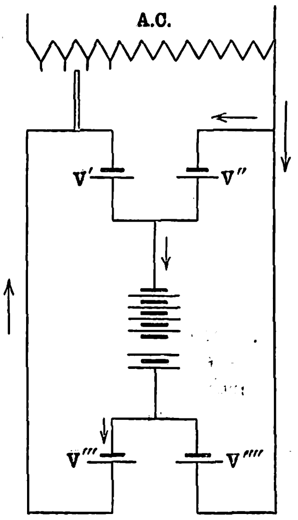

FIG. 1.

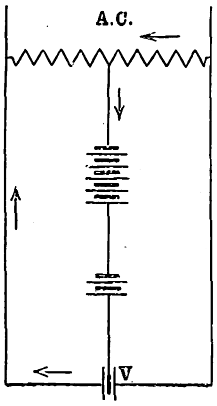

FIG. 2.

*The Mercury Arc Rectifier.**—Gases and vapours in their normal state are practically insulators, but there are various ways in which their insulating properties may be broken down, as, for instance, raising them to high temperatures, also when Röntgen, Lenard or cathode rays are passed through them, or, in short, when the gases or vapours are ionised, as in an electric arc, where a bridge of conducting vapours consisting of the material of the negative or cathode is continually produced and carried over to the positive pole. An electric arc cannot establish itself; it must be produced either by drawing apart two terminals, or by an electrostatic pressure sufficient to jump the gap between two terminals, or by bringing another arc flame into the gap. If an arc is stopped and the cathode blast interrupted, as in an alternating-current circuit, the arc does not restart unless the electrostatic voltage is higher than the striking voltage, at arc temperature, between the electrodes.

With mercury vapour the difference between the electrostatic pressure required to start the arc and the E.M.F. required to keep an arc flowing is very great, due to the low temperature of the arc —that is, the resistance of mercury vapour in normal state, is very high: but, in the presence of cathode rays, it is so low that the vapour becomes a good conductor requiring only a few volts to sustain an arc. When a mercury electrode is used as a cathode, ionized mercury vapour is thrown off; thus, in an ordinary mercury vapour arc lamp, the negative terminal is mercury, the other terminal being any suitable material, as graphite; and, when this lamp is connected on a continuous-current circuit and the arc is once started, it continues to exist until the pressure is switched off, or falls too low to overcome the resistance and back E.M.F. of the arc. If the polarity is reversed and the graphite terminal is negative, it would require an extremely high potential to maintain an arc after it was started. If, therefore, it were possible to start an arc in a mercury arc lamp at every change of polarity on an alternating-current circuit of under 25,000 volts pressure, current would only flow when the mercury terminal was negative, and there would be a pulsating unidirectional current flowing through the lamp. This action is taken advantage of in the mercury arc rectifier, which, for a single-phase circuit, is an exhausted glass vessel containing two anodes, AA, one cathode, B, and one starting anode, C (Fig. 3). The two anodes are connected across the terminals of the alternating-current line, and become alternately positive and negative. While either anode is positive there is an arc carrying the current between it and the cathode. When the polarity reverses, the arc passes from the other anode to the cathode, so that during a complete cycle the cathode is negative and the current at this point is unidirectional, and both semi-cycles of the alternating current are used. The cathode of the rectifier is connected to the load or working circuit, the other pole being connected to the middle point of a reactance coil, which is connected across the alternating-current circuit.

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* Abstract of a Paper read before the Leeds Local Section of the Institution of Electrical Engineers, Jan. 18, 1906.

† See also *The Electrician*, Vol. LIII., p. 1,037.

* See also *The Electrician*, Vol. L., p. 509, Vol. LII., p. 447, Vol. LIV., pp. 165 and 953, Vol. LV., pp. 338 and 389, and Dec. 22, 1905, p. 387.

Without some means of continuing the arc, or establishing it at every reversal of polarity, the rectifier would not work, as the arc would stop at every reversal of the alternating current. Although the current is at zero for an infinitesimally short time, yet this interval even, on a high periodicity circuit, is sufficient for the cathode to lose its excitation and the arc to go out. Owing to the action of the reactance, the wave is no longer a sine wave, and the current waves in each anode overlap by an angle of approximately 20 deg., thus eliminating the zero points previously mentioned.

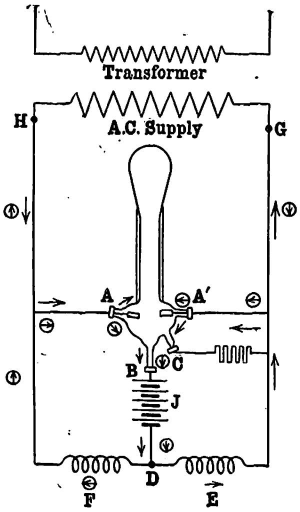

FIG. 3.

The initial ionization of the mercury vapour is accomplished by a small starting anode, C (Fig. 3), which is brought into contact with the cathode by a mercury bridge formed by slightly shaking the tube. The breaking of this mercury bridge starts a small initial arc, and the arc thus obtained excites the cathode, giving the necessary ionized vapours, which enables the working anodes to immediately become active and the tube to start. Fig. 3 shows the connections of a rectifier diagrammatically, the plain arrows marking the path of the current at any moment, and the arrows in circles showing the path on the reversal of polarity. It will be seen that the circuit from the alternating-current terminal is composed of a rectifier arc, the load and one of the reactance coils; the other coil is at the same time discharging energy stored up during the previous half wave, when it was in the line circuit.

It is evident that the reactance must be designed to suit the nature of the load, as with a pure resistance load it is only necessary to have sufficient to keep current flowing when the alternating potential falls below 14 volts, the voltage required for the mercury arc, whereas, when charging accumulators, sufficient reactance is required to keep the arc when the alternating current drops below the back E.M.F. of the cells, plus the 14 volts for the arc, and, as the alternating-current voltage should not be much higher than the cell voltage, the reactance coil has to keep the current flowing through quite a considerable portion of the cycle.

Mercury arc rectifiers can be used on any practical voltage, and for any frequency from 25 to 140 ∿ per second. The maximum voltage is at present unknown, as with a rectifier of proper design and vacuum, a high-frequency oscillator giving an 8 in. spark between 1 in. spheres does not send a discharge through from anode to anode; small currents at 36,000 volts impressed upon the rectifier terminals have been rectified successfully, and a rectifier tube with 24,300 volts at its anodes and 6·25 amperes at 9,500 volts continuous current at the cathode, has been successfully used on a water resistance—that is, a load of about 60 kw. has been rectified in a tube weighing a few pounds.

A high-tension rectifier is now in general use in Schenectady, supplying 57 series arc lamps, giving 4 amperes at 4,260 volts continuous current. Its overall efficiency is over 90 per cent., including losses in the alternating constant-current transformer, in the reactance coils used to carry the arc over from one semi-phase to the next, and in the special reactance coils in the continuous-current circuit used to reduce the pulsations of the current, the loss in the rectifier itself being about 0·4 per cent.

For ordinary commercial work off supply mains the rectifier can be designed for any standard pressure or frequency, the maximum continuous-current pressure being approximately half the alternating-current voltage, and the continuous current nearly double the alternating current, the ratios being varied by means of suitable tappings from the reactance coil.

As the loss in the arc is constant, the efficiency, of course, varies with the direct-current pressure delivered; thus, on a test of a 30 ampere set giving 80 volts on the continuous-current side and working on a 220 volt alternating circuit, the overall efficiency was 75 per cent., but with 112 volts on the direct-current side the efficiency was over 80 per cent. This efficiency holds good down to quarter load, the power factor of such a set being practically 90 per cent.

To charge a battery so that the maximum battery efficiency can be obtained, comparing the watt input and output, it is necessary to reduce the rate of charge as the operation proceeds, so that with a motor-generator starting at 30 amperes and an overall efficiency of about 65 per cent., the motor-generator efficiency falls off as the charge continues until it approaches the neighbourhood of 30 per cent., giving an average efficiency throughout the whole charge of say 55 per cent. Comparing the cost of running a mercury arc rectifier on cells taking 15 units in a five hours' charge at about 110 volts, with the running cost of a motor-generator, the saving would be approximately 8½ units or, at 2d. a unit, 1s. 5d. per charge; and, as there is no part of the apparatus likely to wear out other than the tube itself, there is nothing to set off against this saving; and, should the tubes last, say, 1,000 hours (and some have been tested to 1,500 and 2,000 hours), the saving in current during the life of the tube would amount to £10. 3s. 4d., or 30 per cent. of the current bill for the motor-generator set for the same work. Comparing it with an electrolytic rectifier of 65 per cent. efficiency, the saving on 200 charges of five hours each would be £7. 1s. 8d. at 2d. per unit.

For charging cells the mercury arc rectifier has a certain inherent regulation similar to a shunt-wound dynamo, the voltage at the cathode rising as the current falls, thus tending to compensate for the increase of the counter E.M.F. of the battery, so that the regulating switch need not be moved very frequently during the charge. The regulating switch being connected to the reactance coil, the efficiency of the apparatus is practically constant throughout the charge.

Three-phase current may be rectified into continuous current by means of tubes having three anodes, the load being connected between the cathode and the neutral point of a three-phase star-connected reactance coil; and there is no zero point, as with a three-phase current, the continuous current has less pronounced pulsations, with the same amount of reactance, than with the single-phase system.

## DISCUSSION.

Mr. G. WILKINSON said he was one of the first to obtain an electrolytic rectifier of considerable size from Paris, about three years ago. In order to give it a thorough trial it was used to transform alternating to continuous current for feeding a 6 H.P. motor driving stokers' shafting. This shafting was running 24 hours per day for six days per week; but after two or three days the apparatus went wrong, and this was put down by the manufacturers to faulty electrolyte. After this had been renewed, the rectifier worked for a day or two, when some trouble again ensued. This time they said it was the electrodes. New ones were put it, and then the insulation failed and had to be renewed. After that it would run for 20 minutes or half an-hour at a time and then stop. The rectifier was kept cool by an electrically-driven fan placed beneath it. The efficiency obtained from the apparatus was about 60 per cent. Eventually it was returned at the makers' request. He understood, however, that some progress had since been made in the direction of reliability. He (Mr. Wilkinson) had had considerable experience in making mercury vapour lamps of various kinds, and one thing that troubled him was the loss of vacuum, even in lamps taking the small current of half an-ampere. Extended experience taught him to seal two or three thin platinum wires in the glass rather than one larger one in order to maintain the necessary vacuum. This pointed to a practical difficulty in these rectifiers when designed for heavy currents. He would like to know what was the lowest periodicity that they would work at, the maximum current for which they could be built, and whether there was any possibility of reversing the operation and taking out alternating current when supplied with continuous current.

Mr. CHURTON believed there was some trouble with rectifiers in connection with the graphite anodes, and that some disintegration went on. Mr. Rosling had hardly given the motor-generator its due. He (Mr. Churton) had found the overall efficiency of a ½ kw. motor-generator to be 69·5 per cent. on test. In large sets an efficiency of 81 per cent. was easily obtained.

Mr. G. D. ASPINALL PARR had had two rectifiers through his hands in recent years. One was of the rotary type; the current at the D.C. rectifying commutator was about 25 to 30 amperes at a voltage of about 89 or 90 volts. If the brushes were properly adjusted, there was practically no sparking, and the apparatus would run for hours without the slightest attention. The other rectifier which he had tested was the

Siemens rectifier, in which there was a contact breaker something like the trembler of an ordinary induction coil, and the phase was split by means of a choking coil and a condenser. The efficiency of this apparatus was very low. The power factor curves were very interesting, as also the curve showing the fall of external volts. The machine worked very satisfactorily so far as sparking was concerned.

Mr. MOUNTAIN was of opinion that rectifiers were particularly useful in connection with crane motors and street lighting.

Mr. P. ROSLING, in reply, remarked that the chief difficulty with electrolytic rectifiers had been that they were only serviceable for short runs, and, if they were allowed to get hot, the potential resistance of the anode disappeared. He understood that the electrolytic rectifier now on the market was guaranteed for ordinary commercial purposes. Referring to the mercury rectifier, there was no trouble now in maintaining the vacuum; but owing to other circumstances, one of which was temperature of the anodes, rectifiers for an output of more than 30 amperes were not yet on the market. The 30-ampere size would cost about £50, the 20-ampere size about £45, and the 10-ampere size about £38. As to the reverse operation of the rectifier to act as a converter, such a device had been developed. A mercury vapour tube was used, having four anodes and one cathode, which was placed centrally with reference to the four anodes; two diametrically opposite anodes were connected to the terminals of one primary, and the other two anodes to the terminals of the other primary of a two-phase transformer. The middle points of the two primaries were connected together, and to the positive terminal of the direct-current supply, the cathode being connected through a reactance coil to the negative terminal of the supply. Directly an arc was established between the cathode and one of the anodes, the arc immediately jumped to a neighbouring anode and so on round the tube, with a rapidity depending largely upon the size of the anodes and their distance from the cathode. As the arc rotated, currents were successively generated in the halves of the primaries. One revolution of the arc corresponded to two complete cycles in each secondary, and since the anodes were set at 90 deg. to one another a regular two-phase current was obtained from the two secondaries. The shifting of the arc from one anode to its neighbour seemed to be due to the heat generated by the arc, causing the resistance to rise until a point was reached when less resistance existed between the adjacent anode and the cathode. As this alteration of resistance tended to cause pulsation in the continuous-current circuit, an inductance coil was used as a storing and restoring agent, rendering the flow of power in the continuous-current circuit more steady. Any other number of phases could be obtained by a suitable combination of anodes and transformers. Referring to Mr. Churton's remarks, the overall efficiency of 69 per cent. of the ½ kw. motor-generator was remarkable, as it meant that the loss in the motor and generator was only about 75 watts in each case. Usually the friction and windage would account for nearly that amount of power. There had been no trouble with disintegration of the graphite anode in the mercury arc rectifier. The rectifier alluded to by Mr. Parr was very interesting, but it had the disadvantage of being a machine with revolving parts. Mr. Mountain's reference to the excellent results obtained in mill lighting with mercury arc lamps was most valuable, but although one could tell different colours by it, yet one was liable to be misled when trying to choose tints of the same colour, at least of some colours. There should not be any danger of poisoning from the breakage of a mercury arc apparatus, as the vapour would immediately condense to minute particles of liquid mercury, and the amount that could be breathed in an ordinary room would be infinitesimal.

## A NEW METALLIC FILAMENT LAMP.

The Efandem Co., of 67A, Shaftesbury-avenue, have sent us the following tests on a new metallic filament lamp due to Dr. Hanz Kuzel, of Baden, near Vienna. We are informed that about 100 of these lamps have been manufactured for the purposes of experiment, and that, in order to verify the tests made by Dr. Kuzel and Mr. Joh. Kremenezky, at the latter gentleman's laboratory in Vienna, a number of lamps were also submitted for test to the Electro-Technical Testing Department of the K.K. Technologischen Gewerbe-museum, of Vienna. Our correspondents state that the first two lamps which were submitted to the Institute in the month of August, 1905, for test were taken from a series which had been manufactured on commercial lines, and gave the following results, which were officially certified:—

*Series N. Group A.*

Lamp No. C1, 32 volts, 13·17 c.p., 0·461 ampere, 1·12 watt per c.p.

| Hours. | Candle-power. | Amperes. | Watt per c.p. | Light difference in per cent. |
|---|---|---|---|---|
| 0 | 13·17 | 0·461 | 1·12 | — |
| 98 | 14·06 | 0·462 | 1·05 | + 6·7 |
| 218 | 13·80 | 0·456 | 1·05 | + 4·8 |
| 314 | 14·31 | 0·457 | 1·02 | + 8·6 |
| 434 | 14·10 | 0·456 | 1·03 | + 7·0 |
| 578 | 14·28 | 0·455 | 1·02 | + 8·4 |
| 753 | 12·85 | 0·453 | 1·13 | −10·0 |
| 885 | 12·03 | 0·451 | 1·10 | − 1·6 |
| 1,010 | Filament in the loop after 1,010 hours burnt through, rejoined itself, still burning. | | | |
| 1,029 | 16·72 | 0·482 | 0·992 | +26·9 |
| 1,167 | 15·76 | 0·480 | 0·975 | +19·6 |
| 1,339 | 16·20 | 0·479 | 0·945 | +22·9 |
| 1,468 | 14·97 | 0·472 | 1·002 | +13·6 |

After 1,468 hours burnt out.

*Series N. Group A.*

Lamp No. C2, 30·25 volts, 12·39 c.p., 0·461 ampere, 1·08 watt per c.p.

| Hours. | Candle-power. | Amperes. | Watt per c.p. | Light difference in per cent. |
|---|---|---|---|---|
| 0 | 12·39 | 0·461 | 1·08 | — |
| 314 | 12·39 | 0·463 | 1·13 | — |
| 578 | 12·60 | 0·463 | 1·11 | + 1·7 |
| 885 | 12·28 | 0·462 | 1·13 | − 0·9 |
| 1,167 | 12·04 | 0·461 | 1·15 | − 2·8 |
| 1,339 | 12·22 | 0·459 | 1·13 | − 1·4 |
| 1,468 | 11·83 | 0·456 | 1·16 | − 4·5 |
| 1,490 | Filament in the loop after 1,490 hours burnt through, rejoined itself, still burning. | | | |
| 1,512 | 13·32 | 0·473 | 1·07 | + 7·5 |
| 1,783 | 12·43 | 0·461 | 1·12 | + 0·4 |
| 1,975 | 11·86 | 0·457 | 1·16 | − 4·3 |
| 2,215 | 11·39 | 0·456 | 1·21 | − 8 7 |
| 2,574 | 11·03 | 0·455 | 1·24 | −10·9 |
| 2,881 | 11·09 | 0·454 | 1·23 | −10·5 |
| 3,313 | 11·03 | 0·454 | 1·23 | −10·9 |
| 3,537 | 11·03 | 0·454 | 1·23 | −10·9 |

Lamp still burning.

Another series of tests gave the following results:—

*Series U. Group A.*

Lamp No. 2, 19 volts, 29 c.p., 1·48 amperes, 0·97 watts per c.p.

| Hours. | Candle-power | Amperes. | Watt per c.p. | Light difference in per cent. |
|---|---|---|---|---|
| 0 | 29·0 | 1·48 | 0·97 | — |
| 503 | 28·8 | 1·48 | 1·02 | − 0·7 |
| 1,110 | 26·2 | 1·49 | 1·08 | − 9·7 |
| 1,686 | 25·2 | 1·48 | 1·11 | −13·1 |

After the last figures given above, the current was increased to about 60 volts, thus over-running the lamp, in consequence of which the filament burnt through in the loop. The filament, however, rejoined itself. Lamp still burning.

*Series R. Group A.*

Lamp No. 1, 30 volts, 13·5 c.p., 0·470 ampere, 1·05 watt per c.p.

| Hours. | Candle-power. | Amperes. | Watt per c.p. | Light difference in per cent. |
|---|---|---|---|---|
| 0 | 13·5 | 0·470 | 1·05 | — |
| 467 | 12·1 | 0·465 | 1·11 | −10·4 |
| 1,460 | 12·9 | 0·470 | 1·09 | − 4·4 |
| 2,188 | 13·5 | 0·470 | 1·05 | — |
| 3,103 | 14·0 | 0·480 | 1·03 | + 3·7 |

Lamp still burning.

*Series R. Group B.*

Lamp No. 2, 28·5 volts, 40 c.p, 1·06 amperes, 0·76 watt per c.p.

| Hours. | Candle-power. | Amperes. | Watt per c.p. | Light difference in per cent. |
|---|---|---|---|---|
| 0 | 40·0 | 0·76 | 1·06 | — |
| 467 | 35·0 | 0·87 | 1·06 | −12·5 |
| 850 | 38·0 | 0·81 | 1·07 | − 5·0 |

Filament burnt through and rejoined itself. Lamp still burning.

*Series U. Group B.*

Lamp No. 3, 19 volts, 24·2 c.p., 1·06 amperes, 0·83 watt per c.p.

| Hours. | Candle-power. | Amperes. | Watt per c.p. | Light difference in per cent. |
|---|---|---|---|---|
| 0 | 24·2 | 1·06 | 0·83 | — |
| 503 | 26·5 | 1·06 | 0·76 | + 9·5 |
| 1,110 | 23·5 | 1·06 | 0·86 | + 2·9 |
| 1,686 | 19·0 | 1·02 | 1·02 | −21·50 |

Lamp still burning.

In another test the lamp was over-run 233 per cent. above its normal voltage without the slightest damage. A second lamp was over-run 201 per cent., the only result being that the normal candle-power of 19½ c.p. after being over-run had risen to 20½ c.p.

*Table showing Results of Over-running a Metallic Filament Lamp, normal 20·2 volts, 19·5 c.p., 0·97 ampere, 1 watt per candle-power.*

| Volts. | Candle-power. | Amperes. | Watt per c.p. | Light difference in per cent. |
|---|---|---|---|---|
| 20·2 | 19·5 | 0·97 | 1·0 | — |
| 25·8 | 50·0 | 1·14 | 0·588 | +156·5 |
| 32·7 | 100·0 | 1·30 | 0·425 | +433·3 |
| 34·5 | 125·0 | 1·34 | 0·370 | +451·0 |
| 39 0 | 180·0 | 1·44 | 0·312 | +823·10 |
| 40·6 | 211·0 | 1·475 | 0·283 | +982·0 |

It is also announced that these new metallic filament lamps can at present be manufactured for circuits up to 110 volts, but no tests of lamps for this voltage have been sent us. We are also given to understand that "the manufacturing cost of the lamp will be very little different to that of the ordinary carbon-filament lamp universally used up to the present, as the raw materials used in the process of manufacture of the filaments can be obtained in unlimited quantities and are not expensive."

## ADVANCED TECHNICAL EDUCATION.

The final report of the Departmental Committee appointed to inquire into the present working of the Royal College of Science and School of Mines, and to consider what changes may be desirable to utilise their resources to the fullest extent for higher scientific studies, has now been published. The constitution of the Committee was as follows:—Mr. R. B. Haldane (*Chairman*), Sir Francis Mowatt (chairman up to December, 1904), Sir W. de W. Abney, Sir William S. Church, Mr. A. H. Leech, Sir Philip Magnus, Mr. F. G. Ogilvie, Lord Reay, Sir Arthur Rücker, Mr. S. Webb, Sir Julius C. Wernher, Mr. J. C. G. Sykes (*Secretary*), and Mr. F. E. Douglas (*Assistant Secretary*). The following were members of the Committee during a portion of the inquiry:—The late Sir Edward Carbutt, Mr. J. A. Ewing, Mr. H. Jennings, Mr. W. McDermott and Sir William H. White.

After outlining the scope of its contents, the report gives a short history of the Royal College of Science and the Royal School of Mines, followed by some notes on previous inquiries of like nature which have been held. Mention is also made of the origin and aims of various other bodies by whom technological education has been carried on. "There are now several indications," remarks the report, "that local authorities are alive to the opportunities afforded them by the extension of their powers under the Education Act of making these classes preparatory to more advanced and continuous technical education in the case of suitable students; but inasmuch as up to the present time but little has been done to co-ordinate them with any higher technological teaching of the kind with which we are principally concerned, we will proceed to refer to a class of institution which in its later developments is more akin to our present purpose, viz., the London polytechnics. These institutions, which differ considerably in their functions and ideals from institutions which some little time since bore the same name in Germany, have grown up in London in recent years. They were erected by funds largely supplied by some of the City Livery Companies and by private individuals, supplemented by the means made available by the Charity Commissioners, acting under the City Parochial Charities Act; and since 1894 they have been considerably developed and improved by the wise policy and financial help of the London County Council. In these institutions the instruction is adapted mainly to the requirements of artisans engaged in different branches of the building, engineering and other trades, as well as in the arts and crafts. In many of them opportunities are afforded, principally to evening students, but to some extent to day students also, for the prosecution of research under competent instructors, and for the preparation of students for University degrees under recognised teachers of the University of London. Similar institutions, in some instances even better equipped and possessing larger and more costly buildings, are now found in the larger provincial towns under the name of technical institutions or schools of technology, the chief difference between the London and the provincial institutions being that in London there is attached to the polytechnics a social and recreative side, which is not found in the provincial schools. Both in London and in the provinces the laboratories and workshops of some of these institutions are not yet fully utilised in the day time, owing mainly to the lack of pupils, competent by previous general education, to take advantage of the more advanced teaching provided."

Other bodies, such as University and King's Colleges, London, and Owen's College, Manchester, are then mentioned, and an account is given of the foundation of the Central Technical College of the City and Guilds of London Institute. "The College was placed at South Kensington so that the students might be near the Museum, the Normal School of Science (as it was then called), and other educational institutions, the idea as to the differentiation in the scope of its work, as contrasted with that of the Normal School, being that while the Normal School devoted itself to pure rather than to applied science, the instruction in the newly founded college should have special reference to the particular industries in which the students were proposing to become engaged. It is this college which the Council of the City and Guilds of London Institute appear willing to bring into such a scheme of common government and administration as we shall outline later."

Before proceeding to investigation of examples of foreign methods the report remarks: "A survey of the whole field of technical education would show that England compared not unfavourably with other countries in the provision made for what may be called the lower and intermediate grades of technical education, as well as for the technical training for the learned professions obtainable at many of our Universities. The principal deficiency, whether the resources and needs of this country are viewed by themselves, or whether the rapid strides made by other countries are considered with them, appears to lie in the sphere of the highest technological education."

An account is then given of the provision made for technical education in Germany: "Germany, during recent years, has devoted her greatest energies to the development of technical education of a university grade. The success she has met with in numerous departments of manufacturing chemistry is regarded, by all who have studied the subject, as being mainly due to the utilisation of the results of the researches of an army of highly-trained chemists, who are employed in large numbers in many factories, and are constantly making new discoveries and introducing modifications in manufacturing processes. The achievements of Germany in the field of chemical industry have encouraged her to establish well-equipped electrical laboratories and to develop the practical teaching of physics with a view to assisting electrical trades. It was the belief in the value of the applications of science that led to the creation of technical high schools, for the training of future managers, engineers, manufacturers and industrial chemists. These institutions have in some cases developed gradually from quite small beginnings, in others they have been established fully equipped and staffed from the outset. They now rank generally with the older universities, and poseess similar self-governing and other privileges, including the power of conferring degrees. Taken as a whole, they are the outcome of conditions which do not obtain in this country, and the system which they embody is not one which could with advantage be reproduced here in its entirety. Among the features which distinguish them, we may note in the first place that the preliminary training that is required of candidates before they are admitted is of a severer kind than that required in any of our technical institutions. It is only after the secondary grade of education has been passed through that specialised study and research in the higher branches of scientific knowledge can be undertaken, whether at the University or at the Technical High School, the distinction between them being, roughly, that in the former this knowledge is pursued primarily for its own sake, while in the latter it is avowedly pursued with reference to its practical application. While, however, it is legitimate to draw this essential distinction, it may be well to observe that the Technical High School aims also at giving a broad scientific education, so far as this can be done consistently with its primary aim, while the University in giving a liberal education is not forgetful of the requirements of the practical life. An important feature of the German Technical High School, which distinguishes it from any technical institution or university in this country, is the completeness of its staff of teachers. At the Berlin school there are some 50 State-appointed professors in addition to a large number of assistant professors, demonstrators and lecturers. Every separate branch of engineering is taught by a specialist, and the presence in the same institution of a number of professors, each an eminent authority on his own subject, and giving his undivided attention to the furtherance of the study in which he is engaged, enables the students in attendance to enjoy the advantage, not at present obtainable in a like degree at any school in this country, of receiving the most advanced instruction from men so occupied and of participating in their researches."

After a detailed description of the organisation of the Technical High School at Charlottenburg, the report passes on to the consideration of the systems in vogue in Switzerland, the United States and Canada, describing more particularly the Zurich Polytechnikum, the Massachusetts Institute of Technology, Boston, and McGill University, Montreal. France and Belgium are also dealt with, the close connection between high technical education and the State universities being pointed out.

After this summary of the conditions obtaining in other countries the report continues:—

"The foregoing survey appears to show that at the present time higher technological education is less developed in this country than in several of her principal commercial competitors, but it does not show that this backwardness is necessarily to be traced to the absence of a uniform policy running through the educational system.

"We observed in a previous paragraph that the German system was not suitable for adoption here. In saying this we do not wish to be misunderstood. There are certain elements in the German system which cannot, however admirable in themselves, be reproduced in this country. Thus we cannot require at present, as a condition of admission to our higher technical colleges, the same standard of general education as Germany. Such a requirement might seriously restrict the number of students. Nor can we instantaneously compel ourselves to feel the German love of education for its own sake. Neither could we, even if we desired, imitate the uniformity of the German standard, or, generally, the thoroughness and singleness with which all forms of education are regulated by and made subservient to the purposes of the State. On the other hand, there are certain elements in the German system which can, and in our opinion undoubtedly should, be transplanted here. We have no hesitation in proclaiming this country's urgent need of a greatly-increased provision for education in the sciences applicable to industry, of a university grade, and—so far as consistent with the predominant aim—of a university type, an education concerned with principles rather than with processes, and advancing to the highest planes of specialisation and research.

"The main difficulty in the way of the advancement of higher education in England hitherto has been the attitude of the employer and the parent. The attitude of large numbers of both employers and parents has changed materially in the last few years, and the immense advantage, alike to the industries of the country and to the individual, of an education prolonged to the utmost that economic and social conditions will allow is becoming increasingly recognised. This change of attitude is not yet sufficiently widespread to affect the nation as a whole, and meanwhile there is abundance of scope for some variety in the methods by which higher technical education may be supplied.

"In any consideration of the provision which we hope to see made for this purpose, it will be well to bear in mind, as a first principle, that an essential condition of a good technical education of whatever grade is a good general education of the corresponding preliminary grade. In the second place, care must be taken to avoid any confusion between the aims of general and of technical education. The trend of recent developments in England in the sphere both of elementary and of secondary education has been in the direction of removing this confusion, but in the sphere of education higher than secondary it is open to question whether the confusion has not increased rather than diminished in the past few years. We do not mean that a general education should never take account of the prospective occupation of the student; or that a technical education should be devoid of all elements of general culture; the point of principle is that in every educational institution, or in every faculty of a university, one aim or the other should be avowedly predominant. The scheme which we shall proceed to submit is framed with a due regard to these two principles.

"The conclusion at which we have arrived are: 1. That the position of this country makes further provision for advanced technological education essential. 2. That the students, by whose advanced technological education the nation would profit, are not actually obtaining it to the extent which is desirable, and that this is due to: (*a*) the lack of facilities for instruction in certain important subjects; (*b*) the absence of such co-ordination among existing institutions of technological education as would permit the concentration of the more advanced courses in a limited number of institutions; (*c*) an insufficient appreciation, especially on the part of employers, of the value of such education.

"3. That the opportunities for research in our technological institutions are inadequate to the industrial needs of the empire, owing not to any want of ability on the part of the professors, but to the fact that much of their time is frequently absorbed in the giving of comparatively elementary instruction in pure and applied science.

"4. That in any institution in which the highest technological education is given, the equipment should be adequate for the purpose, and the staff should include, at the head of the several specialised branches of the work, men of the first rank in their profession.

"As stated in our preliminary report, we have inquired into the working of the Royal College of Science and the Royal School of Mines, but we have done so with a definite end in view. We think it appears from the answers we have received from the Board of Education to the questions we ventured to ask in that report, taken in conjunction with the terms of reference, that it is the desire of His Majesty's Government that the staff of the Royal College of Science, including the Royal School of Mines, together with the buildings and appliances now in occupation or in course of construction at South Kensington, should be utilised to the fullest extent for the promotion of higher scientific studies in connection with the larger scheme which we endeavoured to sketch in outline in our preliminary report. We have now to make, so far as appears to us possible, recommendations with regard to the essential features in the constitution and purposes of the new institution which we propose should be created, and with regard to the position of the several bodies brought with it under a common government and administration.

"The main object is the establishment, at South Kensington, of an institution or group of associated colleges, of science and technology, where the highest specialised instruction should be given, and where the fullest equipment for the most advanced training and research should be provided, in various branches of science, especially in its application to industry, for which no sufficient provision already exists elsewhere. The number of the departments will be limited by the resources available, and at first a selection will have to be made among them, but they may be increased almost indefinitely as additional means are provided, and new applications of science to the arts and industries are discovered. The scale on which the departments are established should be capable of gradual expansion with the increase in the number of students, fitted by preliminary education to take advantage of the teaching and training contemplated.

"The scheme should, in the first instance, and subject to necessary adjustments, include the work of the Royal College of Science, the Royal School of Mines, the Central Technical College, and departments to be established on the additional site at South Kensington.

"Such being the scope of the new institution, it is necessary that we should make recommendations with regard to the composition and functions of its governing body, and the question at once arises what should be the relation of the new institution to the University of London. On this question it is necessary to premise that we are agreed that it is desirable that the new institution should be established immediately, and that its organisation should proceed without delay, and there is substantial agreement among us that for this purpose a governing body of the character sketched in a subsequent paragraph should be at once appointed with power to take immediate action. We wish, however, to put in the forefront of our recommendations under this head a proviso that they should not be regarded as in any way intended to prejudice the future settlement of the question of the relation between the new institution and the university. This is a question on which divergent views are held. It is contended, on the one hand, that the constitution we recommend for the immediate future should not be a merely temporary one, but that the new institution should be permanently independent of university control; and, on the other hand, that the new institution should pass, as soon as may be, under the control of the university, the character of the university, and the composition of its senate, being changed to such extent as may be found necessary for this purpose."

A brief summary of arguments in support of these two views is then given. The report, however, continues:—

"We do not consider that the establishment of the new institution should be delayed pending a decision between these two views, or that the general lines of its organisation (except, possibly, as respects the governing body) should be regarded as other than permanent. If changes can be made in the character and constitution of the university which will make it desirable to amalgamate the two institutions, we should wish to see such modifications made, and an amalgamation effected accordingly, and we venture to suggest that a Royal Commission should be appointed to consider what these changes should be.

"Meanwhile, for the reasons we have already given, and subject to the proviso we have already made, we recommend that a governing body should be established consisting of forty members appointed as follows:—

"Six by the Crown; four by the Board of Education; five each by the University of London, the London County Council and the Council of the City and Guilds of London Institute; four by the teaching staff of the new institution; two by the Commissioners of the Exhibition of 1851; one each by the Royal Society, the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Institution of Electrical Engineers, the Iron and Steel Institute, the Institution of Naval Architects, the Society of Chemical Industry, the Federated Institution of Mining Engineers and the Institution of Mining and Metallurgy.

"The governing body should have the general management, direction and administration of the new institution, which should be established in the first instance as a school of the University of London.

"For the purposes of the new institution the governing body should have the entire disposal of the accommodation provided by the Royal College of Science, including the buildings in course of construction at South Kensington, the Central Technical College and all buildings which may be erected on the additional site at South Kensington.

"The site and buildings of the Royal College of Science, including the buildings in course of construction, should either remain the property of His Majesty's Government, or be transferred to the governing body of the new institution as His Majesty's Government may determine.

"The site and buileings of the Central Technical College should, if and so long as they desire it, remain the property of the City and Guilds of London Institute, who should provide for their maintenance and repair

"The governing body should be incorporated and, subject to such special provisions as may be made by the irinstrument of incorporation, they should receive and expend fees and other funds which may be assigned to the purposes of the new institution, they should appoint the professors and the other members of the staff, they should determine the departments and subjects of instruction, they should control the arrangement of the courses of instruction and the award of diplomas, and they should make provision for the protection of students now in the constituent institutions and of the existing diplomas. Further, in each of the departments of the new institution the governing body should appoint a board, not necessarily consisting of members of their own body, and including members of the teaching staff and persons with practical experience of industrial requirements to give expert advice with regard to such particulars connected with that department as the governing body may refer to them.

"We recommend that it be an instruction to the governing body to enter into negotiations with the University of London, with King's College and, pending its actual incorporation, with University College with regard to the co-ordination of the engineering work of these colleges with that of the new institution. If, for the purpose of carrying out such co-ordination, funds are needed, either for transferring the engineering departments of one or both of these colleges to South Kensington, or for carrying on at these colleges work of an advanced type which would otherwise be done at South Kensington, or in aid of any other arrangement for that purpose to which the Governing Body may agree, we recommend that the governing body be authorised to incur such reasonable expenditure as may in their opinion be necessary. Subject to such arrangements, we recommend that instruction in the higher branches of technology should, as far as possible, be concentrated at South Kensington. In the establishment of new departments we do not think it will be possible at present to go much beyond the various branches of engineering, with mining and metallurgy, though we hope provision may be made later for other subjects. We think the principal technical and engineering societies should be consulted as to the departments most requiring development and expansion, and as to the number of students for whom it is desirable to make provision in each department. In view of the character of the subjects which will, it may be expected, predominate on the South Kensington site, it must, we think, before long become a question whether the biological department of the Royal College of Science shall be retained there. As soon as this question becomes ripe for settlement, the provision to be made for that department will be a matter for negotiation.

"In our preliminary report we indicated the principal subjects which should, in our opinion, either at once or in the early future, be within the purview of the institution, and gave illustrations of the kind of higher or more specialised applications of these subjects, some of which we suggested should be dealt with. We do not think we can usefully offer more precise recommendations than are made in that report as to the priority in which the different branches of study should be undertaken, believing that this is a matter which will be best left to the governing body.

"We think, however, that it may be found possible, even in the immediate future, to make arrangements for the establishment of departments dealing adequately with the greater number of the special sections of applied science named. Thus it would seem that certain of these departments might be accommodated in the buildings of existing London institutions, while, for others, special accommodation would fall to be provided at once in the first additions to the buildings already available on the South Kensington site. For example, in view of the character and standard of the work now carried out by the Central Technical College, we think prominence should be given in the new institution to certain specialised developments of mechanical and electrical engineering.

"We have already reported that we think a fully equipped Central School of Mines should be maintained, providing a full course of instruction in mining and metallurgy, especially in the mining and metallurgy of metals produced in India and the Colonies, but not found in workable quantities in the United Kingdom. This would constitute one department of the new institution. In this, as in the other departments, care should be taken that the specialised and advanced instruction is organised with due regard to provision already made elsewhere—for example, it would probably be undesirable to include provision for advanced treatment of the metallurgy of iron and steel.

"No student should be admitted to any specialised technical department who has not received, either in the new institution itself or elsewhere, an adequate training of a technical and scientific character such as should be common to every branch of engineering. He should have spent two years on a course of instruction in science, such as he could obtain in a well-organised college or technical institution, after having reached the standard of general education usually marked by University matriculation. An examination test should be imposed on all candidates for admission to the higher departments, except in the case of students who show, by some recognised qualification, that they have received the necessary preliminary training, and when there are more candidates for admission to a particular department than can be received, the best should be selected on a competitive basis.

"The preliminary training to be given in the new institution should be of the kind which has just been referred to. It should consist of a course of two years' instruction in science, technology and engineering, of such a character as the governing body consider the most suitable preparation for the specialised courses, and it should be, in the main, common to all students proceeding to advanced instruction in any department. We have already indicated our opinion that students who have not attained a certain standard of general education are not fitted to obtain the fullest advantage from the specialised instruction of the higher departments. We therefore think that evidence of this should be required before admission to the preliminary department.

"With regard to educational arrangements we recommend that, subject to reservations made by any constituent institution or co-operating body which may stipulate for the right to enter students under prescribed conditions, students should enter not for any one of the constituent institutions but for the new institution as a whole, with a view to following out courses to be arranged by the governing body.

"The professors of the constituent institutions should be regarded as professors of the new institution.

"There should be a principal officer of the new institution, who should be responsible to the governing body for the supervision of education and discipline in all the constituent institutions.

"It must, in our opinion, be left to the governing body to work out the scheme in detail and to make statutes and regulations for the new institution in general accordance with our proposals."

Two memoranda signed by some of the members of the Committee are added, dealing mainly of the degree of relationship which should exist between the proposed institution and the University of London. The publication concludes with copies of two letters from the Board of Education in which it is stated that "the Government will be prepared to make the following financial arrangements if and when the Royal College of Science, including the School of Mines, is brought into a scheme for the establishment of a new School of Pure and Applied Science at South Kensington, on lines approved by the Board of Education:—(1) To place at the disposal of the new institution the buildings now used for the purposes of the Royal College of Science at South Kensington on the east side of Exhibition-road, and the buildings in course of erection for the same purpose on the west side of the road. (2) To place in the Estimates a grant of £20,000 per annum in respect of the cost of the staff and of the laboratory expenses. (3) To maintain for the present both sets of buildings in external repair. (4) To provide heating and lighting for both sets of buildings, and to pay local rates. (5) To satisfy the claims of the staff for such pensions as may be assumed to have accrued up to the date of transfer."

## A REVERSIBLE BOOSTER AND ITS RUNNING.*

BY C. TURNBULL.

In the first part of his Paper, Mr. Turnbull described the "Lancashire" automatic reversible booster, invented conjointly by himself and Mr. McLeod and fully described in our columns in connection with the Derby electricity works (*The Electrician*, Vol. LIII., p. 303). We will briefly recapitulate its chief features. In external appearance it resembles a four-pole dynamo driven by a four-pole motor; but while the motor is nothing more than a shunt motor, the booster itself has four field windings. One is a shunt winding (referred to as the A winding) across the booster terminals; another (B) is a shunt winding straight across the 'bus bars; the third winding (C) carries the generator current and opposes the coil just mentioned; while the fourth winding (D), finally, is in series with the armature of the booster itself.

The author then proceeds as follows:—

*Combinations of Booster and Battery.*—The booster and battery may be worked in the following ways: (1) Booster and battery on 'bus bars with generator, keeping the load steady within narrow limits. This is the normal method. (2) Booster and battery on 'bus bars with generator, but with coils regulated to make its action comparatively weak. This method is useful when the load on the line is small with occasional jumps. Under these conditions the (battery + booster) meets all the peaks, but maintains a benevolent neutrality during the times when the load is small, when it is not desirable for the battery to charge because it is already full. (3) The battery may be floated on the line without the booster. This method is occasionally suitable when the line load is slack. (4) The booster may be set to mainly charge or mainly discharge the battery, as may be desired; this by regulating coils B and C. Under this state of matters it will still respond to any excessive outside load. (5) The battery and booster can be put on the bars alone without a generator. The 'bus-bar volts can then be regulated by adjusting the strength of coil B by hand. (6) The battery and booster can be put on the 'bus bars with the booster arranged to compound up when the load comes on. (7) The battery can be put on the 'bus bars without the booster. All the above combinations are needed to enable the utmost to be obtained in actual working, and the arrangement of switches on the board permits of the easiest possible working.

In the Lancashire booster the varying conditions of the station load are met by making the machine very flexible in its working. The field coils are stiffened up in their action when it is desired to make the load more constant, and they are slacked off when desired to let the generator follow the peaks and valleys of the load to some extent.

*The Working of the Booster.*—The booster in its working keeps the load steady on the generator within narrow limits. The actual voltage on the 'bus bars has no effect, and the 'bus bar volts can be adjusted at will. The generators can be compound or shunt wound as desired. Reverse current breakers are not needed even with compound-wound generators, because the current cannot come back on the generators. As will be noticed, the C coil would lose all of its power when the generator load fell to nothing, and this would cause the booster to boost about 100 or more volts against the battery. This effectually prevents current from coming back on to the generators. Should any current come back, it would cause the booster to boost still more vigorously against it. Similarly, the action of the coils prevents the generator from taking load off the battery. There is no tendency for the battery to shirk its work, as the operating forces are strong enough to make the battery do its duty as long as its volts are within working limits. The booster is extraordinarily stable in its action, and has no tendency to hunt.

*Paralleling.*—Should the battery breaker come out, the paralleling is as follows: (1) cut out A coil; (2) adjust B coil regulator until paralleling voltmeter is somewhere near to zero; (3) put in breaker; (4) run back regulators to position—time, about four seconds. The voltmeter switch may be left permanently on the paralleling stop. The usual regulator wheels on the switchboard may be replaced by straight handles with great advantage, as these can be operated more rapidly.

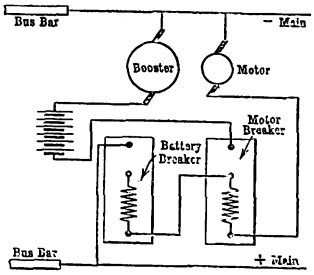

FIG. 1.

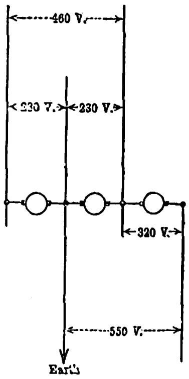

FIG. 2.

*Circuit Breakers.*—There has been a difficulty with booster breakers, because the booster may run to destruction if the motor breaker comes out and leaves the booster breaker in. Breakers have, therefore, generally been interlocked, so that the booster breaker is thrown out by a relay if the motor breaker happens to come out. The arrangement, Fig. 1, is used with the Lancashire booster. The battery current, as will be seen, goes through the two breakers in series, but it only goes through the solenoid of one breaker, called the battery breaker. An excess current on the battery, which is the usual thing, blows the battery breaker, but leaves the motor running on the battery. An excess current on the motor, which is quite a rare thing, also cuts off the battery, but leaves the motor running on the 'bus bars. Thus paralleling is quite easy after a breaker comes out, seeing that it is not necessary to restart the motor. Whichever breaker comes out the motor is still left with a breaker to protect it, so that it would be cut out in the event of a short occurring in the motor itself. Breakers should be of the loose-handle type. A good time limit on the breakers would also be an improvement, allowing the feeder breakers to come out rather than the generator breakers. I have found Bertram Thomas breakers very satisfactory. When the motor is run on the battery without a generator to take small loads, this arrangement of breakers is convenient, as it is only necessary to put the breaker in when it comes out, seeing that the motor remains running on the battery when the breaker opens.

*Three-Wire Booster.*—The Lancashire booster can be made to work on the three wires, but there is the objection that it sometimes happens that one side is permanently out of balance, and hence one side may become over-discharged or over-charged if care be not taken. In certain cases I think it better to put the battery on the outers only, and to use a balancer as a motor. The balancer will then drive the booster and balancer at the same time. This system is particularly applicable where the booster and battery is put on an outlying part of the distributing network.

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* Abstract of a Paper read before the Newcastle Local Section on January 15, 1906.

*Link between Traction and Lighting.*—A link is often required between the traction and lighting boards to enable the one battery or generator to do for both on the light-load periods. A motor-generator is often used—lighting one side and traction the other. This requires that a balancer should be run in addition. It would be better to have a motor connected to a balancer, so that there would be less loss, while the balancer could also be run as a balancer only without the motor being connected to the traction board. A further step is shown in Fig. 2. This would have the further advantage that all of the armatures at any rate could be alike, so that one spare would do for all. It would also be more efficient.

*Most Efficient Size of Battery.*—As a general rule most efficiency is obtained by making the one-hour rate in amperes of the battery equal to the full-load amperes of the generator, with the two together equal to the ordinary demand of the line. The battery circuit breaker should be set at about 75 to 100 per cent. over the one-hour rate to deal with momentary jumps, and the generator breaker can also be set high.

*Rate of Working Battery.*—Battery makers have not so far, I believe, given great assistance in finding out the utmost that can be done with a battery with a reversible booster. Probably the rate of working can be immensely increased over that for ordinary lighting work. The changes of current favour proper diffusion of the acid in the paste, while the cells rarely fall below 1·9 volts per cell. I would suggest that battery makers might be content to work with a *recording voltmeter* across the battery instead of an ammeter in series with it. If they stipulated that the volts were to be kept within certain limits—say 1·8 to 2·6 average per cell in working—it is possible that they might allow the ampere rates to be anything at all so long as the battery volts were kept right. There seems to be no reason why the one-hour rate should not be greatly exceeded for half-minute periods, especially when rapidly followed by a charge. Of course the other ordinary rules could be followed in addition, such as keeping the gravities right, &c. With ordinary care to prevent overcharging and over-discharging, a battery will be found to last much better on traction than on lighting.

*Battery Cleaning.*—Mr. Pickersgill, of Heckmondwike, mentioned to me an interesting way of cleaning out batteries. A cask is connected to the bottom of the cells by means of a tube. The cask is then connected to the condenser, so producing vacuum in it. The rush of liquid from the cell takes the sediment with it. Of course nothing gets into the condenser, as the liquid falls to the bottom of the cask.

*Time Lag for Circuit Breakers.*—The attempt was made to get a lag on circuit breakers by shunting an inductive circuit by a non-inductive one. I mentioned the thing to Mr. Eustace Thomas, who very kindly made considerable investigations on the subject. Mr. Thomas eventually made an arrangement similar to Fig. 3. Two circuits of thick copper rods were put in parallel, one of them being surrounded by a laminated horseshoe magnet having an armature. A rush of current went first through the non-inductive "A" leg, while the growth of current in the "B" leg was slow. As will be seen, the voltage at the terminals of the "B" leg was something exceedingly small, and this voltage had to drive the current against the inductance of the circuit. When the current was becoming approximately equal in both legs, there was only an exceedingly minute force left to overcome the counter E.M.F. of the inductive leg. When the current in the inductive leg reached a certain limit, the armature would be attracted and make contact, so as to work the breaker solenoid in the ordinary way. The apparatus gave considerable lag, but it was abandoned for other reasons.

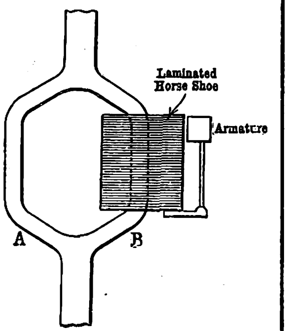

FIG. 3.

## DISCUSSION.

Dr. THORNTON referred to the great fluctuations of load at the opening of the Mersey Railway, and if Mr. Turnbull's system of battery and booster could reduce these fluctuations it would be of good service to railway power stations generally.

Mr. LUNN found that with the reversible booster system under his supervision, which was slightly different to that set forth by Mr. Turnbull, it was better to run the battery without the booster, and, with a view to efficiency, this was generally done, and a steadier voltage curve was the result. With the battery floating, a variation of only from 500 to 520 volts was noticed, which was quite good for traction supply. The watt efficiency of this system of battery and booster was 87 per cent. With regard to the shunt regulator, he preferred this apparatus away from the switchboard. The Crompton booster, which was compound wound, could run with the battery without the generator, and then regulated the volts. This battery was about 1½ times the capacity of the generator. He only used one pair of circuit-breakers on the battery and booster, the booster being on the battery side.

Mr. KIDMAN said he had had experience with the link between the lighting and traction switchboard mentioned by the author, and it proved unsatisfactory owing to the variation of pressure, especially at times when circuit-breakers came out on a temporary short-circuit.

Mr. DAVIS asked if the field of the booster was laminated, and, if so, was it worth the extra expense? In a station of his experience a continuous-current machine and an alternating-current machine were mounted on a common shaft which could be disconnected from the steam engine, thus enabling the machines to run as a motor-generator set.

Mr. FORCETT said that resonance effects did not occur in high-speed generating sets having a heavy drum armature.

Mr. RISELEY referred to the low steam consumption of some non-condensing stations.

Mr. TURNBULL, in reply to the discussion, said he preferred to work his battery very little, but to get full advantage out of it he had to work his booster. In many cases the voltage of a traction system provided with a booster was steadier than that of a lighting system. It was necessary to laminate the fields of the booster in order to keep down heating and to increase the efficiency.

## AUSTRALIAN NOTES.

(FROM OUR ADELAIDE CORRESPONDENT.)

**Wireless Telegraphy in Australia.**—An important announcement was made by Mr. Chapman, Postmaster-General of the Commonwealth, on December 21st, when he stated that the Government had decided that the early introduction of wireless telegraphy into the service of the Federal Post and Telegraph Department should be seriously considered. Before deciding as to the type of apparatus to be adopted it would be necessary to institute careful comparisons between the various systems available, and when tenders were invited (which he hoped would be within a year) specifications would be drawn to allow of world-wide competition. Other things being equal, he would favour the tender of a company who would offer to sell the complete rights to work throughout the Commonwealth under their patents in perpetuity, rather than one requiring an annual royalty.

This announcement is the outcome of an interview held the previous day between the Minister and Capt. Walker, representing the Marconi Wireless Telegraph Co., when the latter suggested the establishment of stations for intercommunication between Victoria, Tasmania, New Zealand and the islands in Bass's Straits, as well as with ships within a radius of 1,500 or 2,000 miles. To demonstrate the capabilities of the Marconi system in regular use, it was suggested that temporary stations should be erected at Queenscliffe, Victoria, and some suitable spot on the Tasmanian coast; and Mr. Chapman has intimated that, under suitable restrictions, he is prepared to allow this to be done, the installation to be worked under the supervision of federal officers, but with no obligation for the purchase of the plant at the conclusion of the tests. A similar privilege of demonstrating the reliability of their systems under official supervision will also be granted to other companies, and it is said that the International Telegraph Construction Co., which controls the Shoemaker patents for Australia, is contemplating the provision of stations communicating between Tasmania and the coast of New South Wales, thus being at a considerable distance from the rival stations of the Marconi Company.

**Australian Telephones.**—Mr. Hesketh, Telephone Superintendent to the Australian Post and Telegraph Department, as the result of his recent visit to America and Europe, is now introducing sundry innovations into the Federal telephone service, and the toll system of charging, formerly unknown to Australia, has just been inaugurated in several of the smaller exchanges, as a first step to its general adoption. Hitherto, very low flat rates had obtained in isolated places having not more than 14 subscribers, the exchanges being at the local post offices, entailing practically no charge for attendance; but with a fifteenth subscriber the exchange ranked (according to official regulation) in a different class, and a very considerably enhanced tariff was demanded, provoking no little dissatisfaction. According to the new tariff, subscribers to such exchanges will pay an annual rent of £4 (or for two-party line £3, and for four-party line £2. 10s. each) with 750 free calls per year, and a toll of ½d. per call beyond this number, such rates applying wherever less than a mile of line is required for the service, and an extra charge of £1 per ½ mile being levied if this length is insufficient. This tariff will still obtain for any increase of subscribers up to 1,000, and will include instruments of modern type and in many cases complete metallic circuits. Mr. Hesketh has recently been in Adelaide in connection with the local telephone service, which is shortly to undergo extensive alterations. An earth return is in general use at present, and in view of the prospective tramway electification an early start is to be made in providing metallic circuits throughout, while it is the intention, in the principal streets at any rate, to place the wires underground, all being overhead at present. It is probable that a more modern type of exchange switchboard will also be provided, as the present telephone service is none too satisfactory and decidedly antiquated.

**Ballarat, Victoria.**—An exciting mishap occurred at Ballarat on the evening of December 23rd, in connection with the newly-opened tramways. As a car was running down Sturt-street its trolley wheel jumped the wire, and fouling a telephone line brought it down upon the trolley wire, which was unprotected. The broken end of the telephone line, hanging in coils, got tangled in a buggy that was passing, and started a vigorous arc on to its wheel, but this seems to have let off the station cut-outs, as the passengers of the buggy, though much frightened, escaped without either burn or shock, as also did the horse. The most untoward result of the mishap was that the telephone wire, on becoming alive, started an arc at the exchange switchboard, in consequence of which some 50 subscribers' services were temporarily disabled. The subscriber's instrument upon the broken line also caught fire, but fortunately this was noticed and extinguished before the damage had spread beyond the instrument itself.

## CORRESPONDENCE.

### TESTS OF GAS LAMPS IN FLEET-STREET.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The last paragraph of the "Notes" in your issue of the 26th ultimo contains a statement which implies that this company put new mantles on all the incandescent gas lamps in Fleet-street on Tuesday, the 23rd ultimo, and made photometric tests of the lamps in question on the following day. Allow me to state that no such photometric tests were carried out by this company, or by anyone on their behalf, while on the Tuesday in question only *four* mantles were used on the 70 burners referred to. On what foundation, therefore, the before-mentioned paragraph is based, I am at a loss to understand. Perhaps you will be able to give your readers further information on the point.

I quite agree that photometric tests carried out in the streets are of little, if any, practical value; being necessarily vitiated by the varying conditions of the atmosphere and by the disturbing influence of neighbouring lights. No better proof of the absurd results that can be obtained by street photometry could be desired than the figures solemnly published in the electrical journals a few weeks ago as the result of some tests made by Mr. Frank Bailey of the City of London Electric Lighting Co. I did not, however, notice that the electrical journals then warned their readers against attaching too much importance to such tests!—Yours, &c.,

Westminster, S.W., Feb. 1. F. W. GOODENOUGH,
Chief Inspector, The Gas Light & Coke Co.

[We willingly publish Mr. Goodenough's letter, but at the same time we must point out that our note was quite accurate. Mr. Goodenough admits that the lamps were inspected and nearly 6 per cent. of the mantles were renewed on the Tuesday; and we repeat our assertion that photometric tests were made on the following day, when some of the mantles were new, and, moreover, at an hour when the number of private lamps alight made it certain that the candle-powers observed would be higher than the candle-powers of the lamps. Doubtless we shall learn who made these tests when the results are published, but those who made them should have chosen an opportunity under more suitable conditions if they desired that the results should have any real value.—ED. *E.*]

### HOW TO SCREW CONDUIT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As our company makes both gas tubes and conduit tubes we have read the recent correspondence respecting the screwing of conduit tubes, and think that our experience may be of interest to your readers. We have been for many years engaged in the gas tube trade and have installed here a plant of the latest type for the manufacture of gas tubes which are of necessity made to gas tube sizes and threads. When we determined to go into the conduit trade we were naturally desirous to use our existing plant, and we therefore put on the market tubes and fittings of gas tube sizes and threads, but we found it impossible to get any business, and after exhaustive inquiries amongst the leading consultants and contractors engaged in the conduit trade we found an overwhelming volume of opinion in favour of conduit sizes and threads; we therefore very reluctantly, and at considerable cost, put down a plant to enable us to supply the requirements of the conduit trade, and have never found any difficulty since.

One of your correspondents says that tubes of gas diameter allow of a greater internal clearance than conduit sizes. This, in face of the facts, is a most extraordinary statement to make. A $\frac{5}{8}$ in. heavy gauge conduit tube, measuring, of course, $\frac{5}{8}$ in. outside diameter, measures $\frac{1}{2}$ in. inside, whereas what is known as a $\frac{3}{8}$ in. gas tube, which is practically the same outside diameter, measures only $\frac{7}{16}$ in. inside. That a better mechanical joint can be obtained with a deeper gas thread is one of those popular fallacies which a better mechanical training is gradually dispelling, although that point does not appear to have been reached by some of your correspondents. Even in the gas fitting trade itself the finer thread is invariably used for copper and brass, and in fact for everything except the iron tube itself. We may also mention that the screwing of a gas thread is a greater strain on the tube and costs more in work and time.

That there is a desperate effort being made by a few firms who do not want to discard their gas screwing plant to force gas sizes and threads on the market is very evident, but there is little doubt that in the long run more up-to-date methods will prevail, and that if a standardisation ever takes place it will be on the lines of conduit sizes and threads.—Yours, &c.,

THE NEW BROTHERTON TUBE CO. (LTD.)
ERNEST WHITE, Managing Director.

Wolverhampton, Feb. 6.

## LEGAL INTELLIGENCE.

### Attorney-General (ex rel. Sutton & Co.) v. Manchester Corporation.

Mr. Justice Farwell delivered his considered judgment in this action on Monday. The facts were fully reported in our last issue.

His LORDSHIP said the action against defendant Corporation claimed in effect an injunction to restrain defendants from acting as carriers or delivery agents excepting on their tramways, and from expending any of the corporate moneys for that purpose and for incidental declarations. Defendants were incorporated by Royal Charter in 1839, and they justified the acts complained of both under the powers given to them by their private statutes and also under their common law rights and powers as a chartered Corporation; and they claimed the right to act generally as common carriers. Defendants had called no evidence to show what business was actually done by them, and their acts and intentions were gathered from the documents put in evidence and their admissions and answers to interrogations. Their intention was to put in operation a large and comprehensive scheme of parcels delivery and collection, and as part of the scheme they proposed to accept "cash on delivery" parcels, "express delivery" parcels at special rates, and to "insure" parcels. They also proposed to act as agents for all railway companies for the receipt of parcels. They proposed also to collect and to deliver parcels outside the radius of their tramway lines altogether, between places having no connection with their tramways, and to collect and deliver goods which had never travelled and were not intended to travel by their trams at all. In April, 1905, they issued a book of rates and arrangements for the conveyance of parcels traffic from Manchester to all parts of the United Kingdom and abroad, and described themselves as agents for all railway companies, and they had spent several thousands of pounds in plant, vans and horses, and had engaged numerous agents and servants with a view to carrying on the business. All that expenditure had been, or was intended to be, entered in account and dealt with as part of the expenditure of the Corporation in respect of their tramway undertaking, as part of the working and establishment expenses and as part of the management of the tramway, &c. All the expenses at present incurred in providing horses, vans, carts, stables, offices and agencies used and to be used in connection with collecting, carriage and delivery of parcels had been defrayed out of money borrowed by the tramway undertaking out of capital applicable thereto. The charges of the services so proposed to be rendered would in many cases be in excess of the maximum charges authorised for the use of the tramways when the tramways were used, and in cases where the tramways were not used would be made without statutory authority. The difference between a statutory Corporation and a Corporation incoporated by Royal Charter was well settled, the former could do such acts only as were authorised directly or indirectly by the statute creating it; the latter, speaking generally, could do everything that an ordinary individual could do. If, however, the Corporation by charter was, as the defendants, a municipal Corporation, then they were subject to the restrictions imposed by the Municipal Corporations Act, 1882, and would be restrained from applying their borough funds to purposes not authorised by that act (vide "Attorney-General v. the Mayor of Newcastle"). If defendants had no statutory powers it was plain that they could not apply their borough fund eitheir for the purposes of the tramways or of the business of general delivery agents or common carriers. Granting that theoretically a Corporation by charter could lawfully run tramways or carry on such a business, they could not do so in practice without the expenditure of money, and it was accordingly argued in the present case that, if and so far as the defendants were carrying on business as carriers in excess of their statutory powers, they were doing so under their common law powers, and that the expenses of such excess added nothing to the expenses incurred in respect of the exercise of the statutory powers, and therefore could not be restrained.

His Lordship, proceeding, referred to the statutory powers of the defendant Corporation, and said a section of the provisional order of 1875 provided that the tramways might be used for the purpose of conveying passengers, animals, minerals and parcels. The Manchester Corporation Act, 1897, clearly contemplated the working of the tramways by the Corporation itself. It was no part of the function of the Court to consider whether municipal trading of this or any other kind was or was not politic. His duty was to construe the act by which the Legislature had conferred that power, and he knew of nothing that would authorise him to apply a princple of construction to an act giving power to a municipality to carry on some trading operation differing from those applicable to their own act. The Act of 1899, on which the defendants mainly relied, enabled the Corporation, in his Lordship's opinion, to run carriages and take tolls on all the network of tramways mentioned therein, and to use such tramways for the purpose of carrying, conveying and delivering animals, parcels, minerals, &c. Counsel for the plaintiffs had pressed upon him that there was no power to carry on delivery, but only to use the tramways for the purpose of carrying and delivering. This appeared to him (his Lordship) to be too narrow a ground on which to found a decision. He referred to the Railway Clauses Consolidation Act, 1845, sec. 86, and he found that there was no power to "carry and convey upon the railway all such passengers' goods," *&c.* He was unable to see any real distinction between this and the power given to the Corporation by secs. 8 and 22 of the Act of 1899. But a railway company acting (as all railway companies now elected to act, and as the defendants acted) as carriers and not as either toll-takers or conveyors, had undertaken the ordinary duties of a carrier. As Mr. Justice Byles put it in "Taylor v. the Great Northern Railway," "the first duty of a common carrier is to carry the goods safely, the second is to deliver them." This duty to deliver would exist without the express use of the word in sec. 22, and he could not read that section as restricting the Corporation to deliver from the trams. In the absence of custom or of special contract, he apprehended that a railway company was not bound to deliver at the house or shop of the consignee, but if they did not they were bound to keep the goods safely for a reasonable time and to deliver to the consignee or his agent when *he called for them.* But there was nothing ultra vires in their delivering by cart or otherwise at the consignee's house or to any other place authorised by him, including the station of a railway company, such goods as they had brought on their train lines; such delivery was fairly incidental to their authorised business. It would be difficult in the present case to put any practical limit to the place of delivery. It could not be at the terminus only—this was probably in the highway. Some radius of space within which a receiving store might be situated must be allowed, and some means of conveying to this store must be permitted. There was no ground for confining it to manual labour; indeed, the weights mentioned in the schedule of tolls negatived this. It must, therefore, be open to the defendants to use horses and carts even to get the goods to their own depot, and if they could do this he saw no reason why they should not be allowed to convey them to the consignee's address or to some other place named by him. So far, therefore, as the expenditure complained of arose out of the working of their tramway undertaking he could see no objection to it. So far as regarded "cash on delivery goods," he had no evidence that this was part of the business of a common carrier, and he could only say that, if it was, then the Corporation could accept goods for carriage and delivery on their trams on these terms. But that was all restricted to goods which travelled along the trams or some part thereof. There was nothing in the acts to authorise the Corporation to act as carriers generally without reference to their tramways. To collect and deliver parcels for the tramway was fairly incidental; to collect and deliver parcels outside the radius of the trams, and without any connection with the trams, was not incidental to the tram business but distinct from it. For the same reasons he held that the Corporation could not act as general agents for the railway companies, but only in respect of tram-borne goods. Defendants, however, further contended, and he thought rightly, that the Corporation could so act by virtue of its corporate existence, and that this Court would only interfere to prevent the expenditure of the borough funds on such a venture. But they said, also, that there was nothing to show that they had made any such expenditure. He had, however, already stated that they threatened and intended to do so, and he was not satisfied that they had not already done so. He could not believe that a large general delivery service and a general railway agency could be added to a service limited to the connection with trams without expense. No evidence had been given of the amount of such expenditure, but the plaintiffs, in his opinion, were entitled to an account at their own risk of all sums so expended. The Attorney-General sued to restrain the improper use of the borough fund and these charges when received were an increase to the borough fund. If anyone could complain it was the person against whom they were made. The retailer profited by them. If they were wrongfully made and litigation ensued, it was not a matter of course that the costs, if the Corporation failed, would be allowed out of the borough fund; but however that might be, he was not aware of any authority which would justify him in preventing the Corporation from receiving payments simply because it might be doubtful, whether they were properly recoverable or not. He proposed to make a declaration that the defendants were not entitled to expend any part of the city funds, or the receipts of their tramway undertaking, or the proceeds of any city rate, or any other moneys of the defendants or of the city for the purpose of establishing, or maintaining, or carrying on the business of carriers, except as part of and in connection with their tramway undertaking and in respect of articles carried along all or part of the tramways for the time being belonging or in lease to the Corporation, or on which they had power to place or run carriages, and to grant an injunction on similar terms. If the plaintiffs desired it, he would also direct an inquiry on similar lines, reserving the costs of such inquiry. He had felt some difficulty as to the costs of the action. Plaintiffs had failed on a part of their claim, but they had succeeded to a substantial degree. The action was properly brought, and plaintiffs ought to have the general costs, but with some considerable deductions. He thought justice would be done by ordering defendants to pay plaintiffs one-half of their costs. The defendants would, of course, bear their own costs. He would suspend the operation of the injunction for 14 days to enable the defendants to decide whether they would appeal.

### The King (Picton Bradshaw) v. Dublin Corporation.

In the King's Bench Division (Dublin), last week (the Lord Chief Baron, Mr. Justice Johnson and Mr. Justice Kenny) judgment was given in an application to make absolute a conditional order that Dublin Corporation should forthwith proceed with the main drainage works and the electric lighting of Clontarf, undertaken by them under 63 and 64 Vic., cap. 264. By that act the Corporation undertook to complete the main drainage of Clontarf in three years, and the electric lighting in four years, and the applicant alleged that the time had expired and that the provisions of the act were not carried out,

The LORD CHIEF BARON, in delivering judgment, said he had no hesitation in granting the application in regard to the main drainage. As regards the electric lighting it was admitted that nothing had been done. The period of four years had long expired. Accordingly the mandamus in that respect would also be made absolute.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT AND FILLED.

A shift engineer is required at a large generating station in the North of England. Applications to the Secretary, Durham Collieries Electric Power Co. (Ltd.), 13, St. Helens-place, London, E.C. See an advertisement.

The council of Armstrong College, Newcastle-on-Tyne, will shortly appoint a professor of electrical engineering. Stipend £500 per annum and one-third of fees until £750 in all is reached. Applications to the secretary (Mr. F. H. Pruen) by March 1. See also an advertisement

The lectureship in electrical engineering at the City of Bradford Technical College is vacant. Salary £200 per annum. Particulars from Prof. G. F. Charnock. Applications to the secretary (Mr. T. Garbutt) by 17th inst. See advertisement.

Mr. Hermann Bohle, lecturer and demonstrator in electrical engineering, Bradford Technical College, has been appointed professor of electrotechnics at the South African Technical College, Cape Town.

Mr. T. S. Midgley, of Keighley, has been appointed junior assistant engineer at Oldham.

Mr. C. A. James, Southampton, has been appointed switchboard attendant at Wrexham.

Mr. Dennis, of Eastbourne Corporation Electricity department, has been appointed improver at Acton Council's electricity department.

Runcorn Education committee have appointed Mr. B. Myer lecturer in electric lighting and power transmission at the Technical Institute.

**Aberdeen.**—The Tramways committee have reduced the short list of seven candidates for the post of general manager of the electric tramways to the following three, whose names will be submitted to the Council: Messrs. John C. Couper (traffic superintendent, Halifax), E. Lafferty (traffic manager, Huddersfield), and R. S. Pilcher (traffic manager, Burton-on-Trent).

**Birkenhead.**—The Electricity committee have resolved to extend the Bentinck-street electricity works at a cost of £11,896. The additional plant will include a 350 kw. steam dynamo, two water-tube boilers, condensing plant, &c.

**Birmingham.**—The Electric Supply committee have reported to the Corporation regarding the Shropshire, Worcestershire and Staffordshire Electric Power Bill, some particulars of which were given in our issues of Nov. 24 (p. 237) and Dec. 22 (p. 398). The committee are of opinion that the passing of the bill would seriously affect the interests of the Corporation's electric supply department, and they recommend that the Council petition against it with the view of the exclusion of the city from the company's area.

The Committee also recommend that they be authorised to supply motors and starting switches on the hire system, and estimate from £8,000 to £10,000 will be required during the first two years.

**Bootle.**—The salary of the borough electrical engineer (Mr. T. D. Clothier) has been increased to £425, with a further increase to £500 in 12 months. The salaries of the deputy electrical engineer (Mr. J. B. Hudson) and the chief clerk (Mr. J. H. Hort) have also been increased.

**Brighton.**—The Corporation have decided to give a supply of electricity for power, heating and cooking at a flat rate of 1½d. per unit, without restriction as to the hours of consumption.

**Chili.**—A standing committee of the Senate has reported favourably on a petition for a 100-years' concession for an electric railway between Valparaiso and Santiago with a branch to Quintero.

**Croydon.**—A Board of Trade inquiry was held here on Tuesday by Lieut.-Col. von Donop into the objections regarding the extensions of the tramways from Croydon to Sutton and other places.

The South Metropolitan Electric Tramways & Lighting Co. have powers to construct electric tramways in the neighbourhood. They have authority to lay single lines in some places and double lines in others, but they were now seeking to lay double lines throughout except from Mitcham to Sutton where they have agreed to put single lines where there was not a 9 ft. 6 in. clearance. After evidence the inquiry was adjourned for a week.

**Customs Decisions.**—The Australian Commonwealth Customs authorities have classified baths (electric hot air, electric light and hot air, and 4-cell) as electrical machinery and appliances, to bear a duty of 12½ per cent. ad val., and sinusoidal transformers (a combination of motor generator, static transformer and electro-medical appliance) in two divisions, the motor generator and electrodes as "electrical machinery and appliances," bearing a duty of 12½ per cent. ad val., and the static transformer as "electrical materials" imported free of duty.

**Darlington.**—The Council have increased the salary of Mr. Redfern, engineer in charge at the electricity works.

**Derby.**—From April 1 it has been decided to adopt the following charges for electric current for power for all-day use: Up to 5,000 units per quarter, 1¼d. per unit; over 5,000 and under 10,000, 1⅛d.; over 10,000, 1d.

**Douglas.**—The Council have decided to adopt electric traction on their present horse and cable tramways. An independent power station will be erected.

**Dundee.**—The recommendation of the Electricity committee that the scheme prepared by the city electrical engineer (Mr. H. Richardson), for the erection and equipment of a new power station at Stannergate at a cost of £75,000 (which was referred to in our last issue), came before the Council on Thursday last, when it was decided to defer the matter for consideration at a special meeting.

**Easthampstead.**—The Camberley Electric Light Co. have now agreed to schedule the roads proposed by the Council as part of the company's compulsory area of supply, and to make the charge for current 7d. per unit for lighting and 2½d. for power.

**Edinburgh.**—The Electric Light committee have asked Sir Alex. B. W. Kennedy and the City electrical engineer (Mr. F. A. Newington) to report on the condition of the electrical plant and machinery, preparatory to considering what provision should be made for renewals. The equivalent of 2,203 8 c.p. lamps was applied for during January, and a total of 46,773 since May 15 last.

**Electric Wires and Fires.**—Mr. W. B. Trafford, consulting electrical engineer, has reported (at the request of the Sun Fire Office) upon the electrical installation at Addenbrooke's Hospital, Cambridge, where a fire recently occurred. There are about 200 lights in the building, supplied with current at a pressure of 200 volts. Mr. Trafford is of opinion that the fire was not caused by defective electrical work, nor by leakage of electricity to a gas pipe. Nearly the whole of the wires were of 600 megohm grade by the Silvertown Co., and were in Simplex seamed tubing. One light, though wired in bitumenised brass gas tubing, being part of an older portion of the work, was also intact. None of the distribution fuses (which are of 5 amperes capacity) were blown, which would have occurred with such small fuses had there been any leakage. No gas barrel was within about 4 ft. of any wiring in the roof where the fire occurred.

**Electricity in Cotton Mills.**—Mr. G. F. Metzger read a Paper before the Manchester Association of Engineers recently on "Modern Electrical Developments."

Dealing with the electric driving of cotton mills Mr. Metzger said that experiments had been carried out with great success, but the conservatism of millowners had still to be broken down. Experience in other countries proved that electrical driving was more economical and realised larger outputs than mechanical driving. The steady running required for spinning and weaving as well as the variable speeds necessary for bleaching, were met exactly by electricity. Constant speeds could be assured by installing three-phase motors, whilst direct current motors were capable of being driven at speeds of any variation. Apart from saving in building space, the reduction of costs and the application of either constant or variable speeds, electric driving in mills, by its flexibility and simplicity, guaranteed increased outputs due to higher speed and a considerable saving in the cost per lb. of yarn. By subdividing the main source of power into three units, one being spare, freedom from breakdown was assured, and at the same time portions of the mill could be run during overtime without spoiling the head-factor of the plant. It was only during the last 12 months that millowners had realised the practicability of that application of electricity, and mills were new being electrically equipped throughout. When the working results were published they could not fail to impress the textile world, and further developments on a large scale might undoubtedly be expected in the industry.

**Factory Prosecution.**—At the Thames Police-court on Thursday last the London Electrical Syndicate (Ltd.) were summoned for having their workshop in such a condition that the process of manufacturing electric accumulators could not be carried on without danger to health.

Mr. Bellhouse, Inspector of Factories, said the proceedings were taken under sec. 18 of the Factory and Workshops Act, and he asked for an order to prevent the further manufacture of electric accumulators at defendants' works.

Dr. T. Morrison Legge, Medical Inspector of Factories, said he visited the workshop on Jan. 23. The manufacture of accumulators had been scheduled as a dangerous trade, and at the works mentioned the regulations in question had not been conformed with. Those regulations dealt with the manipulation of lead compounds, to guard against the danger of lead poisoning; and the work at defendants, manufactory could not be carried on without danger to health, unless the regulations were complied with. The mixing of red lead and litharge paste had been carried on without an exhaust fan to carry away the dust, consequently the workmen had to enhale it. Witness found a workman who had suffered from lead-poisoning, which had been contracted owing to the way the work had been carried on. In addition to the fan he had mentioned, the bench at which the mixing was done should be covered with sheet lead and the floor concreted, so as to be capable of being washed down every day. He recommended the court to make an order that the manufacture of accumulators should not be carried on until the improvements had been effected.

Mr. Mead made the order asked for and allowed 25s. costs.

**Forthcoming Books.**—"The Electrician" Company will publish at the end of next week the 1906 edition of the Big Blue Book ("The Electrician" Electrical Trades' Directory and Handbook), making over 2,000 pages. The new edition will contain a mass of new matter of great interest to the electrical and allied industries, and all the old useful features, brought quite up to date and amplified where necessary, will be retained. The Directory Division will be completely revised up to Feb. 9. There is no book published in any language to compare with the Big Blue Book in up-to-dateness, completeness or accuracy of contents. This can be easily proved by comparison. The published price of the new and enlarged edition remains at 15s., postage extra.

The same Company will issue in a few weeks a new work entitled "Electricity Meters; their Construction and Management," by C. H. W. Gerhardi. This work will form a complete treatise on the electricity meter for every purpose to which this instrument is applied, and all that can be said regarding the electricity meter will be available to the supply station engineer, the manufacturer, the student and the consumer. More than 200 illustrations, the greater portion made expressly for Mr. Gerhardi's text, will be found to completely cover the important subject which they elucidate. Mr. Gerhardi's unique experience, extending over many years, as chief of the meter department of the largest electricity supply undertaking in the world, lends additional interest to the publication of this volume, which will be issued at 9s. net.

A work upon "Steam Turbines," by T. Stevens and H. M. Hobart, will be issued by Messrs. Whittaker & Co. in March, and will contain exhaustive comparisons between steam turbine and piston engine economies. Weights, costs, speeds, number of wheels and blades and other leading data of the various types will be contrasted in tabular form. The book will extend to some 600 pages and will be fully illustrated.

**Fraud.**—At Manchester Assizes last week John M'Cambridge, an employé of the British Westinghouse Co., was sentenced to 12 months' hard labour for obtaining £60 by fraud from the company. Accused made out false expenses sheets, charging for journeys he had never taken.

**French Indo-China.**—In this part of the French oversea dominions there are at present two lines of tramway working, one running through Hanoi and its suburbs, and another running from Nam Giang to Kesat. These lines cannot as yet be considered commercial successes. Two other lines are being started, one from Hanoi to Thai-Ngnyen and another from Hanoi to Sontay. In Cochin China there are four lines of tramways, one from Saigon to Cholon (upper road), one from Saigon to Cholon (lower road), one from Saigon to Gonrap and one from Saigon to Hoc Mon. All these four lines are financially successful, and the turnover increases regularly. A line of tramway is in course of construction in Annam from Tourane to Fai-Fo.

**Hackney (London).**—A report, prepared by the Electric Lighting committee on the system of charging for electric current, recommends that the maximum demand system be altered from 7d. for the first hour and 1d. after to 6d. and 1d. and that the flat rate be reduced from 4d. to 3d.

The new scale of charge for power is to be extended to current supplied for heating and cooking. Power consumers are to have an optional flat rate of 1½d. per unit and the right to use current for lighting up to 20 per cent. of the energy supplied. Places of worship are to be supplied at 3d. per unit for lighting and 1d. for power. The new charges come into force on April 1.

Nine additional streets are to be lighted electrically, and 7-ampere arcs will be used in substitution for the present gas at an annual cost of £1,248, against £676 for the present gas supply.

**Hastings**.—The Hastings & District Electric Tramways Co. have decided to adopt the G.B. surface contact system on the sea-front route.

**Home Office Rules for the use of Electricity in Mines**.—A pamphlet has been prepared by Mr. W. C. Mountain containing some notes on the Home Office mining rules. The wording of the actual rules is given in red, and notes, printed in black, follow each paragraph commenting on and explaining the exact object of each rule, and, in many cases, accompanied by illustrations and descriptions of apparatus suitable for complying with the requirements. The section on switch gear for use with motors is particularly complete in this respect, having some excellent blocks illustrating several types of enclosed starters and motor panels and high-tension oil switches. At the end of the pamphlet some useful tables are to be found dealing with the calculation of sizes of cables, &c., and giving *formulæ* and constants useful for proportioning ropes, belts, gearing and shafting. Tables of friction in water and compressed air pipes are also given, together with conveniently-arranged data of horse-powers required for haulage. Copies of Mr. Mountain's book can be obtained price 2s. 6d.

**Hornsey**.—An inquiry was held last week into the application of the Council for sanction to borrow £10,000 for extensions of the electricity undertaking. The town clerk (Mr. F. D. Askey) gave statistical particulars, and the borough electrical engineer (Mr. Norman Staniland) gave technical details. £7,374 of the loan is for mains, £2,100 for services and £400 for meters. There was no opposition.

**Italy**.—The local authorities of Teramo are desirous of constructing and operating an electric railway between Montesilvano and Penne, and are seeking a subsidy from the Italian Government to partly meet the cost.

**London County Council Tramways**.—At the last meeting of Marylebone Council it was reported that an extension of time had been granted to the L.C.C. for the construction of the Edgware-road tramway.

Paddington Council have decided to petition against the bill to authorise the construction of the Edgware-road line.

**Loughborough**.—A deficit of £329 is reported on the working of the electricity undertaking for the last half year, but as there are now a larger number of customers it is hoped that the winter half-year will show an improvement.

**Light Railways**.—The North Lindsey Light Railways (Extensions) Order has been submitted to the Board of Trade for confirmation. Objections by Feb. 24.

It is stated that Messrs. Bruce Peebles & Co. (contractors for the North Wales Power Co.) will apply for a renewal of the light railway order authorising the construction of the Llandudno and Colwyn Bay light railway and that the local authorities concerned have agreed to the application, on condition that the lines be ready for working by June next.

**Lincoln**.—The Council on Tuesday decided, on the recommendation of the Electricity Works committee, to apply for sanction to a loan of £13,000 for additions and extensions at the electricity works for cables, &c.

**Manchester**.—At a meeting of the Tramways committee on Wednesday Mr. D. Boyle referred to the decision given in the action brought against the Corporation by the Attorney-General (at the relation of Sutton & Co.) and said that the committee would be able to proceed with their business unhampered, and the decision appeared to satisfy all parties. By the judgment they were better off than they had been. They did not intend to appeal against the decision, because they had got everything they wanted, substantially.

**Newcastle-on-Tyne**.—The Corporation have decided to oppose the additional powers bill of the Newcastle-upon-Tyne Electric Supply Co.

**Patent Amendment**.—Mr. F. M. Lewis, electrical engineer, 11, Buckingham-road, Brighton, seeks leave to further amend the specification of Letters Patent No. 4557 of 1903, granted to him for "Improvements in or connected with electric arc lamps." Particulars of the proposed amendment are given in the "Illustrated Official Journal (Patents)" of Jan. 31, 1906, and notice of opposition must be lodged within one calendar month of that date.

**Provisional Order Revocation**.—The Board of Trade have revoked the New Hunstanton Electric Lighting Order, 1901.

**Radial Truck Patents**.—On the subject of the threatened patent litigation in respect to radial trucks, we have received the following from Messrs. Mountain & Gibson (Ltd.):—

ELECTRIC TRAMCARS.—RADIAL TRUCKS.

Our attention has been called to a so-called "Caution" under the above heading appearing in your last issue, wherein it is stated that Messrs. Lycett & Conaty have commenced an action against us for alleged infringement of certain letters patent in respect of electrically-driven tramcars. At the moment we can only say that we have taken the best expert opinion available, and are advised that the letters patent referred to are altogether invalid, that our radial trucks are not an infringement thereof, and that we have a complete defence to the action.

In case any action should be brought against any purchaser of our said trucks, we are prepared at our own expense to defend such action on the conduct thereof being handed over to us forthwith, on the writ being issued.—Yours faithfully, MOUNTAIN & GIBSON (LTD.)

**Reigate**.—The Council have received permission to borrow £4,000 for electric lighting extensions.

**South Lancashire Tramways**.—At the meeting of the Newton-in-Makerfield Council on Monday a letter from the promoters of the South Lancashire Tramways Bill stated that it was at present impossible to raise sufficient money to construct the whole of the authorised tramways, and that therefore they proposed not to apply for any further extension of time in the case of those tramways which they would probably be unable to complete within a reasonable period.

**Southwark (London)**.—The Works committee have been experimenting with various lamps with a view to effecting an improvement in the lighting of the side streets, and consider that the 1 ampere Nernst lamp, fitted in a Windsor lantern, is best suited for their purpose. The lamps had been fitted in one of the thoroughfares, and at a recent inspection the committee were unanimously in favour of their adoption (at a cost of £300) for the whole of the side streets at present lighted by electricity.

The equivalent of 41,481 8 c.p. lamps is connected to the mains, including 9,749 for power.

**Stafford**.—At the Council meeting on Tuesday, Mr. Wright intimated that £6,300 would shortly be required for extension at the electricity works.

**Sunderland**.—The profit on the electricity undertaking for the past year is stated to amount to nearly £700.

**Thornaby**.—The Council have sealed the deed of transfer of the Corporation's electric lighting order to Durham County Electric Lighting Co., who are to pay £200 for expenses incurred by the Corporation, and the latter reserve rights of acquiring the undertaking.

**Tonbridge**.—An inquiry was held here last week into the application of the Council for permission to borrow £2,000 for extensions of the electricity undertaking. The clerk (Mr. E. H. Neve) and the electrical engineer (J. B. Horsley) gave evidence in support of the application. There was no opposition.

**West Bromwich**.—The Electricity committee recommend the borrowing of £1,650 for additional machinery, mains and instruments.

**West Hartlepool**.—Mr. Friederichs (borough electrical engineer) has reported that additional electrical plant will be required to meet next winter's load. Ald. Macfarlane urged at the Council meeting this week that the buildings should be extended by direct labour. Ald. Suggett moved an amendment that the work be done by contract, and the amendment was carried.

**Worcester**.—The accounts of the electricity department for the past year show total capital expenditure £127,384. 14s. 5d., increase £1,553. 10s.

Revenue was £2,582. 7s. 2d. from the tramway company (against £2,059. 13s. 11d.) and £11,263. 11s. 3d. from other sources (against £10,909. 9s. 8d.), the total revenue was £14,945. 15s. 9d. (against £14,154. 8s. 9d.). Working costs were £7,597. 8s. 10d. (against £7,785. 5s. 2d.), gross profit £7,348 (against £6,379. 3s. 7d.). Interest required £3,836. 2s. 9d. (against £3,744. 1s. 9d.) and sinking fund £3,810. 7s. 2d. (against £3,914. 12s. 10d.), leaving a deficit of £298 (against £1,289). There are 708 private consumers (against 666) and the equivalent of 48,543 8 c.p. lamps connected (against 45,632). Units sold were 1,059,094 (against 932,167).

The engineer (Mr. C. M. Shaw) states that the deficit having been reduced by £991. 8s., compared with the previous year, is satisfactory in view of special charges of £709. 2s. 5d. and a charge of £120. 16s. 9d. for repair of cottages which have had to be met during the past year, and that, but for these charges, a profit would have been shown. Coal cost 0·618d. per unit sold (against 0·812d.), and salaries and wages were 0·353d. per unit against 0·421d. The works costs were 1·239d. (against 1·575d.) and the total working expenses 1·602d. per unit (against 1·883d.). The water-works motors used 80,062 units (against 39,548), private consumers' motors 20,186 units (110 per cent. over last year's consumption), and the tramways company had taken 71,770 units (28·3 per unit) more than last year.

**Workhouse Lighting**.—At the meeting of Rathdrum (Ireland) Guardians last week, Mr. Kennedy moved that the resolution of the board postponing for 12 months consideration of the electric lighting of the workhouse and hospital be rescinded. The motion was, however, defeated by 20 votes to 6.

**Festivities.**—The staff of Brighton Corporation Telephone Department held their second annual ball on Friday last at the Old Ship. The initial event in 1905 was a complete success, but on this occasion the committee succeeded in improving on last year's record. The visitors (about 200) were received by the engineer (Mr. D. J. Barnes) and Mrs. Barnes. The mayor and mayoress (Ald. and Mrs. Colbourne) graced the proceedings, whilst several other members of the Town Council also put in an appearance.

The second annual meeting and ball of the employés of Aberdeen Corporation tramways department took place on Wednesday. The convener of the Tramways committee (Councillor Taggart) presided.

## TRADE NOTES AND NOTICES.

### TENDERS INVITED.

*Londonderry* Corporation invite tenders for supply of materials for the electricity department for one year from April 1, 1906, including carbons, meters and demand indicators, bitumen and box compound, cables, boxes and troughs and house fuse boxes. Specifications and tender forms from the electrical engineer (Mr. R. V. Macrory), Strand-road, Londonderry. Tenders to the town clerk (Mr. F. Henry Miller) by noon March 3. See also an advertisement.

*Croydon* Corporation invite alternative tenders for the supply of 15 double-deck double and single truck cars, respectively, complete, equipped with motors, &c., for the overhead trolley system. Specifications from the borough electrical engineer (Mr. A. C. Cramb), Factory-lane, Croydon. Tenders to the town clerk (Mr. F. C. Lloyd), the Town Hall, Croydon, by 11 a.m. Feb. 19. See also an advertisement.

*Sydney* (N.S.W.) Council invite tenders for (*a*) boilers, automatic stokers, pipe work, &c.; (*b*) turbo-alternator, sub-station machinery, switchboards, &c. Specifications from Mr. T. Rooke, at the offices of Messrs. Preece & Cardew, 8, Queen Anne's-gate, Westminster, after 12th inst. Tenders addressed to the town clerk (Mr. Thos. H. Nesbitt) must be delivered at the Town Hall, Sydney, by 4 p.m. May 7. See also an advertisement.

*Sunderland* Corporation invite tenders for supply of one boiler feed pump, one wooden cooling tower, one surface condenser with motor-driven pumps, coal bunkers, gantry and other steel work; also for extension of Hylton-road station. Tenders (addressed to the Chairman of the Electricity and Lighting committee) to the town clerk (Mr. Fras. M. Bowey), Town Hall, Sunderland, by noon March 2.

*Salford* Electricity committee require tenders for stores for 12 months, including cables, meters, house fuse boxes, castings, tubes and fittings, carbons, electric lamps, switches and fittings, electric motors and motor starters, ammeters, oil and engine room stores, &c. Tenders by Feb. 17.

*Salford* Tramways committee require tenders by 3 p.m. Feb. 12, for 12 months' supply of various materials, including electrical and mechanical car accessories, wire, oils, lubricants, &c.

*West Ham* Corporation invite tenders for one 1,500 kw. to 2,000 kw. two-phase turbo-alternator, one 500 kw. motor-generator and switch gear. Tenders to the town clerk (Dr. Fred. E. Hilleary), Town Hall, West Ham, by 4 p.m. Feb. 16.

*Shoreditch* (London) Borough Council invite tenders for stores for one year ending March 31, 1907, including electric cables and sundries, gas pipe and fittings, and engineers' stores. Tenders to town clerk (Dr. H. Mansfield Robinson), Town Hall, Old street, E.C., by 3 p.m. March 13.

*Leyton* Urban District Council invite tenders for underground electric feeders on the solid system for their tramways. Tenders to be delivered to the Electric Lighting committee, Town Hall, Leyton, on Feb. 15 at 7:30 p.m.

*Barnes* District Council invite tenders for supply, delivery and erection of 300 kw. steam dynamo, together with switchboard panels and connections. Tenders to the Clerk, Council House, High-street, Mortlake, S.W., by Feb. 12.

*Islington* (London) Borough Council require tenders by noon, Feb. 22, for 12 months' supply of stores, &c., including meters, carbons, incandescent lamps, terminal boxes, arc lamp globes, oils, engineers' stores, &c.

*Halifax* Corporation want tenders by 26th inst. for 12 months' supply of stores and materials for their electricity tramways and highway departments, including electrical supplies, tools, ironmongery, paints and varnishes, engine room stores, &c.

*Blackburn* Electricity and Tramways committee invite tenders by 10 a.m. Feb. 12 for stores for 12 months to March 25, 1907, including incandescent lamps, meters, pipes, cable, fuse-boxes, switches, &c., motors, arc lamp carbons, &c.

*Bermondsey* (London) Council want tenders by 4 p.m. Feb. 22 for supply of stores for the electricity and destructor works, including lead-covered and indiarubber cables and jointings material, conduits, carbons, electricity meters, engine oils, &c.

Tenders for electrical works and supplies at buildings in *Dublin* and its vicinity are invited by the Commissioners of Public Works, Ireland. Forms of tender, &c., from Mr. H. Williams, Office of Public Works, Dublin. Tenders by 10 a.m. March 1.

*Battersea* (London) Council require tenders by noon 20th inst. for stores for the electricity department, including meters, joint boxes, coal, oil, &c.

*Chelsea* Public Baths committee invite communications from engineers desiring to tender for the electric lighting of the new baths, Manor street. Communications to 171, King's-road, Chelsea, W.

*Cardiff* Corporation invite tenders for cooling towers, electrically-driven pumps, pipe work, &c., for Roath power station. Tenders by Feb. 16.

*Westminster* City Council want tenders by 9 a.m. Feb. 23 for 12 months' stores, &c., including machinery and electrical fittings, iron castings, stoneware goods, &c.

*Rathmines and Rathgar* District Council want tenders by 17th inst. for 12 months' supply of arc lamp carbons, coal for electricity works and general stores.

*Dover* Corporation want tenders by Feb. 12 for a 350 kw. combined steam generator set for traction.

*Wakefield* Corporation invite tenders for a water-softening and purification plant. Tenders by Feb. 17.

*Southend* Electric Light committee want tenders for making a borehole for a well at the London-road depot.

*Hornsey* Town Council want tenders by 26th inst. for cables, junction boxes, fuse boxes, meters, cables, stores, &c.

Tenders are wanted by 16th inst. for the partial installation of electric light at Salop Infirmary *Shrewsbury*.

*Schaffhausen* (Switzerland) Municipality are about to invite tenders for the improvement and extension of the town electricity works, and the provision of turbo-generating plant, at an estimated outlay of over £45,000.

The State telegraph department, *Madrid*, invite tenders by March 4 for the supply of 20 tons sulphate of copper, in accordance with conditions published in the "Madrid Gazette" for Feb. 2.

### TENDERS RECEIVED AND ACCEPTED.

Messrs. Newtons Limited, of Taunton, have received instructions from Messrs. Foote & Milne, London, contractors for the Newquay Electric Light & Power Co. (Ltd.), to supply the generators and boosters for the new generating station.

An order has been placed with the Brush Co. for 40 steel trailer coaches for the Metropolitan District Railway. The cars are to be of similar design to those at present in service on this line, but the use of steel instead of non-inflammable timber has been decided upon.

Croydon Corporation have accepted the tender of Dick, Kerr & Co. for a 1,000 kw. d.-c. steam dynamo at £6,975 and that of Siemens Bros. & Co. for traction feeder panels at £198. 10s.

Birmingham Corporation Tramways Department have placed an order with Veritys Limited for 75 Aston-Worsley weight-relieving arc lamp clutches, winches, &c., for the new car sheds.

Shipley Council have accepted the tender of Smith & Croft for wiring the new fire station.

Southwark Borough Council have placed an order with the General Electric Co. for 16 automatic switch circuit-breakers at £11 each.

Rotherham Council have accepted the tender of Dick, Kerr & Co. for six roof covers for tramcars at £115 each.

West Bridgford Council have accepted the tender of J. W. Smith for installing fire alarm and telephone communication.

Reigate Council have accepted the tender of the Aron Electricity Meter (Ltd.) for the maintenance of meters.

Leyton Council have accepted the tender of W. Manders for construction of permanent way of tramways at £127,485. 11s. 5d.

Birkenhead Council have accepted the tender of Millars' Karri & Jarrah Co. for 170,000 Jarrah wood blocks at £10. 13s. per 1,000.

In reference to the contract for 10 boilers for the Port Dundas Electricity Works, Glasgow (referred to in our issue of Jan. 23), the Corporation have rejected the Electricity committee's recommendation, and have decided by 36 votes to 28 to divide the contract, the order for four boilers going to the Stirling Boiler Co., Motherwell, N.B., and the contract for six boilers to Babcock & Wilcox, Oriel House, Farringdon-street, London, E.C.

### BUSINESS NOTICES.

Mr. A. Eckstein, M.I.E.E., late managing director of the General Electric Co. (Ltd.), who established himself in business in October last at 7, Market-street, Manchester, has taken into partnership Mr. A. C. Heap, and in future the firm will be known as Eckstein, Heap &

Co., manufacturing electrical engineers and suppliers of all kinds of electrical accessories. Works, Waverley Mills, St. Simon-street, Salford; show rooms and warehouse, 5, Chapel-walks, Cross-street, Manchester. Mr. Heap was until recently manager of the switch-gear department of the General Electric Co. at Manchester, and was formerly for many years chief engineer to Messrs. Elliott. Bros. The following gentlemen have also joined the new firm: Mr. Percy B. Hall, A.I.E.E., formerly manager of the General Electric Co.'s switchboard department and latterly assistant manager of the switch-gear department; Mr. A. R. H. Jackson, formerly chief draughtsman of the instrument department with the General Electric Co. at Manchester; Mr. D. B. Mellis, formerly manager of the instrument department of the General Electric Co., Manchester; and Mr. F. Panter, formerly shop manager of the instrument department of the General Electric Co., Manchester.

The St. Helens Cable Co. announce that, with a view to concentrating their Scottish business, the offices at 93, Hope-street, Glasgow, and Telephone House, Rose-street, Edinburgh, have been closed, and new premises at 191, Howard-street, Glasgow, have been occupied. To this latter address large stocks of cable and rubber goods have been transferred, and all Scottish business will there be transacted. The cable department will, as before, be under the management of Mr. A. Cowie. Mr. Robert Sinclair will take charge of the rubber tyre and mechanical departments. In the Newcastle district, where Messrs. R. Dixon & Sons have previously represented the company for electric cables and wires, &c., fresh offices have been taken at 32, Clayton-street West, under the management of Mr. F. H. Morley, who has hitherto represented the company in the Lancashire and Yorkshire districts.

Mr. W. W. Buckton, B.A., A.M.I.M.E., A.M.I.E.E., and Mr. H. J. Jones have entered into partnership as consulting engineers, and have taken offices at 72, Victoria-street, Westminster, S.W. They are devoting themselves more especially to the electrical equipment of collieries, shipyards, ironworks and industrial concerns generally, in which branches of engineering they both have had large experience over a number of years. Telegrams, "Crosshead London," 357 Victoria.

Messrs. Hansard & Watson, consulting electrical engineers, have removed to Parliament mansions, Victoria-street, London, S.W.

Mr. C. C. F. Monckton has removed his office from 53, Victoria-street to Parliament-mansions, Victoria-street, London, S.W., where all communications should in future be addressed.

Saml. Haslam and Arthur Sibley Richardson, electric lamp agents and dealers, 10, Summers-street, Birmingham, have dissolved partnership.

Hy. Geo. Shoolbred and Fredk. Robt. Connell, electrical engineers, Thanet House, 231, Strand, London, W.C., have dissolved partnership. Debts by Mr. Shoolbred, who continues.

Arthur Edwin Lamkin and Thos. Cecil Stuart, electrical engineers, &c., 129, High-street, Croydon, have dissolved partnership. Debts by both the former partners.

## BANKRUPTCIES, LIQUIDATIONS, &c.

A first dividend of 9d. will be payable on 12th inst. at 191, Corporation-street, Birmingham, in the bankruptcy of W. S., H. T. and Grace E. Wright (trading as Wright's Patent Heater Condenser Co.), Great George-street, S.W., and Carlisle-street, Lambeth, S.E., London.

Claims against the Telescriptor Synd. (Ltd.) to Mr. E. Waterhouse, 3, Frederick's-place, Old Jewry, London, E.C., by Feb. 21.

A meeting will be held on March 8 at 32, Strand-street, Liverpool, to receive an account of the winding up of the Anti-Collision Alarm Telegraph Co. (Ltd.).

The Webster Electrical Engineering Co. (Ltd.) is being wound up voluntarily. Mr. W. M. Gray, District Bank-chambers, Bradford, is liquidator.

A meeting will be held on March 13 at 146A, Queen Victoria-street, London, E.C., to receive an account of the winding up of Holophane (Ltd.).

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**Sale by Auction.**—Messrs. Horne & Co., 8, Delahay-street, Storey's-gate, Westminster, S.W., will sell by auction (by order of the Secretary of State for War) at the Royal Arsenal, Woolwich, on Feb. 21 at 11 a.m., a quantity of obsolete stores, including metals, 14 lathes, electrical appliances, telegraph instruments, lamps, &c. Further particulars are given in an advertisement. Catalogues from the War Office, Pall Mall, the Ordnance Office, Tower, and the Ordnance Office, Royal Arsenal, Woolwich.

**Plant for Sale.**—Mr. John S. Brown, Oxford-street, Swansea, has for sale electric lighting plant. See an advertisement.

**Sale by Tender.**—The well-assorted stock-in-trade of electrical and motor fittings, &c., of Wm. Leslie, bankrupt, is offered for sale by tender by Messrs. Hy. W. Figg & Son, metal trade machinery valuers and auctioneers, 128A, Queen Victoria-street, London, E.C. Further particulars are given in an advertisement.

**Factory Sites Offered.**—An offer is made of a freehold site of from 2 to 10 acres, free of cost, to engineers or manufacturers contemplating the erection of works. Particulars from Mr. O. B. Thomas, solicitor, 59, Chancery-lane, London, W.C. See also an advertisement.

**Denial.**—The Hart Accumulator Co., Marshgate-lane, London, E., write us as follows:—

> It having come to our knowledge that a report is being circulated amongst the electrical trade to the effect that we undertake house-wiring contracts, thus acting in competition contrary to the interests of wiring contractors, we wish to emphatically deny this, as our business is, and always has been, confined entirely to storage battery manufacture. It has also been stated that we are foreigners, and that our batteries come from abroad. Such a statement is quite unfounded, as all our batteries are made at our Stratford works with British material and labour, and we have not a single foreigner in our employ. Some confusion may have arisen through a firm that makes switches and other accessories, using in its title our word "Hart," but we have no connection whatever with this firm, and will thank our numerous friends and customers to address all communications to our head office and works, Stratford, London, E.

**New Electric Burglar Alarm.**—A demonstration was given on Monday last at the First Avenue Hotel, London, by Messrs. Carter & Co. of a new form of burglar alarm which they are putting on the market. The instrument is put into action by any one of a series of door or window contacts in the usual way, but instead of the alarm being given by a bell or gong an electrically driven device is provided which blows a police whistle outside the building. The arrangement simply consists of a small motor which, through a suitable gear, compresses and releases two indiarubber bulbs connected by pipes through the wall to the whistles. As soon as the motor starts it closes a second circuit, which causes it to continue running even if the door contact has been again opened, and the whistles will continue to sound until the switch of the instrument is turned off. The makers claim that the apparatus is even more reliable than an ordinary bell and has the further advantage of emitting a more distinctive sound.

**Kryptol.**—A description of this material for electric heating appeared in *The Electrician* for Nov. 11, 1904 (Vol. LIV., p. 156). It is the invention of Dr. A. Voelker, assisted by Dr. Bernbach and Dr. Sulzer, and is a resistance material in powder form which can be applied to all purposes where heat is to be generated electrically. It consists chiefly of carbon in various allotropic forms. There are a number of different kinds of powder, varying in composition and size of grain from 1 mm. to 7 mm. in diameter. In making the powder—which looks like black sand—the ingredients are mixed together, and the whole is formed into briquettes with the aid of suitable binding material. These briquettes are then crushed and screened. Loose powder is only used for laboratory and industrial purposes, and temperatures well above 2,000°C. can be obtained. A nickel coin was melted yesterday (Thursday) in a couple of minutes in a small laboratory furnace by Dr. Voelker, who is holding an exhibition of Kryptol appliances this and next week at 6 and 8, Scrutton-street, Finsbury-square, London, E.C. For domestic and partly for industrial purposes the resistance material is made in the form of bricks, plates or rods. Most of the appliances, such as cooking appliances, stoves, foot-warmers, &c., which we were shown make use of Kryptol rods provided with a metal cap at either side. These Kryptol cartridges are made in two kinds: one for voltages from 100-120 the other for voltages from 220-250, but either is stated to work well with voltages up to 30 per cent. above or below the normal, although the heat given out will, of course, depend upon the voltage. At 110 volts the low-voltage cartridge lets 0·25 amperes pass, while the other cartridge admits only half this current. Both kinds are exactly of the same length and diameter. One cartridge is stated to suffice to keep one cubic metre (35 cubic ft.) of air constantly at 20°C. above the surrounding atmosphere. In all the ovens, stoves, &c., the manner of fixing the cartridges is the same—viz., the cartridges are simply held at either end in clips in electrical connection with the supply.

For heating inflammable liquids, &c., the cartridge is embedded in fire brick, the whole being in a nickel-plated cylinder rounded off at one end and provided with protruding terminals at the other. This appliance is then lowered into the liquid it is desired to heat. The life of a cartridge is guaranteed to be 3,000 burning hours, but its real life is said to be considerably longer. The German patents have been bought up by the Norddeutsche Maschinen und Armaturenfabrik, who have taken up the manufacture on a large scale. The big ocean liners of the Norddeutscher Lloyd are, we understand, all being fitted with this type of electric heater, and we were told that on three of the biggest liners the energy expended in electric heating amounts to some 90 kw. (800 amperes at 110 volts). The exhibition referred to includes heaters of many sizes and descriptions, including foot-warmers for motor carriages, and other portable heaters, cookers, &c. The Kryptol tubes may also be used as resistances for motor starters and other purposes, and we understand that the makers are perfecting the design of a motor starter in which the powder is used in a different manner.

**"Newton" Dynamos and Motors.**—Newtons Limited, of Taunton, have ready a catalogue describing the special construction of their new "Mawdsley" dynamos and motors, made under licence from the "Zone" Patents Co. Two 100 kw. belt-driven dynamos of this type have been supplied to the Home Government, and Newtons Limited have repeat orders on hand from H.M. Office of Works for duplicate plant. Larger machines have been supplied to other orders. Dimensional and sectional drawings accompany the list, which also contains several good illustrations of the complete machine. A brief description of the type of dynamo will not be without interest. Both the magnets and yoke are of high permeability cast iron and of special design and form (see Fig. 1), so as to avoid magnetic leakage. The field coils too, it will be noticed, are of special shape. They are placed in the neutral zone, and this, it is claimed, ensures sparkless commutation, with fixed brushes, at all loads. The field windings may readily be removed without dismantling pole shoes or magnets. It is also seen that this field coil arrangement lends itself to a very effective ventilation. Dynamos and motors are made of the shunt series or compound type, and the design is such that the machines may be run up to 50 per cent. overload without injurious sparking. The design of the armature, commutator, brush gear and so on appears to conform to modern practice. All parts are made to gauge, and are, therefore, interchangeable. Fig. 2 shows the pattern of end covers made by the company for "enclosed ventilated" and "totally enclosed" motors respectively.

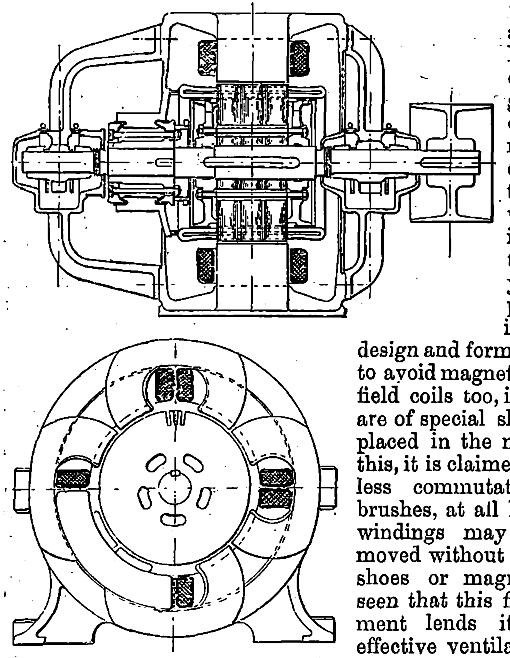
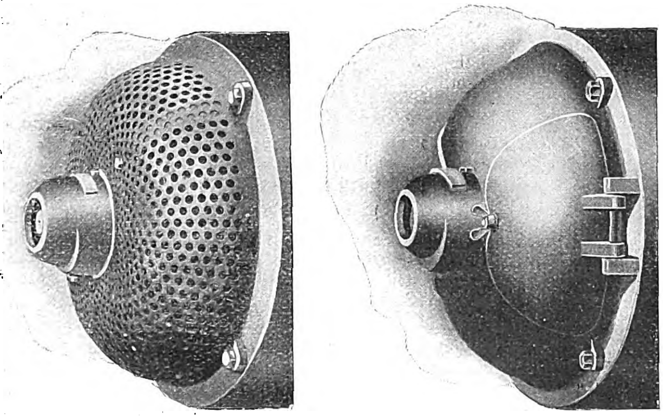


FIG. 1.—SECTIONS SHOWING METHOD OF CONSTRUCTION OF THE "MAWDSLEY" MULTIPOLAR MAGNETIC SYSTEM USED IN NEWTON MACHINES.



Enclosed Ventilated. Totally Enclosed.

FIG. 2.—END COVERS.

**Catalogues, &c.**—A neat and complete catalogue of "Chloride" accumulators is issued by the Chloride Electrical Storage Co., Clifton Junction, Manchester, in the form of a book 4 in. by 3 in., bound in stiffened paper covers and comprising 112 pages of small but clear type. Needless to say, there is a large amount of information packed into these pages, and everything that is needed to be known concerning the "Chloride" accumulator will be found set out. The company in presenting this their 1906 catalogue, call attention to the numerous improvements in details which have been effected in the "Chloride" accumulator, and among various points, the following, extracted from the list, may be given:—

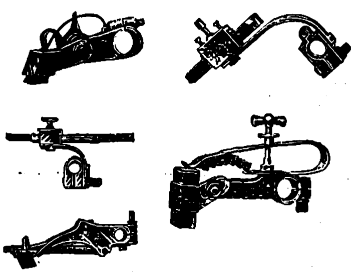
1. The suspension of the plates is now above the level of the acid.
2. The positive plate has been entirely re-designed in detail.
3. A greatly improved type of negative plate has been adopted.
4. Wood diaphragm separators are used exclusively.
5. Increased space beneath the plates is provided.
6. Non-corrosive nuts are employed for coupling up.

"The "KG," "PG" and "LG" types have been introduced for capacities between and under those obtainable from the standard "SG" cells, which have replaced the well-known "R" type. The "DW" type has been designed for cases where very large outputs are required, and the floor space available is limited.

A sheet list of ammeters and voltmeters for laboratory use (type S.C.) is now ready, and can be obtained of Elliott Bros., Century Works, Lewisham, London, S.E. The movement is of this firm's standard dead beat moving coil principle provided with a knife-edge pointer, the special feature being that the pointer is fitted to the end with a small spade piece, enabling approximate readings to be taken at a distance. Campbell's compensating device is employed to accurately compensate for temperature errors. The scale is fitted with mirror to avoid errors due to parallax, and by means of diagonal dividing lines the position of the pointer can be read accurately to 0·2 of a scale division. The length of scale is $8\frac{3}{4}$ in.

The Electrical Co. issue some interesting sheets showing electrically-driven spinning mill machinery, also a new and improved type of push switch electric cigar lighter with burnished handle and nickel-plated fittings.

An illustrated sheet list of brush-holders of different patterns is issued by the machine and apparatus department of the Electrical Co., 121-125, Charing Cross-road, London, W.C. Several of these brushes are illustrated in the accompanying figures.



SELECTION OF BRUSH-HOLDERS SUPPLIED BY ELECTRICAL CO.

Umney & Peckett, 46, King William-street, London, E.C., who are agents for Isaac Storey & Sons; Spurr, Inman & Co., Pollock; Whyte & Waddell, and the Sunderland Forge & Engineering Co., have sent us a copy of their hanging tear-off pad calendar, which we are pleased to receive.

A useful list of miner's electric safety lamps, hand lamps, &c., has been issued by the Electrical Power Storage Co., 4, Great Winchester-street, London, E.C., and copies can be obtained by the trade on application. These lamps are all fitted with high efficiency "Osmi" filaments. The sheet gives illustrations of a number of the lamps.

The Edison & Swan Co. have a new leaflet ready, describing the "wind up" ceiling rose of which a good illustration is shown.

Catalogue No. 66 issued by Ferranti Limited, Hollinwood, Lancs., deals with tubular non-arcing enclosed fuses for continuous and alternating currents, and list 69, also ready, contains some good illustrations and dimensional drawings of single-pole voltmeter switches.

Sheet lists of incandescent lamps of various types and for a large variety of purposes are issued by Messrs. Gabriel & Angenault, 15, Victoria-street, London, S.W.

**Imports.**—The following are official values of imports of electrical machinery, material and apparatus imported into this country during January, 1906:—

Electrical machinery, £52,627 (an increase of £5,699); telegraph and telephone cables, £13,347; telegraph and telephone apparatus, £19,731; other electric wires and cables (rubber insulated) £7,626, (with other insulations, £10,338); other electrical goods and apparatus, £53,800. Total of electrical goods and apparatus (other than machinery and telegraph and telephone wire), £104,842 (increase, £22,533).

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Jan. 31 to Feb. 6, with the ports of destination:—

*Aden*—£29 (including £18 telegraph material). *Africa*—Cape Town, £692 (including £21 telegraph material); Delagoa Bay, £168; Durban, £2,432 (including £1,712 telegraph material); Sierra Leone, £187 (telegraph material). *Argentina*—Bahia Blanca, £671 (telegraph cable); Buenos Ayres, £5,883 (including £330 telegraph material); Rosario, £29. *Australasia*—Melbourne, £118 (including £35 telegraph material); Otago, £1,052; Perth, £58; Sydney, £751; Wellington, £3,701 (including £3,309 telegraph material). *Belgium*—Ostend, £30. *Bonin Islands*, £419 (telegraph instruments and material). *British Guiana*—Demerara, £12. *Ceylon*—Colombo, £75. *China*—Shanghai, £4,508 (including £4,082 telegraph instruments and material). *France*—Boulogne, £146. *Germany*—Bremen, £130 (telegraph material); Hamburg, £50. *Gibraltar*, £18. *Greece*—Piræus, £21 (telegraph material). *Guam*, £5,372 (telegraph instruments and material). *Hawaiian Islands*—Honolulu, £170 (including £158 telegraph material). *Holland*—Amsterdam, £72. *India*—Bombay, £1,774; Calcutta, £1,489; Karachi, £227; Madras, £18. *Japan*—Nagasaki, £618; Yokohama, £647 (including £97 telegraph material). *Philippines*, Manila, £523 (including £489 telegraph material). *Russia*—Riga, £2,463 (including £10 telegraph material). *Siam*—Bangkok, £48. *Straits Settlements*—Penang, £8; Singapore, £113. *U.S.A.*—San Francisco, £24 (telegraph material). *Uruguay*—Monte Video, £9. Total, £34,755, against £21,592 in the corresponding week last year (Feb. 1 to 7).

The total exports of electrical goods and apparatus in January were valued at £303,130, compared with £116,061, an increase of £187,069

# PATENT RECORD.

## APPLICATIONS FOR PATENTS.

Note.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specification. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

January 12, 1906.

843 Conaty & Coxon. Electric lighting of tramway and railway cars fitted with regenerative motors.
852 Anderson. Suspension of electric lamps.
876 Mascord. Application and distribution of electromotive power particularly for use in starting machinery and for such and similar purposes.
800 Gaiffe. Electric current generators.
894 Job. Automatic electric switching apparatus.
918 Lambert. Variable resistance devices.*
923 Cowper-Coles. Electro-deposition of copper.
929 B.T.-H. Co. (G.E. Co., U.S.) Filaments for incandescent lamps.
931 B.T.-H. Co. (G.E. Co., U.S.) Vapour electric apparatus.
932 B.T.-H. Co. (G.E. Co., U.S.) Circuit-breakers.

January 13, 1906.

913 Peacock. Operating tramway and other points.
944 Southgate & Southgate. Connection with electric light fittings.
953 Wilson. Wireless telegraphy.
956 Holt & Rhodes. Fixing tramway rails to anchor rails or girders.
962 Minkley & Bakewell. Telegraphy.
966 Field. Windings of dynamo machines.
973 McIndoe. Charging secondary batteries.
988 Törley & Benkö. Producing electricity and apparatus therefor.
997 Jacobs & Thorrowgood. Telephone circuits.
999 Midgley & Reed. Controlling device for electric motors driving small machines.*
18,673A/05 Millauro. Terminal. (Date applied for, Sept. 15, 1905).*†
18,673B/05 Millauro. Switch. (Date applied for, Sept. 15, 1905).*†

January 15, 1906.

1,019 Gin. Electric furnaces.*
1,065 Wilderman. Batteries.
1,068 Parsons. Preventing overheating of electrical machinery.
1,097 Rhodes Electrical Mfg. Co. & Creedy. Electric motors working with single-phase alternating currents.
1,099 Eisemann. Controlling the contact lever of electrical ignition apparatus.*
1,114 Anning. Electrical leakage discharger and indicator for electric tramcars and the like.
1,115 B.T.-H. Co. & Martin. Relating to electricity meters.
1,116 B.T.-H. Co. (G.E. Co., U.S.) Vapour electric apparatus.

January 16, 1906.

1,151 Oppenheimer (A.-G. Mix & Genest, Germany.) Battery testing apparatus in pocket size.
1,152 Ransome & Lavo. Electric power horizontal log band saw machines.
1,160 Centonze. Points or switches for tramways.
1,161 Centonze. Trolley switches or cross-over devices.
1,186 Wunderlich & Hughes. (London Electric Firm.) Driving and variable speed mechanism.
1,198 Lake. (Steiner Investment Co., U.S.) Automatically indicating and recording movements of trains and tramcars.*

## SPECIFICATIONS PUBLISHED.

1905 Specifications.

608 Maclean. Portable electric drilling machines.
1,299 Starcke. Apparatus for recording telephonic messages or sounds.
1,300 Soar & Joel. Switches, controllers and the like.
1,493 Coachman. Electric time switches.
1,526 Berry. Windings for transformers and other electrical apparatus.
2,004 Bastian & Calvert. Electric vapour lamps or enclosed arc lamps.
2,004A Bastian & Calvert. Electrode material for vapour electric apparatus. (Date applied for, Feb. 1, 1905.)
2,342 Leitner & Lucas. Electric lighting of trains.
2,919 Atkinson. Devices for controlling electric currents.
2,998 Hacking & Pycroft. Ironing machine tables having electrically controlled pressure.
3,706 Bastian Meter Co., Salisbury, Bastian & Calvert. Electrolytic meters.
3,762 Barton. Electric switch and circuit breaker mechanisms.
4,504 Pieper. Governing electrically-driven winding machinery, rolling mills and the like.
5,447 Nalder Bros. & Thompson, & Curtis. Electrical measuring instruments.
7,448 Morris & Lister. Electro-magnetic brakes and clutches.
7,994 Sim-Jensen. Mercury-vapour lamps. (Date applied for, June 18,'04.)
10,017 B.T.-H. Co. (G.E. Co., U.S.) Control of electric motors.
10,215 B.T.-H. Co. (G.E. Co., U.S.) Vapour electric apparatus.
11,074 B.T.-H. Co. (G.E. Co., U.S.) Regulating voltage of alternating current systems.
13,677 Fessenden. Condensers for wireless telegraphy.
13,690 Girod. Electric furnaces. (Date applied for, July 4, 1904.)
16,796 Carbonnelle. Electrographical long-distance transmission and reception of drawings, photographs, &c.
16,971 Armistead. Gommutators of dynamo-electric machines and electric motors.
17,270 Napier-Clavering. Electric hand lamps.
17,722 Lake. (Submarine Signal Co.) Microphones for submarine signalling.
18,381 Askew. Reversible galvanic battery,
23,298 Jacob. Electrical safety devices for guarding against burglary and the like.
23,402 Girod. Electric furnaces. (Date applied for, Dec. 24, 1904.)

# COMPANIES' MEETINGS AND REPORTS.

## City & South London Railway Co. (Ltd.)

The forty-third ordinary general meeting was held on Tuesday, under the presidency of the Right Hon. C. B. Stuart-Wortley, K.C., M.P.

The SECRETARY (Mr. W. F. Knight) read the notice calling the meeting.

The CHAIRMAN in moving the adoption of the report and accounts said: I meet the shareholders under circumstances which give me a special claim on your indulgence. In the first place, I feel how great may be the misgivings with which some of you see a stranger standing in the place so lately occupied by your old Chairman, who is gone to his rest. In the presence of so many to whom he was personally and intimately known, it would be in me the height of presumption to speak my own estimate of the loss that his death means to colleagues, to officers and to shareholders. Suffice it to say that reading, as I have read attentively, the reports of your past meetings, and finding, as I there do, the repeated evidences of the readiness with which his shareholders supported and trusted him, I recognise how my chief study must be to learn how that support was assured and how that confidence was won. Then also the time has been very short in which I have had the opportunity to qualify myself to meet you to-day, and that short time has been made shorter by the fact that it began amid the exacting preoccupations of a General Election. Hoping that I may presume that for these difficulties you will make just allowance, I proceed to review the results of the half-year's working, and the accounts in which they are set forth. Notwithstanding the adverse influences affecting our comparison with the weather of last year and to our having one working day less, we have been able to maintain the dividend in spite of the fact that the additional £150,000 of ordinary stock issued in the June half of last year comes in for its full dividend in the half-year under review. We carried 205,640 more passengers and received £221 more in money. On the other hand, 840 fewer season tickets were issued, representing in money a decrease of £823. Many holders of season tickets appear to have preferred to take advantage of our 6d. return tickets. These results would have been better but for exceptional causes. Taking into account the small miscellaneous items, there is a total net decrease in the total receipts of £179. Fortunately the expenditure shows a decrease of £522. We are increasing the carrying capacity of our trains by gradually substituting five-coach trains for three and four-coach trains, and this, necessarily tends to economy. At the present moment, at the busy times of the day, when we have our maximum number of 24 trains running, 16 out of the 24 are five-coach trains, and we intend, in due time, to put the additional fifth coach on the other eight trains. Now, you will wish to know what the statistical results of the half-year have been, but it is to be borne in mind in this connection that in May of last year we reduced our fares, and the half-year I am now reviewing is the first half-year that has felt the full effect of the reduction. The first result is that we find that in the half-year the receipts per train are 15s. 9·7d. against 15s. 8·01d. last year, and the receipts per train-mile are 2s. 6·9d. against 2s. 6·7d., so that you see in both those items we show better results. The receipts per passenger have been 1·83d. against 1·86d. It is difficult to say exactly what this result points to. Of course, you have had a reduction in the fares on the one hand, but on the other hand it may be said that the reduction of fares should have produced no greater effect on the receipts per passenger, but it may be attributed to the fact that our passengers are travelling, on the average, a longer distance than they formerly did. The percentage of working expenses shows a movement in the right direction; they were 46·64 per cent. against 47·22 per cent. The expenses show increases in the following directions: the expenses per train-mile are 1s. 3·3d. against 1s. 3·26d., the locomotive charges are 4·65d. against 4·54d., and the traffic expenses are 6·79d. against 6·77d. You will, however, see that if we pursue, as we have pursued, a policy of economising our power by increasing the earning capacity of the power used, some increase in the operating charges must be looked for, comparing with the increase in the train-miles. In the past half-year we have effected that sort of economy by running about 9,000 train-miles less than in the corresponding half of the previous year, and the number of the trains run is 89,305, against 90,842—figures which I hope will show you that we are giving our attention to economising our power and getting that advantage to which I have referred. The balance from net revenue shows an increase of £343, in the balance brought forward there is an increase of £340, and there is also a credit on general interest account of £493, against a debit of £54 last year. Those two last items together make a gain of £547, and the three items of gain show a total of £1,230. The additional interest on the £150,000 of extraordinary stock requires £1,312 to pay it, and the £82 which is wanted to make up that amount is taken out of the balance carried forward. On that basis it is that we propose to recommend to you the payment of the same dividend for the present half-year as was paid to you last year.

Turning to the general matters of the report, I am glad to say that satisfactory progress has been made with the extension to Euston. I have visited those works, and can testify to the way in which the work is proceeding. There has been some little delay in consequence of the engineers finding it necessary to use compressed air between Euston and St. Pancras. I may mention here that nearly the whole of the important works under Euston station and buildings will be carried out by this compressed air method, and also the running tunnels under the roof of the St. Pancras station. This is a requirement in the interests of safety in connection with those important structures. We have let the contract for the lifts for the extension, and we shall have the most up-to-date lifts that can be made. An agreement has been made with the North-Western and Charing Cross & Hampstead Companies—a tripartite agreement—for the interchange station and connecting subways at the Euston terminus. Our connection at Euston station proper will be by a subway and lift, which will bring the passengers to the surface at a point near the arrival platforms at Euston station, but at the same time not at all far away, but quite near and handy, to the departure platforms of Euston station, where a great many of the suburban trains depart. At King's Cross we shall have access to our railway from the surface at three points. There will be access to the suburban station at King's Cross, access to the main line platforms rather nearer the departure than the arrival side, and there will be access to the surface in the roadway. There will be a subway across to St. Pancras, where there will be access to the platforms of the Midland Railway Co., rather nearer to the arrival than to the departure side. You will see, therefore, that we have secured a position nearly equi-distant from both those great stations, and about as advantageous a position as could be got under the circumstances. There will be a subway at King's Cross leading on to the departure platforms of the Great Northern main railway, and another to the platforms of the Midland Railway Co.'s station at St. Pancras, with an underground subway to the Great Northern and Strand Railway, and at Euston station there is to be a subway connection with three lifts and a staircase, taking passengers direct on to the London & North-Western arrival and departure platforms. There is also a direct and easy platform exchange with the Hampstead & Charing Cross Railway at that point. These connecting links with the termini of these three important companies ought to be of great value to our Company—at all events in time. It will not do to make too sanguine an estimate of the effect they will have on our fortunes immediately, but I think we have a right to look forward with confidence to the ultimate success of your latest and most important extension. We have another important connection. At our Elephant and Castle station, on the south side of the river, we are going to get a connection with the New Baker Street & Waterloo line. This new tube railway will really be a Baker Street & Elephant & Castle Railway—a fact of very great importance to us. We are informed that this line will be opened, from Baker-street to Waterloo, at all events, in about two months, and the extension from Waterloo to the Elephant and Castle in about three or four months' time. I have visited the works which are going on in the immediate neighbourhood of our Elephant and Castle station. What the value of this connection will be you will be able to guess for yourselves when you reflect upon it. Our passengers coming from Clapham and that part of our system will be able to travel under cover the whole way to that company's stations at Charing Cross, Trafalgar-square and Piccadilly, from which many of the West-end theatres, music halls and the best shops in town will be easily accessible. This is another important connection which ought to operate as a good "feeder" to our trains, and bring us in due time many advantageous results. I do not think I have anything further to add to the facts and figures I have given to you, and I will now conclude by moving the formal resolution.

Mr. C. SEYMOUR GRENFELL seconded the motion.

Col. PERRY said he thought it would be of general interest if the Chairman would state in whose hands the company were at present with regard to their electrical work.

Mr. SHRIMPTON said he desired to ask the Chairman, in view of the Company's position and their failing to earn the money they formerly earned, whether the Directors had made any appeals to the assessment committees of the boroughs through which the line passed for a readjustment of the assessments of the Company, and what the result of such appeals had been.

The CHAIRMAN: In answer to Col. Perry's question with reference to whose hands we are in as regards our electrical work, the construction of the lifts is in the hands of our engineers, Sir Benjamin Baker, Mr. Mott and Mr. Hay, and our own engineer, Mr. McMahon, looks after the lifts which have been constructed. Our electrical power we generate ourselves.

Col. PERRY said he had rather meant his question to apply to the building of the engines and the cost of their electrical locomotives.

The CHAIRMAN: I can give you that information, but not at the moment. With regard to the question which was asked by Mr. Shrimpton, I am informed that such approaches as we have made to the assessment committees have been well received.

Mr. E. A. COX said he thought that it would be a graceful act on the part of the meeting to ask the Directors to convey to the bereaved family of Mr. Mott some intimation of the loss which the Company had sustained by his death, and of the esteem in which the deceased gentleman was held by them.

Col. PERRY then proposed a resolution cordially approving the Directors' action in appointing Mr. Stuart-Wortley to the position of Chairman of the Company.

Mr. COX seconded the motion, which was carried by acclamation.

The CHAIRMAN: I accept this motion with much pleasure, and principally on the ground that I cannot conceive my own position to be better strengthened than it has been by the motion.

The motion for the adoption of the report and accounts was then carried unanimously.

A resolution that a suitable communication be made to the family of the late Mr. Mott expressing the sympathy of the members of the Company at their loss and also the esteem in which the deceased gentlemen was held by the Company.

The dividends having been approved and the retiring Directors re-elected, a very hearty vote of thanks to the Chairman, Directors and officers of the Company was passed, the proceedings terminated.

## Anglo-American Telegraph Co. (Ltd.)

The ordinary general meeting was held on Friday last, Mr. Francis A. Bevan presiding.

The SECRETARY (Mr. T. H. Wells) read the notice convening the meeting and the certificate and report of the auditors.

The CHAIRMAN, in moving the adoption of the report, said: I will begin by congratulating the shareholders upon a very satisfactory year's working. The gross earnings for the past year—that is, the pool earnings—have amounted to £613,660, against £552,390 in the previous year, an increase of £61,000. That increase is not owing to any particular class of business, but is spread over the whole of the business, and we have begun the new year with a considerable advance over the corresponding period of 1905. All our cables are in good working order. Turning to the figures for the past half-year of the Anglo-American Co., there was an increase of £14,675 in traffic receipts, of £2,863 in the receipts from our cable steamer "Minia" and £196 in transfer fees, a total of £17,735 over the corresponding period of the previous year. Working expenses increased by £497, and a sum, to which I will afterwards allude, of £2,330 put down as Newfoundland taxes, making an increase of £2,827. On the other hand, as our renewal fund reached £1,000,000 before we came to the last quarter, we have not had to set aside the usual £5,000 which we had previously done. Therefore, taking that £2,827 from the £5,000, and adding the difference to the £17,735, means a net increase for the half-year of £19,935. As we had brought forward a sum less by £1,282 than in the corresponding half-year, we have £18,652 more to distribute. The dividend we propose to give will absorb £21,000 more than last year. We are going to pay 65s. to our ordinary shareholders, against 55s. last year, the result being that we shall have to take £2,347. 5s. 11d. from the balance carried forward to make up this sum, leaving only £846. 16s. to go forward. The renewal fund on Dec. 31, amounted to £968,927, the interest for the year is £30,946, and we have added £15,000 from revenue—that is, £5,000 for each of the first three quarters. We have had to spend upon repairs and cost of cable during the year £13,948, so that our balance is just over the million. We hope, judging from the past, that the interest upon this fund will provide for our ordinary repairs and renewals and still leave a margin from year to year. In that case we shall not require to put aside the £20,000 that has hitherto been set aside from receipts. Our friends the Direct United States Co. have also obtained the climax that they have aimed at, namely, a renewal fund of £500,000, but it must be remembered that their £500,000 is a renewal fund for one cable, whereas ours is £1,000,000 to renew, if necessary, four cables. With regard to repairs, it is satisfactory to know that we have had very few deep-sea repairs in the past, and those are the repairs that cost much money.

I would now call your attention to the item of £2,330 for taxes in Newfoundland. I have previously mentioned this matter, and you will remember that the Newfoundland Government proposes to tax us, which we think most unreasonable and very impolitic. Our original charter from Newfoundland was dated 1854, and gave us the exclusive right of telegraphic communication for 50 years, and it was only that exclusive right which terminated in 1904. Our charter did not actually take effect until 1866, because there was no successful cable laid until that year. But, in spite of that fact, the Newfoundland Government hold that the charter expired in 1904, and they thought they were going at once to obtain all our rights in the island; but they found they were mistaken. All they could get rid of was our exclusive right, but they could not turn us out. They did their best, and failed. We proposed, however, that for a small money consideration we would hand over our rights, but we could not come to terms. Then they promoted a bill to set up telegraphic communication in the island, and came over here to raise money to carry this project into effect, and to help them to pay the interest on the money they raised they devised a scheme for taxing us. Now, what have we done for them? Here was Newfoundland, an island disconnected altogether from the mainland, suspended, so far as telegraphic connection was concerned, in mid-air. We connected them with both Europe and America, put them into close relation with both, and so pleased were they when we did it that they were ready not only not to tax us but helped us in every way. They gave us a grant of land, and we made a clearance through the island of 600 miles. They helped us pecuniarily with that, and assisted us in every way. Now, after all these years, they turn round and not only tax us, but they have laid a competing cable and connected themselves with our rivals—a foreign cable company. They propose to make us pay a total of £5,000 a year, so that we are in the position of being taxed for the great benefit which we have conferred upon the island, We are in communication with the Colonial Office and with the Newfoundland Government, and we shall leave no stone unturned to succeed in these negotiations and get this tax removed. I think that all I need say in conclusion is how admirably our staff has worked. Owing to the great amount of traffic, especially at times, we have had extra pressure put upon us, but the staff has risen to the occasion. I might mention one particular instance as being of special interest to you. On one occasion when there was great pressure one of our cables in one day carried no less than 42,000 words. Now, I believe that the Post Office idea is that 7,000 words a day is about the outside for a cable to carry, whereas we have carried 42,000 words. I think that does great credit to our staff, who work with a zeal inspired by our general manager, who night and day lives for and thinks of nothing but this company. I might, perhaps, mention one other item of interest. The other day in New York we had a little strike amongst our messengers, and for a few hours they refused to deliver messages. Our staff at once undertook to deliver the messages, so that the company should be put to no inconvenience. I think, gentlemen, it is right to mention these matters, for it is really to the efficient services of the staff that you owe these increased receipts. I now move the adoption of the report and accounts, and the declaration of the following dividends, as recommended by the board: (1) A final dividend of £1. 1s. per cent. upon the ordinary consolidated stock for the year ended Dec. 31, 1905, making £3. 5s. per cent. on the stock for the year; (2) a final dividend of £1. 12s. per cent. upon the preferred ordinary stock for the year ended Dec. 31, 1905, making £6 per cent. for the year; (3) a first and final dividend of 10s. per cent. upon the deferred stock for the year ended Dec. 31, 1905.

Mr. CHARLES BURT seconded the motion.

Mr. ADAMS asked why the value of the leasehold property was considerably reduced every half-year, was the steamer "Minia" valued in the assets, and would the chairman please tell them the result of the decision in the French cable company's case.

Mr. CHESTER: You have during the last 10 years at the meetings said a good deal about the doings of Mr. Marconi. Can you tell us anything of his doings just now? Are not the Marconi companies at present erecting a steel station on the west coast of Scotland, and have they not acquired a large acreage of ground on the west coast of Ireland for another station?

The CHAIRMAN, in reply, said: With regard to the first question, the value of the leasehold property was reduced because they had it for a very short term. The item would ultimately disappear altogether. The "Minia" was not valued in the accounts. As regarded the French cable company's case, they had really come to the end of the litigation. The French company were to hand over to the Anglo Co. all their assets, whatever they might be. If he (the chairman) was asked what these were worth, he should not like to pledge himself, but the directors had an impression that they might be worth possibly £2,000. They had no control over these French people, and could not prevent them making away with their money—that is to say, with their (the Anglo Co.'s) property. The Anglo Co. could do nothing but fight the thing to the bitter end. With regard to the Marconi companies, he had heard nothing concerning them for a long time. The wireless system was not, so far as they knew, a danger to the cable companies. The wireless companies were sending messages from ship to ship and from ship to shore, but, so far as they knew, there was no serious attempt being made to send messages across the Atlantic. He could say no more than that.

The resolution was carried unanimously.

The retiring directors, Mr. F. A. Bevan and Mr. W. S. Cunard, were then unanimously re-elected, as were the auditors, Mr. E. Cooper and Mr. J. Gane.

A cordial vote of thanks to the chairman and directors having been carried, the proceedings terminated.

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**BLACKPOOL & FLEETWOOD TRAMROAD CO.**—For the half-year ended Dec. 31 the balance profit (including amount brought forward), after providing for interest, is £9,537, and the directors recommend a dividend at the rate of 9 per cent., which will absorb £6,750. The number of passengers carried during the half-year was 1,502,057, the receipts from all sources amounting to £20,630. 4s. 11d.

**BRISTOL TRAMWAYS & CARRIAGE CO.** (LTD.)—The gross receipts for 1905 amounted to £256,741. 10s. 7d. and working and general expenses and renewals to £171,661. 9s. 1d., leaving £85,080. 1s. 6d. Debenture interest absorbed £11,276. 11s. 9d., preference dividend £19,000, and interim ordinary dividend at 8½ per cent. ann. for half-year ended June 30 £20,187. 10s. A final dividend at the rate of 9½ per cent., less tax, is now declared (£22,562. 10s.), and £12,053. 9s. 9d. added to reserve. The total number of passengers carried during the year on the company's cars and omnibuses was 45,294,177. Since the close of the year the directors have arranged for the introduction of services of motor omnibuses in conjunction with and as feeders to the electric tramways.

**CENTRAL LONDON RAILWAY CO.**—At the meeting on Wednesday the chairman (Sir Henry Oakley) said in the past half-year 316,000 less passengers travelled on Sundays, compared with the number that travelled in the corresponding period. There was an increase in the number of weekday passengers, showing that the substance of their business remained unaffected. Therewas a diminution in expenses. The blot in the account was the increase in rates and taxes. Out of a total earning of £174,000 rates and taxes were very nearly £15,000, or £700 more than in the corresponding period. Their working expenses, without rates and taxes, were 46 per cent., which he thought a very moderate rate; with rates and taxes added they were about 50 per cent. Their scheme for the completion of their circle was practically held in suspense, first of all during the time of the inquiry by the Royal Commission and subsequently by Parliament. As it was proposed to appoint a Traffic Board to deal with the whole question of London traffic, the directors considered it would be better and wiser, in the interest of the company, to suspend any action until their future course was more clear. A scheme had been launched for the promotion of a line beginning at Southgate, 4 or 5 miles or so north-east of London, passing through the City along the the Strand and Piccadilly, and going on to Hammersmith and Chiswick. The capital was only about £12,000,000; but it was extremely probable that that scheme also would have to be suspended.

**CITY OF BUENOS AYRES TRAMWAYS CO. (1904) (LTD.)**—The report for 1905 states that the net revenue amounted to £64,832. The directors recommend a balance dividend of 1s. 3d. per share (making 5s. per share), that £2,750 be transferred to general amortisation fund and that the balance of £82 be carried forward.

**DUBLIN UNITED TRAMWAYS CO.** (LTD.)—The chairman (Mr. W. M. Murphy) stated at the meeting on Tuesday that though the cars covered more than 100,000 additional miles during the half-year, the receipts from passengers were £16 less than in the corresponding period of 1904, but comparing the whole of 1905 with 1904 there was an increase of £2,361. The parcel traffic showed an increase of £177, and on the whole the gross receipts for the half-year came out with a slight increase of £161. In regard to the parcel traffic they anticipated further development of that business, which was so convenient to the public, for whom they transmitted nearly 750,000 parcels during the past year. They had established another record for economy in the generation of electric current at Ringsend. While the output was increased by 272,286 units the actual works cost was £257 less than in the corresponding half of 1904. The cost per unit was 0·360d., about two-thirds of which (or 0 217d.) represented cost of coal. Those results were not surpassed by any station of corresponding capacity in the United Kingdom, and they showed that with efficient machinery and good management the cost of coal need not be a reason for want of success of any manufacturing industry located on the east coast of Ireland, where the price of sea-borne coal was less than the same article in many of the manufacturing districts of England. Traffic expenses showed an increase of £352, against an increase of 103,347 car-miles run for the half-year. The cost of maintenance, however, was increased by £1,483, chiefly in permanent way. No new tramways were opened during the half-year, but they had commenced the construction of a short length. That was the last of a number of new tramways, and extensions of old ones, for which they obtained powers in 1899, all the others having been constructed.

**ELECTRIC LIGHTING & TRACTION CO. OF AUSTRALIA** (LTD.)—During the year ended Aug. 3 last, capital expenditure in Australia on buildings, plant and mains was £15,004. 15s. 7d. The sale of the company's undertakings at Adelaide and Port Adelaide to the Adelaide Electric Supply Co. took effect as from Sept. 1, 1904, the purchase consideration amounting to £162,500 (£35,000 in cash and £127,500 in fully-paid ordinary shares of Adelaide Co.). At Aug. 31. 1905, the equivalent of 47,854 8 c.p. lamps were connected at Melbourne for lighting, 682 H.P. for power, a total of 69,678 c.p. against 48,692 in 1904. At Geelong the figures were 14,076 8 c.p. for lighting, 430 H.P. for power—total 27,836 8 c.p., against 19,938 8 c.p. in 1904. The Melbourne undertaking has made excellent progress during the year, the result being a gross profit of £6,455 compared with £3,460. The lamp connections increased by 43 per cent., and as the demand for light and power continues unabated, the directors have decided to order a 1,000 kw. steam turbine generating set for shipment at an early date. The Geelong undertaking is also making steady progress, the gross profit amounting to £1,284, while the lamp connections have increased during the period by 40 per cent.

**GREAT NORTHERN RAILWAY CO.**—The report for the half-year ended Dec. 31 states that the company's 1906 bill authorises the company to raise £50,000 (with the usual borrowing powers) and to contribute £50,000 towards the cost of the generating station of the Great Northern & City Railway Co. at Poole-street, Hoxton, in consideration of an annual rent charge of £2,000.

**GREAT NORTHERN & CITY RAILWAY CO.**—At the meeting yesterday (Thursday) it was reported that the total revenue receipts for the six months ended Dec. 31 amounted to £45,711. 8s. 5d., against £36,509. 3s. 4d. for the corresponding period last year. The numbers of passengers carried (excluding season-ticket holders) were 6,330,661 and 5,227,595 respectively. The number of three-route season-ticket holders (G. N. & C., G. N. and N. L.) using the company's line during the past half year was 2,292.

The chairman (the Earl of LAUDERDALE), at the meeting, referred to the progress of the line and spoke hopefully of its future. It was (he said) found that the cold weather brought them more passengers than even the wet. Although the traffic showed a slight decrease against the first half of the year, that was entirely due to the second half including the summer and holiday months. Since August the traffic had risen continually and was still rising. Last month they carried 97,171 more passengers than in January, 1905. It was intended to shorten the interval between trains from 2½ to 2 minutes during the morning and evening services, and also to reduce the time between trains during the light service, their object being to secure the most frequent service possible. Their new cars, six of which had been already delivered, were fireproof and built almost entirely of steel. They carried more passengers and were lighter than the older stock, and were also the first which were not provided with hand straps. During the half-year there had been no interruptions, and in only 28 instances were individual trains more than a minute behind their scheduled time. While their traffic was steadily increasing their power-house expenses were stationary. The half-year's revenue was encouraging, as it showed an increase of £9,202 over the like period of 1904. The extension to Lothbury would be undertaken as soon as the times were propitious for raising capital. They dealt with nearly 15,000,000 passengers during the past year, which proved that the line stood well in popular favour and was well equipped.

**LANCASHIRE & YORKSHIRE RAILWAY CO.**—At the meeting on Wednesday the chairman (Sir George Armytage, Bart.) said that they had now had a full year's experience in the working of electrical trains, and they found, as expected, that the cost of working, when proper allowances were made for depreciation of the more costly plant, was slightly higher per train-mile run. With that, however, they were quite satisfied, as they had been able to do a much greater amount of work and give a very much improved service to the public, which would have been absolutely impossible under the old conditions. They were now contemplating some additions, which would enable them to deal with the rapidly-growing traffic as it arose. They had again carried very large additional numbers of passengers over the electrified portion of their railway, especially for short distances, and the whole system was working smoothly and well. Since the last meeting they had coupled up with the Liverpool Overhead Railway at Seaforth, and were now exchanging traffic.

**ST. JAMES' & PALL MALL ELECTRIC LIGHT CO. (LTD.)**—The report of the directors for the year ended Dec. 31 last states that electricity supply has been distributed from the Carnaby-street and Mason's-yard stations to a total of 286,084 8 c.p. lamps, an increase of 7,195 in the past 12 months. 6,654,217 units were generated at these stations and 2,385,260 were purchased from the Central Electric Supply Co. The directors regret that the profits on the past year's trading do not admit of the payment of a bonus on the ordinary shares as in previous years. The amount ordinarily available for this purpose has been absorbed by the special charges incurred in defending the company's interests in Parliament, by large temporary disconnections of lamps owing to extensive rebuilding operations in the district and by further reduction of the rates for supply rendered necessary by severe competition. The net profits for 1905 were £29,744. 1s., balance forward £2,891. 9s. 3d., total £32,635. 10s. 3d., less interim dividends (£13,500), leaving £19,135. 10s. 3d. The directors propose to divide this amount by payment of the balance preference dividend (£3,500) and a dividend on the ordinary shares for the second half-year of 7s. 6d. per share (making 12½ per cent. for the year), £15,000, carrying forward £635. 10s. 3d.

For the information of shareholders, a copy of the report and accounts for the past year of the Central Electric Supply Co. (Ltd.) is sent out, which shows that no dividend has been declared in respect of the year 1905. The dividend of £2,500 received last year by the St. James' Co. from the Central Co. has not been carried to the contingency fund of the St. James' Co. as had been intended, but has been brought into this year's net revenue.

**SMITHFIELD MARKETS ELECTRIC SUPPLY CO. (LTD.)**—The gross profit for 1905 was £6,770, compared with £6,269 last year. The net profit was £3,649. 19s. 9d., to which is added £1,659. 11s. 3d. from 1904, making £5,319. 11s. £1,500 has been placed to reserve, and the directors propose to pay a dividend of 4 per cent. for the year, requiring £2,400, carrying forward £1,419. 11s. The directors have decided to instal a system of mechanical stokers as a means of dealing effectually with the smoke trouble, and which they confidently expect will result in a saving in working expenses.

**WATERLOO & CITY RAILWAY CO.**—The gross receipts for the half-year ended Dec. 31 (less duty) amounted to £17,464. 2s. 2d. and working expenses to £7,858. 17s., compared with £17,676. 6s. 10d. and £,7891. 14s. 9d. respectively for the corresponding period of 1904. The balance available for dividend, after providing for interest is, £9,155. 4s. 11d., and a dividend at the rate of 3¼ per cent. per annum on the ordinary stock absorbs £8,775, leaving £380. 4s. 11d. to be carried forward. During the half-year 2,206,695 passengers were carried, against 2,219,143 and 2,256,832 in the two preceding half-years. The L. & S. W. Railway Co., who work the railway under a perpetual agreement, have given notice of a bill to take power to acquire the undertaking upon terms.

## NEW COMPANIES, STATUTORY RETURNS. MORTGAGES AND CHARGES, LIENS, &c.

### NEW COMPANIES.

**ANGLO-MEXICAN ELECTRIC CO. (LTD.)** (87,403).—Reg. Jan. 27, capital £300,000 in £1 shares, to acquire any concessions for utilisation of water power, generation and distribution of electricity in Mexico or elsewhere, to erect, construct and maintain reservoirs, dams, canals, power stations, mains and distributing plant and machinery, and to carry on the business of suppliers of electric light and power, manufacturers of motors, generators, converters, meters, lamps, materials and batteries, suppliers of hydraulic power, &c. First directors, S. Mackew, W. R. M. Bird and J. H. Macdonald. Reg. office, 35, Great St. Helen's, London, E.C.

**DYNAMIC SYND. (LTD.)** (87,473).—Reg. Feb. 2, capital £12,300 in 1,200 5 per cent. cumulative preference shares of £10 each and 6,000 ordinary shares of 1s. each, to acquire any patents and inventions relating to production, storage, distribution and use of electricity, and to carry on the business of suppliers of electric light and power, electricians, manufacturers of electric cars and vehicles, &c. First directors are D. H. Allan, A. Goodlet and J. Green. Reg. office, 6, Broad Street-place, London, E.C.

**ELECTROCARS LIMITED.** (87,418).—Reg. Jan. 29, capital £8,000 in £1 shares, to adopt an agreement with W. N. Stewart for acquisition of certain inventions for improvements in (1) mounting or supporting electric motors on electrically-propelled vehicles, and (2) control of electric motors used in connection with secondary or storage batteries, and to carry on the business of manufacturers of electric accumulators, motors, controllers and vehicles and dynamos, electricians, engineers, producers and suppliers of electricity, &c. First directors, W. N. Stewart (permanent), A. R. Baird and B. W. Parker. Reg. office, Alderman's House, Alderman's-walk, Bishopsgate-street, London, E.C.

**NEW ELECTRIC RIFLE & TARGET CO. (LTD.)** (87,477.)—Reg. Feb. 2, capital £16,000 in £1 shares (6,277 A, 5,600 B and 4,123 C), to acquire undertaking of Auto-Electric Rifle & Target Co. (Ltd.) and to carry on the business of manufacturers of and dealers in auto-electric rifles, targets and target apparatus of all kinds. First directors, A. Moul, E. Daoust, D. Winder and W. Firth.

**PORT OF CHICOUTIMI CO. (LTD.)** (87,434).—Reg. Jan. 30, capital £20,000 in £1 shares (10,000 7 per cent. cumulative preference), to acquire powers conferred upon the Compagnie Générale du Port de Chicoutimi for the establishment or acquisition of electric, steam or other railways, the acquisition of lands and construction of plant and works for production, transmission and distribution of electrical or other power within the counties of Lake St. John and Chicoutimi and to take over a portion of the company's undertaking, including an electric railway, Anderson conveying machine and electrical power installation. First directors, E. Pyke, F. Becker, J. E. A. Dubue, H. Tyrer and C. Pyke. Reg. office, 8A, Rumford-place, Liverpool.

**ZIRCON SYND. (LTD.)** (87,466).—Reg. Feb. 1, capital £2,000 in £1 shares, to deal in, manufacture and sell incandescent and electric lamps of all kinds, &c., and to adopt an agreement with the International Dowsing Electric Heating & Appliances Co. (Ltd.). Reg. office, 24, Budge-row, London, E.C.

### STATUTORY RETURNS.

**ARON ELECTRICITY METER (LTD.)**—Return to Dec. 22 gives capital as £250,000 in £1 shares (125,000 preference and 125,000 ordinary), of which 124,896 preference and 125,000 ordinary have been taken up. £1 per share has been called up on the ordinary and £124,948. 10s. has been received, including £52. 10s. paid on 104 forfeited shares. 125,000 ordinary are considered as fully paid. Mortgages and charges, £51,400.

**BURMAH ELECTRIC WORKS SYND. (LTD.)**—In return to Dec. 31, capital is £2,000 in £1 shares, all of which have been taken up. 6s. 1⅛d. per share has been called up and £615 has been received. Mortgages and charges, nil.

**CAPE ELECTRIC TRAMWAYS (LTD.)**—According to return to Dec. 20 capital is £500,000 in £1 shares, of which 491,222 have been taken up. £91,222 has been received, and £400,000 is considered as paid. Mortgages and charges, £426,800.

**CONDUIT & INSULATION (LTD.)**—Return to Nov. 7 gives capital as £40,000 in £1 shares, of which 33,878 have been taken up (including seven forfeited). £1 per share has been called up on 15,878, including those forfeited, and £15,878 has been received. £18,000 is considered as paid on the remainder. Mortgages and charges, nil.

**DOUGLAS SOUTHERN ELECTRIC TRAMWAYS (LTD.)**—In return to Jan. 4, capital is £50,000 in 30,000 preference and 20,000 ordinary shares of £1 each, of which 25,973 preference and 15,472 ordinary have been taken up. £18,370 has been received in respect of 12,566 preference and 5,804 ordinary. £23,075 is considered as paid on 13,407 preference and 9,668 ordinary. Mortgages and charges, nil.

**ELECTRIC LIGHT & POWER CO. OF JAPAN (LTD.)**—Return to Jan. 11 gives capital as £3,000 in £1 shares, of which seven have been taken up. £7 has been received. Mortgages and charges, nil.

**MARCONI INTERNATIONAL MARINE COMMUNICATION CO. (LTD.)**—Return to Dec. 31 gives capital as £350,000 in £1 shares, of which 204,056 have been taken up. £1 per share has been called up on 99,056 and £99,056. 17s. 6d. has been received, leaving £5. 2s. 6d. in arrears. 105,000 shares are considered as fully paid. Mortgages and charges, £8,000.

**PERTH ELECTRIC LIGHTING CO. (LTD.)**—According to return to Dec. 31, capital is £1,000 in £1 shares, of which seven have been taken up. Nothing has been called up. Mortgages and charges, nil.

**PRIVATE WIRE & TELEPHONE INSTALLATION CO. (LTD.)**—In return to Jan. 1 capital is £3,000 in £1 shares, of which 1,807 have been taken up. £7 has been received, and £1,800 is considered as paid. Mortgages and charges, £2,000.

### MORTGAGES AND CHARGES.

**BRITISH PROMETHEUS CO. (LTD.)**—A memorandum of satisfaction in full of a debenture dated Nov. 7, 1903, securing £250, has been filed.

**CHINA & JAPAN TELEPHONE & ELECTRIC CO. (LTD.)**—Issue on Jan 24 of a £500 7 per cent. debenture, part of series created Nov. 28, 1905, to secure £50,000, charged on the company's undertaking and property, present and future. No trustees. Previously issued of same series, £12,000.

## CITY NOTES.

**MEMORANDA** (Feb. 8).—Bank rate 4 per cent. (since Sept. 28, 1905), Price of silver 30¼d. per oz. Consols $90\frac{9}{16}$—$90\frac{11}{16}$ for money, $90\frac{13}{16}$—$90\frac{15}{16}$ for account; 2½ per cent. annuities 89¾—90. Consols Pay Day, March 1. Stocks and Shares Continuation Day, Feb. 20; Ticket Day, Feb. 21. Pay Day, Feb. 22; Mining Share Carry-over Day, Feb. 19.

**BRITISH ELECTRIC TRACTION CO. (LTD.)**—The half-yearly preference dividend has been declared.

**CANADIAN GENERAL ELECTRIC CO. (LTD.)**—During the week Messrs. Sperling & Co. have offered for sale 11,000 shares of $100 each.

**COMPANIES TO BE STRUCK OFF REGISTER.**—Notice is given in the "London Gazette" of 2nd inst. that the following will be removed from the Register of Joint Stock Companies in three months unless cause is shown to the contrary:—Associated American Electrical Manufacturers, Bee-Bee Electrical Engineering Co., Dynamic Gas Power Co., Harbourne Electrical Mfg. Co., Industrial Electric Co., Motor Power Co., Ozone Industrials Synd., Paris Singer Electric Carriage Co., Peking & North China Electrical Corp.

**KENSINGTON & KNIGHTSBRIDGE ELECTRIC LIGHTING CO. (LTD.)**—The directors recommend a dividend on the ordinary shares for the half-year ended Dec. 31 at the rate of 10 per cent., making 10 per cent. for the year.

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | AGGREGATE. No. of weeks | AGGREGATE. Amount. | AGGREGATE. Inc. or Dec. (a) |
|---|---|---|---|---|---|---|
| | | £ | £ | | £ | £ |
| **Aberdeen Corporation** | Feb. 3 | 1,140 | + 16 | 36 | 49,907 | − 964 |
| **Airdrie** | Jan. 23 | 210 | + 17 | 4 | 854 | + 105 |
| Anglo-Argentine | Feb. 4 | 14,322 | + 1,645 | 5 | 72,759 | + 6,726 |
| **Ayr Corporation** | „ 3 | 176 | + 2 | 35 | 11,119 | − 109 |
| **Barnsley** | Jan. 26 | 150 | + 7 | 4 | 531 | + 10 |
| **Barrow** | „ 26 | 192 | + 24 | 4 | 712 | + 78 |
| **Bath Electric Trams, Ltd.** | „ 31 | 615 | + 104 | 5 | 3,231 | + 581 |
| Birkenhead Corporation | „ 4 | 995 | − 45 | 5 | 5,850 | + 56 |
| **Birmingham Corporation** | Feb. 3 | 407 | + 53 | 44 | 16,421 | + 2,122 |
| *Birmingham & Mid. | Jan. 26 | 1,331 | − 250 | 4 | 4,973 | − 982 |
| **Blackpool Corporation** | Feb. 1 | 304 | + 6 | ... | 46,923 | + 1,976 |
| **Blackpool and Fleetwood** | „ 3 | 220 | + 12 | 5 | 865 | − 25 |
| **Bolton Corporation** | „ 4 | 1,802 | + 140 | 45 | 86,195 | + 4,241 |
| **Bournemouth Corporation** | Jan. 31 | 1,313 | + 473 | †44 | 62,273 | + 14,360 |
| **Bradford Corporation** | Feb. 3 | 4,018 | + 234 | 44 | 192,275 | − 2,193 |
| **Brighton Corporation** | „ 4 | 748 | + 18 | 45 | 44,579 | + 578 |
| **Bristol Trams & Carriage** | „ 2 | 4,599 | + 104 | 25 | 86,452 | + 2,190 |
| **Buenos Ayres & Belgrano** | „ 4 | 3,092 | + 823 | 5 | 17,673 | + 1,697 |
| Buenos Ayres Elec. Trams | ... | ... | ... | ... | ... | ... |
| **Burnley Corporation** | „ 3 | 1,065 | + 32 | 44 | 59,190 | + 3,336 |
| **Burton Corporation** | „ 4 | 251 | − 45 | §44 | 13,614 | − 1,531 |
| Bury Corporation | Jan. 23 | 791 | ... | §43 | 32,697 | ... |
| **Calcutta Tramways Co.** | Feb. 3 | R40,584 | + R2,157 | 5 | R238,200 | + R27,785 |
| **Camborne-Redruth** | „ 3 | 103 | + 8 | 14 | 1,524 | + 82 |
| Cardiff | Jan. 27<br>Feb. 3 | 1,796<br>1,848 | + 16<br>+ 57 | 44 | 90,042 | + 114 |
| **Carlisle Tramways Co.** | „ 3 | 162 | + 21 | 5 | 815 | + 76 |
| Cavehill | Jan. 26 | 36 | − 2 | 4 | 109 | − 19 |
| **Central London Railway** | Feb. 3 | 6,903 | − 169 | 5 | 34,778 | − 1,296 |
| **Chatham & Dist. Lt. Rys.** | „ 1 | 596 | + 14 | †5 | 2,752 | + 70 |
| **City of Birm'gh'm Tram Co.** | Jan. 26 | 5,115 | + 78 | 4 | 19,267 | + 367 |
| **City & South London Rly.** | Feb. 4 | 2,936 | + 31 | 5 | 15,146 | − 138 |
| **Colchester Corporation** | „ 1 | 164 | + 16 | 25 | 5,014 | − 1,486 |
| **Cork Electric Trams Co.** | „ 1 | 417 | + 13 | †5 | 1,926 | + 13 |
| **Devonport & Dist. Trams** | Jan. 26 | 405 | + 6 | 4 | 1,572 | − 54 |
| **Dover Corporation** | Feb. 3 | 182 | + 18 | ‡44 | 9,934 | + 53 |
| **Dublin & Lucan Railway** | „ 2 | 82 | − 14 | §5 | 411 | − 46 |
| **Dublin United** | „ 2 | 4,607 | + 157 | ‡5 | 21,939 | + 1,117 |
| **Dudley—Stourbridge** | Jan. 26 | 735 | + 64 | 4 | 2,744 | + 290 |
| **Dundee Corporation** | „ 31 | 991 | + 183 | §37 | 34,921 | + 2,844 |
| **East Ham Council** | Feb. 3 | 780 | + 153 | 44 | 36,535 | + 5,090 |
| **Gateshead & Dist. Trams** | Jan. 26 | 903 | + 63 | 4 | 3,892 | + 250 |
| **Glasgow Corporation** | Feb. 3 | 15,234 | + 1,238 | 36 | 547,283 | + 35,180 |
| Glossop | „ 3 | 128 | + 18 | 5 | 619 | + 100 |
| Gloucester Corporation | Jan. 31 | 225 | + 14 | 44 | 12,793 | + 1,162 |
| **Gravesend—Northfleet** | „ 26 | 189 | + 14 | 4 | 729 | + 62 |
| **Gt. Northern & City Rly.** | Feb. 3 | 1,807 | + 32 | 5 | 9,031 | + 159 |
| **Greenock & Port Glasgow** | Jan. 26 | 483 | + 38 | 4 | 2,074 | + 106 |
| **Halifax Corporation** | „ 31 | 1,349 | + 142 | 44 | 69,875 | + 4,997 |
| **Hartlepool Tramways** | „ 26 | 255 | + 34 | 4 | 931 | + 68 |
| Hastings Elec. Trams Co. | Feb. 1 | 346 | ... | 5 | 1,348 | ... |
| **Huddersfield** | „ 3 | 1,313 | + 138 | 44 | 60,203 | + 3,359 |
| **Hull Corporation** | „ 3 | 2,168 | + 100 | 44 | 98,497 | + 1,918 |
| Ilford Dist. Coun. | „ 3 | 400 | + 53 | 45 | 20,704 | + 9 6 |
| **Ipswich Corporation** | „ 3 | 325 | − 4 | 45 | 1,878 | − 1,824 |
| **Isle of Thanet Co.** | „ 3 | 229 | + 2 | 18 | 4,769 | − 424 |
| **Kidderminster & District** | Jan. 26 | 89 | + 5 | 4 | 334 | + 11 |
| Kilmarnock Corporation | Feb. 3 | 140 | ... | 38 | 5,976 | ... |
| **Kirkcaldy Corporation** | Jan. 31 | 193 | + 16 | 22 | 4,523 | − 59 |
| **Lanarkshire Trams Co.** | Feb. 1 | 833 | + 245 | †5 | 4,107 | + 980 |
| Leamington | Jan. 26 | 116 | + 29 | 4 | 499 | + 169 |
| **Leeds Corporation** | Feb. 3 | 5,661 | + 301 | 45 | 261,850 | + 8,590 |
| **Leicester Corporation** | „ 3 | 1,939 | + 215 | 5 | 9,704 | + 1,167 |
| Leith Corporation | Jan. 27 | 431 | + 229 | 36 | 13,188 | + 10,096 |
| **Liverpool Overhead Rly.** | Feb. 4 | 1,392 | − 55 | 5 | 7,030 | − 314 |
| Liverpool Corporation | Jan. 27 | 9,907 | + 347 | 4 | 40,175 | + 2,003 |
| ***London County Council** | „ 20<br>„ 27 | 14,049<br>13,499 | + 2,579<br>+ 1,451 | 43 | 634,308 | + 65,992 |
| **Lowestoft** | Feb. 3 | 122 | − 6 | 18 | 2,603 | − 7 |
| **Maidstone Corporation** | „ 2 | 83 | − 7 | 44 | 5,865 | ... |
| **Manchester Corporation** | „ 3 | 12,415 | + 827 | 44 | 566,995 | + 28,761 |
| **Mersey Railway** | „ 3 | 169 | − 13 | 4 | 682 | + 10 |
| **Merthyr** | Jan. 26 | 1,663 | + 67 | ... | ... | ... |
| Metropolitan Dist. Railway | Feb. 4 | 7,948 | + 546 | 5 | 40,501 | + 2,597 |
| *Metropolitan Elec Trams | Jan. 26 | 2,608 | + 825 | 4 | 10,072 | + 3,287 |
| **Middleton** | „ 26 | 270 | + 27 | 4 | 1,029 | + 129 |
| **Nelson Corporation** | Feb 3 | 124 | + 13 | 45 | 5,895 | + 647 |
| **Newcastle-on-Tyne Corp.** | „ 3 | 3,745 | + 19 | 44 | 167,94[illegible] | + 4,448 |
| **Newport (Mon.)** | „ 3 | 541 | + 87 | 18 | 9,871 | + 652 |
| Northampton Corporation | „ 2 | 860 | + 25 | 43 | 18,065 | + 5,109 |
| **Oldham, Ashton & Hyde** | Jan. 26 | 499 | + 33 | 4 | 1,956 | + 135 |
| **Oldham Corporation** | Feb. 4 | 1,548 | + 155 | 45 | 73,549 | + 17,279 |
| Perth (N.B.) Corporation | Jan. 31 | 184 | ... | 12 | 1,978 | ... |
| **Perth (W. A.) Elec Trams** | Feb. 2 | 1,801 | + 202 | ‡5 | 7,348 | + 4 5 |
| **Peterborough** | Jan. 26 | 91 | − 2 | 4 | 861 | ... |
| Pontypridd Dist. Council | Feb. 3 | 140 | ... | 44 | 7,074 | ... |
| Portsmouth Corporation | „ 3 | 1,421 | + 50 | 44 | 86,097 | + 1,704 |
| **Potteries** | Jan. 26 | 1,695 | + 157 | 4 | 6,411 | + 553 |
| Preston Corporation | „ 31 | 556 | ... | 4 | 2,331 | ... |
| **Reading Corporation** | Feb. 1 | 558 | − 6 | ... | ... | ... |
| Rotherham Corporation | „ 1 | 450 | + 62 | 44 | 20,039 | − 196 |
| **Rothesay** | Jan. 26 | 51 | + 15 | 4 | 223 | + 46 |
| **Salford Corporation** | Feb. 3 | 4,001 | + 132 | 45 | 191,651 | + 18[illegible] |
| **Sheerness** | Jan. 21 | 54 | + 4 | 4 | 178 | − 5 |
| **Sheffield Corporation** | Feb. 4 | 4,854 | + 410 | 45 | 222,538 | + 12,978 |
| **Southampton Corporation** | Jan. 31 | 852 | + 63 | 17 | 15,505 | − 31 |
| **Southend Corporation** | „ 31 | 288 | + 16 | 41 | 16,506 | + 1,0 6 |
| **Southport Tramways** | „ 26 | 282 | + 37 | 4 | 881 | + 73 |
| **S. Staffordshire Trams.** | „ 23 | 781 | + 130 | 4 | 2,762 | + 521 |
| Sunderland Corpn. | Feb 3 | 1,187 | + 68 | 44 | 58,4 8 | + 2,574 |
| **Swansea Trams** | Jan. 26 | 686 | + 245 | 4 | 2,658 | + 1,038 |
| Swindon Corporation | „ 31 | 190 | + 86 | 41 | 8,669 | ... |
| Taunton | „ 26 | 37 | + 3 | 4 | 167 | + 20 |
| Tynemouth and District | „ 26 | 161 | − 4 | 4 | 608 | − 5 |
| **Tyneside Trams Co.** | „ 24<br>„ 31 | 336<br>348 | + 13<br>+ 20 | ¶4 | 1,503 | + 81 |
| **Wallasey District Council** | Feb. 3 | 676 | + 30 | 44 | 31,219 | + 1,431 |
| **West Ham Corporation** | „ 1 | 2,015 | + 263 | 43 | 80,876 | + 34,918 |
| **Weston-super-Mare** | Jan. 24 | 31 | + 4 | 4 | 95 | − 3 |
| Wolverhampton Corpn. | „ 31 | 729 | ... | 4 | 8,011 | ... |
| **Wolverhampton District** | „ 26 | 356 | + 58 | 4 | 1,307 | + 121 |
| ***Worcester** | „ 23 | 222 | − 12 | 4 | 965 | + 18 |
| **Wrexham** | „ 26 | 100 | + 11 | 4 | 334 | + 14 |
| Yorkshire W.R. Trams | Feb 4 | 718 | + 191 | 5 | 2,991 | + 1,030 |
| **Yorkshire Woollen District** | Jan. 26 | 800 | + 278 | 4 | 2,947 | + 1,178 |

(a) These comparisons are with the corresponding period last year. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days. ¶ Plus 3 days. * Partly electrical.

**LONDON ELECTRIC SUPPLY CORPN. (LTD.)**—The quantity of electrical energy sold during 1905 amounted to 13,042,932 units, producing a net revenue of £78,721. 9s. 4d. compared with 10,531,785 units in 1904, which produced a net revenue of £65,333. 6s. 4d. £30,000 has been carried to reserve, compared with £23,540. 10s. 6d., and a balance of £3,141. 17s. 5d. carried forward, against £2,009. 10s. 8d. last year. The directors propose to pay a dividend of 6 per cent. upon the preference and 4 per cent. (an increase of 1 per cent. on last year) upon the ordinary shares for 1905.

**NORTH-EASTERN RAILWAY CO.**—The expenditure on electrical train working during the past year was £17,513, a decrease of £5,012 on the year. The further experience of electric traction on the suburban lines in the Newcastle district has been entirely favourable, both from the practical and from the financial point of view.

**RAND CENTRAL ELECTRIC WORKS (LTD.)**—During January 889,000 units were generated, yielding a gross revenue of £8,150, compared with 775,000 units and £7,300 for the corresponding period of last year.

**ST. JAMES' & PALL MALL ELECTRIC LIGHT CO. (LTD.)**—The share transfer books will be closed from 7th to 21st inst. inclusive, preparatory to payment of dividend for half-year ended Dec. 31.

**STOCK EXCHANGE NOTICES.**—The Stock Exchange committee have granted quotations to £100,000 5 per cent. A debenture stock and £100,000 6 per cent. B debenture stock of *Kalgoorlie Electric Tramways (Ltd.)* The committee have been asked to appoint a special settling day in 317 £1,000 (£200 paid) shares of the *Shanghai Electric Construction Co. (Ltd.)* and to grant quotations to £800,000 4 per cent. perpetual debenture stock of the *Charing Cross, Euston & Hampstead Railway Co.* (in lieu of Speyer Bros. scrip certificates now quoted) and a further issue of 10,000 £5 fully paid ordinary shares of the *United River Plate Telephone Co. (Ltd.)*

**TELEGRAPH CONSTRUCTION & MAINTENANCE CO. (LTD.)**—The directors propose, subject to audit, to pay a dividend of 10 per cent. (£1. 4s. per share), in addition to the 5 per cent. already paid, making 15 per cent. for 1905.

## COLONIAL AND FOREIGN INVESTMENTS.

| SHARE. | LAST DIVIDEND | NAME. | Price Wed., Feb. 7. | RATE PER CENT. YIELDED. | DIVIDEND DUE. | BUSINESS, WEEK TO FEB. 7. Highest. | BUSINESS, WEEK TO FEB. 7. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | £ s. d. | | | |
| 5 | 8/0 | Anglo-Argentine Ord. Shares | 8⅞—9⅛ | 4 7 9 | Ap, Oct | 9 | 8¾ |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞—6⅛ | 4 10 0 | — | 6 1/16 | 5 15/16 |
| St. | 6% | Do. Permanent 6% Deb. Stock | 140—143 | 4 3 6 | — | 142½ | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 104—106 | 4 14 3 | — | 105 | — |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1—1½ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 3⅞—4⅛ | 6 1 4 | — | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 93—96 | 4 13 9 | — | 95½ | — |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 120—123 | 4 17 6 | — | 121¾ | 120¼ |
| St. | 5% | Do. Pref. Ord. Stk | 110—113 | 4 8 4 | — | 111¼ | 110⅛ |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock. | 108—111 | 4 10 0 | — | .. | — |
| 40 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%—105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 101—104 | 4 6 6 | — | .. | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | 3⅝—3⅞ | 5 3 0 | — | 3 15/16 | 3 13/16 |
| 5 | 8/0 | Do. 6 per Cent. "A" Cm. Pref. | 5¾—6⅛ | 4 13 0 | — | 6 3/32 | 6 1/32 |
| 5 | 8/0 | Do. "B" | 5¼—5¾ | 5 4 0 | — | 5 11/16 | .. |
| St. | 5% | Do. 5 per Cent. Debs. | 105—107 | 4 13 6 | — | 106½ | 105¾ |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102—105 | 4 15 0 | — | .. | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 96—98 | 5 2 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 101—105 | 5 5 2 | .. | 103 | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 101—105 | 5 14 0 | .. | .. | .. |
| 6 | 8/6 | Calcutta Tramways (Nos. 1 to 105) | 9½—10 | 4 5 0 | — | 9 15/16 | 9 13/16 |
| 5 | 2/6 | Do. Nos. 105,001 to 137,610 | 9—9½ | .. | .. | 9 3/16 | 9⅛ |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 104—106 | 4 5 0 | — | 105½ | .. |
| 1 | 0/6 | Cape Electric Tram Shares | ⅞—1⅛ | 4 8 10 | — | 1 1/16 | — |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 102—104 | 4 16 0 | — | .. | — |
| .. | .. | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 95—97% | .. | .. | 97½ | 95¾ |
| 1 | .. | Lisbon Elec. Trams Ord. | 1 7/16—1 9/16 | .. | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛—1⅜ | 4 7 4 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 100—103 | 4 17 0 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 101—103 | 4 17 0 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 102—105 | 4 15 0 | — | .. | .. |
| 100 | 4½% | † Do. Sterling 4½% Debs. (1922) | 104—106 | 4 5 6 | — | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 105—108 | 4 12 6 | .. | 106½ | 104½ |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 140—143 | 5 8 0 | .. | .. | .. |
| .. | 5% | Do. 5% 1st Mt. $100 Dbs. | 98%—100% | 5 0 0 | .. | .. | .. |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | — | Adelaide Elec. S'ply Co. 6% Cu. Pr. | 4¾—5¼ | — | .. | 5⅛ | .. |
| 5 | 8/8 | Calcutta Elec (1-50,000) | 8¾—9¼ | 4 9 0 | — | 9¼ | 9 5/32 |
| 10 | 5% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50—52 | 4 16 0 | .. | 51⅛ | 51 |
| .. | 5% | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 94—96 | 5 4 0 | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½—3 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Debs. | 85—90 | 5 10 0 | — | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | 7¾—8¾ | — | — | 8⅜ | 8 |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92—94 | 5 6 8 | .. | 93¼ | 92½ |
| St. | 26/2 | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. | 109—111 | 5 8 0 | .. | 110¾ | 110¼ |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞—1 | 6 0 0 | — | 15/16 | .. |
| 1 | 1/0 | Rand Electric | 1 5/16—1 7/16 | .. | — | .. | — |
| 1 | .. | River Plate Electricity Co. Ord. | 19/32—23/32 | .. | .. | 21/32 | .. |
| 1 | 1/2⅖ | Do. 6% Non. Cum. Pref | 15/16—1 1/16 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Deb. Stock | 101—103 | 4 17 0 | .. | .. | .. |
| 5 | 8/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5¼—5¾ | 5 4 4 | .. | .. | .. |
| 5 | 9·23d | Do. (12,001-20,000) | 5—5½ | 8 8 0 | .. | .. | — |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100—103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 5% | Shawinigan Water and Power 5% Bds., Scrip | 101—103 | 4 17 0 | .. | 102¾ | .. |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| SHRE | LAST DIVIDEND | NAME. | Price Wed., Feb. 7. | RATE % YIELDED. | DIVIDEND DUE | BUSINESS, WEEK TO FEB. 7. | |
|---|---|---|---|---|---|---|---|
| | | | | £ s. d. | | Highest. | Lowest. |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12⅜–12⅞ | 5 9 6 | .. | 12⅝ | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10¼–10¾ | 4 8 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11¾–12¼ | 4 18 0 | .. | – | – |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 106–108 | 4 8 3 | .. | .. | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼–5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 102–105 | 4 5 9 | – | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord | 8½–9½ | 5 5 0 | – | 8¾ | .. |
| 5 | 8/6 | Do. 7 per Cent. Pref. | 8½–9½ | 3 14 5 | Mar, Sept | – | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 102–105 | 3 16 3 | – | 103 | 102½ |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 6¼–6½ | 5 13 0 | Feb, Aug | 6 | 5¾ |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼–5¾ | 3 18 8 | Feb, Aug | 5 1/16 | 5 1/16 |
| St. | 4% | Do. 4% Deb. Stock (red.) | 101–103 | 3 17 6 | – | 102¾ | 102¼ |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4⅝–4⅞ | 4 12 6 | – | .. | .. |
| 5 | 2/3 | Do. Do. (1903) | 4⅝–4⅞ | 4 12 6 | .. | .. | .. |
| 5 | 2/3 | Chelsea Electric Supply Ord. | 5–6 | 5 0 0 | March .. | 5 11/16 | 5½ |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 108–110 | 4 1 6 | Jn, Dec .. | 108 | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 11–12 | 5 0 0 | Feb, Aug | 11⅝ | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 14¼–14¾ | 4 4 2 | Jan, July | 13⅞ | 13⅝ |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 122–126 | 3 19 4 | Jn, Dec .. | .. | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 100–102 | 4 8 3 | .. | 102 | .. |
| 5 | .. | County of Durham Elec. P.D. Ord. £2pd. | 2–2 1/16 | .. | April, Oct | 2 1/16 | 2 1/32 |
| 5 | 5% | Do. Do. 5% non cum. pref. | 5¼–5⅜ | 4 13 0 | April, Oct | 5⅜ | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 8½–9½ | 4 6 6 | – | 9 | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12½–13 | 4 12 3 | Mar, Sept | 12 13/16 | 12½ |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 109–112 | 4 0 4 | .. | .. | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 101–103 | 4 7 6 | .. | .. | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼–5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5–5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | † Do. 4½ 1st Deb. Stock (red.) | 101–104 | 4 6 6 | – | .. | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8¼–8¾ | 4 17 2 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100–103 | 4 7 5 | – | .. | – |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 10½–11½ | 5 4 0 | .. | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½–7 | 4 5 9 | Jan, July | – | – |
| St | 4% | † Do. 4 per Cent. Deb. Stock (red.) | 98–101 | 3 19 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 102–104 | 3 17 0 | .. | .. | .. |
| 3 | 1/9⅜ | London Electric Supply Ord. | 2–2½ | 3 12 0 | .. | 2 1/16 | .. |
| 5 | 6/0 | Do. 6 per Cent. Pref. | 5–5½ | 5 9 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 98–101 | 3 19 2 | Mr, Jn, S, D | .. | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 9–10 | 5 0 0 | April, Oct | 9¾ | 9½ |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5¼–5½ | 3 18 0 | Jan. July | 5 7/16 | 5⅜ |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 107–111 | 4 1 0 | Jn, Dec .. | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 95–97 | 3 12 3 | – | .. | .. |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 101–103% | 4 7 4 | – | 102 | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 11¾–12 | 5 13 8 | Feb, Aug | .. | .. |
| 100 | 4½% | † Do. 4½% Deb. | 101½–102½ | 4 7 8 | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8 1/16–8 3/16 | 4 18 6 | Feb, Aug | 8⅛ | 8 1/16 |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6¼–6⅜ | 3 19 4 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99–101 | 3 19 7 | Jan, July | .. | .. |
| 1 | 3% | Northern Counties Elec. Sup. | 15/16–31/32 | 3 2 6 | Mar, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 101–102 | 4 7 6 | Jan, July | – | – |
| 10 | 6/0 | Notting Hill Electric Ord. | 13½–14½ | 4 16 8 | March | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98–100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅜–6⅞ | 5 1 6 | March .. | .. | .. |
| St. | 4% | Do. 4% Deb. Stock | 99–101 | 3 19 0 | – | .. | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 11–12 | 6 5 0 | Feb, Aug | .. | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 7–8 | 4 7 0 | Feb, Aug | – | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 97–99 | 3 10 9 | – | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2½–2¾ | 7 5 4 | .. | .. | – |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76–80 | 5 0 0 | – | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 8¼–8¾ | 5 6 8 | .. | 8½ | 8 5/16 |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | ¾–⅞ | .. | .. | .. | – |
| 1 | 0/8⅜ | Do. 7% Cum. Pref. | 1 5/16–1 7/16 | 4 17 2 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105–108 | 4 3 8 | – | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4⅝–4⅞ | 5 2 6 | – | .. | .. |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5–5½ | 4 16 3 | – | 5 3/16 | .. |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 104–106 | 4 5 0 | .. | 105½ | .. |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 10¾–11¾ | 5 19 0 | Mar, Sept | 11⅜ | 11 |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝–5⅞ | 4 9 0 | .. | .. | .. |
| | | **ELECTRIC RAILWAYS, TRAMWAYS &c.** | | | | | |
| 1 | .. | Bath Elec. Trams Pref. Ord. | 15/16–1 | .. | .. | 1 | 31/32 |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16–1 1/16 | 4 14 9 | .. | 1 | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 103–106 | 4 5 6 | .. | .. | – |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 101–103 | 4 7 9 | .. | 102 | .. |
| 10 | 9% | Bristol Tramways and Carriage Ord. | 17–17½ | 5 2 11 | Feb, Aug | .. | – |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10–10¼ | 3 18 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Debs. | 104–106 | 3 15 6 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 8–8½ | 7 1 6 | – | 8½ | 8⅜ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 10½–11 | 5 8 0 | Feb, Aug | 10⅞ | 10¾ |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 119–121 | 4 2 8 | .. | 119¾ | .. |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 98–100 | 4 10 0 | .. | .. | .. |
| St. | 4% | Central London Ordinary Stock | 95–97 | 4 2 6 | June, Dec | 96½ | 95 |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 104–106 | 3 15 4 | .. | .. | .. |
| St. | 4% | Do. Deferred Stock | 87–90 | 4 9 0 | .. | 89 | 87¾ |
| 100 | 4% | Do. 4 per Cent. Debs. | 110–112 | 3 11 3 | .. | 111¾ | 111⅛ |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 5–5¼ | 4 16 0 | .. | 5 3/32 | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 101–104 | 3 17 0 | .. | 103 | 102½ |
| St. | 2% | City and South London Rly. Con. Ord. | 41–43 | 4 7 0 | Feb, Aug | 42⅜ | 42 |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 120–123 | 4 1 4 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 117–120 | 4 3 4 | .. | .. | .. |
| St. | 5% | Do. (1901) | 115–118 | 4 4 8 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 106–109 | 3 13 4 | May, Nov | .. | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13¾–14¼ | 4 1 6 | .. | 14⅛ | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½–15½ | 3 17 3 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 5–5½ | 7 5 6 | .. | 5⅜ | 5¼ |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8–9 | 4 8 11 | .. | .. | .. |
| St. | 4½% | Hastings & Dist. Elec. Tramr. Co. 4½ Db. St. | 102–104 | 4 6 6 | .. | 103¼ | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 17–18 | 5 0 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 13¼–13¾ | 4 7 8 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 109–111 | 4 1 9 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2½–2¾ | 9 8 6 | – | 2½ | 2⅜ |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 82–87 | 4 12 0 | – | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 3 11/16–3 13/16 | 3 13 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref | 9¾–10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99–102 | 3 19 3 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 8¾–9¼ | 5 8 0 | – | 8¾ | 8½ |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 92–97 | 4 2 6 | – | 95 | .. |
| St. | .. | Mersey Con. Ord. Stock | 7–9 | – | – | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8–11 | – | – | .. | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 7/32–9/32 | .. | – | 7/32 | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1–1 1/16 | 4 14 1 | – | 1 1/32 | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104–106 | 4 5 0 | – | 105½ | 105 |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½–1½ | .. | May | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾–9¼ | 5 5 8 | .. | 8 15/16 | .. |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9¾–10¼ | 4 17 6 | Feb, Aug | 10 | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103–106 | 4 5 0 | – | .. | .. |
| 100 | 5% | Sunderland Dst. Elc. Trms. 5% 1st Mt. Db. | 93–96 | 5 4 0 | .. | .. | .. |
| .. | 5% | Underground Elec. Rys. Co. of London | 98–99 | 5 1 0 | .. | .. | .. |
| St. | 3% | Waterloo and City Ord. | 97–100 | 3 0 0 | June, Dec | .. | .. |
| t. | 4½% | Yorkshire W.R. El. Trs. Co. 4½% 1st Debs. | 95–97 | 4 13 0 | .. | 96 | .. |

| SHRE | LAST DIVIDEND | NAME. | Price Wed., Feb. 7. | RATE % YIELDED. | DIVIDEND DUE | BUSINESS, WEEK TO FEB. 7. | |
|---|---|---|---|---|---|---|---|
| | | | | £ s. d. | | Highest. | Lowest. |
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝–⅞ | 5 6 6 | – | .. | .. |
| 1 | 10½d. | Aron El. Met. 6% Cm. Pf. | ½–⅝ | .. | .. | .. | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 4–4¼ | 4 11 0 | .. | 4¼ | 4⅛ |
| 1 | 7½d. | Do. Pref | 1 7/16–1 9/16 | 3 16 10 | .. | .. | – |
| 5 | 4/0 | British Insulated & Helsby Cables Ord. | 7–7½ | 5 6 8 | July, Feb | .. | – |
| 5 | 6/0 | † Do. 6 per Cent. Pref. | 5¾–6¼ | 4 16 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103–106 | 4 4 11 | .. | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 98–100 | 4 10 0 | .. | .. | .. |
| 5 | .. | British Westinghouse 6% Pref. | 1¾–2¼ | .. | .. | 2 3/32 | 2 1/16 |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 77–82 | 4 17 6 | .. | 79⅝ | 79 |
| 2 | .. | Brush Electrical Engineering | ⅜–⅝ | .. | March .. | ½ | .. |
| 2 | 3/4⅝ | Do. 6 per Cent. Pref. Non-Cum. | 1¼–1¾ | 6 17 0 | Mar, Sept | 1 9/16 | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 98–100 | 4 10 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 82–84 | 5 7 4 | Jan, July | .. | .. |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11–12 | 5 0 0 | Jan, July | 11⅝ | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝–5⅞ | 4 5 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 108½–110½ | 4 1 8 | Nov, May | .. | .. |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1 1/16–1 3/16 | 5 1 0 | .. | 1⅛ | .. |
| St. | 4½% | † Do. 4½% 1st Mort. Deb. (red.) | 95–100 | 4 10 0 | – | .. | .. |
| 1 | 2⅜d. | Chadburn's (Ship) Telegraph Ord. | 1–1¼ | 8 0 0 | .. | .. | – |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1 1/16–1 3/16 | 5 2 7 | .. | 1 1/16 | .. |
| 2 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 2–2¼ | 3 9 0 | Jan, July | 2 3/32 | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 96%–98% | 5 2 0 | Jan, July | .. | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8½–9 | 5 11 1 | Sept | 8¾ | 8½ |
| 5 | 6/0 | Do. 6% Cum. Pref. | 6–6½ | 4 14 0 | Sept | 6¼ | 6⅛ |
| St. | 4½% | Do. 4½% Deb. Stock | 104–106 | 4 5 0 | .. | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1½–1¾ | – | Feb, Aug | 1⅝ | .. |
| 5 | 2/6 | Do. (£5 paid) | 2¼–2¾ | .. | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 86–88 | 4 11 0 | June, Dec | – | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92–97 | 5 3 1 | .. | .. | .. |
| 5 | 2/6 | Edmundson's Elec. Corp. Ord. | 4¾–5¼ | 6 18 4 | H'lf-yearly | 5 | 4¾ |
| 5 | 6/0 | Do. 6 per Cent. Cum. Pref. | 5⅛–5⅜ | 5 16 6 | .. | 5¼ | 5 1/16 |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 104–106 | 4 5 0 | .. | 105½ | 104½ |
| 2 | 1/7½ | Electric Construction Co. | ½–¾ | 9 6 0 | July | .. | .. |
| 2 | 2/9⅝ | Do. 7 per Cent. Cum. Pref | 2–2½ | 5 12 0 | July | 2⅛ | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 89–92 | 4 7 0 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9¼–9¾ | 5 4 6 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 95–99 | 4 1 0 | .. | 97 | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 13–14 | 5 7 0 | Feb, Aug | 13 9/16 | .. |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼–5½ | 4 2 0 | Feb, Aug | 5 5/16 | .. |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | – | 4 1 1 | Feb, Aug | .. | .. |
| 10 | 15/0 | India Rubber, Gutta Percha, &c., Wrks. | 18–19 | 2 12 6 | Feb, Aug | 18⅛ | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99–102 | 3 18 5 | Mar, Sept | .. | .. |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¾–12¼ | 4 1 8 | Mar, Sept | .. | .. |
| 1 | 1/⅜ | Richardsons, Westgarth & Co., Ltd. Ord. | 31/32–1 1/32 | 5 17 0 | .. | 1 1/16 | 1 1/32 |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1–1⅛ | 5 7 6 | .. | .. | .. |
| St. | 4½% | Do. 4½% Perp. Deb. Stock | 100–102 | 4 8 8 | .. | .. | .. |
| 12 | 12/0 | Telegraph Construction & Mainten'ce. | 34½–36½ | 4 18 9 | Mar, July | 34½ | 34¼ |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 100–102 | 3 18 6 | Jan, July | .. | .. |
| 1 | 1/0 | Vickers, Sons & Maxim, Ltd., Ord. | 2⅝–2⅞ | 4 9 6 | .. | .. | .. |
| 1 | 6d. | Do. 5% Non-Cum. Preference | 1 3/16–1 5/16 | 3 16 0 | .. | .. | .. |
| St. | 5% | Do. 5% Non-Cum. Preferred | 121–124 | 4 0 8 | .. | 122 | .. |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock Red. | 104–108 | 3 15 6 | .. | 105½ | 105 |
| 100 | 4½% | Do. 4½% 2nd Mort. Debs., Red | 104–106 | 4 5 0 | .. | 104¼ | .. |
| 5 | – | Willans and Robinson Ord. | 2–2½ | – | Apr, Oct | .. | .. |
| 5 | – | Do. 6 per Cent. Cum. Pref. | 4–4½ | – | Apr, Oct | 4¼ | 4⅛ |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 82–87 | 4 12 0 | May Nov | 84¼ | 84 |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | * African Direct Tel. 4% Mrt. Deb. (red.) | 99½–101½ | 3 18 6 | Jan, July | – | .. |
| 10 | – | Amazon Telegraph | 3¾–4¼ | .. | Jn, Dec .. | .. | .. |
| 100 | 5% | Do. 5% Debs. (red.) | 83–88 | 5 18 6 | .. | .. | .. |
| St. | 25/0 | Anglo-American | 65–67 | 4 9 8 | F, My, Ag, N | 67 | 66 |
| St. | 20/0 | Do. Preferred | 111½–113½ | 5 1 6 | F, My, Ag, N | 112½ | 112 |
| St. | 2/0 | Do. Deferred | 17⅞–18⅛ | .. | F, My Ag, N | 18 3/32 | 17⅞ |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 97–99 | 4 1 0 | Jn Ap, Jy, O | 98½ | 98 |
| 10 | 5/0 | Cuba Submarine Ord. | 8½–9 | 5 11 0 | Feb, Aug | 8⅞ | .. |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17–18 | 5 11 2 | Feb Aug | – | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜–3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 8¼–8¾ | 5 14 0 | April, Oct | .. | .. |
| 100 | 4½% | Do. 4½ per Cent. Deb. | 99%–102% | 4 8 0 | Jan, July | .. | .. |
| 20 | 8/6 | † Direct United States Cable | 14½–15½ | 4 4 0 | Ja, Ap, Jy, O | 15¼ | 15 |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 99–101 | 4 9 0 | Jn, Dec .. | .. | .. |
| St. | 25/0 | Eastern Ordinary | 148–151 | 4 12 8 | Ja, Ap, Jy, O | 150¼ | 149 |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 91½–93½ | 3 15 0 | Ja, Ap, Jy, O | 93¼ | 92 |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 107½–109½ | 3 13 0 | May, Nov | 108¾ | 108¼ |
| 10 | 2/6 | Eastern Extension | 14½–15 | 4 13 4 | Ja, Ap, Jy, O | 14 17/32 | 14½ |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 107–109 | 3 13 4 | Feb, Aug | .. | .. |
| 100 | 4% | † Eastern & S. African 4% Mrt. Deb. 1909 | 99–101 | 3 19 3 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101%–103% | 3 18 8 | May, Nov | 102½ | .. |
| 10 | 5/0 | G. N. (of Copenhagen) with coupon 65 | 57½–59½ | 6 1 6 | Jan, July | 57½ | .. |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 100–102 | 4 8 0 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57–59 | 5 10 0 | May, Nov | 57¼ | .. |
| 100 | $1 | Mackay Companies Common | 62 | 3 4 6 | Jan, July | – | .. |
| 100 | 4% | Do. Preference | 76½ | 5 5 0 | Ja, Ap, Jy, O | .. | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1¼–1¾ | .. | .. | 1 5/16 | 1¼ |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 99–102 | 3 18 6 | June, Dec | .. | .. |
| 10 | 4/0 | West African Telegraph Shares | 9½–10 | 5 0 0 | .. | .. | .. |
| 5 | – | West Coast of America | ⅝–¾ | .. | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100–102 | 3 18 3 | Jan, July | .. | .. |
| 10 | – | West India and Panama | ⅜–⅝ | .. | May, Nov | .. | .. |
| 10 | 6/0 | Do. 6% 1st Pref. | 8¼–8¾ | 6 6 8 | May, Nov | .. | .. |
| 10 | – | Do. 6 per Cent. 2nd Pref. | 6½–7½ | .. | May, Nov | .. | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 100–103 | 4 17 0 | Jan, July | .. | .. |
| 10 | 8/0 | Western Telegraph | 14¼–14¾ | 4 17 0 | Mr, Jn, O, D | 14⅜ | 14¼ |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 100–102 | 4 18 0 | June, Dec | 102½ | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 102–104 | 3 16 10 | .. | 103½ | 103 |
| | | **TELEPHONES.** | | | | | |
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 102–104 | .. | .. | .. | .. |
| 5 | 8/0 | Chili Telephone (fully paid) | 8–8¼ | 4 17 0 | August .. | 8⅛ | 8 |
| 1 | 0/9 | Monte Video Telephone Ord. | ⅞–1 | 4 0 0 | – | .. | .. |
| 1 | 1/0 | Do. 5% Pref. | ⅞–1 | 5 0 0 | .. | .. | .. |
| St. | 6% | National Co. Pref. Stock | 112½–114½ | 5 5 3 | – | 113½ | 113 |
| St. | 5% | Do. Def. Stock | 110–112 | 4 8 8 | – | 111½ | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13–15 | 4 0 0 | Feb, Aug | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 11–13 | 4 12 4 | Feb, Aug | – | .. |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅝–5⅞ | 4 5 2 | Feb, Aug | .. | .. |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 99½–101½ | 3 9 0 | June, Dec | 101⅝ | 101¼ |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 104–106 | 3 15 6 | .. | .. | .. |
| 1 | 0/7½ | Oriental | 1 5/16–1 7/16 | 4 11 0 | April, Oct | 1⅜ | .. |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1¼–1⅜ | 4 7 0 | – | 1¼ | .. |
| St. | [illegible] | Do. 4% Red. Deb. Stock | 97–99 | 4 1 0 | .. | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 103–106 | 4 4 9 | .. | .. | .. |
| 5 | 8/0 | United River Plate | 7¼–7½ | 5 6 8 | July | 7½ | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5½–5¾ | 4 7 0 | June, Dec | .. | – |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 110–112 | 4 9 3 | June, Dec | 111¼ | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 5–5½ | 5 9 0 | .. | 5⅛ | .. |
| 10 | 2/0 | ‡ Globe Telegraph and Trust | 11⅛–11⅜ | 4 16 6 | Ja, Ap, Jy, O | 11⅜ | 11¼ |
| 10 | 2/0 | † Do. 6 per Cent. Pref | 14⅝–14⅞ | 4 0 0 | Ja, Ap, Jy, O | 14¾ | 14⅝ |
| 10 | 6% | Submarine Cables Trust (Cert.) | 127–130 | 4 12 0 | April, Oct | .. | – |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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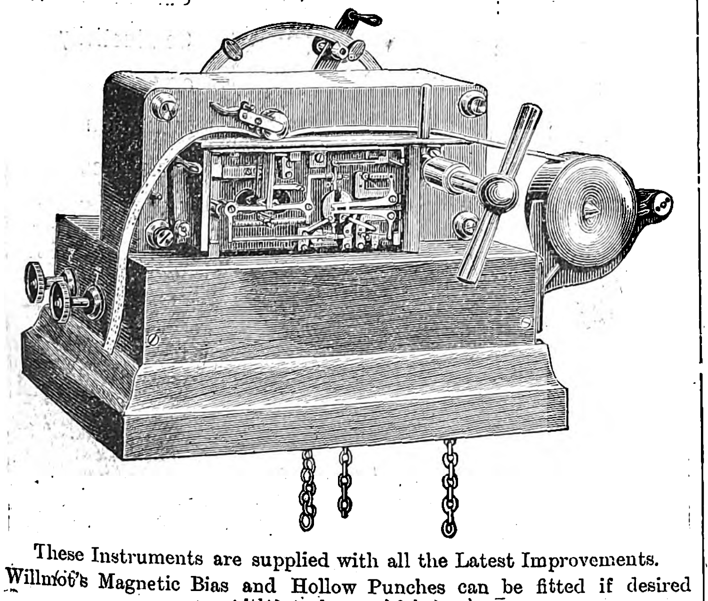

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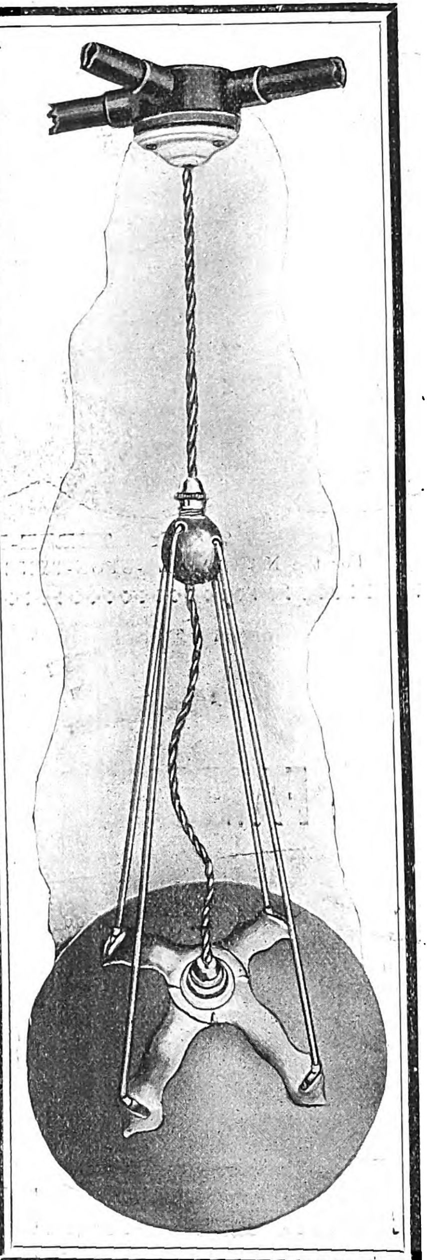

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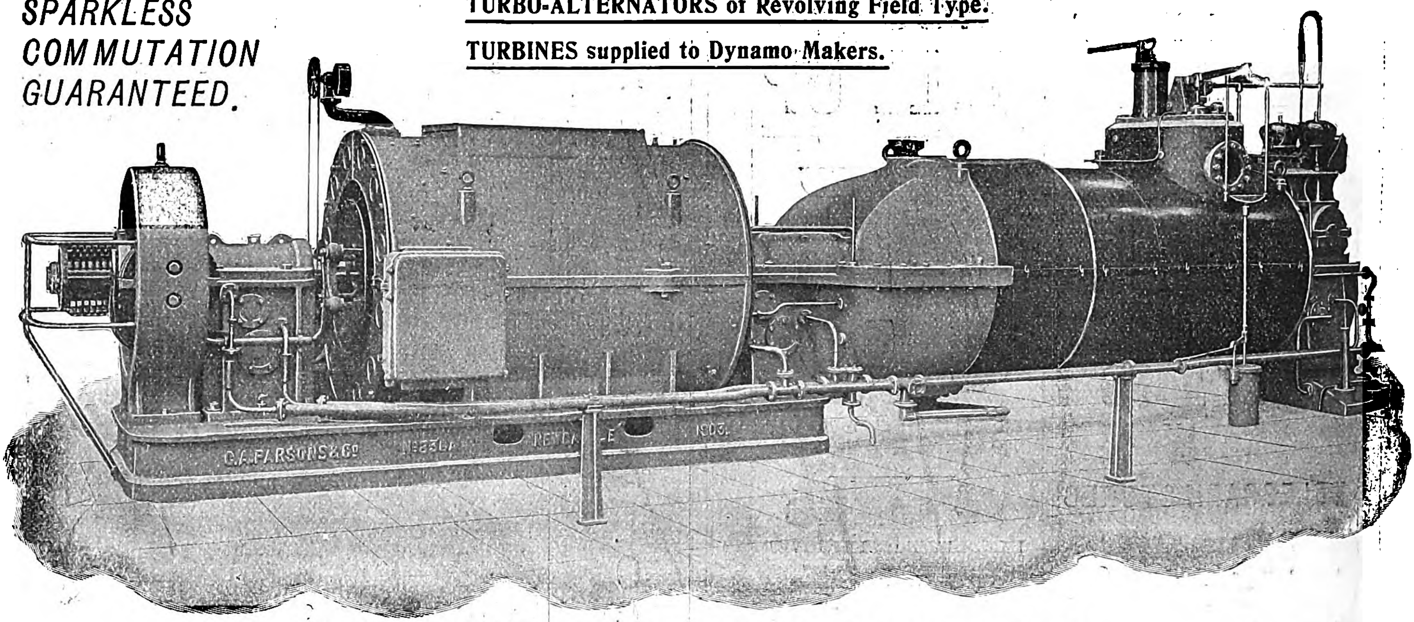

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Total Range:
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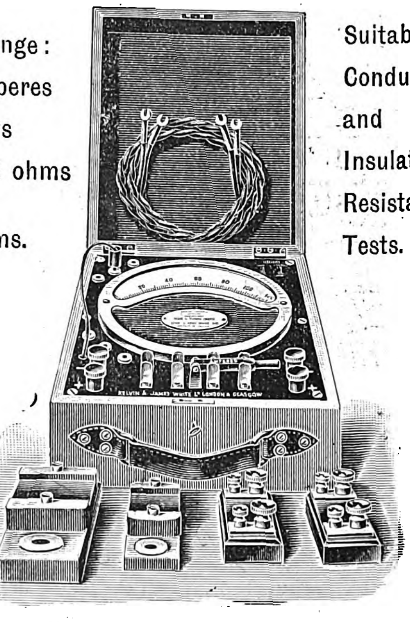
0-600 volts
0·0000008 ohms to 4 megohms.

Suitable also for Conductivity and Insulation Resistance Tests.



(31)

*Full particulars on application to*
18, Cambridge Street, GLASGOW.
66, Victoria Street, LONDON, S.W.

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*(Established 1850.)*

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Periodical Valuations, Stock-takings and Reports for DEPRECIATION, RENEWALS, &c , in conformity with the Acts.

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**And Albert Chambers, Albert Square, MANCHESTER.**

Telephones { 5077 Bank London.
3218 Central Manchester.

Telegraph Addresses { Indices London.
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MORDEY-VICTORIA ALTERNATOR A 12. 75 kw. Rev. per minute 500. Complete with Direct-coupled Exciters. Groved pulley for eight ropes. Hand E.M.F. regulator. Spare armature coils, &c. Guaranteed in perfect working condition.

BRUSH SERIES DYNAMO. suitable for five 10 ampere lamps in series.

BRUSH SERIES DYNAMO, suitable for sixteen 10 ampere lamps in series.

ONE BRUSH-GEIPEL AUTOMATIC REGULATOR suitable for above.

ONE STATIC VOLTMETER reading to 1,500 volts.

EIGHTEEN 10 ampere BRUSH SERIES ARC LAMPS.

A QUANTITY of OLD CABLE. Hard Drawn Wire, &c.

For very low prices and full particulars of above apply to JOHN S. BROWN, Electrical Engineer, Swansea.

## MISCELLANEOUS PLANT, &c., WANTED.

WANTED, 200-Volt DYNAMO, about 30 Amps.—W. AINSWORTH, 5 and 7, Hyde-road, Gorton.

WE are open to PURCHASE for cash a 50-Volt (about) DYNAMO. for charging motor car accumulators. Good make. We are open to EXCHANGE a Thomson-Houston 10 H.P. Electric MOTOR for a good Lighting DYNAMO, 230 volts. What offers ? W. E. CLARK & Co., Motor Engineers, Doncaster.

WE BUY for Cash to re-sell in Italy, INCANDESCENT ELECTRIC POCKET LAMPS, Novelties, Useful Articles, &c.—Address MONDO MEDICO, Naples, Italy.

WANTED, LAMP TOPS, with Platinum, Scrap Platinum, &c.—EDEY & Co., 29, Ludgate-hill, London, E.C.

## MISCELLANEOUS PLANT, &c., FOR SALE.

FOR SALE or HIRE, high-class Dynamos, Motors, Alternators, Cable and Electrical Apparatus.—PERCY HUDDLESTON & Co., 72, Finsbury Pavement, London, E.C.

CHEAP LAMPS, 200 volts, 16 c.p. and 8 c.p., 5s. per doz. DULWICH LIGHTING Co., Lordship-lane, East Dulwich, London, S.E.

SIMPLE ARC LAMP.—Protected by Patent in Great Britain, Germany, United States, Canada and other Countries.

ALL RIGHTS under British and Foreign Patents in connection with the above for IMMEDIATE SALE, under exceptional circumstances,

Apply, S H. JOHNSON & Co., LIMITED, Engineering Works, Carpenter's-road, Stratford, London, E.

**Royal Doulton Potteries.**

**INSULATORS**

AND ALL KINDS OF

**POTTERY FOR ELECTRICAL PURPOSES.**

**DOULTON & CO.,**
*LIMITED,*
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Telegrams: Turnstile London.

**STANLEY**

GOLD MEDAL St. Louis, 1904

**SURVEYING & DRAWING INSTRUMENTS.**

*NOTICE OF REMOVAL OF THE RETAIL DEPARTMENT*
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**286, HIGH HOLBORN, LONDON, W.C.** Price List post free.

## TENDERS INVITED.

### MUNICIPALITY OF JOHANNESBURG.

SPECIFICATION No. 16.

**STREET LAMP FITTINGS.**

The Town Council of Johannesburg is prepared to receive TENDERS for the Supply, free at their Stores, Johannesburg, of :—

350 STREET LAMP FITTINGS.
50 STAYS for ditto.
600 ft. GAS BARREL.

Tenders are to be addressed to The Town Clerk, Municipal Offices, Johannesburg, and must reach him not later than SATURDAY, March 31st, 1906.

Complete delivery of the whole of the material must be made at the Council's Stores, Johannesburg, not later than Saturday, June 30th, 1906. A deduction at the rate of Two per cent. of the total contract sum will be made for each week by which the delivery is delayed beyond the above date.

General Conditions, Specifications and Forms of Tender may be seen on and after Monday, February 19th, 1906, at the offices of the Council's Consulting Engineers, Messrs. Mordey and Dawbarn, 82, Victoria-street Westminster, S.W., and may be obtained from them on payment of Three Guineas, which will be returned on receipt of a bonâ fide tender. Further copies of the General Conditions, Specification, and Forms of Tender may be obtained on payment of Ten Shillings, which will not be returned.

The Council does not bind itself to accept the lowest or any Tender and is not responsible for the cost of tendering.

JOHN DOVE, Town Clerk, Johannesburg.

### COUNTY BOROUGH OF WEST HAM.

**TENDERS FOR SUPPLIES, &c.**

The Council hereby invite TENDERS for the Supply of :—

1. INCANDESCENT LAMPS.
2. CABLE.
3. SINGLE AND TWO PHASE ALTERNATING CURRENT MOTORS.
4. TRANSFORMERS.
5. ALTERNATING CURRENT METERS.
6. HOUSE CUT OUT BOXES.

Forms of Tender and further particulars may be obtained, after the 16th inst., at the Borough Electrical Engineer's Office, Central Electricity Station, Tucker Street, Canning Town.

Tenders for the whole of the Contracts to be enclosed in endorsed envelopes supplied with the forms, and sent to my office not later than Ten o'clock on FRIDAY morning March 2nd, 1906.

The Tenders will be opened at the Town Hall, West Ham, on Friday, March 2nd, 1906, at 5.30 p.m., and persons tendering may be present if they so desire, but no guarantee is given that any information, beyond the names of persons tendering, will be read out.

The Council do not bind themselves to accept the lowest or any Tender. The Contractor will be required to enter into a bond with sureties for the due performance of the contract, and no Goods, Materials, etc., will be ordered under any contract until such bond has been duly executed.

The Contractor whose Tender is accepted, and with whom a contract is entered into, will be required to pay to the whole of his workmen such rate of wages, and observe such hours of labour, as are recognised by the Workmen's Trade Unions and in force at the time of singing the contract. In the event of any breach of such agreement the Council will enforce the penalty clause in its entirety.

By order of the Council,
FRED. E. HILLEARY, Town Clerk.
Town Hall, West Ham, E., 15th February, 1906.

### ILFORD URBAN DISTRICT COUNCIL.

**ANNUAL CONTRACTS.**
ELECTRICITY DEPARTMENT.

The above Council is prepared to receive TENDERS for the Supply of the following required during the year ending 31st March, 1907 :—

1. ELECTRICITY METERS and DEMAND INDICATORS.
2. CABLES
3. INCANDESCENT LAMPS.
4. ARC LAMP CARBONS.
5. HOUSE SERVICE FUSE BOXES.

Forms of Tender, Conditions and full particulars may be had on application to Mr. A. H. Shaw, M.I.E.E., Electricity Department, Ley-street, Ilford, Essex.

Sealed Tenders, endorsed "Tender for ............," as the case may be, addressed to the Chairman of the Council, must be delivered to the undersigned on or before MONDAY, the 26th day of February, 1906.

The Council does not bind itself to accept the lowest or any Tender.

JOHN W. BENTON, Clerk to the Council.
Town Hall, Ilford, Essex, 13th February, 1906.

**TENDERS INVITED continued on next page.**

**GAMBRELL BROS.**
Durham House, North Side,
Clapham Common, London, S.W.

MANUFACTURERS of
**ELECTRICAL TESTING INSTRUMENTS.**
CATALOGUE ON APPLICATION.

# EVERSHED & VIGNOLES, LIMITED.

Our New List of AMMETERS and VOLTMETERS will be forwarded post free on application.

*Makers of all kinds of ELECTRICAL INSTRUMENTS,*

**Acton Lane Works, CHISWICK, LONDON, W.**

◆ ◆ ◆

## TENDERS INVITED—*continued.*

### COUNTY BOROUGH OF SUNDERLAND.

TRAMWAYS DEPARTMENT.

**TO ELECTRIC CAR BUILDERS.**

The Corporation of Sunderland are prepared to receive TENDERS for the Supply of SIX VESTIBULE CARS, DOUBLE DECK TOP COVER TYPE WITH APPROVED RADIAL TRUCKS.

The Specification and Form of Tender can be obtained on application to the Borough Electrical Engineer, Mr. J. F. C. Snell, M.Inst.C.E. at his office, Town Hall, Sunderland, and on payment of a deposit of One Guinea (£1. 1s.), which will be returned on receipt of a bona fide Tender.

Sealed Tenders, addressed to the Chairman of the Tramways Committee, Town Hall, Sunderland, must be delivered at my Office not later than 12 o'clock noon on THURSDAY, the first day of March, 1906. Tenders to be endorsed "Tender for Tramcars."

The Corporation do not bind themselves to accept the lowest or any Tender.

FRAS. M. BOWEY, Town Clerk.

Town Hall, Sunderland, 12th February, 1906.

## FACTORIES & WAREHOUSES TO LET & WANTED.

TO ENGINEERS AND OTHERS.

OFFER is made of a SITE, free of cost, of from two to 10 Acres, to engineers or manufacturers contemplating erection of works. Site is FREEHOLD, and alongside main line of two of largest railways.—Address, for further particulars, OWEN B. THOMAS, Solicitor, 59, Chancery-lane, London.

GOSWELL ROAD.—FACTORY and STABLING, near the Angel. Large two-floor building, with chimney shaft, hitherto used for stabling on first floor, and vehicles beneath, but suitable for any manufacturing purposes.—Detailed particulars of P. BARNETT, 56, Moorgate-street, London, E.C.

TO MOTOR-CAR MANUFACTURERS, Carriage Builders, Electrical Engineers, &c.—Important MANUFACTURING PREMISES to be LET, on lease, situated within a few yards of the London, Brighton and South Coast, and Chatham and South-Eastern Railways, main line stations, at Victoria. Comprising most substantially erected three-storey warehouses, especially designed to carry heavy machinery, spacious storage rooms, forge, range of offices, &c. The whole covering a ground area of some 12,500 super. ft., and having two frontages to the main road.—For further particulars apply to Messrs. WM. GROGAN & BOYD, 125, Piccadilly, London, W.

WAREHOUSE or FACTORY.—To be LET, modern building, close Holborn-circus. Floor space about 4,000 ft. 15 H.P. engine installed. Good light. Low rent.—Apply FREEMANS, Estate Agents, 52, Bedford-row, London, W.C.

FREEHOLD FACTORY to be LET or SOLD. Substantial modern building. 51 ft. frontage, main Harrow-road. Good light, back and front.—For particulars apply to HOLLAND & HOLLAND, LIMITED, Gunmakers, 98, New Bond-street, London, W.

## CHEAP PREPAID ADVERTISEMENTS.

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Ten Words to the Line.

Where answers to any of the above Advertisements are to be sent to the Publishing Offices to be forwarded, the sum of 3d. must be sent with the order to pay for postage of these replies. Six Words must be allowed for the address of the Publishing Offices.

# C. PASS & SON, LTD.,

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***ANTIMONIAL LEAD OF ALL GRADES.***

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PHOTOMETERS
FUEL TESTERS
INSULATORS.
Send for Catalogues.

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REPRESENTATIVE WANTED, as PARTNER or MANAGER, for motor-car and electrical business in London. Must have good London connection, able to influence business. Principals only, not under 35, need apply, and by letter only.—ELECTRICAL, care of Biddles, Solicitors, 22, Aldermanbury, London.

CIVIL SERVICE COMMISSION.—FORTHCOMING EXAMINATION.

ASSISTANT EXAMINERS in the PATENT OFFICE (20-25) 5th APRIL.

The date specified is the latest at which applications can be received. They must be made on forms to be obtained, with particulars, from the SECRETARY, Civil Service Commission, Burlington Gardens, London, W.

# "The Electric Accumulator."

No. 1, Vol. I. Jan. '06.

**The ONLY Storage Battery Paper.**

*Particulars:*—8, St. Ann's Road,

Telegrams: ELECTROLYT. WANDSWORTH, LONDON, S.W.

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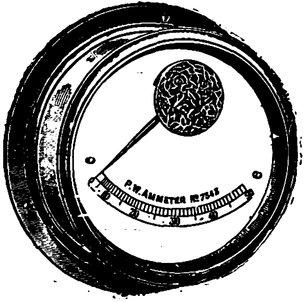
**Makers of**

**AMMETERS, VOLTMETERS; RECORDERS, &c.**



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**MOVING-COIL TYPE.**

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Telephone: No. 11273 CENTRAL.

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**J. W. BARNARD,**

Offices: 4, GREAT WINCHESTER ST., E.C.
Warehouse: 6, Great Winchester St.
*(For Recharging and Repairs).*

SOLE AGENT FOR **E.P.S. SMALL STORAGE BATTERIES** FOR Sale or Hire.

MANUFACTURED BY THE **ELECTRICAL POWER STORAGE CO., Ld.**

Battery Makers by appointment to His Majesty the King.

# PAUL

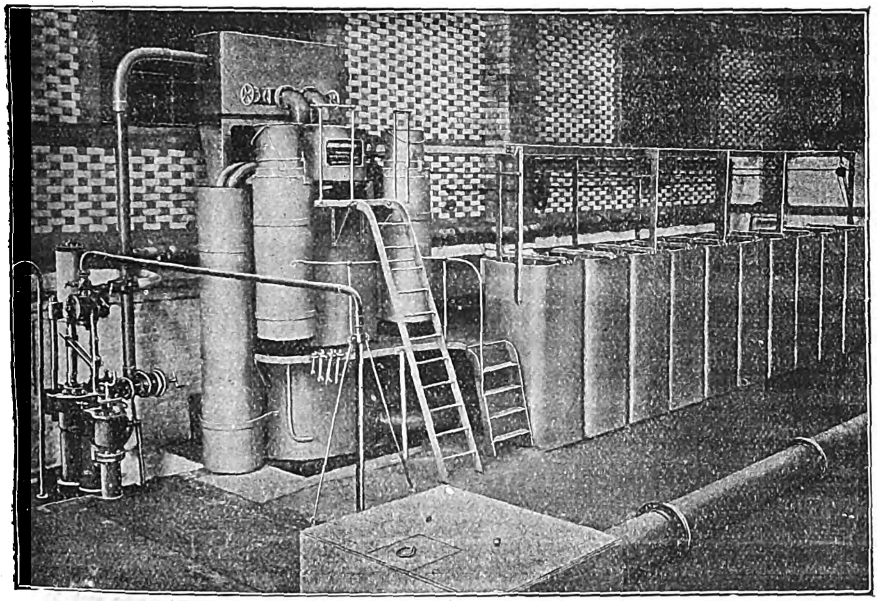
Manufacturer of **ELECTRICAL AND PHYSICAL INSTRUMENTS.**

Newton Avenue Works, New Southgate, LONDON, N.

CATALOGUES FREE.

# NO MORE COLLAPSED FURNACES OR BUCKLED TUBES

## THROUGH GREASE
## IF YOU PURIFY THE CONDENSED WATER
## WITH THE "HARRIS-ANDERSON" PURIFIER.



"Harris-Anderson" Purifier, Pinkston Power Station, Glasgow Corporation Tramways.
Capacity, 22,000 gallons per hour.

Grease Absolutely Removed.
No Objectionable Matter introduced.
Automatic and Simple Action.
Minimum Waste of Water.
Numerous Plants now at work in Electric Light and Power Stations, &c.

*WRITE for FULL PARTICULARS to the—*

**HARRIS PATENT FEED WATER FILTER, LTD.,**
82, Victoria St., Westminster, LONDON, S.W.
Telegrams: WINDTIGHT LONDON.
Nat. Tel.: 876 WESTMINSTER.
**26, St. Thomas Street, SUNDERLAND.**
Telegrams: WINDTIGHT SUNDERLAND. Telephone 569
**2, Hamilton Street, GREENOCK.**
Telegrams: WINDTIGHT GREENOCK. Telephone 127.

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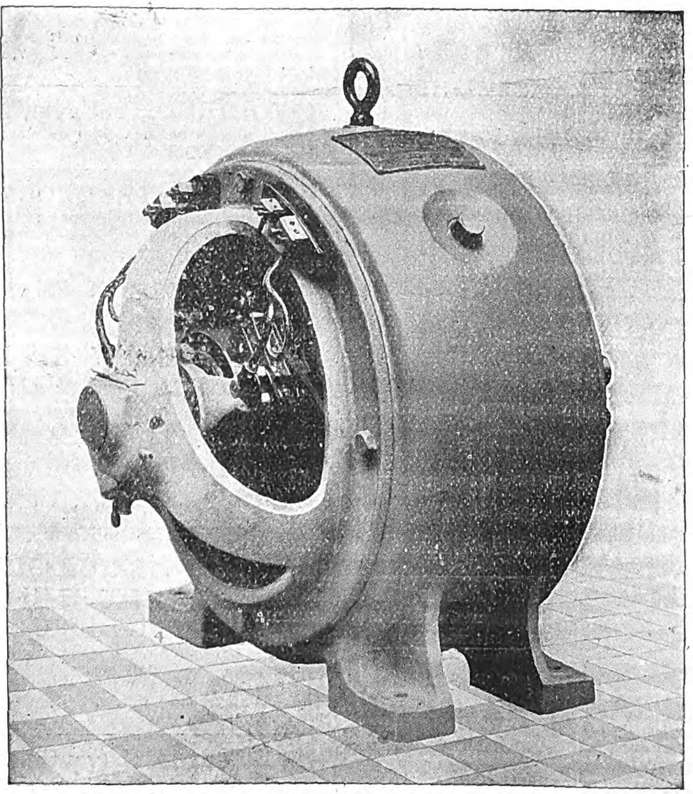
MAKERS OF
**GENERATORS and MOTORS**
FOR
**CONTINUOUS and ALTERNATING CURRENTS.**

**COMPLETE EQUIPMENTS**
FOR
**ELECTRIC DRIVING**
OF
**FACTORIES.**



STANDARD SEMI-ENCLOSED MOTOR.

**VICKERS' VARIABLE SPEED MOTORS.**

**SPEED RANGE, UP TO 6 : 1.**

**BY SHUNT REGULATION ONLY**

**FULL POWER at ALL SPEEDS.**

# FESSENDEN Wireless Telegraph System

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**HANOVER BANK BUILDING.**

PITTSBURG, PA.
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**EIGHTH and WATER STREETS.**

## APPOINTMENT VACANT.

### TRAMWAYS AND LIGHTING.

ELECTRICAL ENGINEER REQUIRED to take charge of a Tramway and Lighting Undertaking in the North. Must have had a thorough practical experience in Central Station Work and Tramway Management, and be able to control a large staff of men.

Salary to commence £300 per annum.

Applications, with copies of not more than three recent testimonials, to be sent to "TRAMWAYS," C. W. A., *Electrician* Office, Salisbury-court, Fleet-street, London.

ARMSTRONG COLLEGE, NEWCASTLE-UPON-TYNE.

The Council will shortly proceed to the appointment of a **PROFESSOR OF ELECTRICAL ENGINEERING.** Stipend, £500 per annum and one-third of fees until £750 in all is reached. Candidates must send in four copies of their application and testimonials, not later than MARCH 1st, to the undersigned, from whom further particulars may be obtained.

F. H. PRUEN, Secretary.

CITY AND GUILDS OF LONDON INSTITUTE.

CENTRAL TECHNICAL COLLEGE.

WANTED, **TWO ADDITIONAL ASSISTANTS** in the Electrical Engineering Department. Salaries £300 and £150 per annum respectively. The former must have intimate knowledge of the latest practice in Extra High Tension Transmission, and the latter experience in design and manufacture of polyphase plant, while both must have experience in teaching.

Apply by letter in the first instance to Prof. W. E. AYRTON, F.R.S, City and Guilds Central Technical College, Exhibition-road, London, S.W.

## PROTECTION OF ENGLISH TRADE IN ELECTRICAL FITTINGS.

All goods made by Members of this Association are marked with this Trade Mark, WHICH IS A GUARANTEE OF ENGLISH MANUFACTURE.

**CHINA FURNITURE AND ELECTRICAL FITTINGS MANUFACTURERS' ASSOCIATION.**

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GASKELL & GROCOTT, Whitehall Works, Longport, Stoke-on-Trent.
WM. KENT, Novelty Works, Wellington Street, Burslem.
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J. WHITEHOUSE & SON, Birchall Street, Birmingham.
WILLIAM WOOD & CO., Albert Street Works, Burslem.

## INSTRUMENTS AND PLANT TESTED.

# THE ELECTRICAL STANDARDIZING, TESTING AND TRAINING INSTITUTION.

(Proprietors: The Syndicate of Electrical Engineers, Ltd.)

**(Established 1889.)**

**FARADAY HOUSE, 66-70, Southampton Row, London, W.C**

**Telephone No. 9999 Central. Telegraphic Address: "Standardising London."**

Standardizes and Tests Electrical Instruments.
Inspects and Certifies every kind of Electrical Plant and Materials.
Investigates and reports upon Electrical Inventions.
Inspects installations of Electric Wires and Plant on behalf of Architects, Householders, Manufacturers, Supply Companies, Fire Offices, &c.
Lets Private Experimenting Rooms, and offers every facility, with skilled assistance when desired, to Experimenters in Electrical Science.

A Scale of Fees will be sent on application to the SECRETARY.

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*Queen Anne's Chambers,*
*The Broadway, Westminster, London, S.W.*

**Patent Agent.**

~~FERBECK CHIMNEY CONSTRUCTION CO.—CHIMNEY SHAFTS, in any part of the World (Economical Patent System), CHIMNEY TANKS, LIGHT TOWERS, WATER TOWERS (Intze System), ELECTRIC and all other FURNACES, SOOT KILNS, ARC and DYNAMO CARBON PLANTS, &c.—FINSBURY PAVEMENT HOUSE, LONDON, E.C.~~

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**Ten Words to the Line.**

**SITUATIONS WANTED.**

***Sixpence per Line of Ten Words, minimum One Shilling.***

**Where answers to any of the above Advertisements are to be sent to the Publishing Offices to be forwarded, the sum of 3d. must be sent with the order to pay for postage of these replies. Six Words must be allowed for the address of the Publishing Offices.**

## SITUATIONS, &c., VACANT.

WANTED, a thoroughly experienced ELECTRICAL ENGINEER to take charge of the Electrical Department in a large contractor's establishment. Must be thoroughly conversant with motor and dynamo repairs, and power installations generally. Must also have a sound knowledge of estimating. Apply, giving age, experience, and salary required to 6029, ***Electrician*** Offices, Salisbury-court, Fleet-street, London.

SHIFT ENGINEER REQUIRED at once to take charge of shift at a large generating station in the North of England. Experience in turbines and extra high-tension three-phase work essential.—State salary and full particulars, in confidence, to SECRETARY, Durham Collieries Electric Power Co., Limited, 13, St. Helen's-place, E.C.

REQUIRED, for Egypt, good FITTER with knowledge of high-speed engines. Two years' agreement: wages £15 per month, and quarters provided.—Address, stating experience. &c., to W., care of Streets, 30, Cornhill, London, E.C.

WANTED, TEST-ROOM ASSISTANT, with practical experience in finishing testing instruments, adjusting and calibrating. State age, experience and salary required.—ROBT. W. PAUL, Newton-avenue Works, New Southgate, London, N.

DRAUGHTSMAN WANTED, with good mechanical training and knowledge of electricity, for instrument and transformer design—Apply, stating full particulars, age, &c., to C. T. S., ***Electrician*** Offices, Salisbury-court, Fleet-street, London.

DRAUGHTSMAN WANTED, accustomed to high and low tension switchgear work.—Apply, stating full experience, age and salary required, to FERRANTI LIMITED, Hollinwood, Lancs.

MECHANICAL DRAUGHTSMAN, used to general work. State age, experience and salary required.—Apply, L. A. A., *Electrician* Offices, Salisbury-court, Fleet-street, London.

## SITUATIONS WANTED.

ELECTRICAL DESIGNER.—Any first-class firm desiring the services of a really front rank designer of A.C. and D.C. machinery (with high specific utilisation of materials, a University graduate., with 13 years' successful experience in large British and Continental works, with an established reputation, should write to C. T. T., ***Electrician*** Offices, Salisbury-court, Fleet-street, London. Cheap firms please refrain from answering.

ELECTRICIAN (youth 17) seeks SITUATION as mate. Two years' experience.—Apply, W. T. R., 26, Horsell-road, Highbury, London, N.

THE ELECTRICIAN:
THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF
ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.
ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.
No. 1,448. [No. 18. Vol. LVI.] FRIDAY, FEBRUARY 16, 1906. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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# NOTES.

THE first of the group of new tube railways associated with the name of the late Mr. C. T. YERKES, which are expected in some quarters to do much for the amelioration of the conditions of London traffic, will be open to the public in about three weeks' time. Our article describing this line—the Baker Street & Waterloo Railway—commences in this issue. The feature which Mr. J. R. CHAPMAN, the engineer-in-chief to the line and general manager of the Underground Electric Railways Co. of London, has kept most prominent is the universal use of uninflammable material, making the line practically fireproof from end to end. This should go far to allay the fears of that section of the public who are nervous regarding tunnel fires. The engineers had the great advantage when designing the equipment of being able to make a close study of the experience with the existing tube lines, and great care has been devoted to the solution of the two problems which have given so much trouble in early undertakings—viz., the avoidance of vibration and the provision of sufficient ventilation.

THE methods by which it is hoped that these ends will be accomplished are described in our article, and we can say that it was certainly our impression on visiting the line, when the working was being rehearsed with a rapid service of full length trains, that the running on the semi-springy track was quieter and the pounding at the rail joints less noticeable than with the rigid permanent way adopted in some other cases. The arrangement of continuous ventilation, whereby a gentle downward current of fresh air is constantly flowing down the lift and staircase shafts, also avoids the unpleasant "earthy" odour noticeable inside the old "twopenny tube" and even outside its stations. How far, however, the precautions taken will be complete and permanent in the fulfilment of their objects will only be seen after a period of actual working. One cannot help being struck with the attention that has been paid to the most minute details of construction and equipment. Even the colour scheme in the interior decoration of the stations has a meaning; the design is worked out in a different colour at every station to render each one easily distinguishable to habitués of the line. Some other novelties tending to comfort of passengers and speed of service are introduced in the arrangements of the lifts, to which we shall refer in our next article. The automatic signalling system is the same as that now used on the District Railway, and it is interesting to note that during one of the early weeks of the working of this system on the western portion of that line, when everything was new, the signal never failed to fall to danger when it should, and only in one case out of every 13,666 signal movements did it refuse to indicate "line clear" at the right moment. Later observations show still better results than this.

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THE second night's discussion on Mr. CARTER'S Paper bore out by its liveliness and spirit the promise of the first, and whilst single-phasers were in a majority, at least of speakers, it must be admitted that Mr. HOBART'S and especially Mr. CARTER'S speeches on the other side left honours easy. We suggest that the result of the discussion on an impartial reader will be the conviction that, for the class of work dealt with by Mr. CARTER as an example, the continuous-current equipment has some decided advantages, and can, in fact, operate severe urban and suburban services calling for the highest acceleration and high overall speeds on short runs which are out of reach of the single-phase equipments at present available. Mr. CARTER'S point as to relative rating goes to the heart of the matter. Nevertheless, it by no means follows that when the equipment of a whole railway system, including main line, suburban and urban services, is studied, that it will be found desirable to instal more than one type of line and train equipment. The important question of capital expenditure on generating and distributing equipments, and its effect upon the total cost of the power delivered to the train was not much dealt with. This, we venture to think, may prove the determining factor in favour of single-phase equipment in many future cases. The author and the Institution are to be congratulated upon a thoroughly live Paper and an earnest and enlightening discussion, recalling the time when another battle between alternating and continuous-current systems provoked similar animation in Great George-street.

An instance of one of the many cases where the application of an electrical method has been a cause contributing to the progress in an industry is found in the now practically universal adoption of electric ignition for petrol engines employed in automobiles. An abstract of a Paper by Mr. F. Little recently read on this subject will be found in another part of this issue. Anything like a complete review of the subject was not attempted, but there are one or two points to which we should like to have seen more attention given. The question of accurate synchronising of the firing of the several cylinders of a multi-cylinder engine, for example, now usually effected by a single coil with high-tension distribution in place of separate coils, received no mention, and only a brief allusion was made to the various forms of magnetos which are apparently ousting the battery from the field. Indeed one would almost think from reading the Paper that only single cylinder cars with battery ignition existed. The whole subject is one to which too little attention has been paid by the skilled electrician; designs have developed by the elimination of the unsatisfactory rather than the building up of a scientifically sound method. There is a great lack of quantitative experiment in this direction. The author of the Paper was, for instance, quite unable to give one of the speakers in the discussion any idea of the output of one of these magnetos in volts and amperes. We admit that there would have been some difficulty in answering this question, owing to the peculiar form of the current waves generated, but a series of records of a similar nature to those obtained by the oscillograph would be of great interest in showing the variation of the current wave-form at different speeds and different positions of the timing gear. More could have been said with advantage on the functions of the condenser in determining the character of the spark, and we were sorry to see no reference to Sir Oliver Lodge's very promising system. Electric ignition, complicated as it may seem to the non-technical motorist, has done more than is generally realised to improve the conditions of running of the motor-car engine. It was only by its adoption that governing and controlling on the throttle became possible. In the old days of hot tubes, reliable as they were in careful hands, it was necessary to run the engine always with its full charge, as it would not fire properly on a weak compression, so that the jerky method of "cut-out" governing was the only arrangement available. The improvements in carburettors which have led to the flexible and almost silent engine of to-day were only rendered possible by the perfection of electrical ignition methods.

Mr. George Wilkinson's Paper, read at Leeds yesterday, raises a question of considerable interest to the supply station engineer. After giving some glaring instances of the use of wasteful lamps, he suggests "remedies." His first suggestion, that the law of the land should be so altered as to authorise the electricity undertaker to refuse to supply a consumer using wasteful lamps, may be set aside at once as impracticable. Leaving this suggestion for grandmotherly protection, we come to the second one, which may be characterised as merely paternal. At Harrogate, Mr. Wilkinson has issued a lamp specification of not too exacting a nature, and he undertakes to test lamps for contractors at a halfpenny apiece to see that the lamps come up to their nominal wattage and candle-power. Lamps which pass this test are stamped with a distinctive mark, and consumers are advised to use only lamps so "certified." An obvious criticism of this system is that the lamp-maker will soon find that he can avoid the rejection of lamps by supplying lamps of high initial efficiency and short effective life. Life tests are obviously out of the question under these conditions.

There is, however, a more serious objection to Mr. Wilkinson's proposal—namely, that it will probably prove on investigation that the testing of lamps by a municipal electricity undertaker in this manner is not authorised under the Electric Lighting Acts. The testing of lamps cannot be deemed necessary and incidental to the supply of electricity—these are the words used in Clause 10 of the Act of 1882—especially when in Clause 18 of the same Act it is laid down that the undertakers are not entitled to prescribe any special form of burner. To emphasise this point still more, we may point out that there is nothing under Mr. Wilkinson's scheme to prevent the Harrogate contractor from selling his certified lamps in Leeds, in which case the money spent on the test by the Harrogate Corporation would not be applied for the benefit of the electric lighting of Harrogate. Unless the undertaker had powers for these lamp-testing operations under a Special Act it would be quite within the province of a conscientious auditor to surcharge the cost of the necessary instruments and the expenses of working the department.

In connection with this scheme of Mr. Wilkinson's it is interesting to recall the fact that a company was established in London in 1899 with the object of testing lamps for consumers or contractors in a somewhat similar way. The idea was further-reaching, however, as the company were practically "expert buyers," buying the best lamps from the makers, subject to certain tests being satisfied, and retailing them to the users or their contractors, and life tests of samples were made, tests for good vacuum, &c. But the "Tested Lamp Co." had a short life; perhaps the consumer thought that its services were not commensurate with the necessarily enhanced price of the lamps, or, perhaps, means were not taken to advertise sufficiently the utility of the tests.

Mr. L. W. Wild, in his practical article on "The Design of Series Transformers for Wattmeters" on p. 705 of this issue, first draws attention to the unexpectedly large errors which may occur in the wattmeter readings if the conductor used for the series coil is not sufficiently sub-divided to prevent serious eddy-current loss. Above a certain size, the use of a stranded conductor becomes impracticable for mechanical reasons, however, and then the current transformer steps in. In an ideal auxiliary transformer of this kind, the chief desideratum is that the ratio of the primary to the secondary current should remain constant over a wide range of working and that the phase of the current in the secondary coil is as nearly as possible half a period behind the primary current. The conditions to fulfil these requirements are lucidly set forth by Mr. Wild, and we have nothing to add except that his article might have been rendered more useful still if he had included the observed net errors not only at the maximum reading of the wattmeter, but also those at some other points of the scale. At the end of his article, the author states incidentally that for a $B_{max.}$ of from 200 and 400 lines per square centimeter, the core loss, expressed in watts, increases in the 2·7th power of $B_{max.}$ According to Steinmetz's well-known rule, the hysteresis loss increases approximately as the 1·6th power, while the eddy-current loss increases as the square, so that the total iron loss increases at a rate which lies between $B^{1\cdot6}_{max.}$ and $B^{2}_{max.}$ These figures, which are widely accepted, relate to high densities, such as are used in everyday dynamo and transformer design, but nevertheless we should like to see further confirmation of Mr. Wild's 2·7 before accepting it unreservedly for an average grade of iron.

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At a meeting of the City Corporation yesterday (Thursday) a report was received from the Streets and Special Joint Committee relative to the electric power bills dealing with London which have been deposited in Parliament this session. The report recommended that the whole of the bills be opposed, and that the Government be asked to appoint a Royal Commission to inquire into and report on the whole question of the supply of electricity in bulk. This report was adopted without discussion, and the Streets and Special Joint Committee were asked to give effect to the suggestion. We have already stated our opinion that, although two or three years ago the appointment of a Royal Commission to consider the matter might have been advisable, the adoption of this course at the present moment will unnecessarily retard the progress of electric power supply in London, and we trust that the Government will not act upon the suggestion of the Corporation.

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**Electric Power Distribution in North Wales.**—The scale of Fig. 23, on page 661 of our last issue, should be 2 in. = 1 ft. instead of 1 in. = 1 ft.

**Second Röntgen Congress.**—According to *Nature* the second congress of the German Röntgen Society will be held at Berlin on April 1st and 2nd, under the presidency of Prof. Eberlein.

**Institution of Electrical Engineers.**—Mr. C. W. Hill's Paper on "Crane Motors and Controllers," the first part of which was published in our last issue, was not read at the last meeting of the Institution owing to lack of time, but it was announced that it would be taken first at next Thursday's meeting.

**Elektrotechnischer Verein, Berlin.**—At the meeting of this electrical society on January 23rd, Dr. Weber, the secretary, made a report on the progress and position of the Verein during 1905. During last year, it appears, 183 new members joined the Verein, 299 members resigned, while 13 members were lost by death. At the present time there are altogether 2,612 members—*i.e.*, 129 less than a year ago; 1,563 members live in Germany and 1,049 abroad. It is interesting to note that no less than 854 members—*i.e.*, more than half the German aggregate, live in Berlin.

**Glasgow Students' Section of the Institution of Electrical Engineers.**—It has been decided to form a students' section in connection with the Glasgow Local Section of the Institution of Electrical Engineers. So far Manchester is the only district in which there is a students' section affiliated to the Local Section of the Institution of Electrical Engineers, but of course the main students' section in London has been in existence for several years.

**Cable Interruptions and Repairs.**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Tarifa—Tangier | Jan. 18, 1904 | — |
| Jamaica—Colon | Jan. 10, 1905 | — |
| Cadiz—Teneriffe | July 20, 1905 | — |
| Puerto Plata—Martinique | Dec. 15, 1905 | — |
| Bolama—Bissao | Jan. 19, 1906 | — |
| Vladivostock—Nagasaki | Feb. 7, 1906 | — |
| Cap St. Jacques—Haiphong | Feb. 14, 1906 | — |
| Jamaica—Porto Rico | — | Feb. 9, 1906 |

**Large Motors for Reversing Mills.**—It is stated in the *Elektrotechnischer Anzeiger* that the Allgemeine Elektricitäts-Gesellschaft of Berlin is at present engaged in equipping the rolling mills of the Hildengardenhütte, in Teschen, with electric motors of a maximum output of 10,000 H.P., and some rolling mills belonging to the Staatseisenbahn-Gesellschaft at Budapest with 12,000 H.P. motors. The same firm is also providing the electric drive for the reversing mills of the Rombacher iron works. These reversing rolling mills are to be directly-driven by two 6,500 H.P. motors, and during the first part of the rolling operations the motors have to reverse six or seven times in a minute.

**Tests on an Electrically-Driven Compressor.**—Our Austrian contemporary *Elektrotechnik & Maschinenbau* describes some tests on an air compressor directly driven by a three-phase motor at 116 revs. per min. The L.P. cylinder is 505 mm. (19·9 in.) in diameter, the H.P. cylinder is 310 mm. (12·2 in.) in diameter, while the common stroke is 520 mm. (20·5 in.). In the tests 1,286 cubic metres (45,500 cubic ft.) of air at atmospheric pressure were compressed to 88 lb. per square inch absolute per hour, the energy consumption being 0·086 kw. hours per cubic metre (0·00244 kw. hours per cubic ft.) of air dealt with. It is stated that the volumetric efficiency was 91·74 per cent., and the losses through leakage, heating and clearance space only 1·74 per cent.

**New Swiss Single-Phase Railway.**—According to *Elektrotechnik & Maschinenbau*, the Oerlikon works have received the order for equipping the Valle-Maggia railway from Locarno to Bignasco on the single-phase system. The line is 27½ km. (17 miles) long, with a maximum gradient of 3·3 per cent., and the gauge is 1 m. (3 ft. 3⅓ in.). A trolley voltage of 5,000 volts is to be employed. The rolling stock is to consist of bogie motor-cars, each of the four axles of which is to be driven by a 40 H.P. single-phase motor, and a number of passenger and goods trailers. It is intended to obtain the necessary power for working the railway from a waterfall, approximately at the centre of the line, and two 350 kw. sets are to be installed in the first instance.

**French High-speed Electric Parcel Post.**—According to *L'Electricien*, a French company, called "Société des Chemins de Fer Electro-Postaux," has recently carried out successful trials on a circular and experimental high-speed electric parcel railway on a route 1 km. (0·62 miles) in diameter. The experimental parcel trolley appears to have been 25 ft. long with pointed ends, and its cross-section 1 metre (3 ft. 3⅓ in.) square. This car was suspended from the track rail by two running wheels and guided by two pairs of side rollers. Each running wheel is belt-driven from a three-phase motor, 31½ in. in diameter. The current was collected by means of three collectors of the bow type. It is proposed to build such parcel posts between large cities, with two tracks (one for either direction of traffic), built one above the other in an underground tunnel of elliptical shape. It is not stated what speed was attained in the trials, but the promoters seem confident that a speed of 155 miles per hour can be safely maintained in practice with parcel trolleys carrying a useful load of 10 cwt.

**Electric Production of Carbon Tetrachloride.**—The *Elektrochemische Zeitschrift* for January gives a short description with photograph of a plant now being worked on a commercial scale for the electric production of carbon tetrachloride. An electric arc is struck in a mixture of broken coke, sodium chloride and quartz sand. The charge must be free from water, and care must be taken to exclude atmospheric oxygen. Chlorine is given off from the sodium chloride in the presence of the silica, and sodium silicate and free silicon is formed from the sodium of the sodium chloride. The chlorine then acts upon the carbon to produce carbon tetrachloride. The carbon tetrachloride so produced is then condensed by means of condensers connected with the plant. By altering the conditions silicon tetrachloride can be produced, and by acting with this upon calcium phosphate phosphorus pentachloride is formed and from this phosphoric acid. The plant at present employed has a capacity of 450 kw.

**The Horseless Carriage.**—A most entertaining lecture on the history and development of mechanically-propelled carriages during the last 20 years, illustrated by numerous excellent lantern slides, was delivered by Mr. Claude Johnson before the Society of Arts last Wednesday evening, Col. H. C. L. Holden, R.A., F.R.S., in the chair. By far the greatest part of the lecture was devoted to petrol cars, but the author also included a brief reference to electrically-propelled carriages, calling attention to the system by which the electric carriages were garaged and maintained by the makers for the owners. This system, he said, was first introduced on a large scale by Mr. Paris Singer in 1901, and had since been carried out on a more perfect system under Mr. Theodore Chambers by the Electromobile Co. The cars of the latter company were particularly attractive, and were considered by many to be the ideal motor car in consequence of their ghost-like silence and the mystery of their swift movement through the London streets.

**Electric Tramways in St. Petersburg.**—It is stated in *Elektrische Bahnen & Betriebe* that tenders for the electrification of the first portion (about 30 miles) of the St. Petersburg tramways are now under consideration by the city authorities. Current is to be supplied from a new tramway power station, which is to be equipped in the first instance with three 2,200 kw. 6,600 volts 25 ∼ three-phase turbo-generator sets, the steam-raising plant consisting of 12 water-tube boilers (3,240 sq. ft. heating surface) with superheaters. There are to be five sub-stations, ranging in capacity from 1,000 to 2,250 kw. for converting the H.T. three-phase current to continous current. The cable network (the laying of which has been let to the Westinghouse Co. for 1,180,000 roubles, or £125,000) will comprise about 37 miles of three-phase cable of a section of 0·0775 sq. in. and 0·108 sq. in. per conductor, and about 52 miles of cable for connecting the sub-stations to the trolley wire and the rails respectively. The track is to be built of "Phœnix" rails, weighing 95 lb. to the yard. The trolley wire is to be grooved and of two sizes—viz., 0·0775 sq. in. and 0·124 sq. in.

**Physical Society.**—At the annual general meeting which took place at the Royal College of Science on Friday last, Prof. Perry was elected president on the retirement, after one year of office, of Prof. Poynting. The Council and the other officers remain much the same, excepting that Prof. Cassie, of Holloway College, has been elected secretary in succession to Dr. Watson, who has held this office for many years. After the elections Prof. Perry, protesting vehemently against the custom of requiring presidential addresses, gave an address which dealt with the value of physics to engineers and with the proper methods of teaching this and other subjects to engineers. Prof. Perry's views on these matters are very well known of course. He would have it that a professor of science should be allowed to teach his students in his own way, and would have the examinations conducted and diplomas granted by each professor just as he liked. In connection with this last matter the audience greatly enjoyed Prof. Perry's onslaughts on universities and all other constituted authorities whatsoever.

**Ventilation of the Simplon Tunnel.**—During the construction of the Simplon tunnel, the ventilation was carried out by forcing air into a side tunnel and letting it return through the main tunnel. Since the tunnel has been completed, the ventilating arrangements have been altered. Air is now forced into the main tunnel at Brieg (on the north side) and sucked out at Iselle (on the south side). In order to diminish leakage, both entrances are closed by a huge shield (consisting of an iron frame and strong sail-cloth) which can be raised vertically—to let a train pass—by means of an electrically-driven hoisting gear set in operation by the pressing of a button. The shield runs on rollers, and the time occupied in raising it is stated to be 30 seconds. No serious consequences would result if a train should by mischance run through a shield. At present the tunnel walls and roof are undergoing examination, and a few "illumination" cars, comprising a dynamo, belt-driven from a petrol motor, and two powerful arc lamps with reflectors, have been built for this purpose.

**Magnetic Survey of America.**—The Department of Commerce and Labour of the United States has issued a publication containing the results of the magnetic observations made on land and sea by members of the Coast and Geodetic Survey in the prosecution of the magnetic survey of the United States and outlying territories during the period July 1, 1904, to June 30, 1905. There are also included the results of some observations by magnetic observers of the Department of Terrestrial Magnetism of the Carnegie Institution. The report is drawn up by Mr. L. A. Bauer. It appears that five magnetic observatories have been in continuous operation throughout the year: at Cheltenham, Md.; Baldwin, Kans.; Sitka, Alaska; near Honlulu Hawaii, and on Vieques Island, Porto Rico. Observations were also made in a great number of places throughout the United States. The report goes on to say that sufficient and precise magnetic data have now been obtained for determining both the distribution of the magnetic elements and their secular change in every State and Territory of the United States at a sufficient number of stations to warrant the publication of a new set of magnetic charts for the year 1905. This work is now in progress, and the present publication (of nearly 200 pages) contains some results of a preliminary discussion of the declination data, a full report to appear later.

**The Berlin Electricity Works.**—According to the report of the Berlin electricity works for the period from July 1, 1904, to June 30, 1905, the net profits of the company during this time amounted to 4,765,748 m. (£238,287), and a dividend of 10 per cent. was paid, compared with 9½ per cent. in the preceding financial year. Some 81,100 incandescent lamps of all kinds, 3,831 arc lamps, 1,937 motors (6,133 H.P.) and 367 miscellaneous electrical apparatus were connected to the supply during the year, and the total connections on June 30, 1905, amounted to 78,436 kw., being made up of 583,375 incandescent lamps, 24,232 arc lamps, 12,549 motors (39,921 H.P.) and 2,057 miscellaneous apparatus. The number of consumers increased from 10,785 to 12,939 (20 per cent.) and the maximum demand for traction was 15,540 kw. These figures relate to Berlin only, but much progress has also been made in the suburbs, and the total connections of Berlin and suburbs together amount to nearly 100,000 kw. For public lighting there are 651 arc lamps and 160 incandescent lamps, 68 of the latter serving to illuminate public clocks. During the financial year in question, the total energy consumed in Berlin and suburbs amounted to 111,572,782 kw.-hours, being distributed as follows: For private lighting 20,139,869 kw.-hours; for public lighting (including railway stations) 2,318,525 kw.-hours; for industrial purposes 36,687,516 kw.-hours; for accumulator plants 3,798,969 kw.-hours; for tramway purposes 47,287,808 kw.-hours; and for the electricity works themselves 1,340,095 kw.-hours. The average price obtained per kilowatt-hour from all sources (including tramways) was 15·48 pf. (1·86d.) as compared with 15·89 pf. (1·9d.) during the previous financial year. Several stations have been enlarged by additional plant, and the company is now engaged in building a sub-station in the Alten Jakobstrasse which will be supplied with three-phase current at 10,000 volts from the power station at Oberspree. The following figures may be of interest: total length of lighting cables in Berlin 1,780 miles, *ditto* for traction 258 miles, *ditto* for telephones and pilot wires 116 miles, H.-T. cables 160 miles.

**An Electrically-driven Water Hoist.**—A recent number of the American *Engineering and Mining Journal* contains a description of a hoist for raising 4,000 gallons of water per minute to a height of 500 ft., driven by an alternating-current motor of 800 H.P. As the starting current of such a motor is very large, the motor is arranged to run continuously in one direction, friction clutches being provided for controlling and reversing the load. Two clutches are employed, which put into action one or other of a pair of bevel wheels for driving the drum in either direction. The actuating mechanism is so designed that only one clutch can be in engagement at a time. The maximum hoisting speed is 550 ft. per minute and the cylindro-conical drums are 16 ft. in diameter at the largest part. All the clutches and brakes are operated by auxiliary air cylinders fitted with oil cushions and supplied by a motor-driven air compressor. The hoist is controlled by a mechanical device consisting mainly of a drum rotated by means of a friction-drive from the motor through a sprocket chain. The drum shaft transmits its motion to a secondary shaft running at variable speed, which in turn operates a secondary stop. The main hoisting drum shaft operates a travelling nut, which is so situated with respect to the controller drum that at either end of its travel it releases a stop and allows the controller drum to make a quarter turn; this movement, through suitable electrical connections, operates the solenoids on the clutch valve, releasing the clutch and the solenoid on the brake valve applying the brake; the further movement of the controlling drum is arrested by the secondary stop. This stop is released by the variable-speed shaft and its connections, which have been given a predetermined time movement corresponding to the interval for emptying the bucket. The further movement of the controlling drum releases the brake and throws in the reversing clutch, thus starting the hoist in the opposite direction, and also starting the travelling nut on the controlling mechanism in the opposite direction. At the end of the hoist the cycle of controlling movements is repeated, making the hoisting operation continuous and automatic. The main brake is of the gravity type, and to be released the current must be on the solenoid operating the valve, so that air can be admitted to the underside of the brake piston. If for any reason either the supply of current or of air pressure is interrupted the valve drops, and the weights on the brake lever apply the brake. The clutches are designed so that they are thrown out by weights. As is the case with the brake, either clutch can be thrown in only when the current is on the solenoid and the air pressure admitted under the piston; if either current or pressure fails the clutch is off. A safety cut-out is provided for in the head frame, so that in case a bucket is carried beyond the proper height the current is cut off. The capacity of each bucket is 17 tons of water, and the contents are automatically discharged on reaching the top of the shaft. Each bucket makes the return trip in 1 min. 50 sec., the total lift being 555 ft.

**Extensions to the Berlin Overhead and Underground Railway.**—Two short extensions to the Berlin overhead and underground railway are being carried out at the present time, and we read in an article in the *Elektrotechnischer Anzeiger* that the authorities hope to inaugurate these new lines in June next. One of the new lines extends from the present terminus at Knie to the south of the West end (1·68 miles long), and comprises four new stations—viz., Krummestrasse, Sophie Charlotteplatz, Ringbahn and Platz B (West end). The second extension, only 0·93 miles long, commences at the Krummestrasse station and terminates at the Wilhelmsplatz. Both lines are in shallow tunnels; the depth of the top of the tunnel below the road surface varies from 2 ft. 4 in. to 3 ft. There are a few slight gradients. In places where the bottom of the tunnel is below ground water level, the foundation is of concrete (up to 3 ft. 3 in. in thickness) with a triple lining of tar-treated paper (Teerpappe), extending well above ground water level. The tunnel walls range in thickness up to 4 ft. and are of 7:1 concrete, and the top of the tunnel is formed of concrete arches between cross girders, the maximum thickness of the arches being 10 in. The cross girders themselves rest on longitudinal girders, which, again, are supported by columns built up of plate iron. A double lining of tar-treated paper is used at the top and sides of the concrete arches for keeping out rain water, &c., and this lining is protected from mechanical injury by a thin covering of concrete or brickwork. Where the bottom of the tunnel is above ground water level, the concrete foundation has been dispensed with. The whole of the tunnels were built up from an open cutting, the ground being mostly of hard clay. Any water in the tunnels is drained away through brick tunnels with concrete covers. Manholes, connecting the tunnel with the road above it, are provided every 220 yds. The track is double in the tunnels and in all the stations except the Krummestrasse station, where there are four tracks, and the Wilhelmsplatz station where there are three tracks. Near the Krummestrasse station the short branch line to Wilhelmsplatz has to cross the main track. This crossing takes place at different levels, so as to facilitate the train service, and has been accomplished by building the two tracks on a slight up and down gradient respectively. In some of the stations the artificial lighting is supplemented by daylight, suitable skylights being provided for this purpose. Since the extensions are too far away from the power station in the Trebbingerstrasse to be directly fed with continuous current, power is to be conveyed to a sub-station at the Krummestrasse station by means of three-phase currents at 10,000 volts and 40 ~ per second, being here transformed to continuous current at 780 volts by 650 kw. rotary converters. A traction battery of 900 ampere-hours capacity at the one hour's rating is also to be provided, as well as two small batteries for the lighting. There will be two reversible boosters of the "Pirani" type. The Siemens-Schuckert works are responsible for the electric equipment of the sub-stations.

## ARRANGEMENTS FOR THE WEEK.

(To-day) **FRIDAY, February 16th.**

Northampton Institute Engineering Society.

*5:45 p.m.* Meeting at the Northampton Institute. St. John-street, Clerkenwell, London. Paper to be read: "Secondary Batteries," by A. G. Savill.

North-East Coast Institution of Engineers and Shipbuilders.

*7:30 p.m.* Meeting at the Literary and Philosphical Society, Westgate-road, Newcastle-on-Tyne. Included in the business of the evening will be the adjourned discussion on the following Paper: "The Engineering Value of Lubricating Oils," by W. F. Parish.

Royal Institution.

*9 p.m.* Evening Discourse on "The Passage of Electricity through Liquids," by W. C. Dampier Whetham, F.R.S.

**SATURDAY, February 17th.**

Glasgow Technical College Scientific Society.

*7:30 p.m.* Meeting at the Glasgow and West of Scotland Technical College, George-street, Glasgow. Paper to be read: "The Inglis Patent Boiler," by G. Inglis.

**MONDAY, February 19th.**

Junior Institution of Engineers.

Visit to the Engineering Standards Laboratory of the Board of Trade, Richmond-terrace, Whitehall, S.W.

**WEDNESDAY, February 21st.**

Royal Meteorological Society.

*7:30 p.m.* Meeting in the Rooms of the Society, 70, Victoria-street, Westminster, S.W. Among the Papers to be read is the following: "The Dispersal or Prevention of Fogs," by W. B. Newton.

**THURSDAY, February 22nd.**

Institution of Electrical Engineers: Students' Section.

*2:30 p.m.* Visit to the Robertson Electric Lamp Works, Brook Green Hammersmith, W.

Institution of Electrical Engineers.

*8 p.m.* Ordinary General Meeting. Paper to be read: "Crane Motors and Controllers," by Claude W. Hill.

**FRIDAY, February 23rd.**

Central Technical College: Old Students' Association.

*7:15 p.m.* for *7:30 p.m.* Annual Dinner at the Trocadero Restaurant, Piccadilly-circus, W.

Electro-Harmonic Society,

*8 p.m.* Concert (Ladies' Night) at the King's Hall, Holborn Restaurant.

**SATURDAY, February 24th.**

Institution of Electrical Engineers: Manchester Students' Section.

*6:45 p.m.* for *7 p.m.* Annual Dinner at the Grand Hotel, Manchester

## THE BAKER STREET AND WATERLOO RAILWAY.

The first of the group of new tube railways associated with the Underground Electric Railways Co. of London is now almost complete, and the major portion of the Baker Street & Waterloo Railway will be opened for traffic early next month. It is unnecessary to recapitulate here the early history of the project and the causes which delayed its construction before the undertaking passed into the hands of the late Mr. C. T. Yerkes. Suffice it to say that since the arrangement between the Underground Electric Railways Company and the Baker Street & Waterloo Railway Co. was entered into, the work of construction and equipment has been pushed forward with great energy. A considerable portion of the tunnelling was completed before the undertaking changed hands, and the staging in the River Thames close to Hungerford Bridge, where the work was commenced, has long been a familiar object.

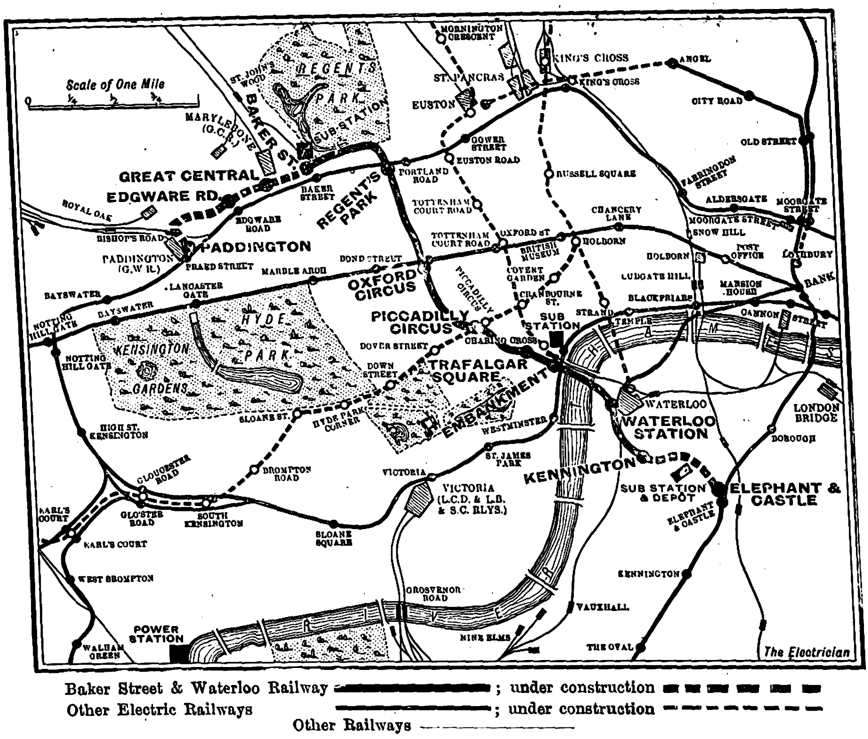
Scale of One Mile
0
¼
½
¾
REGENTS PARK
ST. JOHN'S WOOD
BAKER ST.
SUB STATION
MARYLEBONE (G.C.R.)
GREAT CENTRAL
EDGWARE RD.
ROYAL OAK
BAKER STREET
REGENT'S PARK
EDGWARE ROAD
BISHOP'S ROAD
PADDINGTON
PADDINGTON (G.W.R.)
PRAED STREET
MARBLE ARCH
BOND STREET
OXFORD CIRCUS
LANCASTER GATE
BAYSWATER
BAYSWATER
NOTTING HILL GATE
NOTTING HILL GATE
HYDE PARK
KENSINGTON GARDENS
PICCADILLY CIRCUS
DOVER STREET
DOWN STREET
TRAFALGAR SQUARE
SLOANE ST.
HYDE PARK CORNER
HIGH ST. KENSINGTON
GLOUCESTER ROAD
BROMPTON ROAD
EARL'S COURT
GLO'STER ROAD
SOUTH KENSINGTON
EARL'S COURT
WEST BROMPTON
SLOANE SQUARE
VICTORIA
VICTORIA (L.C.D. & L.B. & S.C. RLYS.)
GROSVENOR ROAD
POWER STATION
WALHAM GREEN
MORNINGTON CRESCENT
KING'S CROSS
ANGEL
ST. PANCRAS
KING'S CROSS
EUSTON
CITY ROAD
GOWER STREET
EUSTON ROAD
OLD STREET
PORTLAND ROAD
RUSSELL SQUARE
FARRINGDON STREET
TOTTENHAM COURT ROAD
CHANCERY LANE
ALDERSGATE
MOORGATE STREET
MOORGATE STREET
SNOW HILL
TOTTENHAM COURT ROAD
OXFORD ST
BRITISH MUSEUM
HOLBORN
HOLBORN
POST OFFICE
LOTHBURY
PICCADILLY CIRCUS
COVENT GARDEN
LUDGATE HILL
MANSION HOUSE
BANK
CRANBOURNE ST.
BLACKFRIARS
SUB STATION
STRAND
TEMPLE
CANNON STREET
CHARING CROSS
THAMES
EMBANKMENT
WESTMINSTER
WATERLOO
WATERLOO STATION
LONDON BRIDGE
BOROUGH
ST. JAMES PARK
KENNINGTON
SUB STATION & DEPOT
ELEPHANT & CASTLE
ELEPHANT & CASTLE
RIVER
KENNINGTON
VAUXHALL
NINE ELMS
THE OVAL
The Electrician
Baker Street & Waterloo Railway; under construction
Other Electric Railways; under construction
Other Railways

Fig. 1.—Map showing Principal Connections with other Railways.

A glance at the accompanying map (Fig. 1) shows the route taken by the line. The total length when complete will be about 5¼ miles, with 12 stations at the following points: Paddington, Edgware-road, Great Central, Baker-street, Regent's Park, Oxford-circus, Piccadilly-circus, Trafalgar-square, Embankment, Waterloo, Kennington and Elephant and Castle. This route possesses exceptional facilities for exchanges of traffic with other railways. Connections will be made with the Great Western, Great Central, South-Eastern & Chatham and London & South-Western main lines, and with the Metropolitan and Metropolitan-District Railways. Inter-changes will also be possible with the City & South London and Central London tubes, and with Great Northern Piccadilly and Brompton, and Charing Cross, Euston and Hampstead tube railways when completed. In most cases the communication will be by subways, and at Piccadilly the station is to be a combined one with the Great Northern Piccadilly and Brompton line. It has been estimated that about 35,000,000 passengers will be carried annually and a three-minute service with 15 second stops is contemplated. The time taken to travel from Kennington to Baker-street, the first portion of the line to be opened, will be about 14 minutes. A uniform fare of 2d. will be charged, and the system of dropping tickets into a box, used on the Central London Railway, will be adopted.

The line has, generally speaking, a gradual rising gradient all the way from the Thames northward. But the grades are by no means severe. The arrangement, now usual on tube railways, of providing down grades on leaving the stations to help acceleration and corresponding up grades to assist braking is adopted. Owing to considerations of keeping the route under the roadways and the position of sites available for stations, a number of curves are met with, the sharpest of which is 330 ft. radius. Separate tunnels are, of course, provided for the up and down lines. The diameter of the straight portions of the running tunnel is 11 ft. 8¼ in., and varies up to 12 ft. 6 in. on sharp curves. It will thus be seen that they are slightly greater in size than those of the Central London Railway (11 ft. 6 in.) and a good deal larger than the City and South London tunnels, which are only 10 ft. in diameter. The largest London tube is, however, the Great Northern and City where the tunnels were originally designed to take ordinary main-line rolling stock, and are 16 ft. in diameter. The station tunnels, as will be seen from Fig. 2, are of 21 ft. 2½ in. internal diameter. All the tunnel is built up of cast iron segments in a manner similar to most of the other tube railways.

The contractors for the tunnel and permanent way construction for the original portion of the railway, from Baker-street to Waterloo, were Messrs. Perry & Co., who have also the extension to Edgware-road in hand. The southern extensions, from Waterloo to the Elephant and Castle, are being carried out by Messrs. John Mowlem & Co., together with the depot at St. George's-circus.

The tunnelling was commenced by sinking a shaft in the river bed, and driving the tunnels north and south by the Greathead shield method. Some trouble was experienced in working through the water-bearing strata under the river; so that compressed air and other special methods had to be made use of on this part of the line. The remaining portion of the tunnel passes almost entirely through ordinary London clay and presented no special difficulty. During the construction of the original section, all the excavated material was removed through the shaft in the river and taken away in barges. Temporary narrow-gauge tracks were laid in the tunnels, and the trucks were hauled by a small electric locomotive taking current through an overhead wire from the temporary generating station on the staging in the river. All the power and lighting required for the tunnels and works was supplied from

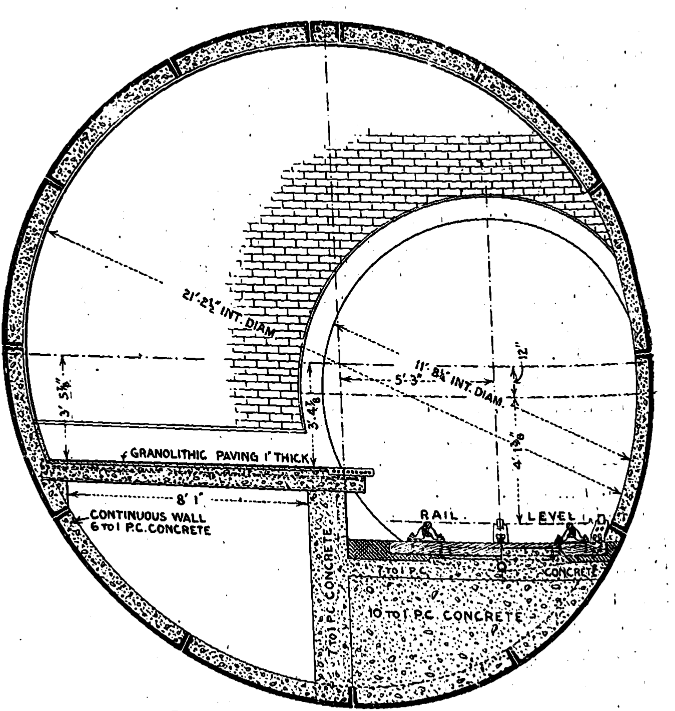
21'-2½" INT. DIAM
11'-8¼" INT. DIAM.
5'-3"
12"
3'-5⅝"
3'-4⅞
4'-1⁹⁄₁₆
GRANOLITHIC PAVING 1" THICK
8'-1"
CONTINUOUS WALL 6 TO 1 P.C. CONCRETE
RAIL LEVEL
7 TO 1 P.C. CONCRETE
7 TO 1 P.C. CONCRETE
10 TO 1 P.C. CONCRETE

Fig. 2.—Section of Station Tunnel.

this plant, so that the whole undertaking was self-contained. Messrs. Baker, Galbraith & Church acted as engineers for the Baker Street & Waterloo Railway Co., and the work was supervised by Mr. H. H. Dalrymple Hay on behalf of the Underground Railways Company.

The construction of the permanent way, which is similar to that being put down in the other tube schemes under construction, is of special interest, as it may be taken to represent the results of experience with the working of the pioneer tube lines. The whole construction is of an extremely substantial nature, to withstand the arduous conditions of the frequent and rapid service of heavy trains; but at the same time, a certain amount of elasticity has been provided for in the track, with the object of reducing noise and vibration to a minimum.

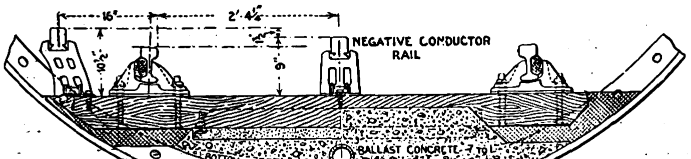

Fig. 3.—Cross Section of Track.

It will be seen from the section through the track given in Fig. 3 that cross sleepers have been adopted, and that they are bedded on concrete at the centre portion of the sleeper only, while the end portions under the track rails are supported on crushed granite. The foundation layer of ballast concrete was laid first very nearly up to the level of the sleepers, the sleepers were then laid on and wedged up, and a fine grouting run in, concrete being also added between the sleepers. Karri wood imported from Australia has been used for sleepers, as the Board of Trade no longer permit the employment of creosoted sleepers in tunnels. The sleepers are placed very near together, and are 14 in. by 5 in. in section, except at the rail joints, where a slightly smaller section is employed.

The track consists of standard 90 lb. bull-headed British standard railway rail supplied by Messrs. Bolckow, Vaughan & Co. The lengths used varied from 34 ft. 11 in. to 36 ft. 5 in., according to the curves. It is, however, intended to use 45 ft. lengths on the other tube railways, but in this case the shorter lengths were adopted owing to the impossibility of taking long rails down the shaft in the river. Since the opening to the surface was made at St. George's-circus, however, this difficulty has disappeared. All the rail bending for the curves was done in the tunnel. It will be noticed that the chairs are held down entirely by screws instead of spikes. Felt pads ¼ in. thick are placed under every chair, and each holding-down screw passes through a fibre brush which insulates it from the chair. Special chairs with extended bases are employed on each side of the joints similar to those used on the Great Western Railway.

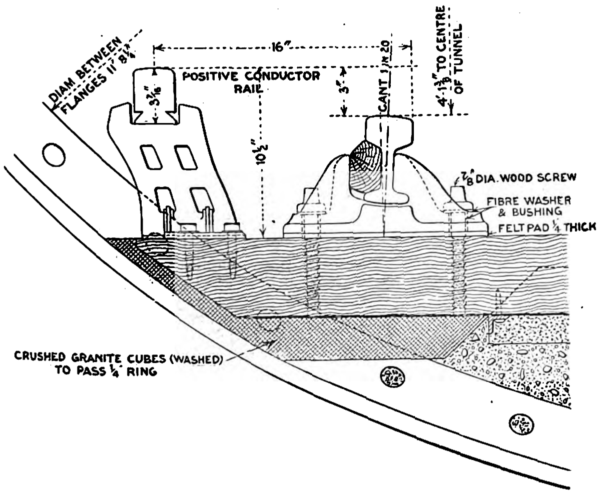

Fig. 4.—Section Showing Positive Insulator and Chair.

The conductor rails are of a somewhat different form to those employed on any of the existing lines. The section is shown in Figs. 3 and 4. A special quality of manganese steel is employed, of which the resistance is about 6·4 times that of pure copper. These rails only weigh 85 lb. per yard, as against the 100 lb. conductor rail employed on the District Railway. The insulators for supporting the conductors are also entirely different from those hitherto employed, and are shown in Figs. 3 and 4. The positive rail outside the track has a clearance of only 2½ in. from the flanges of the segments of the tube, so that a special-shaped insulator is required for the outer conductor. All the insulators are of vitrified earthenware, and were supplied by Messrs. Doulton & Co. Malleable iron clips are used to hold them down, and felt pads ⅛ in. thick are provided. The arrangement of the joints is shown in Fig. 5. Four flexible stranded wire bonds are used at each joint. These were supplied by the American Steel and Wire Co.

The power for working the line is supplied through three sub-stations from the Underground Electric Railway Co.'s power house at Lot's-road, Chelsea, a full description of which was given in *The Electrician*, Vol. LIV., p. 4. Current is there generated at 11,000 volts three-phase and is converted to about 600 volts continuous current at the sub-stations. The main H.T. feeders, after leaving the switchboard, are led in an underground conduit to Earl's Court. From here they run along the District Railway and Great Northern Brompton & Piccadilly Railway tunnels to Charing Cross, where the principal sub-station is situated. A full description of this sub-station, which also supplies a section of the District Railway and which will eventually also supply a part of the Charing Cross, Euston & Hampstead Railway, was given in *The Electrician*, Vol. LIV. p. 615. Further H.T. feeders are taken from Charing Cross through the Baker Street & Waterloo tunnels to the other two sub-stations at Baker-street and St. George's-circus respectively. These cables are of the three-core paper-insulated lead-covered type supplied by the Western Electric Co. They are hung on iron brackets bolted to the flanges of the segments of the tube. All the H.T. feeders are in duplicate and are so arranged that the two feeders supplying any one sub-station are never in the same tunnel. The equipment of all the sub-stations is similar to that already described in the article referred to in connection with the Charing Cross sub-station. Those at Baker-street and St. George's-circus each contain three 800 kw. rotary converters. The sub-station plant was all supplied by the British Westinghouse Company under the supervision of Mr. S. F. Fortenbaugh. The L.T. track feeders are carried on the walls of the tunnels, but are not of great length, owing to the long sections into which the conductor rails are divided. Other cables are also carried on the sides of the tunnels for lighting, lifts and other purposes described below.

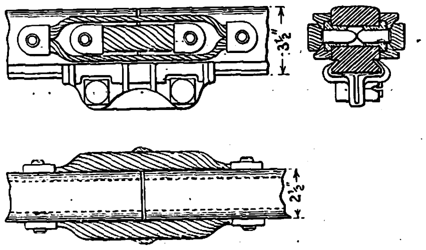

Fig. 5.—Joint in Conductor Rail.

The emergency lights in the tunnels, which are placed at intervals of 40 ft., and the incandescent lighting of the stations, are fed from a three-phase supply at 220 volts obtained from two stationary transformers in the sub-stations. Throw-over switches are provided, so that in event of one sub-station being shut down, connection can immediately be made with another. The tunnel lights are controlled from switches at each end of the platforms. All the lights in the exits are, however, supplied from sources entirely independent of the railway, connections being brought in at each station from the local mains, usually at 220 volts. The continuous-current supply for the arc lighting, lifts and fan motors, at about 570 volts, is brought through special concentric cables in the tunnels from the sub-stations, and is entirely independent of the track feeders. A panel is provided in each station with throw-over switches, so that the lift, fan or arc circuits can be switched over to either the "up" or "down" sub-station, and an additional set of switches is provided, by means of which either of these circuits can be connected in cases of emergency with the track, which is at about the same voltage. The arc lamps are of the "Maxim" pattern, similar to those in use on the District Railway (see *The Electrician*, Vol. LIV., p. 453). A particularly neat lowering gear is employed, the carriage from which the lamp is suspended travelling in a guide fitting the curve of the tunnel.

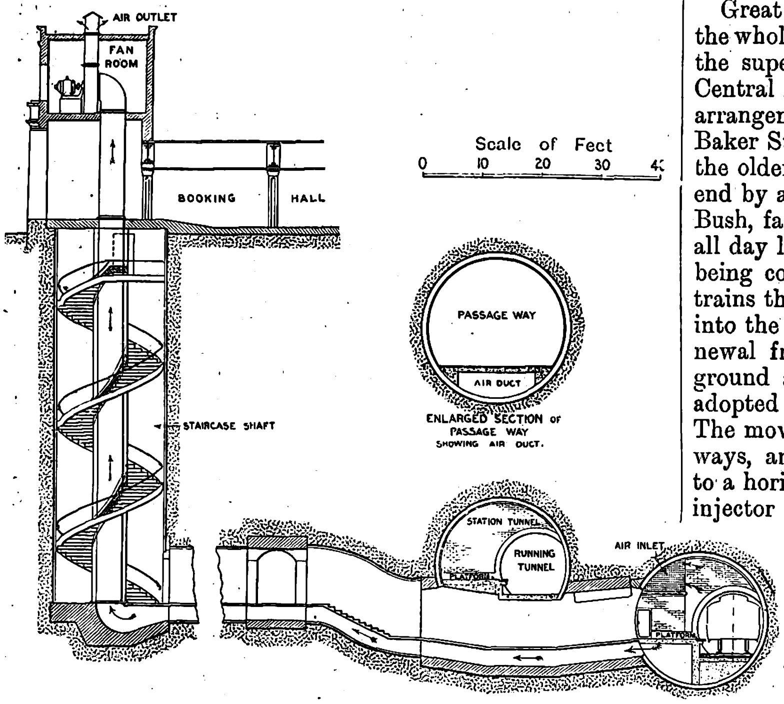

Fig. 6.—Section of Station Showing Ventilating Arrangement.

The station buildings and interior decoration were designed by Mr. Leslie W. Green. The construction consists of a steel framework covered with terra-cotta glazed blocks of a distinctive dark ruby colour. The interior fittings are of simple but artistic design, and the passages and subways are finished in ornamental coloured glazed brick. A different colour scheme is employed in the interior decoration of each station, which should facilitate the recognition of the different stations by passengers in the trains. All the stations buildings are fireproof, and the only wood employed is the joinery of the doors and windows, and this is of uninflammable teak. Even the panels of the doors in the station-masters office are of metal. The Tralfalgar-square and Regents-park stations are completely underground, and the booking halls are reached by short staircases. The station platforms are of concrete with stoneware edging similar in appearance to the new platforms on the District Railway.

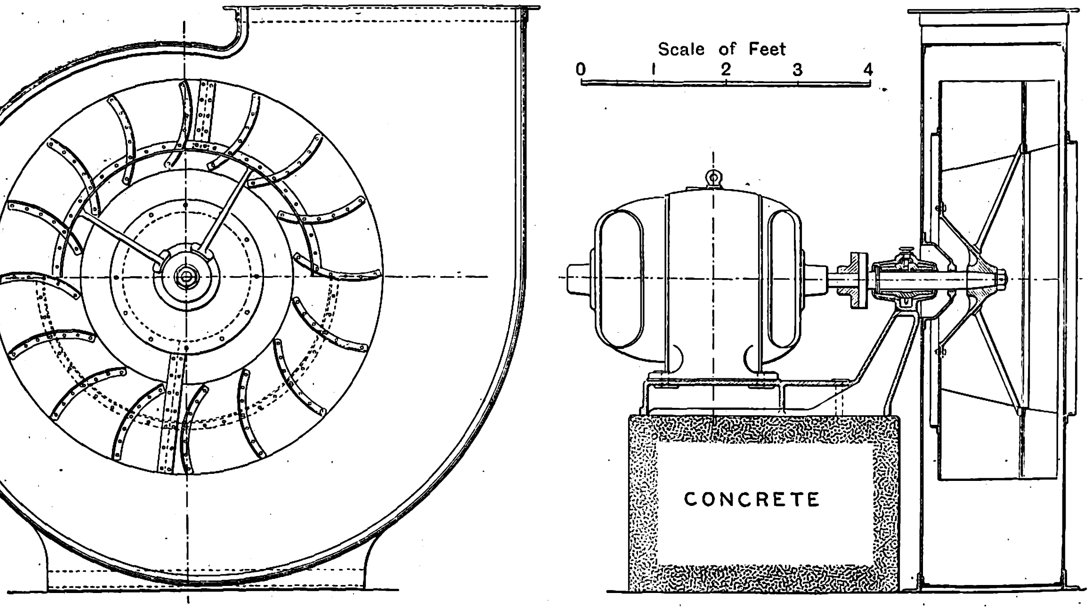

Fig. 7.—Ventilating Fan and Motor.

Great attention has been paid to the problem of ventilation, the whole of the arrangements for which were carried out under the supervision of Mr. G. Rosenbusch. Experience with the Central London Railway showed the importance of adequate arrangements in this respect, and the system employed in the Baker Street & Waterloo Railway differs entirely from that in the older tube. Instead of the air being drawn out from one end by a huge single fan once a day, as is done at Shepherd's Bush, fans are provided at every station and work continuously all day long. By this means a column of air in each station is being continually renewed, and as by the movement of the trains these columns of fresh air are being constantly forced into the tunnels and replaced by columns of air requiring renewal from the tunnels, practically the whole of the underground air is frequently renewed. The exhaust system was adopted in preference to the plenum system for several reasons. The movement of the incoming fresh air is down the passage-ways, and therefore assists the movement given by the trains to a horizontal column of fresh air, even adding to it by the injector principle, at the same time preventing the train from pushing fresh air up the passage-ways. If, on the other hand, the plenum system had been adopted, so the air passed out of the passage-ways, it is probable that the train would have pushed out a large proportion of the newly supplied air up the passage-ways. Another feature of the exhaust system is that by taking out air in a closed duct from the top of the tunnels any smoke which might arise from unforeseen causes would be effectively removed and the exits and passage-ways would be kept clear by the incoming flow of fresh air. The value of this feature was fully recognised by the Board of Trade, who gave their unqualified approval to the exhaust system as laid out. Fig. 6 shows a typical section of a station and illustrates the above points. The air inlet seen in section is at the extreme end of the platform, some distance from the incoming current of air down the lift and staircase shafts. Each fan has been designed to exhaust 1,000,000 cubic ft. of air per hour, which is sufficient to renew all the air in the average length between the stations in both tunnels every 30 minutes. As the path of suction is relatively short and the cross-section of the duct varies between 12 and 16 square feet, no great pressure and velocity were required, so the efficiency is relatively high. Some tests were made at Waterloo, where the ducts are longer and contain more bends than in the majority of stations, so that the results were less favourable than the average. The figures are given below :—

| | |
|---|---|
| Volts at motor terminals | 557 |
| Amperes taken by motor | 12 |
| Electrical horse-power supplied to motor | 8·95 |
| Revolutions per minute | 242 |
| Air pressure at fan inlet in inches of water | 1·2 |
| Cubic feet of air per minute | 18,250 |
| Horse-power-hour per 1,000,000 cubic feet per hour.. | 8·1 |

This result is very much better than that obtained on the high-pressure fan on the Central London Railway, where about 17 H.P. is required per million cubic feet of air per minute. The causes of this high efficiency, apart from the favourable conditions of pressure and air duct section, are partly in the design of the fans themselves. A typical fan, with its motor, is shown in Fig. 7. The size is above that usually employed for the volume of air to be handled and the pressure. This results in a comparatively low speed and a solidity of moving parts. The fan case is also large, a considerable area being left between the wheel and the housing. Another point to which great attention was paid was silence in running, and for this reason the motor carrying the overhung fan wheel was mounted on a separate bedplate and foundations, so that no moving parts are in any way attached to the housing or air ducts, and consequently there is no tendency for vibration to be set up, and a sounding-board effect is avoided. The fans were supplied by Messrs. Heenan and Froude., of Worcester.

The depot, shunting yard and car sheds are situated on the surface near St. George's-circus, and are connected to the line by an inclined tunnel. The contract for the depot was entrusted to Messrs. Mowlem & Co., who carried out the demolition of the former buildings on the site and the excavation, new buildings, &c. Fourteen tracks are laid for the accommodation of trains. The car shed contains three tracks, and inspection pits are provided under two of these. The site also includes a repair shop, paint shop and one of the sub-stations, in addition to a small boiler house, stores and offices. Some machine tools are provided for carrying out repairs, and one room is set apart for armature rewinding. A staircase shaft giving access to the line is sunk from the sub-station, at the head of which an additional ventilating fan is placed.

The Westinghouse electro-pneumatic system of automatic signalling is used, similar to that now employed on the District Railway, including the automatic train stop, but the arrangements are simpler, owing to the smaller number of junctions and crossings. A full description of the system was given in *The Electrician*, Vol. LIV., p. 615. Compressed air for working the signals is provided from the sub-stations. The whole of the signalling gear was supplied by the Westinghouse Brake Co. The arrangement of green and red lamps to repeat the starting signals so that they are visible from all along the platforms familiar in the stations of the District Railway is also employed. A track-voltage indicator is provided at the entrance of every tunnel, by which the driver can see at a glance whether the section in front of him is "live."

A very complete telephone system is installed. There are local exchanges in the station-master's office at each station in communication with each other and the London telephone system, and a pair of bare wires is strung up along the side of each tunnel, to which the driver or conductor of a train can connect a portable telephone set and put himself in communication, not only with the nearest station, but with either sub-station, the depot or the main generating station, or, indeed, to any telephone number in the London District.

(*To be concluded.*)

**Metals and their Ferro-Alloys Used in the Manufacture of Alloy Steels.**—Dr. O. J. Steinhart, F.C.S., has sent us an excerpt from the *Transactions* of the Institution of Mining and Metallurgy, containing a concise account of the present position, manufacture, history and some commercial and statistical data on metals and their ferro-alloys used in the manufacture of ferro-steels. The use of electric furnaces and electrolytic processes for refining and smelting such metals as nickel, chrome, tungsten, molybdenum and vanadium is briefly outlined but not gone into in detail.

## SERIES TRANSFORMERS FOR WATTMETERS.

BY LANCELOT W. WILD.

Alternating-current wattmeters and ammeters having a capacity of 100 amperes and upwards are now very generally arranged to work with series transformers. The current to be measured is passed through the primary winding of the transformer, and the secondary winding is connected directly to the main current coils of a wattmeter or ammeter having a capacity of 10 amperes or less. The main object of this arrangement is to avoid the large errors due to the effect of eddy currents that occur when a conductor of large section is brought into the instrument itself.

For instruments having a capacity of 200 amperes or less eddy currents can be practically eliminated by winding the coils of the instrument with a cable consisting of a number of fine wires insulated from each other and stranded so that each wire occupies in its course every position in turn with regard to the central axis of the cable. For currents of a greater magnitude than 200 amperes this method of stranding becomes impracticable, hence the necessity of using series transformers.

The following two examples will serve to exhibit the magnitude of the errors that occur when a solid conductor is used for the current coils of a wattmeter :—

*First Example.*—Wattmeter for a maximum current of 50 amperes. Conductors copper strip 1 in. by 0·028 in. wound in two coils of 24 turns each. The following errors were found by testing against another instrument of proved reliability.

| Frequency | D.C. | 50 | 50 | 50 | 100 | 100 | 100 |
|---|---|---|---|---|---|---|---|
| Cos $\phi$ | — | 1 0 | 0·48 | 0·20 | 1·0 | 0·48 | 0·18 |
| Error (% low) | nil | 0·4 | 1·6 | 4·5 | 1·7 | 3·1 | 7·2 |

The above errors were due almost entirely to eddy currents in the copper strip, the instrument in other respects being a good one.

*Second Example.*—Wattmeter for a maximum current of 300 amperes. Conductors 0·75 and 0·25, two coils of one turn each. The following errors were found :—

| Frequency | D.C. | 50 | 50 cycles per sec. |
|---|---|---|---|
| Cos $\phi$ | — | 1·0 | 0·50 |
| Error (% low) | nil | 2·5 | 8·0 |

In this case the errors were greatly reduced by reason of there being present a large amount of self-induction in the voltage circuit.

The use of series transformers may also introduce serious errors into alternating-current instruments, unless they are carefully designed. In order that accurate results may be obtained it is necessary that the current ratio of the transformers be as nearly as possible equal to the winding ratio, and also the phase difference between primary and secondary currents as small as possible. This result must be obtained by reducing the core loss and magnetising currents to a minimum and by paying very careful attention to the question of magnetic leakage. The absence of magnetic leakage is of the very utmost importance, as is shown by the following test :—

On an iron core consisting of 100 sets of stampings of an average thickness of 0.013 in., the total area of iron being 1·30 sq. in., and the length of magnetic circuit being 12 in., were wound four coils of No. 14 wire, each of 50 turns. Two coils were wound on one side of the iron circuit, and two coils on the other side of the circuit. With these windings could be obtained a primary and secondary winding each of 100 turns, with the primary and secondary each divided equally between the two sides, or with the primary on one side and the secondary on the other. Two wattmeters, each of 10 ampere capacity were used, one in the primary and the other in the secondary circuit. The wattmeters were first standardised together and brought into agreement without the transformer. When the transformer was connected into the circuit, the following errors were found in the readings of the secondary instrument.

| Winding. | Periodicity. | Cos $\phi$. | Amperes. | Error of reading. |
|---|---|---|---|---|
| P. & S. together | 50 | 1·00 | 10 | 0·3 % low |
| P & S. opposite | 50 | 1·00 | 10 | 4·5 % low |
| P. & S. together | 50 | 0·50 | 10 | 1·0 % high |
| P. & S. opposite | 50 | 0 50 | 10 | 7·5 % low |

The much larger error when the primary and secondary were wound on the opposite sides of the core is due entirely to magnetic leakage, which operates in two ways, firstly by causing the secondary current to lag behind the transformer volts, thus bringing the secondary current more nearly into phase with the magnetising current, secondly by increasing the transformer volts and thus increasing both the magnetising current and core loss.

In order that the magnetising current and core loss may be reduced to a minimum, it is necessary to get rid of magnetic leakage. The ampere turns should also be large and the magnetic reluctance small. Also the volts per turn should be as small as possible. These requirements are to a great extent contradictory. It hardly pays to increase the area of the iron much above 1 square in., as the decreased magnetic reluctance obtained is counterbalanced by the increase of resistance of the secondary winding. Again it hardly pays to increase the ampere turns above 1,000, as any additional increase must be accompanied by an increase of the length of magnetic circuit, owing to the necessity of working the winding at a lower current density to avoid undue heating.

The resistance of the wattmeter should be as small as possible in order to reduce the volts per turn in the transformer, and the self-induction of the wattmeter coils should also be small compared with the total CR drop in the secondary circuit, otherwise the secondary current will approach in phase to the magnetising current, and increase the error on high power-factors.

Having recently had occasion to design for use in the Westminster Electrical testing Laboratory a set of transformers for use with a wattmeter having a capacity of 1 ampere, the writer finally decided upon the following design:—

Fig. 1 shows the iron core, its dimensions being 2 in. by 2 in. inside and 4 in. by 4 in. outside. The stampings were 0·013 in. thick on the average and 100 pairs were used. The length of the magnetic circuit was 12 in. and its area 1·30 square in. All secondary windings were alike, each consisting of 1,000 turns of No. 22 wire wound one-half on each side of the core, and arranged for connection in series or parallel. The primaries comprised two coils of 50 turns each of No. 14 wire for the 10 ampere transformer, five turns of $1\frac{1}{2} \times 0{\cdot}028$ copper strip for the 100 ampere transformer, and one turn bent round as in Fig. 2 for the 1,000 ampere transformer. Thus the full load of each transformer was 1,000 ampere turns, and by connecting the primaries and secondaries in series or parallel three different ranges could be obtained with each. The transformers weigh about 7 lb. complete and fit into a space 6 in. × 4 in. × $3\frac{1}{2}$ in. From tests quoted further on it will be seen that magnetic leakage is entirely negligible in these transformers.

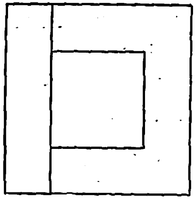

Fig. 1.

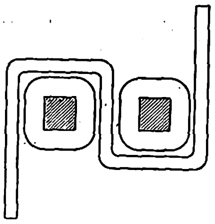

Fig. 2.

Before starting upon the construction of the transformers, the core loss and magnetising current had to be determined throughout their working range. This was carried out by the method described by the writer in *The Electrician*, Vol. LIV., p. 129. The core-loss current was measured by means of a wattmeter and the magnetising current by means of an ammeter and wattmeter, taking the core-loss current as that component of the total current which is in phase with the transformer volts and the magnetising current as that component of the total current which lags 90 deg. behind the transformer volts. The results obtained are given in the form of curves (see Fig. 3), in which the ordinates are expressed in millivolts per turn, and the abscissæ in ampere-turns. These curves apply to this particular sample of iron only, and to a core of 1·3 sq. in. section and 12 in. magnetic length.

Since the full-load current of the wattmeter was 1 ampere and the whole resistance of the secondary circuit 10 ohms, it follows that the total CR drop was 10 volts and the millivolts per turn at full load 10. The magnetising current was 0·52 per cent. at 100 ∼ per second, and 0·82 per cent. at 50 ∼ per second, while the core loss current was 0·21 per cent. at 100 ∼ per second, and 0·39 per cent. at 50 ∼ per second.

It was calculated that the self-induction of the secondary amounted to 0·5 volt only at 100 ∼ per second, and 0·25 per cent. at 50 ∼ per second. In this case it was, therefore, sufficiently accurate to take the secondary current as being in phase with the transformer volts, and consequently in phase with the core loss current, and 90 deg. from the magnetising current. Had the self-induction of the wattmeter coils been larger, it would have been necessary to split the core loss current and magnetising current into two fresh components in phase with and 90 deg. from the secondary current. This can be done quite easily, graphically if the self-induction of the secondary circuit is accurately known. The difficulty is to determine with sufficient accuracy the amount of self-induction in the secondary circuit when it is large enough to affect results, especially as self-induction in the wattmeter coils may induce magnetic leakage to declare itself in the transformer, and thus cause a further increase of self-induction. The core loss current being practically in phase with the secondary current causes a constant error of 0·2 per cent. at 100 ∼ per second, and 0·4 per cent. at 50 ∼ per second, the wattmeter reading low. The magnetising current has no effect on non-inductive load. On inductive loads it tends to cause the wattmeter to read high, the error being proportional to the tangent of the angle of lag.

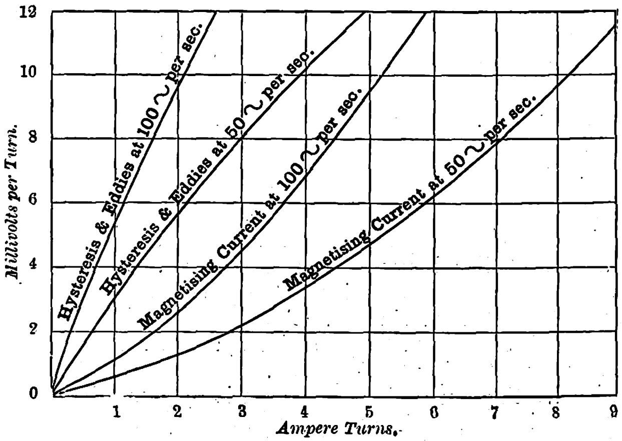

Fig. 3.

The errors due to core loss and magnetising current have been calculated out to the following:—

| Frequency, ∼ per sec.. | 50 | 50 | 50 | 50 | 100 | 100 | 100 | 100 |
|---|---|---|---|---|---|---|---|---|
| Power-factor ........ | 1·00 | 0.75 | 0·50 | 0·25 | 1·00 | 0·75 | 0·50 | 0·25 |
| Core loss error % .... | 0·4*a* | 0·4*a* | 0·4*a* | 0·4*a* | 0·2*a* | 0·2*a* | 0·2*a* | 0·2*a* |
| Mag. cur. error % .... | nil | 0·7*b* | 1·4*b* | 3·0*b* | nil | 0·45*b* | 0·9*b* | 2·0*b* |
| Nett error % ........ | 0·4*a* | 0·3*b* | 1·0*b* | 2·6*b* | 0·2*a* | 0·25*b* | 0·7*b* | 1·8*b* |

*a* low. *b* high.

These figures are calculated for full load—viz., 1 ampere, the error being expressed as a percentage of the true watts, not the apparent watts. For a smaller load the errors would be somewhat greater, the magnetising current curve not being a straight line.

In order to prove the accuracy of these deductions the first completed transformer was tested with its wattmeter, against another larger wattmeter with the following result:—

| Secondary current, amp. | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
|---|---|---|---|---|---|---|---|---|
| Periodicity .......... | 50 | 50 | 50 | 50 | 100 | 100 | 100 | 100 |
| Power factor ........ | 1·00 | 0·75 | 0·50 | 0·25 | 1·00 | 0·75 | 0·50 | 0·25 |
| Error % ............ | 0·3*a* | 0·3*b* | 0·9*b* | 2·5*b* | 0·2*a* | 0·2*b* | 0·6*b* | 1·6*b* |

*a* low. *b* high.

The agreement between the results obtained and those calculated are very satisfactory, for the greatest divergence obtained was 0·2 per cent only, and this was on a low power-factor, where the experimental conditions were not so favourable as on the higher power factors.

Incidentally the curves of core loss have brought out rather an interesting fact not hitherto published—namely, that between values of $B_{max}$ of from 200 to 400 the core loss reckoned in watts increases as about the 2·7th power of $B_{max}$, which contravenes the Steinmetz law (or rule), and is quite different from results commonly obtained at ordinary transformer iron densities of 2,000 to 8,000 $B_{max}$.

# THE CARBON REGULATOR FOR AUTOMATIC BOOSTER CONTROL.

The method of automatic booster control described in this article has only recently been introduced into this country. It is, however, in successful use on several of the American railway systems and large industrial works in the United States.

The chief feature of the method is a special apparatus known as the carbon regulator shown in Figs. 1 and 2. It is a neat and compact apparatus, and occupies about the same space on the switchboard as an ordinary watt-hour meter. The regulator itself consists of a number of piles of carbon discs which are subjected to the varying pressure of a lever. From one end of this lever is freely suspended the soft-iron core of a solenoid which carries the entire generator load, while to the other end is attached a helical spring, whose tension may be adjusted by hand to counterbalance the pull of the solenoid at any desired load on the machines. Slight variations of load above or below this amount will cause changes in pressure on the carbon piles resulting in wide variations in their contact resistance. Advantage is taken of this resistance variation to control the field excitation of the battery booster, usually through the intermediary of a small exciter between whose fields and the carbon piles connections are made similar to those of a Wheatstone bridge, the current in the exciter fields varying in direction and amount with changes in the pressure on the carbon piles.

The arrangement of connections is shown diagrammatically in Fig. 3. $G_1$ G are the main generators, the series regulating coil carrying the main current being shown at H. The battery XYZ in series with the booster armature D is connected across the mains, and its single set of field coils F are supplied by the exciter E. The motor driving the booster is not shown in the diagram. In some cases the exciter is driven by a chain from the booster set, but a separate motor is now more frequently employed. The connections which enable the carbon regulator, KL, to vary the field of the exciter are shown, N and Y being the middle points of the variable resistance and battery respectively in the Wheatstone's bridge arrangement. It will be noted that the construction of the booster machine is greatly simplified by the absence of the usual series field coil carrying the whole load of the station.

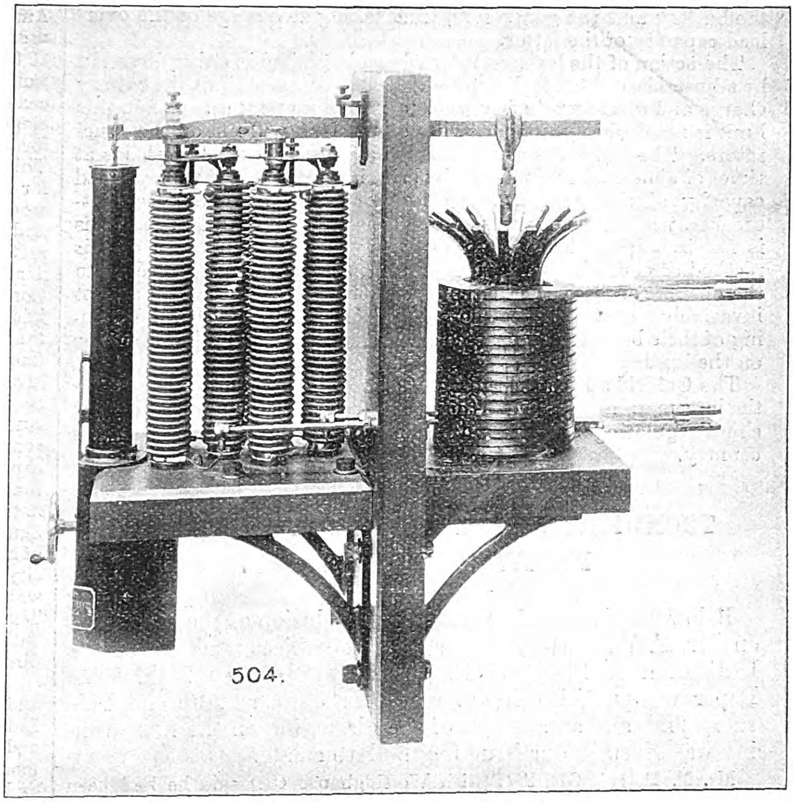

Fig. 2.—Automatic Carbon Regulator showing Solenoid.

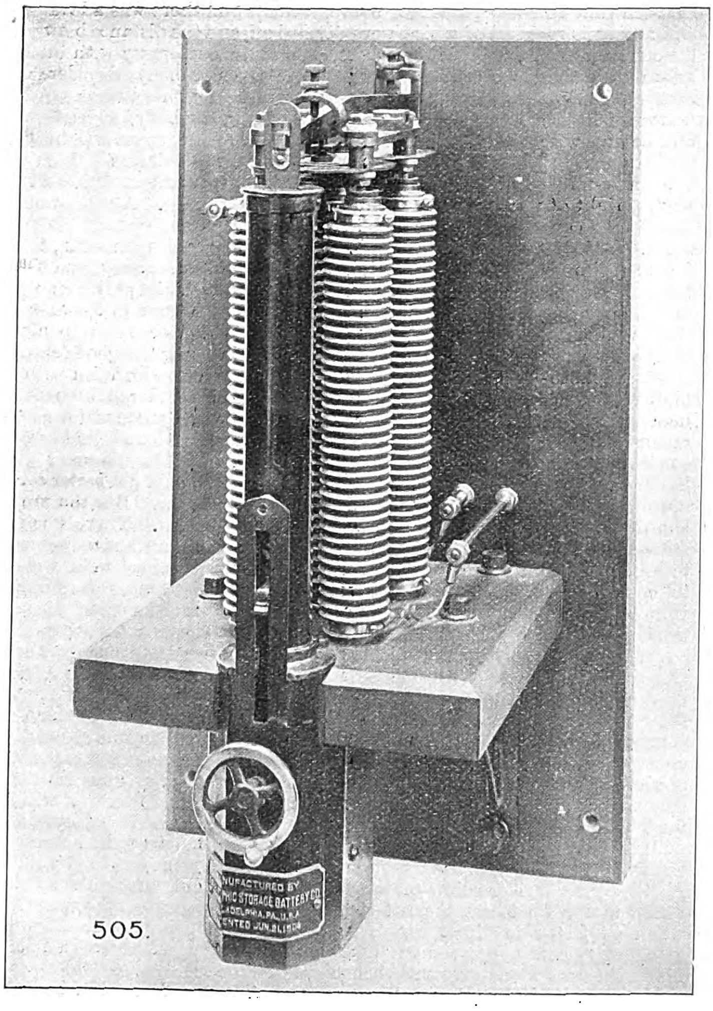

Fig. 1.—Front View of Automatic Carbon Regulator.

The constant load falling on the generators may be adjusted at any desired point by adjusting the tension of the spring above mentioned, which adjustment is instantly made, and may be altered from time to time during the day to meet changes in the load conditions; the battery either simply "floating," or taking a continous peak discharge, or a net charge, according to the adjustment, while always taking automatically the momentary fluctuations of load.

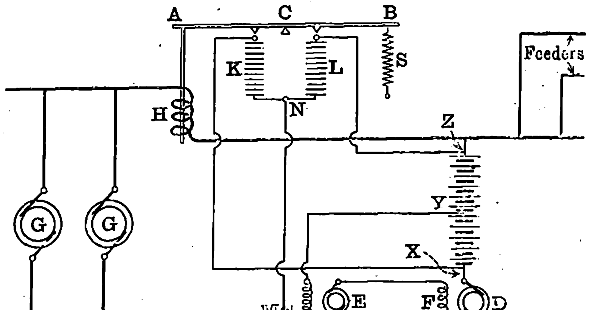

Fig. 3.—Diagram of Connections.

In the case of regulators for very heavy currents, an inverted U-shaped armature is suspended over the main bus bar instead of a solenoid being used. Since the carbon regulator responds to very small changes in the generator load the system is self-corrective, and no accurate pre-determinations or adjustments are required. A large "factor of safety" is introduced in the design of the regulating apparatus, which counteracts the effect of any adverse conditions (such as low temperature, &c.) which might otherwise impair the sensitiveness of regulation, thus ensuring good results under all circumstances.

It is claimed that the sensitiveness of the regulator is as great under heavy load conditions (when close regulation is most important) as at times of lighter loads, a result which it is difficult to secure in cases where the field windings have to be shunted with increasing loads, thus impairing the regulation at the very time when it should be most effective. By the use of this adjustable resistance in the field-controlling circuits, the sensitiveness of regulation can be varied at will, permitting the operator to maintain, when necessary, a constant load on his machines, or at other times to divide the fluctuations of load in any desired proportion between the battery and the generators, thus taking advantage of the overload capacity of the latter.

The action of the lever on the carbons is limited in either direction by adjustable mechanical stops which may be set to limit the battery charge and discharge to any predetermined maximum. When this limit is reached any further swing of the load will fall on the generators. The booster is thus protected against excessive overloads at times of abnormal fluctuations by bringing into service the overload capacity of the generators without opening the battery circuit-breaker, while sensitiveness of regulation under normal conditions is not impaired. This is an especially important feature of this method of control, eliminating as it does the annoyance incident to the opening of the battery circuit-breaker on overload, which almost invariably results in a destructive load on the machines or the opening of their breakers and the consequent total interruption of power on the line.

The Chloride Electric Storage Co., to whom we are indebted for the information contained in this article, have already supplied several shunt-regulating boosters with this type of control for use in this country.

## TECHNICAL CONSIDERATIONS IN ELECTRIC RAILWAY ENGINEERING.

Below we give an abstract of the conclusion of the discussion on Mr. F. W. Carter's Paper on this subject read before the Institution of Electrical Engineers on January 25th. The Paper was published in our issues for January 26th and February 2nd, and an abstract of the discussion on the first evening was given in our issue for the latter date.

Mr. T. H. SCHOEPF (British Westinghouse Co.) said he had been struck by the analytical method which the author advanced for working up train curves. He had had to work up many hundreds of such curves and did not agree with the author that the analytical method would, in any given case, save any time or labour, and it was certainly not so accurate as the point to point method. If Mr. Carter had to give guarantees of an equipment to maintain schedule speeds, and also on the question of energy consumption, he thought he would agree with this. The analytical method gave no information which would guide in choosing a motor of sufficient service capacity for the work in hand. For instance, to determine the service capacity, the characteristic of the motor was known, to start with, so far as its heating was concerned, and they must know the root mean square current and the full voltage, which settled once for all the heating effect resulting from the copper and iron losses. But this could not be got by an analytical method. The point to point method must be adopted in order to get this and to be able to say that the motor is of the service capacity for the work required. In discussing the Paper he proposed to deal more particularly with the statements in it on single-phase equipments, for the conclusions on this point were to him most novel, and differed from the conclusions arrived at by the majority of those engineers who were responsible for the development of single-phase traction. It was stated in the Paper that the weight to be added to the train for the inertia of the rotating parts was 8 to 10 per cent. in the case of continuous current, and it might be as much as double with single-phase. His experience led him to differ from this. He had had to calculate this matter very carefully, and he had adopted 10 to 12 per cent. for continuous current, and 12 to 15 per cent. for single-phase. Of course, the weight of the train and its composition as to motor cars and trailer cars influenced this, but he would take two cases that were well known. In the equipment of the Metropolitan Railway in London, the actual calculated value to be added to the train was 12·1 per cent. For a train equipped with single-phase motors which would be suited for the suburban service on the London, Brighton & South Coast Railway, the extra weight was 14·5 per cent. As a matter of fact these figures could not be properly compared, because the Metropolitan trains weighed 160 tons and the trains proposed for the L. B. & S. C. Railway would only weigh 105 tons. Therefore it really came down to a mere fraction of some percentage as the weight which should be added as between the two systems. With regard to leakage currents with the alternating current, he pointed out that in the gas or water pipe there would be an induced E.M.F., which would counteract the induced E.M.F. in the rail return, so that in his opinion the effective drop in the rail giving rise to electrolysis should be only the ohmic drop, and with alternating current and higher voltages there would be less current, less drop and therefore less leakage, and not equal leakage as stated by the author. Then the author said that in order to overcome this handicap, as he thought, upon the single-phase system it would be necessary to go to 6,000 volts on the trolley or use a negative booster. With regard to the destructive effect of the electrolytic action with the leakage current, he had discussed this matter with Mr. Kintner, an American engineer who had carried out very exhaustive tests, and he said it was practically nil. These tests were reported in the *Electric Journal* for November. In his opinion he did not think a negative booster was needed. He had investigated the question very carefully and made tests, and he thought the drop in voltage was one that could be dealt with, and he did not think that drops of from 60 to 100 volts were excessive, because the indications were that there was no destructive effect from the leakage current in the return circuit or rail return. 6,000 volts single-phase was to be exceeded on the New York, New Haven & Hartford Railway, portions of which the American Westinghouse Co. were converting; 11,000 volts were being used on the trolley. In Sweden he had been present at experiments with 20,000 volts on the trolley, and he was prepared to say that no difficulty would be experienced with this voltage; in fact, he believed we should come to it. In a further comparison between continuous current and single-phase equipments, the author had stated that the range of power for the single-phase was not so wide as that of the continuous current. This might be true, but he did not think that had any bearing on the case, for the simple reason that, if a motor was required for suburban traffic, where there were a great number of stops, and a high rate of acceleration, and not high maximum speed, one type of motor would be used—a motor with a particular characteristic—but if the motor was wanted on a railway for long-distance runs, at a high maximum speed, acceleration being slow, another type of motor would be adopted. Mr. Dawson had so completely replied to the author on the question of efficiency, that anything he himself might say on the matter would be superfluous. The author had stated that a single-phase motor with a given shell (what was meant by this he was not sure, but he supposed it meant a motor which would go in a given space of bogie truck, and that, of course, fixed the general shape of the shell) was some 15 to 20 per cent. heavier than the direct-current motor of equal capacity. As a matter of fact, the motors that he had dealt with showed that a 150 H.P. motor weighed 5,389 lb. for direct current, and an alternating-current motor of the same capacity weighed 5,550 lb. These figures spoke for themselves. He agreed with the author that the rating of a continuous-current motor gave no information of its service capacity, but he did not agree that the service of an alternating-current motor was only half that of a continuous-current motor of the same capacity. The author further stated that the weight of any given train equipped with single-phase was considerably heavier than a train equipped for direct current. In reply to this he could only say that on the Metropolitan Railway, with continuous current, the weight of one motor coach and its equipment was 29,500 lb., whilst the similar equipment for the L. B. & S. C. Railway worked out to 31,500 lb., only 2 per cent. difference, and not 30 to 40 per cent., as stated in the Paper. Reference was made in the Paper to the single-phase equipment on the Indianapolis and Cincinatti* line, and the weight of the car equipped is given as 96,700 lb. This was correct, but the coach would seat 54 passengers, eight more than the ordinary car would seat on an American inter-urban line. Furthermore, there were two passenger compartments with a division between, there was a luggage compartment with a division between that and the passenger compartment, and there was a lavatory and a parcels rack, all of which were divided off, and the distance between the centre pins of the bogie was greater than was customary with inter-urban cars there. All these things made the car body considerably heavier than the standard car bodies referred to by the author. As a matter of fact, he knew for a certainty that that car body, under frame and bogies, weighed 68,000 lb. Furthermore, the equipment was heavy, and the reason for this was that it worked on three voltages. One was 550 single-phase in the town of Rushville, 3,300 volts alternating on the private right of way, and 550 continuous in Indianapolis. All this would explain the considerable difference in weight.

Mr. H. M. HOBART said two things would be agreed upon—viz., that for main-line working high-tension was absolutely necessary, and that for this overhead construction must be adopted. This part was well carried out by single-phase, but it appeared to him that in the motors there was a disadvantage with single-phase. It had occurred to him, therefore, that there would be some advantage in using the good feature of single-phase—viz., the overhead construction, in combination with a high voltage continuous-current motor. This motor had not been used here before through misconceptions. In designing dynamos for generating stations there was unlimited space, and it was found that better commutator results could be obtained by increasing the diameter and having more poles, and so we had come to think we could get better commutating results with reasonable voltages, say, 550 volts. But the problem of railway motor design was considerably different. There was restricted space and also restricted length parallel to the shaft, and as we went to higher voltages actually better results could be obtained with regard to commutation. Whereas 600 volts might be a most favourable voltage for commutation purposes for motors of 30 H.P. to 40 H.P., used up to recently in street tramway work, better commutating results could be obtained by increasing the voltage as the necessity for increasing the capacity arose. With main-line working, motors of 150 H.P. and upwards per axle would have to be adopted—even motors of 300 H.P. and 350 H.P. might be used—and it was absolutely necessary to get them as compact as possible. With a given diameter the problem was altogether changed from dynamo design where the diameter was increased with increasing output, for anybody with the slightest acquaintance with the calculation of commutation properties of motors would find that with a fixed diameter one was absolutely aided in getting good commutation with higher voltage. This consideration, almost exclusively, had stood in the way of raising the voltage of continuous-current motors for traction. He thought that a fraction of the expenditure in developing the single-phase motor up to its present stage—which was considerably wanting when subjected to direct comparison—would have produced a highly satisfactory continuous-current high-voltage motor, and he trusted that manufacturers would give this their consideration.

Mr. C. F. JENKIN (Messrs. Siemens Bros. & Co.) said that Mr. Dawson at the last meeting spoke almost entirely about the compensated repulsion motor. He should like to say a few words about the compensated series motor, as he regarded the author's remarks, speaking generally, as being equally applicable to the one sort of motor as the other. For instance, it was stated that the range of power was more limited with the alternating-current motor than the continuous-current motor. As a matter of fact, in laying out a motor for a particular service there was no limitation owing to this range of power, and, therefore, it was no detriment to the motor that the theoretical range of power was less in one case than the other. The author also stated that there was also a less favourable speed torque with alternating than continuous current, but he thought this was entirely a misapprehension. If they referred to Fig. 3 of the Paper (Fig. 2, *The Electrician*, January 26. p. 597), where the characteristic curves were given, and very fairly plotted out, it would be seen that the single-phase fell to the left of the continuous-current curve—*i.e.*, for a given tractive effort the speed was lower for the alternating-current motor. In other words, the motor was rather more self-regulating than the continuous current. On such a diagram as this, the shunt continuous-current motor would be represented approximately by a vertical line, and would be rated at constant speed for all torques. Comparing the other two curves with this imaginary straight line, the advantage which the series had over the shunt motor was that it fell to the left of it and the alternating-current still more to the left. The only difference between the single-phase curve and the continuous curve was that the single-phase motor was more self-regulating. The fact, therefore, that the alternating-current curve was to the left was an advantage. The author had referred to the lower efficiency of the alternating-current motor. Figures had been published for the motors used on the Oerlikon line. They were 200 H.P. motors and at full load the efficiency was 92 per cent., and this did not seem to him to leave very much to be desired. The motors were designed in the ordinary way with commutating poles between the main poles, which enables good commutation to be obtained without the use of resistances, or only very small resistances, in circuit with the armature coils, and so saves loss there. Mr. Dawson's remarks with regard to weights were quite fair, and had been checked already. On a line in Germany built by the Siemens-Schuckertwerke, the first line in the world on which series commutating motors were used,* certain calculations were made before single-phase was adopted. When the line in question was taken over, it was partly equipped on the three-phase system and it became necessary to ascertain whether it should be completed or altered. Complete calculations for the three systems were gone into, and the results were as follows: The efficiencies of the systems were reckoned from 'bus bars to the tyres of the wheels. The efficiency with three-phase was 66 per cent., continuous-current 62 per cent., and with single-phase 71 per cent. For the same systems the cost of installation—viz., equipping the line and the motors, worked out in these ratios 116, 125, 100, respectively. It would be seen that the single-phase was 16·25 per cent. cheaper and something like 8 per cent. higher in efficiency. This showed that in some cases single-phase was very much in the running. He would point out, however, that these figures were not applicable in general cases, but only to this particular instance. One statement made by Mr. Dawson as to the advantage of single-phase motors he did not think could be upheld—viz., that the acceleration curve could be made to go up straight from the start, or just after, up to the maximum speed—*i.e.*, that there was practically uniform acceleration up to full speed. That certainly could be done, but it seemed to him to be unfavourable and to involve a larger maximum load on the motor by so doing. The economical load on the motor occurred where the straight line of the acceleration curve finished, and began to go off on to the characteristic curve. With this up to full speed it would mean a higher maximum load on the motor, and he did not think this should be done on a railway. Owing to the method of control the voltage could be raised, whilst accelerating, to a higher value than would be afterwards used when running, and this would enable one to get a form of acceleration curve which Mr. Dawson spoke of, but with the extra load on the motor which he had mentioned. He did not think this system was really available.

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* A description of this line appeared in *The Electrician*, Vol. LIV., p. 787.

Mr. P. V. McMAHON (City & South London Railway), speaking on the question of sub-station efficiency, said that the author gave the maximum as 78 per cent., and Mr. Dawson 74 to 75 per cent., which could be obtained with a continuous-current system. By this he took it was meant three-phase generation and distribution, with transformation at the sub-station. But in the ordinary complete continuous-current three-wire system with sub-stations, with 2,000 volts across the outers and 500 volts on the working conductor, as was the case on the City & South London line, the efficiency of one of the sub-stations, 2¾ miles from the generating station, including every loss, was 86 per cent., and another sub-station, 5¼ miles away from the generating station, gave an efficiency of 81 per cent., whilst the efficiency of the whole line between generating station and the locomotive 'bus bars was 90 per cent.† He would not, however, advocate a system of this sort for heavy suburban traffic such as would be met with on the London, Brighton & South Coast Railway, but he did not see why advantage could not be taken of the three-wire method of distribution combined with the single-phase system. In this way a good deal of the rail-drop would be got over, for a very much higher current density per mile of track could be used without having the same rail-drop and the same troubles from electrolysis. The question of balancing might naturally arise, but years ago there were people who did not believe that the three-wire system could be used at all for traction, but five years' actual experience had shown there was no difficulty in balancing. Originally he had installed large balancers, but the traffic was now balanced so well that the balancers were never used. There had seemed to be some condemnation of the third rail, but he did not agree, for it had many advantages over the overhead system. Probably, if the overhead sytsem were properly constructed, it might be preferable, but the cost would be greater as compared with the ordinary third-rail system. He did not see that points and crossings presented any greater difficulties on a main line than on a tunnel railway. With the use of higher voltages, of course, it might be inadvisable to use the third-rail system, but generally speaking the danger to workmen was merely a question of education, and it might be of interest to state that with 15 years' experience he had never had any accident to a workman due to the 500 volts third rail. He thought the third and fourth-rail system was absolutely barred from main-line working with locomotives. With motor cars there was a longer distance between the points at which the current was taken up on one side and returned on the other. This distance was very short on a locomotive, and he did not think it possible to use the fourth rail under these conditions.

Mr. W. M. MORDEY objected to the author's condemnation of one-phase working, and his conclusion that main-line electrification was hopeless; although the author must logically arrive at that second conclusion if he condemned one-phase working. The author was convinced that nothing could be more effective and economical than the Liverpool–Southport direct-current system. To begin with, this was not direct current—it was alternating current up to the sub-stations. Then, nine people, the speaker believed, had been killed on this line already. Surely high-tension overhead work could not be as dangerous as low-tension direct current. Mr. McMahon was to be congratulated upon his exemp- tion from accidents, but at Newcastle and Liverpool and elsewhere there had been a great many fatalities. Tunnel conditions, as on the City & South London Railway, were quite different from main-line working; no one would dream of running live rails through miles of open country. What was this want of efficiency that the author made so much of? The characteristic curves of a continuous-current railway motor might show that for a large range of output the efficiency was nearly 90 per cent., but reference should also be made to Fig. 7 of the Paper (Fig. 6, *The Electrician*, January 26, p. 598), which gave the train losses. If this diagram were analysed, it would be found that the author—for some mathematical reason which was, no doubt, a good one—had taken the mean running speed and multiplied it by the square root of the stops per mile. Therefore, taking the abcissa 36 in the diagram, it would be found that the train resistance, which was the real thing, accounted for 16·6 per cent. of the energy that reached the train; braking accounted for 53·5 per cent. of the energy that reached the train, and the starting resistances, with all the advantages of series-parallel, accounted for more than driving of the train—viz., 17·8 per cent.; the motor and gear accounted for 12 per cent., or nearly as much as the driving of the train. Further down on this curve the figures got a little better. At 24 the train resistance took 43 per cent., and the braking took 33 per cent. of the energy that reached the train. He did not think single-phase advocates need be very much afraid of not equalling that result. There were two examples of direct-current work—viz., Liverpool, where they boasted—and quite rightly—of a very high result, indeed, in accele- ration. This was a typical suburban line with many stops, short line, good slow average speed, but the energy spent on actually driving the train was 21 per cent. of what reached the train; braking absorbed 50 per cent., and the motors and starting resistances 29 per cent. between them. How were they going to get over that terrible 50 per cent.? In one system, a clever engineer sought to get over the difficulty by placing each station on the top of a little hill, with the result that the efficiency was more than double that of the Liverpool line. The Central London train efficiency was 46 per cent.; their braking accounted for 23 per cent. and the motors and starting resistances—series parallel direct-cur- rent motors—accounted for 23 per cent.; half as much as the train got. Alternating-current motors were condemned by the author on account of their low efficiency. He stated that "the power and energy generated must be"—as if it were a law of nature—"some 30 per cent. greater" with alternating-current motors, because "the efficiency of the direct- current motor was higher." Allowing, for the sake of argument, that the alternating-current motor was lower in efficiency—he thought they were and would be—the conclusion which the author came to was not consistent, because in one part of the Paper he admitted that the all-day efficiency was about 9 per cent. better with the alternating than direct current up to the train, so that he had, on the distri- bution system, recovered that extra loss of power in the motor. Then the author said that power and energy must be about 30 per cent. higher. But why must they? This meant that the plant capacity must be higher and the peak load must be higher. Why must it all be higher? If there was anything in what they had all been be- lieving—that it was better to regulate with back E.M.F. than with wasteful resistances—this could not be true. Let him again, for the sake of argu- ment, admit this extra 30 per cent. loss, even then the author's conclusion was not right. He (the speaker) had made a test some time ago on a one- phase locomotive with this result. There were 15,000 volts on the line at 50 periodicity. He got 34 per cent. more than full load torque with only 38 per cent. of full load current. He did not know the power factor, but taking it at unity, that meant that the difference between the direct current would be as 4:1 in the load on the station with motors in parallel. With the motors in series-parallel the difference would be as 2:1, so that instead of 30 per cent. more it would be 50 per cent. less. It must be remembered that they must have the equivalent of variable ratio gear, and back E.M.F. regulation, and this could only be obtained with alternating current. The author's reference to boosting showed an arrangement that forced the return current into the rails, but the object of a booster should be to get the current out of the rails. Four years ago his friend, Mr. B. Jenkin, and himself read a Paper on this subject before the Institution of Civil Engineers, which was discussed for four or five evenings, but nobody then believed in one-phase working, and at the end of the discussion he (Mr. Mordey) stated that they were prepared to wait for ten years for one- phase working, which they felt must come. They argued that there must be overhead construction for open country work, as well as high tension. If there was high tension they must reduce the pressure at frequent intervals with static transformers, and not rotaries, and this meant alternating current. Further, to work economically, variable ratio gear must be used; that meant alternating current. They must have, or should have, variable E.M.F. so as to use high-tension outside and low-tension in the tunnels and the stations—alternating current again—and they must have overhead line simplicity—*i.e.*, they must approximate to the simplicity of the ordinary trolley system, and this brought them to one-phase working. If that was so, Mr. Jenkin and himself argued, four years ago, they wanted a motor. Since then half a dozen motors had put in an appearance.

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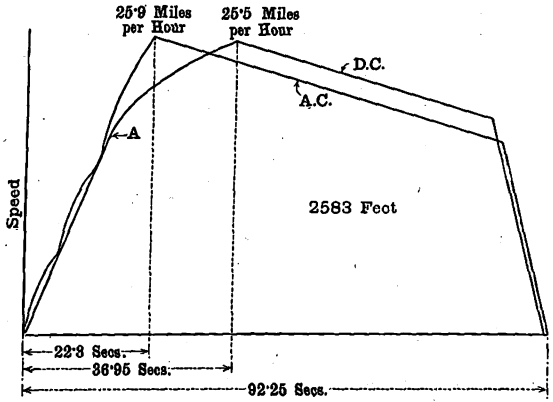
* *The Electrician*, Vol. LV., pp. 757 and 808.

† [This takes account of the fact that a large part of the energy is delivered directly to the line without passing through sub-stations.—ED. *E.*]

Mr. F. W. CARTER then rose to reply to the discussion. He said that if Mr. Mordey would read the Paper again he would see that it did not condemn single-phase current altogether. Anything he had said about single-phase current had been in its application to suburban service only, and to severely suburban service. With a mild service using about the same speed as a steam line, then there was not much to be said against it, but with a severe suburban service he still held that the single-phase alternating-current system would not hold its own against the direct-current system. Mr. Dawson had spoken at length on the Paper, and if he replied to this speaker pretty fully, he would probably cover a good many of the other points raised. In the first place, Mr. Dawson had misunderstood two or three points raised in the Paper. For instance, he had discovered something about the lower power factor of the alternating-current system as compared with continuous current. Whilst he (Mr. Carter) did not admit that the power factor was any higher, he had not said anything about it in the Paper one way or the other. All he had said in that connection had had something to do with the drop in the rail, and there it was only the power factor of the current supplied to the motors. This power factor was unity in the case of continuous-current and less than unity in the case of single-phase traction. Then Mr. Dawson seemed to have discovered somewhere that the Paper made the statement that the multiple unit system could not be used with alternating-current trains. Of course he (the author) knew quite well that the multiple unit system was quite satisfactory; in fact, it was simpler for single-phase than for continuous current because of the absence of the series parallel control. Mr. Dawson seemed to have inferred that in speaking of the alternating-current motor in the Paper he (the author) was referring to some particular type which was not the best type. All he could say in reply to that was that anything he had said was intended to apply as much to the particular type of motor mentioned by Mr. Dawson, and anything he was going to say now could be taken as applying particularly to the motor. Then Mr. Dawson had objected to the statement that the losses in the motor gear and controlling apparatus of the alternating-current system were usually quite as high as in the motors, gears and rheostats of the continuous-current system, and he quoted the motor with which he was acquainted. He had looked this point up, and would admit that with particular ratios of transformers and at a particular load there might be a point at which the loss in efficiency with the alternating-current system was only 4 per cent. less than with the direct-current system, as pointed out by Mr. Dawson, but the average was very much lower. He was not, however, referring to efficiency at any particular point, but to the overall efficiency in service. Mr. Dawson's figures would be sufficient to prove all that he wanted. The curve above showed Mr. Dawson's figures in the form of a diagram. Mr. Dawson gave the figures for the average efficiency of the alternating-current system at 74·2 per cent., and the direct current at 73·6 per cent. Thus the difference in the losses was only 0·6, in spite of the fact that this included a great deal of rheostat loss, which was more than if a scheduled speed was being kept. He repeated, therefore, that the losses in the motors, gears, and the controlling apparatus of the alternating-current system would usually be quite as great as in the motors, gear and rheostats of the continuous-current system, and he was glad to say that he was supported in this by Mr. Dawson himself. There was one point on which Mr. Dawson had been misinformed, and that was where he stated that the motor with which he was acquainted was rated on the same basis as the continuous-current motor. As a matter of fact none of these alternating-current motors were rated on this basis, and Mr. Dawson's motor particularly was not. The 115 H.P. motor to which Mr. Dawson referred, if run giving 115 H.P. through the gears for one hour, would have a temperature rise slightly in excess of 90°C. If it was desired to bring the temperature rise down to 75°C., which was the figure to which it would have to be brought down to put this motor on the same basis as the continuous-current motor, the output through the gears would only be 90 H.P.



Energy consumption D.C. 68 watt-hours per ton-mile.
" " A.C. 63·3 " "
Average efficiency D.C. 73·6 per cent.
" " A.C. 74·2 "

Mr. ALEXANDER SIEMENS here suggested that the temperatures were Fahrenheit and not Centigrade.

Mr. HAMMOND supported Mr. Siemens.

Mr. CARTER referred to the paragraph of the Paper which gave the rule of the Committee of Standardisation of the American Institute of Electrical Engineers, which applied, he said, only to railway motors. This reads as follows: "The commercial rating of a railway motor should be the horse-power output, giving 75°C. rise of temperature above a room temperature of 25°C., after one hour's continuous run at 500 volts terminal pressure, on a stand, with the motor covers removed." Continuing his reply, Mr. Carter said that if this single-phase motor was run on the commercial rating set out in the above rule—viz., 115 H.P. through the gears—the temperature rise would be 90°C., and if it was desired to obtain a temperature rise of 75 deg., only 90 H.P. could be obtained for one hour. Mr. Dawson had given the weight of the single-phase motor at 2·4 tons, which was the correct weight for that motor, including pinion. He (the author) had referred to a 175 H.P. continuous-current motor of 2·15 tons including pinion, which was in common service to-day on the Boston Elevated Railway. Thus, if both motors were rated according to the American Institute rule the direct-current motor would give nearly twice the horse-power. Mr. Dawson had given some comparative figures of train driving for both alternating and continuous current motors, which he recognised as having been given in connection with some curves appearing in the technical journals about the middle of November. But he wanted to show that these curves and these figures had been got up with the special idea of showing the worst features of the continuous-current motor, and were not in any way representative of practice. The curve above, already referred to, was one of these figures. In the first place, the acceleration of the continuous-current motor had been kept down so as to be below the alternating current, or very nearly the same, up to a certain point. It had not been allowed to go up at the commencement. Up to the point A on the curve the loss of energy in rheostats was almost exactly 30 per cent. of the total input, and the loss in the motors was about 12 per cent., so that there was a 42 per cent. loss before A was reached, and, therefore, the efficiency up to that point was 58 per cent. If they tried to start at that point, and did the coasting there, they would get a very unfavourable condition for the continuous-current motor. But it would look a very unnatural curve, so a little speed running had been put in, which was kept as high as possible, to keep the acceleration down, so as to increase the time on rheostats, and the time could be calculated from the dynamics of the thing, and the energy lost was about 15 per cent. of the total input, or something less. This was done in order to make the continuous-current motor appear unfavourable when compared with the other, or rather, to prevent the alternating-current motor from comparing unfavourably. In other words, there had been a disproportionate continuous-current equipment. It could do very much higher service. He could get this himself from other sources of information, but he would show this to be the case from Mr. Dawson's own figures. As he had already pointed out, Mr. Dawson's figures showed that the average efficiency was 74·2 per cent. in the case of the alternating-current motor, and 73·6 per cent. in the case of the direct-current motor, which meant losses of 25·8 and 26·4 per cent. respectively. The loss in the gears was almost exactly 5 per cent, in both cases, and the loss in the direct-current rheostats at least 15 per cent., and in the alternating-current compensating transformer 3 per cent. This showed that there was lost in the continuous current motors themselves 6·4 per cent., and in the alternating-current motors 17·8 per cent. of the total input, and he did not see how this conclusion was to be avoided if Mr. Dawson's figures were correct. Then he would take 6·4 per cent. of the 68 watt-hours per ton-mile shown on the diagram, which was 4·35 in the case of direct current, and 17·8 per cent. of 68 which was 11·25 in the case of alternating current, and this gave the actual losses in watt-hours per ton-mile. The alternating current equipment was certainly heavier than the continuous current—viz., 54,000 lb., against 39,000 lb. for the same number of motors. If the lost watt-hours per ton-mile were multiplied by the weight of the train they would get a result very nearly in the ratio of 1 to 3, which represented the ratio of losses in favour of the direct current—*i.e.*, the alternating-current motor would have to get rid of three times as much heat as the continuous-current motor. With the continuous-current motor they usually worked at as high a capacity as possible, with severe suburban service—*i.e.*, they were taking all they could out of it and had a fairly high temperature. Therefore with three times the heat it would mean three times the temperature if they could only dissipate at the same rate. The alternating-current motor being larger, it should be possible to get rid of a little more, but the ratio would be about 1¼ to 3 instead of 1 to 3 for the two particular motors. Therefore the alternating-current motor was overrun, and was made to do a test which it could not do in regular service, whilst the continuous-current motor was made to do a test which was too simple for it. In fact, there was a bit of both about the matter. As a comparison of the dynamical capabilities of the two motors, Mr. Dawson's comparison was simply worthless, and as a comparison of their service capabilities it was simply ridiculous. Another point of Mr. Dawson's was also a fallacy, as had been pointed out by Mr. Jenkin. Mr. Dawson had claimed as a disadvantage of the continuous-current motor that the acceleration, whilst keeping fairly high up to a certain point, began to fall off and get slower and slower as in that curve, whilst the alternating-current motor could be made to run right up the high peak. As Mr. Jenkin pointed out, this was a very foolish thing to do, although it might be possible, because of the large amount of power required. According to the curve, the power at the point A for the alternating-current motor would be 50 per cent. higher than with the continuous-current motor. What did this mean? Take, as an example, the Central London Railway, where the energy consumption was about 42 watt-hours per ton-mile. The speed was 14·7 miles per hour and the weight of the train 125 tons. Accordingly the average input to the train was 77 kw. These trains had four motors, each of which would take 200 amperes at 550 volts, or 110 kw., and at the point A on the curve, where the acceleration ceased, the total kilowatts would be 4 × 110 = 440. The ratio of the average to the maximum was 440/77 = 5·7, nearly six times the average power. Mr. Dawson might put it up to nine times, but it need hardly be said from an operative point of view that the advantages to be got from that little bit of extra acceleration were more than counterbalanced by the disadvantage of having that high power. One point Mr. Dawson did not mention was that of cost. If anyone went into the question of suburban service, it would be found that the cost would be very much higher for alternating current than for direct current. For long-distance work this would be reversed, but for suburban service he could not see but that it would be higher. Mr. Dawson had mentioned the extra cost of sub-stations. Of course the sub-stations were more expensive, and if only sub-stations were thought of, there would be a strong case for alternating current. But if the system generally were considered, the extra cost of the generating plant for alternating current, due to the extra capacity, owing to the extra weight of the trains for this particular class of service, was an important quantity. Then for the same reason, owing to the weight of the trains, almost all the energy, or a greater part of it, as Mr. Mordey had shown, went in braking, and the operating expenses were greater in proportion to the weight of the train, and the slightly higher efficiency of distribution was not sufficient to make up for this extra loss. It might be asked why such Continental systems as had been installed had been found satisfactory, but the explanation was that these had lower speeds and did not have the severe suburban service which he had provided for. This he had pointed out in the Paper near the end. He saw no reason to change the conclusions he had arrived at in the Paper. Mr. Trotter had expressed the opinion that in alternate-current working the electrolytic corrosion was about one-half that in connection with continuous-current working, but Mr. Schoepf seemed to deny that, and said there was practically none at all. He thought Mr. Trotter was probably right. He did not think the Board of Trade would ever allow 60-100 volts drop in the rails as suggested by Mr. Schoepf, for it would take a good deal of argument to convince them that it would do no damage. Mr. Schoepf had objected to the analytical method, but this was not given in the Paper at all, and he had only mentioned that for certain classes of problems it was easier to use the analytical method. Then the same speaker objected to the figure in the Paper, that the rotary inertia was about double as much in the alternating-current system as in the direct-current system and said that he (Mr. Schoepf) had found it only about 12 per cent. of the weight of the train in the single-phase system. He (the author) had worked out a few of these cases, and it generally came to about 18 per cent., but, of course, this sort of thing could be almost anything, according to the weight of the train and other considerations. The statement was too indefinite for anyone to take too much objection to. Mr. Schoepf had given the weight of a 150 H.P. alternating-current motor as 5,390 lb., and of a continuous-current motor as 5,550 lb., and claimed that this showed they were of nearly equal weight. It would be if they were rated properly, but what was meant by a 150 H.P. motor of the alternating-current type? It was all a question of rating, and unless the rating was precisely similar, such a motor could be called a 200 H.P., and nobody could object. According to his calculations, for suburban service, every type of alternating-current motor was nearly double as heavy as a continuous-current motor, under service conditions. It was not much good to give the weights of the coaches and such things, as they were not comparable. He agreed with Mr. Mordey about the necessity for using single-phase for main-line working. His own remarks had referred to suburban service.

## NOTES ON THE CONSTRUCTION AND MAINTENANCE OF OVERHEAD EQUIPMENT.*

BY ROBERT N. TWEEDY AND H. DUDGEON.

While the capital cost of tramways in Great Britain runs between the extraordinarily wide limits of £10,000 and £24,000 per mile of single track, the cost of overhead equipment may be taken as varying, equally widely, between £700 and £2,000 per route-mile.

*Poles.*—The tendency during recent years has been all in the direction of increased strength and, therefore, weight of poles, while it seems to us, at least, that the greater cost entailed is not warranted. For instance, a certain line was constructed under three contracts. One length of 3 miles is all span wire, and the poles are 29 ft. to 29 ft. 6 in. long, built up of three sections 6½ in. × 5½ in. × 4½ in., out of steel ½ in. thick. Another equal length has poles 31 ft. × 7½ in. × 6½ in. × 5½ in. × ½ in. for all straight-line work, whether span, side bracket, or centre-bracket construction; while the third contains centre, side-bracket and span poles which are all taper 6½ in. × 4½ in. × ⅜ in. Here we have poles of very different sizes doing the same work under the same conditions, and the smallest stand up just as straight as the others. All the sizes cannot be right, and it is plain that the smallest is economically the best. Then the question arises, is the smallest small enough? First, let us see what has determined the size of poles on British tramways. The earliest examples are Leeds, 1891, with light two-section poles, 7 in. × 6 in. × by 4½ in. × ½ in. × 29 ft. 6 in. × 920 lb., and heavy two-section poles, 8 in. × 7 in. × 4⅞ in. × 29 ft. 6 in. × 1,300 lb.; and South Staffordshire, 1893, where on the side-bracket system throughout the taper poles for ordinary construction were 6 in. × 2½ in. × ¼ in. × 450 lb., and for use at loops with longer bracket-arms they were 7 in. × 3¾ in. × ¼ in. × 560 lb. The Kidderminster and Stourport Tramways (1898) afford another instance of a line which had to be constructed in the cheapest fashion if any dividend was to be earned, and the poles here are 28 ft. 6 in. × 6 in. × 3 in. × ¼ in., and 29 ft. 3 in. × 7 in. × 3½ in. × ¼ in. at loops, the weights being nearly the same as the South Staffordshire poles. The South Staffordshire poles are still quite large enough for the work. At the opposite extreme comes West Bromwich, with poles which are monstrous beyond belief. There is no desire to draw a strict comparison between the Leeds and South Staffordshire poles, because much of the Leeds work was span-wire, while the South Staffordshire bracket-arms are very short; nevertheless, where centre-poles and short side-brackets were used in Leeds, one of the South Staffordshire poles would have been almost, if not quite, large enough.

Then we may take Bristol and Dublin, where as many as five different sizes were used in the original construction (P. Dawson), the smallest of them having to stand a lateral strain near the top of 350 lb., and the others 500, 700, 1,000 and 2,000 lb. respectively. The last size may be left out of consideration of the general problem, as it is used for anchoring purposes only. That leaves the 350 lb. pole for the lightest work, the 500 for longer brackets and for straight-line spans, the 700 for somewhat similar duty and for heavier spans and light curves, while the 1,000 lb. pole would be left for all but the heaviest curves and anchorages. As tramways have increased the three light sizes have dropped out almost entirely, and engineers begin now with something like the 1,000 lb.

If engineers could persuade themselves that 18 in. sag in a 30 ft. span and 2 ft. across a 40 ft. road is neither unsightly nor detrimental, and would insist that the span wires are not pulled up any more than that, they would find the light poles which they have cast aside strong enough for 75 per cent. of the construction, allowing heavier poles for curves and the like on 25 per cent. of the line. In average ground with ½ yd. or so of concrete round the pole, 1 in. to 2 in. is quite enough rake to allow when setting. For the average width of street the 500 lb. (lateral strain for 6 in. deflection) pole mentioned in connection with Bristol and Dublin is heavy enough for straight-line work if used in the proper manner. It is not unreasonable to estimate that a saving of £200 per route-mile can be made by following this advice. The height of all the standard poles is 31 ft., but there are many instances, which will increase as the use of guard wires declines, where shorter poles would be as good. That is eminently the case in centre-pole and light bracket-arm work, where it is unnecessary to bury 6 ft. of the pole, and, indeed, we have found a depth of 5 ft. sufficient in straight-line span work of average weight.

*Concrete.*—When poles are subjected to less strain the quality of the concrete setting may be reduced. This costs at present about 9s. per pole for labour and material, and it is usual to find that one bag of Portland cement is allowed per pole. This charge may be brought down to 5s. or 6s. with equal results, and, even with excessive tension on the span-wire, half a bag of cement has been found enough. Naturally, the materials for the poorer concrete must be good; the broken bricks, stone, slag or gravel, clean and wet; the sand sharp and clean, and the whole mixed thoroughly and allowed to set for a week or more.

*Bases.*—Originally intended to protect gas and electric light standards, themselves of cast iron, the cast-iron base was retained by force of habit when steel tramway poles came into use. We suggest that from 6 to 20 tons of cast iron per average mile of tramway, serving no practical purpose whatever, is a luxury. But not only is the base no good, it is actually a negative good: it produces expense. It is usual to bury some inches in the ground, and to make a watertight joint at the top. Thereafter it is not moved, while underneath its well-painted exterior the most important section of the pole is being eaten away. An average base costs from 15s. to 20s., and weighs from 300 lb to 450 lb. If this luxury were relinquished it would make a difference of at least £45 per mile of route for bases alone, excluding materials and labour for caulking, and cost of extra labour and carriage entailed by their presence. Probably the best part of £100 per route-mile would be saved as an average over the whole kingdom.

*Ventilation of Bases.*—If bases are not to be given up, let them at least be drained and ventilated, and if possible let them be designed and erected so that they may be lifted out of the way, to allow the hidden part of the poles to be painted. It is better to steady and centralise the base with distance pieces cast on than to do any caulking, so leaving a passage for air and water. The water must be drained off, and that is facilitated if the concrete setting of the pole is raised in the shape of a cone above the surface of the road or path. With an annular space at the top and drainage at the bottom, there is a thoroughfare which will prevent or minimise sweating.

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* Abstract of a Paper read before the Birmingham Local Section of the Institution of Electrical Engineers on Feb. 14.

*Ventilation of Poles.*—This question of ventilation applies with almost greater force to the poles. The necessity for ventilating such closed spaces is acknowledged by everyone who designs a feeder pillar. If the vents at the top and bottom or at the bottom only are stopped, the state of the switch-panel and of the switch-handles soon tells its tale. Samples on the table will demonstrate more effectively than words one of the evils arising from non-ventilation. These pieces of armoured cable—what is left of them—have been removed from watertight pipes leading from pole to feeder-box. No water could enter via the box, nor at the joint between pole and pipe, nor could it pass from outside by the cables at the top, as these are too well bushed, but the cables may conduct to the pipe the moisture which is deposited on them by sweating; and the fact frequently observed when pulling out the cables, that they are covered with slime from top to bottom, makes this source of moisture indisputable. The cable pipes end in an easy bend, taken into the pole with the end upwards. Notwithstanding all these precautions the pipe filled with water in the course of three or four years, and the cables finally broke down through the armouring to earth. The question of sweating seems to require further investigation, for it is important even when the feeder cables are made of such materials and are treated in such a manner that damp will not affect them, as the poles are reduced gradually by oxidation. Suitable ventilation top and bottom ought to do much to overcome this trouble, and it would help matters to coat the interior of the pole with Angus Smith's compound after manufacture. Experience gathered from various quarters seems to show that "side feeders" or "section cables" should be taken out of the pillar somewhere near the top, passing to the pole in a pipe at that level. Heavily-taped and braided I.R. or V.B. cables are better than lead-covered paper cables, and armouring is unnecessary and objectionable.

*Collars.*—Another luxury, for which there is no more excuse than the base, and to which the objections are even stronger, is the cast-iron collar which conceals the joints in sectional poles. There are two per pole, costing from 2s. to 3s. 6d. each, averaging perhaps 2s. 6d. These run to £30 or so per average route-mile, and are worth saving on that account alone. Like the bases, these collars are rarely, if ever, lifted to paint the hidden parts of the pole, and few people know that they catch and hold rain. If they are examined, many are found to be broken. This follows on the entrapped water freezing. As many as 82 per cent. of the collars on one stretch of line were found in this state. Lift them and a mass of rust is disclosed. The rust holds water like a sponge. If collars are to remain, it is important that they be drained, and that the parts of the pole beneath shall be painted as regularly as the remainder. The last vestige of utility would be taken from pole-collars if the swaged joints were finished taper instead of square,* so forming a watershed as well as a pleasanter sight.

*Section Pillars.*—These may be set on damp-courses with advantage, and the entrance of the cables should be well sealed. It is the practice of some contractors to fill the base of the pillar with bitumen, thus surrounding the cables whenever they leave through the bottom.

*Span Wires.*—For the very reason that poles are too heavy, span wires tend in that direction also. High tensile strength and good galvanising are greater considerations than any other, and 7/15 or 7/14 made strong enough spans for all but very heavy work. Under particularly bad conditions, as, for instance, near chemical works, special precautions have to be taken.

*Bridle and Pull-off Wires.*—The steel wire attached to "pull-offs" should be tied firmly to the eyes, otherwise they become abraded in time, owing to the lift of the trolley poles. If thimbles are used, they take the wear and are satisfactory.

*Guard Wires.*—Guard wires should be tied in at every span to localise breakage, not tied merely to keep them in position relative to the trolley wires. Clamps to perform this duty are sold, and many are in use, but, for the reason which will be given when dealing with "hangers," they ought not to be made of gun-metal. Much trouble from broken guard wires has resulted from this practice. If clamps are favoured against the simpler, cheaper and as effective binding-in, they should be made of malleable iron. It is permissible to insulate such portions of guard wires as lie above specially dangerous points, but proper attention to the overhead construction and the adoption of suitable retrieving trolleys ought to make that kind of thing unnecessary.

*Hangers.*—Other things being equal, gun-metal is the nicest material for the work. It is not liable to rust, and its constituents can be mixed in any proportion to suit the engineer, while it is considered an eminently safe metal when well made. Malleable iron, when made as it should be and as it can be made, is nearly as strong as gun-metal, and is quite as safe in the sizes ordinarily used. Malleable iron goods must be well galvanised before use, and ought to be painted once every two years or so after the first three to five years, except in special circumstances. Economy without the sacrifice of safety can be obtained by the use of malleable iron fittings, and the saving per route-mile will be something like £8 if we assume 100 insulators per mile.

*Local Action.*—Malleable iron hangers have the advantage over those made of bronze that no local action occurs between the span wire and the hanger. This action has not received notice hitherto, but it is marked, and is the cause of serious weakening of the span wire. An excellent instance of this action has come under the direct observation of the authors. On the whole of one route $5\frac{1}{2}$ miles long the hangers are of bronze; on another route 4 miles in length, and a branch of the first, they are of galvanised malleable iron. While the span wires where they clasp the bronze hangers are practically eaten through and have broken in several cases, the galvanising of the span wires under the malleable iron hangers and on the hangers themselves is as good as it was when put up. That is conclusive evidence against the decay of the first span wires being caused by rust. The same action occurs wherever the span wire is attached to secondary insulators in which the eyes are of brass.

*Insulators* divide themselves into two classes, primary and secondary. Of primary insulators, that most commonly used consists of an insulated bolt contained in a metallic waterproof casing, of which the composition has been discussed above. The insulated bolt is exposed from beneath to driven rain, to rain splashed from the trolley-wire ear, and to water thrown during rain from passing trolley-wheels, the last being the most serious, and, until recently, the most unexpected. Water thrown from trolley-wheels contains conducting matter like copper dust from the trolley-wire, brass dust from the trolley-wheel, and graphite or oil from the trolley-wheel bush or bearing; and it is to that extent at least undesirable, as it must deposit in time over the insulated surface of the bolt a conductive layer. But, apart from the deleterious action of the suspended matter, the water itself is injurious to the insulation, as we shall attempt to show. The failure of hanger bolts has been accepted as inevitable, and has been ascribed generally either to bad material or to climatic or local influences.

The first bolts were, and those most commonly used now are, of steel; comparatively lately the steel has been galvanised, and an alternative in the shape of a gun-metal bolt has been introduced. In all cases the average radial thickness of insulation in $\frac{3}{16}$ in., while the length of leakage path runs from 1 in. to $1\frac{1}{2}$ in. The reduction of this leakage path begins from the day of erection, and, sooner or later, depending in some unknown degree on local circumstances, every bolt must fail. First of all, moisture attacks the exposed end of the bolt, and a semi-conducting film is deposited over the whole insulating surface. That may take a year, or two years, or in exceptional circumstances it may take no longer than six months. But the really dangerous action starts when the rust eats under the insulation from the exposed end. Gradually and gradually that process goes on until the cylinder of compressed insulation begins to swell and to crack under the pressure of the increased volume beneath it, and at length there is no effective insulation at all except the $\frac{3}{16}$ in. radial thickness between the bolt and the hanger casing. A little more and that is bridged, with, perhaps, disastrous result. To galvanise the bolt but lengthens the period over which this cycle takes place; it does not stop it. But electrolysis is the main factor concerned in the destruction of both iron and brass bolts, although at first sight plain oxidation seems to be enough to account for the failure of the iron bolts as explained above, and we will leave them for the time in order to consider the history of the brass bolt. Imagine slight leakage occurring over the insulated surface. In the presence of an electrolyte supplied by the trolley-wheels, if by nothing else, particles of brass are carried down the stream and become deposited by degrees over the whole surface, leading finally to failure of the insulation. In the case of the iron bolts the same thing happens, but the deposit of pure iron is oxidised almost immediately and does not afford a good path.

That very fact accounts for the remarkable spreading of the oxidising process, as exemplified by specimens on the table. If the finely-divided iron did not oxidise, the quarry from which the supply is taken would be deepened, while remaining fairly local, until a sufficient film to cause a breakdown is deposited over the insulation, as in the case of the brass bolt. But after every attack the eroded surface oxidises as well as the deposited film, and raises the resistance of the affected surfaces, so that the next attack has to be made from another and easier quarter. These operations recur continually, and their field constantly widens until the metal under the bolt is reached and succumbs in due course. Directly that happens the insulating cover begins to rise off the bolt, and time only—of which there is plenty in five years—is needed to fissure the cylinder and effectually reduce the leakage path and the speed of the action.

A length of 5 miles was equipped with brass bolts; another of 4 miles, in a much less pure atmosphere, but within the same 10-mile circle, had iron bolts. Neither were backed by secondary insulation, except such as might be afforded by sleeves of fibre. During heavy and continuous rain it was always the former line from which came reports of "live poles," although many of the iron bolts had the appearance of being useless as insulators from the way in which the coating was split. It was a noticeable fact that brass bolts lasted for a shorter time, and failed even more suddenly than iron bolts because they give so little visible notice of their intention.

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* Messrs. John Spencer (Ltd.) inform us that to finish the joints taper is impossible, except by the prohibitively expensive method of turning.

There are three ways in which these troublesome and expensive failures may be prevented or alleviated. First of all, we believe that entire prevention can be obtained by the insertion of a shield* between the trolley-wire ear and the hanger, in order to keep the bolt dry. The trolley wheels cannot then throw water into the interior of the hanger, and neither rust nor electrolysis can corrupt. Secondly, the form of the hanger may be altered, making it nothing more than a metallic link between the ear and the span wire, and providing for insulation by means of two (three per span) external and independent insulators. Lastly, the hanger may be composed of homogeneous insulation, such as glazed porcelain, something in the shape of a cable sealing-end, through the centre of which a plain metal bolt is passed. Whatever form the primary insulator takes it must be kept dry, or leakage and carriage of metal will start. Therefore, this porcelain insulator should be provided with a hood of some light material to guard it against rain, and with the shield mentioned above to prevent access of moisture from the trolley wheels.

*Secondary Insulators.*—Those in most general use are of three kinds, known respectively as "Brooklyn strains," turnbuckles, and "globe strains," with a fourth, the porcelain reel, coming into favour. The first two are adjustable. No English linesman wants such devices during the erection of a line, and after this is once done there is still less necessity for them. Nevertheless, both types have been used by thousands, and the illustrations of new lines which appear in technical journals clearly show that their use continues almost unabated. Quite recently an eminent firm of consulting engineers specified "Brooklyns" for the secondary insulation of short flexible suspensions, at a considerable extra cost over the non-adjustable types. It is an axiom that adjustable insulators are not required anywhere on the overhead equipment of a tramway.

Of the other type, that is to be preferred which is the most homogeneous, and has least parts of any kind, and of metal in particular, while giving at least equal results in other ways. On every account the porcelain reel is the one to use. Born under adverse conditions, this insulator has withstood the unclean atmosphere of the Black Country and of the Potteries with remarkable success, and in the larger form shown here it need fear no more expensive competitors.

While in malleable iron the smallest "globe strain" can be bought in large quantities at 8d. to 8$\frac{1}{2}$d., the small reel runs to about 1$\frac{1}{2}$d., and the large to perhaps 3d. Few engineers have considered either the smallest "globe strain" or malleable iron safe to use, and have indulged in the larger sizes, in bronze, at from 1s. 10d. to 2s. 2d., or even 3s. The use of the larger reel, then, will reduce the usual cost per mile by from £8 to £16, and another small saving can be made on flexible suspensions by inserting the reels into special jaws cast on the brackets. In order to simplify matters still further, and at the same time to increase the efficacy of the secondary insulation, a reel with more than one corrugation may be used, preferably one with three, and identical with that proposed above for the hanger. Under such conditions the whole insulation of a span would cost no more than 2s. 6d. to 3s.

*Leakage and Electrolysis across Secondary Insulators.*—Obviously leakage cannot take place across the primary insulator without the consent of the secondary, but luckily the converse is equally true, so that our main efforts should be given to rendering the primary leakage impossible, and the secondary will take care of itself.

That end of a "Brooklyn" or a "turnbuckle" or a "globe" which was attached to the pole—the negative side of that part of the circuit—can be identified by the collection of copper sulphate which has formed close up to the insulation. In the same way the zinc first and the steel next of the span wire where it encircles the reel insulators falls a prey to the action, and gradually changes into a mass of oxide. Probably that was the prime cause of an accident caused by a live span wire which recently cost a certain company some hundreds of pounds in the courts. So marked is this phenomenon after several years that a linesman may save himself time, and his employers money, by inspecting the secondary insulation first. If there is no deposit there is no leak, and the primary insulation is good, and vice versa. As a matter of fact, we do not recommend this method of testing for everybody.

A peculiar instance of the beneficial effect of an accidental occurrence was noticed in connection with this question of electrolysis. Insulated turnbuckles are more liable than any other insulator to rapid deterioration, but on one line on which there were a great number they gave but little trouble. On that line the pole straps were made too narrow to take the insulated end of the turnbuckle, so, contrary to custom, the metal eye was made negative. When used in the orthodox style, electrolytic action removes iron or brass from under the open end of the insulating material and splits it up as in the hanger, while turned the other way, with the insulator next the span wire, the metallic ring or thimble is eroded and deposited over the negative surface of the insulating material and over the metal, but without any splitting taking place. For that reason it is better to use iron rather than brass, or the same troubles will arise as with brass hanger bolts.

That electrolysis is the cause, and not ordinary rust, is proved definitely by the specimens submitted, which are fairly representative of the bulk. Here are two turnbuckles which have been attached to the span wire and pole in opposite directions. The leakage current left one at the insulated end, and in consequence the iron stalk is reduced from $\frac{1}{2}$ in. to $\frac{1}{4}$ in., and the insulation is spread out like a half-opened umbrella, but the stalk at the other end is reduced very little, and that quite evenly. On the other, the current left at the uninsulated end, and electrolysis has carried iron from the thimble or bush which passes through the centre of the insulation, over the length of insulation separating the thimble from the stalk, and has deposited it over the original galvanised surface, as may be seen by scraping off the layer of what is now oxide of iron. The quarry from which this deposited iron was hewn is plainly to be seen in the form of an irregular scar about 1 in. by $\frac{1}{2}$ in. by $\frac{1}{8}$ in. to $\frac{1}{4}$ in. deep, and the path taken by the metal can be traced by the "sign" of yellow rust. Except for a little surface rust the remainder of the turnbuckle is in excellent condition.

As we should expect, this action is much more rapid where there is only one insulator between trolley-wire and earth, or where the primary insulation is defective. For instance, the secondary insulation at certain types of section insulator deteriorates more quickly than those on the next poles, where there are ordinary hangers. The value of a section insulator can be assessed accurately by taking such observations. One of the turnbuckles exhibited comes from a section-span, and is worse than its mate because the pole to which it was attached is bonded to the rail. The leakage paths were of unequal value, so the erosion or solution and the deposition were unequal.

If the other types of secondary insulators are examined the characterists of electrolysis will be found invariably. On brass "globe strains," copper salts at one end deposited over the original surface, and at the other reduced section and the insulation a little disturbed at the edges; on "Brooklyns" the same, and on reel insulators the galvanised span wire in good condition everywhere but round about the best path for current to get to the pole, and there no galvanising and the steel disappearing.

(*To be concluded.*)

## ELECTRIC IGNITION FOR MOTOR CARS.*

BY FRANK LITTLE.

There are two systems of electric ignition in use on motor cars, either of which is capable of giving satisfactory results. These are known as the low-tension and the high-tension systems. The low tension requires a "make-and-break" device inside the combustion chamber, operated from the outside usually by a cam on the valve-gear shaft. This system has the advantage that all the wires are easily insulated, owing to the low voltage of the circuit. The high-tension system is not so simple, and is more likely to break down, owing to the higher voltage. In the high-tension system there are no moving parts within the cylinder, but there is greater difficulty in insulating the conductor of the secondary circuit on this account, which may be as great as 30,000 volts. With the low-tension system it is important that the break between the sparking points in the cylinder should be as rapid as possible. The sparking points require to be in contact long enough to ensure thorough energising of the magnetic core, and with fast-running motors this matter becomes important. Too short a contact will so reduce the spark as to render the ignition of the charge very uncertain, and too long a contact will be wasteful of current. The current should be allowed to flow in either high or low-tension coils for from 0·03 to 0·05 second.

In the case of high-tension systems with a non-trembler coil there must be a separate make-and break device, mounted and operated by the engine half speed shaft. When the trembler forms part of the coil a contact mechanism—often miscalled the commutator—is required. This usually consists of a simple wipe contact. The contact strip requires to be designed with a view to the current being allowed to flow for a sufficient time for energising the coil at the highest speed it is intended to run the engine. Obviously this will involve a certain waste of current at slow speeds, but to compensate the apparatus to give equal time of contact at all speeds would add more complications than the saving in current consumption would warrant.

The timing of the moment of ignition is usually regulated by hand, but it would seem advisable to provide automatic means for doing this. To get the best output from an explosive engine you must ignite at the best moment, which is an art only acquired by experience. The finding of the happy medium is left to the activity and skill of the driver in most cars, which I maintain is wrong, especially on commercial motor vehicles, which have to be handled by unskilled men. It should be remembered that increased speed of the engine requires earlier ignition. The complete ignition of a cylinder full of gas takes an appreciable time. One reason for moving the ignition spark to an earlier moment when running faster is owing to the lost "time in" due to the inertia of the trembler becoming relatively important at the high engine speeds. To supply the current necessary for the production of the spark, we must have primary or secondary batteries, a magneto or dynamo-electric machine. Magneto machines are used without a coil if the low-tension system is employed with a make-and-break inside the cylinders, but they may be used in conjunction with an induction coil and the usual sparking plug. Dynamos are not much used in this country, but there are several makes of cars which have both dynamo and storage batteries fitted. With this arrangement the storage battery is always kept fully charged. An automatic cut-in and cut-out is fitted, so that the dynamo is only in circuit when running at its proper speed when the battery is cut out. The dynamo should be designed so that its output is fairly constant at varying speeds.

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* British Patent No. 13,062/05.

* Abstract of a Paper read on February 5th before the Newcastle Section of the Institution of Electrical Engineers.

Some cars are fitted with accumulators as well as the magneto—that is, when the magneto is of the high-tension type, working on ordinary sparking plugs which are arranged to switch over from one system to the other, the accumulator being used chiefly for starting, and the magneto is then switched on to do the bulk of the running work. With multi-cylinder engines it is very often possible to start the engines by merely switching on the current.

On some cars using the high-tension system the source of current is obtained from a battery of dry cells. They are not, however, as satisfactory as accumulators, and when run down cannot be recharged. A set of dry batteries, however, is useful to have as a stand-by when touring should the accumulator run down.

The chief consideration in the design of sparking plugs is to prevent leakage at any point other than the air-gap or field of work between the points in the combustion chamber. The materials used for the insulation of this high-tension terminal are invariably either porcelain or mica. The disadvantage of porcelain insulation is that it is liable to crack from heat or mechanical injury. In the case of the latter the layers of mica are liable to separate, in either case a short-circuit in the secondary being formed. In the best plugs of to day, however, there is comparatively little trouble.

The desired quality in a trembler coil is certainty of action in combination with high speed, and if we take as an example an engine operating at 1,500 revs. per min., the half-time shaft on which the commutator is mounted, consequently making 750 revs. per min.; and if we further take the segment as 50 deg., or one-twelfth of the contact surface (as is usual), it will be seen that the coil must work at a speed of 9,000 per minute in order to get in one spark during the period of conduction, and that to get three sparks produced before contact is broken the periodicity of the trembler blade must reach 27,000 per minute. High as this speed may sound, it has been exceeded by several trembler coils on the market.

As the "sparking length" of a coil is considerably reduced when the discharge takes place in a dense medium, such as the compressed charge in the combustion chamber, it is advisable to have a coil capable of giving a spark fully $\frac{5}{8}$ in. in air. As this will require an E.M.F. of fully 30,000 volts, and possibly more, the necessity for perfect insulation will be evident. The use of an external spark-gap in series with the sparking plug is not always to be advised. The increased resistance offered to the passage of the secondary current increases the risk of the discharge taking place inside the coil itself, and once this occurs the coil will be ruined. In any case, the external spark-gap strains the insulation of the secondary winding, so to speak, and when it is intended to use this accessory, the coil should be specially insulated.

## DISCUSSION.

Mr. C. FARADAY PROCTOR asked what were the actual volts and amperes generated by these magneto machines.

Mr. HUNT wished to know whether fires had ever occurred on motor cars in consequence of the inflammable nature of the celluloid cases in which accumulators were very often placed.

Mr. CARTY did not like low-tension ignition with make-and-brake inside the cylinder, as the joint for this apparatus often leaked and caused loss of compression. He had found that large spark-gaps were better for low engine speeds and small gaps for high speed; the more usual length was about 1 mm. Referring to dual ignition, he asked if Mr. Little considered it advisable to have two distinct systems of wiring, plugs and switches.

Mr. LITTLE, in reply, said that he had not measured the actual output in volts and amperes of any magnetos used for this purpose. The usual distance for spark-gaps was about $\frac{1}{32}$ in. Dual ignition systems were usually quite independent systems with separate sparking plugs.

## WAVE-LENGTHS IN WIRELESS TELEGRAPHY.

BY H. J. ROUND.

In the choice of a wave-length to be used in a wireless circuit many factors have to be considered, some of the more important of which are, terminal conditions, interference from natural electrical discharges, interference from other stations, distance to be worked and the nature of the surface to be worked over.

The chief limiting terminal condition is the impossibility in certain circumstances of constructing a radiator which is properly efficient. A radiating system consists of an antenna or aerial wire connected with the earth, the energy being supplied by one of several possible methods near the junction of the wire and earth. The three chief factors in the system are size and height of aerial system and quality of the connection to the earth. On land the practical height is limited to about 230 ft., but given plenty of ground around the station the antennæ system can be made as small or as large as required. The earth connection does not give the trouble now that it did before it was understood that a capacity connection to earth, if large enough, was just as satisfactory as a direct connection. On board a ship the earth connection, if properly arranged, is perfect, but the height and size of aerial wire available is very limited. The maximum radiation seems to be obtained from a system when the wave length used is of the order of the fundamental oscillation of the system with no extra inductance in. The wave length of a system can be increased by the addition of inductance coils between the aerial wires and the earth, but the maximum radiation is only obtained when the inductance is a minimum. Consequently on a ship one is limited by inability to properly radiate waves of over 2,000 ft. in length. There are, of course, other limiting conditions which will come in in special cases.

The most serious trouble that practical wireless telegraphy has had to contend with up to the present time is natural electrical discharge. The nearer one is to the equator the more serious does this trouble become. Summer time is much worse than winter in this respect, but the trouble is likely to occur anywhere where there is context of large bodies of land and water. The natural electrical discharges appear almost invariably more serious the longer the wave-length employed.

It is nearly always possible in practice to work even with faint signals with wave lengths under 500 ft. in length, the only exception being when a heavy thunderstorm is in proximity to either of the working stations, but the use of these short waves is limited to about 100 miles sea range. Wave lengths of the order of 1 000 ft. are more seriously interfered with, and when waves of 5,000 ft. are used electrical discharges can be heard practically at all times, and in the summer time would interfere seriously with the reception of all but the very strongest of signals. Large antennæ systems are particularly subject to interference of this kind.

Interference from other stations is not at present a serious question, unless the interfering is deliberately and scientifically done at a moderately short range. With signals of equal intensity from the foreign station and the station desired to work with, a 10 per cent. difference in wave length serves easily to eliminate the interference, and the wave length can be made still more different than this from the foreigner.

Wave length and distance to be worked over are connected owing to the fact that at the present time only one method of transmission over considerable distance is known.

The energy of a spark discharge in a primary oscillating circuit is radiated in every direction. The amount of energy in the primary circuit is regulated by the capacity of the circuit and the spark length, the former practically regulating the wave-length.

The spark length cannot be indefinitely increased as, above a certain length, waste is introduced. Many methods of overcoming this waste have been proposed, such as sparking in compressed air, in the cold vapour of liquid air, &c., but although each method has had a good trial it has finally been rejected. The only remaining method of obtaining more energy in the circuit is by using larger condensers, and this at once lengthens the wave. Practically speaking, at present if one wants to increase the distance signalled over, one has to increase the wave-length.

Much has been written about the difference between sea and land working. Distance of sea working, using the same energy and different wave-lengths does not vary greatly although there is probably an advantage in favour of longer wave working. Over land it is different. Using the same amount of energy the advantage of increasing the wave-length is at once shown.

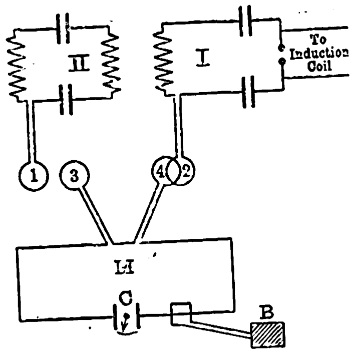
The law governing this undoubtedly depends on the quality of the ground, the amount of hills, &c., but up to a certain point, probably when the wave length begins to get too large for the radiating system used, signals get stronger the greater the wave-length used. Day and night signals vary greatly with the shorter waves, but tend to equality as the waves are lengthened.

These considerations are taken into account when a wireless circuit is designed, and, as the second consideration is of great importance, the minimum wave-length compatable with distance is usually chosen. Over great distances only very long waves are possible, as the energy required is very large, and then the only hope for good working is that the signals shall be stronger than any interference. No doubt there are other solutions possible; the perfect syntony that would be obtained if a continuous wave could be produced would make the elimination of interference a simple matter. Also, if the energy at present radiated in all directions could in some measure be concentrated in the necessary direction, a satisfactory solution of long-distance working with moderate quantities of energy and moderate wave-lengths would be obtained.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

*Coupled Oscillators.*—If two condenser circuits or other electric oscillators of the same frequency are not coupled extremely loosely, we know that in each circuit two oscillations of different frequency and damping are generated. If these two oscillations are, in accordance with the Hertz-Bjerknes method, made to act upon a condenser circuit of variable frequency, resonance curves with two maxima are obtained. The frequencies and decrements are easily measured by that method if the circuits are fairly closely coupled, since in that case the two maxima are separated by a region of zero resonance. But when the coupling is loosened, the two maxima gradually coalesce, and the Bjerknes method can no longer be employed. For this case C. Fischer has worked out a new method proposed by Zenneck, by means of which each of the two maxima can be studied separately on Bjerknes' principle. It is essential that the oscillations of the same frequency in the two systems shall have nearly the same phase, or else differ by 180 deg. The arrangement is shown in the diagram, where I and II are the oscillators, B a bolometer, C a variable condenser, and M the measuring circuit. If 4 is coupled with 2, and the measuring circuit is brought into resonance with one of the oscillations, then on adjusting the coupling of 1 and 3 to a minimum, the only maximum shown is that of the other oscillation.



[C. Fischer, *Annalen der Physik*, No. 1, 1906.]

*Polonium and "Radio-tellurium."*—Madame Curie has undertaken further researches into the rate of decay of the radio-activity of polonium, in order to establish its identity with Marckwald's "radio-tellurium." She finds that, like other radio-active bodies, it obeys a simple exponential law. If $I_0$ is the initial activity, $t$ the time, and $a$ a constant, the activity at any time is given by

$$I=I_0e^{-at}.$$

If $t$ is expressed in days, $a=0{\cdot}00495$, so that the intensity of radio-activity falls to half its value in 140 days. The constant $a$ is as characteristic of the substance as a spectrum line. For his radio-tellurium, Marckwald found $a=0{\cdot}00497$, practically a complete identity. "Polonium" having had priority of discovery (being named after the authoress's country), that name should displace the name "radio-tellurium."

[Sklodovska Curie, *Comptes Rendus*, January 29, 1906.]

*Double Range Portable Electroscope.*—C. T. R. Wilson has designed a gold leaf electroscope which reads from +5 to −5 volts and also from 95 to 105 volts, and, therefore, allows of leakage observations both at high and at low potentials. The gold leaf is suspended inside an insulated brass sphere charged to a positive potential of 50 volts. When the leaf is earthed, it differs in potential by 50 volts from the sphere, and is deflected away from its vertical support. A small positive potential makes it fall, and a small negative potential makes it rise. On increasing its positive potential it gradually falls to a minimum deflection, which it reaches at 50 volts. On further raising the potential of the inner coating of the small Leyden jar with which the gold leaf is connected, the latter rises again, and reaches at 100 volts the same deflection as it had at zero potential. The scale will then be the same, only reversed. The gold leaf used is 1·1 cm. long and 0·2 mm. wide, giving a deflection of 0·1 mm. per volt. The gold leaf system is charged through the intermediary of a sliding condenser, which gives complete control of the potential. The readings of the instrument are very steady; owing, no doubt, to the double case there is apparently a complete absence of disturbances due to convection currents. The gold leaf takes up its position of equilibrium within a small fraction of a second, so that very rapid potential changes can be followed.

[C. T. R. Wilson, *Proceedings* of the Cambridge Philosophical Society, January 31, 1906.]

*Discharge from Hot Platinum.*—It is known that hydrogen has a marked power of increasing the negative leak from metals. O. W. Richardson proves that this is not an action in the interior of the platinum, due to the absorption of hydrogen, but a surface action. The method adopted was to measure the saturation current from the outside of a hot platinum tube to a surrounding cylinder in air, both when hydrogen was diffusing from the tube from inside and when it was not. The surrounding air would of course oxidise the hydrogen as fast as it came out, and thus keep the surface in a constant state, so that presumably any change in the leak would be due to the hydrogen and not to a change in the platinum surface. Even when hydrogen was allowed to diffuse through the tube at a rate equal to 2 c.c. at 76 cms. pressure per sq. centimetre of surface per minute, not the slightest change could be detected in the value of the negative leak. This result points strongly to the conclusion that the increase in the ionisation observed in an atmosphere of hydrogen is not due to the presence of the hydrogen in the metal as hydrogen, but to some alteration it produces in the superficial regions of the metal. The hydrogen acts by producing a change in the wire, which takes a long time to complete itself. The results appear to be capable of explanation by assuming that the positively charged hydrogen forms a double layer at the surface of the platinum which helps the electrons out. The positive leak, on the other hand, is directly proportional to the amount of hydrogen diffusing through.

[O. W. Richardson, *Proceedings* of the Cambridge Philosophical Society, January 31, 1906.]

*Canal Rays.*—J. J. Thomson has studied the properties of the canal rays obtained by means of a perforated cathode by allowing them to impinge upon a charged metal plate mounted in an auxiliary tube at angle to the path of the rays. When the canal rays strike against a solid they cause it to emit cathode rays moving with small velocities. This can easily be shown by charging the metal plate, against which the canal rays impinge negatively to a potential of, say, 80 volts, then from the part of the plate struck by the canal rays a pencil of feebly-luminous rays can be seen. These rays are easily deflected by a magnet in the direction indicating a negative change. The canal rays ionise the gas they traverse, and the presence of electrons is proved by the deflection of portion of the beam towards the plate when charged positively. When the canal rays, consisting as they do of positive ions, lose a certain portion of their velocity, they combine with electrons to form uncharged molecules or atoms. This critical velocity is about the order of $10^8$ cm. per second, but is higher in the $\alpha$-rays of radium. The canal rays disintegrate a metal plate against which they strike, for after a long-continued bombardment of the metal plate the walls of the tube in the neighbourhood of the plate are found to be covered with a deposit of the metal. When the canal rays impinge on a salt of sodium the salt gives out yellow light in which the D line is very bright. It is remarkable that this line is not given out when canal rays impinge on the metal sodium itself. A mirror of sodium with specks of oxide on it presents a beautiful appearance when struck by these rays. The spots of oxide shine out brightly with a greenish-yellow light, while the surface of the metal itself seems quite dull if no external light falls upon it.

[J. J. Thomson, *Proceedings* of the Cambridge Philosophical Society, January 31, 1906.]

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## "ELECTRIFIED" RAILWAYS.

Electrical engineers need not be alarmed by the reports of one or two railway companies who have just completed the electrical equipment of their lines and have found that the economies promised are not immediately apparent, and, in fact, that in some cases there has even been an increase in the working costs. The reason is merely that the permanent conditions of working have not yet been reached, and in some cases there is still a double organisation—a combination of that required for the steam and electric service. Moreover, apart from all questions of economy in working expenses, there is no doubt that the chief effect of a change from steam to electric driving on suburban lines is an increase in the traffic owing to the greater speed and convenience of the trains, and this cannot have its full effect during the experimental period of the "change-over." A contrast to the unfavourable reports to which we have alluded is that of the North-Eastern Railway Co., whose suburban lines in the Newcastle district have been running since the spring of 1904. In the last half-year of 1903 the bookings with steam-driven trains numbered 2,884,000; in the last half-year of 1905, with electrically-driven trains, they were 3,548,000, an increase of 23 per cent. The corresponding increase in the gross receipts was from £129,000 to £151,000, or 17 per cent. As in most cases, the introduction of electric driving was made the opportunity for the inauguration of a new system with smaller trains and a more frequent service, and the running costs went up 12 per cent—from £42,761 to £47,779; but this was for approximately double the number of trains, so that the cost per train-mile showed considerable reduction. Including all repairs and depreciation of rolling stock, the cost per train-mile with electric traction was 9d., as against 1s. 5½d. with steam. From the above figures it will be seen that the gross profits from the electrically-driven lines have increased by 20 per cent., and that there is every prospect of a further increase.

Sir GEORGE GIBB, who has been General Manager of the North-Eastern Railway, has now been chosen as Managing Director of the Metropolitan-District Railway, and he will, we hope, demonstrate the advantages of electric traction on this line in a precisely similar way. The Metropolitan-District is among those railways which have not yet shown a direct financial profit from "electrification," but it must not be forgotten that the entire supersession of the steam locomotive did not take place until last December. The presence of some steam-driven trains between the others prevented the line from profiting by the increased acceleration of the electric trains, and although the new ones traversed the distance between stations in quicker time, the time-table had to remain unaltered. In addition to this the six months in question were the transitory period of the change of organisation, and thus the expenses must necessarily have been higher than under permanent working conditions, and the running costs have actually been greater than with purely steam traction. It is safe to prophesy a reversal of these results during the next 12 months. The same remarks apply to the Metropolitan Railway. Although this railway made more rapid progress than the Metropolitan-District in the electrical equipment at first, it is now more severely handicapped, for the steam trains from the extensions to Hammersmith and Addison-road, owned jointly by the Metropolitan and Great Western Companies, still run on the north side of the Inner Circle. They will very shortly be drawn by electric locomotives (in the same way as the London & North-Western trains on the south side of the Inner Circle) pending the completion of the generating station at Park Royal and the electrical equipment of the track on the extension, but the locomotives have not been delivered. The same applies to the through trains running beyond Harrow, which will be drawn by electric locomotives between Harrow and Baker-street. Five locomotives have just been delivered, so that it may be hoped that the conditions will soon be improved. Notwithstanding these adverse circumstances, which have increased the working costs, the number of bookings on the Metropolitan Railway has greatly increased, and the Company is in a fair way to recover the traffic it lost on the opening of the Central London Railway.

Of the "electrified" steam lines, the most disappointing of all has been the Lancashire & Yorkshire Railway. The electrical equipment of the Liverpool–Southport–Crossens line was completed at about the same date as that of the Tyneside lines of the North-Eastern Railway, and its prospects should be as good. Yet, although there has been an increase in the number of passengers, this has been set off to some extent by a slight increase in the running costs which is still maintained and has diminished the benefit arising from the electrification. Still the system is said to work smoothly and well, and the directors are sanguine that a further improvement will be effected. As we have already pointed out, the full realisation of the economies in organisation consequent upon the introduction of electric traction is impeded considerably when steam trains still run on the same lines. Possibly this is the reason why the advantages of electric traction have not yet been so apparent on the Lancashire & Yorkshire Railway as was expected.

Taken as a whole, therefore, the electrical engineer and the general public may be satisfied with the progress that is being made. There can be little doubt that electrical equipment is the correct policy for managers of suburban railways to pursue. Let them not be deterred, however, by the alternating *v.* continuous-current battle. For main lines, it is believed that the single-phase system will give the best results of any, and it may also be preferable to the continuous-current system on suburban lines. But the railway manager may take it as an axiom that, no matter which system is chosen, electric driving is more economical than steam driving on a suburban railway.

## REVIEWS.

**(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign book.)**

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**Physics.** By C. H. MANN and G. R. TWISS. (Chicago: Scott, Foresman & Co.) $1.25.

The preface to this work informs us that within the last 20 years the methods of teaching physics have been revolutionised. A glance at the pages of the volume is sufficient to show this. The title had led us to expect contents of a ponderous nature, but on turning over the leaves we find the letterpress livened up by some 200 illustrations, mostly from half-tone blocks, representing a wide range of subjects but distantly related to the test. For example, in a chapter headed Mass and Energy we have a charming little picture of two men ploughing to illustrate the principle "work is proportional to force and distance" and, on the next page, a photograph of a man loading hay into a bullock waggon is explained by the sentence "a man cannot work unless he consumes food." The authors have adopted this course because, in their opinion, the present methods of instruction have failed to arouse in students that real enthusiasm for the pursuit of the subject which is indispensable for the mastery of its principles. Apart, however, from the illustrations, the treatment of the various subjects is sound, although, of course, somewhat sketchy, owing to the wide range covered. The earlier chapters deal with the conceptions of mass, energy and motion, and are followed by a short chapter on heat and work, too short to be of any practical use and containing paragraphic references to gas engines and steam turbines. The space devoted to electricity and magnetism fills about a quarter of the book, but the superficial nature of the information imparted is apparent from the fact that the chapter on magnetism contains no closer reference to the relation between flux density and magnetising force than the statement that magnetic force acts more easily through iron than through the air. The two following chapters, entitled Wave Motion and Simple Harmonic Motion respectively, are the best arranged portion of the book. After some readable chapters on sound and light, the volume concludes with a dozen pages on "electrons," which give a short but clear account of some of the more important results of recent researches. The latter portion of the book is distinctly better than the early chapters. The authors have undertaken a difficult task in attempting to serve up a palatable dish of so many ingredients and have acquitted themselves on the whole well, for their straightforward writing and logical sequence have lifted their work above the level of the little volumes so often met with, which can only be described as compressed tabloids of information.

**La Séparation électromagnétique et electrostatique des Minérals.** By RÉSIRÉ KORDA. (Paris: *L'Eclairage Électrique.*) 1905. 6fr.

M. Korda has produced a notable book, extremely topical. Old methods of dressing minerals are being supplemented and replaced by new devices ranging from surface flotation to static attraction. In early days minerals were separated from their worthless concomitants by the selection afforded by eye and hand, a little later gravity was invoked and various systems of levitation were devised. Then it was found that the size of the particles counted as well as their intrinsic weight, and, as a result, elaborate methods of crushing and sieving were employed. In this way one physical property of matter was turned to account; others are now being utilised. The different behaviour of different materials when given a "static" charge, typified by the classical experiment with red lead and sulphur, has been pressed into service and has been tried on a practical scale. Electromagnetic methods have passed far beyond the tentative stage, and in their various modifications are in operation industrially. From the old idea of picking iron or some ferruginous mineral out of an indifferent mass we have passed to the notion of separating minerals according to their magnetic behaviour, and no longer regard it as necessary that they should stick to the poles of the magnet. It may be said without qualification that the book is good. It is written with learning and judgment, and is so easy to read that it must have been extremely difficult to write.

**The Science Year Book.** Edited by Major B. F. S. BADEN-POWELL. (London: King, Sell & Olding.) 5s.

The second annual issue of this book opens with a portrait of Sir William Huggins as frontispiece, and contains a number of additions and improvements on the original edition. The astronomical section includes some new maps, and charts of magnetic variation and rainfall have been added. The progress of science during 1905 is well summarised in a series of articles by various authors, that on electro-technics being from the pen of Prof. W. E. Ayrton. A list of scientific and learned societies and a brief "biographical directory" are also included in the book, the greater portion of which, however, consists of a full-page diary. The arrangement of the calendar, which is seen through an opening in the cover, is convenient, each month being torn out when done with.

## THE DARTFORD URBAN DISTRICT COUNCIL LIGHT RAILWAYS.

The system of tramways opened on Wednesday last at Dartford comprises some six miles of route, and connects the town of Dartford with the existing tramways of the Bexley Urban District Council, and through these to the Erith tramways, as shown in the accompanying map (Fig. 1). The first negotiations for the construction of tramways in Dartford date back to the year 1900, and the original order was confirmed by the Board of Trade in 1902. In the same year application was made for an order authorising extensions to form a connection with the Gravesend and Northfleet tramways at Greenhithe, but owing to the opposition of the South-Eastern & Chatham Railway Co. the scheme for these extensions fell through. The route sanctioned, therefore, terminates at Horn's Cross, about a mile and a half from the commencement of the Gravesend and Northfleet tramways. The contract for the construction of the whole of the line, with the exception of the power plant, was eventually let to Messrs. J. G. White & Co., and this firm also secured a lease of the light railways for 15 years, terminable at the end of 5 or 10 years at the option of the Council. The capital cost of the construction was defrayed by the Council, Messrs. White paying the interest and sinking fund charges during the term of the lease. The ground was opened on July 12th last year, so that very little time has been lost in the construction of the lines.

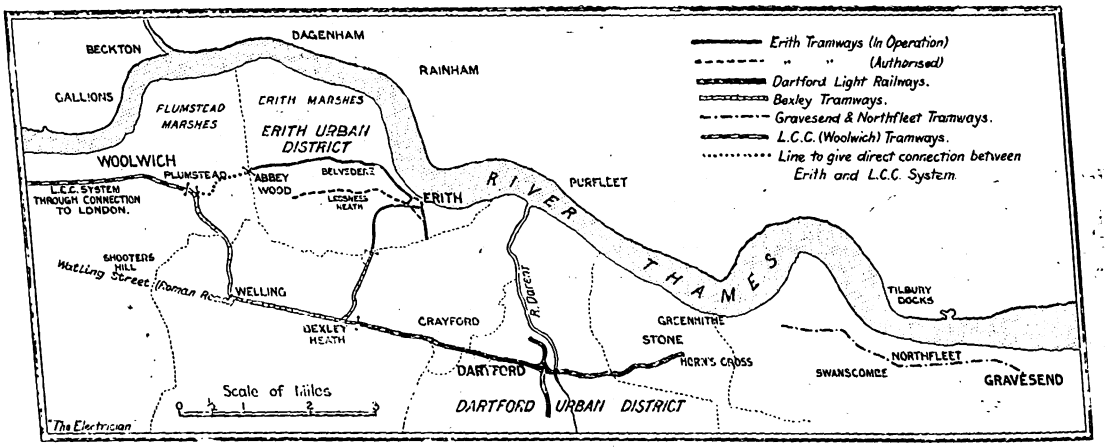

FIG. 1.—MAP SHOWING POSITION OF SYSTEM WITH RELATION TO OTHER LINES.

The line was formally inaugurated on Wednesday last by Mr. J. Lawrence Mitchell, chairman of the Urban District Council of Dartford, and after a pleasant trip over the route in three cars, gaily dressed with bunting, a large party sat down to lunch at the "Bull" hotel, Mr. Lawrence Mitchell being in the chair. A number of speeches were made, the toast of "The Press" being proposed by Mr. Rowlands, the newly-elected member of Parliament for the Dartford division. Other speakers included Mr. Vaughan, chairman of the Maidstone Corporation Railways Committee; Mr. Keyes, chairman of the Dartford Urban District Council Railways Committee; Mr. Zeden, one of the consulting engineers; and Mr. Balfour, of Messrs. J. G. White & Co.

The consulting engineers to the scheme are Messrs. Hawtayne & Zeden, who have kindly put drawings and details of the work at our disposal. The tramways manager is Mr. A. D. Murdock, and Mr. J. D. Pember is acting as resident electrical engineer. The line is entirely on the overhead trolley system, and, as mentioned above, Messrs. J. G. White & Co., were the main contractors for the permanent way, feeders, cars and electrical equipment. Excepting for one short gradient of 1 in 12 and two of 1 in 13½ and 1 in 15½ respectively, the gradients met with on the line are only of a slight character.

The permanent way is of ordinary standard construction, with 100 lb. rail of British standard section in 60 ft. lengths from the North-Eastern Steel Co., Middlesbrough. The special work is of Messrs. Hadfield's manganese steel, and the track is bonded with double concealed bonds of 4/0 B. & S. gauge, further cross bonds being provided every 40 yds. The rails are mechanically coupled by continuous rail joints, weighing about 96 lb. per pair, all joints being anchored to the concrete underbed. Automatic spring points are used at all the crossings.

The greater part of the overhead work is of the bracket-arm pole type, but cross suspension is made use of in a few places. The poles were supplied by Messrs. Stewart & Lloyd, and are 31 ft. in length, made up of three sections of solid drawn steel tube. The heavier poles weigh 1,220 lb. each and the lighter poles 870 lb. A 2/0 (B. and S.) copper trolley wire is used, flexiby supported from the bracket arms on the span wire in the usual manner. The ears are of the soldered type, all the castings being of bronze. Where the trolley wire passes under the S. E. & C. R. bridge a special wooden troughing shown in Fig. 2 is provided above the wire.

The feeder arrangements are quite simple, owing to the situation of the generating station near the centre of the line. Two main feeders run from the power house in opposite directions along the route, a short branch feeder being taken from one of these to a feeding point in Sowfield-street. The other five feeding points are on the main road. The section pillars contain the usual switchgear and telephone connections, and were supplied by Messrs. Henley's, who also supplied and laid the paper-insulated feeder cables. These are, wherever possible, laid in troughing run in solid and placed under the footpath.

Twelve double-deck cars, 27 ft. 6 in. in length, have been supplied by the United Car Co., of Preston, each to seat 56 passengers. The cars are mounted on Brill 21 E type single trucks, and are equipped with Messrs. Dick, Kerr & Co.'s motors and controllers and the Westinghouse magnetic track brake, in addition to the usual hand brake. Each car is provided with two motors rated at 30 B.H.P. and each capable of a tractive effort at 1,100 lb. at the car wheels at a speed of 8 miles per hour. The bodies are good examples of modern practice, and are tastefully finished both inside and out. Semi-reversed stairways, collapsible gates and folding steps are fitted, and the cars are provided with the Tidswell trigger-type lifeguard; 17 incandescent lamps are used to light each car, not including the illuminated route indicators at each end.

The car shed adjoins the power house, and was erected by Messrs. W. F. Blay & Co., of Dartford. The main building is 120 ft. long by 48 ft. wide, with a clear headroom of 21 ft. Four tracks with inspection pits are provided, and these are capable of accommodating 16 cars. A temporary wall at one end allows of extensions being easily made when required.

The supply to the trams is from the Dartford Urban District Council's generating station in Priory-road, Dartford, where extensions of plant have been added, bringing up the capacity of the plant from the 200 kw. installed in 1901 to about 850 kw. The boiler plant now comprises four Lancashire boilers, of which the original three (supplied by Messrs. J. Carter & Sons) are 28 ft. by 7 ft., and capable of evaporating 4,000 lb. per hour. The new large boiler by Messrs. Ruston, Proctor & Co. is of 6,000 lb. evaporative capacity, and is 26 ft. long by 8 ft. diameter. All work at 160 lb. per square inch, and the large boiler is provided with a Sugden superheater per 100°F. superheat. A Ledward evaporative condenser capable of dealing with 10,000 lb. of steam per hour is installed, but the pipe work is arranged so that the station can be run either condensing or non-condensing. Water is obtained from two wells, supplemented by the town supply. A filtering and purifying plant of Messrs. Lassen & Hjort's make is provided, and a Pimbley economiser of 192 tubes has been installed.

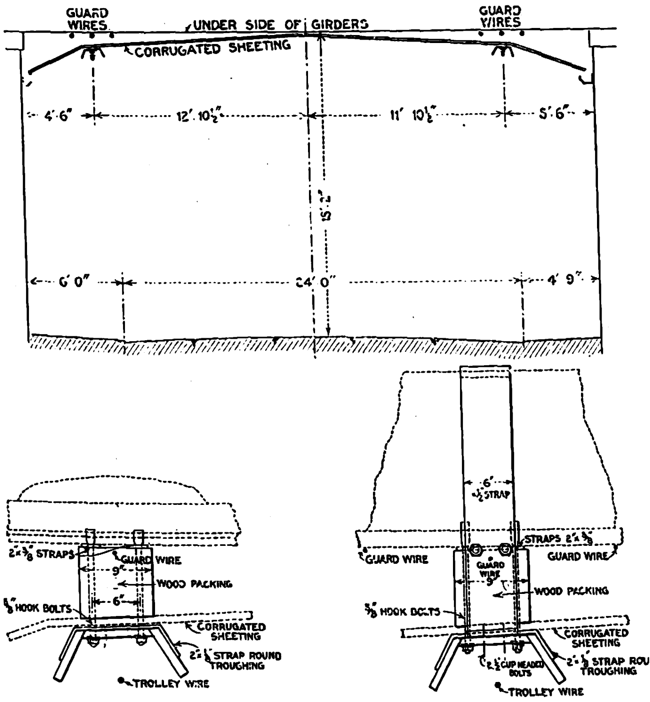

Fig. 2.—Details of Special Construction under Railway Bridge.

The generating plant consists of four sets, all of which can be used for lighting or traction. The two original 100 kw. General Electric and the 300 kw. Lancashire Dynamo Companies' machines are driven by Reavell engines, and the latest addition, a 200 kw. Fowler generator, is coupled to a two-crank Browett, Lindley engine. A new traction battery of 250 E.P.S. cells has been put down in addition to the original lighting battery, and the sudden variations of load are dealt with by a "Lancashire" automatic reversible booster. A complete new traction switchboard has been supplied by Messrs. Ferranti Limited.

## BRAKES.

Mr. A. L. C. Fell was unable to reply at the time to the discussion on his Paper on "Brakes," read before the Tramways and Light Railways Association on January 10th, and reported in our issues for January 19th, p. 543, January 26th, p. 586, and February 2nd, p. 635. His written reply has now appeared in the Official Circular of the Tramways and Light Railways Association for February, and is given below *in extenso*:

I propose to deal briefly with the points mentioned by each speaker. With regard to Sir William Preece's query as to the distance the car travels from the time that the brake is applied by hand and the moment retardation commences, I am afraid that the records of the hand and momentum brake trials only show the total time taken from the application until the car is stopped, but from the records of the rheostatic and magnetic track brake trials this information is obtainable, as a mark was made on the charts immediately the controller handle was moved on to the first brake notch. From these charts it appears that the magnetic track brakes commenced to act immediately they were applied. Sir William Preece mentioned an electromagnetic track brake on the Port Elizabeth tramways. I find that both the A type and B types of magnetic track brake with the older forms of magnets have been successfully used on these tramways. No doubt the authorities will be glad to hear that still better results can be obtained with the new form of shoes.

Mr. Lacey, in his verbal and written comments, compares the results obtained with the rheostatic and magnetic track brakes. If he will kindly again refer to the curves, he will see that the results obtained with the rheostatic brake are very poor when compared with those obtained with the magnetic track brakes, and that the general results do not show the enormous difference which he mentions. I have made no temperature tests with the motors, but it is a simple matter to calculate the rise in temperature from the figures obtained at the tests. The brakes are applied for such a short time that the increase of temperature of the motors is inappreciable either with the A or B types of magnetic track brake of the latest patterns, and they could both be used as service brakes. We have not had a very long experience with the latest forms of magnetic brakes, but we find that the type B brake requires very much more careful and frequent adjustment than the A brake, and it must be pointed out that during the tests both types of brake were perfectly adjusted to give the very best possible results.

Mr. Sayers calls attention to what he considers somewhat serious disadvantages in connection with magnetic track brakes: (1) That the surfaces between which the friction takes place are both iron, and one is the rail; (2) that using motors to actuate the brakes undoubtedly warms them up, and, on a hilly line, the effect may be of considerable importance; (3) the capital cost of magnetic track brakes. With regard to objection No. 1, the tests clearly show that excellent results can be obtained with magnetic track brakes with the surface of the rails in practically any condition without having to use sand, whereas such good results cannot be obtained with an ordinary mechanical slipper brake even when sand is used. I contend that although the coefficient of friction is not as high between the soft cast-iron magnetic track brake shoe and the steel track rail as between a mechanical track brake wood slipper and the steel rail, the wear and tear on the rail with the former will not be as great in the long run as with a wooden shoe which is permeated with sandy grit. Objection No. 2: With the older forms of magnetic track brake, overheating of the armatures proved a very serious matter. I found, when recently inspecting various tramways in America, that the older types of magnetic brakes were being replaced by air brakes, but, apparently, the latest patterns of magnetic brakes had not been tested on any of the tramways. With the latest types of magnets the effective area of the shoes has been increased, and the magnets are much more powerful, although much less current passes through the brake shoe windings and the motors are not overheated. Objection No. 3: Mr. Sayers has apparently not obtained any recent quotations for magnetic track brakes. I may say that we have lately had both A and B magnetic track brakes fitted on single truck cars. The former costs £41 per set of four shoes, and the latter £56 per set of four shoes, with the wheel brake attachment. The additional cost of magnetic track brakes is certainly a serious item, but if a general all-round increase in speeds can be secured by their adoption, the increased revenue will make it possible to write off the whole cost in a very short time. Mr. Sayers' rail corrugation theory is very interesting and, if correct, will be a further inducement to tramway managers to adopt magnetic track brakes.

In reply to Mr. Pott, I would like to point out that the instruments with which the whole of the tests were made were kindly lent to me by the British Thomson-Houston Co., who had the instruments specially designed for rolling stock tests. The following data of the cars used during the tests should have been given in the Paper, but they were unfortunately omitted: Weight of bogie car, 13 tons; weight of single truck car, 10½ tons; length of bogie car (over fenders), 33 ft. 6 in.; length of single truck car (over fenders), 28 ft. 9 in.; bogie car mounted on maximum traction McGuire trucks; single truck car mounted on Brill trucks; wheel base, single truck, 6 ft.; pivotal centres, bogie truck, 12 ft. 6 in.; wheel base, bogie truck, 4 ft.; average number of persons on car during test, 6; gear ratio, bogie car, 4·85 to 1; diameter of driving wheels, bogie car, 30 in.; diameter of pony wheels, bogie car, 20½ in.; diameter of wheels, single-truck car, 30 in. The next point raised by Mr. Pott is as to the use of sand in making brake tests. I purposely did not use sand on the rails during the tests. Sand unfortunately has to be used when starting cars on greasy rails in order to obtain rapid acceleration and when ascending steep gradients, but I consider that sand should as far as possible be avoided when using magnetic track brakes. As excellent results can be obtained without sand on a bad rail, better results could naturally be secured if sand was used, but except in very remote cases better results would not be necessary. I would also point out that, owing to the introduction of a human sand operator, great discrepancies would appear in the tests, and with a so-called greasy-rail test the rail would cease to be greasy after the sand had been applied. With regard to the best wood for use in mechanical slipper brakes, I found on the steep gradients in Sheffield that poplar wood cut across the grain was the best and cheapest, the softer wood being tougher and taking up sand more readily than harder woods, and it does not splinter. Mr. Pott requires the definition of the word "greasy." The best examples of a greasy rail were obtained after a slight shower on what had been a dry rail, or where the mud had partly dried on the rail. The dry rail was perfectly dry on the surface, but it may have had a skin of compressed road refuse in places. It must be remembered that the tests were made in the dark, and there may have been a few blemishes on the rail. I did not have the rails specially polished for the tests. We always find that the rail is at its best on a thoroughly wet day. Mr. Pott discusses the question of total power consumption at the higher speeds. I am afraid my statement was not quite clear. To drive a car at a higher speed more power, of course, is required, but by applying a greater amount of power for a short time it is possible to coast greater distances. The total power required to drive the car over a long route under actual working conditions, with frequent stops, is not appreciably greater than when running the car with lower maximum speeds and having to keep the power on practically the whole time whilst it is in motion.

In reply to Mr. Baldwin, I still maintain that the brakes were operated more skilfully as the trials proceeded and the drivers became accustomed to the equipments, and, furthermore, I would state that the man who operated the B type of brake was very much more accustomed to brake tests than the man who operated the A type of brake, although the latter was a good motorman. Three tests were made in each instance to obtain an average result at each speed. The diversity between readings taken in each of these three tests with practically the same rail conditions tend to show the variations in the human element. I quite agree with Mr. Baldwin that no doubt the greasy rail was not as bad as it looked. One great difficulty which had to be contended with was the fact that the tests had to be made over a length of track which had been used for traffic during the day time; and as the rail had, during the latter part of the day, been in a very greasy state, in all probability the drivers had used sand, and this, although not apparent, was no doubt present in the muddy slime. Mr. Baldwin gives some very interesting comparative figures. I hope we shall find under actual conditions that with the B type of brake there will be no additional wear on the gears and pinions. I should like to have particulars of the data on which Mr. Baldwin's assumptions are based, as a good deal naturally depends on the value which he gives to the unknown quantities. May I point out that the primary object of the series of brake tests which were carried out was to ascertain whether the results obtained with magnetic brakes would warrant the additional expenditure. The tests were made under what appeared to be the best and worst practical working conditions. There was no endeavour to provide conditions which would be theoretically perfect and which might never be met with under working conditions.

Mr. Clough states that the first cost ought not to weigh very much with managers when considering the question of brakes. I venture to think that with some of us this will be a very serious item. On the London County Council tramways about 1,500 to 2,000 electric cars will be required, so that the difference in cost between the A and B types of brakes represents a considerable sum. Although the money may not have to be repaid for a fairly long period, it has to be borrowed.

In reply to Mr. Raworth, who states that he is rather surprised that I did not say more about the ordinary mechanical track brakes. The chief reason that I did not do so is that we have no brakes of this description fitted on our London cars. I was, therefore, unable to make comparative tests under similar conditions. I quite agree with Mr. Raworth that this brake can be of very good service on steep gradients, and have already expressed this opinion in the Paper. Mr. Raworth calls attention to the rheostatic brake, which he considers is better than I imagine. No doubt the results with this brake in cases of emergency are good, but the results can only be obtained in a very inefficient manner, which may have a very destructive effect on the electrical equipment of the cars.

Mr. Worby Beaumont calls attention to the fact that particulars have only been given with speeds up to 15 miles per hour. A few special tests were made up to speeds as high as 25 miles per hour, but as it was impossible to attain this speed on the short length of practically level track on which the tests were made, the figures are not comparable with the figures which I have given in the Paper. I propose, as soon as a suitable length of track is available, to make a series of tests at the higher speeds, as no doubt we shall be able to obtain sanction for higher speeds on our tramways in outlying districts.

Mr. Trube discusses the question of temperature rise, and apparently considers this would be so serious in the A type of brake that the maintenance of the electrical equipment would be much higher than with the B type of brake. I do not consider that this would be the case in actual practice. In support of this opinion the results of a calculation may be of interest. Taking the total watts lost in the motors when driving the car, and adding in each case the watts lost in the motors (on account of the current required for the brakes), and assuming that the temperature rise of the motors would be proportional to the total watts lost—which is approximately correct as the motor is the same in each case—it appears that the A type of brake would increase the temperature of the motor about 8 per cent., the B type about 1¼ to 1½ per cent., and the rheostatic brake about 25 per cent. When it is considered that the temperature of a motor after a day's work is only about 60°C. to 65°C. the increase of 8 per cent. is not a serious matter, but an increase of 25 per cent. with a rheostatic brake may seriously affect the motors and resistances. No doubt the motors would be slightly cooler when using the B type of brake, but the difference between the temperatures of the motors when using the A and B types of brake can only be compared to that between tepid and warm water.

As requested by Prof. Ayrton, I give below the areas of the brake shoes and blocks: Total area of four type A magnetic track brake shoes with new pattern of magnet 87·5 sq. in.; total area of four type B magnetic track brake shoes with new pattern of magnet 126 sq. in.; total area of four brake blocks on driving wheels of bogie car 68 sq. in. (No brake shoes were used on the pony wheels of the bogie car.) Width of rail head 2⅛ in.

There seems to have been a little confusion as to what was meant in the Paper by the terms "old magnets" and "new magnets." I did not intend these terms to refer to the state of the magnet shoes, but to the old and new designs of the magnets. The majority of the magnetic track brakes now in use are of the older types, the new types were not developed until the early part of last year.

In the limited time at my disposal I have only been able to deal very briefly with the interesting points raised in the discussion, but I trust that the additional particulars I have furnished in this reply will provide the speakers with the information they require.

Before concluding I should like to express my thanks to Mr. J. Bowden, who rendered valuable assistance in connection with the tests, and to Mr. B. G. Thomas, who assisted in the preparation of the diagrams, also to the various brake manufacturers who so kindly placed their apparatus at my disposal.

## GAS ENGINES AS APPLIED TO ELECTRIC DRIVING.*

BY JAMES ATKINSON.

The application of gas engines to electric driving commenced in a very small way some 25 to 28 years ago. In those days a gas engine of more than 2 H.P. or 3 H.P. was the exception, and such installations were mainly confined to lighting houses or shops. These installations were the pioneers of what has grown to be an enormous branch of engineering, and it seems as though it were almost impossible to fix a limit to the magnitude to which gas-driven electric generation will grow in the future. It is of great interest to realise how economically electric current can be generated when producer gas is used. As a typical instance the following particulars of three sets of engines with suction gas plants will be of interest:—Each complete unit consisted of a gas producer in which common coke was burnt, two coke filled scrubbers, a motor-driven rotary tar separator, a sawdust scrubber, and the engine directly coupled to a direct current Crompton dynamo. The three units were tested on a six hours' run, one of such tests giving the following results: Total fuel consumed 488 lb., total kilowatt hours 368·4, fuel per hour 81·3 lb., kilowatt-hours 61·4, fuel per kilowatt hour 1·325, fuel per brake horse-power per hour 0·92 lb., thermal efficiency of the entire plant 22·75 per cent., proportion of total heat in the fuel converted into electric current on the switchboard 20·87 per cent.

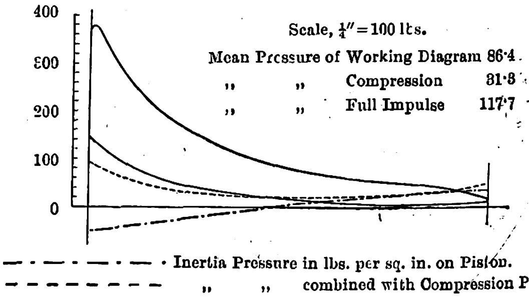

FIG. 1.—SINGLE-CYLINDER ENGINE.

An investigation as to the amount of irregularity in the turning moment will show what is permissible in a single cylinder "Otto" type engine, directly coupled to a continuous current dynamo, giving steady lights and sufficient regularity to run two or more units in parallel. In Fig. 1, a diagram taken from such an engine is shown, also the effect of the inertia of the reciprocating parts expressed as pounds per square inch on the piston. In addition a third line is given, showing the combined effect of the compression and the inertia of the reciprocating parts. Fig. 2 gives the full impulse diagram corrected for inertia of reciprocating parts, illustrating the amount of work developed during a working stroke, together with the rate at which such work is developed. Fig. 3 shows the turning moment on the crank pin during the complete cycle. If we assume that work is being done by the engine at a constant rate, and include friction, which also may be regarded as being a constant resistance, the dotted line on Fig. 3 drawn above zero line represents the mean rate at which work is being done, and from this diagram the exact speed rate of the flywheel at any portion of the cycle can be ascertained. For the present purpose it will, however, be sufficient to ascertain the maximum and minimum speeds of the flywheel and percentage variation.

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* Paper read before the Manchester Section of the Institution of Electrical Engineers on Tuesday last. Abstract.

Let us assume the diameter of cylinder to be 18 in., stroke 2 ft., revolutions 200 per min., and energy stored up in flywheel and revolving parts 720 foot-tons. In Fig. 4 the amount of acceleration due to excess work is represented by the shaded portion. On calculating this excess it works out to 21·524 foot-tons, therefore we have 741·524 foot-tons stored up energy at *c*; as a maximum, the speed of the flywheel will be in the ratio of the square roots of these stored up energies, and the flywheel at *c* will be moving at the rate of 1·492 per cent. faster than it is at the point *b*; from the point *c*, of course, the flywheel begins to slow down. At the time of the next ignition it will be at its original rate of 200 revs. per min. Should the engine be governed by "hit and miss" governing, and an impulse cut out, it would fall below 200 revs. per min. by an amount corresponding to the loss of one impulse; this amount is 19·635 foot-tons. The stored up energy in the flywheel would drop from 720 to 700·365, representing a decrease in speed of 1·406 per cent. The 1·492 per cent. is what is commonly known as cyclical variation, and the 1·406 per cent. as governing variation, the cyclical and governing variation thus together amounting to 2·898 per cent.

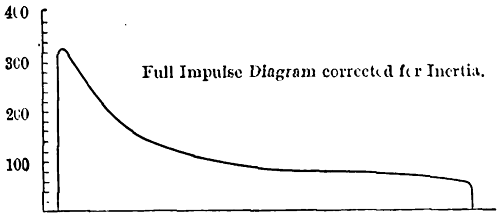

Fig. 2.—Single-cylinder Engine.

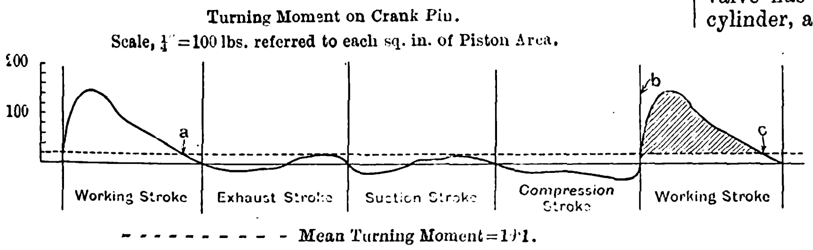

Fig. .—Single-cylinder Engine.

Extensive experience with a great number of installations has shown that this degree of irregularity is permissible. The simplicity of "hit-and-miss" governing, together with the economical results thereby attained, make such an arrangement thoroughly satisfactory in many instances. There are cases, however, where automatic regulation has been introduced with a view to eliminating the governing variation. Broadly speaking, four methods have been adopted for this purpose: (1) Throttle governing. (2) Cut-off governing. (3) Varying the richness of the charge by throttling the gas. (4) Varying the richness of the charge by admitting the gas earlier or later during the suction stroke, but cutting it off always at the same period at the end of the suction stroke. The writer proposes briefly to give his views as to the relative merits and demerits of these various methods.

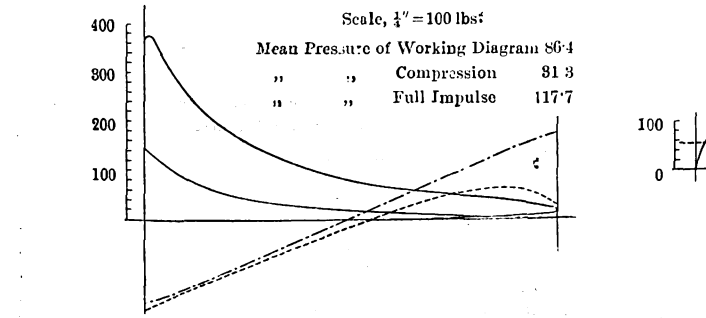

Fig. 4.—Four-cylinder Engine.

1. *Governing by Throttling an Uniform Mixture.*—This method has been adopted by the Westinghouse Co., by many of the Continental firms, and by other makers in England. As adopted by the Westinghouse Co., the mixture is throttled before reaching a pipe which supplies the cylinder or cylinders, the amount of throttle being regulated by the governor. In other instances the lift of the admission valve is directly controlled by the governor. A very satisfactory way of doing this is the method adopted by the Gasmotoren Fabrik, of Deutz, in which a shifting fulcrum for the admission valve lever is moved by the governor, the gear otherwise being undisturbed. The principal objections to this method of governing are the increase in gas consumption as the load decreases, also, there is a considerable resistance during the suction stroke, causing a good deal of negative work; the reduced pressure at the end of the compression stroke interferes with prompt ignitions, and in some instances leads to reversal of stresses in the moving parts owing to reduced compression.

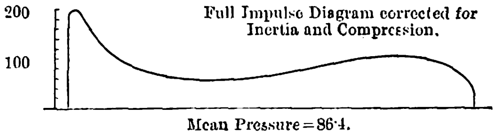

Fig. 5.—Four-cylinder Engine.

*Cut-off Governing.*—This has been very largely adopted on the Continent. In the case of larger engines "Trip" gears are used, very similar in construction to those used in steam engines. Governing by this method has been very satisfactory so long as the speeds of the engines were moderate. It is, however, not suitable for engines running at high speeds. Messrs. Crossley Bros. have made engines to work with cut-off gears consisting of a separate multiported valve moved by an eccentric, the valve being modified in its relation to the eccentric by means of the governor, thus altering the cut-off as may be desired. In other instances the cut-off valve has been held up by means of a vacuum in a suitable air cylinder, and allowed to close when the vacuum was destroyed by the admission of air into the vacuum cylinder through an opening regulated by a small valve controlled by the governor. Compared with throttle governing there is very little loss from negative work; it also lends itself to combining the cut-off with "hit and-miss" governing —that is to say, if the engine is working on heavy or medium loads the regulation is entirely by means of cut-off, but on lighter loads the governor can allow the gas valve to remain closed, so that the regulation is partly by small charges and partly by cut-out impulses, thus avoiding the very heavy consumption on light loads.

For charges down to half-load, although the charge is ignited at a lower compression pressure, still it expands to a very much lower terminal pressure, and from experiments which the writer has made, the economy with such governing is quite as good as with ordinary "hit-and-miss" governing. When running on or below a half-load a little consideration will show that this irregularity of turning moment, with occasional cut-out charges, is no greater than it would be at full load without any misignitions, the stored up energy in the flywheel being proportionately greater than the impulses and the load for the time being. This style of governing is open to the objection mentioned in connection with throttle governing, the reduced compression pressure under some circumstances not being sufficient to take up the inertia of the reciprocating parts.

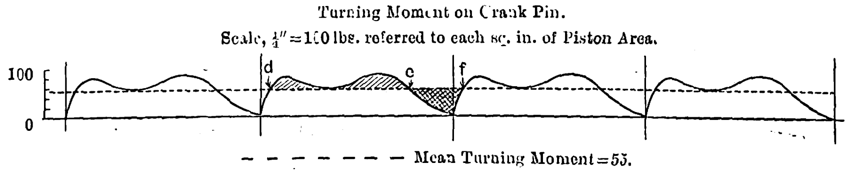

Fig. 6.—Four-cylinder Engine.

*Governing by Varying the Richness of the Mixture.*—This method can scarcely be said to be generally used in practice. The amount to which the richness of the mixture of the charge in a gas-engine cylinder may be varied is somewhat limited, if the gas is to be economically consumed. If either too rich or too weak, the gas is not properly burnt, and there is considerable risk of irregularities in the working of the engine, causing bangings or ignitions at improper times, sometimes in the admission pipes and sometimes in the exhaust pipes.

It would appear that such irregularities, combined with the somewhat narrow range of governing, are sufficient to prevent this method of governing from being largely adopted.

*Varying the Timing of the Admission of the Gas, but always cutting it off at the end of the Stroke at the same Time.*—This method is being largely adopted on the Continent, and is the revival of an old method of governing introduced originally by the late Mr. Frank Crossley in the very early days of electric driving by means of gas engines. Though differently carried out, the same method of governing is used exclusively in the Korting and Oechelhauser type of gas engines. Messrs. Crossley Bros. are also constructing engines governed in this manner. This method also has the advantage of not decreasing the compression pressure. In this connection there is a very great difference between the older arrangement referred to above, and the newer methods. In the old arrangements the compression pressure was about 45 lb. per square inch, whereas in the present type of engines the compression pressure would probably be in the neighbourhood of 150, or perhaps more. The particles of gas and air are more nearly brought together, and the heat due to compression is so high as to bring the charge at the time of ignition to closely approaching ignition temperature, with the result that the gas is more thoroughly burnt, and there is no reason to suppose that this method of governing will be uneconomical.

The driving of alternating-current dynamos in parallel is an altogether different problem. Probably all connected with alternating machine driving will welcome the action taken by the Standardising Committee in endeavouring to limit the periodicity of alternators to either 50 or 25 cycles per second. It must be a great relief to the makers of the machines, and gas engine makers are enabled to fix on certain revolution speeds of their engines as standards. The writer frequently has to deal with enquiries relating to engines for driving alternators, and would like electricians to note that the steadiness of rotation necessary for driving alternators differs most materially from the kind of steadiness required for driving continuous-current machines. In almost every instance enquirers and specifications for engines to drive alternators state that the variation in speed of the engine must not exceed some particular fraction of the mean speed, varying from $\frac{1}{150}$th to much smaller fractions, or ask what degree of regularity would be guaranteed. He begs to submit for their consideration that this is a wrong method of defining the necessary steadiness of such an engine. The required regularity is a function of the angularity difference between, say the flywheel of the engine, and a flywheel running at absolutely constant speed. This angular variation is certainly due to speed variation, but it is speed variation qualified by a time element.

It is pretty well understood that for alternating machine driving a multiple cylinder engine will be used. After going carefully into the best arrangement for such engines, it is clear that engines giving two impulses per revolution will be mainly adopted for moderate powers, and for larger powers two such engines would be combined having their cranks at right angles. It will be of interest to show the degree of regularity which can be obtained by such engines. For the sake of comparison the same diagram has been taken as illustrated in Fig. 1, and curves have been plotted out showing what will take place with a vertical four-cylinder "Otto" cycle engine. Fig. 4 shows the diagram, a line showing the inertia for four sets of reciprocating parts, and a line showing the inertia pressure combined with the compression. Fig. 5 shows the full impulse diagram corrected for inertia and compression, and Fig. 6 shows the turning moment on the crankpin; the dotted line being the mean turning moment. In this four-cylinder engine the size of cylinder is taken as before—viz., 18 in. diameter by a 2 ft. stroke, the revolutions being also 200, and the power of the engine, of course, being four times as great. The diagram shown in Fig. 6 shows what a remarkable effect the inertia of the four sets of reciprocating parts has upon the resulting turning moment on the crankpin, the shaded portion between *d* and *e* representing the excess of energy put into the flywheel, being such a small percentage of the work done during one impulse, the impulse giving as before 19 365 foot-tons, and the excess being 3·39 foot-tons; the deficiency from *e* to *f* of course being also 3·39 foot-tons, the increase in speed takes place from *d* to *e*, and decrease from *e* to *f*. Assuming that we have 610 foot-tons energy stored up in the revolving parts when running at 200 revolutions at the point *d*, excess energy to the extent of 3·39 foot-tons being added by the time *e* is reached, the speed at *e* would be increased in the ratio of the square roots of 610 to 613·39, which works out to 0·312 per cent. From an inspection of Fig. 6 it is evident that the flywheel compared with a wheel running with absolute regularity will be at its mean speed at a point between *d* and *e*, a little nearer to *e*, and again at a mean speed between *e* and *f*, a little nearer to *f*, changing from these positions approximately every 90 deg. In passing from the mean speed position to the most advanced position the flywheel is travelling at a speed varying between mean speed and maximum speed, which is 0·312 per cent. faster, consequently its excess angular advance becomes about 0·14 deg.

With such a small deviation it is obvious that it is not necessary to go into intricate mathematical calculations to ascertain more closely what the actual deviation is, as no alternator can possibly require such regularity as $\frac{1}{7}$th of one degree either way, and as it is impossible to get absolutely equal impulses in all the cylinders under all circumstances, it is necessary to provide for such contingencies, therefore in this instance these contingencies are the controlling elements in deciding on the required amount of stored up energy, not the cyclical variations. The synchronising efforts of the alternators themselves, of course, assist in keeping them in step, and thus still further counteracting any irregularity in the working of the engines.

Various arrangements have been made to enable two strokes per revolution to be obtained, and four-cylinder vertical engines on to four cranks seem as though they would be very suitable for engines up to moderate powers. For large powers horizontal cylinders promise to be the most convenient, either having four single-acting cylinders arranged on two cranks with the alternator on the shaft between them, or two-double-acting cylinders on to one crank, and for still greater powers four double acting cylinders on to two cranks at right angles. The Korting and Oechelhauser engines have also been used for this purpose. In these latter types of engines the governing is practically the same as varying the timing of the admission of the gas, but always finishing up the charge with an uniform mixture.

Considerable care should be exercised as to the relative positions of the cranks, the flywheels, and the alternators. If it can be arranged it is desirable to build up the armature of the alternator on the flywheel itself, or at any rate directly couple it to the flywheel, without passing the strain through separate keys on the shaft. Should there be four cranks, as in a vertical four-cylinder engine, it would seem desirable to use a similar arrangement, and only have one flywheel at the same end as the alternator. A considerable number of such engines have been made with a flywheel at each end, an arrangement which does not commend itself to the writer, as vibratory strains might be started up in the crankshaft itself, which under certain circumstances may be so serious as to cause fracture to the shaft.

It may be true that large steam turbine installations have greatly interfered with the development of large gas engines for electric driving; it is well to bear in mind, however, that the steam turbine has taken considerably longer to bring to its present state of perfection than the large gas engine, which has only been developing during the last few years. Those only who are thoroughly conversant with the subject of large gas engines can estimate the serious difficulties which have been overcome, and appreciate the efforts which have been made in this direction; it is very satisfactory to realise the enormous strides and the solid advances which have been made. There is no doubt that great developments are taking place, and the increasing use of large gas engines is certain to continue. The writer has a very strong feeling that the gas turbine will ultimately be made a practical success, and should this be so it would hold an unique position as the motive power, at any rate for electric-current driving.

The discussion was opened by the chairman (Mr. S. L. Pearce), who doubted whether gas engines, with their uneven turning moment, were suitable for the parallel running of alternators, and this point was also raised by Mr. G. D. Seaton and Mr. T. L. Miller. Mr. Pearce stated that the Manchester electricity department could compete with private gas-driven plants, and Mr. R. L. Gamlen said that he understood that the Newcastle-on-Tyne Electric Supply Co. had replaced 800 H.P. of gas engines with electric motors in the past 12 months.

## WASTE IN INCANDESCENT ELECTRIC LIGHTING AND SOME SUGGESTED REMEDIES.*

BY GEO. WILKINSON.

Every enterprising station engineer, in order to secure a healthy growth of business against increasing competition, diligently seeks to reduce his cost of production and distribution. Labour-saving appliances—such as fuel and flue gas testing instruments, superheaters, improved forms of steam and electric generators, better methods of conversion and distribution, together with a more intelligent idea as to the effect of load and diversity factors—have done much towards reducing these costs (allowing a corresponding decrease in the tariff charges to consumers), and yet finality in this direction, even with our present methods and knowledge, still lies some distance in the future. The average prices obtained per unit in Great Britain (omitting exclusively tramway undertakings) during 1904 and 1905 were as follows :—

| | Year ending March, 1904. | Year ending March, 1905. |
|---|---|---|
| Limited liability undertakings | 4·26d. | 4·06d. |
| Municipal undertakings | 3·08d. | 3·02d. |

It is when we get beyond the meter fixed on consumers' premises, which marks the boundary of the supply undertakers' authority and jurisdiction, that waste and extravagance take place. This is mainly due to the use of incorrectly-graded and inefficient lamps, and the persistent use of lamps after they have become blackened on the inner surface of the glass bulb. So marked is this lamentable waste, and its effect upon the future of electric lighting is so serious, that it is high time some definitely concerted action was taken by the supply authorities throughout the country to deal effectively with the matter, and to educate every consumer so that he may know how to get efficient electric lighting at a reasonable cost.

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* Abstract of a Paper read before the Leeds Local Section of the Institution of Electrical Engineers, February 15th.

Electrical engineers have too long considered themselves simply producers and purveyors of electrical energy, and have not concerned themselves with the problem of turning a minimum amount of electrical energy into a maximum of lighting power, the consequence being that many a user is paying for double the amount of electrical energy for lighting he ought to pay, and not a few lucrative electric light consumers have, regardless of health considerations, gone back to the use of gas.

To show an urgent need for attention on the part of engineers to the points raised, I set forth a few of the many cases which have come under my personal notice during the last few months.

(a) *Public Building.*—Eighty 32 c.p. British-made 100 volt lamps, taking an average of 170 watts each. The light in this case was exceedingly unsatisfactory, owing to drop in pressure, and by putting in 16 c.p. lamps certified by the Corporation (as hereinafter explained) the light was improved and the current consumption very greatly reduced.

(b) *Private House.*—Consumer using 8 c.p. British-made lamps giving in one case only 2·1 c.p. at 11 watts per candle, and another 3·2 c.p. at 8 watts per candle; also one 16 c.p. giving 8·9 c.p. at 6·6 watts per candle.

(c) Four special 16 c.p. 200 volt foreign lamps, sent for test, dropped from 16 c.p. to 7 in less than 100 hours. These might have been used on consumers' premises with disastrous results.

(d) *Private House.*—Consumer found to be using 230 volt lamps on a 200 volt circuit.

(e) *Private House.*—Consumer found to be using 2½ c.p. lamps taking 30 watts each, or 12 watts per nominal candle at 200 volts. Actual c.p. given by the lamps was 5 on photometric test.

(f) *Shop.*—Nominal 8 c.p. lamps, giving 5·5 c.p. and taking 6·6 watts per candle.

The following cases have been given to me by engineers of other electrical undertakings:—

In the public buildings of a large city in Scotland, the British-made lamps from a number of tests made were found to be taking an average of 8·29 watts per mean horizontal candle-power, and 9·14 watts per mean horizontal candle-power in the case of Continental-made lamps.

Investigations made in a leading manufacturing city in Yorkshire show an average of 7·6 watts per mean horizontal candle-power in the case of foreign lamps, and 7·03 watts per mean horizontal candle-power in the case of British-made lamps. Tests made on 8 and 16 c.p. lamps in stock in the same city, showed a variation of from 2·98 to 5·67 watts per mean horizontal candle.

Investigations in one of the chief cities in Lancashire on new 16 c.p. lamps held in stock by the Corporation showed a variation of from 3·25 to 8 watts per candle, with a variation in candle-power on standard voltage from 10¼ to 20 candles.

I do not suggest that the lamps in all the above-cited cases are necessarily bad lamps, but they are certainly wrongly graded and marked. These are only a few instances, and I am convinced that in many towns the cost of electric lighting is greatly increased to the consumer, due to errors in the grading and marking of lamps. So far as I can ascertain it appears to be the general practice amongst lamp makers to sell lamps marked with a nominal candle-power, but actually giving considerably less than that marked on the bulbs.

### SUGGESTED REMEDIES.

*Legislative.*—Clause No. 18 of the 1882 Electric Lighting Act* should be immediately abolished, and a new clause substituted, giving the electricity supply undertakers right of supervision over the lamps used on their supply mains, and the right to refuse to supply customers using wasteful lamps. In my view this desirable supervision can be exercised without the undertakers taking the lamp trade from the local contractors: such a step on the part of municipalities would be an unwarrantable and unfair interference with the business of private tradesmen in the district.

*Local Precaution.*—I have, in co-operation with the local contractors in Harrogate, developed a system of control over the lamps used in the supply mains which, while it secures to the Corporation the control referred to, leaves the contractors the benefit of their trade in lamps, and puts no restriction upon them as to what make or class of lamp they supply to their customers. It is desirable that we should have legal powers to compel contractors to supply, exclusively, lamps approved by the supply authority. At present we are able to get a written undertaking only, and depend upon the contractors to abide thereby honourably. In Harrogate such undertaking appears to be quite sufficient at present to effect what we want.

*Lamp Specification.*—Twelve months ago I drew out a specification (see Appendix), which was issued to all lamp manufacturers supplying lamps to the district, with the intimation that in future lamps would not be certified for use on the Harrogate supply mains which did not come within the specification, both as to candle-power and wattage. The result of the specification was that many grosses of lamps of all makes were returned to the manufacturers from Harrogate. Considerable feeling was manifested on the part of several manufacturers, due to the constant refusal of lamps: now, however, they appear to have settled down to comply with our requirements, and very few lamps which are now sent for certification fail to pass the required tests, and the consumer has already begun to feel the benefit of their improved efficiency. We have numbers of instances where the accounts have decreased since certified lamps were used, and the ultimate result is bound to be an increase of business accruing to the electricity department.

*Notices to the Consumers.*—A notice is attached to the quarterly account calling the attention of the consumer to the importance of using, exclusively, lamps certified by the supply authority, and warning him against buying lamps from casual travellers.

The question of the efficiency and grading of lamps has recently been taken up by the Municipal Electrical Association, and a more comprehensive and detailed specification than that set forth in the appendix has been drawn up; but its issue to the members of the Association is postponed at the request of the Physical Standards Sub-Committee of the Engineering Standards Committee, and the Municipal Electrical Association has elected Mr. C. D. Taite and myself as their representatives on this sub-committee. This committee has gone into the question of lamp efficiency and grading in great detail; have had careful tests carried out by various lamp manufacturers, and have held an all-day conference with the representatives of the manufacturers, and their deliberations are now approaching completion. Doubtless the effect of the Municipal Electrical Association's recommendations, when issued, will be beneficial to all parties concerned, and especially to the consumers. It is difficult, however, to see how the full benefit of these proceedings can be felt until Clause 18 of the 1882 Electric Lighting Act is annulled or modified. It is to be hoped that concerted action will at once be taken by the supply undertakers in this direction.

It is usual in ordering lamps from manufacturers to specify the maximum drop in candle-power allowable after the lamps have been on circuit a stated number of hours at the standard voltage marked upon the lamps. The specification generally fixes a maximum of 20 per cent. drop in candle-power on a 400 or 600 hours' run. In making this test a maximum rise in pressure of 2 per cent. should be allowed, as closer regulation is not obtained on public supply mains.

A difficulty presents itself in the length of time required to verify the drop in candle-power; very few makers or dealers will consent, or can afford to lay large stocks of lamps aside for five or six weeks while drop in candle-power and life tests are being made on sample lamps drawn from each consignment; the consequence is that these important tests are almost entirely neglected, and in the writer's opinion large numbers of lamps are continually put on circuit which blacken prematurely and bring discredit upon the industry. Experiments which I have made show that a very thin film of deposit on the internal surface of the glass bulb serves to reduce the light by 50 per cent., and a lamp loses two-thirds of its original candle-power before it gets to the condition commonly accepted as "black."

The lamp merchants should rigidly insist upon the makers submitting a percentage of each batch of lamps to an independent and recognised authority for drop in candle-power test; such lamps being selected promiscuously from the bulk; and the maker should furnish a certificate setting forth the results of such tests. A life test is not nearly so important as the drop in candle-power test, and lamps which show good results on candle-power after the specified number of hours may generally be accepted as satisfactory on the score of durability.

It is better to use lamps with large glass bulbs, as the internal blackening process is thus spread over a greater area and is therefore thinner, presenting less obstruction to the light. This view is confirmed by the rapidly increasing use of lamps with large spherical bulbs, which do not reveal the blackening process nearly as quickly as the ordinary sized glass bulbs. It is of great practical importance that drop in candle-power tests should be considerably shortened by employing a pressure higher than the standard working pressure, for, say, 150 to 200 hours; this will decrease the expense and inconvenience of keeping back lamps during the weeks at present absorbed in making these tests. Fortunately the time can be shortened to about 150 hours by applying a slightly increased uniform pressure, but this method at present is followed by only one or two British firms; it is, however, common in America, and will doubtless become regulation practice everywhere in the near future.

### EQUIPMENT OF LOCAL LAMP-TESTING ROOM.

The large numbers of lamps which are likely to be submitted for test in all local centres where lamp supervision and certification is adopted and the small charge which can be made per lamp (½d. in the case of Harrogate), necessitate expeditious methods, giving reliable results. The writer has experimented in many directions and with many instruments before arriving at a fairly expeditious, reliable and simple method, employing current derived from the ordinary supply mains. The equipment is as follows:—

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* 18.—The undertakers shall not be entitled to prescribe any special form of lamp, or burner, to be used by any company or person, or in any way to control or interfere in the manner in which electricity supplied by them under this act, and any licence, order or special act is used: Provided always that no local authority, company or person, shall be at liberty to use any form of lamp or burner, or to use the electricity supplied to them for any purposes, or to deal with it in any manner so as to unduly or improperly interfere with the supply of electricity supplied to any other local authority, company or person, by the undertakers, and if any dispute or difference arises between the undertakers and any local authority, company or person entitled to be supplied with electricity under this act, or any licence, order or special act, as to the matters aforesaid, such dispute or difference shall be determined by arbitration.

*Wattage Measurements.*—The method employed entails the use of a standard voltmeter and a small hand-regulated booster (or sliding resistance in the case of direct currents), by means of which the volts are adjusted to and maintained at the exact pressure marked upon the lamps. After the pressure adjustment is made, each lamp is in turn inserted into a lamp-holder connected with a standarised dead-beat wattmeter, the resultant reading in each case being recorded in ink pencil upon the brass cap of the lamp. They are then placed in light baskets and passed on to the photometer. Any lamps falling outside the specified wattage limits are placed on one side for return as unsatisfactory.

*Photometric Measurements.*—A grease-spot photometer is employed with a scale graduated directly in candle values, so that the illuminating power of any lamp can be read off at once without calculation of any kind; the scale is an open one, and is graduated up to 70 candles on each side of the zero centre line.

In cases where lights of different colours are being prepared a flicker head is substituted for the ordinary grease-spot head. The light standard is securely clamped on the left of the spot box in such a position on the scale as to give an 8, 16, 32 c.p., or other definite illuminating value upon one side of the grease spot. The lamp under test is placed in a lamp-holder upon a moving carriage on the other half of the scale, this holder being rotated at about 200 revs. per min. by means of a small motor and worm gear carried on the moving carriage and controlled by a switch near the operator. A standard voltmeter with illuminated dial is placed immediately over the photometer head, and a small booster adjusted by a screw motion (or sliding resistance in the case of direct currents) is located under the bench carrying the photometer, so that the operator can with facility maintain the exact standard electrical pressure.

*Standard of Light.*—I strongly condemn the general use of pentane or any other flame standard; they are very difficult to manage and vary in illuminating effect, from time to time, according to atmospheric and other conditions. Good pentane is difficult to obtain, still more difficult to keep, and it is expensive. Ordinary incandescent lamps which have been "aged" until their illuminating power becomes stable should be selected and sent to the National Physical Laboratory to be standardised at a declared voltage, and the position in which they are standardised should be carefully marked upon the glass bulb near the cap. These lamps then form reliable standards of reference, from which sub-standards can readily be obtained for use on the photometer by the lamp testing assistant; thus, the original standards being little used, do duty for a long period and seldom require re-standardising.

Lamps which pass are finally stamped upon the glass bulb by means of a rubber stamp and etching fluid, with the word "Certified" and the initials or crest of the authority certifying same. This stamping operation is accelerated by slightly warming the lamp bulb in a spirit lamp before the stamp is applied. The equipment described is not expensive, and it is not too delicate for a youth of ordinary intelligence to use. The average rate of testing, including every operation, is about four dozen lamps per hour, and there appears to be no good reason why in regular work the rate should not be increased to six dozen per hour.

## PRESSURE REGULATION.

The present low average efficiency of lamps is, at least in some measure, the result of bad-pressure regulation on the supply network which is destructive to high-efficiency lamps. Many lighting circuits are unfit to supply any lamps of higher efficiency than "Traction" lamps.

In Harrogate uniformity in pressure is secured by the use of automatic pressure regulators at the generating works. Doubtless, recently obtained motive power loads which are supplied from the lighting distribution mains have in some instances rendered the already unsteady pressure much worse, and, to sacrifice the steady pressure necessary for good lighting in order to pick up a few motors is questionable policy. Circuits for the supply of power should be separate from those supplying light, when the fluctuations due to varying and erratic power load will not have a prejudicial effect upon the lighting.

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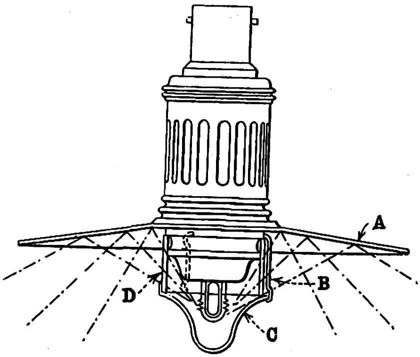
Before concluding I desire to mention a few other types of incandescent electric lamps which are coming into active competition with carbon filament lamps. Of these the best known and largest is the:—

*Nernst Lamp.*—The experiences of engineers with this type of lamp is very conflicting, some appear to get satisfactory and economical results, others complain of rapid fall in candle-power and short life of filament. It would be interesting in the latter cases to examine the pressure charts. The Nernst lamp, notwithstanding the steadying effect of the wire compensator, is very sensitive to fluctuations of voltage. Economical and good average duration of candle-power and life can only be obtained on steady voltage. It is stated that the filaments should be run for at least 12 to 16 hours when first put on circuit, in order that the filament may get into a stable condition, and lamps which survive this preliminary run are likely to have a life of satisfactory duration. It would be interesting to know how far these statements are confirmed by extended experience. The writer has found the burners last well on both direct and alternating-current circuits, but in each instance automatic pressure regulators are used which keep the voltage variation within two per cent. In street lamps the average has been close on 500 hours per burner. For street lighting the B and D type of burner are very little use, as they cannot be depended upon to light up on a cold or stormy night, due to the filaments being below the heaters, also the heaters are particularly frail and liable to break. The A type lamps, on the other hand, will light up within a minute on the coldest night, and the 100 watt A type filament, due to its superior conformation, gives approximately 30 per cent. more light on the roadway than the 100 watt D type burner, which has a U-shaped filament. A type lamps are, however, expensive, and the writer has adapted the A type burner to the D type body, whereby the cost is reduced to less than half that of the A type lamp, while the lighting efficiency of the A type lamp is obtained. This has been recognised by the Nernst lamp manufacturers, who are now arranging to put a lamp of this type on the market, which for convenience I have designated the AD type. The AD type lamp put into clear well-shaped glasses and supplied with current at 1d. per unit is in successful competition with the gas mantle for street lighting in several towns, and their use in this way will doubtless rapidly increase in the near future.



A. Opal reflector. B. Three-pronged clip attached to ring supporting reflector and carried by three hangers. C. Opal clip clipped by three prongs termed "Diffuser." D. Clear glass cylinder termed "draught excluder."

By careful photometric measurements the writer finds the Nernst lamps, in clear globes, give a greater amount of light pro rata on the amount of electrical energy than "Midget" arc lamps furnish; probably on a time test, however, the Nernst lamps would fall in candle power to a greater extent than the arc lamp.

Nernst lamps, especially the B and D types, are badly designed from a light-giving point of view; the opaline globes, especially the pear shaped pattern, obstruct a great amount of light, and there is no means of placing a reflector in an effective position. Recognising this, the writer designed and patented the modifications illustrated above, and has obtained thereby a wonderfully-improved lighting effect, as shown by the following certificate:

This is to certify that we have tested for candle-power at all angles below the horizontal a 200 volt ¼-ampere Nernst lamp—firstly, when fitted with your diffuser and reflector, and, secondly, fitted with the ordinary alabastrine pear-shaped globe.

The following results were obtained:—

| | Candle-power. | |
|---|---|---|
| Angle below the horizontal. | With diffuser. | With globe. |
| 0 degrees | 19·5 | 29·0 |
| 10 ,, | 26·0 | 31·0 |
| 20 ,, | 32·5 | 32·0 |
| 30 ,, | 38·5 | 31·0 |
| 40 ,, | 44·0 | 29·0 |
| 50 ,, | 48·5 | 26·5 |
| 60 ,, | 52·5 | 24·0 |
| 70 ,, | 55·5 | 21·5 |
| 80 ,, | 58·5 | 19·0 |
| 90 ,, | 60·5 | 17·0 |
| Mean hemispherical candle-power | 38·6 | 29·0 |
| Watts: 51·2 at 200 volts | — | — |
| Watts per mean hemispherical candle-power | 1·325 | 1·76 |

For and on behalf of

WESTMINSTER ELECTRICAL TESTING LABORATORIES,
(Signed) LANCELOT W. WILD, Chief Electrician.
December 29, 1904.

It will be seen from the above figures that below the angle of 20 deg. from the horizontal, which includes all the useful lighting area, the mean spherical candle-power shows an efficiency of one candle per watt, a result unapproached by any other electric lamp of small candle-power.

*Vacuum Tube Lighting.*—Some good examples of this system of lighting can be seen operating in business premises along Broadway, New York, notably at the office of the *New York World*, which is illuminated by one tube 86 ft. long, running round the office and fixed beneath the ceiling cornice. Lighting tubes of this class are in operation up to 155 ft. long. They are operated by extra high-pressure alternating current, ranging from 5,000 volts upwards, produced by a transformer enclosed in an earthed metal box; the light produced is soft and agreeable, and is a near imitation of daylight; the intensity of light can be regulated from a faint glow to 20 or more candles per foot of tube, which tubes are about 1¾ in. diameter. The illuminated tube can be looked at without inconvenience to the eye, and it appears as though it were a long cylinder of densely white smoke. The light radiating from such a large surface area gives a very perfect diffusion, and a practically "shadowless light" result. No mercury is used in these tubes, and the makers claim an efficiency as high as 1½ watts per candle, including transformer loss, and state that the life of the tubes is "almost unlimited." Very little information is available about this form of lighting; I cannot find that there are any of these lamps in Great Britain, but the American examples are strikingly effective, and the method is worthy of more attention than it obtains at present. Probably the ultimate form of electric lighting will be by means of incandescent vapour, of which the well-known mercury vapour lamp forms an unsatisfactory and crude example.

This Paper is already too long, and I therefore pass over the osmium, tantalum and other new types of electric incandescent lamps, which are still in their experimental stage and unsuitable for the ordinary working pressures of town lighting circuits.

### APPENDIX.—LAMP SPECIFICATION.

#### WATTAGE TESTS.

2½ c.p. lamps are not recommended, as they have been found to be very inefficient.

#### 100 VOLT LAMPS.

A nominal 5 c.p. lamp will not be certified if the watts consumed are above 26.

A nominal 8 c.p. lamp will not be certified if the watts consumed are above 34.

A nominal 16 c.p. lamp will not be certified if the watts consumed are above 66.

A nominal 32 c.p. lamp will not be certified if the watts consumed are above 130.

#### 200 VOLT LAMPS.

A nominal 5 c.p. lamp will not be certified if the watts consumed are above 28.

A nominal 8 c.p. lamp will not be certified if the watts consumed are above 36.

A nominal 16 c.p. lamp will not be certified if the watts consumed are above 68.

A nominal 32 c.p. lamp will not be certified if the watts consumed are above 140.

#### CANDLE-POWER TESTS.

*Note.*—Lamps are tested in the horizontal plane, and the mean of two readings taken at right angles is the assumed candle-power.

5 c.p. lamps will not be certified if their actual candle-power is below 4 or above 6·5.

8 c.p. lamps will not be certified if their actual candle-power is below 7 or above 9, or if the watts consumed per actual candle-power exceed 4 for 100 volt lamps, or 4·25 for 200 volt lamps.

16 c.p. lamps will not be certified if their actual candle-power is below 14 or above 18, or if the watts consumed per actual candle-power exceed 3·75 for 100 volt lamps, or 4 for 200 volt lamps.

32 c.p. lamps will not be certified if their actual candle-power is below 28 or above 36, or if the watts consumed per actual candle-power exceed 3·75 for 100 volt lamps, or 4 for 200 volt lamps.

## ELECTRIC-RAIL WELDING IN AMERICA.

We read in the *Street Railway Journal* of New York that the Lorain Steel Co. has recently completed a contract for the electric welding of 3,087 rail-joints on the South Jersey division of the Public Service Corporation. About one-third of these joints were in the city of Camden proper, while the other two-thirds were on the Haddonfield and Moorestown divisions of the company. In Camden a portion of the track is laid in asphalt, with Belgian block along the rail, a part in brick and a part in macadam. On the other two divisions all of the track was in macadam. On these two latter divisions a high speed inter-urban service is run. According to the company, the result of the electric welding has been a marked improvement both in the riding qualities of the track at the joints and also in ground return.

All of the joints welded were in a more or less battered condition, so that the joints had to be raised before being welded. This was done by raising the receiving rail so that the lowest point in this rail was level with the head of the abutting rail, after which the elevations were ground off with a corundum wheel. It has been found that the electric weld holds the rail absolutely firm, and that the rolling of wheels across the joint since the work was finished has tended to make the joint smoother than it was immediately after the welding. It is true that by grinding off a portion of the head of the rail some of its wearing qualities are sacrificed. The experience at Camden, however, has been that this is necessary, and that the battered end of the rail must be ground level before a good joint can be obtained.

Table I. shows a summary of the cost of electrically welding these joints, including contract price of $5.25 per joint. Table II. shows the cost per joint, type of paving, type of rail section and number of joints welded on each of the five streets on which the work was done. It is estimated that the life of the welded rail on the Haddonfield Pike will be eight years, whereas during the last two years with angle plate joints, this track has cost the company about $1 per joint each year for tightening bolts and shimming. This maintenance work has only temporarily relieved the situation, for each year the joint has been worse, and it was estimated that at the end of four years the rail would have been so bad at the joints that the track would have to be relaid. In other words, it is expected that in this particular case, by electrical welding, the life of the rail will be practically doubled at a less cost than would have been required simply for maintaining angle plate joints during the life of the rail.

**Table I.**—*Cost of Electrically Welding 3,087 Joints in Camden, N.J.*

| | | |
|---|---|---|
| Cost of labour | $7,031.24 | |
| Cost of material | 581.09 | |
| | | $7,612.33 |
| Credit from sale of old fish-plates and bonds | 2,816.59 | |
| | | $4,795.74 |
| Cost of welding 3,087 joints, at $5.25 each | | 16,206.75 |
| Cost of replacing asphalt, 899·6 yds., at $2.53; 117 yds. at $2.51 | | 2,569.65 |
| Total cost of operation | | $23,572·14 |
| First cost per joint, labour | | 2.277 |
| First cost per joint, material | | 0.188 |
| First Cost per joint, labour and material | | 2.465 |
| Cost per joint, labour and material, after credit is deducted | | 1.553 |
| Final cost per joint, all labour, material, welding and asphalte charges | | 7.635 |
| Cost per mile, under similar conditions, 30 ft. lengths | | 2,687.52 |
| Cost per mile, under similar conditions, 60 ft. lengths | | 1,343.76 |

**Table II.**—*Cost per Joint, Paving and Rail Sections on the Differen Streets.*

| | |
|---|---|
| Haddonfield Pike, 7 in. girder (P.S. Co., section No. 238 and Cambria No. 824); rubble stone on sand, 989 joints | $6,684 |
| Moorestown Pike, 9 in. girder and 7 in. girder (P.S. Co. sections 238 and 200); rubble stone on sand, 1,128 joints | 6,701 |
| Broadway, 7 in. girder (P.S. Co. section No. 238), asphalt between rails and part of shoulder, Belgium block along rail, on 6 in. concrete, 715 joints; Kaighn-avenue, 7 in. girder (P.S. Co. section No. 238), bricks between rails and shoulder, on 6 in. concrete, 64 joints; total, Broadway and Kaighn-avenue, 779 joints | 10,438 |
| State-street and River-road, 7 in. girder (Cambria section No. 834); rubble stone on sand, 191 joints | 6,632 |

## TEST OF A VALVE MAGNET.*

BY C. P. NACHOD.

The following test on a magnet shows the effect which the position of the magnetising coil with respect to the air-gap has on the pull produced. This magnet, shown in Fig. 1, has a short stroke and is designed to operate an air-valve by means of a brass rod (not shown) passing through the hole in the core. The core and armature are of Norway iron; the core has an outside diameter of 1¼ in. and has a ⅜ in. hole through it. The magnet is of the iron-clad type with cast-iron shell and top. There is a cylindrical clearance gap between the armature and top, which, being invariable, has not

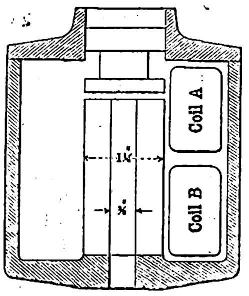


FIG. 1.—VALVE MAGNET.

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* From the *Electrical World* of New York.

been considered. A and B are the two exciting coils. The former, having 1,860 turns of No. 25 wire, is used as an operating coil to draw down the armature, while the latter, of 1,765 turns of No. 26 wire, serves as a retaining coil to hold it down against the air-pressure, after the circuit in the other coil is broken. Coil A, as shown in Fig. 1, encircles the working gap, which is not the case with B.

The test was made with a simple traction permeameter, definite air-gaps being obtained by measured brass washers. Fig. 2 shows the pull produced with varying excitation for each coil separately, with a constant air-gap of 0·0162 in. In the curve for coil A, the range of magnetic densities is sufficient to show clearly the change in permeability of the iron circuit. For so small an air-gap, the difference between the pulls produced by the two coils with the same magnetising force is remarkably great. The ratio of these pulls has been plotted, and the curve shows that coil B is only from 0·4 to 0·8 as effective as A, due solely to its position on the core, which permits a larger magnetic leakage. This ratio curve has a peculiar feature, in that it approaches unity as the flux-density is increased. Fig. 3 shows the same relations with an air-gap of 0·081 in. or five times as great as in the previous case. With this gap the range of flux density is not great enough to produce an inflection point in either curve; and the ratio of pulls for the same excitation is more nearly constant, averaging a little over 0·7, but decreasing with increasing density.

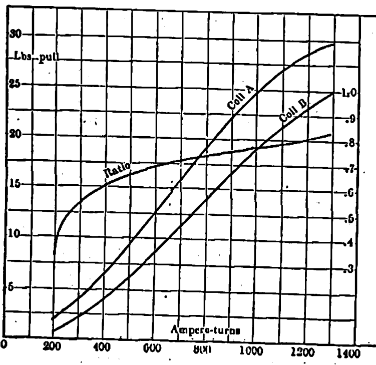

FIG. 2.—PULL WITH 0·0102 IN. GAP.

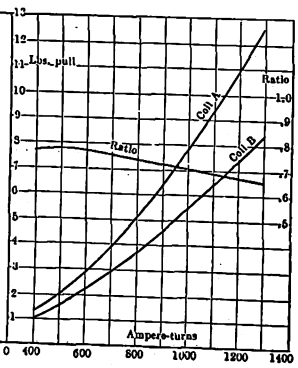

FIG. 3.—PULL WITH 0·081 IN. GAP.

From the curves it appears that, if it were desired to connect the coils in series so that the magnetic effect of B would neutralise that of A, it would be possible to do so for only one, instead of all current values, and that such a neutralising coil for all current values should have the same axial length and slide within or without the other.

## THE FRANCO-VENEZUELAN DISPUTE.

The following facts with regard to the dispute between France and Venezuela reach us through a well-informed source, and they represent the version of the case which is current in semi-official circles in Paris. The present trouble has arisen principally through the action brought against the Venezuelan Government by the Compagnie Française des Câbles Télégraphiques, the result of which was that the Federal Appeal Court of Caracas annulled on August 4th last the concession that had been granted to the company. The company's concession is the result of several contracts: the first dates back to 1887. It was obtained by M. Cuenca Creus, who had been given power to establish a telegraphic communication between Venezuela and the Northern United States of America. M. Cuenca Creus transferred this concession to the Société Française des Télégraphes Sous-Marins, and this company, on amalgamating with the Compagnie Française du Télégraphe de Paris à New York, became the Compagnie Française des Câbles Télégraphiques. The 1887 contract was given effect to in the following year by means of several cables and landlines from La Guayra via Curaçao, St. Domingo, Puerto Plata and Cap Haïtien to Santiago de Cuba, whence the Cuban landlines and cables of the Cuba Submarine and Western Union Telegraph Cos. completed the connection to the United States at Key West.

In 1895 the company, desiring to extend its range of activity, obtained a new contract which extended the concession from 20 to 50 years, and applies to all the telegraph communication between Venezuela and the exterior. In return, the company undertook to establish a new series of telegraph cables to connect various Venezuelan ports to the international telegraph system. Among these was Ciudad Bolivar, situated on the Orinoco at about 200 miles from the mouth of the river.

The company constructed and laid a considerable part of these coast cables, but in endeavouring to connect Ciudad Bolivar with the rest of the system it encountered insurmountable technical difficulties, chiefly due to the shifting of the bed of the River Orinoco. As a consequence, the negotiations with the Venezuelan Government were renewed, and in view of these difficulties it was arranged in 1900 that the Government would relieve the company from the obligation of connecting Cuidad Bolivar by cable to the international system, and that the company should replace this cable by others more easy to lay. In return for this, the company was to make a reduction of the period of the concession to 35 years, it accepted certain reductions in tariff and finally agreed to relieve the Venezuelan Government from the payment of a considerable debt which had accrued for the transmission of official telegrams. This last contract was signed by President Castro himself, who had just come into power.

The next event was the unsuccessful revolution of Matos. The company instructed its staff to refrain from any political interference, but in order to avoid a renewal of the misconception with regard to the payment of sums due from the Government, it refused to accept official telegrams for transmission except against payment of the fees for such messages provided for under the company's contracts. This refusal to give the Government credit irritated President Castro, who was then rather embarrassed financially. The blockade and claiming of indemnities by foreign Governments which followed made him completely hostile to all foreign enterprises and ready to seize upon any pretext for reprisals. An opportunity was given him by some interruptions which occurred in the telegraphic communication on the line to the United States which crossed the island of St. Domingo. This interruption was due to "revolutionary troubles."

The attack against the company was started by a violent press campaign. President Castro then claimed that the 1895 contract with the company called for a connection exclusively by submarine cables between Venezuela and the United States. Then, without taking account of the fact that the rights of the company under its concession had been officially recognised and consecrated by fifteen years of working, he instituted an action against the company for the annullment of the concession. The three principal clauses of the indictment were: (1) That the first article of the 1895 contract pledged the company to establish communication by a direct cable; (2) that the company had not constructed the system of coast cables in conformity with its engagements; and (3) that the company had maintained and encouraged the revolutionary movement of Matos. The last clause, however, was put aside for a special action, which is at present pending before the Venezuelan tribunals. With regard to the first clause the Venezuelan Government relied on an expression "by one or more submarine cables," which occurred in the contract, while the company contended that the very fact of suggesting more than one cable implied the possibility of an indirect route, and in no way interdicted the employment of landlines to complete the connection between the two countries. Further, the company contended that Article 3 of the contract of 1895 actually contained a formal confirmation of the regular establishment of the desired communication, for it said: "With the object of realising a reduction in its tariffs, the Société Française des Télégraphes Sous-Marins, *which has already established a telegraphic communication between Venezuela and North America. . . .*"

The second point was that the company had not laid the system of coast cables under the conditions agreed upon, as it had laid a cable from Curo to Curaçao, instead of one between Curo and Puerto Cabello. The company contended that the cable in question did all that was required in connecting Curo to the international telegraph system at Curaçao, and, moreover, that the Venezuelan Government at the time the cable was laid had made no objection to the routes chosen by the company. They further pointed out that this cable was already in use when the arrangement of 1900 was arrived at, the terms of which had been completely fulfilled by the company.

The Venezuelan tribunal rejected all these arguments and refused to admit the validity of the contract of 1900. The company protested against this decision without avail, and President Castro ordered that all the offices of the company in Venezuela should be closed, with the exception of that at La Guayra, whence communication was allowed with the exterior on the payment of an addition of one bolivar per word on all telegrams sent abroad. With the approval of the French Government the company protested against these measures, and it was then that the Venezuelan Government expelled M. Brun, the manager and representative of the Cable Company at Caracas. Then M. Taigny, the French Chargé d'Affaires, formulated a protest in his turn in the name of his Government, and the events which followed and led up to a rupture of diplomatic relations are of recent occurrence and are well known. President Castro has now closed the La Guayra station of the company and sealed the cables. In addition to the expulsion of M. Taigny, several of the chief officials of the cable company have also been expelled from Venezuela, and there will probably be no further developments in the matter until the arrival of French warships off the coast of Venezuela.

We may add incidentally that telegrams to and from Venezuela are still accepted, as they are sent by post between Venezuela and Curaçao whenever there is a boat.

## CORRESPONDENCE.

### RAIL CORRUGATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In *The Electrician* of Feb. 2 you make some comment upon the trouble experienced at Ealing owing to noise upon the tramways, corrugated rails being one of the causes to which this trouble is attributed. I am unable to agree with the suggestion that "prevention will probably be achieved only by a modification in the composition and quality of the rails."

I have been closely connected with one section of the Handsworth cable tramway, mentioned by Col. Yorke, ever since it was constructed, and thereby became very familiar with the phenomenon referred to long before it became a source of trouble to engineers of electric tramways: the facts connected with this line are quite inconsistent with the theory suggested by you. Shortly, these facts are as follows:—

The line is three miles long, double track; rather more than 1¼ miles are in the city of Birmingham; the remaining length is in Handsworth. The Birmingham section was laid in 1887, Handsworth a year later. The structure is identical on both sections, except as to the paved portions of the roadway, but it has never been suggested that this has any influence on the result. Rail used in original construction came from Barrow, but German rails were used when the lines were relaid, both inside and outside the city.

The winding station is just inside the city boundary; it drives one cable at seven miles an hour for working the city section, and another at nine miles for the traffic outside. All cars run full length of route and change cables in crossing the boundary. The traffic in the two districts is therefore identical as to cars, differing only as to speed. In Handsworth there has been perpetual trouble with corrugations ever since about two years after the line was opened; they have been ground out and the rails changed over and over again only to reappear as fresh as ever every time. In the city there has been no trouble whatever; no rail has ever been ground, and not one has been changed from this cause during the 18 years the line has been in service. Until a few months ago corrugation has not appeared upon the city section, then it began faintly in one place, but it is yet in a very mild form.

These facts do not fit any theory depending upon variations in density or composition of the rails themselves; if this were the cause the trouble would have reached an acute stage on railways very many years ago, whereas it is well known that the phenomenon is very rare upon railways, and upon steam tramways also. As I have pointed out elsewhere ("Permanent Way for Tramways and Street Railways," p. 195) it is due to a torsional vibration of the wheels and axles, becoming acute and causing mischief only when the speed exceeds a certain limit. In considering the mechanics of a pair of equal wheels rigidly attached to an axle, and trying to roll round a curved track, or of slightly unequal wheels on a straight track, it is difficult to see how the motion can be effected without this vibration being set up; and it appears strange that its effects were so seldom observed before the advent of electric traction. This was undoubtedly due to the absence of constant conditions such as vibration period of wheels and axles, and especially of constancy in speed. On a cable line we get the required constancy in both these elements; with electric traction, everything standardised and made uniform as far as possible, we get the first condition fulfilled, but not quite such uniformity of speed, and, therefore, constancy of "touch" between the wheel and rail. The corrugations produced are those due to that set of conditions which prevail most in actual traffic.

Tramway managers will be worried by corrugated rails, and will have to find money to grind them or to replace them, for at least as long a time as they continue to assume that the defect is due to a varying composition in the rails. They have looked for proofs of this theory in several places, but I never heard of the search being successful. The remedy is rather to be found in a study of the rolling stock and traffic. Since the speed cannot be conveniently interfered with, means must be taken to prevent the wheels and axles all having the same, or nearly the same, natural periods of vibration, and sufficient variations can probably be provided for without interfering with the leading dimensions of wheels and bearings. The problem is well worth the attention of managers and their car-building experts.—Yours, &c.,

T. ARNALL.

Birmingham, Feb. 12.

[We agree with Mr. Arnall that the causes of rail corrugation are certain actions of the car wheels and axles. We should class them generally as "chattering," which includes the action on curves described by Mr. Arnall as "torsional vibration." It also includes incipient skidding under the application of the brakes when the wheels alternately skid and roll, and chattering from tightness of rail gauge springing the axles. The part contributed by rail composition is undue ductility or susceptibility to "cold rolling." This seems to be associated with relatively low carbon and high manganese contents. Where tramway rails containing over 0·55 per cent. of carbon and under 0·8 per cent. of manganese have been used rail corrugation is unknown. Unfortunately the British rail rollers persuaded the Engineering Standards Committee to agree to less than 0·5 per cent. of carbon on the plea of manufacturing difficulties, although certain German and Belgium rollers are quite successful with tramway rails up to 0·6 per cent. C. This is the meaning of our reference to the composition of rails. It may be of interest to observe that corrugation is becoming very obvious upon the rails in several of the Metropolitan-District stations. The severity of the braking on the electric trains is well known.—ED. *E.*]

## BOOKS RECEIVED.

**(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)**

"Proceedings of the Royal Society." Series A. Vol. LXXVII. No. A515. Mathematical and Physical Sciences. (London: Harrison & Sons.) 3s.

"Construction of Electric Machines and Apparatus." Edited by C. Kinzbrunner. Part 1: Switchboard Apparatus, consisting of 10 plates. (London: Harper & Bros.) 2s. 6d. net.

"Alternating Current Windings: Their Theory and Construction." By C. Kinzbrunner. (London: Harper & Bros.) 3s. 6d. net.

"Continuous-Current Armatures: Their Winding and Construction." By C. Kinzbrunner. (London: Harper & Bros.) 3s. 6d. net.

"Science Abstracts." January. Section A.: Physics. Section B.: Electrical Engineering. With Indices. (London: E. & F. N. Spon, Ltd.) 1s. 6d. each.

"Lehrbuch der Allgemeinen Elektrotechnik für Studierende der Elektrotechnik an Technischen Hochschulen und Elektroingenieure." By Prof. K. Zickler. Vol. I. (Leipzig: Franz Deuticke.) 10m.

## ANNUAL DINNER OF THE POST OFFICE ENGINEERING DEPARTMENT.

The third annual dinner in connection with the Post Office Engineering Department was held on Tuesday evening, Mr. John Gavey, C.B., Engineer-in-Chief of the Post Office and President of the Institution of Electrical Engineers, presided. The guests of the evening included the Right Hon. Sydney Buxton, M.P., Postmaster-General, Mr. H. Babington Smith, C.B., C.S.I., secretary, Mr. J. Ardron, Sir Robert Hunter, Mr. S. C. Hooley, Mr. T. R. Baillie Gage, Mr. A. J. M. Ogilvie, Sir William Preece, K.C.B., Major Boys, R.E., D.S.O., Mr. A. W. Heaviside, Dr. R. M. Walmsley, Mr. E. Ogden, Mr. G. Morgan, Mr. J. W. Willmot, Mr. G. F. Preston, and Mr. W. J. Etheridge, &c., &c.

Mr. BABINGTON SMITH, in proposing the toast of "The Engineering Department," referred to the recent agreement by which the enormous system of the National Telephone Co. will pass into the hands of the Post Office on January 1, 1912. He had the greatest confidence that the efficiency and energy of the engineering service of the Post Office would enable that transfer to be accomplished with success. But undoubtedly in the years that will intervene between the present time and 1912, there would be a great deal to do in the way of preparation for the adaptation that must take place when so large an addition was made at one time to the business of the Post Office. After referring to the recent visit of Mr. Gavey to the United States to inspect the telephone system of that country, Mr. Smith said that on Saturday next an important step would be taken in the history of the Post Office telephone system. That day had been fixed for the transfer of the subscribers to the Central Exchange to the new City Exchange, the largest operation of the kind, he believed, that had ever been undertaken. In the course of a few hours some 12,000 subscribers would be transferred from one switchboard to another. Another step had in the past year been taken in the direction of progress—viz., the inception of the idea which will result in the institution of Post Office Electrical Engineers. The conception of that Institution had orginated from among the members of the electrical engineering department themselves. It had been felt in the service that there was some lack at present of opportunities for mutual improvement, some deficiency in the means of access to the latest literature on the subjects with which they dealt. It had been felt that men who might be employed on one particular branch of their work would not have perhaps sufficient opportunities of acquainting themselves with the latest advances in other detartments of electrical science and engineering, and thereby fitting themselves more completely for the higher posts to which they hoped to rise. The idea had been put forward by their chairman and was at once accepted as a sound idea by the Postmaster-General, who has been able to persuade the Treasury to give a substantial grant for the purposes of the intended Institution. That grant would be available on April 1st next.

Mr. GAVEY, in responding, said that he would adhere to the old custom at these dinners of giving a glance backwards at the work that they had carried out in the course of the year. The great underground line from London to Glasgow, commenced under the ægis of Sir William Preece, had been completed, and on or after April 1 they all hoped that that line would be at work from end to end. In the course of the present year they would finish an underground line from London eastwards to Chatham, and would make good progress with one westwards from London to Reading. They might be rather proud of this great work. There was nothing equal to it in the whole world. It was only recently that he had been approached by representatives of the great American companies, who were desirous of obtaining such information as was available on the subject. Another line of progress was the completion of the great telegraph switch for providing telegraphic inter-communication throughout the metropolitan area. It had been on the initiation of Sir John Lamb that the switch was designed, and it is one of the most up-to-date pieces of telegraphic apparatus that had been introduced anywhere. He had recently come across the following extract from the report of the commission established in connection with the St. Louis Exhibition last year. The report said that in the Telegraph Group the exhibit of the British Post Office was the finest display in the exhibition relating to ordinary land telegraphy, whilst it went on to refer to certain English exhibits from manufacturers. Then the paragraph read: "None of the other foreign exhibits were particularly worthy of note. There appears to be little field for introducing new telegraphic inventions in America, American inventors themselves complaining that their opportunities in their own country were very limited, and that Great Britain was much more ready to give new ideas a fair trial." It had been said from time to time that a Government monopoly tended to stifle invention. He thought that this was a very good counterblast to a statement of that sort. Turning for a moment to telephonic matters, they had somewhat exceeded the results in the previous years. In London they had joined up 10,000 additional telephone stations. Even at that, however, they lagged behind the Americans. He had recently received some statistics from the vice-president of the New York Telephone Co., in which he said that in Central New York they joined up in the year ended December 31, 1905, 29,032 telephones, and in Greater New York, which would be the equivalent of Greater London, 45,115 telephones in one year. If they assumed that the National Telephone Co., who share with the Post Office the telephonic service of London, had joined up 10,000 also, that brought up the total to 20,000, about one-half that in New York. In conclusion he joined with Mr. Babington Smith in congratulating them on forming the new Institution of Post Office Electrical Engineers. He thought it was the wisest and best step that had ever been taken by the members of the engineering branch or by the members of any body in the service of the Post Office.

Mr. HARRISON then proposed the toast of "The Visitors."

Mr. SYDNEY BUXTON (Postmaster-General), in the course of his reply, said that it had struck him in going round the various departments, and in seeing the various heads of the departments, that they had not only the intelligence which all of those present that evening brought to bear on the matter, but what was also very important indeed, and what their chairman had in a very large degree, the great gift of very effective organisation and administration.

Sir ROBERT HUNTER proposed the health of Sir William Preece.

Sir WILLIAM PREECE, in reply, said that he had been 54 years engaged in the development of electrical industries and applications of all kinds, but there was nothing that he looked back upon with such pride and with such pleasure as the 30 years that he had spent in the Post Office.

## PARLIAMENTARY INTELLIGENCE.

### PETITIONS AGAINST PRIVATE BILLS.

Practically all the petitions against private bills in the House of Commons have now been deposited, and in consequence of the nature of many of the bills the opposition is considerable. Over 300 petitions in all have been deposited against the London electric power bills. All the Borough and other Councils and the electric supply companies, both inside and in the neighbourhood of London, are petitioning against the companies' power bills, but the London County Council bill is the bill with the greatest number of petitions against it. Although it is not opposed by all the London Borough Councils, this is more than counterbalanced by the extra number of outside authorities who are opposing, due to the larger area which it schedules. There are 75 petitions against the L.C.C. bill, 65 against the Administrative Co.'s bill, and 53 against the Additional Co. All the promoters of the bills have lodged cross petitions against each other.

There are 65 petitions against the Lancashire Electric Power Co.'s bill, which, it will be remembered, proposes a modification of its original powers so as to bring it more into line with recent power companies, and the Hammersmith, City & North-East London tube railway bill has, so far, 75 opponents. Some 60 petitions have been lodged against the London Outer Circle Railway, and among the other bills to which there will be considerable preamble opposition are the London County Council (Tramways and Improvements), London United Tramways, Middlesex County Council (General Powers), North-West London (tube) Railway, Derbyshire & Nottinghamshire Electric Power and the London County Council (General Powers).

In addition to the above there remain the petitions against those bills originating in the House of Lords, none of which have yet been deposited.

### STANDING ORDERS COMPLIANCE.

Mr. Campion, Examiner of Standing Orders, had before him yesterday two opposed bills—viz., the London County Council (Tramways and Improvements) and the London United Tramways.

#### London County Council (Tramways and Improvements).

Mr. BROWNE (Messrs. Dyson & Co.), Parliamentary agent for this bill, first dealt with tramway No. 1, which, he said, was from Cricklewood, through Hampstead, Paddington and St. Marylebone to the Edgware-road. The question involved was one of consents of road authorities, and he claimed that he had substantially received the necessary two-thirds consent, inasmuch as the St. Marylebone and Hampstead Borough Councils had given their consent on certain conditions as to the system of traction to be used, &c., although he did not go so far as to say that the London County Council would adopt the conditions. But for Standing Orders purposes he claimed he had the necessary consents. With regard to Paddington, he could not secure the consent of that Council.

Mr. GREIG, Parliamentary agent for the Willesden Urban District Council, which withheld its consent, opposed on the ground that he knew of no case in which conditional consents had been accepted by the Standing Orders Examiners.

Mr. BROWNE contended that the objections of the two road authorities who had given conditional consents were on points relative to construction, and were, therefore, preamble opposition, which could be dealt with competently by a Select Committee, but if the Examiner reported a non-compliance, he would ask that the fact of his having received conditional consents should be stated in his report to the Standing Orders Committee.

Mr. CAMPION said the House attached great importance to the words of the Standing Order, and he must report a non-compliance in the ordinary course adding that there was no evidence that the conditions imposed in the consents would be fulfilled.

Mr. BROWNE then referred to tramways No. 6 and 6A, in respect of which a conditional consent had been given by the Hackney Borough Council, but in view of the decision just given, he would take a non-compliance in connection with this and also tramway No. 20, which proposed lines in Deptford.

The bill will, therefore, go before the Standing Orders Committee on these points.

#### London United Tramways.

Mr. H. L. CRIPPS (Messrs. Dyson & Co.) Parliamentary agent for this bill said that as the company could not obtain the consents of any of the authorities concerned with the new lines proposed, he was bound to take a non-compliance in respect of these.

The portion of the bill as regards tramways, will, therefore, be abandoned. Standing Orders as regards the remainder of the bill, which relates to street widenings, &c., were proved.

The consideration of the Macclesfield Tramways Bill and the Middlesex County Council Tramways Bill was postponed until Tuesday, when, in all likelihood, they will be unopposed on Standing Orders.

# LEGAL INTELLIGENCE.

### Bridges & Smith v. Burt & Co.

At Shoreditch (London) County Court last week, Judge Smyly heard an action for the recovery of £6. 14s. 2d. from N. Burt & Co., for electricity supplied to them during the holding of the Electrical Exhibition at Olympia in September-October last. Defendants counterclaimed £4. 13s. 6d. for a cable which they alleged plaintiffs had taken away wrongfully when removing the meter. The claim was admitted, and in support of their counterclaim defendants said that as plaintiffs' "ran" the exhibition they were responsible that nothing was removed belonging to anyone else. After the exhibition was over there was the usual rush to clear things away, and Messrs. Burt contended that they cleared as soon as they possibly could, but before this the meter had been removed and also the cable (444 ft.) which did not belong to plaintiffs.

Plaintiffs denied that they were liable in any way; the exhibition closed on the Saturday, and it was not until the following Thursday that defendants applied for their pass into the building to clear away their goods, and by that time there had been hundreds of carmen in and out clearing away stuff. The agreement between the parties contained a clause to the effect that plaintiffs would use every reasonable care to ensure to any exhibitor that anything appertaining to the exhibition would be looked after, but they did not hold themselves responsible for any burglary, fire or illegal act. They knew nothing about the cable. They cleared the meter away, but beyond that knew nothing.

Judge SMYLY: And therefore if it was stolen by one of the carmen, you consider you are shielded by the larceny clause in the agreement?

PLAINTIFFS: Most certainly. We say that under any circumstances we are not liable.

Judge SMYLY asked if defendants could prove the cable was taken away by plaintiffs.

DEFENDANTS: No; but it must have been, though.

After hearing the evidence, His HONOUR said it seemed pretty clear that plaintiffs were protected, and therefore he gave judgment for them on the claim and non-suited defendants on the counterclaim, with costs.

# MUNICIPAL, FOREIGN & GENERAL NOTES.

## APPOINTMENTS VACANT AND FILLED.

An electrical engineer is required to take charge of a tramway and lighting undertaking in the north; must have had a thorough practical experience in central station work and tramway management. Commencing salary £300 per annum. See an advertisement.

The council of Armstrong College, Newcastle-on-Tyne, wil shortly appoint a professor of electrical engineering. Stipend £500 per annum and one-third of fees until £750 in all is reached. Applications to the secretary (Mr. F. H. Pruen) by March 1. See also an advertisement

Two additional assistants are wanted in the electrical engineering department of the Central Technical College, Exhibition-road, London, S.W. Salaries £300 and £150 per annum respectively. Applications to Prof. W. E. Ayrton, F.R.S. See also advertisement.

Ferranti Limited, Hollinwood, Lancs., require a draughtsman accustomed to high and low-tension switch gear work. See an advertisement.

A good fitter, with knowledge of high-speed engines, is required for Egypt. Wages £15 a month and quarters. Two years' agreement. See an advertisement.

**Civil Service Examination.**—An examination for assistant examiners in the Patent Office (20–25) is announced. Applications to the Secretary, Civil Service Commission, Burlington-gardens, London, W., by April 5. See an advertisement.

Liverpool City Council on Wednesday made the following appointments in the newly formed joint tramways and electricity supply department:—Mr. C W Mallins (traffic superintendent) as traffic manager, with an increase in salary from £500 to £600 per annum, and a further increase at Jan 1 next to £700; Mr. Thomas Bulmer (deputy accountant in controller's department) to be also secretary to the tramways department, increase from £400 to £600; Mr. Alfred Clough (resident electrical engineer of the electricity department) to be also resident electrical engineer to the tramways department, increase from £900 to £1,000, to be further increased in Jan. next to £1,100; and Mr. A Bromley Holmes (consulting engineer to the electricity department) to perform similar work for the tramway department for an additional £250 per annum.

Mr. Richard Lees has been appointed chief superintendent of telegraphs at the Manchester General Post Office, in place of Mr. W. E. Halton, retired.

Major G. F. H. Le Breton Simmons, R.E., has been appointed chief instructor at the schools of electric lighting, Chatham, vice Major C. B. Collins, R.E., who has vacated that appointment. Lieut. P. S. Watkins, R.E., is to be assistant instructor, vice Capt. J. R. Garwood, R.E., whose tenure of that appointment has expired.

Mr. Sedgwick has been appointed shift engineer at St. Helens (Lancs.) electricity works.

Mr. W. H. Wilson, of Lincoln, has been appointed chief engineer at Sleaford electricity works.

**Aberdeen.**—The Corporation have entered into an agreement with the Great North of Scotland Railway Co. for the supply of electric current for lighting and power for four years at 2¼d. per unit, the company to take a minimum of 110,000 units per annum for the first two years, and 120,000 units for each of the last two years.

**Adelaide Tramways.**—Our Adelaide Correspondent informs us that proposals have been received by the South Australian Government for the electrification and leasing of the Adelaide tramways upon certain terms. The Government has replied that its hands are tied by the Tramways Act, 1904, and that it is unable to consider any offer until such offers are publicly advertised for. It is stated that the proposals emanate from a Victorian gentleman associated with Sir Alexander Peacock (a former Premier of that State), who is said to have the same backing as the Essendon–Flemington tramway of Victoria. This line, which is fast approaching completion, is to be transferred to a London company bearing the title of "The North Melbourne Electric Tramways & Lighting Co. (Ltd.)"

**Argentina.**—Mr. Francis K. Cassels has petitioned the Chamber of Deputies for a concession for the utilisation of the Falls of Iguazu for the generation of electrical energy, and the distribution of the same in various parts of the Republic.

Mr. Cassels, in his petition, states that the applications of electric power in Argentina to-day are limited to lighting, mechanical power for small installations and for traction, and that if power were generated on a vast scale—up to hundreds or thousands of millions of kilowatt-hours annually—and distributed on liberal conditions, it would apply to nearly all the uses which coal and other fuel have at present, and proceeds to argue that this would obviate to a great extent the importation to Argentina of coal from abroad, which amounts to 1,460,000 tons annually. On condition that a 90 years' concession is granted for the sole usufruct of the Iguazu Falls, for the distribution of energy throughout the country, and for the acquisition of all private lands that may be necessary for the undertaking, Mr. Cassels will undertake to submit plans within two years, the charges for energy to be fixed by a committee of six experts, so as to give 6 per cent. profit per annum to the undertakers during the first 45 years and 5 per cent. during the succeeding 45 years, after which time the undertaking is to become the property of the Government.

**Beckenham.**—The Council have declined to pass a recommendation of the Electricity committee to apply for powers to supply electricity in West Wickham.

**Belfast.**—The official inspection of the Cavehill and Whitewell Tramway Co.'s line took place on Tuesday, and the line was opened for traffic.

**Bethnal Green (London).**—Several authorities being willing to supply electrical energy in bulk, the Council has abandoned its scheme for establishing a municipal generating station.

**Bournemouth.**—The Corporation having decided not to experiment with Sunday cars. this question is to be the chief issue of the fight at the next municipal elections.

**Bradford.**—The City Council decided on Tuesday to ask the Board of Trade to increase the maximum speed of running Corporation tramcars from 12 to 17 miles an hour.

The Council also decided (by 36 votes to 15) that no accounts should be paid by or for the tramways department without a bill certified by the tramways general manager and the chairman or deputy-chairman of the Tramways committee. Ald. Priestly explained that the Tramways committee considered this rule necessary because hundreds of pounds had been paid without the sanction of the Tramways committee, and Mr. Palin said the committee did not know what they were spending until the end of the year, when they were open to the charge of extravagance. He recalled an instance where the Finance committee had passed an account for about £5,000 without the knowledge of the Tramways committee or the manager.

**Bristol.**—The Council on Tuesday rejected, by 31 votes to 27, the Electrical committee's proposal to increase the salary of the city electrical engineer (Mr. H. Faraday Proctor) from £700 to £800 per annum.

Ald. Pearson, who moved the adoption of the recommendation, referred to the great growth of the undertaking since Mr. Proctor's appointment, and said the revenue and the units sold in 1902 were £44,946 and 2,756,624 respectively, compared with £69,687 and 5,217,528 in 1905. A proposal to increase the salary of the deputy electrical engineer (Mr. H. H. Couzens) from £350 to £375, with a further £25 increment in January next, was adopted.

On the motion of Ald. Pearson the Council instructed the Electrical committee to consider and report as to the desirability of endeavouring to obtain from the Board of Trade an order that the powers of the Somerset & District Electric Power Co. under their 1903 Act shall cease to be operative in Bristol.

**Burton-on-Trent.**—In order to increase the traffic on the tramways the Council have agreed to an advertisement contractor's suggestion as to the issuing of booklets containing four penny tramway tickets, or coupons which could be exchanged for tickets, to tradesmen for 2½d., the tradesmen either selling or giving away the tickets to customers, and the deficiency being made up by the cost of the advertisements printed in the booklets.

**Chesterfield.**—Mr. R. L. Acland, borough electrical engineer and tramways manager, has been given an honorarium of £400 for extra work when acting as consulting engineer for the tramway scheme recently brought into operation.

**Chile.**—A concession for the electric lighting of Iquique for a term of 10 years has been granted to the Iquique Lighting Co.

**Crediton.**—The Council have decided to oppose the gas company's bill, which seeks powers for electricity supply.

**Dolgelly.**—The Council on Tuesday received 14 offers to prepare preliminary schemes for the electric lighting of the town. The fees asked ranged from £6. 6s. to £125. Seven applications were selected for consideration after the election, which takes place next month.

**East Ham.**—An inquiry will shortly be held into the application of the Council for sanction to borrow £18,750 for electric lighting extensions.

**Exhibition.**—In order to stimulate the demand for electricity for power, heating and cooking, Morley Electricity committee are arranging an exhibition for April 5, 6 and 7.

**Fareham.**—The Council have resolved to hold a special meeting to consider the advisability of purchasing current in bulk (at 2½d. per unit) instead of borrowing additional capital for the extension of the Council's works when the demand renders this necessary.

**Frimley.**—Mr. H. B. Renwick attended a meeting of the District Council on 6th inst., when consent was accorded to the application of the Camberley Electric Supply Co. for a provisional order, subject to details being settled.

**Fulham (London.)**—Eelbrook Common, now lighted by gas, is to be lighted by Nernst lamps at an estimated cost of £270. The dust destructor and boiler house is to be rewired at a cost of £100.

**Glasgow.**—The Corporation have received from the Secretary for Scotland consent to the borrowing of £300,000 further for electricity supply, bringing the total up to £1,700,000 authorised. In forwarding the sanction, the Secretary for Scotland states that he gives his consent the more willingly in view of the considerable sums written off for depreciation and carried to reserve. At the same time he advocates an increase of the provision for the redemption of £885,000 borrowed under the consents given from 1892 to 1900. The Electricity committee have postponed consideration of this suggestion till the end of the current financial year.

**Gravesend.**—The Council have entered into an arrangement with Sidney Blandford and Hooper, Leavy & Co. for wiring consumers' premises.

**Hackney (London).**—The Council are willing to consent to the bill for the construction of a proposed electric tramway in Lea Bridge-road on condition that the Council's share of the expense of road widening is reduced to one-sixth. The Council also consents to the use of the overhead system from the terminus to Lea Bridge

**Hammersmith (London).**—On the advice of the electrical engineer (Mr. G. Gilbert Bell) the Council have decided to replace the old transformers as opportunity offers by new transformers of modern design, and Mr. Bell has been authorised to replace 16 transformers at once at a cost of £665, less £305, the estimated selling value of the old machines.

**Hereford.**—Sanction to a further loan of £4,550 for cable extensions has been obtained, the period of repayment not to exceed 25 years.

**Horley.**—The Board of Trade intend to revoke the Electric Lighting Order, 1904, which was transferred to the Horley Electricity Supply Co.

**Kingston-on-Thames.**—At Tuesday's Council meeting permission was given for opening the tramways lines on March 1.

**Kirkcaldy.**—The demand for current for lighting has increased by 47 per cent. during the year and the tramcars are now carrying 10,000 people more per week than at the corresponding time last year.

**Leeds.**—The Tramways committee have undertaken to convey material from the N. E. Railway depot to the new filter beds at Headingley for the Waterworks committee at 1s. 3d. per ton.

**Lecture.**—Mr. Charles Bright, F.R.S.E., gave a lecture at the Royal Military School, Chatham, on 9th inst., entitled "Submarine Telegraphy."

The lecture was fully illustrated by lantern slides, and Mr. Bright described the methods of transmitting electrical signals through cables, pointing out that the present speed of working was limited only by the type of cable employed. The various stages of construction, from the copper conductor and insulator to the iron sheathing, were described, and reference was made to recent great improvements effected in the quality of materials, &c. The methods of surveying the ocean beds, of providing for irregularities of the bottom when laying the cable, landing shore ends, picking up and repairing, the localisation of faults, &c., were dealt with. A résumé of submarine cable work from the very commencement was given, with portraits of the pioneers, as well as an account of the telegraph fleet of some 50 vessels. Some interesting statistics followed, and completed a very instructive lecture.

**Light Railways.**—The Board of Trade have confirmed the Tarporley Light Railway Order, 1906.

An inquiry was recently held into the application of the Lindsay Light Railway Synd. for an order authorising the construction of the Fairford and Cirencester light railway. The commissioners decided to provisionally approve the scheme.

**Liverpool.**—On Wednesday the City Council considered the proposal that the undertakings of the tramways and electricity supply departments should in future be managed by one committee, to be called the Tramways and Electric Power and Lighting committee. It is considered that this arrangement will result in more economical administration. Some rearrangements of the staff, referred to in another column, were also discussed. The capital of the joint undertaking is about £2,000,000.

Ald. SMITH, in moving the adoption of the proposals, paid a tribute to the excellent services of Mr. A. Bromley Holmes, consulting electrical engineer, and Mr. Alfred Clough, the resident electrical engineer.

Mr. H. R. RATHBONE thought the sole reason for the amalgamation was that there was no one on the staff to fill the place of the late tramways manager (Mr. C. R. Bellamy).

Mr. ALSOP thought the amalgamation might lead to confusion of accounts, and that the committee might elect to make one concern look profitable at the cost of the other.

The proposals were ultimately adopted by 58 votes to 40.

**London County Council.**—At Tuesday's meeting £1,965 was loaned to St. Pancras and £2,000 to Woolwich for electric lighting.

*Lighting of Theatres.*—The report of the Theatres and Fire Brigade sub-committee was again submitted, recommending that as from April 1 the chief officer of the Fire Brigade be responsible to the Council for the inspection of electric lighting installations and heating and other mechanical arrangements in theatres and the other places of public entertainment licensed by the Council, and further recommending certain appointments to the Fire Brigade department in connection with their new duties, including the appointment of an electrical and mechanical engineer, at a salary of £400 a year, and an electrical engineer, at a salary of £200 a year.

The recommendations were carried.

*School Lighting.*—The Education committee reported that the gas lighting at the L.C.C. school and building, Brixton, was unsatisfactory, and advising that a system of electric lighting be installed at an estimated cost of £2,250 for the plant, wiring and lamps. Postponed.

*Electric Clocks.*—It was agreed to instal the magnetic system of electric clocks in the Lower Market-street buildings of Woolwich Polytechnic.

*Tramways.*—It was agreed that the contract with General Electric Co. be extended to include the provision of additional switch gear required at the tramway sub-stations at Brixton and the Elephant and Castle at a cost of £2,200.

Replying to questions, Mr. J. Allen Baker, M.P., said the Paris visit of the Council had shown that the Council's decision to adopt the conduit system of electric tramways was justified.

**London United Tramways.**—The company state that in consequence of opposition by Middlesex and Surrey County Councils they have withdrawn from their bill the proposal for laying and working tramways over Kew Bridge.

**Maesteg (Glam.).**—The Council are asking for an extension of time for complying with their electric lighting order, 1903.

**Maidstone.**—Electric current is to be supplied at 1d. a unit for heating and cooking.

**Manchester.**—A report presented to the electricity committee on Wednesday stated that the output of current during the past year showed a satisfactory increase, and arrangements are being made for further extensions of plant and mains.

The committee have decided to rearrange and reduce the charges for current for power. At present the charges are based upon the units consumed per quarter per E.H.P. of the consumers' maximum load, beginning with 1⅞d. per unit for less than 150 units per E.H.P., and ending with 1d. per unit for 450 units per E.H.P. and upwards. The committee propose to charge 1¼d. per unit for less than 300 units per E.H.P. per quarter, and 1d. per unit for 300 units or upwards after March 31. If the reduced rates are adopted the committee recommend the adoption of a minimum charge for power of 7s. 6d. per quarter, this minimum to apply to new consumers only.

The chief engineer and the secretary advise the committee that the time is opportune to develop the sales of current. and suggest that radiators should be supplied to customers on the hire-purchase system and the current be supplied to same at the proposed new rates for power supply.

Owing to the adverse vote of the ratepayers the Corporation have decided to drop the Urmston tramways clause of their bill.

**Marriage.**—On Wednesday, at St. Mary's, Hampstead, London, N.W., by the Rev. E. A. Chattock, assisted by the Rev. W. Stone, Mr. Richard Alexander Chattock, city electrical engineer, Birmingham, was married to Miss Clara Valentine Sisson, youngest daughter of Joseph Sisson, Esq., of Penrith, Cumberland.

**Marylebone (London)**—Application is to be made to London County Council for an advance of £48,545 for electric lighting. During the quarter ended Dec. 31 1,524,976 units were sold at an average price of 5·05d. per unit, the total receipts being £32,133, and the meter rents £736. Working expenses were £8,866, leaving £24,287 to meet interest, sinking fund, &c.

**Metropolitan District Railway.**—The directors have abandoned the idea of zone fares.

**Middlesbrough.**—The Electric Lighting committee have granted an honorarium of £50 to the borough electrical engineer, Mr. H. M. Taylor, whose salary has also been increased from £400 to £450 per annum.

**Motor-omnibuses as Tramway Feeders.**—Bath Electric Tramways (Ltd). have inaugurated their motor-omnibus service to the Lansdown district.

**Municipal Telephony.**—A conference of representatives of municipalities owning telephone services was held in London on Monday. The towns represented were Glasgow, Hull, Brighton, Swansea and Portsmouth. The conference was private, but the chief topic of discussion was the means to be employed in obtaining from the Postmaster General his consent to the renewal of their licences. The views of the municipalities are to be put before the Postmaster-General upon his receiving a deputation, and the precise form in which those views should be presented was decided upon at the conference.

**New Books.**—Messrs. Harper & Brothers have recently issued the following:—

1. "Constructions of Electric Machines and Apparatus" (by C. Kinzbrunner), a series of plates showing how the various problems arising in the construction of machines and apparatus have been solved by various manufacturers and designers. The first part, to be issued immediately (price 2s. 6d.), consists of 10 folio plates showing switchboard apparatus.
2. "Continuous-Current Armatures: Their Windings and Construction," by C. Kinzbrunner (3s. 6d.).
3. "Alternating-Current Windings: Their Theory and Construction," by the same author (2s. 6d.).

**Patents at the Milan Exhibition, 1906.**—Dr. A. Gentile writes to say that, by a recent Royal decree, all inventions relating to any exhibited object at this exhibition for which an Italian patent has already been applied for or granted will be considered as having been worked throughout the duration of the exhibition.

**Poplar (London).**—On the recommendation of the engineer and manager of the electricity undertaking (Mr. J. Horace Bowden) the Council have decided to oppose the L.C.C. Electric Power Bill in order to obtain protective clauses.

**Presentation.**—Mr. T. Taylor, chief superintendent of Post Office Telegraphs at Bristol, last week made a presentation of a service of plate on behalf of the local officials of the department to Mr. E. J. Sherring, assistant superintendent of telegraphs, on the occasion of his retirement after 40 years' service.

**Provisional Order Transfer.**—Notice is given of intention to transfer to the Chichester Electric Light & Power Co. (Ltd.) the Chichester Corporation electric lighting order, 1898. The consideration is £500. The Corporation reserve rights of re-purchase.

**Roof-covered Tramcars.**—Cars with upper deck covers have now been introduced on the London United Tramways between Shepherd's Bush and Hampton Court.

**Roumania.**—Electric lighting is to be installed at Hitesci, Roumania, and the tenders are shortly to be invited for the supply of plant and material.

**Rugby.**—The Council have reduced the charge for current for lighting to 5d. per unit for the first 500 units per quarter, and 4½d. beyond.

**Ryton.**—The Council have entered into an agreement with the Stella Coal Co. for street lighting by electricity at Clara Vale.

**Stepney (London).**—The Council is applying for a loan of £10,000 for electric lighting extensions.

**Sunderland.**—On Wednesday the Council resolved to oppose the bills promoted by the County of Durham Electric Power Supply Co. and the Newcastle-upon-Tyne Electric Supply Co., which seek powers to supply consumers in the borough.

**Telegraphic Communication Between Spain and the Canaries.**—The Spanish Government have appointed a Royal Commission to consider and report upon the most efficacious and speedy means of establishing telegraphic communication between Spain and the Canaries.

**Theft.**—At Leicester Police Court on Tuesday Harold Roll was sentenced to three months' imprisonment for stealing 150 ft. of cable from the Leicester Corporation power station at Belgrave. A dealer named Barratt said he paid prisoner £12. 12s. for the cable, after going to view it at the station.

**Tunbridge Wells.**—The Council have decided, owing to a demand for electric current outside the borough boundary, to apply for powers to extend their area of supply.

**Walsall.**—The Council have decided to apply for sanction for a further loan of £13,000 for extensions of the generating plant and mains, &c.

The net profit on the tramways for the past year was £3,893, which it is proposed to carry to reserve.

**West Fife Tramway Scheme.**—A public meeting at Lochgelly last week decided to protest against the action of any local body insisting on such terms as might wreck this tramway scheme, and to assist in the promotion of the undertaking. Mr. R. G. E. Wemyss said the cost of the conditions imposed by the District Committee of the County Council would be about £2,000 per mile, and was little short of blackmail.

**West Ham.**—On Tuesday the Corporation decided to memorialise the Government to appoint a Royal Commission to inquire into the question of electricity supply in bulk in London and neighbourhood.

The charge for current for lighting is to be reduced from 4d. to 3d. per unit from March 31, and a maximum for power of 1d. per unit, power consumers to be allowed to use 10 per cent. off their current for lighting.

The Council's largest customers, the Stratford Co operative Society, are to be supplied under a 12 months' contract at 2½d. per unit.

In future there is to be an annual contract for motors and accessories.

A 1,500 kw. turbine generator and a 500 kw. motor generator are to be put down, at an estimated cost of £12,000.

**Wimbledon.**—Prepayment meters are to be installed in short-term tenancy houses, and current is to be supplied to them at 5d. per unit.

The revenue from the supply of current for private lighting during the past year was £15,222. The equivalent of 95,937 8 c.p. lamps is connected.

**Workmen's Tramway Fares.**—The Metropolitan Electric Tramways (Ltd.) issue workmen's tickets for the return journey between Edmonton and Finsbury Park (about 12 miles) at 2d. each.

**Dinner and Celebration.**—On Wednesday, in the Royal Venetian Chamber of the Holborn Restaurant, London, W.C., a large gathering of friends and clients met to celebrate the 30th anniversary of Mr. F. A. B. Lord's association with the well-known firm of W. F. Dennis & Co., 49, Queen Victoria-street, London, E.C., who have for many years been the British representatives of the firm of Felten & Guilleaume. Mr. Lord is now senior partner in the firm which he entered 30 years ago as junior clerk, and he has the satisfaction of knowing that he has helped to raise his firm to a leading position in the special branch of trade with which Messrs. W. F. Dennis & Co. have been so long and so honourably associated.

Mr. Lord received about 100 guests, after which ceremony adjournment was made and ample justice done to an excellent dinner. A short respite during the dinner gave Mr. Spoerer the opportunity to read a number of congratulatory telegrams to Mr. Lord, from friends, relations and clients in all parts of the world, all testifying to the high esteem in which Mr. Lord is held. After dinner, and the usual loyal and patriotic toast having been enthusiastically drunk,

Mr. SPOERER proposed the health of Mr. F. A. B. Lord, and echoed the good wishes of all his friends, present and abroad, for his continued prosperity and good health. He said he had known Mr. Lord for 25 years, and in their business relationships they had always been friends. It was impossible to know Mr. Lord without liking him, and he sincerely trusted he would be spared for many years.

At this stage Mr. Lord was presented with a number of handsome presents.

Mr. LORD, in responding to the toast, thanked his friends for their presence on the occasion and for their many substantial tokens of goodwill. He looked back on 30 years of a busy life, and deeply felt the honour of the present occasion. He would like to refer especially to a kind letter he had received from Mr. A. Guilleaume, who expressed his pleasure at congratulating him upon his many years of faithful work and service, and sent him his best wishes for a pleasant evening, and hoped they would work together mutually and amicably in the future, as they had for 30 years past. His commencement with the firm of W. F. Dennis & Co. was at the bottom of the ladder. When 14 years of age he learned that an office boy was wanted, and despite his very youthful appearance at that time he secured the post. His chance came later as the business grew. New agencies were taken up, barbed wire was invented, and in the 80's electricity began to be talked about, and the manufacture of wire caused the firm they represented to build and extend their works to cope with what was rightly foreseen would be a big business. Then came the telephone, and that fairly started things along a line of great development. He was appointed traveller, and this just brought him in contact with outside work and with many of those whom he was proud to see there that evening. In 1902 Mr. Arthur Dennis died, Mr. Hood joined the firm, and he (Mr. Lord) rose from office boy to senior partner. (Applause.)

Mr. F. W. Dennis proposed the toast of "Our Cliéntèle," which was responded to by Mr. Bidmead, Mr. London, Mr. Hooper and Mr. Pettey.

Mr. Hood proposed "Our Confrères," which, being taken to apply to competitors, was responded to by several gentlemen in friendly business competition with Messrs. Dennis & Co.

The musical and vocal portion of the programme was contributed to by Mr. F. Rome, Mr. T. E. Gatehouse, Mr. J. H. Dunn and Mr. York Bowen, A.R.A M. (a nephew of the late W. F. Dennis).

The second of the social gatherings of the Glasgow tramways employees was held in the City Hall on Friday. There was a large attendance.

Mr. James Dalrymple, general manager, occupied the chair, and said Glasgow tramways occupied an enviable position; they had the longest track mileage and the biggest annual revenue of any tramway undertaking in the Kingdom, and all tramway managers, when they looked at the weekly revenue, envied them very much. They had also the biggest tramway staff in the country.

**Electro-Harmonic Society.**—A ladies'-night concert is to be held in the King's Hall, Holborn Restaurant, London, W.C., on Friday next, 23rd inst.

# TRADE NOTES AND NOTICES.

## READY TO-MORROW.

**"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1906 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.**

**All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is even more complete and accurate than in previous issues, and has been revised up to Feb. 12, 1906. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Traders' purposes. The valuable large sheet Tables, &c., have been very carefully revised and extended, making the 1906 Edition of this indispensable work the most complete book of the kind ever published.**

### TENDERS INVITED.

*Ilford* Urban District Council invite tenders for the supply of stores for the electricity department during the year ending March 31, 1907, including electricity meters and demand indicators, cables, incandescent lamps, arc lamp carbons and house service fuse boxes. Forms of tender, &c., from the chief engineer (Mr. A. H. Shaw, M.I.E.E.), Electricity Department, Ley-street, Ilford. Tenders (addressed to Chairman of Council) to the clerk (Mr. John. W. Benton), Town Hall, Ilford, on or before Feb. 26. See also an advertisement.

*Sunderland* Corporation invite tenders for supply of six vestibule cars (double-deck top-cover type) with approved radial trucks. Specification, &c., from the borough electrical engineer (Mr. John F. C. Snell, M.Inst.C.E.), Town Hall, Sunderland. Tenders (addressed to Chairman of Tramways committee) to the town clerk (Mr. Fras. M. Bowey), Town Hall, by noon March 1. See an advertisement.

*Sunderland* Corporation also invite tenders for supply of one boiler feed pump, one wooden cooling tower, one surface condenser with motor-driven pumps, coal bunkers, gantry and other steel work; also for extension of Hylton-road station. Tenders (addressed to the Chairman of Electricity and Lighting committee) to the town clerk (Mr. Fras. M. Bowey), Town Hall, Sunderland, by noon March 2.

*West Ham* Corporation also invite tenders for the supply of incandescent lamps, cable, single and two-phase alternating-current motors, transformers, alternating current meters and house cut-out boxes. Forms of tender, &c., of the borough electrical engineer (Mr. A. Hugh Seabrook), Central Electricity Station, Tucker-street, Canning Town. Tenders to the town clerk (Dr. Fred E. Hilleary) by 10 a.m. March 2. Further particulars are given in an advertisement.

*Johannesburg* Town Council desire tenders for supply (free at their stores, Johannesburg) of 350 street lamp fittings, 50 stays for ditto and 600 ft. of gas barrel. Tenders addressed to the town clerk (Mr. John Dove), Municipal Offices, Johannesburg, by March 31. Specifications, &c., may be seen after Feb. 19 at the offices of the Council's consulting engineers, Messrs. Mordey and Dawbarn, 82, Victoria-street, London, S.W. See also an advertisement.

*Shoreditch* (London) Borough Council invite tenders for stores for one year ending March 31, 1907, including electric cables and sundries, gas pipe and fittings, and engineers' stores. Tenders to town clerk (Dr. H. Mansfield Robinson), Town Hall, Old-street, E.C., by 3 p.m. March 13.

*Londonderry* Corporation invite tenders for supply of materials for the electricity department for one year from April 1, 1906, including carbons, meters and demand indicators, bitumen and box compound, cables, boxes and troughs and house fuse boxes. Tenders to the town clerk (Mr. F. Henry Miller) by noon March 3.

*Croydon* Corporation invite alternative tenders for 15 double deck double and single truck cars, respectively, complete, equipped with motors, &c., for overhead trolley system. Tenders to the town clerk (Mr. F. C. Lloyd), by 11 a.m. Feb. 19.

*Croydon* Corporation also require tenders by 11 a.m. Feb. 28 for one year's supply of coal to the electricity works.

*Portsmouth* Corporation want tenders by 6 p.m. March 5 for water tube boiler, economiser, feed pumps, surface condenser and cooling tower and triple-expansion 1,000 kw. generating set, and for alterations to switchboard.

Tenders are wanted by 4 p.m. 21st inst. for 12 months' supply of electric light fittings, engine-room stores, &c., to Richmond District Asylum, *Grangegorman*, and *Portrane* Auxiliary Asylum, Co. Dublin.

*Sydney* (N.S.W.) Council invite tenders for (*a*) boilers, automatic stokers, pipe work, &c.; (*b*) turbo-alternator, sub-station machinery, switchboards, &c. Specifications from Mr. T. Rooke, at the offices of Messrs. Preece & Cardew, 8, Queen Anne's-gate, Westminster. fications and tender forms from the electrical engineer (Mr. R. V. Tenders, addressed to the town clerk (Mr. Thos. H. Nesbitt), must be delivered at the Town Hall, Sydney, by 4 p.m. May 7.

The Norwegian Telegraph Department, *Christiania*, invite tenders for 3 tons 1·25 mm. bronze wire, 500 metres 26-pair branch cable, 25,000 metres double tar wire spun together, 200,000 metres double wire, 900 kilos. sal-ammoniac, 2,700 kilos. copper vitriol, 1,000 kilos. gum arabic, battery zinc and Morse paper. Tenders from British firms should be lodged in Christiania by properly accredited agents by noon Feb. 21. Specifications, &c. (in Norwegian) can be seen at the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C. Agents can obtain tender forms from the Board of Telegraphs, Christiania, or the Inspector of Telegraphs at Trondhjem, Bergen, Stavanger or Arendal. It has to be remembered that, apart from the usual Customs duties, a preference of from 10 to 15 per cent. is given to Norwegian manufacturers.

The Telegraph Administration of *Denmark* calls for tenders by Feb. 26 for telegraph material, including 29,000 kilos of copper wire, 21,000 kilos sulphate of copper and 28,000 insulators. Conditions on application to Engineers' Department, Danish Telegraph Administration, 28, Frederiksholms Kanal, Copenhagen,

The *Spanish* Government Telegraph Department invite tenders for the supply of 35,000 zinc cylinders for telegraph working at an upset price of 1,600 pesetas (about £51) per 1,000. The "Madrid Gazette" of Feb. 6 contains particulars. Tenders by March 8.

The Directorate-General of Public Works, *Madrid*, is open to receive tenders up to April 11 for a 60-year concession for the construction and working of an electric tramway in Madrid. Competition will turn on the tariff of fares and rates for goods proposed to be charged.

### TENDERS RECEIVED AND ACCEPTED.

Marylebone Electric Lighting committee have accepted the following tenders for tools for the generating station workshop:—

Hobdell, Way & Co., one 15 in. lathe (£275), one 10 in. lathe (£82), one 6 in. lathe (£35. 10s.), one radial drill (£90), one screwing machine (£28. 15s.), one emery grinder (£7. 10s.), one grindstone (£6. 5s.), one bench drill (£4. 10s.), and motor shafting and belting (£95); Selig, Sonnenthal & Co., one 24 in. stroke shaping machine (£82. 10s.); Herbert Morris & Bastert, one workshop crane and rails and one jib crane, including erection (£89. 14s.).

Stepney (London) Council have accepted the tender of Everett, Edgcumbe & Co. for 22 edgewise voltmeters at £76. 5s. Nalder Bros. & Thompson tendered at £79. 15s., Crompton & Co at £81. 15s., Evershed & Vignoles at £86. 6s. 8d., Kelvin & James White at £95 and Elliott Bros. at £97. 15s. For two years' supply of arc lamp globes the tender of De Grelle, Houdret & Co. was accepted at £77, Carl Quitman's tender was £79. 16s. and City Glass Co. £84. 12s.

West Ham Corporation have accepted the tender of the British Westinghous Co. for eight tramcars on radial trucks at £546. 10s. for the first car, and £568 for each of the others, the Council to have the option of ordering additional cars to the number of seven at the latter price, providing the order is given within 18 months.

The British Thomson-Houston Co. have secured a contract from Birmingham Corporation for 90 5 ampere, fixed frame, continuous-current series multiple enclosed arc lamps with self-contained substitutional resistance. These are to be connected five in series on the tramway circuit, and equipped with solid copper casings, single enclosing globes and two spherical 1½ in. diameter metal reflectors.

Wimbledon Council have accepted the following tenders: Mid-British Co. for two 6 ton traversing jacks, and two 1½ ton bottle jacks, at £4. 16s.; J. H. Tucker & Co., 10-way street lighting switchboards, £5. 11. 3d. each.

Hammersmith (London) Council have placed an order with Babcock & Wilcox for coal-weighing apparatus for the electricity works at £206, including two sets of overhead rails, weigh-hoppers, shoots, mouthpieces, &c.

Dundee Tramways committee have accepted the following tenders:—Walter Scott (Ltd.), for rails and fish plates; Edgar Allan & Co., for joint plates, points and crossings; L. P. Winley & Co., for anchor plates; and the Lorain Steel Co. for points and crossings.

Fulham (London) Council have accepted the tender of Edward Le Bas & Co. for steam piping at £990, and that of Clapham Bros. for water and exhaust piping at £1,284. 6s.

Swindon Council have accepted the tender of Hadfield's Steel Foundry Co. for a single-track tramway layout at £112 and that of A. & G. Main & Co. for the erection of a temporary car shed at £315.

Colchester Corporation have accepted the tender of Reavell & Co. for an air compressor at £40 and for 50 ft. of hose piping at about £3, and that of E. B. Gray for a motor to work the compressor at £12.

Bury St. Edmunds Corporation have accepted the tender of the Electrical Power Storage Co for renovating the storage battery at the electricity works at £364. 13s.

Tunbridge Wells Council have accepted the tender of the General Electric Co. for supply of meters, and have decided to purchase 100 demand indicators from Chesterfield Corporation.

Bath Council have accepted the tender of the National Telephone Co. for a fire-alarm installation, at an annual charge of £106 for seven years.

Torquay Council have placed an order with British Insulated & Helsby Cables for lighting cable.

Salford Council have accepted the tender of B. Thomas for an extension of the lighting and power switchboard.

Croydon Guardians have accepted the tender of Newbold & Co. for a fire alarm installation at £115. 10s.

Yarmouth Corporation have accepted the tender of C. A. Camplin (Ltd.) for tram tickets at £6. 10s. per million.

## BUSINESS NOTICE.

Wm. Gee and J. W. Ditchfield, electrical and mechanical engineers, Weymouth, have dissolved partnership. Debts by Mr. Gee, who continues.

## BANKRUPTCIES, LIQUIDATIONS, &c.

The examination of Harry Jones and Gwilt Cathrall, trading as Jones and Cathrall, electrical engineers, &c., Wrexham, was closed at Wrexham on Tuesday.

An application for the discharge of Robert Pries (trading as Durtnall & Pries), electrical sundriesman, 75, City-road, London, E.C., will be heard on March 2, at Bankruptcy-buildings, London, W.C.

Claims against Alex. Holmes and Alex. M'Callum, electrical engineers, Crown Works, Darwen, to Mr. T. Hindle, District-chambers, Darwen, by Feb. 24.

Claims against the McGuire Mfg. Co. (Ltd.) to Mr. R. J. Ward, 2, Clements-inn, London, W.C., by Feb. 24.

Claims against the Mexican Electric Works (Ltd.) to Mr. Arnold Ellert, 65, Old Broad-street, London, E.C., by March 24.

The Sphere Lighting Co. (Ltd.) is to be wound up voluntarily. Mr. J. Gordon, 19, Bond-street, Leeds, is liquidator.

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**Plant for Sale.**—Mr. John S. Brown, Oxford-street, Swansea, has for sale electric lighting plant. See an advertisement.

**Factory Sites Offered.**—An offer is made of a freehold site of from 2 to 10 acres, free of cost, to engineers or manufacturers contemplating the erection of works. Particulars from Mr. O. B. Thomas, solicitor, 59, Chancery-lane, London, W.C. See also an advertisement.

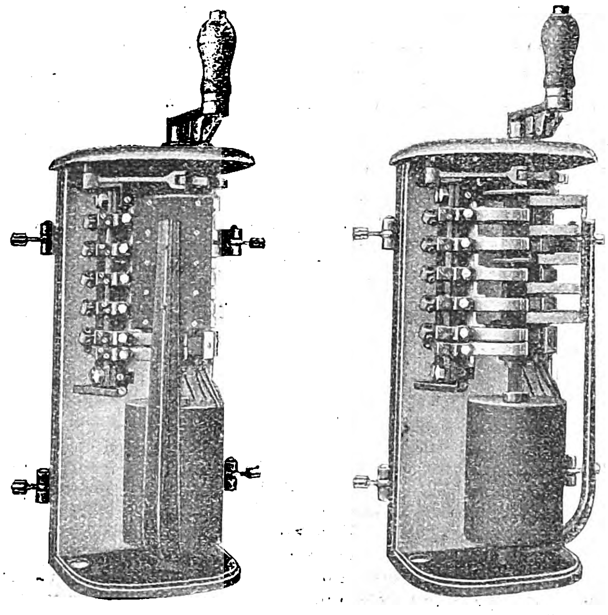
**Arc Lamp Patent Rights for Sale.**—The British and foreign patent rights for an arc lamp are advertised for sale by S. H. Johnson & Co. (Ltd.), Engineering Works, Carpenter's-road, Stratford, London, E.

**A Cheap Battery Wall Telephone.**—The General Electric Co. have ready a description of a new wall telephone set which is claimed to be the cheapest on the market. The set is fitted with a buzzer instead of a bell, a receiver with nickel-plated mouthpiece, an induction coil, a double-pole watch receiver ringing key, and automatic switch hook. The whole is mounted in a polished walnut case. The same company also forward a price list of their latest form of "Carsak" low-resistance Leclanché cell.

**Boiler House Economy.**—In a couple of well-illustrated pamphlets to hand Messrs. Ed. Bennis & Co., Little Hulton, near Bolton, and 28, Victoria-street, Westminster, London, show some excellent examples of "Bennis" plants recently erected in electricity works in London and at Coventry. A view of the Bennis coal elevators and mechanical stokers at Coventry forms the frontispiece to one pamphlet, which also contains a side elevation and plan of the Bennis barge elevator, conveyor and coal stores at the same works. Another view shows the coal barge unloading plant, and two illustrations are devoted to the Bennis automatic coal weighing apparatus. The second pamphlet shows a variety of Bennis machinery and apparatus employed in the work of coal serving operations on economical lines. The view of the weighing machine and chain conveyor taking coal to bunkers at the County of London Co.'s station in City-road, London, E.C., shows how compactly this plant can be installed.

**Telephone Card.**—A useful advertising device has been sent by Messrs. Johnson & Phillips in the form of a hanging telephone card printed both sides, and providing room for a sufficient list of names and telephone numbers to serve the purpose of most firms. Messrs. Johnson & Phillips will supply a copy free by post to any applicant.

**Catalogues.**—A catalogue of "Stellite" patent controllers has been prepared for publication by the Electrical & Ordnance Accessories Co., Birmingham. These machines are of British manufacture, made for shunt, series or compound-wound machines up to 500 volts. There are a number of types of controllers listed, including a small compact crane controller of the combination type (with resistance combined), which we illustrate. This controller is a combination of the T.S. type of controller supplied for series-wound reversible motors, and a resistance, the whole being fitted in one carcase. The regulating operation consists of an insulating disc upon which are mounted cast brass contacts, five in each direction, which make connection through two of the company's standard copper fingers, one having a lead of the other to insure proper bridge-over between contacts when regulating. The resistance, which consists of a Eureka strip wound between asbestos, is carried on a cast-iron spool keyed to the main shaft, the connections between the resistance regulating contacts being permanent. Efficient ventilation is provided, the resistance drum thus formed catching a magnetic field between the pole-piece swivel on the drum shaft and the cast-iron barrel, giving a powerful magnetic blow-out effect. The pole-piece carries a series of fire-proof chambers, which enclose and separate the fingers and so prevent arcing across. The blow-out drum is made to swivel to give easy access to the fingers and wearing parts. Snap action is obtained by means of the pawl and disc attachment. In the catalogue under notice sufficient information is given to enable contractors and users to select a controller suitable for all ordinary conditions of service.



"STELLITE" CRANE CONTROLLERS, COMBINATION TYPE

The Electrical Co., 121-125, Charing Cross-road, London, W.C., have ready a new list of luminous electric radiators. Numerous illustrations are given.

Babcock & Willcox have issued a series of loose sheet illustrations showing the Babcock-Willcox marine type boilers, economisers and coal-conveying plant installed at the St. Denis works (Seine) for the Société de Electricité, Paris. 20 of these boilers, fitted complete with integual superheaters and chain-grate stokers, are well illustrated, together with a battery of economisers and a fine view of the coal-conveying apparatus at these works.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Feb. 7 to Feb. 13, with the ports of destination :—

*Africa*—Alexandria, £20 (telegraph material) ; Beira, £81 ; Cape Town, £110 (including £80 telegraph material) ; Delagoa Bay, £25 ; Durban, £2,575 (including £1,626 telegraph material) ; East London, £340 (including £190 telegraph cable) ; Mombasa, £29 ; Port Elizabeth, £45 ; Sekondi, £14. *Argentina*—Buenos Ayres, £3,549 (including £667 telegraph material). *Australasia*—Adelaide, £113 ; Auckland, £269 ; Brisbane, £70 (telegraph cable) ; Freemantle, £992 ; Melbourne, £1,264 (including £1,040 telegraph material) ; Otago, £135 ; Perth, £441 ; Sydney, £1,845 (including £480 telegraph material) ; Wellington, £236. *Belgium*—Brussels, £241 ; Ostend, £14. *Borneo*—Sarawak, £12. *Brazil*—Pernambuco, £233. *Burma*—Rangoon, £722. *Canada*—Halifax, £42 (telegraph material) ; Montreal, £46. *Ceylon*—Colombo, £23. *China*—Canton, £269 ; Hankow, £22 ; Shanghai, £224 (including £41 telegraph material) ; Tientsin, £78. *Fiji Islands*, £16. *Germany*—Bremen, £90 ; Hamburg, £15. *Guam*, £87,000 (telegraph cable). *Holland*—Amsterdam, £149 (including £109 telegraph material) ; Rotterdam, £48. *Hong Kong*, £17. *India*—Bombay, £746 ; Calcutta, £1,631 ; Madras, £10 ; Marmagoa, £10. *Japan*—Nagasaki, £90 (telegraph material) ; Yokohama, £3,376. *Malta*, £23 (including £11 telegraph material). *Portugal*—Lisbon, £17 ; Oporto, 34. *Russia*—Reval, £22,000. *Siam*—Bangkok, £408. *Straits Settlements*—Singapore, £30 (including £8 telegraph material). *U.S.A.*—New York, £258. *Zanzibar*, £11 (telegraph material). Total, £130,068, against £48,144 in the corresponding week last year (Feb. 8 to 14).

## COMPANIES' MEETINGS AND REPORTS.

### St. James' & Pall Mall Electric Light Co. (Ltd.)

The ordinary general meeting was held on Tuesday, Mr. WALTER LEAF (vice-president) in the chair.

The GENERAL MANAGER and SECRETARY (Mr. Frederic J. Walker) read the notice calling the meeting and also the auditors' report.

The CHAIRMAN said : Gentleman, the past year, as you are no doubt aware, has been one of exceptional difficulty, anxiety and labour for all engaged in electrical industries. As your Directors have long foreseen, the question of the bulk supply of electric energy for London has now become acute. You will recollect that when we formed the Central Company some years ago, it was with the idea of offering such a supply to the West End. Parliament, however, decided to confine the Central Company to the supply of this Company and the Westminster Electric Supply Corpn. Your Board, however, some 15 months ago, considered that the time had come when we might apply a second time for the larger powers originally asked for, and the Central Company accordingly promoted a bill for that purpose. We were, however, met by formidable opposition in the shape of the very ambitious scheme of the Administrative County of London Co., with the result, unfortunately, that so much of the Central scheme as related to the bulk supply in the West End was defeated in Parliament. though certain useful extensions of power were accorded to us. Your Directors felt bound to oppose, by every means in their power, the bill of the Administrative County of London Co., and succeeded thereby in securing in the last stages of the bill, important concessions which would, in their opinion, have effectually safeguarded your interests. Although the bill was lost for want of Parliamentary time, the safeguarding clauses which we obtained will be a valuable basis on which to work in the next session of Parliament, and we must not regret the money spent in the opposition as thrown away. The costs, however, have been large, and have been an appreciable factor in the diminution of profits. Next session we have again to face an even more formidable competition. We have decided to limit our own action to promoting a bill under the title of the "West London Electric Undertakers' Association," to enable ourselves and our neighbours, the Westminster Electric Supply Corpn., the Kensington & Knightsbridge and the Notting Hill companies to link up our respective districts for the purpose of bulk supply. We do not anticipate that this will meet with any serious opposition, as it is entirely unaggressive and in the public interests, but regret that among the other schemes we shall have to deal with are not only those of the Administrative County of London Co., who still seek powers in our own area, and of what is known as "The Additional Power Supply Co."—of the exact scope of which we are still hardly informed—but a bill of the London County Council, which recent political events have now brought into the first place. On this we can only say at present that you can rely on the most earnest efforts of your Board to protect you against any unfair competition from municipal enterprise. The whole matter has now become so complicated, and is of such great importance to the future of the London electrical industries, that it is a question if it can be properly dealt with unless by a Royal Commission or similar body empowered to consider comprehensively the whole supply of the metropolis, including the subject of the final purchase terms of the undertakings. In our report we indicate three causes to which are due the serious falling off in our revenue available for dividend. The first of these is the cost of parliamentary proceedings—with this I have already dealt. The next is the reduction of rates brought about by severe competition. To some extent this has been caused by statements made in Parliament and the Press in connection with the bulk power schemes which, imperfectly understood, have, it would appear, tended to misapprehension on the part of the public as to the price at which electricity can be supplied to the consumer without loss. Competition by gas has been most energetically pushed, and we have felt bound to meet it by corresponding efforts on own our part. For instance, at the time of lighting of the new thoroughfare of Aldwych, it was widely advertised that the Westminster City Council had abandoned electric lighting. As a matter of fact, this Company had just secured an extension of contract for five years, in spite of the determined efforts of the Gas Company to get the public lighting back into its own hands ; but to do this, we had to furnish an increase of 50 per cent. of illumination at a considerable reduction of price. In our opinion, however, the time has come when we can show that for power purposes electricity furnishes at once the cheapest and most adaptable form of energy, and we have, therefore, decided to offer our consumers a flat rate of 1d. per unit for power and heating from the beginning of the year, and although this must leave at first but a narrow margin of profit, we have every reason to expect that it will materially strengthen our position by increase in the output and consequent reduction of cost and ultimate growth of revenue. The Directors feel sure that in this policy they will have the support of their shareholders, for they are convinced that the future of the industry depends on the popularisation of the supply and wide extension of consumption, rather than on the maintenance of prices on a comparatively small output. The reduction in the charge for electricity which has been made during the past year is shown clearly in the accounts, where you will see that, although we have supplied some 300,000 units in excess of those of the previous year, our net revenue from the sale of electricity is some £5,000 less, the average cost to our consumers being reduced from 3.7d. to 3.4d. per unit. The third cause to which the Report refers is one more or less peculiar to this Company, and is happily of a temporary nature. The demolition of large buildings with a view to reconstruction, such as the blocks indicated by the names of the St. James's Hall and Restaurant, the Egyptian Hall, the Baker Street & Waterloo Railway site in Piccadilly-circus, and other large blocks in Jermyn-street, St. James's-street, Regent-street, and elsewhere, has during the past year been on an exceptionally extensive scale. The immediate result of this demolition has, of course, been a very large loss of business, and although the ordinary increase in new connections for the past year has been quite satisfactory, the result is that we are able to show a net increase of only about 7,000 8 c.p. lamps. What this means to our revenue you will see at once when I tell you that the demolition of the St. James's Hall block alone has involved for 1905 a loss of some £1,500. This loss has, however, a bright side, as there is every reason to suppose that the new premises will be much better customers to us than the old. I now move the adoption of the report and accounts.

Sir JOHN H. MORRIS, K.C.S.I., seconded the resolution, and there being no discussion, the resolution was carried unanimously.

The retiring directors and auditors were then re-elected.

The CHAIRMAN : I think, on these occasions, the chairman generally puts a motion which is not on the agenda, and that is a vote of thanks to the staff for the way in which they have conducted the affairs of the Company during the past year. I have great pleasure in proposing that this year, because the period under review has been for them, even more than for the Directors, one of exceptionally hard work and much anxiety. Only the Directors can fully know what Mr. Walker and Mr. Dobson and the staff have gone through in the way of negotiations on all hands, and no one better than the Board can understand the extremely able and tactful way in which these negotiations have, from first to last, been conducted. I wish, on behalf of the Board, and also of the shareholders, to propose a vote of thanks to Mr. Walker, Mr. Dobson and the staff for the way in which they have conducted the company's business.

Sir JOHN MORRIS seconded the resolution, which was carried unanimously.

A meeting was then called to confirm the resolution passed on Jan. 22, and this having been carried, a cordial vote of thanks to the chairman and directors terminated the proceedings.

**CHARING CROSS, WEST END & CITY ELECTRICITY SUPPLY CO. (LTD.)**—The directors' report for 1905 states that there has been a large increase in the demand for energy for motive power and heating, and, in addition, the demand for lighting has been well maintained.

*West End Undertakings.*—The company has now connected to its mains a total equivalent of 453,285 8 c.p. lamps, an increase of 43,622 upon last year's figures. The total includes 349,630 in lighting and heating apparatus, and 103,655 (4,146 H.P.) in motors. The total mileage of mains now laid is 347. The directors, some time since, decided to convert the steam-generator station at Maiden-lane into a motor-generator and battery station, and the necessary reconstruction of the buildings has been completed. This has involved the sale of the old plant, but the result is to double the capacity of the buildings. The difference between the cost and selling prices of the old plant has been written off through depreciation account. Revenue from sales of current for 1905 amounted to £127,787. 3s. 7d., against £122,877. 11s. 6d. last year. The balance of the net revenue account is £47,686. 18s. 2d., and it is proposed to pay dividends on the 4½ per cent. preference shares (£18,000), on ordinary shares at 5 per cent. for the year (£20,000) and to carry forward £9,686. 18s. 2d.

*City Undertaking.*—The company has now connected to its City mains the total equivalent of 371,209 8 c.p. lamps (an increase of 70,128), including 274,509 in lighting and heating apparatus, and 96,700 (3,868 H.P.) in motors. The total mileage of mains now laid is 286. The gross revenue from sales of current during 1905 amounted to £92,210. 9s. 1d., or £13,779. 7s. in excess of 1904. The balance of net revenue shows a profit of £8,353. 7s., which has been applied towards payment of £18,000 required for dividend on the preference shares, leaving £9,646. 13s., which has been advanced by West End undertaking under its guarantee.

**GREAT NORTHERN, PICCADILLY & BROMPTON RAILWAY CO.**—The report states that the rent due from the Underground Electric Railways Co. of London permits of a dividend of 4 per cent. per annum. The capital expenditure during the past half-year was £578,645, and the estimate for the current half-year is £700,000. Satisfactory progress has been made with the works. At the meeting on Wednesday the Rt. Hon. Sir Henry Fowler, M.P., said he had hoped, as that was the last occasion on which he should preside at their meetings, that he would have been in a position to state when their line would be opened. All he could say was that the engineers were doing their utmost to complete it at the earliest possible date.

**LIVERPOOL OVERHEAD RAILWAY CO.**—Sir Wm. B. Forwood, at the meeting on Tuesday, said that during the past half-year the railway had encountered a new and serious competition from the electrical service of the L. & Y. Railway. The transition from a uniform charge to all their stations to a differential system of fares took place during the same period, and whilst they had suffered severely from the new competition, they had not had yet had time to reap the benefit which they hoped would come to them from the alteration in fares, nor the full advantage of their connection with the Seaforth station of the Lancashire & Yorkshire Railway, which was opened in July. In the aggregate they carried more passengers during the half-year (5,617,632 against 5,613,752), but had lost both in first and third-class traffic, and the gain had been entirely in workmen's special return tickets. Their gross earnings were £39,338, against £41,487. The tramway receipts had fallen off £547, and the takings at Seaforth Sands by £1,003. The average receipts per passenger worked out at 1·78d., comparing with 1·83d. on the City & South London, 1·83d. on the Central London, and 1·79d. on the Mersey Railway. While their earnings had only been 20·91d. per train-mile, those on the City & South London had been 30·79d., Central London 66·80d, and Mersey Railway 25·35d. Expenditure had gone up from £29,550 to £30,686, but the actual increase in working charges was still greater because last year they were still relaying the line, and spent £821 more than this year for that purpose, so that the extra cost of working might be taken at £1,957. That increase was mainly due to the differential system of fares. Rates had increased, and it was a cruel injustice that they had to pay them whilst the tramways paid nothing. They had determined to leave no stone unturned to find out if any screw was loose, and therefore they engaged Mr. Jenkins, general manager of the City & South London Railway, to examine the line to make a report to them. He had made several important suggestions, which were now engaging the attention of the board. The past half-year had been full of difficulties, which had not made for the company's prosperity.

**LONDON ELECTRIC SUPPLY CORPN. (LTD.)**—The report of directors for the year to Dec. 31 states that the profit on the working for the year is £78,721. 9s. 4d., added to interest on deposit and £2,614. 5s. 1d. brought forward, less expenses incurred in Parliament (£1,946. 1s.), making £79,389. 13s. 5d. Out of this interest on debenture stock (£14,975. 16s.) has been paid, leaving £64,413. 17s. 5d. The balance dividend on the 6 per cent. preference shares will absorb £17,952, a 4 per cent. dividend on the ordinary shares £13,320. £25,000 is put to reserve (making £50,000), £5,000 to contingencies (making £10,000) and £3,141. 17s. 5d. carried forward. The supply of current for power and lighting has been efficiently maintained during the year, and the decrease in cost of production (over 20 per cent) has more than fulfilled anticipations. The number of units sold amounted to 13,042,932, compared with 10,531,785 during 1904. Capital expenditure for the year was £42,042, principally in connection with the two new low-tension stations in Southwark and Deptford, and the mains thereof. Plant and machinery have been maintained out of revenue and are in efficient condition. The directors have entered into a further agreement with London County Council for three years for supplying power to the Council's tramways at the expiration of the existing agreement. Other negotiations are in progress for large power contracts.

**METROPOLITAN DISTRICT RAILWAY CO.**—For the half-year ended Dec. 31 the total receipts were £203,509, increase £6,092; working expenses £144,076, increase £29,863; profit £59,433, against £83,204. The total number of passengers carried was 2,220,631 in excess of the corresponding period of 1904. Electric traction was partially commenced on July 1, but the entire substitution of electricity for steam was not completed until December. The working of steam concurrently with electric traction not only involved special expenditure, but delayed the completion of the automatic signal installation, dislocated the train services, and prevented the running of a sufficient number of trains during the rush hours to provide for any substantial increase of traffic. The total cost of the electrical equipment and installation, including 434 cars, was, up to Dec. 31, £1,677,000, exclusive of discount on stock issued in payment thereof. It is estimated that subsequent outlay, including 70 additional cars, will be £235,000. Power is being taken in the company's bill to provide the necessary capital.

**NATIONAL ELECTRIC SUPPLY CO. (LTD.)**—At the meeting last week Mr. John Booth said their income had increased from £21,700 to £22,700, mainly owing to the demand for power, and they expected a much larger income from this source in future. There was also a growing demand for electric heating and cooking apparatus. During the year they reduced their rates for current. After careful consideration the directors decided to recommend a dividend of 7s. per share in order that they might increase the amount placed to reserve for depreciation and have a little in hand to carry forward.

**NATIONAL TELEPHONE CO. (LTD.)**—The income for the half-year ended Dec. 31 amounted to £1,125,977. 14s. 2d., compared with £1,033,705. 17s. 5d. for the corresponding period of 1904, an increase of £92,271. 16s. 9d. Working expenses were £647,846. 11s. 1d., compared with £591,335. 16s. 11d., an increase of £56,210. 14s. 2d. The net result (after deducting P.O. royalties amounting to £105,866. 2s. 1d.) is a profit balance of £372,265. 1s., compared with £316,874. 17s. 4d. The rentals carried forward for unexpired terms of running contracts amount to £972,500. 3s. 7d., compared with £889,577. 14s. 1d., an increase of £82,922. 9s. 6d. Out of the available balance of £285,108. 12s. 8d. the board recommend payment for the half-year of the dividend at the rate of 6 per cent. per annum on the first and second preference, 5 per cent. per annum on the third preference shares, 6 per cent. per annum on the preferred stock, and 5 per cent. per annum on the deferred stock, less tax in all cases. The board propose to transfer £125,000 to reserve and to carry forward £9,858. 12s. 8d. £497,962. 3s. 7d. has been expended on capital account during the half-year in the erection of 24,179 additional exchange and private stations and in the construction of underground works. The Board anticipate that there will be considerable development in the business during the next few years, and proposals will therefore be submitted for an increase in capital.

During the half-year the agreement with the Postmaster-General for the sale to him on Dec. 31, 1911, of the undertaking of the company was considered by a Select Committee of the House of Commons, who reported in favour of the agreement with modifications, some of which the board accepted. With regard to the Postmaster-General's statement that the bulk of the company's staff and servants will be taken over at the date of the purchase, the directors point out that there will be a limited number to whom the Postmaster-General's undertaking does not apply, and others not coming within such undertaking, and the board propose to forthwith establish a fund to compensate in these cases.

**NORTH-EASTERN RAILWAY CO.**—The Right Hon. J. L. Wharton, at the meeting on Friday, said that the company's further experience of electric traction on the suburban lines in Newcastle and district had been entirely favourable, both from a practical and a financial point of view. In the last half-year of 1903, with steam traction, they had 2,844,000 bookings, and in the corresponding period of 1905, with electric traction, they had 3,548,000, increase 25 per cent. The gross amount of money earned in the whole of 1903 with steam traction was £129,000; in 1905, with electric traction, £151,000. The running expenses in 1903 were £42,761; in 1905, running twice the number of trains, the expenses were £47,779. The running cost per train-mile, including all repairs of rolling stock and full depreciation of rolling stock, had been, with electric traction, about 6¾d. per train-mile, compared with 1s. 2½d. per train-mile under steam conditions. By running smaller trains and more of them, they were able to serve the public better, and to make a better profit for themselves.

**NORTH STAFFORDSHIRE RAILWAY CO.**—Mr. Towman Mosley stated at the meeting last week that the directors had under consideration the question of mechanical haulage on the canal. They recognised that there was a danger in the use of petrol and also compressed gas where they had valuable cargoes to carry, but it was possible they might be able in the course of time to use electrical energy and so adopt electric haulage.

**NORTH OF SCOTLAND POWER SYND.**—The first meeting of the members was held on Friday. Mr. R. G. Wilson was elected chairman, and Mr. A. J. W. Storie secretary. Messrs. Thomson & Wilson are consulting engineers to the syndicate, which has been formed to supply cheap electric or other power on Donside and other districts.

**NOTTING HILL ELECTRIC LIGHTING CO. (LTD.)**—The capital expenditure increased during the past year by £4,092. 14s. 9d. (including £2,302. 8s. 4d. for new mains, and £1,157. 3s. for new machinery at Bulmer-place station), bringing the total to £228,360. 1s. 6d. The cost of the joint station to date has amounted to £152,727. 10s. 1d., and joint debenture stock amounting to £152,500 has been issued. At the end of 1905 the equivalent of 143,102 8 c.p. lamps was connected to the mains, against 132,132 in 1904. The number of consumers is 2,486, and 98 per cent. of these are supplied at 200 volts. The gross revenue for the year was £35,314. 15s. 7d., an increase of £750, and the net profit was £19,983. 12s. 7d. (against £19,890. 9s. 5d. in 1904). After deducting £3,000 for depreciation, renewal and reserve, £2,560 for interest, £1,872. 1s. 7d. for Kensington and Notting Hill joint debenture stock interest and £992. 18s. 3d. for sinking fund, the balance available for dividend is £11,558. 12s. 9d. The directors recommend that this be appropriated in payment of the usual dividend of 6 per cent. on both preference and ordinary shares, and that the balance of £3,248. 12s. 9d. be divided (in accordance with the articles of association) one-half to founders' shares and the other half to ordinary and preference shares. This will enable a further 1½ per cent. to be paid on both ordinary and preference, and a distribution of £3 per share on the founders' shares. The value for rating of the company's individual property has been raised from £4,598 to £7,656, and that of the Wood-lane works from

£3,567 to £5,688. The directors point out that the rating of the company's property is based upon its earnings, and is, therefore, in reality an additional income tax.

**TYNESIDE TRAMWAYS & TRAMROADS CO.**—At the meeting on Monday Lord Armstrong said that the results of the past half-year's operations were rather disappointing; but there was an increase in the gross profits for 1905, and they had made progress in every direction. The number of miles run was 666,820, and they carried 3,809,432 passengers, the total traffic receipts being £20,963. The most important factor in their receipts had undoubtedly been the competition of the electrified railway to Tynemouth. The adverse effect of that was practically inappreciable during the first six months of the electrification; but it had become very marked during the early months of 1905. So far as could be seen from the traffic records, they had now experienced the full effects of that competition.

**WATERLOO & CITY RAILWAY CO.**—Sir Charles Scotter stated at the meeting on Tuesday that the failures in working on the line had been fewer than in any previous half-year since the line had been open; there was not a single case of serious delay. In December, through the unfortunate accident at Charing Cross, there was a very heavy traffic over the Waterloo & City Railway, a large number of the South-Eastern season-ticket holders being allowed to use the line. At present the company were supplying the L. & S.W. Co. with power to light Waterloo station. That was being done at a slight profit, and when the current was used to a larger extent the profit, of course, would be greater.

At the subsequent Wharncliffe meeting the bill promoted by the London & South-Western Railway Co. for the purchase of the Waterloo & City line was approved.

**YORKSHIRE ELECTRIC POWER CO.**—In the report for the half-year ended Dec. 31 the directors express their conviction that it has been shown during the half-year that there is a large and increasing demand from manufacturers and consumers in many different branches of industry for electrical energy, and that the purposes for which the company has been formed are fully justified. Inquiries are being received almost daily from would-be consumers in many parts of the area, and it is evident that the company must play a considerable part in the development of the trade of Yorkshire. Agreements have already been entered into with several local authorities for the supply of electrity in bulk, and further agreements are being discussed with other local authorities. Pudsey Corporation and the Urban Councils of Mirfield, Liversedge and Ravensthorpe have already consented to the company supplying power users in their areas, and negotiations are proceeding with several other local authorities to this end. Agreements have been made with colliery proprietors, textile manufacturers and other power users requiring approximately 1,600 H.P., and, in addition, inquiries are being dealt with which will, when concluded, require more than double this horse-power. The directors expect that definite agreements will be concluded at an early date. Several consumers have decided to increase their original installations. The generating station at Thornhill is now in thorough working order. All the machinery is running satisfactorily and the third turbo-generator (which has passed its test at the works of the makers) is being erected. These tests have shown that, although ordered of 1,500 kw. capacity, the rating may be safely increased to 2,000 kw., and when the contracts entered into are complete machinery will have been installed at Thornhill capable of producing 6,000 kw., or slightly over 8,000 H.P. The load on the generating station is increasing, whilst the unit cost of producing the power is diminishing in a most satisfactory manner. The directors are satisfied that the plant and system which have been adopted is of the most up-to-date type, and it is their opinion that they are in a position to produce energy on as favourable terms as any other undertaking in Great Britain. Energy is being supplied in Thornhill, Mirfield, Gomersal, Pudsey, Ravensthorpe, Hartshead, Chickenley, Kirkheaton, Soothill Nether and Drighlington. Important inquiries have been received from colliery proprietors in districts in the company's area which are somewhat distant to be supplied conveniently from Thornhill, and negotiations are at present in progress for the development of the company's business in these areas by subsidiary generating stations. Several inquiries of considerable importance have also been received from the various railway and navigation companies. Underground cables to the extent of 65 miles have been laid and brought into use to the end of 1905, and further extensions of mains have been ordered. The constructional work in connection with the company's first station having been completed, and the business of supply to consumers entered into, the directors have decided that for the present, during the early period of development, they will forego £600 out of the £1,100 per annum voted to them for their services and travelling expenses. An issue of debenture stock is contemplated at an early date.

## NEW COMPANIES, STATUTORY RETURNS. MORTGAGES AND CHARGES, LIENS, &c.

### NEW COMPANIES.

**BETTWS-Y-COED ELECTRIC LIGHTING CO. (LTD.)** (87,552.)—Reg. Feb. 10, capital £5,000 in £1 shares, to acquire from Bettws-y-Coed Urban Council the Bettws-y-Coed electric lighting provisional order (1906), to adopt an agreement with and to carry on the business of an electricity supply company, electrical and mechanical engineers, manufacturers of and dealers in electric, telegraphic, telephonic and other apparatus, &c. First directors, R. Conway and S. London. Reg. office, Miners Bridge House, Bettws-y-Coed, Carnarvon.

**ELECTRICAL IMPROVEMENTS (LTD.)** (87,499.)—Reg. Feb. 5, capital £2,000 in £1 shares, to acquire certain inventions relating to improved methods of electrically turning on and lighting up street and other gas lamps, and to carry on the business of electricians, mechanical and general engineers, producers and suppliers of electricity, &c. Reg. office, 44, Parliament-street, Nottingham.

**TRAMWAYS CONSTRUCTION SYND. (LTD.)** (87,507.)—Reg. on Feb. 5, capital £5,000 in £1 shares, to construct, improve, work, lease or control electric and other tramways and railways, motor buses, &c., power and lighting works in any part of the world, and to carry on the business of carriers of passengers and goods, electrical engineers, electricians, contractors, manufacturers of and dealers in tramway, railway, motor, electric and other apparatus, &c. Reg. office, 22, Staines-road, Ilford, E.

### STATUTORY RETURNS.

**ADELAIDE ELECTRIC TRAMWAYS (LTD.)**—In return to Jan. 11 capital is £3,000 in £1 shares, of which seven have been taken up and paid for in full. Mortgages and charges, nil.

**BRITISH ELECTRIC LIGHT WIRING CO. (LTD.)**—Return to Dec. 14, gives capital as £10,000 in £1 shares, of which 156 have been taken up. £1 per share has been called up on 149 and 10s. per share on 7 and £152. 10s. has been received. Mortgages and charges, nil.

**TRAMWAYS EXTENSION SYND. (LTD.)**—According to return to Dec. 30 capital is £5,000 in 4,750 preference shares of £1 each and 5,000 ordinary shares of 1s. each, of which 3,000 preference and 140 ordinary have been taken up. £2,000 has been received, leaving £1,007 in arrears. Mortgages and charges, nil. (N.B.—Charge for £600 subsequently registered.)

### MORTGAGES AND CHARGES.

**TRAMWAYS EXTENSION SYND. (LTD.)**—A charge on the sum of 10s. per share payable on 2,000 preference shares, to secure £600, has been registered. Date of charge Feb. 1, 1906. Holders, P. Macfadyen & Co.

**MANN, EGERTON & CO. (LTD.)**—Issue on Feb. 5 of £300 5 per cent. debentures, part of series created April 1, 1905, to secure £10,000, charged on certain freehold and leasehold properties in Norwich and Ipswich and company's undertaking and property present and future, including uncalled capital. Trustees, G. F. Buxton, J.P., and J. J. D. Paul, J.P. Previously issued of same series £9,100.

## CITY NOTES.

**MEMORANDA** (Feb. 15).—Bank rate 4 per cent. (since Sept. 28, 1905). Price of silver 30$\frac{5}{8}$d. per oz. Consols 90$\frac{1}{2}$—90$\frac{5}{8}$ for money, 90$\frac{11}{16}$—90$\frac{13}{16}$ for account; 2$\frac{1}{2}$ per cent. annuities 89$\frac{1}{2}$—89$\frac{3}{4}$. Consols Pay Day, March 1. Stocks and Shares Continuation Days, Feb. 20 and March 7; Ticket Days, Feb. 21 and March 8. Pay Days, Feb. 22 and March 9; Mining Share Carry-over Day, Feb. 19.

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**CARLISLE ELECTRIC TRAMWAYS CO. (LTD.)**—For the year 1905 the surplus was £2,346, a decrease of £602 compared with last year. The balance profit, after providing for interest, is £1,665. £500 is carried to depreciation and a dividend at the rate of 1$\frac{1}{4}$ per cent. per annum (absorbing £750) is declared.

**CHELSEA ELECTRICITY SUPPLY CO. (LTD.)**—The directors have decided to declare a final dividend for 1905 on the ordinary shares at the rate of 7$\frac{1}{2}$ per cent. per annum (making 6 per cent. for the year) and a dividend of 3 per cent. on the ordinary shares issued in exchange for founders' shares, after carrying £10,918 to renewals and depreciation fund account and writing off £1,891 out of revenue from suspense account, carrying forward £916 against £1,170 brought in.

**CLONTARF & HILL OF HOWTH TRAMROAD CO. (LTD.)**—The profit for 1905 was £1,288. After paying interest (£1,125), £163 has been applied in reduction of debit balance.

**IMPERIAL TRAMWAYS CO. (LTD.)**—The gross receipts from the Middlesbrough, Stockton & Thornaby Electric Tramways amounted to £51,387. 8s. 6d. during 1905, and the number of passengers carried was 9,935,876, compared with £51,097. 4s. 4d. and 9,818,349 passengers in 1904. The net profit was £16,824. 16s. 3d. The work of constructing the extensions at Middlesbrough has not yet been proceeded with, as up to the present satisfactory arrangements have not been concluded for dealing with the interests of the toll-gate owners and other important bodies. The company's holding in the London United Tramways (1901) (Ltd.) remains at 41,446 fully-paid 5 per cent. preference £10 shares, and the dividends received for the past year amounted to £21,111. 17s. The available balance for the year is £41,617. 11s. 3d., and after payment of interest and interim dividends to June 30 (£26,125), the balance dividend on the preference capital is declared (£5,700), a final dividend at 10 per cent. per annum (making 9 per cent. for year) on ordinary capital (less tax) (£9,500), and £322. 11s. 3d. is carried forward.

**INDIA RUBBER GUTTA PERCHA & TELEGRAPH WORKS CO. (LTD.)**—The Company's 4 per cent. first mortgage debentures for £300,000 and 4$\frac{1}{2}$ per cent. second debentures for £100,000 will be paid off on the 25th prox., and the directors intend to issue at par 4 per cent. mortgage debentures to bearer for £400,000, repayable at par on March 25, 1906; but the company reserves the option (upon three months' notice) to pay off all or any part (not less than £100,000) of the debentures on March 25, 1911,

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (*a*) | Aggregate. No. of weeks | Aggregate. Amount. | Aggregate. Inc. or Dec. (*a*) |
|---|---|---|---|---|---|---|
| | | £ | £ | | £ | £ |
| **Aberdeen Corporation** | Feb. 10 | 1,113 | + 23 | 37 | 51,020 | − 936 |
| **Airdrie** | ,, 2 | 212 | + 17 | 5 | 1,046 | + 122 |
| Anglo-Argentine | ,, 11 | 14,927 | + 1,848 | 6 | 87,686 | + 8,674 |
| **Ayr Corporation** | ,, 10 | 172 | − 4 | 39 | 11,813 | − 55 |
| **Barnsley** | ,, 2 | 160 | + 5 | 5 | 694 | + 14 |
| **Barrow** | ,, 2 | 206 | + 14 | 5 | 918 | + 92 |
| **Bath Electric Trams, Ltd.** | ,, 7 | 585 | + 50 | 6 | 3,817 | + 631 |
| Birkenhead Corporation | ,, 11 | 915 | − 29 | 6 | 6,165 | + 27 |
| **Birmingham Corporation** | ,, 10 | 880 | + 32 | 45 | 16,801 | + 2,155 |
| ***Birmingham & Mid.** | ,, 2 | 1,371 | − 360 | 5 | 6,844 | − 1,842 |
| B'ham & Mid. Motor O'bus | ,, 2 | 1,348 | ... | 5 | 6,214 | ... |
| **Blackpool Corporation** | ,, 8 | 331 | + 16 | 6 | 47,255 | + 1,995 |
| **Blackpool and Fleetwood** | ,, 10 | 177 | − 14 | 6 | 1,042 | − 39 |
| **Bolton Corporation** | ,, 11 | 1,709 | + 32 | 46 | 87,905 | + 4,274 |
| **Bournemouth Corporation** | ,, 7 | 1,190 | + 335 | †45 | 63,463 | + 14,695 |
| **Bradford Corporation** | ,, 10 | 3,828 | + 11 | 45 | 196,104 | − 2,988 |
| **Brighton Corporation** | ,, 11 | 680 | + 72 | 46 | 45,260 | + 506 |
| **Bristol Trams & Carriage** | ,, 9 | 4,451 | − 69 | 26 | 90,903 | + 2,121 |
| **Buenos Ayres & Belgrano** | ,, 11 | 3,509 | + 360 | 6 | 21,182 | + 2,115 |
| Buenos Ayres Elec. Trms | ,, 6 | 1,652 | ... | 2 | 8,000 | ... |
| | ,, 13 | 1,348 | ... | | | |
| **Burnley Corporation** | ,, 10 | 988 | − 38 | 45 | 59,478 | + 3,298 |
| **Burton Corporation** | ,, 11 | 243 | − 45 | §45 | 13,887 | − 1,575 |
| **Bury Corporation** | ,, 4 | 760 | ... | §44 | 33,457 | ... |
| **Calcutta Tramways Co.** | ,, 10 | R45,623 | + R9,151 | 6 | R283,826 | + R36,936 |
| **Camborne-Redruth** | ,, 10 | 93 | − 6 | 15 | 1,617 | + 26 |
| Cardiff | ,, 10 | 1,793 | − 11 | 45 | 91,834 | + 111 |
| **Carlisle Tramways Co.** | ,, 10 | 152 | + 14 | 6 | 967 | + 90 |
| Cavehill | ,, 2 | 31 | − 6 | 5 | 140 | − 25 |
| **Central London Railway** | ,, 10 | 6,991 | − 131 | 6 | 41,772 | − 1,427 |
| **Chatham & Dist. Lt. Rys.** | ,, 8 | 595 | − 45 | †6 | 3,307 | + 24 |
| ***City of Birm'gh'm Tram Co.** | ,, 2 | 5,247 | − 56 | 5 | 24,514 | + 311 |
| **City & South London Rly.** | ,, 11 | 3,020 | + 124 | 6 | 18,166 | − 14 |
| Colchester Corporation | ,, 8 | 147 | + 16 | 26 | 5,162 | − 1,503 |
| **Cork Electric Trams Co.** | ,, 8 | 400 | − 15 | †6 | 2,325 | + 3 |
| **Devonport & Dist. Trams** | ,, 2 | 405 | − 28 | 5 | 1,977 | − 82 |
| **Dover Corporation** | ,, 10 | 166 | + 6 | ‡45 | 10,100 | + 59 |
| **Dublin & Lucan Railway** | ,, 9 | 82 | − 17 | §6 | 493 | − 63 |
| **Dublin United** | ,, 9 | 4,453 | − 188 | ‡6 | 26,892 | + 978 |
| **Dudley—Stourbridge** | ,, 2 | 746 | + 13 | 5 | 3,490 | + 303 |
| **Dundee Corporation** | ,, 7 | 960 | + 160 | §38 | 35,862 | + 3,005 |
| **East Ham Council** | ,, 10 | 749 | + 98 | 45 | 37,583 | + 5,198 |
| **Gateshead & Dist. Trams** | ,, 2 | 939 | + 54 | 5 | 4,331 | + 304 |
| **Glasgow Corporation** | ,, 10 | 14,999 | + 1,043 | 37 | 562,282 | + 36,822 |
| Glossop | ,, 10 | 113 | + 7 | 6 | 732 | + 107 |
| Gloucester Corporation | ,, 7 | 216 | − 5 | 45 | 18,009 | + 1,157 |
| **Gravesend—Northfleet** | ,, 2 | 196 | + 10 | 5 | 925 | + 72 |
| Gt. Northern & City Rly. | ,, 10 | 1,792 | + 33 | 6 | 10,823 | + 192 |
| **Greenock & Port Glasgow** | ,, 2 | 606 | + 59 | 5 | 2,680 | + 165 |
| **Halifax Corporation** | ,, 7 | 1,290 | + 103 | 45 | 70,196 | + 5,118 |
| **Hartlepool Tramways** | ,, 2 | 270 | + 26 | 5 | 1,201 | + 95 |
| Hastings Elec. Trams Co. | ,, 8 | 323 | ... | 6 | 2,171 | ... |
| **Huddersfield** | ,, 10 | 1,273 | + 81 | 45 | 61,476 | + 3,440 |
| **Hull Corporation** | ,, 10 | 2,111 | + 85 | 45 | 100,609 | + 2,003 |
| Ilford Dist. Coun. | ,, 10 | 272 | + 4 | 45 | 21,076 | + 919 |
| **Ipswich Corporation** | ,, 10 | 288 | − 38 | 45 | 19,117 | − 1,871 |
| **Isle of Thanet Co.** | ,, 10 | 195 | − 44 | 18 | 4,954 | − 468 |
| **Kidderminster & District** | ,, 2 | 80 | − 6 | 5 | 421 | + 6 |
| Kilmarnock Corporation | ,, 10 | 138 | − 8 | 39 | 6,114 | ... |
| **Kirkcaldy Corporation** | ,, 7 | 182 | − 25 | 28 | 4,705 | − 84 |
| **Lanarkshire Trams Co.** | ,, 8 | 798 | + 160 | †6 | 4,905 | + 1,140 |
| **Leamington** | ,, 2 | 129 | + 31 | 5 | 628 | + 200 |
| **Leeds Corporation** | ,, 10 | 5,346 | + 49 | 46 | 270,196 | + 8,526 |
| **Leicester Corporation** | ,, 10 | 2,008 | + 170 | 6 | 11,712 | + 1,735 |
| Leith Corporation | ,, 3 | 447 | + 234 | 37 | 13,636 | + 10,330 |
| **Liverpool Overhead Rly.** | ,, 11 | 1,341 | − 215 | 6 | 8,371 | − 629 |
| Liverpool Corporation | ,, 3 | 10,216 | + 403 | 5 | 50,401 | + 2,412 |
| ***London County Council** | ,, 8 | 14,146 | + 1,591 | 44 | 648,455 | + 87,538 |
| **Lowestoft** | ,, 10 | 107 | − 15 | 19 | 2,710 | − 24 |
| **Maidstone Corporation** | ,, 8 | 76 | − 14 | 45 | 5,442 | ... |
| **Manchester Corporation** | ,, 10 | 11,917 | + 318 | 45 | 678,912 | + 29,080 |
| **Mersey Railway** | ... | ... | ... | ... | ... | ... |
| **Merthyr** | ,, 2 | 171 | − 6 | 5 | 801 | + 3 |
| Metropolitan Dist. Railway | ,, 11 | 8,074 | + 411 | 6 | 48,578 | + 3,008 |
| ***Metropolitan Elec. Trams.** | ,, 2 | 2,832 | + 981 | 5 | 12,954 | + 4,270 |
| **Middleton** | ,, 2 | 291 | + 17 | 5 | 1,420 | + 146 |
| **Nelson Corporation** | ,, 10 | 118 | + 14 | 46 | 6,008 | + 662 |
| **Newcastle-on-Tyne Corp.** | ,, 10 | 3,670 | + 50 | 45 | 171,512 | + 4,465 |
| **Newport (Mon.)** | ,, 10 | 527 | + 42 | 19 | 10,398 | + 774 |
| Northampton Corporation | ,, 9 | 854 | + 4 | 45 | 19,198 | + 5,236 |
| **Oldham, Ashton & Hyde** | ,, 2 | 523 | + 14 | 5 | 2,878 | + 139 |
| **Oldham Corporation** | ,, 11 | 1,397 | + 24 | 46 | 74,947 | + 17,808 |
| Perth (N.B.) Corporation | ... | ... | ... | ... | ... | ... |
| **Perth (W. A.) Elec Trams** | ,, 9 | 1,557 | + 96 | ‡6 | 9,405 | + 521 |
| **Peterborough** | ,, 2 | 97 | − 4 | 5 | 468 | − 4 |
| Pontypridd Dist. Council | ,, 10 | 148 | ... | 45 | 7,218 | ... |
| Portsmouth Corporation | ,, 10 | 1,410 | − 4 | 45 | 87,508 | + 1,700 |
| **Potteries** | ,, 2 | 1,719 | + 4 | 5 | 8,180 | + 563 |
| Preston Corporation | ,, 7 | 592 | ... | 5 | 2,923 | ... |
| **Reading Corporation** | ,, 8 | 519 | − 53 | ... | ... | ... |
| Rotherham Corporation | ,, 11 | 416 | + 19 | 45 | 20,506 | − 177 |
| **Rothesay** | ,, 2 | 37 | + 1 | 5 | 260 | + 47 |
| **Salford Corporation** | ,, 12 | 8,902 | + 83 | 46 | 195,555 | + 11,877 |
| **Sheerness** | Jan. 31 | 44 | − 4 | 5 | 223 | − 9 |
| **Sheffield Corporation** | Feb 11 | 4,660 | + 196 | 46 | 227,098 | + 13,174 |
| **Southampton Corporation.** | ,, 7 | 802 | ... | 18 | 16,107 | − 31 |
| **Southend Corporation** | ,, 7 | 299 | + 13 | 45 | 16,736 | + 1,041 |
| **Southport Tramways** | ,, 2 | 234 | + 11 | 5 | 1,119 | + 85 |
| **S. Staffordshire Trams.** | ,, 2 | 685 | + 186 | 5 | 3,597 | + 707 |
| **Stockport Corporation** | Jan 26 | 713 | + 208 | 45 | 34,242 | + 9,587 |
| | Feb. 2 | 764 | + 388 | | | |
| | ,, 9 | 716 | + 282 | | | |
| Sunderland Corpn. | ,, 11 | 1,179 | + 110 | 45 | 59,586 | + 2,683 |
| **Swansea Trams** | ,, 2 | 718 | + 257 | 5 | 3,377 | + 1,289 |
| Swindon Corporation | ,, 7 | 150 | − 15 | 45 | 8,759 | ... |
| Taunton | ,, 2 | 38 | − 1 | 5 | 205 | + 18 |
| **Tynemouth and District** | ,, 2 | 165 | − 3 | 5 | 778 | − 8 |
| **Tyneside Trams Co.** | ,, 7 | 346 | + 5 | ¶5 | 1,848 | + 87 |
| **Wallasey District Council** | ,, 10 | 659 | + 8 | 45 | 34,909 | + 1,487 |
| **Warrington Corporation** | ,, 8 | 388 | + 81 | 45 | 15,458 | + 911 |
| **West Ham Corporation** | ,, 8 | 1,854 | + 752 | 44 | 82,780 | + 35,673 |
| **Weston-super-Mare** | Jan. 31 | 24 | + 2 | 5 | 119 | ... |
| Wolverhampton Corpn. | Feb. 7 | 702 | ... | 5 | 8,713 | ... |
| **Wolverhampton District** | ,, 2 | 884 | + 32 | 5 | 1,691 | + 153 |
| ***Worcester** | ,, 2 | 286 | − 23 | 5 | 1,141 | − 11 |
| **Wrexham** | ,, 2 | 97 | + 2 | 5 | 431 | + 15 |
| Yorkshire W.R. Trams | ,, 11 | 667 | + 185 | 6 | 3,658 | + 1,165 |
| Yorkshire Woollen District | ,, 2 | 894 | + 291 | 5 | 3,812 | + 1,463 |

(*a*) These comparisons are with the corresponding period last year. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days. ¶ Plus 3 days. * Partly electrical.

at 2 per cent. premium. Holders of existing debentures will each have the right to take up an amount of the new issue equal to his present holding by making application on or before 28th inst.

**LANARKSHIRE TRAMWAYS CO.**—For the half-year ended Dec. 31 receipts were £22,882. 12s. 11d., and expenses £13,032. 17s. 9d. After paying interest and contributions to local authorities (£662. 15s. 8d.), and crediting balance forward (£2,372. 6s.), £10,621 3s. 10d. is available. £2,500 is placed to reserve, £1,249. 7s. 2d. written off, £5,500 absorbed in dividend at 5½ per cent. per annum on original capital, £473. 8s. 1d. in dividend at 5½ per cent. per annum on new shares, and £898. 8s. 7d. carried to revenue new account. The capital expenditure during the half-year amounts to £48,128, mainly on the Larkhall extension and five new cars.

**LONDON UNITED TRAMWAYS (1901) (LTD.)**—The directors recommend (subject to audit) a dividend on the ordinary shares for the half-year ended Dec. 31 at the rate of 2 per cent. (less tax), making 3 per cent. for the year. £10,000 is carried to reserve.

**MATHER & PLATT (LTD.)**—The directors have declared an interim dividend on the ordinary shares of 3 per cent. (6 per cent. per annum) for the half-year to Dec. 31.

**NORTHAMPTON ELECTRIC LIGHT & POWER CO. (LTD.)**—During 1905 the lamps and motors connected to the company's mains were equivalent to 6,335 8 c.p., making a total of 53,766 8 c.p. Motors increased from 351½ H.P. to 500 H.P., and of these 356½ H.P. are hired from the company. The output was 706,590 units, an increase of 24 per cent.

**OXFORD ELECTRIC CO. (LTD.)**—A final dividend is announced, making, with the interim dividend of 2½ per cent. declared last September, 7 per cent. for the year.

**STOCK EXCHANGE NOTICE.**—The Stock Exchange Committee have been asked to appoint a special settling day in 56,000 £1 fully-paid vendors' shares of the *Electro-Peat Coal Co.* (*Ltd.*)

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Feb. 14. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Feb. 14. Highest. | Business, Week to Feb. 14. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | £ s. d. | | | |
| 5 | 3/0 | Anglo-Argentine Ord. Shares | 8⅞—9⅛ | 4 7 9 | Ap, Oct | 9 1/16 | 8 15/16 |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞—6⅛ | 4 10 0 | — | 6 3/32 | 6 |
| St. | 6% | Do. Permanent 6% Deb. Stock | 141—144 | 4 3 3 | — | 142 | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 104—106 | 4 14 3 | — | .. | — |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1—1½ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 3⅞—4⅛ | 6 1 4 | — | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 93—96 | 4 13 9 | — | 95¾ | — |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 120—123 | 4 17 6 | — | .. | .. |
| St. | 5% | Do. Pref. Ord. Stk | 110—113 | 4 8 4 | — | 111 | .. |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock. | 108—111 | 4 10 0 | — | 108 | .. |
| 100 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103½—105½ | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 101—104 | 4 6 6 | — | .. | — |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | 4⅝—4⅞ | 5 3 0 | — | [illegible] | .. |
| 5 | 3/0 | Do. 6 per Cent. "A" Cm. Pref | 5¾—6⅛ | 4 13 0 | — | .. | .. |
| 5 | 3/0 | Do. "B" | 5¼—5¾ | 5 4 0 | — | 5⅝ | 5½ |
| St. | 5% | Do. 5 per Cent. Debs. | 105—107 | 4 13 6 | — | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102—105 | 4 15 0 | — | .. | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 96—98 | 5 2 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 102—106 | 5 4 3 | .. | .. | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 101—105 | 5 14 0 | .. | .. | .. |
| 5 | 3/6 | Calcutta Tramways (Nos. 1 to 105) | 9½—10 | 4 5 0 | .. | .. | .. |
| 5 | 1/6 | Do. Nos. 105,001 to 137,610 | 9—9½ | .. | — | .. | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 104—106 | 4 6 0 | .. | .. | .. |
| 1 | 0/6 | Cape Electric Tram Shares | ⅞—1⅛ | 4 8 10 | — | .. | .. |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 102—104 | 4 16 0 | — | .. | — |
| .. | 5% | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 96—98½ | 5 2 0 | .. | 97⅜ | 96¼ |
| St. | .. | Kalgoorlie Elec. Trams 5% "A" Deb. Stock | 93—98 | | | | |
| St. | .. | Do. 5% "B" Ditto | 85—90 | .. | .. | 90⅝ | .. |
| 1 | .. | Lisbon Elec. Trams Ord. | 1 7/16—1 9/16 | .. | .. | 1 15/32 | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛—1⅜ | 4 7 4 | .. | .. | 1½ |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 100—103 | 4 17 0 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 101—103 | 4 17 0 | Ja, Jul | 101½ | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 102—105 | 4 15 0 | — | 103 | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102—104 | 4 6 6 | — | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 105—108 | 4 12 6 | .. | .. | .. |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 146—148 | 5 8 0 | .. | .. | .. |
| .. | 5% | Do. 5% 1st Mt. $500 Dbs. | 98½—100½ | 5 0 0 | .. | 100 | .. |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | — | Adelaide Elec. S'ply Co. 6% Cu. Pr. | 4¾—5¼ | | | | |
| 5 | 3/8 | Calcutta Elec (1-50 000) | 9—9½ | 4 6 6 | .. | 9¼ | 9 |
| 10 | 5% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50—52 | 4 16 0 | — | .. | .. |
| .. | 5% | Cordoba Lt. and Power Co. 1st Mt. Stk. £100 000 5% Bds. | 94—96 | 5 4 0 | .. | .. | .. |
| 1 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½—3 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Debs. | 86—90 | 5 10 0 | .. | .. | — |
| 10 | .. | Havana Electricity Co. Shares | 7¾—8¾ | .. | — | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92—94 | 5 6 8 | — | 93 | .. |
| St. | 16/2 | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. | 109—111 | 5 8 0 | .. | .. | .. |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞—1 | 6 0 0 | .. | .. | .. |
| 1 | 1/0 | Rand Electric | 1 5/16—1 7/16 | .. | — | 1⅜ | .. |
| 1 | .. | River Plate Electricity Co. Ord. | 19/32—23/32 | .. | — | 21/32 | — |
| 1 | 1/2⅖ | Do. 6% Non. Cum. Pref | 15/16—1 1/16 | .. | .. | 1 | .. |
| St. | 5% | Do. 5% Deb. Stock | 101—103 | 4 17 0 | .. | 102 | .. |
| 5 | 3/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5¼—5¾ | 5 4 4 | .. | .. | — |
| 5 | 9·13d | Do. (12,001-20,000) | 5—5½ | 8 8 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100—103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 5% | Shawinigan Water and Power 5% Bds., Scrip | 102—104 | 4 16 0 | .. | 102½ | .. |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Shre. | Last Dividend | Name | Price Wed. Feb. 14. | Rate % Yielded. £ s. d. | Dividend Due | Business, Week to Feb. 14. Highest | Lowest |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12½—12¾ | 6 8 0 | .. | 12 9/16 | 12⅝ |
| 10 | 4/6 | † Do. 4½ per Cent. Cum. Pref | 10—10½ | 4 5 9 | .. | .. | .. |
| 10 | 6/0 | † Do. 6% Cum. Second Pref. | 11—12 | 5 0 0 | .. | .. | — |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 106—108 | 4 3 3 | .. | 107 | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 103—105 | 4 5 0 | — | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 8½—9½ | 5 5 0 | — | 8⅞ | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 8½—9½ | 3 14 5 | Mar, Sept | 8 9/16 | 8½ |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 102—105 | 3 16 3 | — | 105¾ | — |
| 5 | 2/6 | CharingCross(W.End&City)El.Sup.Co. | 5—6 | 6 4 0 | Feb, Aug | 5½ | 5 |
| 5 | 2/3 | † Do. 4½ per Cent. Pref. | 5—5½ | 4 2 0 | Feb, Aug | 5⅛ | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 101—103 | 3 17 6 | — | .. | .. |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4½—4¾ | 4 14 9 | — | 4⅝ | .. |
| 5 | 2/3 | Do. Do. (1908) | 4½—4¾ | 4 14 9 | .. | .. | .. |
| 5 | 2/3 | Chelsea Electric Supply Ord. | 5—6 | 5 0 0 | March .. | .. | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 108—110 | 4 1 6 | Jn, Dec .. | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 11—12 | 5 0 0 | Feb, Aug | 11½ | 11¼ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13½—14½ | 4 4 2 | Jan, July | — | — |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 122—126 | 3 19 4 | Jn, Dec .. | 124 | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 100—102 | 4 8 8 | .. | .. | .. |
| 5 | .. | County of Durham Elec. P. D. Ord. £2pd. | 2—2 1/16 | .. | April, Oct | 2 1/16 | 2 1/32 |
| 5 | 5% | Do. Do. 5% non cum. pref. | 1¼—1⅜ | 4 3 0 | April, Oct | 1⅜ | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 8½—9½ | 4 6 6 | — | 9⅛ | 8⅞ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12½—13 | 4 12 8 | Mar, Sept | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 109—112 | 4 0 4 | .. | .. | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 101—103 | 4 7 6 | .. | 102¾ | 101¾ |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5½—5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5—5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101—104 | 4 6 6 | — | .. | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8¼—8¾ | 4 17 2 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100—103 | 4 7 5 | — | .. | — |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 10½—11½ | 5 4 0 | .. | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½—7 | 4 5 9 | Jan, July | — | — |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98—101 | 3 19 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 103—105 | 3 16 0 | .. | .. | .. |
| 8 | 1/9⅜ | London Electric Supply Ord. | 2—2½ | 3 12 0 | .. | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¼—5¾ | 5 10 6 | .. | 5 9/16 | 5 7/16 |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 98—101 | 3 19 2 | Mr, Jn, S, D | .. | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 9—10 | 5 0 0 | April, Oct | 9⅝ | 9½ |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5½—5½ | 3 18 0 | Jan. July | 5½ | 5 5/16 |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 107—111 | 4 1 0 | Jn, Dec .. | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 95—97 | 3 12 8 | — | .. | .. |
| 100 | 4½% | MidlandElec. Corp. for P. D. 1stMort. Db. | 101—103% | 4 7 4 | — | .. | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 11¾—12 | 5 18 8 | Feb, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 101½—102½ | 4 7 8 | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8—8⅛ | 4 19 8 | Feb, Aug | 8⅛ | 8 1/16 |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6½—6⅝ | 3 19 4 | Feb, Aug | 6⅝ | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99—101 | 3 19 7 | Jan, July | .. | .. |
| 1 | 3% | Northern Counties Elec. Sup. | 1/16—3/32 | 3 2 6 | Mar, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 101—102 | 4 7 6 | Jan, July | — | — |
| 10 | 6/0 | Notting Hill Electric Ord. | 13½—14½ | 4 16 8 | March .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98—100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6⅜—6⅞ | 5 1 6 | March .. | .. | .. |
| St. | 4% | Do. 4% Deb. Stock | 99—101 | 3 19 0 | — | .. | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 11—12 | 6 5 0 | Feb, Aug | 11⅜ | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 7—8 | 4 7 0 | Feb, Aug | 7½ | 7⅜ |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 97—99 | 3 10 9 | — | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2¾—3¼ | 7 3 0 | .. | 3 1/32 | 2⅞ |
| St. | 4% | † Do. 4 per Cent. Deb. Stock | 76—80 | 5 0 0 | — | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 5⅜—5⅞ | 5 8 0 | .. | 5 11/16 | 5 7/16 |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | ¾—⅞ | .. | .. | .. | .. |
| 1 | 0/8¾ | Do. 7% Cum. Pref. | 1¼—1⅜ | 5 2 0 | .. | 1 1/16 | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105—108 | 4 3 8 | — | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4½—4¾ | 5 5 0 | — | 4 9/16 | .. |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5—5¼ | 4 15 8 | — | 5 3/16 | 5⅛ |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 104—106 | 4 5 0 | .. | 105½ | 105¼ |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 11—12 | 5 17 0 | Mar, Sept | 11½ | 11 |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝—5⅝ | 4 9 0 | .. | 5½ | .. |
| | | **ELECTRIC RAILWAYS, TRAMWAYS &c.** | | | | | |
| 1 | .. | Bath Elec. Trams Pref. Ord. | 15/16—1 1/16 | .. | .. | 1 | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1⅛—1 1/16 | 4 14 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 102—104 | 4 6 6 | .. | 102¾ | .. |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 101—103 | 4 7 9 | .. | 102 | .. |
| 10 | 9% | Bristol Tramways and Carriage Ord. | 17—17½ | 5 2 11 | Feb, Aug | .. | .. |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10—10¼ | 3 18 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Debs. | 104—106 | 3 15 6 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 7¾—8¼ | 7 5 0 | — | 8 | 7⅞ |
| 10 | 6/0 | † Do. 6 per Cent. Cum. Pref. | 10¼—10¾ | 5 11 6 | Feb, Aug | 10 11/16 | 10¼ |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 119—121 | 4 2 8 | .. | 120½ | 119 |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 98—100 | 4 10 0 | .. | .. | .. |
| St. | 4% | † Central London Ordinary Stock | 93—95 | 4 4 0 | June, Dec | 95 | 93 |
| St. | 4% | † Do. 4 per Cent. Pref. Stock | 102—104 | 3 17 0 | .. | 104 | 103 |
| St. | 4% | † Do. Deferred Stock | 83—86 | 4 13 0 | .. | 84⅞ | 84½ |
| 100 | 4% | Do. 4 per Cent. Debs. | 110—112 | 3 11 3 | .. | 111¾ | .. |
| St. | 4% | Charing Cross, Euston & Hampstead Perp. Deb. Stk. | 96—98 | 4 1 6 | .. | 96½ | .. |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 6—6¼ | 4 16 0 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 101—104 | 3 17 0 | .. | .. | .. |
| St. | 1¾% | † City and South London Rly. Con. Ord. | 41—43 | 4 7 0 | Feb, Aug | 42¾ | 41⅝ |
| St. | 5% | † Do. 5 per Cent. Perp. Pref. (1891) | 120—123 | 4 1 4 | Feb, Aug | 123 | .. |
| St. | 5% | † Do. (1896) | 115—118 | 4 4 8 | .. | .. | .. |
| St. | 5% | † Do. (1901) | 113—116 | 4 6 0 | — | 115½ | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 106—109 | 3 13 4 | May, Nov | .. | .. |
| 10 | 6/0 | † Dublin United Trams. (1896) Ltd., Ord. | 13¾—14¾ | 4 1 6 | .. | .. | .. |
| 10 | 6/0 | † Do. 6 per Cent. Pref. | 14½—15½ | 3 17 8 | .. | .. | .. |
| 10 | 4/0 | † Gt. Northern & City Rly. Prf. Ord. (4%) | 4¾—5¼ | 7 12 0 | .. | 5¼ | 4⅞ |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8—9 | 4 8 11 | .. | 8¼ | .. |
| St. | 4½% | Hastings&Dist. Elec. Trams. Co. 4½ Db. St. | 103—105 | 4 5 8 | .. | 103¾ | — |
| 10 | 9% | ‡ Imperial Tramways Ord | 17—18 | 5 0 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 13—13¼ | 4 10 8 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 109—111 | 4 1 9 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼—2¾ | 0 8 6 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 82—87 | 4 12 0 | — | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 3⅛—3⅜ | 3 18 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾—10½ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99—102 | 3 19 8 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9—9½ | 5 5 0 | — | 9 | 8¾ |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 93—96 | 4 8 8 | — | 95½ | 94½ |
| St. | .. | Mersey Con. Ord. Stock | 7—9 | — | — | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8—11 | — | — | .. | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 3/32—9/32 | .. | — | .. | .. |
| 1 | 0/6 | † Do. 5% Cum. Pref. | 1—1 1/16 | 4 14 1 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104—106 | 4 5 0 | — | .. | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½—1½ | .. | May — | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾—9¼ | 5 5 8 | .. | 9 1/16 | .. |
| 10 | 5/0 | † Do. 5 per Cent. Cum. Pref. | 9½—10 | 5 0 0 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103—106 | 4 5 0 | — | .. | .. |
| 100 | 5% | Sunderland Dst. Elc. Trms. 5% 1st Mt. Db. | 93—96 | 5 4 0 | .. | .. | .. |
| — | 5% | Underground Elec. Rys. Co. of London | 98—99 | 5 1 0 | .. | 98½ | 98¼ |
| St. | 3% | Waterloo and City Ord. | 97—100 | 3 0 0 | June, Dec | .. | .. |
| St. | 4½% | Yorkshire W. R. El. Trs. Co. 4½% 1st Debs. | 95—97 | 4 13 0 | .. | .. | .. |

| Shre. | Last Dividend | Name | Price Wed. Feb. 14. | Rate % Yielded. £ s. d. | Dividend Due. | Business Week to Feb. 14. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅛—⅜ | 5 6 6 | — | — | .. |
| 1 | 10½d. | Aron El. Met. 6% Cm. Pf. | ½—⅝ | .. | .. | .. | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3⅞—4⅛ | 4 11 3 | .. | 4 5/16 | 4⅛ |
| 1 | 7½d. | Do. Pref | 1 7/16—1 9/16 | 3 16 10 | .. | .. | — |
| 5 | 4/0 | British Insulated & Helsby Cables Ord. | 6¾—7¼ | 5 10 0 | July, Feb | .. | — |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 6¾—6¼ | 4 16 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103—106 | 4 4 11 | .. | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db | 98—100 | 4 10 0 | .. | .. | .. |
| 5 | .. | British Westinghouse 6% Pref. | 1¾—2¼ | .. | .. | 2⅛ | 2 1/16 |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 77—82 | 4 17 6 | .. | 80 | 79½ |
| | .. | Brush Electrical Engineering | ½—¾ | .. | March .. | 9/16 | .. |
| | 2/4½ | Do. 6 per Cent. Pref. Non-Cum. | 1½—2 | 6 0 0 | Mar, Sept | 1⅛ | 1 1/16 |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 98—100 | 4 10 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 82—84 | 5 7 4 | Jan, July | .. | .. |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11—12 | 5 0 0 | Jan, July | 11⅛ | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝—5⅞ | 4 5 0 | Jan, July | 5 15/16 | 5⅞ |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 108½—110½ | 4 1 8 | Nov, May | 109¾ | .. |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1 1/16—1 3/16 | 5 1 0 | .. | 1⅛ | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 95—100 | 4 10 0 | — | .. | .. |
| 1 | 9⅗d. | Chadburn's (Ship) Telegraph Ord. | 1—1¼ | 8 0 0 | .. | .. | — |
| 1 | 7⅕d. | Do. 6% Cum. Pref. | 1 1/16—1 3/16 | 5 2 7 | .. | .. | .. |
| 3 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 2—2¼ | 3 9 0 | Jan, July | 2 3/16 | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 97%—98% | 5 2 0 | Jan, July | 97½ | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8½—9 | 5 11 1 | Sept — | 8¾ | .. |
| 5 | 3/0 | Do. 6% Cum. Pref. | 6—6½ | 4 14 0 | Sept — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104—106 | 4 5 0 | .. | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1½—1¾ | — | Feb, Aug | .. | .. |
| 5 | 2/6 | Do. (£5 paid) | 2¼—2¾ | .. | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 86—88 | 4 11 0 | June, Dec | — | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92—97 | 5 8 1 | .. | .. | .. |
| 5 | 2/6 | Edmundson's Elec. Corp. Ord. | 4¾—5¼ | 6 13 4 | H'lf-yearly | 4¾ | — |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5⅛—5⅜ | 5 16 6 | .. | 5 15/32 | 5 7/16 |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 104—106 | 4 5 0 | .. | 105 | — |
| 2 | 1/7½ | Electric Construction Co. | ½—¾ | 9 6 0 | July — | — | .. |
| 2 | 2/9⅗ | Do. 7 per Cent. Cum. Pref | 2—2½ | 5 12 0 | July .... | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 89—92 | 4 7 0 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9¼—9¾ | 5 4 6 | .. | 9 9/16 | 9 11/16 |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96—99 | 4 1 0 | — | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 13—14 | 5 7 0 | Feb, Aug | 13⅜ | 13¼ |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼—5½ | 4 2 0 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Mort. Deb. Stock (rd.) | — | 4 1 1 | Feb, Aug | .. | .. |
| 10 | 15/0 | India Rubber, Gutta Percha, &c., Wrks. | 18—19 | 2 12 6 | Feb, Aug | 18⅛ | 18 |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99—102 | 3 18 5 | Mar, Sept | — | — |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¾—12¼ | 4 1 8 | Mar, Sept | .. | — |
| 1 | 1/⅔ | Richardsons, Westgarth & Co., Ltd. Ord. | 15/16—1 | 6 0 0 | .. | 1 | .. |
| 1 | 7⅕d. | Do. 6% Cum. Pref. | 1—1⅛ | 5 7 6 | .. | 1 | .. |
| St. | 4½% | Do. 4½% Perp. Deb. Stock | 100—102 | 4 8 8 | .. | .. | .. |
| 12 | 12/0 | Telegraph Construction & Mainten'ce. | 34½—36½ | 4 13 9 | Mar, July | 36 | 34¾ |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 100—102 | 3 13 6 | Jan, July | .. | .. |
| 1 | 1/0 | Vickers, Sons & Maxim, Ltd., Ord. | 2⅝—2⅞ | 4 9 6 | .. | 2 11/16 | 2 9/16 |
| 1 | 6d. | Do. 5% Non-Cum. Preference | 1 3/16—1 5/16 | 3 18 0 | .. | .. | .. |
| St. | 5% | Do. 5% Non-Cum. Preferred | 122—126 | 4 0 0 | — | 124 | 123½ |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock Red. | 104—108 | 3 15 6 | .. | 104½ | .. |
| 100 | 4½% | Do. 4½% 2nd Mort. Debs., Red | 105—107 | 4 4 0 | .. | 106½ | 106¼ |
| 5 | — | Willans and Robinson Ord. | 2¼—2¾ | — | Apr, Oct | 2½ | 2⅜ |
| 5 | — | Do. 6 per Cent. Cum. Pref. | 4—4½ | — | Apr, Oct | .. | .. |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 82—87 | 4 12 0 | May Nov | 85 | .. |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | *African Direct Tel. 4% Mrt. Deb. (red.) | 98½—101½ | 3 18 6 | Jan, July | — | .. |
| 10 | — | Amazon Telegraph | 3¾—4¼ | .. | Jn, Dec .. | 4 | .. |
| 100 | 5% | Do. 5% Debs. (red.) | 83—88 | 5 18 6 | .. | .. | .. |
| St. | 21/0 | † Anglo-American | 64—66 | 4 11 0 | F, My, Ag, N | .. | .. |
| St. | 32/0 | † Do. Preferred | 110½—111½ | 4 13 6 | F, My, Ag, N | 111¾ | 110½ |
| St. | 10/0 | † Do. Deferred | 18—18½ | .. | F, My Ag, N | 18 | 17½ |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 97—99 | 4 1 0 | Jn Ap, Jy, O | 9 ¼ | 9 ¾ |
| 10 | 5/0 | Cuba Submarine Ord. | 8½—9 | 5 11 0 | Feb, Aug | — | .. |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17—18 | 5 11 2 | Feb, Aug | — | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜—3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 8¼—8¾ | 5 14 0 | April, Oct | .. | .. |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 99%—102% | 4 8 0 | Jan, July | .. | .. |
| 20 | 2/6 | Direct United States Cable. | 14½—15½ | 4 4 0 | Ja, Ap, Jy, O | 16¼ | 14 |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 99—101 | 4 9 0 | Jn, Dec .. | .. | .. |
| St. | 25/0 | Eastern Ordinary | 148—151 | 4 12 8 | Ja, Ap, Jy, O | 150½ | 149 |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 91½—92½ | 3 15 0 | Ja Ap, Jy, O | 92½ | 92 |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 107½—109½ | 3 13 0 | May, Nov | 108¼ | .. |
| 10 | 2/6 | Eastern Extension | 14¾—15¼ | 4 11 6 | Ja, Ap, Jy, O | 15 | .. |
| St. | 4% | † Do. 4 per Cent. Deb. Stock | 105—107 | 3 14 8 | Feb, Aug | .. | .. |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 99—101 | 3 19 3 | Feb, Aug | 100½ | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101%—103% | 3 18 8 | May, Nov | .. | .. |
| 10 | 5/0 | G. N. (of Copenhagen) with coupon 65 | 37½—39½ | 6 1 6 | Jan, July | 38 | .. |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 100—102 | 4 8 0 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57—59 | 5 10 0 | May, Nov | 58¼ | .. |
| 100 | $1 | Mackay Companies Common | 6⅛—⅜ | 3 8 6 | Jan, July | — | .. |
| 100 | 4% | Do. Preference | 76—⅛ | 5 5 0 | Ja, Ap, Jy, O | .. | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1¼—1½ | .. | .. | 1 5/32 | .. |
| 100 | 4% | Pacific&Europe'nTel. 4% Guar. Dbs. (rd.) | 99—102 | 3 18 6 | June, Dec | .. | .. |
| 10 | 4/0 | West African Telegraph Shares | 9½—10 | 5 0 0 | .. | .. | .. |
| 2⅓ | — | West Coast of America | ⅜—¾ | .. | — | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100—102 | 3 18 3 | Jan, July | .. | .. |
| 10 | — | West India and Panama | ⅜—⅝ | .. | May, Nov | .. | .. |
| 10 | 6/0 | Do. 6% 1st Pref. | 8¼—8¾ | 6 6 8 | May, Nov | .. | .. |
| 10 | — | Do. 6 per Cent. 2nd Pref. | 6½—7½ | .. | May, Nov | .. | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 100—103 | 4 17 0 | Jan, July | .. | .. |
| 10 | 3/0 | Western Telegraph | 14½—15 | 4 13 0 | Mr, Jn, O, D | 14⅞ | .. |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 100—102 | 4 18 0 | June, Dec | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 102—104 | 3 16 10 | .. | .. | .. |
| | | **TELEPHONES.** | | | | | |
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 102—104 | .. | .. | — | .. |
| 6 | 3/0 | Chili Telephone (fully paid) | 8—8¼ | 4 17 0 | August — | — | .. |
| 1 | 0/9⅜ | Monte Video Telephone Ord. | ⅞—1 | 4 0 0 | — | .. | .. |
| 1 | 1/0 | Do. 5% Pref. | ⅞—1 | 5 0 0 | .. | .. | .. |
| St. | 6% | National Co. Pref. Stock | 111½—114½ | 5 5 3 | — | 114½ | 114⅛ |
| St. | 5% | Do. Def. Stock | 110—112 | 4 8 8 | — | 111¼ | 110½ |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13—15 | 4 0 0 | Feb, Aug | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 11—13 | 4 12 4 | Feb, Aug | 11½ | 11 |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅝—5⅞ | 4 5 2 | Feb, Aug | 5⅝ | .. |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 99¾—101½ | 3 9 0 | June, Dec | 99½ | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 102½—104½ | 3 16 0 | — | 105 | 104½ |
| 1 | 0/7⅕ | Oriental | 1 5/16—1 7/16 | 4 11 0 | April, Oct | .. | .. |
| 1 | 0/7⅕ | Do. 6 per Cent. Cum. Pref. | 1¼—1⅜ | 4 7 0 | — | .. | .. |
| St. | 2¼/7⅔ | Do. 4% Red. Deb. Stock | 97—99 | 4 1 0 | .. | 97 | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 103—106 | 4 4 9 | .. | .. | .. |
| 5 | 3/0 | United River Plate | 7¼—7½ | 5 6 8 | July — | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5½—5¾ | 4 7 0 | June, Dec | 5½ | 5 11/16 |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 110—112 | 4 9 8 | June, Dec | .. | — |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 5—5½ | 5 9 0 | .. | — | .. |
| 10 | 2/0 | Globe Telegraph and Trust | 11⅛—11⅜ | 4 16 6 | Ja, Ap, Jy, O | 11⅛ | 11⅛ |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14⅝—14⅞ | 4 0 6 | Ja, Ap, Jy, O | 14⅞ | 14¾ |
| 10 | 6% | Submarine Cables Trust (Cert.) | 127—130 | 4 12 0 | April, Oct | .. | — |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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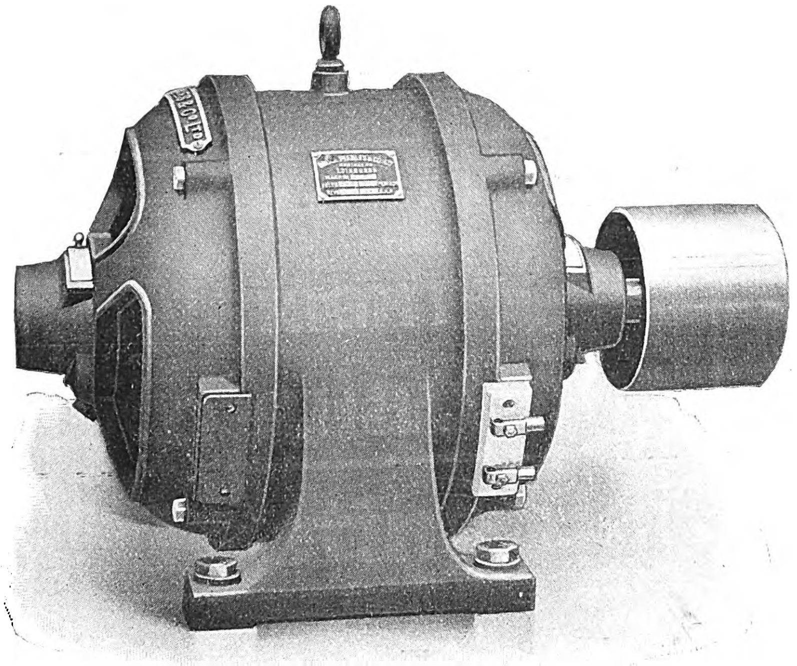

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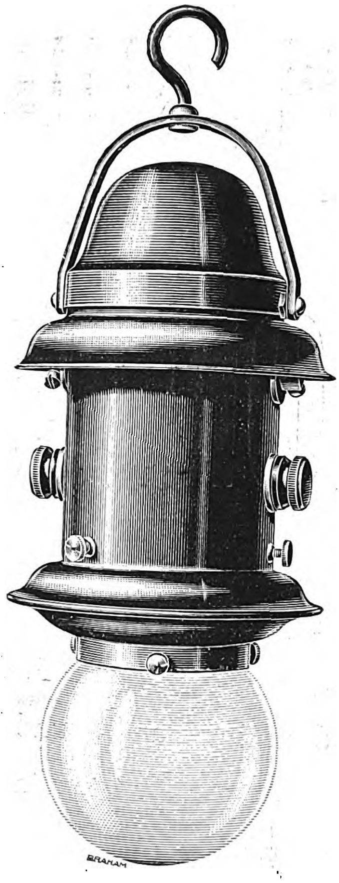

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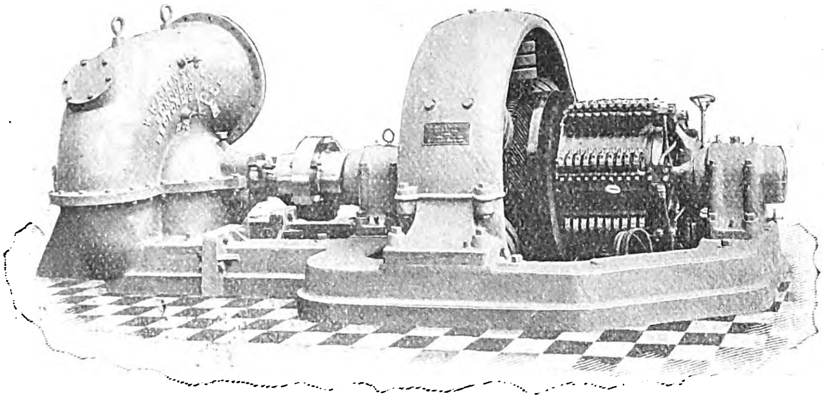

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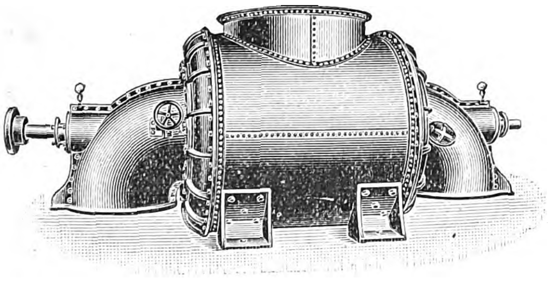

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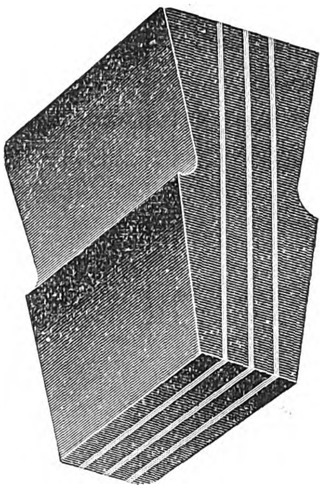

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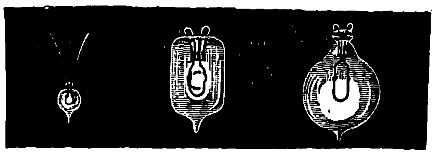

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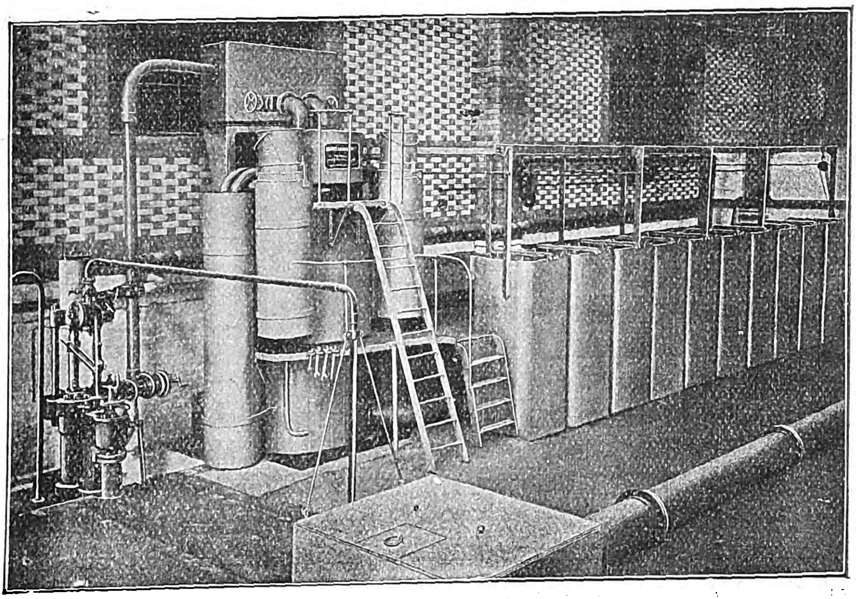

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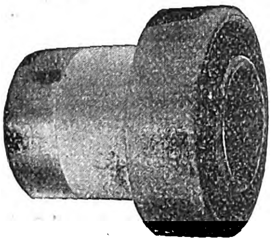

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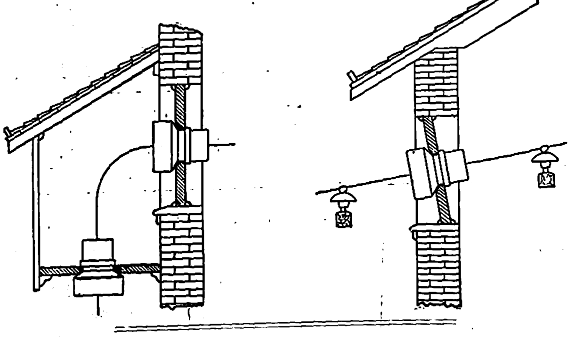

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No. 1,449. [No. 19. Vol. LVI.] FRIDAY, FEBRUARY 23, 1906. PRICE SIXPENCE (by post, 6½d.), *Abroad 9d., or 18 cents, or 90c., or 80pf.*

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## NOTES.

THERE is very little published information upon the life, behaviour and common causes of failure of the various items that go to make up the overhead equipment of an electric tramway. The experience of the men responsible for its maintenance has been chiefly in their own memories and private records; but it is well known that the life of the insulating fittings is in many cases deplorably short. To understand the fundamental causes is the first necessary step toward such improvements in design and materials as shall lead to better results. The Paper read before the last meeting of the Birmingham Local Section of the Institution of Electrical Engineers by Messrs. TWEEDY and DUDGEON is one of the very few attempts yet made to put on public record the observations of men who have had to keep overhead work in running order, and who have endeavoured to find out why things fail with a view to prevention in future. The Paper is of far wider scope, and is valuable throughout, but we hold that its treatment of the matter indicated, and its records of trolley wire wear under a number of differing conditions, are the features of greatest originality and worth, representing as they do practical experience extending over several years on a particular tramway network exposed to a considerable variety of conditions.

◆

THE serious and rapid evil effects of electrolytic and galvanic corrosion upon the insulating fittings are well demonstrated, and the path of avoidance clearly indicated. Observations of a similar kind from men who have had the like opportunities are needed to enable detailed conclusions to be drawn. On the vexed question of the wear of trolley wires at the supports, the measurements given locate the effect, but hardly indicate the primary cause. It is clear that a trolley wheel of proper groove section will run under a smoothly hung wire with very little friction or wear, and at first sight it should run equally smoothly under the point of suspension, always provided that the attachment does not foul the wheel. But experience shows that every suspension point interrupts the smoothness of the run, the noise and the flash alike testify to a jerk or blow. Abnormal wear is but a permanent record of the repeated blows. It is impossible to suppose that contact between the trolley wheel and the ear occurs in every such case. The cause of the blow effect is rather kinetic than massive, and is the rapid change of direction imposed upon trolley wheel and head at every ear. This change is mainly in the vertical plane, but a lateral component must be frequently present. Reduction in the weight of trolley head and boom is an important remedy entirely overlooked by many engineers and manufacturers, who seem to think ponderous swivelling heads and long booms marks of good design. The whole subject is worthy of careful investigation, and the comparison of other records similar to those so carefully made by Messrs. TWEEDY and DUDGEON will be helpful.

◆

THE results of the year's working of the Charing Cross, West End & City Electricity Supply Co. were announced on Tuesday last at the annual general meeting of the company, of which a report will be found in another column of this issue. In common with some of the other supply undertakings, there is a slight reduction in the dividend earned, but the diminution was by no means so serious as had been expected in some quarters. The Chairman stated, however, that the directors did not regret for one moment that powers for giving a supply in the City area had been obtained. Had this not been so, he believed the state of affairs would have been far less satisfactory. He considered that on the whole they had done remarkably well, as with a new undertaking it was impossible to gauge to a nicety the exact amount of expenditure which would be equivalent to the business they would obtain; in more than one case they had looked forward to sources of revenue which, from various reasons out of their control, had not fulfilled expectations. Therefore, for a time at any rate, a small portion of their capital expenditure was unproductive. Another cause suggested as contributing to diminution of receipts was that consumers are getting to understand better the uses of electric supply and are more economical in the way they apply it. Moreover, the competition of the gas industry, although it has probably not actually taken away any consumers from the company, has necessitated a reduction in the price charged for electricity in order that the consumers might not be lost.

◆

ON another page we give an analysis of costs, obtained from the accounts of the company. It will be seen that the matter is a little complicated, owing to the fact that the West End and City undertakings to some extent supply each other in bulk. The costs would have more interest to the electrical engineer if we could have stated the exact load factors of the two undertakings; but the material published with the accounts was not sufficient to enable this to be arrived at. The arrangement between the two undertakings is that one supplies the other at times of sudden accession of load, or whenever circumstances render it advantageous. In this manner the load factors of both stations are improved and economies are made in the cost of generation.

◆

THESE considerations point to an error sometimes made in calculations which involve the load factor. The load factor is the ratio of the mean load to the maximum load, expressed as a percentage. In practice, however, the mean load for this calculation is obtained by dividing the units *sold* during the year by 24 × 365, while the maximum load is the maximum power *generated* as read from the 'bus bar ammeters, including always the power lost in distribution and meter shunts, and sometimes also the electric power used on the works. The load factor obtained is, therefore, lower than it should be, and if, as is sometimes done, the costs of the works are estimated for higher load factors by a sort of extrapolation process, the results obtained may be too favourable. If, as not infrequently happens, one-third of the units generated are made up by those used on the works and "unaccounted for," it is evident that a steady 24-hour load would only give a 67 per cent. load factor reckoned in this manner.

◆

A MEETING of gas engineers met at the Saracen's Head Hotel, in the City of London, on Tuesday to hear a Paper by Mr. F. W. GOODENOUGH, the chief inspector of the Gas Light & Coke Co., on "Gas *versus* Electricity." The engineers of some of the electricity supply companies had been invited to attend at short notice, but they preferred not to avail themselves of the opportunity. As we were not favoured with an invitation to send a reporter, we have to rely on the account in the *Journal of Gas Lighting* for our information as to the proceedings. The Paper contained the usual remarkable figures which the gas companies are fond of producing in their efforts to stem the progress of their competitor. We do not propose to deal with these, but we wish to correct a misquotation from *The Electrician*, made twice by Mr. GOODENOUGH, who accused us of publishing statements not consistent with facts. Four new mantles were inserted in the Fleet-street lamps on Tuesday, January 23rd, and on the following day photometric tests of these lamps were made. In our issue of January 26th we warned our readers against attaching any value to these tests, should they be published. The number of brand-new mantles so tested had little to do with the matter and we did not mention it. Mr. GOODENOUGH now goes out of his way to credit us with the incorrect statement that "the whole of the mantles had been renewed" on the day in question, and then contradicts this statement which we never made. The misrepresentation is, therefore, on Mr. GOODENOUGH'S side and not on ours.

◆

**The Nobel Prizes.**—Last night's *Westminster Gazette* states that Lord Rayleigh has sent to the Vice-Chancellor of Cambridge University the balance of the Nobel Prize, awarded to him in 1904, amounting to £2,733, and requests that the interest of this sum may be spent on the purchase of books on science and scientific periodicals for the University library.

**Personal.**—Mr. Charles H. Lees, D.Sc., lecturer in physics and assistant director of the physical laboratories of the University of Manchester, has been appointed to the position of professor of physics at the East London Technical College, in succession to Dr. R. H. Lehfeldt, recently appointed professor of physics at the Transvaal Technical Institute, Johannesburg. Mr. Lees was recorder of Section A (Physics) of the British Association last year.

**Cable Interruptions and Repairs.**

| | Date of Interruption. | | Date of Repair. |
|---|---|---|---|
| Tarifa—Tangier ............ | Jan. 18, 1904 | .. | — |
| Jamaica—Colon ............ | Jan. 10, 1905 | .. | — |
| Cadiz—Teneriffe............ | July 20, 1905 | .. | — |
| Puerto Plata—Martinique.... | Dec. 15, 1905 | .. | – |
| Bolama—Bissao ............ | Jan. 19, 1906 | .. | Feb. 10, 1906 |
| Vladivostock—Nagasaki .... | Feb. 7, 1906 | .. | Feb. 21, 1906 |
| Cap St. Jacques—Haiphong.. | Feb. 14, 1906 | .. | Feb. 21, 1906 |
| Tangier—Cadiz ............ | Feb. 17, 1906 | .. | — |
| Santa Lucia—St. Vincent.... | Feb. 19, 1906 | .. | — |
| St. Vincent—Grenada ...... | Feb. 19, 1906 | .. | — |

**Mr. Gavey's Presidential Address.**—We have received from Mr. Gavey a full reprint of the presidential address which he delivered before the Institution of Electrical Engineers in November. The reprint is amplified by a page of curves showing the growth of the telegraph and telephone plant maintained by the General Post Office between 1880 and 1905. This shows a most satisfactory increase in the number of telephone instruments and the mileage of underground wire taken into use during the last three years. Some views are also added of the new Post Office City exchange during construction, and there is a careful reproduction of the oscillograms which were imperfectly seen on the screen when the address was given.

**Royal Institution.**—On Friday last an evening discourse was delivered by Mr. W. C. D. Whetham, of Cambridge, on "The Passage of Electricity through Liquids." The lecturer limited the liquids to dilute electrolytes, and dealt with the rudimentary facts and theory of electrolysis. With the possible exception of the Orme Masson experiment, which is an improvement of Lodge's method of showing the speeds of migration of the ions, there was little that has not already been often seen and heard at the Royal Institution.

Mr. W. Duddell will deliver the Friday evening discourse at the Royal Institution on Friday, March 16th. The subject will be "How to Improve Telephony." This lecture takes the place of the one announced to be given by Sir Andrew Noble.

**The Birmingham Local Section of the Institution of Electrical Engineers.**—At the meeting of the Local Section held on February 14th Dr. W. E. Sumpner announced that Prof. Threlfall found himself unable to continue the chairmanship for several reasons, among which was the fact that he was shortly proceeding to America, where he would be staying for some time. In view of the large amount of work which must fall to the chairman in connection with the forthcoming visit of foreign electrical engineers, Prof. Threlfall felt that the interests of the Local Section would best be served by his resigning Mr. J. C. Vaudrey, past-chairman, has been chosen to fill the office of chairman for the remainder of the session, and has accepted the reponsibility.

**The Institution of Mechanical Engineers.**—The annual report of the Institution of Mechanical Engineers records an increase of members of all classes of 273 during the past year, bringing the total up to 4,750. The Steam Engine Research Committee, under the chairmanship of Mr. W. H. Maw, has done good work during the session, and Prof. Capper's report on his experiments at King's College, extending over about eight years, was fully discussed. Some experiments are being conducted under the Steam Jacket Research Committee, and Prof. Beare hopes to present a report on the subject during 1906. The Alloys Research Committee has also met twice, under the chairmanship of Sir William White, and researches on the alloys of copper and aluminium are in progress. The researches on gas engines are being continued by Prof. Burstall at Birmingham in connection with a committee, of which Sir A. B. W. Kennedy is chairman. The institution paid a visit to Liège last summer. Monthly meetings have been held during the session, and a large number of Papers read and discussed. It is intended to hold the next summer meeting in Cardiff.

**Incorporated Municipal Electrical Association.**—The eleventh annual convention of the Incorporated Municipal Electrical Association will be held in London during the week commencing June 18 next. In the meantime, the Council invites offers of Papers from the representatives of committees and engineer members on any of the subjects stated below, or on any others to be approved by the Council, affecting municipal electrical undertakings:—

The Commercial Development of Electricity Undertakings. With special reference to publicity departments, free and assisted wiring schemes, prepayment meters, show rooms, electrical exhibitions, inspection and maintenance of consumers' lamps, canvassers, reduction of selling price of electrical energy, &c.

Boiler House Plant. With special reference to flue gas testing, treatment of feed water, coal analysis, the actual saving (in cash) attained by using condensers, superheaters, and feed water heaters, at various load factors, &c.

Steam Turbines.

The Depreciation of Machinery and various Parts of the Equipment.

Carbon Filament Lamps.

Public *v.* Private Supply.

Tramways.

The names of contributors, together with the title of the Paper or the subject proposed to be dealt with, should be sent to Mr. C. McArthur Butler, secretary of the Association, at Staple Inn-buildings, Holborn, London, at once.

**City & Guilds of London Institute.**—The annual prize distribution of the City & Guilds of London Institute took place at the Mansion House on Friday last, February 16th. The Lord Mayor presided. The report, which was read by Sir John Watney, honorary secretary, showed that the number of students now attending at the Central Technical College was the highest on record, whilst that at Finsbury was also above the average. In addition to the certificates and prizes to be then awarded, there were a large number granted to students at technical schools in the provinces and in the colonies. The Lady Mayoress having distributed the prizes and certificates, the customary address was delivered by Lord Halsbury in the absence through illness of Sir Edward Busk, Vice-Chancellor of the University of London.

Lord Halsbury, referring to the old apprenticeship system, said that although this was a good rough-and-ready way of teaching young people what they wished to practice later in life, the more modern method of teaching the underlying principles in addition, had much to recommend it, and already had been very successful. Germany, France, Switzerland, and other Continental nations had long recognised that the old ways in trade and commerce must be modified, and consequently they had developed technical education at a very rapid rate. As a judge he had often been struck with the large number of patent cases that came before him in which the patents had been taken out in Germany and brought over here to be developed. The reason for this, he thought, was that the facilities for research in Germany were far superior to those provided in Great Britain. His opinion was that as a country we were not doing all that we ought to meet the competition of other countries; it was a matter of national concern to stimulate scientific and industrial activity.

Sir John Wolfe Barry moved a vote of thanks to Lord Halsbury.

Lord Portsmouth, in seconding, referred to the report of the Departmental Committee on the Royal College of Science (*The Electrician*, Feb. 9, pp. 674 and 680), and thought a debt of gratitude was owing to the late Government for their action in this matter.

Votes of thanks to the Lord Mayor and Lady Mayoress closed the proceedings.

**The York Meeting of the British Association.**—The seventy-sixth meeting (1906) of the British Association will, as already reported, be held in York, commencing on August 1st next. The president will be Prof. E. Ray Lankester, F.R.S., and *The Times* of Saturday published a list of the sectional presidents and vice-presidents as now appointed by the Council. We extract the following:—

*Section A.—Mathematical and Physical Science.* President, Principal E. H. Griffiths; vice-presidents, Prof. A. R. Forsyth and Prof. H. L. Callender.

*Section B.—Chemistry.* President, Prof. Wyndham Dunston; vice-presidents, Mr. G. T. Beilby and Prof. A. Smithells.

*Section F.—Economic Science and Statistics.* President, Sir George S. Gibb; vice-presidents, Rev. Dr. W. Cunningham and Mr. Ashley.

*Section G.—Engineering.* President, Mr. J. A. Ewing; vice-presidents, Sir Colin Scott Moncrieff and Mr. W. Cudworth.

*Section L.—Educational Science.*—President, Prof. M. E. Sadler; vice-presidents, Mr. Grant Ogilvie, Sir Philip Magnus and Mr. Dyke-Acland.

It is stated that a sum of £700 has been promised for the purpose of a medal fund to commemorate the visit of the British Association to South Africa last year, and to this amount it has been decided to add the balance of the special funds raised to meet the expenses of the South Africa meeting. This will make the total sum available between £1,500 and £1,600. This sum, together with a die for the medal (sketches of obverse and reverse designs have been prepared), it is proposed to transmit to the South African Association for the Advancement of Science. The medal is to be struck in bronze, which, together with the balance of the income on the fund after paying for the medal, is to be awarded annually, so far as circumstances will allow, "for achievement and promise in scientific research in South Africa." It is intended to call a meeting of the subscribers to the fund on Friday, March 2nd, to receive the report of the Executive Committee and to confirm the above proposals.

**The Niagara Power Schemes.**—Prof. Unwin delivered an interesting lecture last week on the Niagara power stations before a meeting of the students of the Institution of Mechanical Engineers, and gave a very complete account of the establishment of the five different schemes. After dealing with the early purely hydraulic projects, the lecturer described the well-known original power house on the American side and the transmission line to Buffalo, along which some 30,000 H.P. is transmitted. As soon as this station, which had a capacity of 50,000 H.P., was completed, a second one was commenced close by to yield 55,000 H.P. The first works to be started on the Canadian side was that of the Canadian Power Co., closely connected financially with the original American Company. Here a 120,000 H.P. power house was constructed with 10,000 H.P. units, the intake being immediately above the Horse Shoe Fall and the discharge from a tunnel ending just below the Falls. Competing schemes were then started, and the Electrical Development Co. of Ontario is at the present time putting down a power house of 125,000 H.P. from which power will be transmitted to Toronto. The discharge from this works is carried in a tunnel under the upper rapids which terminates in the face of the Horse Shoe Fall. Yet another scheme was that of the Ontario Power Co., who, owing to the positions already occupied by the other two works on the Canadian side, are laying down long pipe lines from their head works beyond the other works above the Falls to their power house a short distance below the Falls. Prof. Unwin then described the arrangements used for governing these large turbines and gave some interesting notes on the special methods of construction necessary for pipe lines dealing with so large a moving mass of water and drew attention to the proportion of the water which would be taken from the

Falls when all these schemes were completed, and would amount to some 30 per cent. of the minimum flow.

**The Bessemer Memorial Fund.**—We have received a letter from the chairman of the Bessemer Memorial Fund for the advancement of Metallurgy and Mining Technology, enclosing a circular setting forth the aims and objects of the fund. The memorial was founded in 1903 with the object of commemorating the great achievements of the late Sir Henry Bessemer by furthering some educational work as far-reaching in its beneficent influence as are the results of Bessemer's great inventions. The committee deferred the active prosecution of their scheme pending the decision of the Government Committee in regard to the future organisation of the Royal College of Science and Royal School of Mines. Now that the final report on this subject has been issued, the memorial committee have further formulated their schemes and appeal to the public for support to the fund, the objects of which are: (*a*) The establishment of open international memorial scholarships for post-graduate practical work, tenable (except such as it is intended to allocate to the Royal School of Mines, the Sheffield and Birmingham Universities, the Armstrong College, Newcastle-upon-Tyne, or other approved British Institutions) in any part of the British empire, in the United States of America and in Europe. It is intended that these scholarships shall be of such value and shall be awarded under such conditions, that they will be regarded by students of any nation as a prize worth striving for, and as an incentive to the highest scientific attainments; (*b*) The equipment of mining and metallurgical memorial laboratories in the Royal School of Mines at South Kensington as the centre of the memorial; and (*c*) The erection of a statue of Bessemer in the new Royal School of Mines at South Kensington. The chairman and vice-chairman of the memorial committee are Sir William Preece and Sir John Wolfe Barry, and the signatories to the appeal comprise many distinguished men from both sides of the Atlantic. A sum of over £8,000 has already been collected. Communications should be addressed to Mr. C. McDermid, Hon. Secretary Bessemer Memorial Fund, Salisbury House, E.C. The central object of the memorial should commend itself strongly to the British people, for the proposed memorial laboratories at the reorganised and enlarged Royal School of Mines would go far towards removing the disadvantages under which mining students in this country have of late years laboured compared with those in some other countries.

**Annual Dinner of the Students' Section of the Institution of Electrical Engineers.**—The Students' Section of the Institution of Electrical Engineers held their second annual dinner at the Holborn Restaurant on Thursday, February 15th. Mr. A. G. Ellis, the chairman of the Students' Section, presided, and a large number of students and guests were present, amongst whom we noticed Mr. Gavey (*President of the Institution of Electrical Engineers*), Prof. W. E. Ayrton, Prof. Silvanus Thompson, Dr. R. T. Glazebrook, Mr. W. M. Mordey, Mr. James Swinburne, Mr. W. H. Patchell and others. The after-dinner speeches alternated pleasantly with the musical items on the programme. The toast of "The Institution and its President" was proposed by Mr. C. H. Lang (*Students' Vice-Chairman*), who appealed to the students for enthusiastic support of the work of the institution. Mr. Gavey, in his reply, compared the conditions obtaining when he was himself a student with the great opportunities possessed by the students of to-day. He dwelt on the advantages of the close connection between the students' section and the institution, and was pleased to see the steady growth of the section, the number of whose members had increased from 419 in 1900 to 1,470 at the present time. Prof. Ayrton also replied in a most humorous speech, and alluded to his first meeting with the President 38 years ago, in the days when telegraphy represented the whole electrical industry. Prof. Silvanus Thompson then rose and proposed the toast of the Students' Section. He was happy in addressing a body with their years before them, and urged them to take advantage of the privileges of being able to come in contact with leading men in the industry and profession at the meetings of the Institution, and seeing how things were actually going in the industry. In speaking of the great organisation of which they had become a part, he said that everyone did not realise the amount of quiet work which is being done behind the scenes by that body, who had the interests of the industry, which were also the students' own interests, so fully at heart. Mr. A. G. Ellis responded, and thanked Dr. Thompson for his kind words. The students' section, he thought, was getting on well, and much was due to the work of its honorary secretaries, Mr. Taylor and Mr. Moss. He would like to see a larger attendance, however, at the students' meetings, as it was only by this means that the coefficient of mutual instruction could be increased, however high the coefficient of self-instruction of the individual members might be. Mr. Taylor proposed "The Guests," and told an amusing story of how it was claimed that plague in India was being reduced by the use of flame arc lamps, the light of which attracted the insects that carried the germs, but soon caused them to fall stupefied to the ground, when they were immediately eaten up by frogs waiting at the base of the lamp-post. The first to respond to the toast was Mr. Swinburne, who told some excellent tales of experience in the days when nobody knew anything about electricity, but most pretended that they knew everything. Mr. Swinburne was followed by Mr. Patchell, who, in a few well-chosen words, pointed out how everyone following electrical pursuits, from the youngest to the oldest, was a student, so rapid was the advance of the industry. Those entering the profession might have their difficulties, but they must bear in mind that there was still ample room at the top of the tree.

## ARRANGEMENTS FOR THE WEEK.

**(To-day) FRIDAY, February 23rd.**

CENTRAL TECHNICAL COLLEGE OLD STUDENTS' ASSOCIATION.

*7:15 p.m.* for *7:30 p.m.* Annual Dinner at the Trocadero Restaurant, Piccadilly-circus, W.

ELECTRO-HARMONIC SOCIETY.

*8 p.m.* Concert (Ladies' Night) at the King's Hall, Holborn Restaurant.

**SATURDAY, February 24th.**

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER STUDENTS' SECTION.

*6:45 p.m.* for *7 p.m.* Annual Dinner at the Grand Hotel, Manchester.

**MONDAY, February 26th.**

INSTITUTION OF ELECTRICAL ENGINEERS: NEWCASTLE LOCAL SECTION.

*7:30 p.m.* Meeting at the Armstrong College, Newcastle-on-Tyne. The following Paper will be read: "The Distribution of Magnetic Induction and Hysteresis Loss in Armatures," by Dr. W. M. Thornton. A General Meeting will be afterwards held to discuss the entertaining of the Members of the Foreign Institutions who will visit Newcastle on July 6th.

ENGINEERING AND SCIENTIFIC ASSOCIATION OF IRELAND.

*7:45 p.m.* Meeting at the Royal College of Science, Stephen's Green, Dublin. Paper to be read: "The Rubber Industry," by T. St. John Bagnall.

**TUESDAY, February 27th.**

LIVERPOOL UNIVERSITY ENGINEERING SOCIETY.

*5:30 p.m.* Meeting at the Liverpool University, when the following Paper will be read: "Wireless Telegraphy," by F. A. Lawson.

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER LOCAL SECTION.

*7:30 p.m.* Meeting at the Manchester University. Paper to be read: "Single-Phase Railway Working," by T. H. Schoepf.

TRAMWAYS AND LIGHT RAILWAYS ASSOCIATION.

*8 p.m.* Meeting at the Society of Arts, John-street, Adelphi, when Prof. C. A. Carus-Wilson will deliver a lecture on "The Radial Truck."

**WEDNESDAY, February 28th.**

INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.

*7:30 p.m.* Meeting at 92, Victoria-street, Westminster. Short Papers will be read on "Fuses" by H. W. Taylor and C. E. Greenslade.

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. Capt. G. S. C. Swinton (London County Council) will read a Paper on "London Traffic."

**FRIDAY, March 2nd.**

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER LOCAL SECTION.

*6:45 p.m. for 7:15. p.m.* Annual Dinner at the Midland Hotel, Manchester.

JUNIOR INSTITUTION OF ENGINEERS.

*7 p.m.* Meeting at the Westminster Palace Hotel. Papers to be read: (1) "Acceleration and Accelerometers," by A. P. Trotter; (2) "Gas Engine Indicators," by L. F. de Peyrecave.

**SATURDAY, March 3rd.**

INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.

*3 p.m.* Visit to the Post Office Telephone Exchange, Addle-bill, London, E.C.

GLASGOW TECHNICAL COLLEGE SCIENTIFIC SOCIETY.

*7:30 p.m.* Meeting at the Glasgow & West of Scotland Technical College, George-street, Glasgow. Paper to be read: "Portable Electric Tools and their Application to Industrial Purposes," by Andrew Stewart.

# THE GREENWICH POWER HOUSE OF THE L.C.C. TRAMWAYS.

Although the London County Council Tramways have been in operation since May 15, 1903, when they were opened by the Prince of Wales, the supply of electrical energy has hitherto been from temporary sources. Under the original scheme for the tramways, drafted by Sir Alexander Kennedy in 1901, the power house was to have been at Camberwell, where the present offices and one of the depots and sub-stations of the tramways department are situated. Some difficulties cropped up, however, with regard to obtaining coal, and as the site was not an ideal one in other respects, having no natural supply of condensing water, the scheme was abandoned, although the tenders for the boilers had been let already, and the present site at Greenwich was chosen in place of it. The position of this, at East Greenwich, opposite the Isle of Dogs, is shown in Fig. 1, and it is seen that it lies to the east of the Council's network of lines, but is not more than 9 miles from the extreme points north and south of the Thames. It was already the property of the London County Council, having been used previously as a car depot. In selecting the site, Mr. John H. Rider, electrical engineer to the London County Council Tramways, was greatly influenced by the fact that it lay far down the River Thames, where coal could be obtained directly from ocean steamers; moreover, the river will afford an unlimited supply of condensing water, and the works are removed to a position where there will be no objection to its chimneys. Unfortunately, this alteration in the original plans meant considerable delay, for entirely new specifications had to be drawn up, and, although Mr. Rider lost no time in preparing these, with the help of Mr. J. Shepherd, his chief assistant, it has been impossible to complete the power house until this year. It may be anticipated, however, that the works will be supplying current to the tramways before Easter.

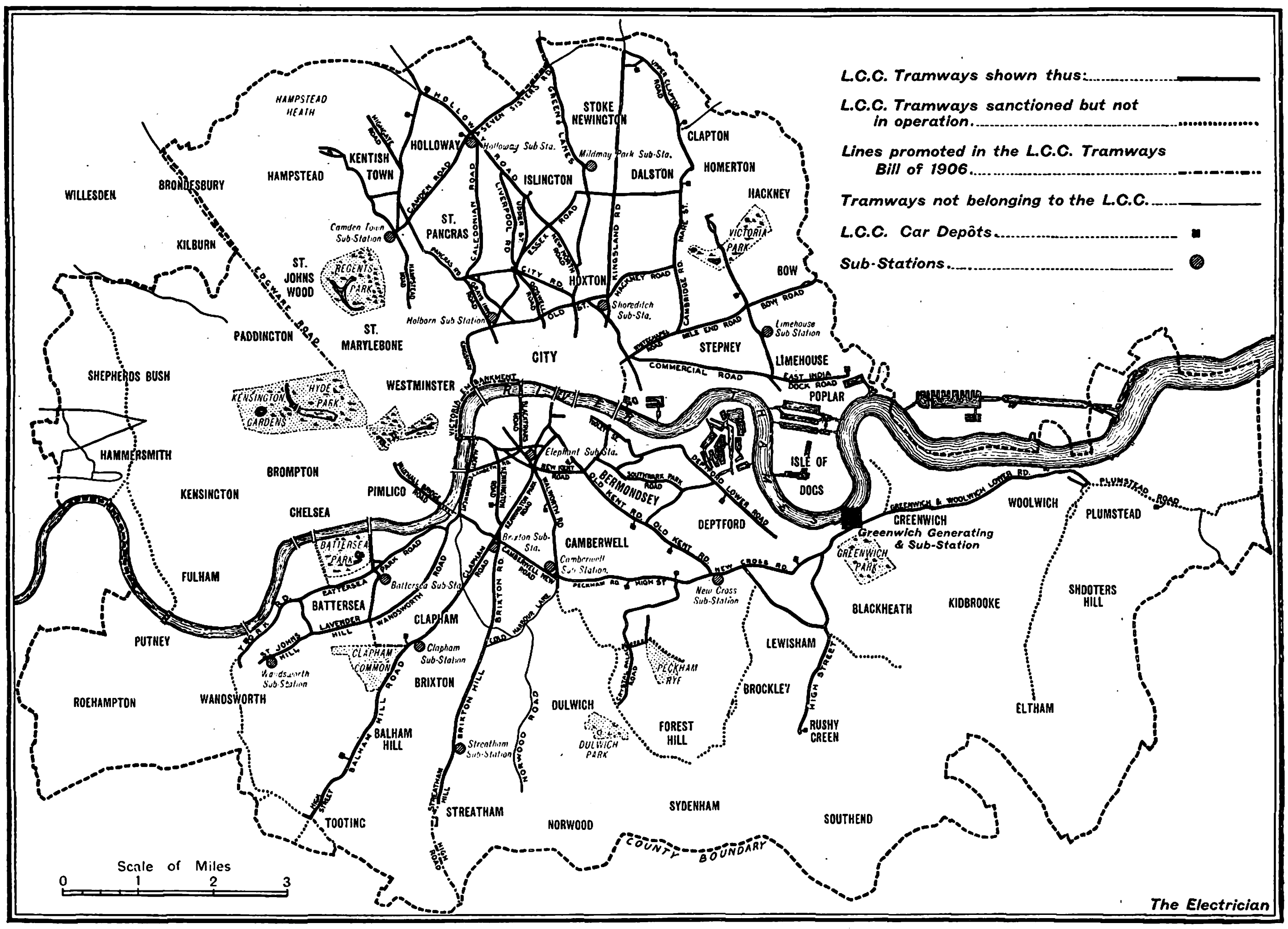
L.C.C. Tramways shown thus
L.C.C. Tramways sanctioned but not in operation
Lines promoted in the L.C.C. Tramways Bill of 1906
Tramways not belonging to the L.C.C.
L.C.C. Car Depots
Sub-Stations
HAMPSTEAD HEATH
HAMPSTEAD
WILLESDEN
BRONDESBURY
KILBURN
KENTISH TOWN
HOLLOWAY
Holloway Sub Sta.
STOKE NEWINGTON
Mildmay Park Sub-Sta.
CLAPTON
HOMERTON
HACKNEY
ISLINGTON
DALSTON
ST. PANCRAS
Camden Town Sub-Station
ST. JOHNS WOOD
REGENT'S PARK
VICTORIA PARK
BOW
HOXTON
Shoreditch Sub-Sta.
Holborn Sub Station
Limehouse Sub Station
PADDINGTON
ST. MARYLEBONE
CITY
STEPNEY
LIMEHOUSE
POPLAR
SHEPHERDS BUSH
WESTMINSTER
KENSINGTON GARDENS
HYDE PARK
HAMMERSMITH
BROMPTON
KENSINGTON
PIMLICO
CHELSEA
Elephant Sub-Sta.
BERMONDSEY
ISLE OF DOGS
DEPTFORD
GREENWICH
Greenwich Generating & Sub-Station
GREENWICH PARK
WOOLWICH
PLUMSTEAD
BATTERSEA PARK
Brixton Sub-Sta.
CAMBERWELL
Camberwell Sub-Station
FULHAM
Battersea Sub-Sta.
BATTERSEA
New Cross Sub-Station
BLACKHEATH
KIDBROOKE
SHOOTERS HILL
CLAPHAM
PUTNEY
Wandsworth Sub-Station
CLAPHAM COMMON
Clapham Sub-Station
LEWISHAM
PECKHAM RYE
BRIXTON
BROCKLEY
ROEHAMPTON
WANDSWORTH
DULWICH
FOREST HILL
RUSHY GREEN
ELTHAM
BALHAM HILL
Streatham Sub-Station
DULWICH PARK
SYDENHAM
TOOTING
STREATHAM
NORWOOD
SOUTHEND
COUNTY BOUNDARY
Scale of Miles
0
1
2
3
The Electrician

Fig. 1.—Map of the London County Council Tramways.

In the meantime the conversion of the lines themselves had been proceeding rapidly, and arrangements were, therefore, made for the supply of current under temporary conditions. For the Tooting lines, opened in May, 1903, a small power house was built near Loughborough Junction, adjoining the electricity works of the South London Electric Supply Corpn. Two 1,500 kw. Ferranti-Dick Kerr 630 volt sets were erected, and steam was bought from the South London Company. A description of this station formed part of an article on the tramways published when they were opened in 1903.*

For supplying the Greenwich lines, opened in January, 1904, two 1,500 kw. Ferranti-Dick Kerr sets were erected in the works of the London Electric Supply Corpn., and they supply current at 6,600 volts and 25 ∿ per second (the pressure and frequency of the L.C.C.'s own station at Greenwich) to the Council's permanent motor-generator sub-stations† which were then ready. This supply will be continued until December, 1908, to supplement the supply from the Council's own station, but under different conditions. The London Electric Supply Corpn. will buy the two generating sets from the Council, and they will supply electrical energy at 1d. per unit, instead of steam at 1½d. per unit (the higher price previously was in view of the temporary nature of the load), and the Council agrees to buy 1½ million units per annum instead of seven million as heretofore.

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* *The Electrician*, Vol. LI., pp. 9, 112, 159 and 241.

† *The Electrician*, Vol. LII., pp. 478 and 516.

The lines marked as in operation in the map include both horse and electric lines. Of these lines it may be taken approximately that all the routes on the south of the river are electrically equipped and those to the north of the Thames, with one or two exceptions, are still run by horses. The subway line under Aldwych and Kingsway will be opened in a few days, and the route in connection with this from Theobalds-road to Islington will then be run electrically.

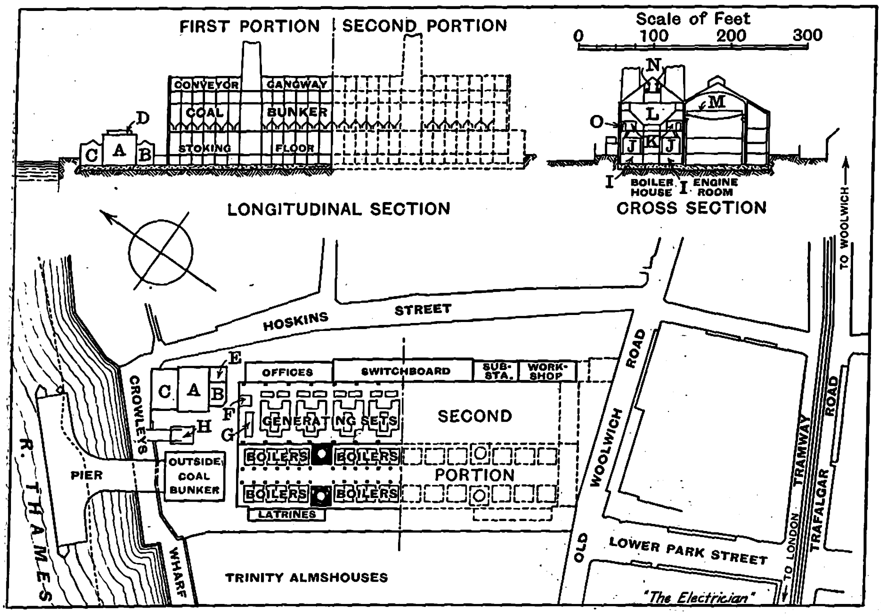
FIRST PORTION
SECOND PORTION
Scale of Feet
0 100 200 300
CONVEYOR
GANGWAY
COAL
BUNKER
STOKING
FLOOR
LONGITUDINAL SECTION
BOILER HOUSE
ENGINE ROOM
CROSS SECTION
HOSKINS STREET
OFFICES
SWITCHBOARD
SUB-STA.
WORK-SHOP
GENERATING SETS
SECOND PORTION
BOILERS
LATRINES
OUTSIDE COAL BUNKER
PIER
R. THAMES
CROWLEYS WHARF
TRINITY ALMSHOUSES
OLD WOOLWICH ROAD
LOWER PARK STREET
TO LONDON
TRAMWAY
TRAFALGAR ROAD
TO WOOLWICH
'The Electrician'

Fig. 2.—Block Plan and Sections of Power House.

A. Pump house.
B. Valve house.
C. Strainer house.
D. Tank.
E. Water softener.
F. Cart dock.
G. Auxiliary engine.
H. 30-ton jib crane.
Pumps.
J. Boilers.
K. Economisers.
L. Bunker.
M. 50-ton crane.
N. Conveyor.
O. Flue.

We now return to the Greenwich power house. Its total capacity will be 34,000 kw., but this has been divided into two parts, of which the first only is being proceeded with at present. This part contains four machines of 3,500 kw. capacity each, so that the total is 14,000 kw.; the second part will have four machines of 5,000 kw. each. Current is generated at 6,600 volts three-phase 25~ (centre of generators earthed), and is transmitted to motor-generator sub-stations, where it is converted to the line pressure of 550 volts. The general layout of the works is seen in Fig. 2. The position of the works right on the river has greatly facilitated the delivery and erection of the machinery. A 30 ton travelling jib crane was fixed on the wharf at a very early stage of the building operations, and a track of light rails has also been run all round, with sidings in the engine room outside the boiler house. The track from the wharf to the engine room had been laid before any plant was delivered and was of considerable service to the contractors. The jib crane was supplied by Messrs. Ransomes & Rapier and is equipped with two three-phase motors. Induction motors with squirrel-cage armatures have been chosen, and they are started with auto-transformers. A 40 H.P. motor serves for lifting and slewing, and a 10 H.P. motor for travelling. Current for this has been temporarily supplied from the mains of the South Metropolitan Electric Light & Power Co., from whom also current was obtained for such lighting as was required during the erection of the works.

The pier is 200 ft. long. It is built on cast-iron cylinders sunk in the ordinary way, and extends far enough into the river to accommodate a 2,000 ton steamer at half-tide. At the end of the pier three electrically-driven jib cranes with grabs have been erected, and these will raise the coal out of the hold of the steamer, slew it round and discharge into hopper waggons. The waggons run on a system of rails so arranged that the trucks will circulate continuously between the crane and the outside coal bunkers, and it is estimated that the 2,000 ton steamer already mentioned will be able to discharge in 24 hours. The cranes, supplied by Messrs. C. & A. Musker, are in this case fitted with continuous-current motors supplied at 550 volts. They are two-motor cranes with a 50 H.P. motor for lifting, and a 10 H.P. for travelling and slewing, and will lift at rate of 150 ft. per minute. The automatic grabs are of Priestman Bros.' make. For the electric locomotives that draw the coal waggons, ordinary Brill tram trucks with motors

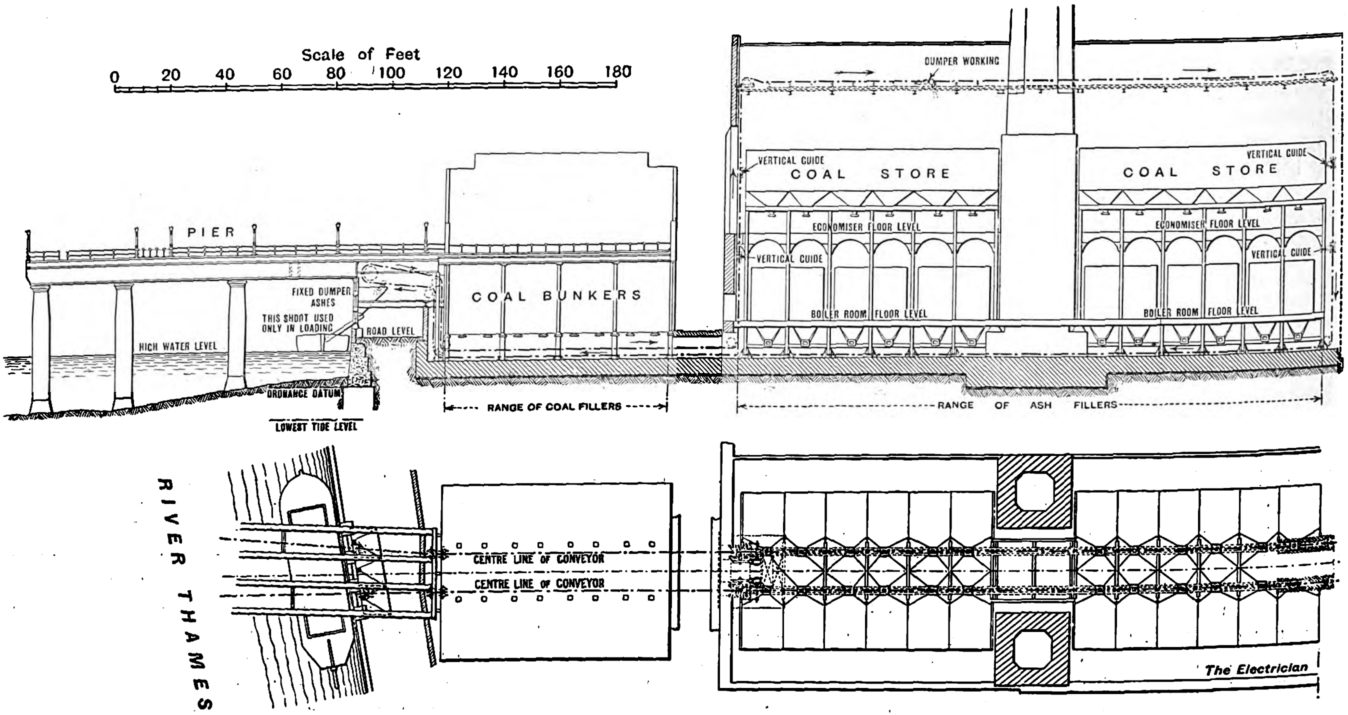
Scale of Feet
0 20 40 60 80 100 120 140 160 180
PIER
HIGH WATER LEVEL
FIXED DUMPER ASHES
THIS SHOOT USED ONLY IN LOADING
ROAD LEVEL
ORDNANCE DATUM
LOWEST TIDE LEVEL
COAL BUNKERS
DUMPER WORKING
VERTICAL GUIDE
COAL STORE
ECONOMISER FLOOR LEVEL
BOILER ROOM FLOOR LEVEL
RANGE OF COAL FILLERS
RANGE OF ASH FILLERS
RIVER THAMES
CENTRE LINE OF CONVEYOR
CENTRE LINE OF CONVEYOR
The Electrician

Fig. 3.—Longitudinal Section and Plan showing General Arrangement of Pier, Coal Bunkers and Conveyor.

and controllers are employed. Between the coal trucks and locomotives there are automatic couplers which are released by pulling a lever, and while the trucks are being discharged the locomotive can return and fetch another set of trucks. Current is supplied to the locomotives by a third rail, as an overhead wire might be fouled by the cranes. The pier has been built to the design and under the superintendence of Mr. Maurice Fitzmaurice, C.M.G., the chief engineer to the London County Council. Fig. 3 gives the general arrangement of the pier and coal-conveying plant, and Fig. 4 a view of the works and pier. The large outside bunker is seen in these two illustrations, and the coal is first discharged into this and then carried to the boiler house coal bunkers by two lines of bucket conveyors. The reason for having the large outside bunker is to discharge the steamer at a much quicker rate than would be possible with the conveyors alone, thus saving demurrage, and also to furnish additional storage capacity. While the capacity of the bunkers over the boiler house in the half-station now constructed is 5,000 tons, the capacity of the outside bunkers is 2,000 tons. With the present number of tramcars running on the system, 5,000 tons of coal represents about 4 weeks' supply.

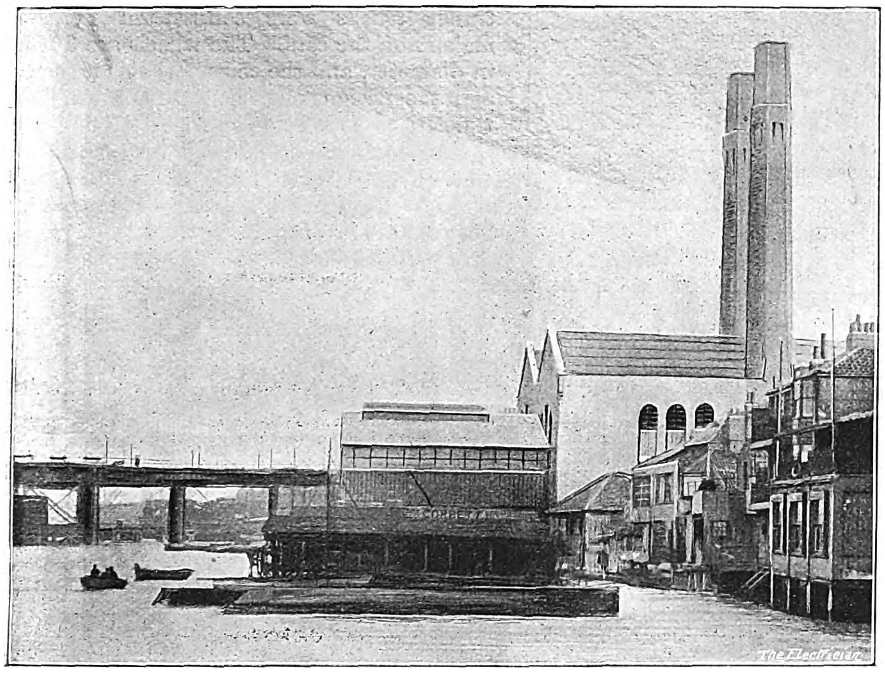

Fig. 4.—View of the Works, Pier and Outside Coal Bunkers.

The coal waggons are of uniform tare, and the coal is weighed in them, the scale of the weighing machine being "set up" a corresponding amount, so that it gives directly the weight of the coal. The bottoms of the coal waggons are hopper-shaped, and they thus discharge quickly into the two halves of the bunker. This large outside bunker is constructed of ordinary steel stanchions, and has sloping concrete sides lined with steel. The staging above the bunkers is roofed in and glazed. From the underside of the bunkers two lines of gravity-bucket conveyors, supplied and erected by the New Conveyor Co., carry the coal to the bunkers over the boiler house, which are divided into 24 pockets, one for each boiler. The two conveyors are about 14 ft. apart. Each half of the outside bunker is fitted with 8 outlet ports, and the supply of coal is regulated by sliding doors in these ports and by automatic portable fillers running on rails over the conveyors. After passing under the bunkers, the conveyors take an upward turn inside the boiler house, and rise vertically to a height of 86 ft. above boiler floor, when they again resume their horizontal travel over the top of storage hoppers. The arrangement is seen in Fig. 3. At points on the top horizontal travel, tilters are fixed, enabling the attendant to discharge the coal from buckets into any desired compartment. After travelling the full length of the boiler house at this high level, the conveyors turn downwards and drop about 98 ft. to the basement level, when they pass back beneath the front of the boilers to collect the ashes from their ash hoppers, rising again to a sufficient height to discharge into a steel hopper under the pier at the edge of the wharf, whence the ashes are emptied into barges by means of a shoot. After discharging the ashes the conveyors proceed for a short distance horizontally, and then they drop down to the low level under bunkers ready for charging with coal. The buckets are of the built type, being made of 3 ft. 6 in. mild steel plate flanged over and jointed on the underside. Each line of conveyors is driven by a 25 B.H.P. E.C.C. motor through machine-cut wheels keyed to shafts which are mounted upon one solid bed-plate. These motors are three-phase 220 volt machines with short-circuited rotors, and they are purposely of larger dimensions than necessary, so that they may be sufficient for the increased length of conveyor chains when the remainder of the boiler house is built. The maximum duty of each conveyor is 40 tons per hour.

(*To be continued.*)

## BAKER STREET AND WATERLOO RAILWAY.

(*Concluded from page 705.*)

The arrangement of the lifts varies at the different stations. In some cases two shafts each 23 ft. in diameter containing two lifts each are provided, but other stations have a single shaft 30 ft. in diameter in which three lifts are placed. The total number of lifts is 37. They are all electrically driven and were supplied by the Otis Elevator Co. The cage bodies of the lifts are entirely of steel with the usual collapsible lattice work gates. A novelty has, however, been introduced into the working of the gates. The exits and entrances to the lifts are so arranged that passengers enter the cars at one end and leave by the other, an arrangement possessing some advantages over the Central London Railway system, where the last to enter is the first to leave the lift, and everyone crowds near the gate at one end. The attendant, however, does not have to leave his controller as he can open and shut the gates at the end of the lift away from him by means of compressed air. The controlling mechanism actuating the gates is interlocked with the driving controller, so that if the attendant forgets to close the gates before starting they shut automatically as soon as he reaches the second notch of the controller. The lifts are driven by continuous-current motors supplied, as already stated, through special cables from the sub-stations, switches being also provided so that they can be connected on emergency to the track conductors. The motors vary in size for the different size of lifts and drive the drums through a double worm gear in which the thrusts of the right and left-handed worms are balanced. An electric brake of the usual type, which is held off by the current, is provided. The controller in the car is simply a master controller of small size, the main controller consisting of a series of contactors mounted on panels close to the motors. The staircase shafts, which are in all cases provided in addition to the lifts, are 18 ft. in diameter and contain the 4 ft. 6 in. ventilating tubes. The whole of the lift work was carried out under the supervision of Mr. G. Rosenbusch. In most cases the cables from the sub-stations are taken down the lift shafts.

The rolling stock consists entirely of steel cars constructed by the American Car & Foundry Co. The erection and fitting together of the parts made in America was done at Manchester at a works established for the purpose at Trafford Park. The constructional method is shown in Figs. 8 and 10, and the appearance of the complete cars in Figs. 9 and 11, which represent a motor car and trailer respectively. The sides of the car body form steel plate girders of great depth, from which the floor is supported by diagonal ties. The side and floors, as well as the framework, are entirely of steel, only a very little wood is employed in the fittings of the windows, and this is treated by a special process to render it incombustible. Each train will consist of six cars, a motor at each end and four trailers between. The trailers will have seats for 52 passengers each, 36 on longitudinal and 16 on transverse seats, arranged in a similar way to the Central London Railway cars. The motor cars will seat 46 persons. The arrangement of end platforms and gates is similar to that in use on the Central London and some of the Metropolitan Railway cars. The system of automatic doors in the centres of cars used on the District Railway is not adopted. All the cars are 50 ft. in length overall, 8 ft. 8 in. wide and 9 ft. 5⅝ in. high from the rail level. The cars are coupled by Stearn & Ward's patent automatic vertical plane drawbar which is in use on the District Railway. The wearing parts are of manganese steel, and the buffer face is deeply corrugated to prevent riding up in case of collisions. Ball bearings are provided for the centre plates. The driving bogies, of which one is provided to each motor car, are interchangeable with those in use on the District Railway and those that will be employed on the Great Northern, Piccadilly & Brompton and Charing Cross, Euston & Hampstead Railways (see *The Electrician*, Vol. LI., p. 64). Each is equipped with two motors with single reduction gear, and the driving wheels are 36 in. in diameter, the distance between centres being 6 ft. 6 in. As will be seen from the illustrations, the floor of each motor car is raised at one end to accommodate the motor truck, in a similar manner to that employed on the Waterloo & City line and later on the motor cars of the Central London. The trailing bogies, however, are of a new design, which keeps the floor level of the cars as low as possible. The weight of the car, instead of being supported above the level of the axles is hung from below the axles. The truck frame is, so to speak, inverted and kept entirely below the axle level, only 6 in. clearance being provided between the bottom of the truck side frame and the level of the rails. Both the motor and trailer trucks were constructed by the makers of the cars. The wheels are 30 in. in diameter, and the centres are 5 ft. apart, and the design enables the floor level of the cars to be kept down to 1 ft. 10 in.

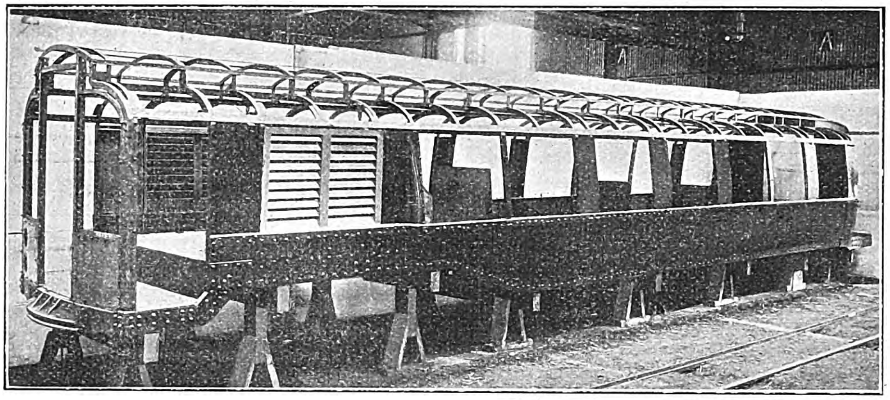

Fig. 8.—Motor Car under Construction.

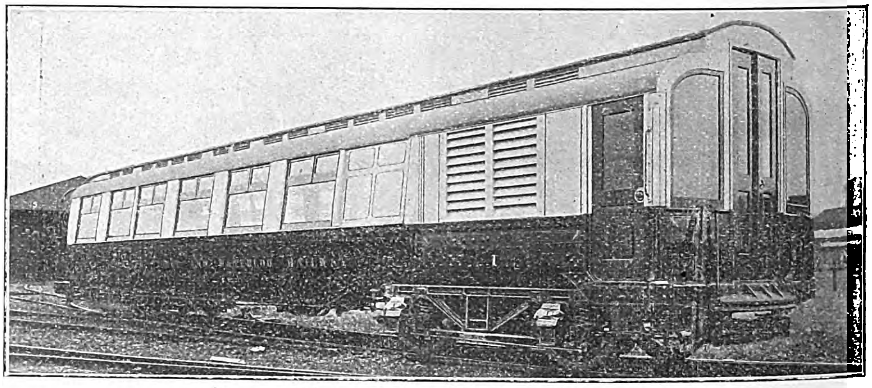

Fig. 9.—Motor Car Complete.

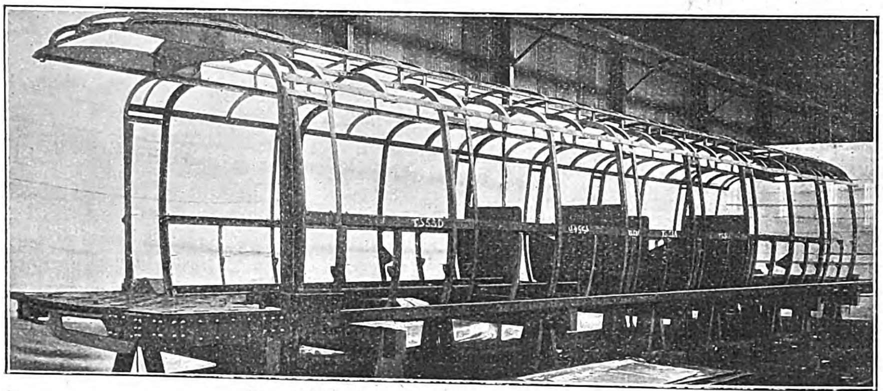

Fig. 10.—Trailer under Construction.

The electrical equipment is very similar to that on the District Railway, and was supplied by the British Thomson-Houston Co. The motors are of the G.E. 69 type, rated at 200 b.h.p. each, four motors being provided on each train. The control is on the standard Sprague-Thomson-Houston multiple unit system. The only difference between the electrical equipment on this line and on the District is that all the control apparatus is carried in a steel cab in the driving end of the car, where the floor is raised over the motor trucks. A full description of the various items composing the control equipment was given in *The Electrician*, Vol. LI., p. 64, in connection with the original cars of the District Railway. The arrangement of the contactors, resistances, &c., however, more nearly reremBles that of the motor cars on the Central London Railway, of which an account is to be found in *The Electrician*, Vol. LI., p. 317.

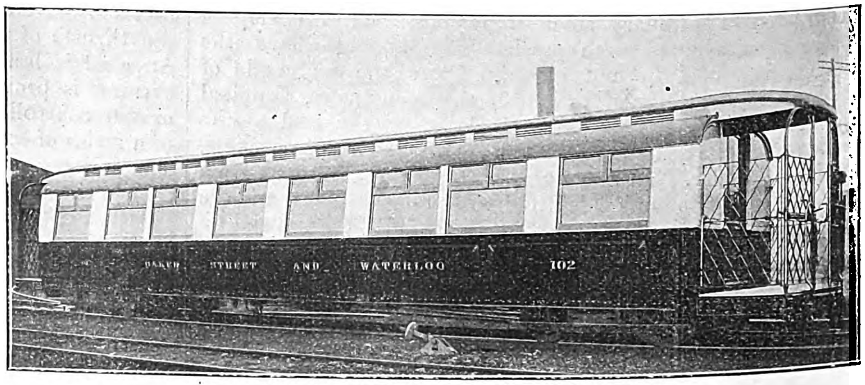

Fig. 11.—Trailer Complete.

The arrangement of contactors and circuit-breakers, supported on horizontal slate panels, is shown in Fig. 12, which is from a photograph of the interior of one of the Baker Street & Waterloo cars. The collection of the apparatus together in steel cabs at the ends of the trains, rendered necessary by the absence of sufficient space under the low floors of the cars, is considered advantageous on tube lines in case of any possible fault developing while a train is in a tunnel, as the under part of the cars would not be accessible. The other side of the cab, not shown in the photograph, contains the compressor and reservoir belonging to the Westinghouse air-brake equipment. The master controller is situated, as usual, in front of the driver, on the left-hand side, and is fitted, as in the case of the District Railway, with the "dead man's" handle, by which the current is cut off from the train if the driver releases his hold. The driver's brake valve is situated alongside the master controller, and the hand brake wheel, sand blast and whistle handles, &c., are within easy reach. The drivers will have been thoroughly trained by the time the line is opened for traffic, for a full experimental service has been in operation for the last few weeks.

The control cables run the whole length of the trains in the usual way, and each motor car is fitted with its own set of collecting shoes. Thus no power cable is carried along the train. The control circuit usually takes current from the shoes of the forward car; a double-pole throw-over switch is, however, provided by which the control circuit may be supplied from the rear car through the lighting mains in case the shoes of the front car should happen to be over a gap when the train is standing.

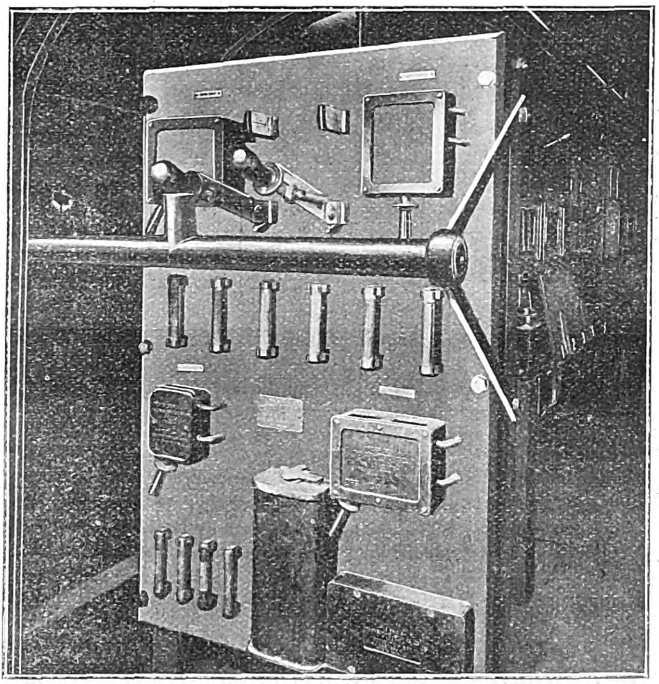

Fig. 12.—Controlling Gear in Motor Car.

The lighting of each car is effected by 20 incandescent 16 c.p. lamps arranged five in series in four circuits. The interior lighting is independent of the head lamps in front of the train. The arrangement of lighting circuits is as follows:—A pair of lighting mains from one motor car is run along one side of the train and another pair from the second motor car along the other side. Half the lamps in every car are supplied from each of these mains, but no cross connection is provided between the two sets, so that the shoes of the forward and rear cars cannot be accidentally connected through the lighting circuits. Thus only half the lamps in each car will be extinguished when a train passes over a gap in the conductors greater in length than the distance between the shoes of the front car, and these will, of course, light up long before the second half of the lights are put out by the rear car passing over the gap.

The maximum speed attained by the trains is over 35 miles per hour, and the acceleration and working is very smooth, the unpleasant chattering of the brakes so noticeable on the District Railway being absent. The whole of the work connected with the rolling stock was supervised by Mr. F. D. Ward, master mechanic of the Underground Railways Co.

We have to express our thanks for putting information, drawings and photographs at our disposal to Mr. James R. Chapman, engineer-in-chief and general manager of the Underground Electric Railways Co. of London, and Mr. Z. E. Knapp, assistant engineer; to Mr. G. Rosenbusch, who kindly conducted our representative over the line; and to the British Thomson-Houston Co., who sent us the photograph of the controlling gear.

## CRANE MOTORS AND CONTROLLERS.*

BY CLAUDE W. HILL.

*(Concluded from page 665).*

*The Load Factor.*—In the general run of crane work the load factor is low, as might be expected from the fact that ½-hour motors have been found satisfactory. The lowness of the load factor is due not only to the motors having fairly long standing periods, but also because they do not exert their full power every time.

Where the motor exerts its full power each time the load factor is given by the formula No. 6—

$$f=\frac{t'}{t'+t''} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

in which $t'$ is the time of working and $t''$ the time during which the motor is stopped.

Where the power varies we have to include the horse-power, and the formula then becomes

$$f=\frac{\mathrm{H\,P}_1\times t'}{\mathrm{H\,P}\times(t'+t'')} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

in which $\mathrm{HP}_1$ is the horse-power exerted during the time $t'$ and HP is the rated horse-power of the motor. The load factor so found is correct so far as the supply of current to the motor is concerned, but is not correct with respect to the heating of the motor, which is proportional to the internal losses, which, again, are approximately proportional to the square of the horse-power.

For the purpose of dealing with the motor temperature we require, then, a second load factor given by formula No. 8—

$$f_1=\frac{\mathrm{H\,P}_1{}^2\times t'}{\mathrm{H\,P}^2\times(t'+t'')} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

We may call the first the external load factor and the second the internal.

In Tables II., III. and IV. are given some test figures taken from an overhead travelling crane which was designed by the author and constructed by the Cleveland Bridge Co. From these figures the external and internal load factors have been calculated and added at the foot of each table. On the hoisting gear a shunt motor is used, giving a regenerative effect when lowering, and so reducing the external load factor. On the other hand, the internal load factor is slightly increased by the regenerative current, as the heating of the machine depends only on the passage of a current through it, and not upon its direction. This method of using a shunt motor to drive the hoisting motion of cranes has been in use by the Cleveland Bridge Co. for nearly 2½ years on several cranes, the advantages being complete control over the speed of lowering, a slight economy in current consumption and a considerable economy in wear and tear of brake gear.

In settling the test to be specified for a crane motor, the internal load factor is an important figure. Having (either by the test figures of a previous crane or by calculation) constructed a table such as Table II. and found the load factor, and having also determined the horse-power necessary for the crane when fully loaded, we may by means of curves such as those of Figs. 11 and 12 ascertain the length of run at the full horse-power of the motor which will give the same rise of temperature as will be attained when the motor is driving the crane in regular work. Figs. 13 to 16 are examples of ampere-meter diagrams taken from the overhead crane of which figures are given in Tables II., III. and IV. Figs. 17 and 18 are from a 5-ton derrick crane, and Fig. 19 from a 15-ton Goliath. In the two latter cases the electrical driving arrangements only were designed by the author, and not the cranes. These diagrams show the relative starting and running currents, from which the equivalent mean currents during each run have been calculated. They also show the regenerative currents obtained when lowering loads with the shunt motors.

*Controllers.*—In the design of a controller there are two principal objects to be attained. Firstly, the height of the current peaks must be limited to such an amount as may be convenient, having regard to the circuit-breakers and fuses; and secondly, the motor to which the controller is connected must be brought to full speed within such time as may be required. In order to attain full speed in the

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* Paper read before the Institution of Electrical Engineers last night.

**Table I.**—*Volts in All Cases 220.*

| Machine. | A. | | | B. | | | C. | | |
|---|---|---|---|---|---|---|---|---|---|
| Rating | ¼ Hour | ½ Hour | 1 Hour | ¼ Hour | ½ Hour | 1 Hour | ¼ Hour | ½ Hour | 1 Hour |
| Rrake horse-power | 5·62 | 4·4 | 3·45 | 53·0 | 38·5 | 27·0 | 166·0 | 122·0 | 84·0 |
| Revolutions per minute | 345·0 | 420·0 | 490·0 | 360·0 | 395·0 | 450·0 | 320·0 | 360·0 | 440·0 |
| Efficiency | 69·5 | 76·5 | 80·5 | 83·0 | 87·5 | 90·0 | 86·25 | 89·25 | 91·0 |
| Armature: | | | | | | | | | |
| Temperature rise at rated load | 41·5 | 41·5 | 41·5 | 41·5 | 41·5 | 41·5 | 41·5 | 41·5 | 41·5 |
| M. | 240·0 | 130·0 | 82·0 | 425·0 | 235·0 | 128·0 | 575·0 | 295·0 | 150·0 |
| T. | 80·0 | 80·0 | 80·0 | 150·0 | 150·0 | 150·0 | 188·0 | 188·0 | 188·0 |
| Watts per cubic inch | 3·5 | 1·9 | 1·18 | 3·75 | 2·05 | 1·1 | 4·1 | 2·1 | 1·05 |
| Watts per square inch | 3·8 | 2·08 | 1·3 | 7·0 | 3·65 | 2·1 | 9·2 | 4·6 | 2·4 |
| Current density | 5,500 | 3,900 | 2,900 | 6,300 | 4,450 | 3,000 | 4,950 | 3,300 | 2,320 |
| Reactance voltage | 2·8 | 2·4 | 2·1 | 3·5 | 2·6 | 2·0 | 4·9 | 4·0 | 3·3 |
| Approx. temp. rises with overloads: temp. rises per minute at rated load | 2 76 | 1·38 | 0·69 | 2·76 | 1·38 | 0·69 | 2·76 | 1·38 | 0·69 |
| Ditto, current by 2 | 14·3 | 6·3 | 3·2 | 11·5 | 2-8 | 1·9 | 15·0 | 6·4 | 2·5 |
| ,, ,, 3 | 45·3 | 17·0 | 8·2 | 42·5 | 12·0 | 4·6 | 50·0 | 18·2 | 6·6 |
| ,, ,, 4 | 147·0 | 39·0 | 17·0 | 175·0 | 28·8 | 9·6 | 172·0 | 42·0 | 13·4 |
| Magnet: | | | | | | | | | |
| Temperature rise at rated load | .. | .. | .. | .. | .. | .. | 45 deg. | 42 deg. | 35 deg. |
| M. | .. | .. | .. | .. | .. | .. | 320·0 | 162·0 | 73·5 |
| T. | .. | .. | .. | .. | .. | .. | 99·0 | 99·0 | 99·0 |
| Watts per cubic inch | .. | .. | .. | .. | .. | .. | 2·9 | 1·46 | 0·66 |
| Watts per square inch | .. | .. | .. | .. | .. | .. | 1·61 | 0·815 | 0·36 |

**Table II.**—*30-Ton Crane. Handling 30 Tons.*

| — | Lifting motion. | | | | Traversing motion. | | | | Travelling motion. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | H.P. | Time (secs.) | H.P. × time. | H.P.$^2$ × time. | H.P. | Time (secs.) | H.P. × time. | H.P.$^2$ × time. | H.P. | Time (secs.) | H.P. × time. | H.P.$^2$ × time. |
| 1. Lifting | 13 | 144 | 1,872 | 24,336 | .. | .. | .. | .. | .. | .. | .. | .. |
| 2. Traversing | .. | 18 | .. | .. | 4 | 18 | 72 | 288 | .. | .. | .. | .. |
| 3. Travelling | .. | 52 | .. | .. | .. | .. | .. | .. | 15 | 52 | 780 | 11,700 |
| 4. Traverse | .. | 18 | .. | .. | 4 | 18 | 72 | 288 | .. | .. | .. | .. |
| 5. Lower | −6 | 120 | −720 | 4,320 | .. | .. | .. | .. | .. | .. | .. | .. |
| 6. Taking off slings | .. | 30 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 7. Lift hook | 9·5 | 34 | 323 | 3,068·5 | .. | .. | .. | .. | .. | .. | .. | .. |
| 8. Travel back | .. | 49 | .. | .. | .. | .. | .. | .. | 13 | 49 | 637 | 8,281 |
| 9. Lower hook | 8·5 | 34 | 289 | 2,456·5 | .. | .. | .. | .. | .. | .. | .. | .. |
| | .. | 499 | 1,764 | 34,181 | .. | .. | 144 | 576 | .. | .. | 1,417 | 19,981 |

| — | External load-factor. | Internal load-factor. |
|---|---|---|
| Lifting motor | 1,764/15 × 499 = 0·234 | 34,181/$15^2$ × 499 = 0·305 |
| Traverse motor | 144/4 × 499 = 0·072 | 576/$4^2$ × 499 = 0·072 |
| Travelling motor | 1,417/15 × 499 = 0·188 | 19,981/$15^2$ × 499 = 0·178 |

**Table III.**—*30-Ton Crane, Handling 15 Tons.*

| — | Lifting motion. | | | | Traversing motion. | | | | Travelling motion. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | H.P. | Time (secs.) | H.P. × time. | H.P.$^2$ × time. | H.P. | Time (secs.) | H.P. × time. | H.P.$^2$ × time. | H.P. | Time (secs.) | H.P. × time. | H.P.$^2$ × time. |
| 1. Lifting | 15 | 64 | 960 | 14,400 | .. | .. | .. | .. | .. | .. | .. | .. |
| 2. Traversing | .. | 18 | .. | .. | 3·75 | 18 | 67·5 | 253 | .. | .. | .. | .. |
| 3. Travelling | .. | 52 | .. | .. | .. | .. | .. | .. | 14·5 | 52 | 754 | 10,933 |
| 4. Traverse | .. | 18 | .. | .. | 3·75 | 18 | 67·5 | 253 | .. | .. | .. | .. |
| 5. Lower | −6 | 54 | −325 | 1,944 | .. | .. | .. | .. | .. | .. | .. | .. |
| 6. Taking off slings | .. | 30 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 7. Lift hook | 9·5 | 34 | 325 | 3,068·5 | .. | .. | .. | .. | .. | .. | .. | .. |
| 8. Travel back | .. | 49 | .. | .. | .. | .. | .. | .. | 13 | 49 | 637 | 8,281 |
| 9. Lower hook | 8·5 | 34 | 290 | 2,456·5 | .. | .. | .. | .. | .. | .. | .. | .. |
| | .. | 353 | 1,250 | 21,869 | .. | .. | 135 | 506 | .. | .. | 1,381 | 19,314 |

| — | External load-factor. | Internal load-factor. |
|---|---|---|
| Lifting motor | 1,250/15 × 353 = 0·237 | 21,869/$15^2$ × 353 = 0·275 |
| Traverse motor | 135/4 × 353 = 0·095 | 506/$4^2$ × 353 = 0·089 |
| Travelling motor | 1,381/15 × 353 = 0·261 | 19,314/$15^2$ × 353 = 0·243 |

**Table IV.**—*30-Ton Crane. Handling 5 Tons.*

| — | Lifting motion. | | | | Traversing motion. | | | | Travelling motion. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | H.P. | Time (secs.) | H.P. × Time. | H.P.$^2$ + Time. | H.P. | Time (secs.) | H.P. × time. | H.P.$^2$ × time. | H.P. | Time (secs.) | H.P. × time. | H.P.$^2$ × time. |
| 1. Lifting | 7·25 | 64 | 480 | 3,363·8 | .. | .. | .. | .. | .. | .. | .. | .. |
| 2. Traversing | .. | 18 | .. | .. | 3 5 | 18 | 63 | 220·5 | .. | .. | .. | .. |
| 3. Travelling | .. | 52 | .. | .. | .. | .. | .. | .. | 13 | 52 | 675 | 8,788 |
| 4. Traverse | .. | 18 | .. | .. | 3·5 | 18 | 63 | 220·5 | .. | .. | .. | .. |
| 5. Lower | 0 | 61 | 0 | 0 | .. | .. | .. | .. | .. | .. | .. | .. |
| 6. Taking off slings | .. | 30 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 7. Lift hook | 9·5 | 34 | 325 | 3,068·5 | .. | .. | .. | .. | .. | .. | .. | .. |
| 8. Travel back | .. | 49 | .. | .. | .. | .. | .. | .. | 13 | 49 | 640 | 8,281 |
| 9. Lower hook | 8·5 | 34 | 290 | 2,456·5 | .. | .. | .. | .. | .. | .. | .. | .. |
| | .. | 360 | 1.095 | 8,889 | .. | .. | 126 | 441 | .. | .. | 1,315 | 17,069 |

| — | External load-factor. | Internal load-factor. |
|---|---|---|
| Lifting motor | 1,095/15 × 360 = 0·202 | 8,889/$15^2$ × 360 = 0·109 |
| Traverse motor | 126/4 × 360 = 0·087 | 441/ $4^2$ × 360 = 0·076 |
| Travelling motor | 1,315/15 × 360 = 0·243 | 17,069/$15^2$ × 360 = 0 210 |

shortest possible time the height of current peak on each step of the controller should be the maximum permissible. When the controller is on the first step the current simply depends upon the voltage of the circuit and the resistance of the motor and controller. At this point, then, the resistance in the controller must be such that at the moment the circuit is made the current which flows shall not exceed the maximum allowable. This decides the total amount of resistance, and in order that the current shall rise to the same value, each time the controller is moved a step forward the resistance must be graded in accordance with formula No. 9—

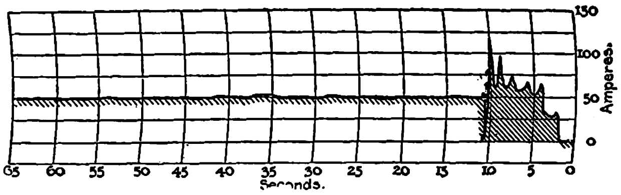

FIG. 13.

Lifting 15 tons.—Mean starting current, 53 amperes. Mean running current, 50 amperes. Mean during run, 50·4 amperes.

$$Ra, b, c, \&c. = r \times \left(\frac{C_1}{C_2}\right)^{n-1} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

in which R*a* is the total resistance with the controller on the first step, R*b* the resistance on the second step and so on, *r* the resistance of the motor, $C_1$ the maximum current and $C_2$ the value to which the current falls before moving on to the next step and *n* the number of steps in circuit at any time.

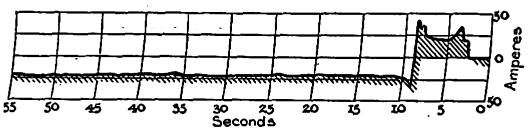

FIG. 14.

Lowering 15 tons.—Mean starting current, 25 amperes. Mean running current, 21 amperes. Mean during run, 21·5 amperes.

From the above formula we can also determine the number of steps which a controller must have in order to fulfil the given requirements, by means of formula No. 10—

$$n = 1 + \frac{\log R - \log r}{\log\left(\frac{C_1}{C_2}\right)} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

As an example of the application of the above formula we may compare Fig. 13 with Fig. 19. The motors and controllers in both cases were identical, but the controller of Fig. 19 had the resistances graded in accordance with the formula, while that of Fig. 13 had not. It will be noted that in Fig. 13 the mean starting current is 53 amperes with a maximum of 140, a ratio of 2·6 to 1, while in Fig. 19 the mean starting current is 58·6 amperes with a maximum of 80, the ratio being in this case 1·36 to 1, so enabling the circuit-breaker to be set much closer to the running current of the motor. In addition to the two principal requirements above mentioned, the controller is sometimes required to be capable of bringing the motor down to a very slow speed. For this purpose additional steps have to be provided, with further resistance in addition to that found by the above formula.

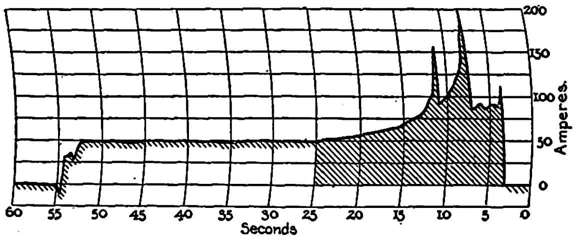

FIG. 15.

Travelling 30 tons.—Mean starting current, 79 amperes. Mean running current, 50 amperes. Mean during run, 67·5 amperes.

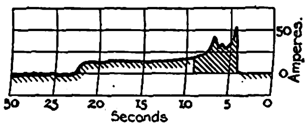

FIG. 16.

Traversing 30 tons.—Mean starting current, 28 amperes. Mean running current, 14 amperes. Mean during run, 19 amperes.

As an example of the application of the formula a controller design has been worked out for machine C $\frac{1}{4}$-hour rating, and the complete starting diagram is given in Fig. 20. In this it is assumed that the slowest speed required will be 10 per cent. of full speed, and that the lightest load will be equivalent to $\frac{1}{5}$ the full torque of the motor, and it is further assumed that a mean starting current 25 per cent. in excess of the normal running current is required to give the necessary acceleration. The full lines in Fig. 20 show the diagram when starting on full load, and the dotted lines the diagram when starting on the lightest load. The first three steps are slow-speed steps, and the remaining five are acceleration steps. The motor can, however, be run with the controller on any step without the height of the current peaks exceeding those shown.

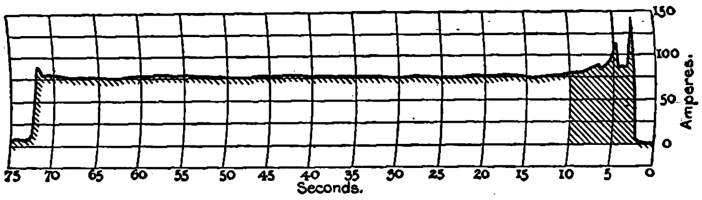

FIG. 17.

Lifting 5 tons.—Mean starting current, 86·5 amperes. Mean running current, 79 amperes. Mean during run, 83·7 amperes.

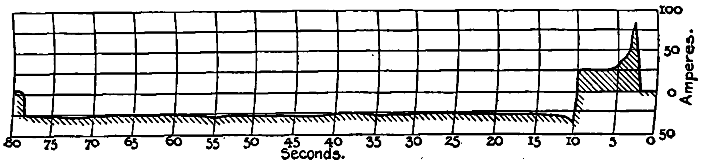

FIG. 18.

Lowering 5 tons.—Mean starting current, 31·9 amperes. Mean running current, 25 amperes. Mean during run, 25 8 amperes.

Although this controller will reduce the speed to 10 per cent. of full speed on full load and on the lighest load, it will not do so on intermediate loads, as will be seen from Fig. 21. To do so using series resistance only would require an altogether impracticable number of steps. A generally lower speed with any load from the lightest to full load without increasing the number of steps may be obtained by arranging resistances in parallel with the armature, in addition to those in series on the slow-speed steps.

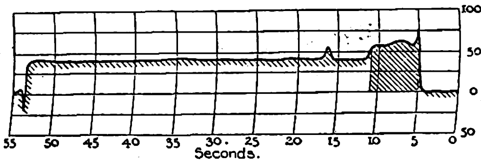

FIG. 19.

Lifting 10 tons.—Mean starting current. 58·6 amperes. Mean running current 42 5 amperes. Mean during run, 43·7 amperes.

By using a resistance of 0·1 ohm in parallel with the armature on the first steep, 0·075 ohm on the second step, and 0·065 ohm on the third step, we obtain the speeds, torques, and currents shown on Fig. 22, which it will be seen give slow speeds over a wide range of load. This digram shows the currents on the first three steps, while the currents on the remaining steps are as shown in Fig. 20. One advantage of using parallel resistances for the slow-speed steps is that the current through the armature when standing exceeds the running current by a greater amount than when series resist-

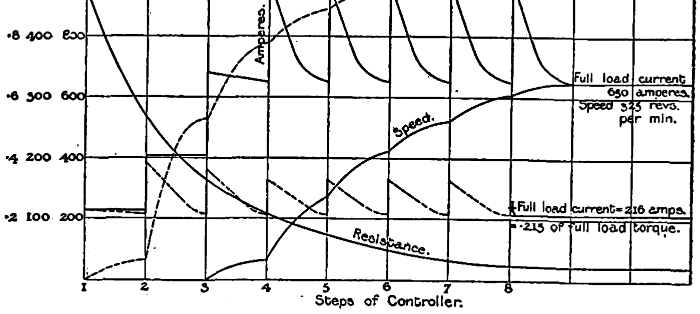

FIG. 20.

Full lines indicate controller diagram with full load Dotted lines indicate controller diagram with load requiring $\frac{1}{3}$ full current = approx. $\frac{1}{5}$ full torque ances are used, so that the machine can exert a greater starting torque on these steps.

The controller described is only suited for a series motor and positive driving, so that it is necessary to provide in the hoisting train an automatic mechanical brake which will prevent the load overhauling the motor. When it can conveniently be arranged, it is better to use a shunt motor and regenerative control for lowering as already described.

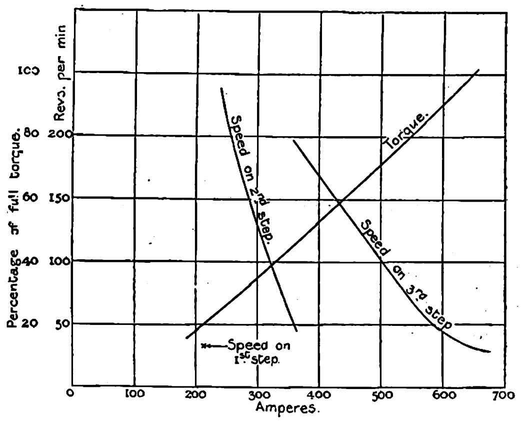

FIG. 21.

## APPENDIX.

The following formulæ, most of which are based on the curves, &c., in the foregoing Paper, are useful for the purpose of determining times and temperatures and the relation between the temperature attained when working intermittently with different power factors and that attained when working continuously.

*Value of T.*—When designing a machine in detail, formula No. 3 may conveniently be used. It will, however, be noted that as M and $w_1$ both vary in proportion to the watts lost in the coil, the value of T depends only on the space factor and dimensions of the coil, and is independent of the current passing through it. The value may then be found by the formula—

$$T = WCV/60S, \quad \ldots \ldots \ldots \quad (10)$$

in which V is the volume in cubic inches and S the surface in square inches, W being taken as before from curve No. 4. The formula of this curve being—

$$W = 23{\cdot}12 + 34{\cdot}88g, \quad \ldots \ldots \quad (11)$$

in which $g$ is the space factor, the formula for T becomes—

$$T = (23{\cdot}12 + 34{\cdot}58g)CV/60S. \quad \ldots \quad (12)$$

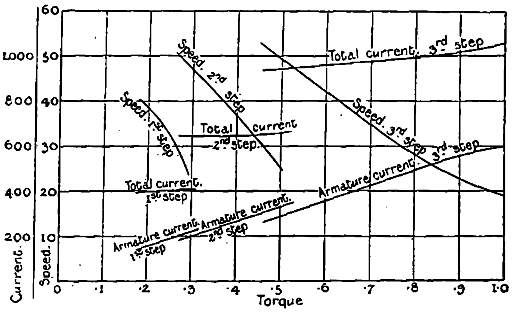

FIG. 22.

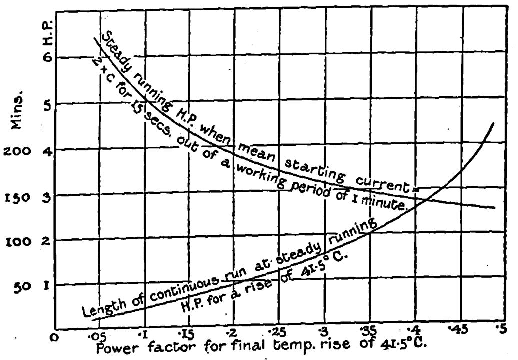

FIG. 23.

*Relation of Intermittent to Continuous Running.*—The formula for the heating curve being

$$C_t = M \times (1 - 2{\cdot}718^{-\frac{t}{T}}), \quad \ldots \ldots \quad (1)$$

for the cooling curve

$$C_t = M \times 2{\cdot}718^{-\frac{t}{TK'}}, \quad \ldots \ldots \ldots \quad (1a)$$

and for the ultimate rise of temperature when running continuously—

$$M = CW/S, \quad \ldots \ldots \ldots \quad (2)$$

we may by means of these formulæ ca'culate such curves as Fig. 11, in which is shown the relation between power factor and ultimate temperature rise of a machine working intermittently which, if worked continuously at the same load, would have a temperature rise of 41·5°C. in one hour.

The curve may alternatively be arranged as shown in Fig. 23. This has been worked out for machine A, for a case in which the mean starting current is twice the running current as shown on the small diagrams Fig. 24 A, B, &c., and shows the relation between power factor and horse-power which will give an ultimate temperature rise of 41·5°C., and also the length of continuous run which for each horse-power will produce the same rise of temperature. Thus, turning to the curve, for a power factor of 0·5, the machine may be worked at 3·4 H.P. for an ultimate rise of 41·5°C., and the temperature rise will be the same if the machine is worked continuously for one hour at this horse-power.

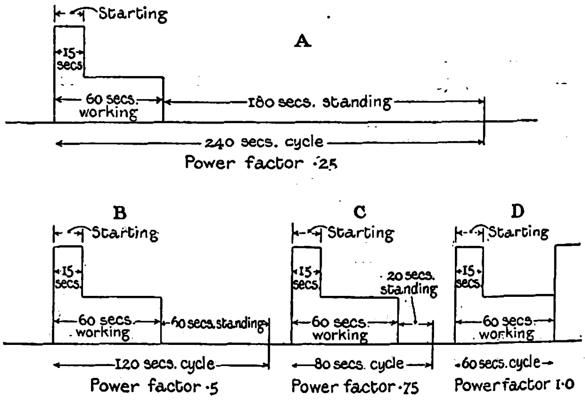

FIG. 24.

In addition to the formulæ already given, we require, in calculating curves such as Figs. 11, 12 and 23, to be able to determine the power factor and ultimate temperature rise when working intermittently.

The temperature rise will be steady, or rather, will regularly rise above and fall below a steady mean when—

$$\frac{dC_t}{dt}_{t'} = \frac{dC_t}{dt}_{t''} \quad \ldots \ldots \ldots \quad (13)$$

in which the differential coefficients represent the rate of heating when working and the rate of cooling when stopped. The differential coefficient of the heating curve, formula No. 1, being—

$$\frac{dC_t}{dt} = \frac{M}{T} 2{\cdot}718^{-\frac{t}{T}}. \quad \ldots \ldots \ldots \quad (14)$$

and the times of working and standing being, for a given power factor, inversely proportional to the differential coefficients, we may find the power factor for any given ultimate rise of temperature by the formula—

$$f = \frac{\frac{M}{TK'} 2{\cdot}718^{-\frac{t}{TK'}}}{\frac{M}{T} 2{\cdot}718^{-\frac{t}{T}} + \frac{M}{TK'} 2{\cdot}718^{-\frac{t}{TK'}}}. \quad \ldots \ldots \quad (15)$$

The calculation is simplified by the fact that while the rate of heating at the given temperature (say 41·5°C.) increases with the load on the machine, the rate of cooling at this temperature remains constant.

## CHARING CROSS, WEST END & CITY ELECTRICITY SUPPLY CO.'S ACCOUNTS.

We give below an analysis of the accounts of the above company for the year 1905, showing the costs per unit subdivided under various heads. The West End and City undertakings are dealt with separately in the published accounts of the company, but some explanation is needed to make clear how our figures are arrived at. In the case of both undertakings a portion of the electrical energy distributed was purchased "in bulk" from the other undertaking. The West End undertaking buys 3,396,337 units from the City undertaking, and the City undertaking in its turn is a purchaser from the West End branch to the extent of 854,674 units. Thus each undertaking sells more than it generates, and if we were to divide the several items of the works costs by the number of units sold in each case, the costs would come out lower than they actually are. It has been a simple matter to work out the costs of the combined undertakings, but our readers will wish to gain an idea also as to how the costs have come out at the works recently described by Mr. Patchell in his Paper before the Institution of Electrical Engineers. We have proceeded as follows: The generating costs are first given per unit *generated*, and this figure is, of course, exact. To estimate the equivalent figure per unit sold, we have split up the total units sold to consumers by the two undertakings in the proportion of the units generated at each station less the units used on the works, and this gives figures on a basis fairly comparable with the ordinary analyses of costs of other undertakings such as we publish from time to time.

The units generated, bought and sold are as follows:—

| City Undertaking. | | West End Undertaking. | |
|---|---|---|---|
| **Units generated** | **12,174,104** | **Units generated** | **10,633,778** |
| Units used on works | 2,934,393 | Units used on works | 3,660,034 |
| | 9,239,711 | | 6,973,744 |
| Total units sold | 9,757,600 | Total units sold | 9,976,598 |
| Units sold to West End | 3,396,337 | Units sold to City | 854,764 |
| Units sold to consumers | 6,361,263 | Units sold to consumers | 9,121,834 |

| | |
|---|---|
| Total units sold to consumers | 15,483,097 |
| say | 15,483,000 |
| Proportion obtained from City | 8,828,000 |
| Proportion obtained from West End | 6,655,000 |

### CITY UNDERTAKING.

Generating Costs.

| | Total. | Per unit *Generated* (inc. units used on works). | Per unit *Generated* (ex. units used on works). | Per unit sold to consumers. |
|---|---|---|---|---|
| Coal (including carriage) | £13,149 | 0·259d. | 0·341d. | 0·36d. |
| Oil, waste & station expenses | 591 | 0·012d. | 0·015d. | 0·02d. |
| Proportn. of engineers' salaries | 1,804 | 0·035d. | 0·047d. | 0·05d. |
| Wages | 6,442 | 0·127d. | 0·167d. | 0·17d. |
| Repairs and maintenance | 4,016 | 0·079d. | 0·104d. | 0·11d. |
| | £26,002 | 0·512d. | 0·674d. | 0·71d. |
| Distributing Costs. | | | | |
| Salaries, wages, repairs, maintenance, &c. | £6,261 | | | 0·17d. |
| **TOTAL WORKS COSTS** | **£32,263** | | | **0·88d.** |
| Management Charges. | | | | |
| Rents, rates and insurance | 7,905 | | | 0·21d. |
| Salaries, fees and establishment charges | 7,727 | | | 0·21d. |
| Law, Parliamentary and other charges | 995 | | | 0·03d. |
| | £16,627 | | | 0·45d. |
| **TOTAL COSTS (excluding capital charges)** | **£48,890** | | | **1·33d.** |

The following analysis of the capital account for the City undertaking is of interest:—

| Account. | Total Dec. 31, 1905. | £ per kw. | Per cent. of total. |
|---|---|---|---|
| Lands and buildings | £311,830 | 19·5 | 24·6 |
| Machinery | 333,938 | 20·8 | 26·8 |
| Accumulators and accessories | 36,458 | 2·3 | 2·9 |
| Mains | 541,302 | 33·8 | 42·9 |
| Meters, &c. | 21,841 | 1·4 | 1·7 |
| Instruments, tools and furniture | 5,016 | 0·3 | 0·4 |
| Provisional order and special act | 5,522 | 0·3 | 0·4 |
| Artesian wells | 3,327 | 0·2 | 0·3 |
| | £1,259,264 | £78·6 | 100·0 |

### WEST END UNDERTAKING.

Generating Costs.

| | Total. | Per unit *Generated* (inc. units used on works.) | Per unit *Generated* (ex. units used on works.) | Per unit sold to consumers. |
|---|---|---|---|---|
| Coal (including carriage) | £14,894 | 0·336d. | 1·514d. | 0·54d. |
| Oil, waste, &c., & station exes. | 719 | 0·016d. | 0·024d. | 0·03d. |
| Proporn. of enginrs', &c., salaries | 1,465 | 0·033d. | 0·050d. | 0·05d. |
| Wages | 6,933 | 0·157d. | 0·238d. | 0·25d. |
| Repairs and maintenance | 5,988 | 0·135d. | 0·206d. | 0·21d. |
| | £29,999 | 0·677d. | 1·032d. | 1·08d. |
| Distributing Costs. | | | | |
| Salaries, wages, repairs, maintenance, &c. | £9,339 | | | 0·34d. |
| **TOTAL WORKS COSTS** | **£39,338** | | | **1·42d.** |
| Management Charges. | | | | |
| Rents, rates and insurance | £7,350 | | | 0·27d. |
| Salaries, fees & establishment charges | 6,072 | | | 0·22d. |
| Law, Parliamentary & other charges | 636 | | | 0·02d. |
| | £14,058 | | | 0·51d. |
| **TOTAL COSTS (excluding capital charges)** | **£53,396** | | | **1·93d.** |

### COMBINED CITY AND WEST END UNDERTAKINGS.

Generating Costs.

| | Total. | Per unit sold to customers. |
|---|---|---|
| Coal (including carriage) | £23,043 | 0·43d. |
| Oil, waste, &c., and station expenses | 1,310 | 0·02d. |
| Proportion of engineers', &c., salaries | 3,269 | 0·05d. |
| Wages | 13,375 | 0·21d. |
| Repairs and maintenance | 10,004 | 0·16d. |
| Total generating costs | £56,001 | 0·87d. |
| Distributing Costs. | | |
| Salaries, wages, repairs, maintenance, &c. | 15,600 | 0·24d. |
| **TOTAL WORKS COSTS** | **£71,601** | **1·11d.** |
| Management Charges. | | |
| Rents, rates and insurance | 15,255 | 0·24d. |
| Salaries, fees and establishment charges | 13,799 | 0·21d. |
| Law, Parliamentary and other charges | 1,631 | 0·03d. |
| | £30,685 | 0·48d. |
| **TOTAL COSTS (excluding capital charges)** | **£102,286** | **1·59d.** |

Notes.—A sum of £11,000 was charged to revenue account for depreciation on the West End undertaking, but is not included in the above analysis.

The West End undertaking supplied 461,549 units for public lighting (179 lamps), but there are no public lamps on the mains of the City undertaking.

| | | |
|---|---|---|
| Maximum loads: | City undertaking | 8,977 kw. |
| | West End undertaking | 5,245 kw. |

An abstract of the directors' report appeared on p. 731 of our last issue, and we publish a report of the annual general meeting this week on a later page.

## LIVE-WIRE INDICATORS.

In view of the number of fatalities due to workmen touching live wires which were thought to be "dead," the French Minister of Commerce, Industry, Posts and Telegraphs made the suggestion to a number of societies and associations some time ago to arrange a competition for an apparatus which would enable a live conductor to be detected with certainty, safety and speed.

In response, the societies and associations appealed to charged "L'Association des Industriels de France contre les Accidents du travail" with the organisation of such a competition. This association then elected a special commission, this consisting of MM. E. Sartiaux, G. Cordier, G. Dumont, G. Forque, E. Fontaine, E. Genty, M. Leblanc, E. Simon, H. Mamy and G. Roux, to carry through the competition. Rules were drawn up by this commission, and an international competition was duly announced. Descriptions of detectors by 18 different competitors were received by the end of 1904, the date fixed for the preliminary competition. The apparatus of eight of these competitors being judged promising, the eight gentlemen in question were asked to submit actual designs for further inspection and investigation by June 1st, 1905. The outcome of this final examination was announced during the course of last year, and a report on the history, development and result of this international competition has been published by M. G. Roux, one of the members of the special commission. A sum of 6,000f. (£240), subscribed by a number of donors, was to be awarded as first prize, or else divided amongst the competitors according to merit. The commission's verdict was that none of the apparatus was entirely satisfactory. A first prize was therefore not awarded. A second prize of 3,500f. (£140), however, was given to M. Maurice Miet, and Mr. J. B. Taylor received the third prize, 1,000f. (£40), while Prof. W. Thornton, of Newcastle-on-Tyne, and the Minerallac Co., of Chicago, were each the recipients of an "honourable mention" and 500f. (£20) each.

Fig. 1 illustrates M. Miet's detector. It consists of a test tube of thin glass, through the indiarubber stopper B of which protrudes a brass rod C, terminating at one end in a copper knob, D, and at the other end in two strips, E, of aluminium foil. By bringing D near to a charged conductor (the apparatus being held in the hand by the glass tube), the aluminium strips will repel each other, and the angle formed between them is a rough measure of the line voltage. It is estimated that an apparatus of this kind will not cost more than 5d. In its report the commission says that such a detector is safe to handle, inasmuch as it need not be brought into contact with the conductor under test except for low voltages. When held about 1 in. away from a conductor charged at 2,500 volts, for instance, the aluminium strips spread out to their fullest extent. At a pressure of 10,000 volts, the spreading out of the aluminium strips was clearly noticeable at a distance of 4 in. An unmistakable deflection was also observed when the copper knob was brought into contact with a conductor at 100 volts potential. For pressures above 20,000 volts M. Miet proposes to use a block of hard wood in place of the copper knob. Successful tests were made with bare, insulated and armoured conductors, but the apparatus, of course, could not be used for armoured concentric cables.

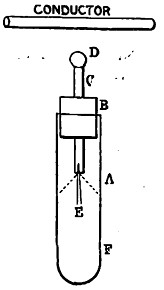

Fig. 1.—M. Miet's Device.

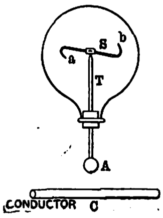

Fig. 2.—First Device by Mr. Taylor.

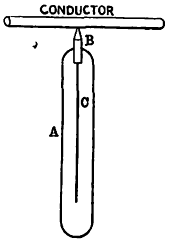

Fig. 3.—Second Device by Mr. Taylor.

Mr. Taylor submitted the two apparatus shown in Figs. 2 and 3. Fig. 2 is a H.T. detector, its essential part being a short and light wire bent into an S and well pivoted, so as to spin round when electricity is discharged from its needle points. This takes place when the metal knob A is brought into contact with a charged conductor. The moving system is enclosed in a glass globe about 3 in. in diameter. According to the commission's, report the S wheel only commences to move when the pressure has reached 7,000 volts, and its speed increases with the voltage. It has the drawback that it cannot be used for insulated conductors.

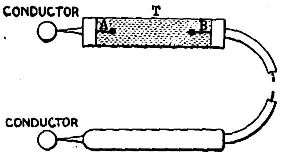

Fig. 4.—Dr. Thornton's Detector.

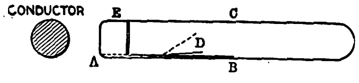

Fig. 5.—The Minerallac Company's Detector.

Fig. 2 indicates Mr. Taylor's detector for low voltages. It consists of a glass tube, A, about 3 in. long and ½ in. in diameter, and is filled with gasoline holding in suspension bisulphate of tin, powdered aluminium or bronze. After shaking the detector, the metallic point B is applied to the conductor under test. If the latter is charged, the finely divided metal in suspension will at once coagulate, but if not, the suspended matter will settle down very slowly. Referring to this apparatus, the commission states that the sensitiveness of this device depends on the fluidity of the liquid used and on the lightness of the powder employed. Alternating current is more easily detected than continuous current; in fact, a continuous current at less 200 volts pressure is said to be difficult to detect. This device will indicate a current at from 6,000 to 8,000 volts when brought within a few centimetres of the conductor under test.

Mr. Thornton's device (Fig. 4) consists of a glass tube, T, filled with petrol, in which are suspended carbonised threads of cloth. When the electrodes A and B are brought into metallic contact with the two conductors of an electric supply, a feeble current flows through the tube, the carbonised threads arrange themselves in form of a chain, and bright sparks jump between the carbonised particles. According to the Commission's report, the sparks are even visible in sunlight, and the employment of an insulating handle renders the manipulation safe. But the apparatus has the drawback that its ends have to be in metallic contact with the two conductors of the system.

The Minerallac Co., of Chicago, submitted an electroscope (Fig. 5). C is a glass tube, AB a copper strip, and D a strip of aluminium foil. When approached to a live conductor, the aluminium strip D stands up as indicated by the dotted line. It is stated in the commission's report that the device lacks sensitiveness, and that the protection to the operator appears insufficient, this being due to the smallness of the actual design submitted.

The other apparatus submitted made use of the electromagnetic transformer and other principles, but they were rejected on account of weight, complication, uncertainty of action in damp weather, difficulty of manipulation and so on.

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**Growth of Electricity Works in Germany.**—The *Elektrotechnische Zeitschrift* publishes in its issue of February 15th for the eleventh time tabular statistics relating to public electricity supply works in Germany. A new feature is the inclusion in the tables of a column containing the prices charged for current. According to the statistics before us there were 1,175 works in operation on April 1, 1905, the date to which the tables refer, while 540 works were under construction. In addition there were about 80 works of which no data could be obtained. Of the 540 works referred to above, about one-third have since been put into operation, so that altogether the number of German electricity works in operation at the present time does not fall far short of 1,500. A great variety of systems of charging for current are in vogue, the most in use being a flat rate with discounts. Fifty-three supply systems have a total plant capacity exceeding 2,000 kw. Those with more than 10,000 kw. are: Berlin (Berliner Elektricitäts-Werke, seven stations, of an aggregate plant capacity, excluding accumulators, of 81,040 kw.); Hamburg (Hamburger Elektricitäts-Werke, four stations, 19,950 kw.); Rheinfelden (12,700 kw.); Dresden (two stations, 11,330 kw.); and Frankfurt (two stations, 10,922 kw.). These 53 supply systems which are distributed over 40 towns, account for 330,203 kw. of plant, including accumulators. The total capacity of these 53 systems, excluding accumulators, is not given by our contemporary. The total plant capacity of the 1,175 German works in operation is 517,494 kw. without reckoning the battery plant and 625,870 kw. with the accumulators. On April 1st of 1903, 1904 and 1905, the number of electricity works in Germany were 939, 1,028 and 1,175, so that the increase has been progressive. The same remark applies to the number of incandescent lamps and motors connected to the supply systems, but the increase in the number of arc lamps during the year 1904-1905 was not as large as in the previous year. We learn that on April 1 of last year the number of incandescent lamps connected to the mains were equivalent to 6,301,718 50-watt lamps, the number of arc lamps were equivalent to 121,912 10-ampere (550 watts) arc lamps, while the total capacity of the motors aggregated 310,428 H.P. Of the 1,175 works, no less than 929 (231,596 kw.) are exclusively provided with continuous-current machinery and accumulators; 44 works (2,960 kw.) also supply continuous-current alone, but have no storage batteries; 75 works (87,666 kw.) supply three-phase current; 43 works (38,718 kw.) are provided with single-phase or two-phase plant; and 82 works (155,524 kw.) supply both continuous and alternating currents. The figures in brackets are exclusive of accumulators. The electricity works are distributed in 1,133 places. More than half the number of works (630) are steam-driven, 125 make use of water power, and 124 are equipped with gas engines. In 219 cases both steam and water-power is used.

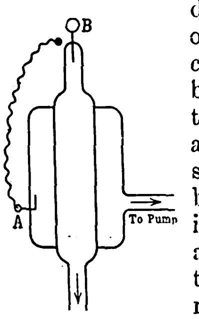
## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

*Depolariser for Standard Cells.*—G. A. Hulett, finding that "chemically pure" mercurous sulphate gave variations of over a millivolt, devised an electrolytic method for preparing the depolariser. Mercury to a depth of 2 cm. was placed in the bottom of a battery jar and over this was poured dilute sulphuric acid (1 to 6 by vol.) to a depth of 12 cm. The mercury was made the anode, and a platinum wire which dipped into the acid served as cathode. As soon as the solution became saturated with mercurous sulphate, the salt began to deposit in the form of small grayish crystals. It was found necessary to provide the apparatus with a motor-driven stirrer, so arranged that the L-part of the stirrer passed close to the surface of the mercury, and at a rate sufficient to prevent the solid sulphate from interfering with the anode reaction (about 150 revs. per min). The current density was 0·30 amperes per 100 cm.$^3$ of mercury surface. Later results show that with lower current densities a clear white product is formed, but when this is used as depolariser the cells have a higher and more variable E.M.F. Another important point developed by later work is that the acid used must be of greater than molecular concentration in order to avoid hydrolysis. Cells made with this depolariser require no "ageing."

[G. A. Hulett, *Physical Review*, January, 1906.]

*Non-Metallic Condenser.*—W. A. D. Rudge finds that an ordinary vacuum tube or incandescent lamp may be made into a condenser by coating it with tinfoil on the outside only, the exhausted air acting as the inner coating. And, further, the outside coating may be replaced by a second vacuum surrounding the first, thus obtaining a condenser without any metallic coatings. Such a condenser is shown in the diagram. Exhaustion need not be carried beyond 1 cm. of mercury. Charging may precede exhaustion without greatly altering it, and the air may be renewed between charge and discharge without greatly reducing the effect.



[W. A. D. Rudge, *Proceedings* of the Cambridge Philosophical Society January 31, 1906.]

*Conductivity of Flames.*—J. F. Davidson proves that the conductivity of flames is independent of the temperature of the electrodes. When the electrodes consist of tubes cooled by a current of cold water running through them no difference is produced in the conductivity of the flame in which they are immersed. Whatever slight difference is found in some electrodes is due to their containing alkaline salts. The material of the electrodes is also without influence. A porous carbon rod gives the same current as a metallic rod of the same dimensions. The author obtained very interesting results by coating platinum electrodes with various salts. He obtained currents about 100 times stronger than those obtained by Wehnelt, and found a very decided influence of salts of the alkalies, which Wehnelt failed to find. With an E.M.F. of 300 volts and a coating of potassium chloride on the cathode he got a current of $\frac{1}{40}$ ampere. With sodium salts he obtained $\frac{1}{60}$ ampere, and with calcium salts $\frac{1}{200}$ ampere. With the calcium coating, the current may be maintained at that value for half-an-hour together. The strong current does not set in until the cathode is incandescent, so that the salt is easily ionised. Platinum gives much stronger currents than any other electrode, most likely because it is capable of retaining and binding the salts firmly on its surface. If the anode is covered with the salt instead of the cathode, there is also an increase in the current, but the latter does not reach more than one-quarter of its former value. This property may be utilised for the rectification of alternating currents. Such a rectifier consists of a coil of a length of 4 cm. of platinum wire covered with CaO, and mounted in a flame just under an anode. Then on feeding it with 110 volts continuous current, a current of $\frac{1}{200}$ ampere is maintained for half an hour. An alternate current of the same voltage yields a steady current of about $\frac{1}{400}$ ampere. The author expects that these researches will throw light on the connection between gaseous and electrolytic ionisation.

[J. F. Davidson, *Physikalische Zeitschrift*, February 15, 1906.]

*Ionic Theory of Electric Discharge.*—K. von Wesendonck admits that the ionic theory of gaseous discharges unifies and clears up the observed phenomena in a manner not hitherto possible. For that very reason he considers it advisable to point out some directions in which the theory requires completing or revising. One of these concerns the lag observed in spark discharges. On the first application of the field the number of ions and the current through the gas is small, but, says Thomson, the number of ions and the current rapidly increases until finally a steady state is reached. As against this, the author mentions that discharges are often preceded by partial or preliminary discharges, which are observed as slight impulses in the galvanometer succeeded by short intervals of rest. Another matter which requires investigation is the valve action of points and knobs. The author believes that if the discharge is a pure spark, without point or glow discharge, the action of both electrodes is precisely similar, and the quantity is independent of the sign of the discharge. Especially when the distance between point and plate is very great, the polar difference in favour of the negative ions tends to disappear, or even to be converted into the opposite, as shown in the strong projection of positive ions by the Tesla discharge.

[K. von Wesendonck, *Physikalische Zeitschrift*, February 15, 1906.]

*Conductivity of Dielectrics under Radium Rays.*—A. Becker refers to Righi's observations of the increase of conductivity of liquid dielectrics under the influence of radium rays, and the extreme smallness of a similar effect in solid dielectrics. He maintains that the effect is very well marked in such solid dielectrics as paraffin and mica. The conduction current through them is approximately proportional to the difference of potential between the condenser plates, and does not seem to depend upon the sign of the charged electrode. The conductivity does not assume a steady value immediataly on the establishment of the radiation, nor does it at once return to zero on its cessation. This has also been observed by Righi in liquid dielectrics. The conductivity appears to be due to the absorption of the $\beta$-rays or electrons rather than the $\alpha$ or $\gamma$-rays. It is also due, not so much to the mere presence of the absorbed electrons, but to the ionisations produced by them in the dielectrics, since it can be shown that the absorbed electrons could not convey more than one-tenth of the current actually observed. The objection that the gases contained in pores of the paraffin may be ionised by the $\beta$-rays is met by cooling the paraffin in different ways, a process which, while changing the pores, does not change the observed conductivity.

[A. Becker, *Physikalische Zeitschrift*, February 15, 1906.]

*E.M.F.s in Wireless Receivers.*—When a receiving antenna is earthed and exposed to waves from a tuned sender, there is a stationary wave in the receiving antenna, exhibiting a node of current intensity at the summit and a ventral segment at the base. The potential, on the other hand, has a ventral segment at the summit and a node at the base. If $l$ is the length of the antenna, $r$ its radius, V the effective potential and $i$ the effective current as indicated by a bolometer or other thermal instrument, the equation holds

$$V = 2L\frac{2l}{r}i.$$

Tissot succeeded in measuring the effective E.M.F. at the summit by a direct idiostatic electrometer method. It was 4·6 volts, the stations being 1 km. apart, the receiving antenna 70 metres long and the spark length 5 cm. The theoretical value was 4·4 volts. The author also measured the effective voltage in a "jigger," or secondary coil influenced by the induction of the receiving antenna, and found it to be of the same order of magnitude as in the antenna itself—viz., from 4 to 5 volts—at a distance of 1 km.

[Tissot, Société Française de Physique, *Bulletin*, January 19, 1906.]

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## THE COMING PARLIAMENTARY SESSION.

With the opening of Parliament on Monday, a new order of political government has come into being, and this should be of peculiar interest to electrical engineers in view of the unsuccessful efforts which were made on behalf of the industry to secure certain necessary reforms at the hands of the late Administration. As a technical journal we are free from political bias. It is practically immaterial to the interests of the industry which we represent whether Ireland and the Transvaal should be granted a degree of Home Rule or that the Nonconformists are to succeed in their energetic endeavours to obtain an amendment of the existing law with regard to primary education. In fact, the only measures forecasted in the King's Speech last Monday which may materially affect the electrical engineering industry are those which will deal with the laws relating to Trades Disputes and Workmen's Compensation. These two matters are of importance to every industry, but there are matters relating to our own industry particularly to which the attention of the Government may be advantageously directed. The old definitions of Conservative and Liberal have undergone much modification in recent years, but it should still be a fair assumption to make that the fundamental idea upon which any Liberal programme is based is the energetic advancement of every civilising agency and application of science and industry that may conduce to the well-being of our country and its colonies; while the party defined as Conservative has always been taken, perhaps wrongly, to be one that is less active in promoting rapid changes in existing conditions. The electric industry is destined to be, if it is not already, the most important one in the world. The telegraph and telephone, electric light, electric traction and electric power distribution have already had far-reaching and beneficial effects on the general economic conditions of nations and on the life and comforts of the people. It behoves the Government, therefore, to do all in its power to assist this industry, and to remove those conditions which have hindered its proper progress in this country. Hence we have no hesitation in laying down a complete programme of electrical legislative reforms which are seriously needed. The necessity for these has been urged by us frequently in the past, but in such a cause no harm can be done by frequent reiteration. No importance need be attached to the order in which we place our suggestions, but we propose to deal first with the question of London traffic, a problem which should concern not only Londoners, but a large number of electrical manufacturers all over the country.

Everyone is now familiar with the history of the appointment of the Royal Commission on London Traffic in 1903, after an emphatic protest in Parliament against the methods adopted by the various tube railway promoters in order to secure the most profitable routes. This Commission did not complete its report until the end of 1905, having shelved all systematic efforts to improve locomotion in London for four sessions. We took up the position from the commencement, that this Commission was hardly required to devise further means of communication, for nearly all the routes necessary to serve the busy centre of London were then provided for, if we include not only the lines then existing and in course of construction, but also those proposed in the Bills then before Parliament, which were still capable of modification in any direction necessary to safeguard the public interest. Events have proved this to be the case, and the report of the Royal Commission on London Traffic also to a large extent bore out this contention. In fact it was very generally recognised that the only recommendation in the report at all likely to be acted upon immediately was the constitution of a Traffic Board, whose function should be the co-ordination of existing means of communication, and the examination, prior to their deposit in Parliament, of all schemes of locomotion, in order to expedite the granting of any powers which it might finally recommend. With this recommendation there was a ready sympathy, and general satisfaction was noted when the following reply was sent by the then President of the Board of Trade (Lord SALISBURY), early in November last to Sir HENRY OAKLEY, Chairman of the Central London Railway Co.:—

> I am authorised by Lord SALISBURY to inform you that His Majesty's Government have sanctioned the preparation of a Bill relating to London traffic and involving the establishment of a Traffic Board, as recommended by the Royal Commission. It is impossible to say what effect (if any) the introduction of the Bill will have upon the decisions of Parliamentary Committees appointed to deal with railway and other private Bills touching the traffic interests of London, but Lord SALISBURY thinks it is only fair that notice should be given of the intention of the Government to introduce such a Bill, in order that, in the light of this information, promoters might determine what course they think it right to adopt as to proceeding with their proposals during the coming session.

An unofficial report is current that it is not the intention of the new Government to give effect, this session, to the recommendations of the Royal Commission on London Traffic. Such a decision would mean one of two things: either that the enormous labour and expense involved in the deliberations of the Traffic Commission are to be absolutely wasted and that the old methods are to be reverted to, or that, after having suspended all traffic legislation in London for four sessions, the objectionable condition of things obtaining in 1902 is to be temporarily brought into use until such time as it is found advisable or possible to give full effect to the recommendation of the Royal Commission. We strongly urge that this is not a question for which there is justification for delay from any point of view. Acting on the information given in the letter from the Board of Trade, quoted above, the Central London Railway, which for two sessions deposited a Bill extending its present line so as to make it a "circle," did not promote its Bill this year, and it is conceivable that other and even more comprehensive schemes may have been similarly withheld. This is not a matter of party politics, and the intentions of the late Government may very well be adopted by its successors.

No greater argument is required for the need of a modification of the law relating to electricity supply than a glance at the number of Bills which have been deposited in Parliament this session seeking relief from certain onerous clauses in the Electric Lighting Acts, and an amplification of the powers contained in others, such as the right of undertakers to give mutual supply, the exemption of generating stations from liability for nuisance, and so on. Since the deputation to Mr. GERALD BALFOUR at the Board of Trade in June, 1902, organised by the Institution of Electrical Engineers, the whole of the electrical industry has been unanimous as to the necessity for a revision of the Electric Lighting Acts, and the earnestness of both company and municipal supply authorities was emphasised during the proceedings before the House of Lords Committee of 1904, presided over by Lord WOLVERTON, which considered the Supply of Electricity Bill brought in by the Government that session for the second time. On certain points, of course, conflict was bound to arise between the two sections, but the final result was a Bill which fairly met the claims of all parties. Hence there was keen disappointment, not to say irritation, when the Bill proceeded no further in 1904; and again in 1905, when it was reasonably expected to proceed almost as an uncontentious measure, it was abandoned for a third time. These matters are vital to the rapid progress of the electric supply industry, for it is, we believe, a quite anomalous position that there should be general Acts applying to an industry from which the members of that industry have perpetually to seek relief in special private Bills.

Similar remarks, also, are applicable to the tramway laws, the objectionable features of which have now become historical. The necessity of buying the consent of the local authority to the construction of a tramway and the terms of purchase at "scrap iron value" after 21 years' life, both of which are prescribed under the Tramways Act of 1870, would long ago have killed a less robust industry; and to this Act, which is still unamended, although it dates back to a time when electric traction was not even thought of, can be traced the comparative belatedness of the development of electric tramway traction in this country. Even nowadays, when the public mind is enlightened as to the necessity of tramway facilities, it is not uncommon to learn that tramways have had to be abandoned through the refusal of the road and local authorities to give their consent except upon terms which are found to be too onerous by the tramway promoter. Sir CLIFTON ROBINSON has twice abandoned Bills for constructing new lines from this cause, and other companies in the provinces have been forced to act in a like manner. In this respect the procedure under the Light Railways Act of 1896, originally not intended to apply to tramways at all, is a great improvement, and the perpetuation of this Act, on a broader basis, is much to be desired. At present the Act only remains in force for twelve months, but is renewed annually under the Expiring Laws Continuance Bill.

These matters formed the main programme placed before the Government by the Institution of Electrical Engineers in 1902. They are equally pressing to-day: even more so, owing to the technical advances which have been made by the industry since then. In 1902 Mr. SWINBURNE, President of the Institution, and leader of the deputation in question, characterised the electrical industry as working under parochial legislation, and in many respects this condition still exists. The progress of legislation has not been commensurate with the advances which have been made in electrical engineering, but it lies easily within the power of the new Government to remedy this state of affairs by removing the obstacles which have hindered the progress of that great industry in the land of its birth.

## REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign book.)

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**Radio-activity.** By Prof. E. Rutherford, F.R.S. 2nd Edition. (Cambridge: The University Press.) 12s. 6d.

The second edition of Prof. Rutherford's book has followed on the first so quickly that readers of our former review will scarcely need reminding of the important position the volume was at once given in the literature of radio-activity. The book was, in fact, a very complete and well-balanced survey of all the facts up till then accumulated. But perhaps its most striking feature was the success with which the mass of material handled, already great, was displayed as a fabric of understandable pattern. This success was due largely to the use, more or less tentative, of the atomic disintegration hypothesis, and indeed then constituted the best evidence of the value of the theory of atomic change. During the past 18 months, however, the trustworthiness of this theory has been so overwhelmingly emphasised by its powers of interpretation and of prophecy that Prof. Rutherford, in this second edition, has unreservedly made the disintegration theory the guiding principle of his book. Thus we find in this volume considerable, and advantageous, rearrangement and reconstruction. More important than these changes in the architecture are the additions to and extensions of the edifice. Determined to keep his treatise the reigning authority, Prof. Rutherford has made a splendid effort to bring his work up to date. And so perfectly has this chronicling of the world's researches been accomplished that it seems impossible to detect any omission of importance. The added matter deals mainly with the origin of the radio-active elements, with the experimental facts of their successive changes, and with the radio-activity found associated with ordinary matter. The discussion of the origin of the radio-active substances tends, the layman will be glad to hear, towards reducing the number of independent substances. Thus, the actinium of Debierne and the emanium of Giesel are shown to be manifestations of one and the same kind of radio-active matter; the primary constituent of radio-lead and the active part of radio-tellurium are both shown to be slow transformation products of radium. Radium itself is given uranium as its putative parent, and thorium, the author suggests, is not itself radio-active, but owes its activity to an undiscovered, unnamed companion element. But while thus reducing the number of known radio-active elements to three, the seer of radio-activity predicts the discovery of new active elements—of greater atomic weight, probably, than uranium; and our author's anticipations have in the past proved so shrewd that we may place some confidence in this forecast.

The most important part of the treatise is, however, that devoted to the theory and facts of the successive changes of the known radio-active substances. Here are laid out, more perspicuously and connectedly than was possible in the original papers, the methods by which the long chain of descendants of radium have been brought link by link to our knowledge. The reasoning processes involved may be described in two words as exponential analysis—being somewhat analogous to the harmonic analysis of periodic curves. This process is now, of course, very well known, but here it is set forth with unprecedented lucidity and fullness.

Enough has been said to indicate the scope and strength of this comprehensive and compact volume; more than enough, we must admit, when we consider that everyone interested in radio-activity is bound to read the book for himself.

**Alternating Currents, their Theory, Generation and Transformation.** By Alfred Hay, D.Sc. (London and New York: Harper & Bros.) 6s.

Although there is no lack of books on alternating currents, the one under review has various distinctive features to recommend it. It is thoroughly up-to-date, and includes improved methods of testing, new and promising designs of alternating-current instruments and machinery, novel methods of investigating alternating-current phenomena, &c., culled from the latest technical literature of all countries. It also contains a more complete theory of measuring instruments and of power measurements in alternating-current circuits, balanced and unbalanced, than is found in most books of like character. More than the usual space has been devoted to the description and investigation of methods of testing. The subject is treated both mathematically and graphically, but the mathematics are not beyond the reader who possesses an elementary knowledge of the calculus. After a concise treatise on alternating-current phenomena in general, the author discusses alternating-current instruments of all kinds, and then deals successively with the theory, construction, testing and pre-determination of alternators, transformers, auto-transformers and choking coils, induction motors, synchronous motors, phase transformers, rotary converters and single-phase commutator motors, including "mixed-action" motors. The chapter on single-phase commutator motors is rather brief, however, and the important question of commutation is only touched upon. By writing concisely and omitting all historical and purely academic matter, the author has been able to compress the vast amount of matter dealt with in a book of less than 300 pages. Altogether, the book can be confidently recommended to engineers who, although already well up in alternating-current work, may desire to enlarge and secure or to fix their ideas as to the theory of alternating-current phenomena and machinery. Advanced students will also undoubtedly find the book of much value.

**Practical Dynamo and Motor Construction.** By Alfred W. Marshall. (London: P. Marshall & Co.) 1s.

Those who delight in making small dynamos for purposes of experiment or instruction will find Mr. Marshall's little book very useful, for it contains a large amount of sound advice as how to make and not to make the various parts of small machines, such as field and armature coils, pole pieces, armatures, brush gear, bearings, terminals, and so forth. It is written in clear language, and the text is illustrated by some 130 serviceable drawings. Beginners will also appreciate the author's critical remarks regarding the pros and cons of the various kinds of varnishes, brushes, &c., and the information as to where to obtain materials is also useful. It must be understood that the book under review does not deal with the calculation of dynamos, but only with the practical side of construction. Figs. 85 and 89, showing sections through small commutators of ordinary design, call for slight comment. As shown, the corners of the segments where they are held by the insulating cones, are cut off far too much, and are not rounded off either. In tightening up a commutator of such a design, the insulation would, undoubtedly, suffer. In describing former-wound field coils, the author refers to the occasional difficulty of slipping the finished coil from the cylindrical former. This can, and is, obviated by making the former in halves, the division being in a plane oblique to the cylinder axis.

**The Seven Follies of Science.** By John Phin. (London: Archibald Constable & Co.) 5s.

This is a book for the leisure hour, and contains a popular narrative of some of the famous impossibilities which have been attempted by those who have taken the name of science in vain, as well as a number of arithmetical puzzles, optical delusions and similar entertaining matter. The seven follies with which the author deals in the larger part of the book are "The Squaring of the Circle," "The Duplication of the Cube," "The Trisection of the Angle," "Perpetual Motion," "Alchemy," "The Fixation of Mercury" and "The Elixir of Life." A book of this kind does not call for serious criticism, and it would even be too much to expect that the author's explanations of why the perpetual motion absurdities cannot work should in every case be as ingenious as the absurdities themselves.

**Traité de Physique.** By O. D. Chwolson. Vol. I. (three parts).—"Introduction, Mécanique, Méthodes et Instruments de mesure." Translated by E. Davaux. 16fr. Vol. II., First Part.—"Emission et absorption de l'Energie rayonnante, Vitesse de propagation, Réflexion et Réfraction." Translated by E. Davaux. 6fr. (Paris: A. Hermann.)

**Lehrbuch der Physik.** By O. D. Chwolson. Vol. I.—"Einleitung, Mechanik, einige Messinstrumente and Messmethoden, die Lehre von den Gasen, Flüssigkeiten and festen Körpern." Translated by H. Pflaum. 20m. Vol. II.—"Die Lehre vom Schall and die Lehre von der Strahlenden Energie." Translated by H. Pflaum. 14m. Vol. III.—"Die Lehre von der Wärme." Translated by E. Berg. 16m. (Braunschweig: F. Vieweg & Söhne.)

Prof. O. D. Chwolson's book appeared originally in Russian in 1897, and received at once widespread recognition, as witnessed by the two bulky translations now before us.

For many years Ganot's famous treatise on Physics has been recommended by teachers to students as being the standard work of its kind, but if ever a person should be found who is sufficiently courageous to translate Chwolson's book into English, then the popularity of Ganot may conceivably decline

The present part of the first volume of the French translation is divided into three parts: Part I. consists of a general introduction to physical science, and enunciates the theory of ether, the law of conservation of matter and several other laws and mathematical propositions. Part II. is devoted to mechanics, and really forms an admirable little text-book in itself. In writing this section of his book the author was careful to bear in mind the fact that the study of simple and complex vibratory movements plays an exceedingly important part in the study of physics, and he has, therefore, dealt very fully with this somewhat difficult subject.

Methods of making physical measurements and the theory and use of instruments for this purpose form the subject matter of Part III. The inclusion of less advanced work in this division is desirable; but, on the other hand, there is little, if any, of the existing matter which could safely be left out, and the book is already of very large dimensions.

The second volume consists, so far, of one part dealing with heat, light and electric waves. Nearly all this volume is taken up by optical matter, and less than two pages are devoted to the means of detecting Hertzian waves; the only apparatus described in this section is the broken ring resonator and the most primitive form of coherer. It should be observed, since Vol. I. is composed of parts 1 to 3 and Vol. II. of part 8, that there are still four parts to come in between.

The French edition has been revised and augmented in various directions compared with the Russian original and the German translation, and is followed by "Notes sur la Physique théorique," by MM. C. and F. Cosserat.

The German edition is somewhat differently arranged. Vol. I. includes the same subject matter as the first three parts of Vol. I. of the French translation, with the addition of a treatise on gases, liquids and rigid bodies. Vol. II. is devoted to acoustics and radiating energy, while Vol. III. treats of thermo-dynamics.

A feature of the work is the truly astounding number of references to the international, scientific and technical literature.

**Lexikon der Elektrizität und Elektrotechnik.** Edited by Fritz Hoppe. In 20 parts. (Vienna: A. Hartleben.) Part I. 60h.

Part I. of this new electro-technical dictionary contains descriptions, definitions and miscellaneous data concerning electric and general engineering subjects, both scientific and practical, coming under the first letter of the alphabet from Aal to Anzünder. The present part has not quite 50 pages and, since the available space is further reduced by the illustrations (some of which are unnecessarily big, by the way), it is clear that the average space devoted to a subject is very limited. For this reason the subjects could be treated only very briefly. Under "Abkühlungs-oberfläche" (cooling surface) we read that Herr Feldmann recommends a cooling surface of from 30 to 40 square cm. in a transformer per watt lost, while Herr Dobrowolsky is said to be content with from 18 to 20 square cm. These figures, which do not even overlap, are of little use, for there is no definition of the surface which assists in cooling, nor is it stated to what temperature rise the figures quoted refer. Similar criticisms may be urged against other paragraphs. For the general public the subject matter is too technical, while for the electrician it is not sufficiently so.

## SELF-INDUCTION EFFECTS IN STEEL RAILS.

BY ERNEST WILSON.

The two bull-headed railway rails experimented upon were supplied to me by Mr. H. J. Lane, of the Phœnix Engine Works, London, E., and are each 60 ft. long and weigh 70 lb. per yard. They were rolled in 1894 and have a specific resistance of $21{\cdot}5 \times 10^{-6}$ ohms per cubic centimetre at about 9°C. The object of this Paper is to discover (1) how the ohmic resistance of the rails is varied when alternate-currents of different magnitudes traverse them at different frequencies; (2) how much the P.D. (impedance volts) between the ends of a given length of rail is increased over the direct current value under the action of alternate currents of different magnitudes and frequencies, when the return circuit consists of a copper conductor suspended parallel with the rails at different distances from them; (3) how, when two rails are used in parallel, the P.D. between their ends varies for a given height of the suspended conductor as the distance between the rails is varied; (4) the self-induction of circuits consisting of a rail or rails and a parallel overhead conductor.

The method employed for finding the self-induction coefficients has been described* and consists in the use of a Kelvin Quadrant Electrometer whose "case" is connected to a point midway along the circuit and whose "quadrants" are connected respectively to the terminals of the circuit. The P.D. between the "needle" and "case" was supplied by the secondary circuit of an air transformer whose primary was placed in the circuit between the alternate-current generator and the circuit whose self-induction it was required to find. A Paul reflecting electrostatic voltmeter was used to measure the impressed volts and a Kelvin balance was used to measure the current in the circuit. The alternate currents were generated by two distinct types of machines giving totally different wave-forms. All the tests at 50 and 100 frequency were made with a Siemens W 12 alternator, whose wave-form is represented very closely by the series

$$216 \sin \frac{2\pi t}{T} + 0{\cdot}76 \frac{6\pi t}{T} + 12{\cdot}6 \frac{10\pi t}{T} - 2{\cdot}6 \frac{14\pi t}{T} + 0{\cdot}52 \frac{18\pi t}{T}.$$

Most of the tests at about 25 frequency were made with a Siemens alternator of the revolving-field type, the wave-form of which has prominent high harmonics, due to the teeth between which the armature coils are bedded. In all cases, however, the reactance voltage has been assumed equal to $2\pi f L x$ where $f$ is the frequency, L the coefficient of self-induction and $x$ the current.

The first experiments were made to find the increase in the ohmic resistance of the rail due to the passage of alternate currents The rails were placed on the ground with their webs horizontal and a distance between their running faces of ½ in. and 12½ in. respectively. They were bonded together at one end by stout copper bonds, and the other ends were connected to the source of the alternate currents as already described. The results of the tests are given in Table I. It will be seen that for a given frequency the ratio of the ohmic resistance to alternate and direct currents is greater the higher the current. That the proximity of the rails to one another has not greatly disturbed the resistance is shown by a comparison of the results obtained at 100 frequency where the rails are at the two distances apart.

The next experiments were made (1) with one rail and a return overhead copper conductor; (2) with the two rails in parallel 18 in. and 4 ft. 8½ in. apart respectively, using the same overhead conductor as a return. The rails were placed on the ground in the position they would occupy in practice, that is, with their webs vertical, and the overhead conductor consisted of stranded copper 0·33 in. diameter. In working out the figures with a view to finding the actual P.D. between the ends of the rail portion of the circuit when it had the copper conductor opposed to it at various heights, it is necessary to find (*a*) the ohmic resistance opposed to the alernate current at the particular frequency; (*b*) the self-induced E.M.F. The ohmic

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* See *The Electrician*, January 5, 1906. I may here mention that this method has been employed to eliminate resistance drop in circuits containing E.M.F.'s other than or in addition to those of self-induction.

## Table I.

| R.M.S. amperes, $x$. | Direct current, $Rx$ volts. | Two parallel rails ½ in. apart.—Temperature about 10°C. | | | | | | | | | Two parallel rails 12½ in. apart.—Temp. about 10°C. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Frequency 100. | | | Frequency 50. | | | Frequency 27. | | | Frequency 100. | | | Freq. 50. | Freq. 27. | Freq. 12. |
| | | L in $10^{-6}$ henries. | Impedance volts. | Resist. ratio alt. to D.C. | L in $10^{-6}$ henries. | Impedance volts. | Resist. ratio alt. to D.C. | L in $10^{-}$ henries. | Impedance volts. | Resist. ratio alt. to D.C. | L in $10^{-6}$ henries. | Impedance volts. | Resist. ratio alt. to D.C. | L in $10^{-6}$ henries. | L in $10^{-6}$ henries. | L in $10^{-6}$ henries. |
| 50 | 0·089 | 19·5 | 0·85 | 6·67 | 25 | 0·46 | 2·68 | 31 | 0·28 | 1·91 | 25·0 | 1·1 | 8·69 | 33·5 | 41·5 | 50 |
| 100 | 0·18 | 21·0 | 1·88 | 7·45 | 27 | 1·14 | 4·24 | 36 | 0·75 | 2·99 | 29·5 | 2·3 | 7·6 | 36·0 | 44·5 | 57 |
| 150 | 0·269 | 22·5 | 3·05 | 8·17 | 29 | 1·9 | 4·89 | 41 | 1·4 | 4·01 | 31·5 | 3·7 | 8·22 | 39·0 | 46·0 | 64 |
| 200 | 0 36 | 24·0 | 4·65 | 9·83 | 31 | 3·0 | 6·33 | 46 | 2·2 | 4·86 | 33·5 | 5·7 | 10·67 | 42 0 | 48·0 | 71 |

## Table II.

| R.M.S. amperes, $x$. | Direct-current $Rx$ volts. | | Frequency 100. | | | | | | | Frequency 50. | | | | | | | Frequency 27. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L for whole circuit experimented upon in $10^{-6}$ henries. | Rail portion per mile. | | | | | Impedance volts for whole circuit experimented upon. | L for whole circuit experimented upon in $10^{-6}$ henries. | Rail portion per mile. | | | | | Impedance volts for whole circuit experimented upon. | L for whole circuit experimented upon in $10^{-6}$ henries. | Rail portion per mile. | | | | | Impedance volts for whole circuit experimented upon. | |
| | For whole circuit experimented upon. | Per mile of rail portion. | | L′ in $10^{-6}$ henries per 60 ft. | Reactance volts. | Resistance volts. | Impedance volts. | Ratio of alternate to direct-current volts. | | | L′ in $10^{-6}$ henries per 60 ft. | Reactance volts. | Resistance volts. | Impedance volts. | Ratio of alternate to direct-current volts. | | | L′ in $10^{-6}$ henries per 60 ft. | Reactance volts. | Resistance volts. | Impedance volts. | Ratio of alternate to direct-current volts. | | |
| 50 | 0·66 | 3·92 | 55·1 | 17·2 | 47·5 | 26·1 | 54·1 | 13·8 | 2·1 | 56·0 | 18·1 | 25·0 | 10·6 | 27·1 | 6·92 | 1·15 | 66·0 | 28·1 | 21·0 | 0·149 | 22·2 | 5·68 | 0·9 | * |
| 100 | 1·32 | 7·84 | 57·6 | 19·7 | 108·0 | 58·4 | 123·0 | 15·7 | 4·0 | 59·0 | 21·1 | 58·3 | 29·8 | 65·5 | 8·35 | 2·55 | 71·0 | 33·1 | 49·4 | 0·227 | 54·4 | 6·94 | 2·05 | |
| 150 | 1·98 | 12·5 | 60·1 | 22·2 | 184·0 | 96·0 | 208·0 | 16 6 | 6·1 | 62·0 | 24·1 | 100·0 | 58·8 | 116·0 | 9·26 | 3·9 | 74·0 | 36·1 | 80·8 | 0·298 | 92·5 | 7·39 | 3·1 | |
| 200 | 2·64 | 15·7 | 63·0 | 25·1 | 277·0 | 154·0 | 318·0 | 20·4 | 8·1 | 65·0 | 27·1 | 150·0 | 94·0 | 177·0 | 11·3 | 5·2 | 78·0 | 40·1 | 119·8 | 0·376 | 141·0 | 9·0 | 3·9 | |
| | | | | | | | Av. | 16·6 | | | | | | Av. | 8·7 | | | | | | Av. | 7·2 | | |
| 50 | 0·57 | 3·92 | 46·0 | 16·9 | 46·6 | 26·1 | 53·4 | 13 6 | 1·75 | 50·0 | 20·9 | 28·9 | 10·6 | 30·8 | 7·85 | 1·05 | 59·0 | 29·9 | 22·3 | 0·149 | 23·5 | 6·0 | 0·75 | † |
| 100 | 1·14 | 7·84 | 48·0 | 18·9 | 104·0 | 58·4 | 119·4 | 14·2 | 3·5 | 52·0 | 22·9 | 63·3 | 29·8 | 70·0 | 8·93 | 2·3 | 61·0 | 31·9 | 47·6 | 0·227 | 52·7 | 6·73 | 1·9 | |
| 150 | 1·71 | 12·5 | 50·0 | 20·9 | 173·0 | 96·0 | 198·0 | 15·8 | 5·4 | 53·0 | 23·9 | 99·1 | 58·8 | 115·0 | 9·18 | 3·4 | 63·0 | 33·9 | 75·9 | 0·298 | 88·1 | 7·05 | 2·85 | |
| 200 | 2·28 | 15·7 | 52·0 | 22·2 | 245·0 | 154·0 | 290·0 | 18·5 | 6·8 | 55·0 | 25·9 | 143·0 | 94·0 | 171·0 | 10 9 | 4·7 | 65 0 | 35 9 | 107·0 | 0·376 | 131·0 | 8·35 | 3·75 | |
| | | | | | | | Av. | 15·5 | | | | | | Av. | 9·2 | | | | | | Av. | 7·0 | | |
| 50 | .. | 3·92 | .. | .. | .. | .. | .. | .. | .. | 33·0 | 15·8 | 21·8 | 10·6 | 24·2 | 6·18 | .. | 41·0 | 23·8 | 17·75 | 0·149 | 19·2 | 4 9 | .. | ‡ |
| 100 | .. | 7·84 | .. | .. | .. | .. | .. | .. | .. | 33·5 | 16·3 | 45·1 | 29·8 | 54·0 | 6·89 | .. | 44·0 | 26·8 | 40 0 | 0·227 | 46·0 | 5·88 | .. | |
| 150 | .. | 12·5 | .. | .. | .. | .. | .. | .. | .. | 36·0 | 18·8 | 78·0 | 58·8 | 97·7 | 7·80 | .. | 47·0 | 29 8 | 66·7 | 0·298 | 80·4 | 6·41 | .. | |
| 200 | .. | 15·7 | .. | .. | .. | .. | .. | .. | .. | 37·0 | 19·8 | 109·0 | 94 0 | 144·0 | 9·18 | .. | 50·0 | 32·8 | 97·8 | 0·376 | 123·0 | 7·84 | .. | |
| | | | | | | | | | | | | | | Av. | 7·5 | | | | | | Av. | 6·26 | | |
| 50 | 0·61 | 1·96 | 50·0 | 12·1 | 33·4 | 12·7 | 35·6 | 18·2 | 1·75 | 50·0 | 12·1 | 16 7 | 4·5 | 17·3 | 8·82 | 1·04 | 57 0 | 19·1 | 14·2 | 0·0549 | 14·4 | 7·37 | 0·65 | § |
| 100 | 1·23 | 3·92 | 50·3 | 12·4 | 68·5 | 26·2 | 73·4 | 18·7 | 3·4 | 50 3 | 12·4 | 34·2 | 11·0 | 35·9 | 9·16 | 2·1 | 57·5 | 19·6 | 29·2 | 0·0745 | 30·1 | 7·68 | 1·75 | |
| 150 | 1·84 | 6·26 | 51·0 | 13·1 | 108·4 | 41·7 | 116·2 | 18·6 | 5·1 | 51·0 | 13·1 | 54·2 | 19·3 | 57·5 | 9·18 | 3·15 | 59·0 | 21·1 | 47·2 | 0·0941 | 49·4 | 7·88 | 2·5 | |
| 200 | 2·46 | 7·84 | 51·5 | 13·6 | 149·8 | 59·6 | 161·2 | 20·6 | 6·8 | 51·5 | 13·6 | 74·9 | 29·8 | 80·6 | 10.3 | 4·25 | 60·0 | 22·1 | 65·9 | 0·114 | 69·7 | 8·9 | 2·9 | |
| | | | | | | | Av. | 19·0 | | | | | | Av. | 9·36 | | | | | | Av. | 7·96 | | |
| 50 | 0·55 | 1·96 | 37·0 | 7·9 | 21·8 | 12·7 | 25·2 | 12·8 | 1·45 | 37·0 | 7·9 | 10·9 | 4·5 | 11·8 | 6·01 | 0·75 | 45·0 | 15·9 | 11·9 | 0·0549 | 12·2 | 6·23 | 0·55 | ‖ |
| 100 | 1·09 | 3·92 | 39·0 | 9·9 | 54·6 | 26·2 | 60·5 | 15·4 | 2·75 | 39·0 | 9·9 | 27·3 | 11·0 | 29·4 | 7·51 | 1·8 | 47·0 | 17·9 | 26·7 | 0·0745 | 27·7 | 7·07 | 1·5 | |
| 150 | 1·64 | 6·26 | 40·0 | 10·2 | 84·6 | 41·7 | 94·3 | 15·1 | 4·3 | 40·0 | 10·2 | 42·3 | 19·3 | 46·5 | 7·43 | 2·7 | 49·0 | 19·9 | 44·5 | 0·0941 | 46·7 | 7·45 | 2·15 | |
| 200 | 2·18 | 7·84 | 42·0 | 12·2 | 137·0 | 59·6 | 148·0 | 18·9 | 5·9 | 42·0 | 12·2 | 68·5 | 29·8 | 74·7 | 9·53 | 3·6 | 51·0 | 21·9 | 65·3 | 0·114 | 69·1 | 8·82 | 2·6 | |
| | | | | | | | Av. | 15·5 | | | | | | Av. | 7 62 | | | | | | Av. | 7·4 | | |

REMARKS.—* One rail and conductor 12 ft. overhead. † One rail and conductor 6 ft. overhead. ‡ One rail and conductor 1 ft. overhead. § Two rails 1 ft. 6 in. or 4 ft. 8½ in. apart, and conductor 12 ft. overhead. ‖ Two rails 1 ft. 6 in. or 4 ft. 8½ in. apart, and conductor 6 ft. overhead.

resistance previously found (Table I.) was taken, and from it the P.D. between the ends of a mile length of the rail portion of the circuit was calculated. In order to find the reactance volts per mile of the rail portion of the circuit, the coefficient of self-induction L was first corrected for the vertical portions of the copper conductor at each end which completed the rectangular circuit. The self-induction due to two parallel copper conductors of the size used, and at a distance apart equal to the distance between the rails and the overhead conductor in the particular experiment was halved and the value so found was subtracted from the self-induction L corrected as above described. This newly found self-induction L′ was then used in the formula $2\pi f L' x$ to find the reactance volts due to the rail portion alone. The impedance volts due to the rail portion alone were then calculated by compounding the resistance and reactance volts in the vector sense. Figs. 1, 2 and 3 show the impedance volts per mile plotted in terms of the r.m.s. amperes at the three frequencies 100, 50 and 27 respectively. The volts due to direct currents of corresponding values are shown for comparison. The ratio of the total drop in the rail portion due to alternate and direct current is a function of the currents, as one would expect, having regard to the magnetisation curve of the iron. This is emphasised by the fact that under the same conditions as to frequency current and height of overhead conductor, a one-rail circuit has larger self-induction than a double-rail circuit. In order that the value of this ratio may be obtained for other heights than those employed in the tests, the average value for each set has been taken and plotted against height. A mean curve has been drawn, and the results are given in Table III. The same ratio for frequencies varying from 15 to 100 are given in Table IV.

These experiments show how important is the part played by the rail, so far as self-induction is concerned. A longitudinal current traversing a medium of such permeability as this iron possesses increases the self-induction enormously at the frequencies used in the experiments. To show this more forcibly, the overhead conductor was dropped and placed on the rail. The circuit thus formed of one rail and the conductor had a self-induction of $29 \times 10^{-6}$ henries at frequency 50 when 150 amperes traversed the rail, and $36 \times 10^{-6}$ henries at frequency 23 with the same current value. Comparing these with the self-induction obtained when the overhead conductor was 12 ft. above the rail at corresponding frequencies and current, we see that the 12 ft. air space only about doubles the self-induction of the circuit. And yet there is evidence to show that the frequencies dealt with are enormous as compared

**Table III.**

| Height of copper conductor above ground. | Ratio of volts due to alternate and direct currents in rail portion of circuit. | | | | | |
|---|---|---|---|---|---|---|
| | Frequency 27. | | Frequency 50. | | Frequency 100. | |
| | 1 rail. | 2 rails. | 1 rail. | 2 rails. | 1 rail. | 2 rails. |
| 6 | 6·8 | 7·3 | 8·3 | 8·3 | 15·6 | 16·6 |
| 12 | 7·2 | 7·8 | 9·2 | 9·2 | 16·5 | 18·0 |
| 18 | 7·8 | 8·4 | 10·0 | 10·0 | 17·7 | 19·2 |
| 24 | 8·2 | 9·0 | 10·5 | 10·6 | 18·6 | 20·5 |

**Table IV.**

| Frequency. | Ratio of volts due to alternate and direct currents in rail portion of circuit. | | | | | |
|---|---|---|---|---|---|---|
| | 12 ft. | | 18 ft. | | 24 ft. | |
| | 1 rail. | 2 rails. | 1 rail. | 2 rails. | 1 rail. | 2 rails. |
| 15 | 6·2 | 6·8 | 6·7 | 7·4 | 7·0 | 7·8 |
| 25 | 7·0 | 7·7 | 7·5 | 8·2 | 8·0 | 8·8 |
| 35 | 8·0 | 8·6 | 8·4 | 9·2 | 9·0 | 9·7 |
| 50 | 9·2 | 9·8 | 10·0 | 10·6 | 10·5 | 11·5 |
| 75 | 12·6 | 13·6 | 13·0 | 14·0 | 13·8 | 15·0 |
| 100 | 16·5 | 18·0 | 17·7 | 19·2 | 18·6 | 20·5 |

with the frequencies which would be required to produce an approximately uniform distribution of current over the section of the rail. That is to say, at the frequencies dealt with the outer layers of the rail are carrying most of the current. The greater penetration at the lower frequencies is shown by the increased self-induction.

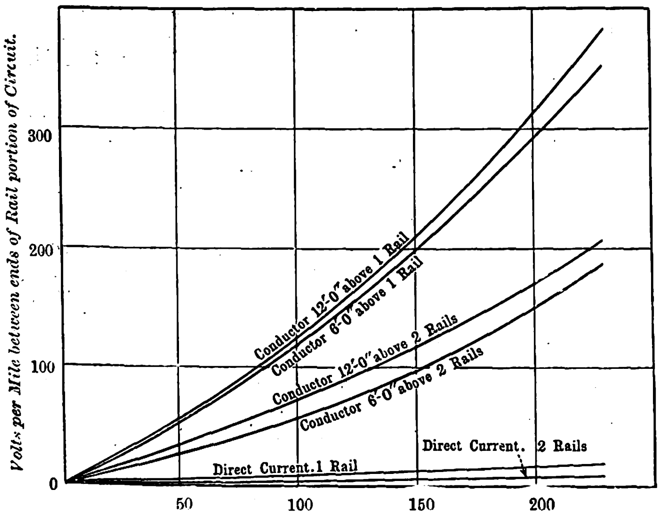

Fig. 1.—Frequency 100.

Table II. gives the results for the cases when the overhead conductor was opposed (1) to one rail at three heights; (2) to two rails in parallel when 18 in. apart at two heights. The rails were separated to a distance of 4 ft. 8½ in., and gave the coefficients so closely in agreement with those obtained when the rails were 18 in. apart that the figures, if given, would only add unnecessary matter.

Table II. gives in addition the impedence volts for the whole circuit, and the resistance to direct currents. The influence of the copper is to bring down the ratio of the resistances to alternate and direct currents to a figure more nearly unity.

In the calculations no allowance has been made for the joints which would be met with in a length of rail in practice. For well bonded rails this correction is now well known. Applying it to the tests it might, perhaps, be added as a term practically the same for alternate as for direct currents, although any throttling at the joints might give rise to considerable eddy current effects.

It would be valuable if the results herein given could be applied to rails having other similar cross-sections, magnetic properties and specific resistances. With regard to other sections it is difficult, in the absence of further experimental data, to say what is the relation between the frequencies for a given total current in order that similar electric and magnetic distributions may be produced. If the frequencies vary inversely as the square of the linear dimensions, or as the weights per yard, the results of the experiments could at once be applied to other sections. With regard to specific resistance, varied by employing a different material at a given temperature, or the same material at different temperatures, one may say that the lower its value the greater will be the ratio, and the greater the phase displacement between currents at the centre and near the surface of the rail for the same frequency. This will vary the self-induction and effective resistance. The specific resistances commonly met with in present-day rails is lower than in the rails experimented upon.

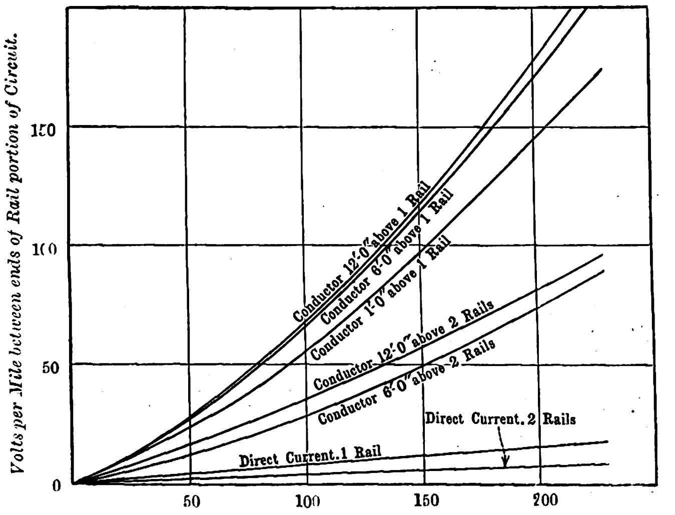

Fig. 2.—Frequency 50.

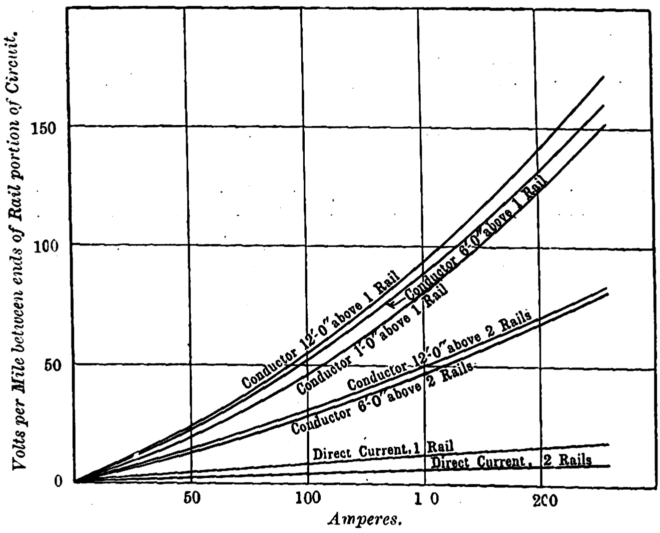

Fig. 3.—Frequency 27.

These experiments were carried out in the Siemens Electrical Engineering Laboratory, King's College, London. I wish to thank those gentlemen who have assisted me. They are Messrs. A. D. Keigwin, T. Mitchell and A. E. O'Dell.

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**Inauguration of the Frankfurt–Vienna Telephone Service.**—The *Elektrotechnische Zeitschrift* announces that the telephone service between Frankfurt and Vienna has been inaugurated. Between Frankfurt and Munich and Munich and Salzburg the telephone wire has a diameter of 4 mm. (0·158 in.), but between Salzburg and Vienna the wire is only 3 mm. (0·118 in.) thick, self-induction coils being employed on this last section. A description of the method of "loading" this line was published in *The Electrician*, Vol. LV., p. 668.

## PHASEMETERS AND THEIR CALIBRATION.

BY W. E. SUMPNER, D.Sc.

Phasemeters are instruments closely allied with voltmeters and wattmeters of the dynamometer type. The chief difference arises from the number of circuits used with the instrument. Dynamometers only have coils for two circuits, one for the fixed and the other for the moving system. Phasemeters have at least three such circuits, and may have as many as six, some of the coils forming the fixed system and the rest constituting the moving system. The only other difference is due to the fact that no spring or other form of control is used with phasemeters.

So far as the theory of these instruments is concerned, it does not matter how many coils there are in the two systems, or how these coils are arranged, provided that all the coils of the moving system are relatively fixed and move as one body. Of course, the arrangements of the coils, their winding, and their mode of connection with the circuit all affect the calibration of the scale. For the sake of clearness, we shall at first assume that there are three coils in the fixed system suitable for current working, and that the moving system consists of a single coil containing several turns of fine wire put in series with a non-inductive resistance, and applied to one of the voltages of the main circuit.

Now, if currents are flowing in all the coils the moving coil will be acted upon by three moments or deflecting forces, one due to each fixed coil. Let us consider each of these separately. Let the current through the fixed coil be $A_1$, and that through the moving coil V. Just as in the case of an ordinary zero dynamometer the torque acting on the moving coil will be proportional to the product $A_1V$ for any given relative position of the fixed and moving coils. If the moving coil is allowed to alter its position, as indicated by the deflection of the instrument, the torque will be $A_1VF_1$ where $F_1$ is a quantity which will vary with the deflection, but which for any deflection will be constant, whatever $A_1$ or V. We have not yet said whether the currents are steady or alternating. The statement above will be true in either case at any given instant, and if the currents vary the only modification necessary is that the average value of the changing torque will be the product of $F_1$ into the average value of the product $A_1V$. We shall denote such an average by placing a bar over the symbols representing the factors of the product, so that the mean torque will be $F_1\overline{A_1V}$.

If the currents in the three fixed coils are respectively $A_1$, $A_2$ an $A_3$, the resultant torque acting on the moving coil will be

$$F_1\overline{A_1V}+F_2\overline{A_2V}+F_3\overline{A_3V}, \quad . \; . \; . \; . \; . \quad (1)$$

where $F_1$, $F_2$ and $F_3$ are each constants for a given deflection of the moving coil, but are dependent upon this deflection.

If this resultant torque is not zero the coil will turn, since there is no controlling spring to cause it to remain in any particular position. But as the coil turns the values of the quantities F will alter, and it is not difficult to see that there will be one position of stable equilibrium to which the coil will move, and at which the resultant torque will be zero, so that for a particular deflection $\theta$ we shall have

$$F_1\overline{A_1V}+F_2\overline{A_2V}+F_3\overline{A_3V}=0. \quad . \; . \; . \; . \; . \quad (2)$$

Now, suppose that, instead of using *alternating* currents in the coils, we pass *steady* currents $D_1$, $D_2$, $D_3$ through the fixed coils, and a constant current, *d*, through the moving coil. Suppose we adjust the currents D until each is proportional to the value of the corresponding product $\overline{AV}$, as indicated in (3), where $\lambda$ is some constant.

$$\left.\begin{aligned} D_1&=\lambda\overline{A_1V} \\ D_2&=\lambda\overline{A_2V} \\ D_3&=\lambda\overline{A_3V} \end{aligned}\right\} \quad . \; . \; . \; . \; . \; . \; . \quad (3)$$

The torque acting on the moving coil when the deflection is $\theta$ will be $(F_1D_1+F_2D_2+F_3D_3)d$, and since the quantities F will be the same as the corresponding ones in (2), it follows from (3) and (2) that the torque on the moving coil will be zero at the deflection $\theta$, and thus $\theta$ will be the deflection in the direct-current test.

Now, the fact to be remarked about the relationships denoted in (3) is that they are *quite independent of the structure of the instrument.* The ratio between the steady currents causing a deflection $\theta$ is merely determined by the relationship of the alternating currents and voltages causing the same deflection $\theta$. The calibration of the scale—that is to say, the value of $\theta$ corresponding with a particular state of the alternating-current circuits—will, of course, depend on the quantities F and the structure of the instrument; but the steady currents causing a given deflection will be related to the alternating currents causing the same deflection in a way quite independent of the instrument. It is thus possible to calibrate the scale by a purely direct-current method.

If the instrument is to measure some property of the alternating circuit current, say a phase angle $\phi$, or some function, like the power factor $\cos\phi$, of this phase angle, all we have to do is to determine the ratios of $\overline{A_1V}$, $\overline{A_2V}$, $\overline{A_3V}$ for a particular value of $\phi$, to use direct current D through the fixed coils in proportion to these ratios, and to observe the corresponding deflection $\theta$. We shall then know that the deflection $\theta$ corresponds with the phase angle $\phi$ when the instrument is connected with the alternating-current circuit in the manner intended.

There are a vast number of different ways in which a four-coil instrument may be put in connection with a multiphase set of mains, and there will be a calibration curve for the instrument corresponding with each mode of joining up. It is thus necessary that the mode of calibration shall exactly correspond with the mode of connection with the circuit, and this leads us to a relationship between the quantities D which must be maintained in carrying out the direct-current test.

Suppose the three fixed coils of the instrument be represented diagrammatically by $C_1$, $C_2$, $C_3$ in Fig. 1, the three-phase mains being denoted by the numbers 1, 2 and 3. These coils, which we suppose are suitable for current working, will probably be placed in series with the corresponding mains. For high-tension working they will form part of the secondary circuits of suitable current transformers, but we need not now complicate matters by assuming this to be the case. The coil $C_1$ will thus be placed in series with the first main, but it may be joined up in two ways and only one of these will be correct. Let us assume that the left-hand end of $C_1$ is joined to the left-hand end of the break in the first main, and similarly for coils $C_2$ and $C_3$. Suppose the alternating currents in the mains are $A_1$, $A_2$, $A_3$, and that these currents are considered positive when flowing from left to right along the mains. There is thus in each coil a definite direction of flow which has to be considered positive. Also, whatever the alternating currents may be, and whatever their frequency or wave form, the following equation must be true at every instant:—

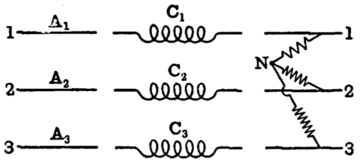

FIG. 1.

$$A_1+A_2+A_3=0. \quad . \; . \; . \; . \; . \; . \; . \; . \quad (4)$$

Whatever V may be, we thus have at every moment

$$VA_1+VA_2+VA_3=0.$$

If we take averages we must also have

$$\overline{VA_1}+\overline{VA_2}+\overline{VA_3}=0.$$

This equation, in conjunction with (3), shows that we must always have in the direct-current test

$$D_1+D_2+D_3=0. \quad . \; . \; . \; . \; . \; . \quad (5)$$

This condition is easy to secure in the test, and really simplifies the method, since it is only necessary to measure two currents instead of three. All that is required is to join all three coils together at one point by star-connecting corresponding ends, say the left-hand ends, of the coils $C_1$, $C_2$, $C_3$ as in Fig. 2, and to arrange a circuit with one of the coils, say $C_1$, in series with a battery, B, the circuit being completed through two paths in parallel, each of these consisting of one of the remaining coils, an adjustable resistance, R, and an ammeter, D. The moving coil of the instrument is independently supplied with a steady current of any value suitable for the winding. The arrangement shown in Fig. 2 may only suffice to calibrate the instrument through a portion of the scale. For other parts of the scale all that is needed is to interchange coils $C_1$ and $C_2$, or coils $C_1$ and $C_3$, but, of course, care must be taken that the current readings are credited to the proper coils.

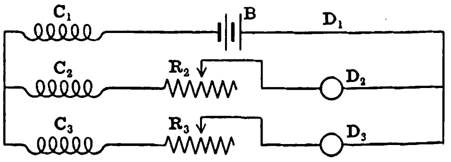

FIG. 2.

We thus get an instrument deflection, $\theta$, for two observed values of $D_2$ and $D_3$, the currents in the coils $C_2$ and $C_3$ respectively. It remains to show what is the corresponding value of $\phi$ or $\cos\phi$ for alternate current working.

Now this will depend upon the manner of connecting the moving coil with the alternating-current circuit. Referring to Fig. 1. Suppose the moving coil is put in series with a non-inductive resistance, and that the two ends of this combination are joined to the main (1) and to the neutral point N of the system, obtained, say, by star connecting three equal non-inductive resistances, the other ends of which are joined respectively to the three mains. Of course, the moving-coil circuit may form one of these resistances. When the load is non-inductive the moving-coil current will then be in phase with the current $A_1$, through the coil $C_1$, if the instrument is joined up as indicated in Fig. 1. If we assume the load has a power-factor cos $\phi$, and that the load currents are all equal, so that the load is balanced, the vector diagram will be as represented in Fig. 3, in which the current triangle is equilateral, the length of each side being, say, A, and the voltage vector will make an angle $\phi$ with the vector $A_1$, representing the current in the first main. In this case the equivalent direct currents determined by (3) will be proportional to the projections of the corresponding sides of the current triangle on the line representing V. These will be respectively $-A\cos\phi$; $+A\cos(60-\phi)$; and $+A\cos(60+\phi)$. Hence the currents $D_2$ and $D_3$ used in coils $C_2$ and $C_3$ in the direct-current test will be such that $D_2/D_3 = \cos(60-\phi)/\cos(60+\phi)$

or

$$\tan\phi = \frac{1}{\sqrt{3}}\,\frac{D_2-D_3}{D_2+D_3}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (6)$$

and the observed deflection $\theta$ of the instrument in the direct-current test corresponds with $\phi$ or cos $\phi$ as deduced from this formula.

It will be observed that this method is closely analogous with that used in finding the power factor of a balanced three-phase load by means of two wattmeters, and that the formula is the same in each case.

It will also be seen that the above proof makes no assumption as to which system of coils in the phasemeter is fixed. It still applies if the coils $C_1$, $C_2$, $C_3$ form the moving system, instead of the single coil. Moreover, the three-coil system might be wound for pressure circuits, the single coil taking the current. We may even suppose one of the coils in the three-coil system removed without affecting the reasoning. Thus if the coil $C_1$ were omitted, as in most actual phasemeters, the restriction corresponding with (5) has no meaning. There are only two coils to be traversed by currents in the direct-current test, and these currents may have any relative values. Formula (6) still applies.

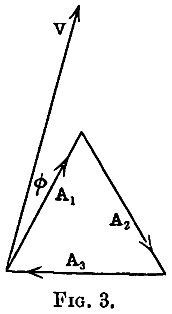

Fig. 3.

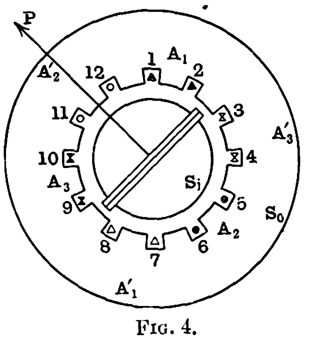

Fig. 4.

The case of a phasemeter for two-phase circuits can be similarly treated. The alteration required in Fig. 3 is to omit the vector $A_3$ and to draw the vector $A_2$ perpendicular to $A_1$. The equivalent currents in the corresponding direct-current test will be

$$D_1 = A\cos\phi, \text{ and } D_2 = A\sin\phi,$$

so that the formula for the power factor will be simply

$$\tan\phi = \frac{D_2}{D_1}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (7)$$

where $D_1$ and $D_2$ are the steady currents through the two coil system producing the observed deflection $\theta$.

The foregoing theory has been fully tested by the writer not only in connection with instruments having air-magnetic circuits, but also in reference to several new instruments each provided with iron-cored magnetic circuits. The structure of one of these is sufficiently indicated in Fig. 4. The iron parts are built up of thin circular stampings arranged in two fixed cylindrical coaxial blocks, $S_0$ and $S_i$. The outer ones $S_0$ are provided with 12 slots on their inner periphery arranged symmetrically at angular intervals of 30 deg. In each pair of diametrically opposite slots a coil of eight turns is wound, and adjoining coils are series connected in pairs to form the three fixed coils $A_1$, $A_2$, $A_3$. When positive currents are sent through the coils the currents flow downwards through the slots 1, 2, 5, 6, 9 and 10, and upwards through the remaining slots. This is indicated in the figure by the use of full signs and corresponding outline signs. The moving coil is rectangular in shape, and turns with its sides in the circular air-gap about the common axis of the system. To this moving coil a pointer, P, is attached, which reads on a fixed scale of degrees. For any given values of the currents in the fixed coils, the space distribution of induction density in the gap tends to vary rapidly at the slots and to be nearly uniform in the space between one slot and the next. To overcome this effect, which was foreseen, successive stampings had been slightly sheared circumferentially, so that the line of centres for any slot, instead of being quite parallel to the axis, was slightly spiral in reference to it. The stepped nature of the curve connecting $\theta$ and $\phi$ shows that the effect in question was only partially neutralised. But this tends to make the correspondence of the direct-current and alternating-current tests the more convincing. It will be noted that the angular period of the steps in the curve is 30 deg., the same as the angular interval between successive slots.

The results are set forth in Fig. 5. The direct-current tests were 33 in number, and are indicated on the curve by delta signs. About 40 tests were taken with alternating currents, half of them with a non-inductive resistance in series with the moving coil, and the rest with a condenser substituted for this resistance. These tests are separately marked on the curve with rings and crosses. The observations are not all plotted, as several of the points were too close to be distinguishable, but a fair selection is given.

A few typical observations with direct currents are given in Table I. and will be sufficient to show the conditions of the test. The currents $D_2$, $D_3$ are in amperes, $\theta$ is the observed deflexion of the pointer in degrees, and $\phi$ is calculated from formula (6).

**Table I.**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $D_2$ ...... | +2·2 | +1·1 | +0 42 | - 0·5 | - 2·8 | - 5·2 | - 6·2 | -8·9 | - 9·3 | -9·5 |
| $D_3$ ...... | 2·7 | 7·0 | 7·2 | 7·45 | 7·6 | 10·9 | 7·2 | 8·2 | 4·3 | 0·5 |
| $\theta$ ...... | 30·0 | 40·0 | 50·0 | 60·5 | 70·0 | 80·0 | 100·0 | 119·7 | 139·0 | 161 |
| $\phi$ ...... | 176·4 | 157·3 | 153·0 | 146·7 | 128·9 | 121·7 | 97·4 | 85·9 | 57·3 | 32·6 |

The value of $\phi$ so calculated corresponds in the alternating tests with the phase difference between the alternating current $A_1$ through the first fixed coil and the moving coil current. For both the direct and alternating-current tests, the deflection $\theta$ of the instrument could be read to, and appeared reliable to, one-tenth of a degree. The value of $\phi$ was determined with almost equal accuracy for the direct-current tests, the conditions for which were simple and could easily be kept constant, while the value of $\phi$ depended merely on the ratio of the readings of two excellent instruments of the permanent magnet type. But $\phi$ could not be determined with such accuracy in the alternating-current tests for several reasons. The testing conditions with running machinery involved cannot easily be kept very constant; alternating-current instruments are not so reliable as those for direct currents; while $\phi$ has to be determined from the readings of three instruments instead of from those of two. The alternator used was provided with six terminals arranged for the supply of two-phase and three-phase current. The three-phase terminals were connected to the positive ends of the fixed coils through ammeters and banks of lamps, the negative ends being connected together to form the neutral point. The currents were adjusted to approximate equality, but only one good hot-wire ammeter of the range required was available, and this was put in the $A_1$ circuit. At first the wattmeter method of testing $\phi$ was used, a Mather-Duddell instrument being utilized, with its current-coil placed in the $A_1$ circuit. The pressure circuit of this instrument was put in parallel with the moving-coil circuit of the phasemeter, and with a Weston dynamometer voltmeter. The current circuits were not altered during the tests. The six terminals of the alternator, together with the neutral point, formed seven points, any two of which could be selected for application to the pressure circuits. In

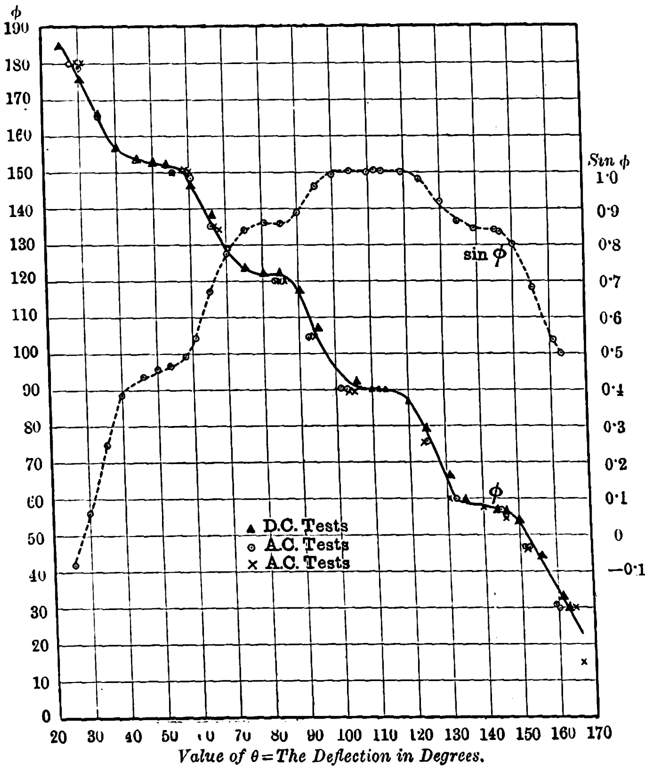

Fig. 5.

this way many different values of $\phi$ could be obtained, and a new set of tests could be made with a condenser substituted for the non-inductive resistance in series with the moving coil of the phasemeter. Of course, when interpreting the results in the latter case, the value of $\phi$ as deduced from the wattmeter readings had to be changed by 90 deg. to get the corresponding phase-difference between the moving coil current and the current $A_1$. The wattmeter tests were made on the instrument shown in Fig. 4, but not with the particular arrangement of coils there indicated; and the results found were in close agreement with the curve between $\theta$ and $\phi$ as determined by the direct-current method. The wattmeter method proved laborious when a large number of tests were needed; and it was found sufficiently accurate, and much quicker and simpler, to assume that the six terminals of the alternator gave voltages in the precise phase relation indicated by the geometrical properties of Fig. 6, in which the points $A_1$, $A_2$, $A_3$ are 120 deg. apart and correspond with the current circuits, while the points $A_1$P and QR are the extremities of two perpendicular diameters. The centre of the circle N denotes the neutral point. The current vectors are $NA_1$, $NA_2$, $NA_3$. The vector $NA_1$ represents zero phase, while the angle between $NA_1$ and the vector joining the two points selected for the voltage applied to the moving coil circuit is $\phi_1$ the phase of this voltage. When a non-inductive resistance was used with the moving coil, $\phi_1$ was the same as $\phi$ the phase of the moving coil current; but when a condenser was used it was found that $\phi_1$ had to be diminished by 90 deg., or increased by 270 deg., in order to get $\phi$ the value to plot with $\theta$. A few of the observations taken are given in Table II. Particulars are given in the column V of the voltage points chosen for the pressure circuits. $\phi_1$ was not a measured quantity, but one calculated on certain assumptions from Fig. 6. Any error in these assumptions may serve to explain the slight divergence of some of the points obtained with the alternating-current tests from the curve deduced from the direct-current measurements, but the general agreement observed between the two sets of tests can only be made closer by putting any such error right.

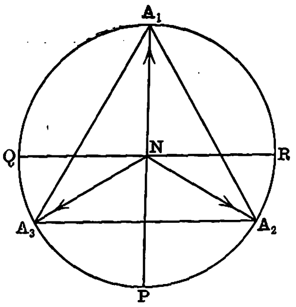

FIG. 6.

**Table II.**

| With resistance. | | | With condenser. | | | |
|---|---|---|---|---|---|---|
| V. | $\phi_1=\phi$. | $\theta$. | V. | $\phi_1$. | $\phi$. | $\theta$. |
| $A_1A_3$ | 150 | 60 | $A_3A_2$ | − 90 | 180 | 27 |
| RP | 135 | 67 | $NA_2$ | −120 | 150 | 55·5 |
| $NA_3$ | 120 | 87 | $A_1A_2$ | −150 | 120 | 84·2 |
| $RA_3$ | 105 | 94·5 | $RA_2$ | 165 | 75 | 125 |
| $A_2Q$ | 75 | 124 | $A_2P$ | 120 | 30 | 158·7 |

Another complete set of tests was made on this instrument with one of the coils, $A_2$, reversed, so as to make the instrument unsymmetrical. The end of the coil $A_2$, formerly considered positive, was thus made negative. The direct-current test yielded a curve between $\theta$ and $\phi$ of a most extraordinary character, yet a number of tests made by the alternating-current wattmeter method yielded points which plotted perfectly on the curve so found.

Several other iron-cored instruments have been made, and the scales obtained by the direct-current method have been found by testing to be accurate on alternate-current loads. One of these instruments yielded a perfectly smooth curve between $\theta$ and $\phi$, the sharp bends due to the slots as exhibited in Fig. 5 being eliminated by suitably distributing the winding. The shape of the $\theta\phi$ curve can also be controlled by suitably designing the magnetic circuits and by concentrating or distributing certain of the windings so as to secure a set of scale markings appropriate and convenient for use.

We have throughout assumed that the load currents are balanced. The theory of these instruments on unbalanced loads is intricate. The writer has fully investigated this matter in a Paper entitled "The Theory of Phasemeters," printed in the *Philosophical Magazine* for January, 1906. It is there shown that the accuracy of these instruments is not affected by variations of frequency or wave-form or by the introduction of iron into the magnetic circuits. The error of a phasemeter on unbalanced loads may become serious, but the error is not really the fault of the instrument, since it is a precise function of the want of balance of the load. It is determined by the ratios of the currents in the three mains and not by the structure of the instrument itself. A number of phasemeters of different makes, if of the same type, and all connected to the mains in precisely the same manner, will, if properly calibrated, all read the same whatever the nature of the load; but the common reading is not necessarily correct.

# THE MEASUREMENT OF HIGH FREQUENCY CURRENTS AND ELECTRIC WAVES.*

BY PROF. J. A. FLEMING, M.A., D.SC., F.R.S.

(*Concluded from page 671.*)

## LECTURE IV.—STATIONARY ELECTRIC WAVES ON WIRES.

In acoustics we are not only familiar with progressive waves travelling through space, but also with so-called stationary waves in pipes or on strings.

Consider, in the first place, a very long wire immersed in an insulator; it has a certain capacity and inductance per unit of length, and also a certain wire resistance and dielectric conductance per unit of length. If at any point of this wire we apply an alternating E.M.F., then at any instant any section or element of the wire will have a different electric potential in its two ends, and less current flowing out of it than flows into it. The drop in potential is due to resistance and inductance ot the wire, and the drop in current down the element is due to its capacity and the conductance of the dielectric. We can easily write down certain mathematical equations which express this fact symbolically. These equations also tell us that the voltage of the current does not instantly appear at all parts of the wire, but that if an alternating E.M.F. is applied at one place, the potential and current are propagated along the wire, with a velocity measured by $1/\sqrt{CL}$, where C and L denote the capacity and inductance per unit of length of the wire. Also the amplitude of the current and potential is weakened as we pass along the wire, in a ratio depending ou R and K, the resistance of the wire and the conductance of the dielectric per unit of length of the wire.

In the next place suppose that the cable is finite in length, the result then is that the wave of potential or current is reflected at the open end, and by interference with the direct wave produces standing waves of potential, just as when a rope fixed at one end is appropriately jerked at the other. In order that these standing waves may be produced, it is necessary, however, that the length of the finite wire shall bear a certain relation to the wave length of the potential wave on the wire. The distance from one loop to the next loop, or one node to the next node, is called half a wave length, and the relation between the wave velocity, wave length and frequency is given by the well-known formula, *wave velocity = wave length × frequency*. Hence, since the wave velocity along the cable is $1/\sqrt{CL}$, if $\lambda$ denotes the wave length and $n$ denotes the frequency, we must have the following relation: $1/\sqrt{CL}=n\lambda$.

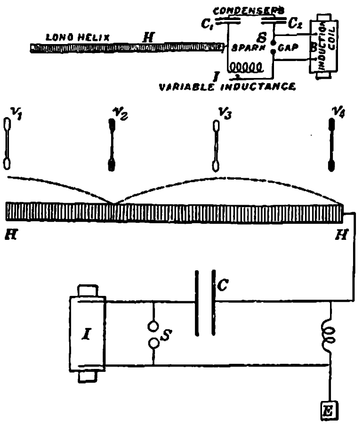

FIG. 26.—STATIONARY WAVES OF ELECTRIC POTENTIAL ESTABLISHED ON A HELIX BY DIRECT COUPLING.

Suppose, then, that we apply to the end of the cable or wire a high frequency E.M.F. with a frequency, $n$, we can do this by connecting the end of the wire to a condenser circuit having a capacity, $C^1$, an inductance, $L^1$, so that the frequency $n$ is defined by the equation—$n=1/2\pi\sqrt{C^1L^1}$, then it follows that the wave length on the wire of which the capacity per unit of length is denoted by C, and the inductance per unit of length by L, is given by the equation $\lambda=2\pi\sqrt{C^1L^1}/\sqrt{CL}$. Suppose then that the wire is cut of such a length $l$, that $l$ bears the following relation to $\lambda$: $l=\lambda/4=3\lambda/4=5\lambda/4$, &c., we shall have stationary waves produced on the wire.

It is very difficult to show this experiment with a straight wire, because, for any frequency which we can command, we need a wire of such an enormous length, since the potential and current travel along the straight wire with the speed of light, but if we wind a fine, silk-covered copper wire in one layer of closely adjacent turns on an ebonite or glass tube, we can make a helix or conductor which has large inductance per unit of length, and hence, comparatively speaking, a small velocity of propagation. It is quite easy to make such a helix as that I now exhibit to you, on which the velocity is only 150th part of the velocity of light. It is for this helix in question $173 \times 10^6$ cm., or about 1,200 miles per second. The helix before you has the total length of 210 cm. and 5,470 turns of wire. The capacity of this helix per unit of length is $C = 45 \times 10^6 \div 210$ mfd., and the inductance per unit of length, $L = 32 \times 10^6 \div 210$ cm. This helix is supported on insulating stands, and one end of it is connected with an oscillatory circuit consisting of a condenser and variable inductance as shown in the diagram, Fig. 26. By properly adjusting this last-named capacity and inductance, we can create a wave of such length on the helix that the length of the helix is about one-quarter of the wave-length, and we shall then find that we have a stationary wave produced upon the helix which has a node of potential at the generating end, and a loop or maximum of potential at the far end.

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* Cantor lectures delivered at the Society of Arts, Nov. and Dec., 1905. Slightly abstracted.

This variation of potential is best shown by means of a neon vacuum tube which is held near the helix and moved about in the space around. It shows us the distribution of potential by the variation in its glow. We can then vary the frequency of the oscillations in the condenser circuit so as to make the corresponding wave-length on the helix respectively equal to $4\,l/3$, $4\,l/5$, $4\,l/7$, &c., and under these circumstances we find that there are nodes and loops of potential created upon the helix. When the neon tube is held near a node it does not glow, but when it is held near a loop of potential it glows brightly and we can create on the helix stationary electric waves having one loop of potential, two loops, three loops, &c.

The relation between the capacity and the condenser circuit, the inductance of the condenser circuit, and the observed wave-length in centimetres on this helix is given in the following Table :—

**Table V.**—*Observations made with a Helix-Wire wound on an Ebonite Core, and with an Ebonite Condenser, Variable Inductance and Neon Vacuum Tube to determine the Wave-velocity along the Helix.*

| Oscillation. | Capacity in mfds. in condenser circuit. C. | Inductance in cms. in condenser circuit. L. | Calculated frequency. $n$. | Observed wave-length in cms. $\lambda$. | Calculated wave-velocity. $W = n\lambda$ in cms./sec. |
|---|---|---|---|---|---|
| Fundamental. | 0·005835 | 110,000 | $0{\cdot}197 \times 10^6$ | (871) | $(172 \times 10^6)$ |
| 1st Harmonic. | 0·002887 | 35,000 | 0·583 ,, | 292 | 172 ,, |
| 2nd ,, | 0·001461 | 18,000 | 0·977 ,, | 175 | 172 ,, |
| 2rd ,, | 0·001464 | 9,000 | 1·379 ,, | 124 | 171 ,, |
| 4th ,, | 0·001461 | 6,000 | 1·70 ,, | 95 | 163 ,, |
| 5th ,, | 0·001461 | 5,000 | 1·9 ,, | 80 | 152 ,, |

From the above table it is seen that the wave-lengths of the first, second and third harmonics are very nearly in the ratio of 3 : 5 : 7, for $292 \times 3 = 876$, $175 \times 5 = 875$, and $124 \times 7 = 868$. Hence the fundamental wave-length should be 871. If we insert the value in Table V., and calculate the wave-velocity for the fundamental frequency, we find it to be $172 \times 10^6$ cm. per second, or exactly the same value as that obtained for the three succeeding harmonics. Hence, from the fundamental and the three succeeding higher harmonics, we obtain values for the wave-velocity which are closely identical, and equal to $172 \times 10^6$ cm./sec., and in very near agreement with the velocity of $174 \times 10^6$ cm./sec. calculated from the constants of the helix itself.

There is a slight falling off in the velocity obtained from the fourth and fifth harmonics, but the difficulty of measuring the small inductance then used in the condenser circuit is considerable. Hence, we may say that when a helix wound on an ebonite core is used, observations confirm theory substantially, and show us that the stationary waves are formed as predicted, the wave-velocity being calculable from the observed inductance and capacity of the helix. This experiment shows us, therefore, in a very striking manner, the production of loops and nodes of potential of current on a conductor. An interesting point to notice is this, that the current in this long wire is not in the same direction at all parts of the wire at the same time, but there are places on this continuous wire in which there is practically no electric current, and other places not far apart in which the current is moving in opposite directions at the same time.

I have applied such a helix as a means of measuring the frequency in a wireless telegraph antenna. Suppose that we have a wireless telegraph transmitter, and we desire to know the wave-length radiated from the antenna, we can do it in the following manner: Let a long helix, made as described, be connected through a small condenser with the antenna, and let a metal saddle slide on the helix, the said metal saddle being connected by a flexible wire with the earth (see Fig. 27). We can then adjust the position of this saddle so that by means of a neon tube we have one complete stationary wave, as indicated by the dotted line set upon the helix. We can measure the length of this wave, and, knowing the velocity of propagation along the helix, we can calculate the frequency of the oscillations. But this frequency must be the same as that of the oscillations in the antenna, and since the wave-length of the wave radiated from the antenna is numerically equal to the quotient of the velocity of light, divided by the frequency, we obtain in this manner the measure of the wave-length of the radiated wave. Prof. Slaby has employed a helix in the same way as an indicator or measurer of the frequency in a wireless telegraph antenna, only instead of using a metal saddle, he shortens or lengthens the helix, more or less, by holding it in the hand, and instead of using a neon tube he employs some fluorescent material, having particles of gold leaf disseminated through it, spread on paper fixed near the open end of the helix. When the helix is adjusted to be of such a length that this fluorescent paper glows most brightly, then it is known that the length of the helix is approximately one quarter of the stationary wave upon it.

It will be seen, therefore, that there are two classes of cymometers or wave meters for measuring long electric waves. First, the open circuit, or helix type, and, second, the closed circuit. One of my own cymometers, which I have just described to you, and also that of Prof. Slaby, is of the open circuit type, and my other form of cymometer and that of Dönitz are of the closed-circuit type. The characteristic quality of my own form of closed-circuit cymometer is that in it the inductance and capacity are varied simultaneously, and in the same proportion, by one movement of a handle, and that, therefore, an index can indicate directly on a scale the wave-length of the radiated wave, and also render the scale showing the oscillation constant equidivisional. In using any form of cymometer it is essential that we should not alter the quantity we are trying to measure, thus, in using a closed-circuit cymometer which is coupled inductively to an antenna, the coupling must be very loose, that is to say, the mutual inductance between the antenna and the cymometer must be small, or else each oscillation in the antenna will give rise to two oscillations of different period in the cymometer, neither of which is that of the antenna, which we are desirous of measuring. Accordingly in my form of cymometer I have so arranged matters that we can get an indication by means of the neon tube with a very weak coupling indeed between the cymometer and the circuit tested, so that what the cymometer measures is the frequency of the oscillation or oscillations which only exist in the antenna when the cymometer is not there.

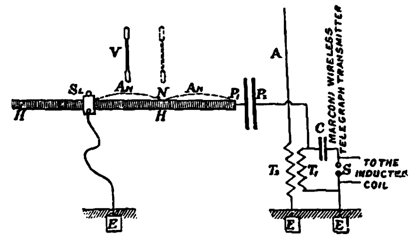

Fig. 27.—Use of a Long Helix as a Cymometer for measuring the Wave Length of a Wireless Telegraph Transmitter.

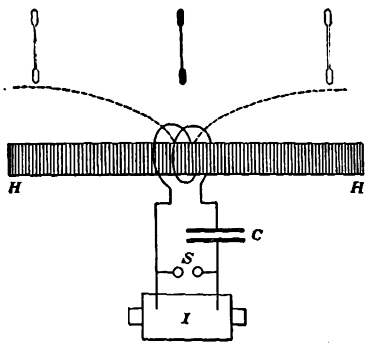

Fig. 28.—Stationary Wave of Electrical Potential established on a Helix by Inductive Coupling.

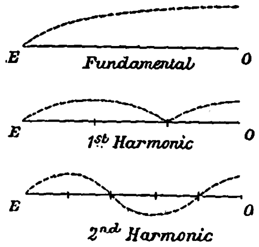

Fig. 29.—Stationary Waves of Potential on a Wire.

Similarly, in using an open-circuit cymometer we have to avoid producing a change in the capacity of the aerial by an earthed conductor held near it, and so alter its natural time period. It is easy to avoid the above-mentioned errors with a closed-circuit cymometer when using a sensitive detector such as the neon tube. We can also make use of the cymometer shown to you to measure the wave-length of the arriving wave as received on the receiving antenna if we substitute a magnetic detector for the neon tube and coil a few turns of the receiving antenna round the spiral inductance of the cymometer.

If we return again for a moment to the subject of stationary electric waves on spiral wires, I may draw your attention to another method of setting up electrical oscillations on a spiral wire by coupling it inductively instead of directly with the condenser circuit, as shown in Fig. 28. In this manner we can start the free oscillations in a perfectly-insulated helix. If we investigate the distribution of potential of current by means of the neon tube or a hot-wire ammeter, we find that in this case both the free ends of the helix are nodes of current, but antinodes or loops of potential, and that the centre of the helix, where the inductive coupling takes place, is a place of current antinode and potential node. By appropriately adjusting the frequency of the condenser circuit, we can establish harmonic oscillations on such a helix, and make loops and nodes of potential all along it just as in the case of the spiral insulated at one end only. In this manner of operating, the length of the helix proves to be rather less than half the wave-length on the helix.

It has generally been assumed, and indeed may be shown by a certain simple mathematical analysis, that when oscillations are set up in an insulated linear conductor of the Hertzian type the wave length corresponding to the fundamental oscillation is twice the length of the wire, but it has been shown mathematically by Mr. H. M. Macdonald in his book on "Electric Waves," that the length of waves is really 2·53 times the length of the linear oscillator, and this fact has been experimentally confirmed by Prof. Pollock and others. In experiments with helices I have always found that the distance from the open end of the helix to the first potential node is much less than a quarter of the wave-length on the helix, that is to say, is less than half the distance between the two next nodes. Thus reverting to the helix of which data has been given to you, the diagram in Fig. 29 shows the distribution of the nodes of potential on the helix for the different harmonics used, and we see that the distance from the end of the helix to the first node is always less than half the distance between the two nodes.

Theory shows that the distance between the first and second nodes is always exactly or very nearly half the wave-length, hence it follows that when we set up the fundamental oscillation on a helix by coupling it directly at one end to an oscillation circuit, the length of the stationary wave established on the helix is more than four times the length of the helix. In the same way, when a wireless telegraph antenna of the simple Marconi type is in operation, the wave sent off from it is more than four times the length of the wire, and by experiments with the cymometer I have found it is nearly five times the length of the wire, thus supporting the conclusions derived from Macdonald's theory. If, however, we insert in the base of the antenna an inductance coil forming the secondary circuit of a transformer, then the conditions are totally different, and it is a more difficult matter to ascertain the length of the wave radiated by such an aerial.

The circuit of the oscillation transformer adds considerably to the effective inductance of the antenna, and we cannot even say that the radiated wave-length is five times, far less four times, that of the total length of the antenna and of the oscillation coil taken together. From experiments made with the cymometer I have ascertained that when using the ordinary forms of oscillation transformer used in wireless telegraphy the relation between the length of the wave radiated from the antenna to the length, $l$, of the wire forming the antenna itself and the length, $l'$, of the wire forming the secondary circuit of the oscillation transformer in series with the antenna, is given by an empirical formula of the form

$$\lambda = 5\,(l + \mathrm{M}l')$$

where M is some number lying between 2 and 5.

The only satisfactory method, however, of measuring the length of the radiated wave is to measure as described above, the frequency of the oscillation in the antenna by means of the cymometer. This, of course, will tell us where there are oscillations of one or two frequencies in the antenna, and will give us the corresponding wave-length for these two oscillations. In practical wireless telegraphy, when using oscillation transformers with a coupling coefficient lying between 0·4 and 0·6, one radiated wave may have from 20 to 50 per cent. greater wave length than the other, and the lengths of these radiated waves are connected with the natural free frequency $n$ of the antenna by the formula. Thus, for instance, at University College, London, I have an antenna consisting of four aluminium wires arranged fan-shaped, each 50 ft. 6 in. in length, conducted by a semi-rectangle of wire, and also connected to the secondary circuit. The capacity in the primary circuit is 1/40 of a microfarad, and the oscillation constant of this condenser circuit and the antenna, each taken separately, is 6·9, but when the antenna and condenser circuits are coupled together with a transformer having a coefficient of coupling of 0·5, I find two resultant oscillation constants in the aerial having values 5 and 8·5 corresponding with waves of 1,000 and 1,700 ft. long respectively. The longer of these two waves is the more energetic and the less damped, the ratio of the damping being about 3 to 1.

In conclusion, I may indicate a few outstanding problems in connection with the measurement of long electric waves which have not yet received complete solution. We have much need of a more simple quantitative wave detector which will provide means for determining the maximum intensity and damping of the waves impinging on a receiving aerial. If we possessed this, and had details as to the sending apparatus used, we should have data which would enable us to determine approximately the distance of the sending stations, provided we were not working over distances at which atmospheric ionisation becomes objectionable. In the matter of transmitters, the objections to the use of the spark-gap are many and serious. It will no doubt be found possible at some time to solve the important practical problem of producing continuous trains of electric waves of known or regulated amplitude. When this is done many other problems will receive solution, but in spite of numerous patents and announcements nothing satisfactory has yet been found. The important practical problem of locating the radiant point has attracted many inventors, and it is possible that before long a solution may be arrived at in a manner least expected. Such progress has, however, been made in dealing quantitatively with the problems of high-frequency currents and electric waves that we have every confidence that in time these outstanding problems will be successfully solved.

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## NOTES ON THE CONSTRUCTION AND MAINTENANCE OF OVERHEAD EQUIPMENT.*

BY ROBERT N. TWEEDY AND H. DUDGEON.

(*Concluded from page 713.*)

*Trolley-wire and Trolley-wire Ears.*—Until quite recently the general practice has been to use circular trolley wire fastened to the supports by sweated ears. The ears have been either deep or shallow grooved, the former encircling the wire almost completely, and the latter only in part. Very few have refused to recognise that circular wire suspended in this way is unsatisfactory, but the fault lies with the ears and not with the wire. Many attempts have been made to overcome this difficulty with mechanical ears of various kinds, but without full success. The only problem involved is to provide an absolutely smooth and unbroken path for the trolley-wheel. If there is any change of section or gap in that path the wheel must jump, with the result that when no current is passing to the car the effect is identical with the effect of car-wheels at the joints of rails, and that when current is passing a more or less destructive arc is formed. This trouble is the direct cause of the substitution of flexible suspensions for rigid suspensions on bracket-arms, for double insulation could be managed without the "bow-string." So long as the trolley-wheel runs with perfect smoothness, flexible suspensions have no particular advantage over rigid suspensions, if the trolley-wire is as taut as it ought to be. In fact, we suggest to this audience that economies may be made in this direction now that figure 8 and grooved wire have come into fashion.

There is no doubt of the efficacy of 8 wire in supplying the desideratum mentioned above, but the grooved section hardly does this, as the ears cannot be made to clear the trolley-wheels. Nevertheless, the use of 8 wire is not extending in any marked degree. Two well-known firms of wire-drawers replied to an inquiry as to the ratio of 8 and grooved wire to circular supplied by them in the following terms:—(1) "We cannot say exactly, but the proportion of figure 8 is very small, and we have been informed that this is being practically discarded in America, where it was very much used a few years ago." (2) "The present ratio of demand for grooved is about 10 per cent. of the round, while figure 8 is practically ceased to be used according to our experience." These makers state that the extra cost of grooved and 8 wire (weight for weight) is from £2. 7s. to £3 per ton, but a large user of 8 wire writes that "there is no difference in the cost of wire, makers quoting us the same price per pound for each type." In any event, the difference in price is almost negligible, and might become so altogether if either section were used to the same extent that circular wire is now.

Then with regard to erection, a correspondent who has designed a complete line of fittings for both grooved and 8 wires, and has supplied large quantities of both, but has not carried out the erection, says: "The first cost of the fitting for the grooved wire is slightly more than the round, but not so much as in figure 8. It is very easily adjusted when up, and the wear on the fittings is practically nil. The wear of the wire is less than in the sweating system, as there is practically no under-running, and there is not the objection of having heated wire as in the sweating. . . . The objection to figure 8 wire is that it is more difficult to erect than the grooved wire, and more expensive in fittings, and in requiring more experienced men to fix it, but when properly fixed makes a very satisfactory job." On the other hand, the user quoted above on price says that "there is no greater difficulty in erecting figure 8 than circular wire of similar sectional area, contractor's price for two recent contracts being the same per 100 yds. for both. . . . One section . . . we have had working has given us no difficulty or trouble of any description," and he adds: ". . . in my opinion figure 8 is much better than grooved, one of the chief reasons being that the top lobe of the figure 8 allows a much better grip for ears than grooved wire, also *the bottom lobe, if you used, say, 2/0 section, can be made so that the contact area to the trolley-wheel is equivalent to 4/0 circular.*"

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* Abstract of a Paper read before the Birmingham Local Section of the Institution of Electrical Engineers on Feb. 14.

The fact has to be faced that circular wire with the present forms of ear means continual expenditure for repairs and an unpleasant feeling that too much depends on the linesmen. Under these conditions there are nearly 100 potentially weak points in every mile. We submit an ear for your criticism which we have some reason to believe fulfils the requirements, and as we have not protected it we do not hesitate to bring it before you in this manner. The great objection which we foresee will be raised against it is that it is a return to soldering just when everyone is trying to make mechanical ears for circular wire successful. We have no new excuse to offer, and only venture to express an opinion that copper may be soldered to copper easily and cleanly without hurting the wire, and that a bad workman will spoil anything. Moreover, in every length of trolley-wire sold there are several points which have been heated for soldering after manufacture, and in this ear the soldered area is less than has been proposed before; but the area is quite enough, and the part soldered to the wire is made of copper tapered off to flexible ends, in order to overcome the tendency of ordinary shallow-grooved ears to part from the wire at each end because of their inability to follow the small but frequent movements of the trolley-wire at the points of suspension. These ears put circular wire on the same plane as 8 wire. Whatever ear giving these advantages is to be used, we think that it is better to continue the use of circular wire even though 8 be as cheap, as easy to erect and as satisfactory in use. That is almost entirely because we do not not consider any other than circular wire can be quite as satisfactory in the long run.

Out of the 47 corporation tramways which answered Mr. McElroy's question as to the size of wire in use in 1904, 14 use 1/0, 4 use 2/0, 15 use 3/0, and 17 use 4/0 S.W.G. circular wire, these including three tramways on which two sections are in use. In a few cases there is some difficulty in determining from the printed replies whether the sizes are given in B. & S. or S.W. gauge, and in view of the difference between the two clear distinction is desirable. It is evident that the tendency in 1904 was towards heavier sections than the 1/0, which was almost a standard for several years, and during the interval that tendency has become more strongly marked. In face of such a definite expression of opinion it will seem rashness on our part to suggest that the factors which have led to this radical change are not sufficiently clear.

Mr. Sayers said, in his Paper before the Tramways and Light Railways Association,* that "there is no electrical necessity for using any wire larger that 0 S.W.G. . . . . unless the traffic is extremely heavy," and in certain other special cases, as on curves of short radius. The average density of traffic is not what Mr. Sayers means by "extremely heavy," nor is it likely to become so. The necessity for heavy wire on the electrical count being removed, the mechanical count alone remains, and on this point every engineer has his own opinion, as it does not lend itself so readily to exact demonstration. Our opinion is that an equivalent section to 2/0 circular wire is the maximum required by the average tramway. The following table shows the relation between the four sizes in use :—

**Table I.**

| S.W.G. | Diameter. Inch. | Area. Square inch. | Breaking strain. | | | Cost per mile at 11d. per lb. |
|---|---|---|---|---|---|---|
| | | | For 2% to 3% elongation. Lb. | For 4% to 4½% elongation. Lb. | Weight per mile. Lb. | |
| 4 | 0·400 | 0·12566 | 6,410 | 5,550 | 2,650 | £117 |
| 3 | 0·372 | 0·10868 | 5,870 | 4,790 | 2,220 | 101 |
| 2 | 0·348 | 0·09511 | 5,140 | 4,195 | 1,940 | 89 |
| 1 | 0·324 | 0·08244 | 4,620 | 3,635 | 1,680 | 77 |

Therefore, those tramways using 4/0 have sunk £80 and £56 per mile more than they need if they had used 1/0 or 2/0 respectively; and those who have used 3/0 have sunk £48 and £24 extra.

There is a real need for larger contact area between trolley-wheel and wire than is possible with 1/0 or even 2/0 circular wire, and it may be that this need has helped engineers towards the use of 3/0 and 4/0 circular wire, but the same effect can be obtained in a cheaper way by rolling 1/0 or 2/0 wire to a flattened curve on the under side. Whether that is done with circular, 8, or grooved wire must rest with the individual engineers, and probably figure 8 and grooved wires are not feasible in such a size as 1/0. We are the more insistent on the subject of returning to smaller sizes because the figures of wear which we give below show clearly that, points of suspension apart, No. 0 S.W.G. has a useful life which meets all present requirements.

*Wear of Trolley Wire.*—Trolley-wire wears from four causes: (1) Rolling friction due to trolley-wheels. (2) Sliding friction due to trolley-wheels in fixed heads on curves and badly aligned wire. (3) Arcing due to high current density. (4) Impure atmosphere.

Although circumstances have prevented the figures being complete, and although much remains to be done in this way by other and more competent observers, we think that the general statement above is fairly well borne out, and that there is some positive foundation for our conclusions :—

(1) That the depreciation due to rolling friction is almost negligible. (2) That sliding friction may be reduced to the same negligible quantity by attention to alignment and by the universal use of swivel trolley heads of the freest type. (3) That arcing is the most serious trouble of all, and must be discounted by the use of modified trolley-wire section and a complementary trolley-wheel. (4) That the effect of an impure atmosphere requires further elucidation. (5) That the method of suspension does not affect the wear, and (6) That the effects of (*a*) height of wire and (*b*) pressure of trolley-wheel require careful examination.

In all the following tables the original diameter of the wire was 0·324 in. maximum.

### Table II.—*Illustrating Conclusion 1.*

*Observation No. 1.*—Line six years old. Level road. Single wire joining two wires at junction. Diameter of single wire 0·312 in.; diameter of double wires 0·315 in. and 0·317 in.

*Observation No. 2.*—Same conditions. Another junction. Diameter of single wire 0·302 in.; diameter of double wires 0·310 in. and 0·3105 in. (Nos. 1 and 2 together also illustrate Conclusion 6.)

*Observation No. 3.*—Line two years old. Level road. Diameter of up wire 0·3185 in.; diameter of down wire 0·3180 in.

*Observation No. 4.*—Line two years old. Level road. Diameter of up wire 0·3205 in.; diameter of down wire 0·3210 in. (Nos. 3 and 4 together also illustrates Conclusion 6.)

*Observation No. 5.*—Line five years old. Level road. Diameter of up wire 0·3095 in. and 0·310 in.; diameter of down wire 0·311 in. and 0·3115 in. (No. 5 also illustrates Conclusion 4.)

The results of Observations 1 and 2 are discrepant, perhaps, because in the second case the wires are lower than in the first. Observations 3 and 4 are discrepant for the same reason. Observation 5 was taken over a railway bridge, and it is thought that the somewhat large reduction for a level road is due to fumes from the engines.

### Table III.—*Chiefly to Illustrate Conclusion 3.*

*Observation No. 6.*—Line five years old. Steep hill (1 in 12). Heavy cars. Diameter of up wire 0·307 in.; diameter of down wire 0·321 in.

*Observation No. 7.*—Line five years. Level road, but measurements taken at starting place. Diameter of single wire 0·317 in.

*Observation No. 8.*—Line two years old. Slight hill. Diameter of up wire 0·315 in.; diameter of down wire 0·320 in.

*Observation No. 9.*—Same line. Level starting-place. Outgoing wire 0·317 in. and 0·3175 in.; incoming wire 0·322 in.

*Observation No. 10.*—Same conditions as 9, on another line five years old. Outgoing wire 0·312 in. and 0·313 in.; incoming wire 0·3175 in. and 0·318 in.

*Observation No. 11.*—Line two years old. Hill. Up wire 0·3175 in.; down wire 0·320 in.

*Observation No. 12.*—Line five years old. Hill (1 in 11). Up wire 0·3075 in., 0·3085 in. and 0·3080 in.; down wire 0·320 in., 0·320 in. and 0·319 in.

*Observation No. 13.*—Line five years old. Steep hill. Measurements taken at intervals of 40 yards. Up wire 0·308 in., 0·314 in., 0·307 in. and 0·307 in.; down wire 0·320 in., 0·319 in., 0·3175 in. and 0·3175 in.

*Observation No. 14.*—Line two years old. Steep hill. Wires higher than usual (21 ft. 6 in. to 22 ft.). Up wire 0·319 in. and 0·3195 in.; down wire 0·322 in. and 0·322 in. (These results may be compared with 11.)

*Observation No. 15.*—Line four years old. Level. Both wires 0·3195 in. and 0·3205 in. Same line, steep hill: Up wire 0·3105 in. and 0·311 in.; down wire 0·3205 in. and 0·320 in. Same line, steep hill: Up wire 0·3145 in.; down wire 0·319 in. Same line, steep hill: Up wire 0·314 in. and 0·313 in.; down wire 0·319 in. and 0·319 in.

These observations cover some 20 miles of route operated under divers conditions, and they seem to prove Conclusion 3 to the hilt. At the same time, taking a general view of the whole, it is probable that the first wear is rapid down to a certain point, both on up and down lines, and thereafter does not proceed at such a rate. That requires more substantiation than we are able to give at present, but the figures suggest that whether a line is two years old or six years old, the down wire has worn much the same. Careful records kept from the beginning of traffic on a dozen lines scattered over the country are sadly needed.

### Table IV.—*To Illustrate Conclusion 4.*

*Observation No. 16.*—Line six years old. Hill by gasworks. Up wire 0·3025 in.; down wire 0,3095 in.

*Observation No. 17.*—Line two years old, in smoky atmosphere. Up wire 0·316 in.; down wire 0·320 in.

Observation 16 is not of great value by itself, but it may be compared with No. 13, where the hill is steeper and the traffic, if anything, heavier. In such circumstances, we should look for the down wire to be smaller in No. 13 than in No. 16, but the reverse is the case, and the only reason we can suggest is that the atmosphere in No. 13 was comparatively pure. Moreover, an abnormal reduction in *both* wires of No. 16 is to be noticed. No. 17 is an example of a smoky atmosphere causing no apparent damage.

### Table V.—*To illustrate Conclusion 5.*

*Observation No. 18.*—Line five years old. Level. Measurement taken—

| | |
|---|---|
| (*a*) 3 in. from end of ear at a rigid support .......... | 0·317 in. |
| (*b*) 6 ft. from end of ear at a rigid support .......... | 0·317 in. |
| (*c*) Half way between rigid and flexible suspensions .. | 0·315 in. |
| (*d*) 6 ft. from flexible suspension .................... | 0·317 in. |
| (*e*) 3 in. from flexible suspension .................... | 0·317 in. |

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* *The Electrician*, Vol. LIV., pp. 553, 593 and 633.

*Observation No. 19.*—Line five years old. Hill, span-wire construction. Measurements taken—

| | | | | |
|---|---|---|---|---|
| (*a*) 4 in. from ear ............ | Up | 0·308 in. | down | 0·320 in. |
| (*b*) Midway between ears ....... | ,, | 0·307 in. | ,, | 0·322 in. |
| (*c*) 4 in. from next ear ........ | ,, | 0·3085 in. | ,, | 0·320 in. |

These seem to illlustrate Conclusion 5, that the method of suspension does not matter, but more proof is needed to settle that conclusively.

### Table VI.

*Observation No. 20.*—Wires held rigidly by ears at short distances apart under bridge. 11 ft. 3 in. clearance between wire and rail. Usual clearance beyond bridge. Measurements taken on—

(*a*) One wire under bridge .. 0·322 in., 0·320 in., 0·318 in., 0·318 in.
(*b*) Same wire clear of bridge 0·319 in., 0·320 in.
(*c*) Other wire under bridge 0·315 in., 0·316 in., 0·316 in., 0·316 in.
(*d*) Same wire clear of bridge 0·318 in., 0·317 in.

*Observation No. 21.*—Line five years old. *Wires very slack.*
One bracket arm between two span wires.
No. 1. Span wire.—Trolley wire 19 ft. 7 in. from rail.
No. 2. Bracket arm.—Rigid suspension wire 21 ft. 4 in. from rail.
No. 3. Span wire.—Trolley wire 20 ft. 6in. from rail.

| | | | | | | |
|---|---|---|---|---|---|---|
| (*a*) 6 in. | from end of ear | | ........ | No. 1 | 0·317 in. | |
| (*b*) 2 ft. | ,, | ,, | ........ | ,, | 0·3175 in. | |
| (*c*) 60 ft. | ,, | ,, | ........ | ,, | 0·3215 in. | |
| (*d*) 6 ft. | ,, | ,, | ........ | No. 2 | 0·3205 in. | Towards No. 1 |
| (*e*) 6 in. | ,, | ,, | ........ | ,, | 0·320 in. | |
| (*f*) 6 in. | ,, | ,, | ........ | ,, | 0·318 in. | Towards No. 3 |
| (*g*) 2 ft. | ,, | ,, | ........ | ,, | 0·319 in. | |
| (*h*) 60 ft. | ,, | ,, | ........ | ,, | 0·320 in. | |
| (*i*) 2 ft. | ,, | ,, | ........ | No. 3 | 0·317 in. | |
| (*j*) 6 in. | ,, | ,, | ........ | ,, | 0·317 in. | |

*Observation No. 22.*—Same line as 21. Steep hill, span-wire construction. Wires fairly tight,

| | | | | | |
|---|---|---|---|---|---|
| (*a*) 6 in. from ear .... | Up wire | 0·308 in., | down wire | 0·320 in. |
| (*b*) Centre of span .... | ,, ,, | 0·307 in.. | ,, ,, | 0·322 in. |
| (*c*) 6 in. from next ear.. | ,, ,, | 0·3085 in., | ,, ,, | 0·320 in. |

Here we have three seemingly conflicting results.

In the first place, Observation 20 demonstrates that the wear is independent of the height of the trolley-wire under peculiarly harsh circumstances. Secondly, Observation 21 points to a much slighter difference in height, causing variations in diameter, and last there is Observation 22, in which the results on the up wire are directly contradictory of No. 21, while the down wire is in agreement with it.

We do not advance any explanation of the first contradiction, but suggest that the second is due to the fact that at the point farthest from the points of suspension of a wire which is passing current to a car, the contact pressure of the trolley wheel must be less whenever it lifts the slack wire above the points of suspension ; but the whole subject merits extended and patient observation by someone who will not try to make figures fit theories.

*Conclusion.*—In conclusion, we would say that, however erroneous may be our observations and our deductions, however far-fetched and inopportune our suggestions and our strictures, we have the satisfaction to know that this Paper has been written as the indirect result of practical experience, gained since the year in which electric traction made a substantial start, and as the direct result of several months' labour and thought. We submit it to your criticism as an earnest attempt to ventilate the question of lowering capital expenditure.

Our best thanks are due to the following firms for courteous replies to inquiries :—Messrs. S. Dixon & Son, R. W. Blackwell & Co., Estler Bros., W. F. Dennis & Co., John Spencer (Ltd.), Jas. Russell & Sons, and A. Dickinson & Co., consulting engineers ; also to R. F. Browne, Esq., of the Birmingham and Midland Tramways Joint Committee, who has taken much trouble in supplying us with information out of his experience. We are indebted also to the Birmingham and Midland Tramways Joint Committee for most of the specimens exhibited to-night.

## DISCUSSION.

Mr. H. M. SAYERS, in a written communication, sympathised with the authors in their attack on needless expenditure in overhead construction. He suggested that every specification for overhead work should provide that no two metals galvanically different should be in contact. The use of insulated bronze bolts was, however, strongly resisted by contractors, and, in fact, the breakages of the screwed ends were excessive. Iron or steel bolts deteriorated very badly just above the ears, and also rusted upwards and under the insulation as observed by the authors. He found it hard to understand the authors' statements with regard to the difficulties experienced with bronze bolts. Electrolysis would no doubt lead to a metallic deposit advancing from the edge of the hanger-bolt socket towards the line surface of the bolt. But this presupposed some solvent of the metal, and a strong solution, since weak solutions and high pressures led to the evolution of gas and the formation of a loose non-coherent metal paste of high resistance. It did not seem that the somewhat more rapid oxidation of the deposited iron could come into play, since so long as the line was alive it would be negative to the electrolyte and much mingled with hydrogen. He had seen many iron bolts that had failed in bad atmospheres, yielding iron sulphate, but believed that the breakdown was generally due to charring of the insulator surface. Hence, if shellac and other organic substances were discarded and hanger bolts insulated with porcelain reels, strung in the span wire as suggested, the most serious trouble with overhead work would disappear. He did not agree with the advocacy of slack wiring. It was mechanically wrong, just as were slack tension bars in a bridge truss. But overhead work might be overstrained, especially when put up in the summer. He had dealt with the matter of wiring tension, and partly with the cause of wear of ears in his Paper read before the Tramways and Light Railway Association last year.* He thought that the authors' figures and examples did not entirely justify their explanations. He suggested that what was wanted in an ideal trolley wire was uniform vertical rigidity, and any departure from uniformity must result in local wear.

Mr. H. E. YERBURY, in a written communication, said he was strongly impressed with the desirability of placing all telephone and Post Office wires underground. In Sheffield this had been done in several instances. The Corporation bore approximately half the expense. He thought that the poles in any section should be kept as nearly as possible of one diameter, the thickness being varied according to the strains. He believed that to dispense with the base would shorten the life of the pole. In Sheffield they painted the poles once a year, and raised all bases and collars, which was a simple matter when only a thin film of mastic cement was used at the joint. In some parts of their system the atmospheric conditions were very bad, and they found it economical to use phosphor bronze or copper span and guard wires, as galvanised material did not last longer than about three years. They had discarded ordinary hanger bolts, as the rust split the insulating material, and used either galvanised or sheradised insulated bolts which lasted several years longer. In his opinion, porcelain reels were entirely satisfactory on pole straps or flexible suspensions. He did not agree that flexible suspensions had no advantages over rigid suspensions. With a one to two-minute car service there was always a certain amount of "see-saw" action, and it was better for the ear to assume the same angle as the wire than to remain in a horizontal position. He approved of deep-grooved ears, unsweated, and if of correct shape and properly clamped there should be no sparking. In Sheffield they had discarded soldered ears for about five years with gratifying results. Wire of 8-section was desirable where wall rosettes were used as it was less noisy than ordinary wire. He was surprised that no mention had been made of either phosphor bronze or "Phono" trolley wire. They had had both materials in use about four years with good results, the only drawback being the comparatively high resistance. He could not agree that arcing was the most serious trouble, as there should be no signs of it on an efficient system.

Mr. HENRY MOZLEY (Burnley) wrote that improvements in the direction of reducing expenditure would enable many a branch line to be opened on which at present there was no prospect of meeting capital charges.

Mr. HENRY LEA said that the sizes of poles recommended by the British Standards Committee were the result of very careful investigation and, he thought, should be accepted. The authors had referred to the use of brass bolts. This was about the last material that should be used in damp situations. In the Lorain system in use at Wolverhampton there was nothing to be seen above the surface, and there was a remarkable freedom from breakdown. He believed that it was now being run at a lower cost per car-mile than any other tramway of the same size in the country.

Mr. C. W. HILL said it had been suggested that the guard wires might not be at the same potential as the wires they were supposed to protect, since the latter might be connected with earth in a certain position near the rails, where the potential was higher or lower than at the point where the guard wire was bonded to the rails, the difference being anything up to the Board of Trade limit of 7 volts. It was claimed that this effect was likely to give false instrument readings, and, so far as railways were concerned, it might be the cause of accidents. With regard to the Standard Committee's poles, he had found from actual load tests within the specified limits that all the deflection took place in the bottom section. The detrimental effects on the life of the poles due to bases could be overcome by a liberal use of Dr. Angus Smith's compound, by coning the concrete at the ground level and by properly caulking round the top of the base. With reference to fittings, he had found gun-metal perfectly satisfactory where properly galvanised span wires were used, and, in any case, the author's remarks only applied to straight line hangers, as he assumed galvanised thimbles were now used on all new work. He believed the grooved circular trolley wire would prove more satisfactory than the 8-section. His experience showed that the greater the rigidity of the suspension the greater the wear due to increased arcing and hammering. He was also convinced that too much tension on trolley-pole springs increased the arcing and hammering to a considerable degree.

Mr. R. F. BROWNE quoted the results of some tests on three types of tramway pole. The first was a three-section pole $7\frac{5}{8}$ in. by 0·4 in., $6\frac{5}{8}$ in. by 0·3 in., and $5\frac{5}{8}$ in. by 0·26 in., weighing 840 lb. The second a taper pole, tapering from 7 in. by 0·43 in. to $4\frac{1}{2}$ in. by 0·43 in., weight 865 lb. The third was the British Standard medium size $8\frac{5}{8}$ in. by 0·34 in., $7\frac{1}{2}$ in. by 0·31 in., and $6\frac{1}{2}$ in. by 0·25 in., weight 875 lb. The first gave a 6 in. deflection with a 500 lb. pull, and a permanent deflection of $\frac{1}{2}$ in. with 1,000 lb. The second $3\frac{3}{4}$ in. and $\frac{3}{16}$ in. respectively for the same pulls, and the British Standard pole $5\frac{3}{8}$ in. deflection with 750 lb., and $\frac{3}{8}$ in. permanent set with 1,250 lb. The latter was much the strongest although the weight varied very little. The joints of the three section poles added to the weight when compared with the taper pole. The taper pole cost about 9s. more than the British Standard.

Mr. P. J. PRINGLE (Burton-on-Trent), in a written communication, said he had recently closely examined the overhead work in Burton-on-Trent, which had been erected $2\frac{1}{2}$ years ago, and had found decided evidences of bolt deterioration. He believed that the shield introduced by the authors would remove the cause of the trouble and he was having these fitted in all extensions. He suggested that the authors should modify the shield so that it could be fitted to existing hangers without removing the bolts. On a hill with a maximum gradient of 1 in 11½ he had had to replace some of the ears on the upline, which were of the ordinary deep groove pattern with 3/0 circular wire in about 1½ to 2 years. He found the wear on the up line trolley wire in the vertical plane from 5 to 6 mils. more than on the down line. The side wear on the trolley wire towards the end of the ears, owing to the rapid wearing away of the ear (no doubt principally due to arcing) was in some cases as much as 25 mils. No mention had been made of the greatly-reduced conductivity of the ear compared with the trolley wire, and this, coupled with the reduced contact surface between the wheel and the ordinary ear, caused the pitting appearing on ears. This was very marked on up grades, the trolley wire on the down line showing no such appearance.

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* See *The Electrician*, Vol. LIV., pp. 553, 593 and 633.

Mr. R. N. TWEEDY, in reply to the discussion, paid a tribute to the important share which Mr. Dudgeon had taken in the preparation of the Paper. It was he who had discovered that the deterioration of hanger bolts and secondary insulators was due to electrolysis, and it was he who had followed through to logical conclusions the whole subject of the wear of trolley wire and ears. With regard to Mr. Sayers' communication, he had samples on the table which went far to prove his (the author's) assertions, and a careful study of all the circumstances which attended the deterioration of insulators left little room for doubt in the minds of the authors that not only were bronze bolts not exempt from this insidious form of decay, but that they were actually more prone to failure than iron bolts. There was some doubt in his mind as to whether Mr. Sayers objected to slack trolley wire or to slack span wire. Personally he thought that trolley wire ought to be as tight as was consistent with its ultimate strength, and that span wire ought to be much slacker than it now was, although there was no necessity to go to the extremes of which Mr. Hill spoke. As to the satisfactory results obtained with gun-metal fittings attached to the line by galvanised span wire it was only to straight line hangers that the authors referred, and it was difficult to see how the best galvanising could prevent local action between the dissimilar metals. Apart from that question altogether the use of gun-metal was an extravagance so long as malleable iron or some such cheap metal gave satisfactory service. The authors believed that, given proper ears which did not obstruct the passage of trolley wheels by coming into contact with them under any circumstances, and a wire no larger than 2/0 S.W.G., but rolled with a specially large radius for the under-side, then the heaviest city service would not depreciate that wire to anything like the extent that the largest wires now used were depreciated under the generally defective methods of suspension now in use. While the strength of an uncircular section was perhaps 10 or 15 per cent. less than the strength of an equivalent circular section, the authors' contended that a 1/0 S.W.G. circular wire had proved itself strong enough for safety over 10 years' service under bad conditions, and that no harm would follow the use of a 2/0 S.W.G. wire even though its ultimate strength was no greater than a 1/0 S.W.G. wire. Undoubtedly the degree of tension on the trolley pole was of great importance wherever anything but "figure-eight" wire was used, but the authors' point was that the wear of the wire between the ears seemed to be unaffected by the tension; that was to say, the measurements given went to prove that rolling friction was of little importance as a factor in wear. Mr. Yerbury expressed surprise that the new phosphor-bronze trolley wires were not used more, but the extra strength they gave was not required, while the resistance was very much higher than that of hard drawn copper. Until that day the speaker had not heard of "sheradised" hanger bolts, but there was a sample on the table now, and he assured his audience that, no matter how the metal was treated, so long as it remained metal, and so long as the "protective" coating was metallic, electrolysis would set in with finally destructive results provided there was leakage, and leakage which could not be prevented unless the insulator was kept dry. He assured Mr. Pringle that attention was now being given to the problem of attaching the patent "shields" to the hangers without removing the bolts. It was necessary to clear up the general misconception of the authors' meaning when they spoke of the serious wear due to arcing. They did not refer so much to the arc struck sometimes between the trolley wheel and the end of an ear at the moment of impact, or at the moment of leaving, as to the arcing (not visible to an observer unless on a level with the wire) which was due to the excessive current density at the actual contacts either when the car was taking heavy currents from a small section wire, or when the section of the path presented to the trolley wheel was enlarged, and the contact accordingly diminished when an ear of the ordinary type was encountered.

**Large Electric Power Scheme in Sweden.**—The scheme for transmission of power by a submarine cable from Sweden to Denmark, to which we alluded in a note on p. 277 of *The Electrician* for December 22nd, has, according to *Engineering*, been abandoned for the present. It is proposed, however, to distribute power over a large area, including all the principal towns in South Sweden. The generating station will be placed at Höganäs, and power will be obtained from four waterfalls on the Lagaa River. A portion of the power will also be derived from the coal found in the Höganäs district, which, although of too poor a quality to stand the cost of lengthy transport, is expected to answer satisfactorily when used for local power stations.

## OPENING OF THE NEW POST OFFICE CITY EXCHANGE.

The change-over of all the subscribers on the Post Office "Central" exchange to the "City" exchange took place on Saturday, and although it is doubtless not the first time a complete exchange has been changed over from one switchboard to another, it is certainly the first time that it has been done in the case of an exchange of such magnitude. The number of subscribers and junction lines transferred was about 14,000.

It will be remembered from the description of the exchange published in our issue of January 26th that the subscribers' lines to the "Central" exchange have been gradually connected up to the new board by means of a subsidiary intermediate distributing frame. Owing to the fact that the two exchanges have distinct power circuits, and that it was not advisable to connect the new batteries in parallel with the old one, the new circuits could not be connected right up to the switchboard; but each line was isolated at the cut-off relay by inserting a thin slip of glass—a microscope glass, in fact—between the contact of the cut-off relay. At 4:30 on Saturday afternoon everything was made in readiness for the simultaneous change-over of all the lines on the main distributing frame of the old exchange. Lengths of tape were passed behind each line of heat coils, and men stood ready to pull these out when the signal was received. This, of course, isolated all the lines from the old exchange, and, immediately this had been done, the operators sitting ready at the new switchboard commenced to plug into every one of the subscribers' answering jacks. It had been previously determined that by plugging into the jack three times in quick succession, and thus causing the relay to act three times, the dropping out of the microscope glass already mentioned would be ensured. The board had been manned with its full complement of operators, and this work only took a quarter of an hour from the time the signal was given to pull out the heat coils of the old board. Every line was then proved by ringing up the subscriber, but, of course, as it was Saturday afternoon, there were several "can't gets." This process was continued up to 10 p.m., and, in the meantime, men were told off to test that the circuit of the lines upon which no reply was received was quite in order within the exchange from the main distributing board to the switchboard. On Monday morning this work of trying the lines both in and outside the exchange was resumed and continued up to 10 a.m., when the ordinary full load came on; and on Tuesday morning a staff of young operators was put on the multiples of the spare positions of the junction board to verify the remainder.

It is interesting to note that over £200 worth of heat coils were withdrawn and £20 worth of microscope glasses were used in connection with the change-over. The men who pulled out the heat coils wore canvas shoes to minimise as much as possible damage to the fallen coils in collecting them, and a large sheet was hung up behind the men to catch the coils as they flew out. The microscope glasses were caught in a sheet placed below the relays, but in this case also there were necessarily a certain number of breakages. Mr. John Gavey (Engineer-in-Chief to the Post Office) and a party of his staff, witnessed the pulling out of the heat coils, which struck against the sheet with a noise like hail. They then proceeded to the lamp resistance frame, and found that only about 1 per cent. were glowing (indicating earths on B-lines), and about the same number of calling lamps were glowing on the switchboard (indicating shorts and earths on A-lines). This very small percentage of faults was set right by five o'clock on Monday, when it was found that there were no glows left.

It may be mentioned, although it will have been gathered from our previous article, that the subscribers changed over will retain their old numbers and the appellation "Central," but, as a matter of fact, they will eventually be changed back again to the "Central" switchboard in the floor above when this switchboard has been remodelled to the same design as the new board. As on this new arrangement the subscribers section will not be required to be multiple, a portion of the recovered multiples up to the equivalent of 6,000 lines will be reserved for fire stock—*i.e.*, stock which is ready to be fitted into any exchange which may have been destroyed by fire, so that should such an event occur the time taken to re-establish the service will be a minimum.

The reason for transferring back the "Central" subscribers from the new board to the old one is that the present arrangement takes up all the cross-connection facilities between the two exchanges, and the subsidiary cross-connection board will have to be released for its ordinary functions as soon as possible, as the "City" and "Central" exchanges both serve the City district.

The method of dealing with the junction wires may also be mentioned. The out-going junctions had all been paralleled before, so that no special arrangements were necessary for the transfer. After two o'clock on Saturday the traffic on the exchange is, of course, very light, and between two and four o'clock nearly all the in-coming junctions were diverted on to the new board and only sufficient junctions were left on the old board to ensure continuity of the Saturday afternoon traffic. This merely left the junction wires in-coming from the small exchanges to be dealt with (for in many cases, of course, there were too few junction wires to divide in this way) and these had to be transferred as quickly as possible after the change-over.

# CORRESPONDENCE.

## HYSTERESIS LOSSES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In 1892 Mr. Steinmetz published his formula expressing E, the loss of energy in hysteresis, by the equation $E = \eta B^x$ where $x = 1{\cdot}6$ and $\eta$ is a constant dependent on the iron. This rule is well known, but it does not seem at all understood that it is only true approximately, and even then only for a narrow range of values of $B$ suitable for transformer working. The law has no physical basis, and Mr. Steinmetz merely arrived at it from an examination of the experimental results contained in Prof. Ewing's earlier Papers. He never claimed for it what so many seem to assume about it, that it is a precise law invariably true. I am not aware that it has been much used by designers, to whom tables or curves are much more convenient and in much closer accordance with experimental results. But it has been greatly used in theoretical work by a number of people who are fonder of formulæ than of facts, though they never seem to work out these formulæ themselves, and display a power of ignoring inconvenient facts which is wonderful beyond words.

Shortly after Mr. Steinmetz announced his rule, Prof. Ewing, jointly with Miss Klaassen, issued a Paper on the Magnetic Qualities of Iron (*Phil. Trans.*, 1893), which forms the most accurate and comprehensive experimental research yet made on the hysteresis of iron. In this Paper Steinmetz's rule is discussed, and the authors show that no such formula can accurately represent the facts. It is shown that in some cases the exponent $x = 1{\cdot}6$ fairly well represents some of the tests for the range in $B$ most usual in tranformers. But the most accurate tests yielded an exponent $x = 1{\cdot}475$ for values of $B$ lying between 2,000 and 8,000 C.G.S. units. For high induction densities $x$ is even lower still, but for low values of $B$, $x$ is sometimes not only as large as $1{\cdot}6$ but even larger. Thus, for values of $B$ between 200 and 500 Prof. Ewing finds that $x = 1{\cdot}9$ and in some specimens nearly $2{\cdot}0$.

In your last issue you comment with surprise that Mr. L. Wild, in some recent tests, has found an exponent $x = 2{\cdot}7$ for low values of $B$. It is not surprising to me that $x$ should exceed 2 for low values of $B$. For some months past I have been investigating the behaviour of electromagnets for instrument purposes, and I have proved that the phase difference between the magnetising current and the magnetism is dependent upon the ratio of E to $B^2$, where E is the energy loss in hysteresis for a cycle of maximum flux density $B$. Now, if the exponent $x$ is less than 2, the ratio of E to $B^2$ must decrease as $B$ increases. This, I find, is the fact for values of $B$ over 1,000. But for low values of $B$ the ratio of E to $B^2$ would become excessively large if $x$ remained less than 2. I have found as the result of very numerous tests that the curve connecting the value of $E/B^2$ with $B$ has a maximum value for some value of $B$ generally lying between 600 and 1,000, and that as $B$ is diminished below these values the value of $E/B^2$ falls very rapidly, showing that if $E = \eta B^x$ the value of $x$ must be greater than 2 for these low values.

Any law may be made to fit with any facts if it contains sufficient arbitrary constants, and if these are adjusted every now and then to meet the needs of the moment. We may say of it as Captain Cuttle said of his famous timepiece "Put you back half an hour every morning, and about another quarter during the afternoon, and you're a watch as can be ekalled by few and excelled by none."—Yours, &c., W. E. SUMPNER.

Technical School, Birmingham, Feb. 19.

## WASTE IN INCANDESCENT LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should be glad if you could allow me space for a few remarks with respect to Mr. Wilkinson's Paper on the above subject read before the Local Section of the I E.E. at Leeds on Thursday, Feb. 15.

In the first place the Paper is essentially of interest to consumers of electricity, and this being so, the question arises as to whether he has gone far enough into the subject. Whilst not altogether disputing Mr. Wilkinson's argument in favour of certifying the efficiency of new lamps, I would point out that it is of more importance to make a test after they have been in use some time, as experience has proved to me that consumers will not take the trouble to renew their lamps when they become blackened and inefficient, and this is the time when attention is most needed. I would even go further than this by stating that installations, as well as lamps, should be periodically tested, and for this purpose the Northern Electrical Testing Co. was formed, working independently of electrical contractors and supply authorities.

During the 18 months the company has been in operation a large number of consumers have availed themselves of its benefits, which are a thorough test and inspection of the whole installation, including the lamps, and a report submitted as to the state thereof, together with suggested remedies whereby economies might be effected.

That such a course as this is necessary is shown from the number of faulty installations come across, and letters received from consumers testifying to the advantages derived from having had their installations and lamps periodically overhauled.

I am of opinion, however, that municipal authorities should not take up this work themselves, but would do much to popularise electric lighting by giving their support to such a scheme as this, and reminding their consumers of the beneficial results of these tests.—Yours, &c.,

THE NORTHERN ELECTRICAL TESTING CO.
(C. R. Heron.)

Huddersfield, Feb. 21.

# PARLIAMENTARY INTELLIGENCE.

## PETITIONS AGAINST BILLS.

The period for lodging petitions against private bills in the House of Lords has now elapsed. Although the number of bills "originating" in the Upper House is the same as in the House of Commons, the petitions are by no means so numerous, although a large proportion of the bills have petitions lodged against them. Those bills which will meet with the greatest opposition are the Shropshire & Worcestershire Electric Power, Kent Collieries Electric Power, Kent Electric Power, County of Durham Electric Power, the Cumberland Electricity & Power Gas, and the two bills seeking powers to construct tramways in Folkestone, Sandgate and Hythe.

## COMPLIANCE WITH STANDING ORDERS.

### Middlesex County Council (Tramways) Bill.

This bill, which was opposed on Standing Orders, came before Mr. Campion on Tuesday.

Mr. PRITT (Messrs. Sherwood & Co., Parliamentary agents), said that the opposed portion of the bill related to a tramway along the Edgware-road. The boundary of the counties of London and Middlesex was down the centre of that road, and the two road authorities concerned—viz., the Metropolitan Borough of Hampstead and the Willesden Urban District Council—had refused their consents. There was a conflict of opinion as to what extent these authorities were liable for the repair of the roads, and he was, therefore, bound to take a non-compliance with Standing Orders concerning this one line.

The Examiner stated he would report to the Standing Orders Committee in the usual way.

Several Scotch tramway provisional orders, which are opposed on Standing Orders, will be considered on Tuesday next, at the same time as the two Folkstone, Sandgate and Hythe tramway bills.

### BILLS READ A FIRST TIME.

A large number of private bills were laid on the table of the House of Commons on Wednesday and read a first time. We mention below those of electrical interest:—

Administrative County of London & District Electric Power, Additional Electric Supply, Ascot Gas (Electric Lighting), Baker-st. & Waterloo Railway, Brixham Gas (Electric Lighting), City of London Electric Lighting, Derbyshire & Nottinghamshire Electric Power, Hackney Electricity, Hammersmith, City & North-East London Railway, Lancashire Electric Power, London County Council (Electric Power Supply), London Electric Supply Corporation, London Outer Circle Railway, London Southern Tramways, Macclesfield & District Tramways, Metropolitan District Railway, Metropolitan Electric Supply, North & South Shields Electric Railway, North-East London Railway, North Metropolitan Tramways, Oldham & Saddleworth Tramways (Abandonment), St. Pancras Electricity, Shoreditch Electricity, South Metropolitan Electric Light and Power, Watford & Edgware Railway, West End Electric Undertakers.

## LEGAL INTELLIGENCE.

### Bournemouth Corporation v. Poole and District Electric Traction Co. (Ltd.)

This action and counter-claim came before Mr. Justice Joyce in the High Court on Wednesday.

Mr. HUGHES, K.C., for plaintiffs, said the case raised points involving substantial sums of money in connection with an agreement executed between the parties for the sale and purchase of the company's tramways. It was agreed that the Corporation should pay the fair market value as a going concern of the Poole undertaking of the company, certain parliamentary costs and expenses and the fair market value of the Christchurch undertaking. The appointed day for the completion was Dec, 31, 1903, but the actual completion did not take place until June 15, 1905. It was arranged that the arbitrator should base his calculations on the balance-sheet of the company for the year ended Dec. 31, 1903. The award was made on Dec. 21, 1904, under which the Corporation had to pay the company £112,000. The action, as originally started, was for specific performance immediately after the tender of the purchase money. Possession, however, was given shortly afterwards, and the Corporation now gave up the question of damages for the delay on the company giving up another matter of compensation. Several questions had arisen on the balance-sheet, but many of them were of minor importance, and had been disposed of by concessions on either side. What the company now claimed to be paid was the amount of four items in the balance-sheet—(1) temporary loan from bankers secured by a charge on the company's undertaking, £7,000; (2) sundry creditors, including the British Electric Traction Co., £4,558; (3) depreciation and reserve fund, £4,253; and (4) profit and loss account, £6,628.

In the result his LORDSHIP decided that the items of £7,000 in respect of bankers' loan and £4,558 sundry creditors should be referred to an accountant as referee to make a special report on the findings as to fact. His Lordship reserved judgment on the question of Parliamentary deposit, sundry debtors and cash in hand.

### Morphew v. Electrical Corporation.

In the City of London Court, on Monday, before Judge Lumley Smith, K.C., plaintiff (Mr. R. Morphew, designer and architect) sought to recover £100 from defendants for making designs for electrical fittings.

For plaintiff it was stated that Mr. Bower (one of defendant company's directors) had suggested that plaintiff should make designs for electrical heaters and other fittings for the company. Plaintiff was to be paid a royalty of 2½ per cent. for the first two years and then 5 per cent. on whatever money defendants obtained from the sale of goods made from his designs. Defendants would not bind themselves not to employ other designers, although he was willing to work for them exclusively. He had supplied 93 different designs, and those had all been returned because defendants would not be bound not to go to other designers. Plaintiff now demanded payment for his services.

Defendants pleaded that they were willing to pay plaintiff the royalties that might be found due when an account was taken. They had made up goods from plaintiff's designs and they found that they were not going as rapidly as both parties could have hoped. They had never agreed to take all plaintiff's work and pay down for it.

The Judge said there was no evidence that plaintiff had suffered damage, and he found for defendants with costs.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT AND FILLED.

Dublin Corporation require an electrical engineering assistant for temporary employment. Applications to city electrical engineer (Mr. Mark Ruddle), Central Station, Fleet-street, Dublin, by Feb. 26. See an advertisement,

Two additional assistants are wanted in the electrical engineering department of the Central Technical College, Exhibition-road, London, S.W. Salaries £300 and £150 per annum respectively. Applications to Prof. W. E. Ayrton, F.R.S. See also advertisement.

The Council of Armstrong College, Newcastle-on-Tyne, will shortly appoint a professor of electrical engineering. Stipend £500 per annum and one-third of fees until £750 in all is reached. Applications to the secretary (Mr. F. H. Pruen) by March 1.

A junior test-room assistant is wanted by the Cambridge Scientific Instrument Co., Cambridge, to assist in the manufacture and adjustment of electrical instruments.

Barking District Council require a meter superintendent inspector. Applications by noon March 8.

**Civil Service Examination.**—An open competitive examination for not fewer than 12 situations as assistant examiner in the Patent Office will be held by the Civil Service Commissioners in April next. The examination will commence on April 23. Forms of application obtained from the Secretary, Civil Service Commission, Burlington-gardens, London, W.

Mr. J. H. Fooks-Bale is resigning his appointment as electrical engineer and tramways manager to Walthamstow District Council, having been appointed superintendent of London General Omnibus Co.'s motor department.

Mr. R. S. Pilcher, of Burton-on-Trent, has been appointed manager of Aberdeen Corporation tramways.

Mr. Edward Winram Dickinson has been appointed by the London County Council superintendent of the Greenwich electricity generating station at a commencing salary of £350 a year, rising to £400.

Hampstead (London) Council have appointed Mr. F. E. Limbrey (electricity rental clerk) to be outdoor inspector at £110 per annum.

Dr. Black, of Armstrong College, Newcastle-on-Tyne, has been appointed junior demonstrator in physics, and R. A. Sheldon, M.A., of Belfast, has been appointed junior demonstrator in engineering at University College, Nottingham.

Mr. Roland E. Hunt has been appointed assistant manager of the Buenos Ayres and Belgrano Tramways Co.

### EDUCATIONAL NOTICES.

**London Inter-Collegiate Scholarships.**—We have received from the Secretary of the London Inter-Collegiate Scholarships Board particulars of the scholarships that may be awarded by the board during the present year. A combined examination for entrance scholarships and exhibitions tenable at University College, King's College and the East London College will be held on May 15 and following days. Among the scholarships to be awarded are:—

*Andrews Scholarship* at University College (of £30 for one year) in two of the following subjects: Mathematics, Physics, Chemistry, and either Elementary Biology or Botany.

*Two Clothworkers' Science Exhibitions* of £30 and £20 for two years, and two *Engineering Entrance Exhibitions* of £25 each for one year, at King's College.

*Nine Drapers' Company Science Scholarships* of £40 each for three years at East London College.

The scholarships and exhibitions at University and King's Colleges are open to men or women under 19, while three of the scholarships at the East London College are reserved for women.

Further particulars from the secretary (Mr. A E. G. Attoe), University College, Gower street, London, W.C.

**Technological Scholarships.**—The West Riding (of Yorks.) County Council offer four technological scholarships of the value of £60 each, open to residents within the administrative area of the West Riding of Yorkshire, and available for courses of instruction in connection with engineering (mechanical or electrical), metallurgy, textiles, dyeing or other approved industry. The scholarships are intended for young artisans who already have a suitable amount of mill or workshop experience. The awards will be mainly based on the results obtained at examinations of the Board of Education, South Kensington, and City and Guilds of London Institute. Application forms, &c., from the Education Department (Technical Branch), County Hall, Wakefield.

**Belfast Municipal Technical Institute.**—We have received a copy of the "Students' Guide to Prizes and Scholarships," which has been compiled by the principal of the institute, Mr. Fras. C. Forth, Assoc.R.C.S.I. It is a very useful compilation and will enable students of the institute to see at a glance the various educational advantages in the shape of prizes, scholarships and exhibitions which are open to them. Particulars are given of the scholarships and exhibitions awarded by the Department of Agriculture and Technical Instruction in Ireland, the Board of Education, the City and Guilds of London Institute, the Society of Arts, the Whitworth Scholarships and Exhibitions, &c. In addition the more ambitious students are afforded the means of obtaining information as to university education.

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**Argentina**.—The "Review of the River Plate" says the Bahia Blanca-N.W. Railway Co. have bought, and intend to reorganise, the undertaking of the local electric light company.

The Rural Tramway Co., Buenos Ayres, have received Government permission to convert their system to electric traction.

Messrs. Gandulfo & Co. have secured a concession for a tramway from Barracas Bridge to La Plata.

**Australasia**.—The "Australian Mining Standard" says the Federal Government have decided to create the position of chief electrical engineer of the Commonwealth Postal Department, and terms and conditions of the appointment are now being drawn up. The salary will be £750 per annum. One of the first subjects to which the new officer will be asked to devote his attention will be the toll or measured rate telephone system which it is intended to gradually introduce in the telephone exchanges of the several States.

During 1905 the units generated by Sydney electricity works were 2,614,866 (compared with 512,991 in 1904). It is estimated that the total demands will by June 30 next be at the rate of 3,600,000 units per annum. Application has been made to the Governor-in-Council for consent to a further loan for extensions.

The electric lighting scheme of Balmain, a suburb of Sydney, and the destruction of the refuse of the district has fallen through. The Council have declined to consider proposals for a modification of the agreement proposed by the contractors, Messrs. Kenway & Co.

**Baker Street & Waterloo Railway**.—At yesterday's meeting the chairman stated that it was proposed to open the portion of the company's new line from Baker-street to Kennington on Saturday, March 10, at one o'clock.

**Bradford**.—A special committee of the City Council met on Thursday last to consider a proposal for the construction of a subway under the principal streets for the reception of electric cables, pipes, &c., and will again consider the matter at a future meeting.

**Brighton**.—The Lighting committee have decided to abandon their present system of charging and to introduce a flat rate.

**Bude**.—The Council decided to enter into an agreement with Christy Bros. & Middleton for provision by the latter of electricity supply in the district, the Council being supplied with current for power at 2½d. per unit, and reserving the right of purchase (after 14 years) for the amount of capital expended, plus 10 per cent. if the Council's water be used, or plus 5 per cent. if the Council's water be not used by the contractors.

**Burgess Hill**.—Electricity supply has been inaugurated this week. The installation has been carried out without statutory powers and overhead wires are used.

**Canterbury**.—The Council last week considered a recommendation of the Lighting committee that the salary of the borough electrical engineer (Mr. C. A. Blascheck) be increased to £325, but although Mr. Blascheck's work has greatly increased, the recommendation was referred back.

**Chili**.—The public electric lighting at Chacabuco was inaugurated last month.

**Coal Cutting Machinery**.—In a report upon the coal industry of the United States in 1904 it is stated that the amount of coal produced by undercutting machinery continues to increase, and that 7,671 machines were in use in the bituminous coal mines for this purpose. No figures are, however, presented as to the proportion of electrical machines employed. In the Illinois coal mines 9·3 per cent. of the coal production is hauled by electricity, compared with 3·4 per cent. by cable and 69·4 per cent. by mule or horse. In the anthracite coal mining industry 115 electric locomotives were employed and 100 dynamos. In the bituminous mines 560 electric locomotives and 463 dynamos were similarly employed.

**Country House Lighting**.—R. J. Nicholson & Co., Manchester, have recently carried out an interesting electric light installation at a country house near Hereford. The plant consists of a 4 B.H.P. "Ideal" petrol engine direct coupled to a dynamo, a battery of accumulators, &c. For the effective protection of the battery charge and discharge ampere-hour meters have been fixed, so arranged, however, that when running direct on the lights they can be cut out of circuit by means of change-over switches.

**Croydon**.—The Tramways committee recommend the Corporation to appoint Mr. T. B. Goodyer (who has acted as general manager for the British Electric Traction Co. during the currency of their lease) as manager of the Corporation tramways at £600 per annum, from June 1, 1906. Mr. Goodyer would have charge of all matters in connection with the working of the undertaking, with the exception of the rails and track, which will be under the control of the borough surveyor, Mr. G. F. Carter.

**Cuba**.—The expenditure of $20,000 has been sanctioned on the construction and repairing of telegraph lines and wireless telegraph installations.

**Dover**.—An additional 500kw. direct-current set, with condensing plant, &c., is to be purchased for the electricity works at an estimated cost of £4,500. Application for sanction to borrow this sum has been made.

**Dundee**.—At a special meeting last week, the tramway manager, Mr. Fisher, submitted a scheme for the erection and equipment of a separate station for supplying electric energy for the tramways, which, he said, could be accomplished for less than £17,000, and which he contended would prove a more economical mode of meeting the increased demand for electrical energy for lighting and power than the adoption of the electrical engineer's scheme for a new combined lighting and traction station.

The city electrical engineer (Mr. H. Richardson) reported, on the other hand, that, in his view, the present was not an opportune time for the erection of a separate tramway power station. The available margin of power in the present station for lighting and power would be increased but little thereby, and not by one-half as was claimed by Mr. Fisher. It was not a question of average outputs, but of simultaneous maximum demands. Moreover, the tramways department would have to recoup the electricity department for expense already incurred (about £21,500) in erection of switchboard, laying cables, &c., for purely traction purposes. The statement made by the tramway manager that a station for tramway purposes could be put down for under £17,000 was, he urged, hopelessly irresponsible.

After adjourning the consideration of these reports, the Council decided on Tuesday in favour of the scheme proposed by Mr. Richardson, who will report further upon the site of the new power station.

**Dunfermline**.—In reply to an inquiry from the Board of Trade asking if the Council intend to give effect to their application for a provisional electric lighting order in the event of their application being granted, the Council replied that they intended to exercise the powers if these are granted.

The question of electricity supply was again debated by the Council on Friday.

Provost Mackbeth favoured an agreement being made with the Fife Electric Power Co. for a supply of current in bulk, but as other members were not in entire sympathy with the proposal, the Special committee was instructed to deal with the matter and to meet a representative of Crossley Bros. regarding their proposal to generate current by suction gas plant.

The Council agreed to withdraw their opposition to the tramway scheme.

**Dysart**.—Kirkcaldy Council propose to apply for a provisional order for electricity supply in this town. Dysart Council have referred the question to their Tramways committee.

**Ealing**.—An inquiry has been held into the application of the Council for permission to borrow £25,000 for electricity extensions.

The town clerk (Mr. GEORGE BRYDGES) stated that £5,000 was wanted for machinery, £278 for transformer sub-stations, £19,184 for main extensions and house service connections and £537 expended on house service connections in excess of previous sanction.

The resident engineer (Mr. J. D. KNIGHT) aid there was at present insufficient machinery to meet next winter's load.

Mr. PEAL said the Electric Light Committee had instructed Mr. Knight to ask the Metropolitan Electric Supply Co. to state their terms for supplying current in bulk, and if the Council could buy it cheaper than they could generate it they would do so, instead of putting down additional plant.

**Electricity in Naval Dockyards**.—The schools of submarine mining for Royal Engineers at Portsmouth, Plymouth and Sheerness have ceased to exist, and schools of electric light are to be established at these stations in substitution therefor. The Admiralty have decided that the subordinate supervising staff for the Electrical Engineers' Department at *Sheerness* dockyard is to consist of an assistant electrical engineer-in-charge, at a salary of £300 on appointment under the non-pensionable scale, and £250 on appointment (if promoted from inspector of electrical fitters) under the pensionable scale, and two inspectors of electrical fitters. The assistant electrical engineer is to be in lieu of the electrical engineer (Mr. Z. H. Kingdon), who has been selected for service at the Admiralty. The drawing staff of the department is to consist of a second-class draughtsman and two mechanics on drawing duties and the writing staff of a first-class and a hired writer.

As a result of the development of the electrical work at *Pembroke* dockyard the Admiralty have approved of the establishment of an inspector of electric fitters in addition to the present staff, and of three draughtsmen and a supernumerary.

**False Pretences**.—At Middlesex Sessions on Saturday Peter Frank (otherwise Laxton), described as an engineer, pleaded guilty to obtaining a dynamo from Mr. M. W. Woods, electrical engineer, and a field regulator and a cutting machine from Mr. R. A. Pott. When arrested prisoner said his name was Laxton. Prisoner received a sentence of 12 months' hard labour.

**Folkestone.**—The Council have conditionally approved the bill of the National Electric Construction Co. for power to construct tramways between Folkestone, Cheriton, Sandgate and Hythe. The Dolter surface-contact system is proposed, the promoters agreeing to a clause providing that the system shall be in working elsewhere in the United Kingdom for six months before it is adopted at Folkestone.

**Gravesend.**—An unopposed inquiry was recently held into the application of the Council for power to borrow £7,000 for extending the electricity undertaking.

**Grays (Essex).**—The Council have abolished the maximum demand system and will supply current at the following rates: Up to 100 units per quarter, 5d. per unit; 250 units, 4¾d.; 500 units, 4½d.; over 500, 4d.

**Greenock.**—The deputation appointed to inspect refuse destructors in various towns of the United Kingdom has reported recommending top feeding for destructors. The cost of proposed destructor works at Greenock is put at from £15,000 to £16,000, and it is estimated that 660,000 units of electricity per annum could be produced from steam generated at the destructor at a cost of 0·45d. per unit.

**Greenwich.**—The Council has issued a circular to the Metropolitan Borough Councils upon the subject of breaking up streets by electricity and other companies. It will be remembered that the Council obtained the insertion in a bill last year of a clause providing that if the Council, before paving a street, should have given a company notice and an opportunity of laying mains, the company should be precluded for three years from breaking up the surface of the street for laying mains, except on relaying the entire width of the pavement. Greenwich Council suggest that other London boroughs should obtain similar powers.

**Halesowen.**—The Board of Trade have declined to reconsider their decision to revoke the Council's electric lighting order.

**Hammersmith (London).**—Sinclair-road, at present "illuminated" by 16 incandescent gas burners, is to have small arcs fitted to brackets on the existing posts at a cost of £138, the extra annual cost of the improved lighting being only £4. 7s. 7d per post on such number of posts as remain in use.

**Hartlepool.**—The Northern Counties Electricity Supply Co. have reduced the prices for electric current for private consumers to 4d. per unit, for municipal buildings to 3d. and for street lighting to 2½d.

**Hebden Bridge.**—An inquiry was held last week into the application of the Council for sanction to borrow £2,570 for electric lighting.

The clerk (Mr. CRABTREE) stated that the total expenditure on the electricity scheme was £11,238, or £978 in excess of the amount borrowed. It was proposed to spend an additional £1,592 on new services, motors, generator, switch gear and accessories. There had been a loss on the first year's working of £160, but the prospects for the future were much brighter.

The inspector (Mr. NORTH) objected to the Council altering the original scheme after sanction to a loan had been obtained. It was most irregular, and he could not say what action the Board would take in the matter.

**Holyhead.**—The Council have received sanction to a further loan of £3,000 for electricity supply.

**Huddersfield.**—The receipts of the electricity department last year were £26,116 and the working expenses £14,242. After paying interest (£4,964), sinking fund (£3,492) and amount repaid to public works (£1,365), the net profit is £2,053 (a decrease of £1,822 compared with previous year). This sum is to be transferred to depreciation and contingency account, which now amounts to £11,935.

**Italy.**—Great advance was made during 1905 in the development of the telephone system in Italy. All the chief towns are now connected, the latest addition being Palermo, which can now speak with Turin or Venice, a distance of about 1,700 miles. Angelini microphones are employed on this long line. The island of Sardinia has no telephonic communication with the mainland, a wireless telegraph station being the means of communication, a Government station at Maddalena having been opened during the past year for the purpose. It is stated to be the intention of the Italian Government to create a State telephone department, and to take over the whole of the Italian telephonic system. The existing services, short and long, which the Government will have to purchase are very numerous.

It is announced that the Municipal Council of Savigliano have appointed a commission to consider a scheme for an extensive system of railway or electric tramway communication throughout that district.

An association has been formed of the various local authorities of Marches for the construction and working of an electric tramway between Ancona and Loreto.

Milan Municipality have been authorised to construct and operate two electric tramway routes in Milan. An extensive water-power utilisation scheme has been prepared which provides for the generation of 30,000 H.P. of electric energy to be available for distribution in the Milan district at a cost of £720,000.

Mestre Municipality have received authority to construct and operate an electric tramway in the town.

The application for, and granting of, concessions to responsible firms and public companies for the utilisation of the water powers in many districts in Italy continues to be a feature of Italian industrial enterprise, and the "Bulletin" for February of the French Chamber of Commerce at Milan contains interesting particulars regarding these enterprises.

**Ince.**—The Council have accepted the terms of Wigan Corporation for the transfer of the Ince Electric Lighting Order, 1901.

**Kent Electric Power Bill.**—It having been decided by representatives of the municipalities and urban district councils of Kent to oppose the Kent Electric Power Co.'s bill, a committee has been formed for the purpose, and the town clerk of Dover has been appointed secretary.

**Leeds.**—The city electrical engineer (Mr. Harold Dickinson) is to prepare specifications and invite tenders for two turbo-alternator generating sets, owing mainly to the greatly-increased demand for current for power. Of the 6,600 customers of the Corporation electricity department 600 take current for power. Motors of a total of about 5,000 H.P. have been supplied by the Corporation, varying from ½ H.P. up to from 800 H.P. to 900 H.P., and these are used in almost every business in which machinery is employed. During the past six months the increase in the demands by power consumers has been about 30 per cent.

**Leigh.**—The Council have increased the salary of the borough electrical engineer (Mr. A. T. Smith) from £250 to £270 per annum.

**Leyton.**—The Council have adopted a flat rate of 3½d. per unit, where the minimum payment is £200 per quarter.

**Light Railways.**—An inquiry was held on Wednesday into the application to construct a light railway from Clayton West to the L. & Y. Railway at Darton, at a cost of £42,000.

The Light Railway Commissioners on Tuesday heard an application for powers to extend the Mansfield and District tramways. The extensions proposed are to Mansfield Woodhouse, from Sutton-in-Ashfield to Skegby and Stanton Hill, and from Hucknall Huthwaite (to which place the line was opened on Saturday last) to the county boundary in the direction of Blackwell. The latter extension has been sanctioned in the Notts. and Derbyshire Tramways Act, but the promoters of the bill are willing to transfer the powers for this line to the Mansfield Co. 8½ miles of line are already completed, and the present proposals will make a total of 15 miles authorised. Evidence in support of the application was given, and the County Council withdrew their opposition to the Skegby and Stanton Hill sections on the company undertaking to pay £1,000 towards the road widening.

**Limerick.**—The revenue of the Corporation electricity department for the year ended Dec. was £3,547, and working expenses £2,553. After payment of capital charges (£4,782), there is a deficiency of £3,789.

**Liverpool.**—The income from the sale of electrical energy for lighting and power during 1905 was £145,785. 4s. 3d., for public street lighting £2,362. 6s. 6d., and for tramways £92,876. 1s. 3d.; meter rentals came to £2,653. 5s. 1d., the profit on the manufacturing department was £2,156. 9s., and miscellaneous receipts brought the total £246,366. 19s. 10d. The total expenses (including £61,784. 7s. 9d. cost of generation, £12,163. 18s. 11d. management expenses, and £17,847. 0s. 2d. rent, rates and taxes) were £98,235. 12s. 2d. Interest absorbed £54,878. 17s. and sinking fund £42,477. 13s. 10d. £17,874. 16s. 2d. was placed to reserve, £13,160. 0s. 4d. to renewal account, and the balance (£19,740. 0s. 4d.) has been contributed to the general rate. The total capital expenditure at Dec. 31 was £1,849,775. 3s. 5d., an increase of £131,062. 6s. 9d. (£67,729. 17s. 8d. on machinery and £52,728. 14s. 5d. on mains) during the year.

The annual report of the assistant lighting engineer (Mr. A. G. Smith) states that at the end of 1905 4½ miles of streets were lighted electrically, 430¾ miles by incandescent gas, and 9¾ miles by flat-flame gas burners. Last year's total charge for public lighting was £51,351.

**London County Council.**—At Tuesday's meeting Hammersmith was granted a loan of £15,120 for electric lighting purposes.

*School Lighting.*—The recommendation of the Education committee that £2,250 be expended for the electric lighting at the L.C.C. School of Building, Brixton, was approved.

*Tramways.*—The Highways committee recommended that the laying of cable ducts of the tramways between Camberwell Green to Lordship Lane, of the estimated value of £8,000, be entrusted to Reid Bros., and an extension of their present contract. Also that an additional motor generator for the Camberwell sub-station be obtained from Dick Kerr & Co. at a cost not exceeding £2,000.—Agreed.

**London Power Bills.**—At their meeting last week the Council of the London Chamber of Commerce resolved that "it was most undesirable in the interests of the trading and commercial community (and calculated to destroy private enterprise) that the right to supply electricity in bulk should be placed in the hands of the London County Council or of any private monopoly."

**Newcastle-on-Tyne.**—An official inspection of the working of the tramway service on the Walker & Wallsend tramways (riverside route) took place on Tuesday.

**Norwich.**—At the Council meeting on Tuesday the mayor (Mr. E. T. Boardman) moved that the salary of the city accountant (Mr. A. Gentry) be increased from £500 to £550 per annum, the Electricity committee to pay the increased amount.

Mr. Wild said the committee were so fully cognisant of the services rendered by Mr. Gentry that they felt he ought to receive an increase of salary. When the electricity undertaking was taken over by the Council it was decided that it should be carried on as a business affair, and that the committee should be under no obligation to the general funds of the city. In other towns certain charges were manipulated so that the electricity undertaking was made to show a considerable profit, whereas the charges were paid out of the general fund of the town.

The increase of salary was sanctioned.

The Mayor moved that an order be given to the several departments of the Corporation to place in the hands of the Electricity committee all work required with respect to electric lighting, fittings, wiring, maintenance, &c.

Mr. Wild, who seconded, said it was suggested that such work should be done by the Electricity committee at cost price. The committee declined to tender in competition with other traders, but would estimate if they alone were asked to do so.

Mr. Crotch said the matter of lighting several of the evening continuation schools in the city was now under consideration. Were the Education committee to be placed entirely at the mercy of the Electricity committee? The former would have no means of telling whether the price charged was cost price or not.

The resolution was, however, agreed to.

**Oldham.**—The Council have unanimously resolved to oppose the bill of the Lancashire Electric Power Co.

**Ormskirk.**—The Council have received an offer from the National Electric Construction Co. to pay the cost of the additional provisional order if the company are permitted to carry the electricity supply scheme through. It was resolved to ask the company to seal the agreement as to the refuse destructor. There is likely to be opposition by a minority of the Council at the forthcoming inquiry into the application for sanction to a loan.

**Orrell.**—The Board of Trade have extended the period of the Council's electric lighting order, 1903, for twelve months.

**Paraguay.**—The contract for the electric lighting of the town of Asuncion expires on June 30 next. The municipality have applied to the Government for permission to invite tenders four months prior to the expiration of the contract.

**Peru.**—Sanction has been given for the expenditure by the Postal Telegraph Department of £1,091 during each of the years 1906 and 1907 on the construction of telegraph lines to connect Puquio and Coracora with Nazca.

**Plymouth.**—The charge for electric current supplied to the tramways has been fixed at 1·75d. per unit.

**Portsmouth.**—As the result of the past year's working of the municipal tramways £3,500 has been devoted out of the profits to relief of rates.

**Provisional Orders Revocation.**—The Board of Trade have revoked the Halesowen Electric Lighting Order, 1899, and the Horley Electric Lighting Order, 1904.

**Shoreditch (London).**—Application is to be made for a loan of £5,000 for expenditure in connection with the change of pressure of electric supply.

**Shropshire, Worcestershire & Staffordshire Electric Power Bill.**—A conference of representatives of local authorities of Birmingham and district was held last week to consider the question of opposing this bill. No resolution, however, was moved, the several councils being left to act independently.

**South Africa.**—"The British and South African Export Gazette" states that in addition to the Victoria Falls electric power scheme and Mr. Robert Hammond's project for a large station at the Vereeniging Coalfields, the Anglo-French Exploration Co. have a project for meeting to some extent the demands for power on the Rand. The Anglo-French Co., which represents over 20 mines, intend to erect a large generating station at the Apex mine for the supply of energy for power and lighting. Other mine owners are also erecting new electrical plant, notably electric winders at the Village Main Reef and the Robinson Deep, and electrically-driven mills at the Anglo and Cason mines.

In connection with the *Kalk Bay-Muizenburg* electricity supply works, which have been in course of construction for 12 months and which are to cost about £20,000, there is to be erected a destructor for burning the town refuse, and power is to be supplied for, among other purposes, driving heavy pumping plant at the sewage works and bacteria beds. This is said to be the first attempt in South Africa to generate electrical energy from the burning of town refuse.

*Kroonstad* Corporation have now the equivalent of 5,890 8 c.p. lamps connected for lighting and 1,563 for power, which is nearly the full capacity of the plant. On the recommendation of the consulting engineer (Mr. F. Saunders) an additional generating set is to be put down, at a cost of £1,800.

*Bloemfontein* Council are about to invite tenders for extensions of their electricity undertaking.

The electric tramway concessionaires at *Bloemfontein* are expected to begin operations in April.

*Durban* Corporation intend to hold an exhibition of domestic electrical appliances.

The *Cape Peninsula Lighting Co.* intend to greatly extend their distribution system in Capetown suburbs.

Mr. Wheeler is negotiating with *Maitland* (Cape Colony) Council for the construction of electric tramways.

**Stepney (London).**—The Council decided last week to apply for a loan of £10,000 for electricity extensions.

**Swansea.**—The borough electrical engineer (Mr. C. A. L. Prussmann) recently reported to the electric and tramways committee that replies to inquiries he had sent to other towns did not justify him in recommending the adoption of prepayment meters.

**Telephony in Berlin.**—The postal authorities have decided to erect telephone kiosks in the streets of Berlin.

**Torquay.**—An inquiry was held here on Tuesday into the application of the Corporation for permission to borrow further moneys for extensions of the electricity generating plant and mains.

The Town Clerk (Mr. F. S. Hex) suggested that the loan for additional mains should be £2,900 and for plant £2,060, or about £5,000 in all.

The Inspector (Mr. Hooper) remarked that they might ascertain what had been expended on mains, house services, feeders and distributors, and meters for the last three years, and this basis would form a valuable guide for the next three years.

The Electrical Engineer (Mr. P. Storey), stated that each house service cost £4. 10s., and there had been on an average 40 house connections a year for the last three years. This did not include voids, which might be estimated at from five to ten per annum, and, therefore, the net number of house connections might be taken at 30 a year.

Mr. Hooper said the Local Government Board recommended that, in view of the evidence and information as to street lighting, it would not be desirable for the Corporation to expend money on unremunerative undertakings, such as public lighting, especially in view of their present weak financial condition.

The Town Clerk stated that the electricity accounts up to Dec. 31 showed a profit for the year of £1,319, in addition to a reserve fund of £500.

Evidence was given by the Electrical Engineer and by Mr. H. A. Garrett, borough surveyor, as to the desirability of providing water purifying snd condenser plant, and in support of the proposal to extend the mains to Kilmorie and Livermead.

**Village Lighting.**—It has been decided to light Trewoon (Cornwall) by means of current to be supplied from St. Austell electricity works, a distance of 1½ miles. Overhead cables will be employed.

**Walthamstow.**—The resignations of Mr. G. H. Fooks-Bale, the electrical engineer and tramways manager, and of Mr. W. H. Wilkinson, tramways inspector, have been accepted by the Council. Testimonials under seal are to be given to both officers.

**West Ham.**—The following recommendations of the Electric Lighting and Tramways committee have been recently adopted by the Council:—

That the electrical engineer (Mr. A. Hugh Seabrook) recommended that, as wiring contractors' showrooms were advertising the sale of electricity, as well as the means by which electricity could be used for lighting, cooking, heating, power, &c., a special rate be charged to those contractors in order to induce them to make the most brilliant display possible.

Having very carefully considered the whole question, your committee recommend the Council to reduce the charge for current for lighting from 4d. to a maximum of 3d. per unit, and for power to a maximum of 1d. per unit, consumers using power to be allowed to use for lighting at power rates a number of units equivalent to 10 per cent. of the total units used for power, and that the proposed reduction take effect as to lighting from March 31 next and as to power from June 30 next.

The charge for current for contractors' showrooms has been reduced to 1½d. per unit.

**Westminster.**—The contract of the Scott Snell Co. for lighting Parliament-street and Whitehall having lapsed, competitive tenders are to be called for the lighting of those thoroughfares.

**Weston-super-Mare.**—The Council decided at their last meeting to oppose the proposal of Weston-super-Mare and District Electric Supply Co. to construct a tramway on the Marine Parade.

**Willesden Polytechnic Institute.**—The electrical installation at this institute now comprises the equivalent of about 720 30-watt lamps, in addition to motive power. Luna type Nernst lamps have been freely adopted, as 41 of these lamps are in use for the lighting of the chief class rooms, drawing office, science lecture theatre, art room and entrance. Current is supplied from the mains of Willesden Council. The greater part of the wiring is carried out in the Simplex Co.'s screwed brazed tube. The great hall is lighted by five seven-light electroliers carrying 32 c.p. lamps. In the laboratories, electrical workshop, and lecture theatre, special plug points are provided, these being supplied through special distributing boards. The wood-working machines in the carpenters' workshop are driven by Turner electric motors, the starters and main switches being of the Sturtevant type. Mr. Frederic H. Taylor, A.M.I.E.E., of 14, Victoria-street, Westminster, was consulting engineer for the entire scheme.

**Windlesham.**—The Council have decided not to oppose Messrs. Foote & Milne's application for a provisional electric lighting order.

**Wireless Telegraph Ordinance.**—A wireless telegraphy ordinance has been enacted for New Guinea, in which the Administrator is granted the sole privilege of establishing, erecting, maintaining and using stations and appliances for the purpose of transmitting and receiving messages by wireless telegraphy in British New Guinea, or to or from any place or ship outside that possession. Power is given to the Administrator to grant licences for the establishment of stations and appliances for similar purposes on the payment of prescribed fees.

**Woodford.**—The National Provincial Electricity Corporation have withdrawn their application for a provisional order.

**Dinner.**—It has been decided to hold, at the Holborn Restaurant on Saturday, March 10, at 6:30 o'clock, the first annual dinner of electricians who have served on the P. & O. Steam Navigation Co.'s mail steamers. 36 members, all former P. & O. electricians, have already joined the new society (the P. & O. Batti Wallahs Society), and the hon. sec. (Mr. E. Sheppard, 20, Bucklersbury, E.C.) will be pleased to hear from other gentlemen who have not been enrolled.

**Electro-Harmonic Concert.**—A ladies' night concert will be given this (Friday) evening at the Holborn Restaurant, Holborn, London, W.C., commencing at eight o'clock.

# TRADE NOTES AND NOTICES.

**NOW READY.**

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1906 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is even more complete and accurate than in previous issues, and has been revised up to Feb. 12, 1906. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Traders' purposes. The valuable large sheet Tables, &c., have been very carefully revised and extended, making the 1906 Edition of this indispensable work the most complete book of the kind ever published.

A full Digest of Contents will be sent post free on request.

## TENDERS INVITED.

*Manchester* Tramways committee invite tenders for the supply of various stores, including motor parts and accessories, controllers, resistances, fuses, switches, trolley poles, arc and incandescent lamps, telephones, lighting material and bells, insulating material, carbon brushes and carbons, cable, copper, brass and steel wire, overhead line material, oils, lubricants, lamp glasses, globes, porcelain and brown ware insulators, crucibles, rubber goloshes, gloves, &c. Further particulars are given in an advertisement. Specifications, &c., from the general manager (Mr. J. M. McElroy), 55, Piccadilly, Manchester. Tenders (addressed to Chairman of Tramways committee) by 1 p.m. March 3.

*Leeds* Electricity committee invite tenders for one or two sets of electric generating and condensing plant, each comprising a steam turbine, two-phase alternator and exciter of 3,000 kw. capacity, electrically-driven surface-condensing plant, and the necessary pipes and valves. Preference will be given to tenders for plant of British manufacture. Specifications from the manager of the department (Mr. Harold Dickinson), 1, Whitehall-road, Leeds. Tenders to the town clerk (Mr. Robert E. Fox), Town Hall, Leeds, by 10 a.m. April 9. See also an advertisement.

The *Great Central Railway Co.* invite tenders for supply, during 12 months, of various stores and materials, including telegraph materials, asbestos, &c., packing, brass sheets and tubing, glass, hardware, indiarubber, iron and other metals, screws, signal materials, &c. Samples and patterns can be seen on application to the storekeeper (Mr. A. W. Longden), Cornwall-st., Openshaw, near Gorton station, from whom specifications and forms of tender can be obtained. Tenders to the secretary (Mr. Oliver S. Holt), Marylebone station, London, N.W., by 10 a.m., March 6. Further particulars are given in an advertisement.

*Barnes* Urban District Council invite tenders for supply, delivery and erection of one straight-tube type water-tube boiler, surface condenser, feed pump and pipe work. Specifications from the electrical engineer (Mr. C. S. Davidson), Electricity Works, High-street, Mortlake, S.W. Tenders to the Clerk, Council House, High-street, Mortlake, not later than March 12. See also an advertisement.

The Asylums committee of *London County Council* invite tenders for the installation of electric lighting and power (including generating plant) at Long Grove Asylum, Epsom. Forms of tender, &c., from the clerk of the committee (Mr. H. F. Keene), 6, Waterloo-place, London, S.W., after 26th inst. Tenders to the offices of the committee by March 26. Further particulars are set out in an advertisement.

*Edinburgh* Corporation invite tenders for stores for 12 months from May 16, 1906, including arc lamp carbons, cast-iron pavement boxes and pipes, electricity meters, house service fuse boxes and bitumen. Specifications, &c., from the engineer (Mr. Frank A. Newington), 5, Dewar-place, Edinburgh. Tenders to the town clerk (Mr. T. Hunter, W.S.), City Chambers, Edinburgh, by March 12. See also an advertisement.

*Shoreditch* (London) Borough Council invite tenders for stores for one year ending March 31, 1907, including electric cables and sundries, gas pipe and fittings, and engineers' stores. Tenders to town clerk (Dr. H. Mansfield Robinson), Town Hall, Old street, E.C., by 3 p.m. March 13.

*Ilford* Urban District Council invite tenders for the supply of stores for the electricity department during the year ending March 31, 1907, including electricity meters and demand indicators, cables, incandescent lamps, arc lamp carbons and house service fuse boxes. Tenders to Chairman of Council, Ilford, on or before Feb. 26.

*West Ham* Corporation invite tenders for supply of incandescent lamps, cable, single and two-phase alternating-current motors, transformers, alternating-current meters and house cut-out boxes. Tenders to the town clerk (Dr. Fred E. Hilleary) by 10 a.m. March 2.

*Sunderland* Corporation invite tenders for supply of six vestibule cars (double-deck top-cover type) with approved radial trucks. Tenders to Chairman of Tramways committee by noon March 1.

*Sunderland* Corporation also invite tenders for supply of one boiler feed pump, one wooden cooling tower, one surface condenser with motor-driven pumps, coal bunkers, gantry and other steel work; also for extension of Hylton-road station. Tenders to Chairman of Electricity and Lighting committee by noon March 2.

*Londonderry* Corporation invite tenders for supply of materials for the electricity department for one year from April 1, 1906, including carbons, meters and demand indicators, bitumen and box compound, cables, boxes and troughs and house fuse boxes. Tenders to the town clerk (Mr. F. Henry Miller) by noon March 3.

*Wimbledon* Corporation want tenders by noon March 17 for 12 months' supply of stores and materials for their electricity department, including cables, joint boxes, transformers, meters, incandescent lamps, carbons, &c.

*Paddington* (London) Council want tenders by March 3 for 12 months' supply of stores and materials, including electric lamps and shades, lamp columns, lanterns, ironmongery, iron, steel, &c.

*Stockport* Electricity committee want tenders by noon March 1 for 6 or 12 months' supply of coal for the electricity department, and 12 months' supply of ironmongery, iron tubing and castings, &c.

*Stockport* Corporation want tenders by noon March 5 for supply of five double-deck top-covered single-truck tramcars, with electrical equipment.

The managers of *Poplar and Stepney* (London) Sick Asylum, Bromley-by-Bow, London, E., want tenders by 10 a.m. March 13 for 12 months' electrical supplies.

*Croydon* Corporation want tenders for wiring the central fire station for the electric light. Tenders by March 1.

*Lincoln* Corporation want tenders by noon March 6 for water tube boiler and 500 H.P. high-speed engine coupled to c.c. dynamo.

*Dublin* Cleansing committee want tenders for supply of new tramway rails.

*Johannesburg* Town Council desire tenders for supply (free at their stores, Johannesburg) of 350 street lamp fittings, 50 stays for ditto and 600 ft. of gas barrel. Tenders addressed to the town clerk (Mr. John Dove), Municipal Offices, Johannesburg, by March 31. Specifications, &c., may be seen at the offices of the Council's consulting engineers, Messrs. Mordey and Dawbarn, 82, Victoria-street, London, S.W.

## TENDERS RECEIVED AND ACCEPTED.

The Admiralty have placed an order with Joseph Kaye & Sons, Lock Works, Leeds, for 8,100 of their patent seamless serrated oil feeders, and a like number of their patent seamless spouts, for use in His Majesty's naval establishments as may be required. This order is part of a contract which is to extend over the next three years.

Barnes District Council received about 60 tenders for the supply and erection of a 300 kw. steam dynamo, together with switchboard panels and connections. The tenders, which varied in amount from £1,530 (Davey, Paxman & Co.) to £2,443 (Bruce Peebles & Co.) will be considered by the Electric Light committee on Saturday.

Manchester Corporation electricity department have given a repeat order to Bruce Peebles & Co. for Peebles-LaCour motor converters (6,000 to 500 volts, 50 periods, four 500 kw. and five 200 kw. sets).

Birmingham Electric Supply committee have accepted the tender of T. A. Cole & Son for erection of Bordesley sub-station at £8,800, that of T. Johnson for Saltley sub-station at £4,827, and that of J. Dallow & Son for Balsall Heath sub station at £4,884.

Fulham (London) Council have accepted the following tenders (the lowest tender received in each case):—Edward Le Bas & Co. for section A of contract S (steam piping) at £990, Clapham Bros. for section B of contract S (water and exhaust piping) at £1,284. 6s.

Castlerea (Ireland) Rural Council have accepted the tender of James Gordon & Co., 52, Lime-street, London, E.C., for turbine, gas engine and suction plant, forming the complete power equipment of their electric lighting station.

Hackney Borough Council has accepted the tender of Joseph Amos, Kingsland-road, N.E., for the removal of scrap metal from the electricity works.

Durban Corporation have placed orders with W. T. Henley's Telegraph Works Co. for 3,200 yds. h.t. c.c. cable and 3,370 yds. 0·2 in. single cable.

Rand Water Board have placed an order with the British Westinghouse Co. (through their Johannesburg agents, C. C. George & Co.) for electrical plant.

Cardiff Corporation have accepted the tender of J. B. Saunders & Co. for wiring the medical superintendent's house at Whitchurch Asylum.

Weston-super-Mare District Council have placed a contract with the National Telephone Co. for eight fire alarms and posts for seven years at £42 each per annum.

Newcastle (N.S.W.) City Council have accepted the tender of Noyes Bros. for an extension of the municipal electric lighting plant at £2,585.

The tender of the Bromley Electric Light & Power Co. has been accepted for wiring and fitting Bromley (Kent) parish church at about £250.

Brighton Corporation have accepted the tender of the British Insulated & Helsby Cables for telephone cables and that of the Sloan Electrical Co. for arc lamp carbons.

Poplar (London) Council have accepted the tender of the A.E.G. English Mfg. Co. to maintain a minimum of 190 $\frac{1}{4}$-amp. Nernst lamps in the public libraries at 4s. 6d. per lamp per annum.

Hammersmith Council have placed an order with the British Transformer Co. for three Berry controlling boards at £105.

Dartford Council have placed an order with W. H. Willcox & Co. for an oil filter for the electricity works.

The India-Rubber, Gutta-Percha & Telegraph Works Co. have secured a contract for the lighting of Vryheid, Natal.

**A "Tall Order" for Electrical Plant.**—The "Manchester Guardian" on 22nd inst. is responsible for the following:—

> An order has been placed in the United States for hydro-electric plant of 100,000 H.P. for the Rio de Janeiro Tramway & Light Power Co. The order is valued at upwards of £5,000,000.

## BUSINESS NOTICES.

Mr. W. A. Scott and Mr. John Leggat have opened offices at Caledonian-chambers, 102, St. Mary-street, Cardiff, where they have started practice as consulting engineers for collieries, steel works and engineering works generally. Mr. Scott has been for 15 years with Ernest Scott & Mountain, and has been resident engineer for them in South Wales during the past five years, where he has been responsible for carrying out several large installations in collieries and steel works. Mr. Leggat has been chief designer to Ernest Scott & Mountain for the past five years. The new firm are acting in Wales for P. A. Mitchell, of London, who owns the Rateau exhaust steam utilisation patents.

R. J. Nicholson & Co., 26, Cannon-street, Manchester, have been appointed sole agents in Lancashire and district for Hugh Scott & Co.'s electric motors.

## BANKRUPTCIES, LIQUIDATIONS, &c.

A receiving order has been made against A. Parker & Co., electrical engineers, 130, Upper Richmond-rd., East Sheen, Surrey.

A first dividend of 1s. is payable on 28th inst. by Poppleton & Appleby, 3, Barbican, London, E.C., in the bankruptcy of Chas. Vigant Tyge De Falbe, lately trading as the Electrical & General Contracting Co., at 17, Shaftesbury-avenue, W.

Claims against Jas. Wood Smith, electrical engineer, 55, Bolton-road, Darwen, to Mr. C. H. Plant, 14, Chapel-street, Preston, by March 13.

An application for the discharge of Wm. Wenham, electrical engineer, 5, Century-buildings, London-road, Croydon, will be heard on March 13 at the County Court, Croydon.

Application for the discharge of Jas. Stephen Blackwell, trading with Wm. Arthur Charles as the Central Electrical and Engineering Co., 74 and 111, Church-gate, Leicester, and 22, Kennington-rd., London, S.E., will be heard on March 7, at Bankruptcy-bldgs., London, W.C.

Claims against "Everyday Electricity" Publishing Co. (Ltd.) to Mr. H. L. Price, 15, Fountain-street, Manchester, by March 3. A meeting to receive an account of the winding up will take place on March 16, at 15, Fountain-street, Manchester.

Claims against Nernst Electric Light (Ltd.) to Mr. M. Levinger, 5, London Wall-buildings, London, E.C., by March 15.

The Taunton & West Somerset Electric Railways & Tramways Co. (Ltd.) is being wound up voluntarily. Mr. P. N. Gray is liquidator, with authority to enter into an agreement with Taunton Electric Traction Co. (Ltd.)

The Electric Works Co. (Ltd.) is being wound up voluntarily. Mr. D. L. Chalmers, 12, St. John's-lane, Liverpool, is liquidator.

A meeting will be held on March 24, at 66, Victoria-street, London, S.W., to receive an account of the winding up of the Pioneer Electric Supply Co. (Ltd.) (in liquidation).

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**Plant for Sale.**—Mr. John S. Brown, Oxford-street, Swansea, has for sale electric lighting plant. See an advertisement.

Messrs. White Bros. & Co., engineers, Stratford, London, E., have for sale some electrical plant, particulars of which are set out on another page.

Some electric lighting plant (consisting of a Cochran boiler, pair of Browett-Lindley engines and Elwell Parker shunt-wound dynamo) is advertised for sale by the Colosseum Theatre, Oldham.

**Catalogues.**—An illustrated export catalogue for stationary batteries of the Tudor type has been issued by the Tudor Storage Battery Export Synd., 35, Surrey-street, London, W.C. The aim in preparing this catalogue has been to supply data to intending purchasers abroad in order that they may be in a position to prepare precise estimates and other preliminary work connected with Tudor battery plants without previously referring to the makers. Detailed specimens of all parts connected with Tudor batteries and technical data concerning the same have been provided, and for the convenience of ordering cells and accessories from abroad code words for all types of cells are included. The weights and measurements given are expressed in English and metric equivalents. The frontispiece shows a large Tudor cell supplied to Stockholm electricity works. This cell has a capacity at five-hour rate of discharge of 11,624 ampere-hours, the output for one hour being 7,104 amperes, and the charging current 3,456 amperes. A good selection of illustrations is given, which include the usual accessories used in connection with storage battery installation.

Single-pole, double-throw, slow-break knife switches form the subject of catalogue No. 72, just issued by Ferranti Limited, Hollinwood, Lancs.

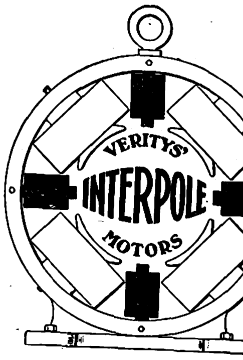
An excellent pocket list dealing with the special manufactures of the Consett Iron Co. (Ltd.) of Consett, co. Durham, has been published, and contains, besides particulars of these manufactures, a large number of tables and other matter interesting to those engaged in the manufacture of heavy machinery and other plant, &c.

Flexible couplings are listed in a catalogue issued by Bergtheil & Young, Camomile-street, London, E.C. These couplings are the latest development of the "Rafford" type of flexible coupling. In the list directions are given for calculating the size of coupling required in varying circumstances, and tables of dimensions of standard coupling, flywheel coupling and reversible coupling are given (in millimetres).

A list of leather beltings and other leather goods has reached us from Peter M'Intosh & Sons, 129, Stockwell-st, Glasgow.

Those of our readers who are interested in the subject of photography will find a novel newly-patented form of tripod camera stand described in a catalogue which has been prepared by Mr. W. Butler, 20, Crosby-road, Birkdale, Southport.

The "Aston" interpole motor, the "Cyclax" slow-motion starting switch, and the "Peard" patent fuse (new and improved switchboard type) are listed in sheets Nos. 520, 521 and 522 respectively issued by Veritys Limited. The "Aston" interpole motor, which is illustrated herewith, is claimed to be the latest development of the direct-current electric motor. This motor runs from no load to heavy overload in either direction with fixed brush position and generates the magnetic field necessary for the commutation by means of small poles placed in the neutral line of the main field, with the result that commutation is independent of the strength of the main field. This enables the magnetic field to be weakened within very wide limits, and provides an increase of speed in the ratio of 1 : 4 or 1 : 5 to be easily obtained by shunt regulation. The brushes being always in the neutral line, the interpole motor can run in either direction with fixed brush position, making it especially suitable for crane work and in all positions where reversible motors are required.



**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Feb. 14 to Feb. 20, with the ports of destination :—

*Aden*, £81. *Africa*—Alexandria, £25; Cape Town, £178; Delagoa Bay, £670; Durban, £1,572 (including £1,197 telegraph material); Mozambique, £10 (telegraph material); Port Said, £10; Port Elizabeth, £988. *Argentina*—Buenos Ayres, £1,243. *Australasia*—Auckland, £130; Brisbane, £2,312; Launceston, £24; Melbourne, £12; Otago, £40; Perth, £17; Sydney, £266; Townsville, £80; Wellington, £262 (including £128 telegraph material). *Belgium*—Ghent, £50; Ostend, £70. *Brazil*—Rio Janeiro, £8 (telegraph material). *British Guiana*—Berbice, £10; Demerara, £10. *Burma*—Rangoon, £331. *Ceylon*—Colombo, £69. *Chili*—Valparaiso, £134. *China*—Shanghai, £14,052 (including £14,000 telegraph cables). *Denmark*—Copenhagen, £22 (telegraph material). *Dutch Guiana*—Surinam, £31. *France*—Boulogne, £157; *Germany*—Stettin, £566. *Gibraltar*, £98 (including £51 telegraph material). *Holland*—Amsterdam, £50; Rotterdam, £45. *Hong Kong*, £32. *India*—Bombay, £4,908; Calcutta, £1,795 (including £345 telegraph material); Madras, £351; Marmagoa, £113. *Japan*—Kobe, £110; Moji £79; Tokyo, £655; Yokohama, £1,105. *Malta*, £1,910. *Portugal*—Lisbon, £32; *Peru*—Iquique. £11. *Russia*—Odessa, £30; Reval, £115; Riga, £574. *Straits Settlements*—Penang, £44 (telegraph material); Singapore, £298 (including £52 telegraph material). *Sweden*—Gothenburg, £18. *U.S.A.*—New York, £264. *West Indies*—St. Thomas, £41; Trinidad, £6. Total, £36,114, against £54,298 in the corresponding week last year (Feb. 15 to 21).

## COMPANIES' MEETINGS AND REPORTS.

### Charing Cross, West End & City Electricity Supply Co. (Ltd.)

The annual general meeting was held on Monday, Mr. William Francis Fladgate presiding.

The SECRETARY (Mr. Edward Wilmot Seale, F.C.I.S) having read the notice convening the meeting,

The CHAIRMAN said: I should like, before commenting upon the accounts, to refer to the two paragraphs of the report which deal with the City undertaking net revenue account. I am afraid that the impression made upon many of our shareholders and the public by the statement in the report is that the City undertaking has, during the past year, been deficient in earning the dividend on its preference shares by a large sum of money, and I must admit that, except to the accountant, that is an error which may be easily pardoned. As a matter of fact, the earnings of the City undertaking this year have been sufficient to pay the whole of the dividend on the City preference shares with the exception of £2,373. The net revenue was £43,742, which was sufficient to pay £20,000, the interest on the debenture bonds, £8,015 interest on temporary loans, and leave a balance of £15,723, applicable to the payment of £18,000, the dividend on the preference shares. Therefore the deficiency is really £2,272. Turning to the state of the Company generally, and to the work which we have been doing, it is naturally with feelings of regret that we have felt bound to give you a dividend at the rate of only 5 per cent. per annum. But, speaking from this chair on more than one occasion, I have stated that I feared that the result of undertaking the work in the City would be sooner or later that we should be obliged to reduce our dividend, and that all we could do was to do our very utmost to keep it up as long as possible. Notwithstanding that drop in our dividend, I may tell you, perfectly frankly, that I do not regret for the moment our having taken powers to supply the City of London. I feel confident that, had we not done so, and had we not increased our area of supply, we should have found ourselves in a by no means satisfactory position, so that I in no way regret the course which my Board, with my full and unabated concurrence, took when some years ago we obtained that order. Now, the reason of the drop in the dividend is really obvious. It was absolutely impossible, in dealing with a large area like the City, that we could gauge to a nicety the exact amount of expenditure which would be equivalent to the exact amount of work which could be done and of profit that could be earned. I think we have done exceedingly well. There is one other matter which we had in consideration when we designed the Bow station and put down the mains. It was this: that under our act, which we obtained to enable us to run the mains from Bow to the City, we had power to supply, if they would take our energy, certain of the local authorities. We thought at that time that it was not at all unlikely that those local authorities would come to us for a large amount of power. They have not done so, but we could not help it. If they had we should have been supplying and getting a profit on money which at present is unproductive. This unproductive money is no less a sum than £350,000 to £370,000. The buildings are there, the machinery is there, the mains are there, and we are in a position to at once give that supply, and to illustrate the necessity for having put ourselves into this position, I might instance how that two years ago, for practical purposes, we had come to terms with one of the railway companies electrifying their system to supply them with a large amount of energy. We quoted a price and they accepted it. The whole matter was complete as far as the engineers could go, and as far as the two offices could go. We were satisfied with the terms, which would have very appreciably helped our dividend, and they were satisfied that we should supply, but the difficulty arose as to whether legally we could supply the current, and, unfortunately, I was obliged to advise my Board to get better opinion than my own to confirm that opinion that we had no legal powers to supply a railway company, as they were using the current outside our provisional order, so that fell through. That result was due not owing to any want of power on our engineer's part, but it was simply that we had not the Parliamentary powers. Incidentally, I may say, in a matter upon which I shall speak hereafter, the bill we are now promoting is for the express purpose, among others, of giving us that power. Then, the second reason for the dropping of the dividend is this—that although business has been moving, and we have been making progress, there has been competition all round, and the fact that the public are beginning to understand electric lighting, and to economise in the use of it by efficient control, has had a disastrous tendency—first, in the price we could obtain, and, secondly, in the profits we could get out of the price which had been obtained. In many cases, too, customers are hanging back because they think that under the new power schemes they will get their current at a cheaper rate hereafter. The revenue from the sale of current in the last five years, shows there is a continuous satisfactory progress. In the West End undertaking, in 1901, our revenue from sale of current, &c., was £102,700. In 1902 it rose to £119,000. In 1903 there was a drop, for it went down to £113,000, but in 1904 it recovered itself again to £125,500, and in 1905 it came up to £130,733. The City undertaking figures, are, I think, even more encouraging. We started in 1901 with a modest sum of £9,824, on which year we made a loss of £776. In 1902 we mounted to £28,537, and in that year we made a profit of £4,600. In 1903 we rose to £57,700, with a profit of £21,000; in 1904 to £80,868 with a profit of £33,000; in 1905 to £95,340 with a profit of £41,000. Now, I really think those figures speak for themselves, and I think we may say they show a regularity, and healthy increase as far as the City is concerned if we omit the second year of this undertaking. As soon as we have made sufficient progress there should be a dividend on the whole of the capital of the City undertaking. We have added in the West End district, 43,622 lamps, bringing our total up to 453,285, and you will see from the report that of that a very considerable amount is now being supplied to motors. Of the 453,285 8 c.p. lamps, 103,655 represent motors. We think that the increase is satisfactory, and there are areas which are not now by any means fully occupied by buildings—the new streets of Aldwych and Kingsway—which are hardly yet touched, and which we hope will be a fruitful source of profit in the future. Turning to the accounts, we have written off £36,419 from the depreciation account of the West End undertaking. Then with regard to the other items of expenditure during the past year, the only important one on capital account is £21,000, which has been spent on mains, and that has been principally employed in the ordinary normal increase of business of the Company, particularly in laying down mains in connection with what I have already referred to—Aldwych and the Kingsway, in the lighting of which we hope to get a share in the near future. The balance of capital, £336,000, is, as has been often explained to you, used in the City undertaking. In the revenue account, there are not many items with which I need trouble you. The cost of our coal per Board of Trade unit has decreased 0·11d., almost exactly the same decrease as last year, and we think it is quite satisfactory. The actual money saving on the West End undertaking is, in round figures, some £2,000. We have carried £11,000 to depreciation, and £48,647 to the net revenue account, and the latter sum is dealt with as proposed. On the credit side of the revenue account sales of current have increased by £4,900. The only other item to which I need call your attention is the item in the share premiums account of £3,665. 13s. 9d. which represents the cost in relation to the promotion of our bill this session and opposition to the other bills in Parliament. The share premium account is in the nature of a capital account. We are not allowed to use it for any purposes of income, but under the advice of our auditors we have thought that it is a fair account against which we may write the very heavy expenses of opposing the bills of last year and of promoting our own bill. Our reserve still amounts to £194,900, which we think is quite sufficient, and is a very healthy amount to have as a reserve. Passing to the City undertaking, on the capital account during the past year there has been a total expenditure of about £72,000, the bulk of which, £50,000, has been laid out in building the Bow station, which is being gradually brought up to a capacity of 800,000 lamps. That gives us a very large margin. It is 600,000 lamps now, and will shortly be 800,000, when a small amount of remaining expenditure has been made upon it. The revenue account of the City is, I think, exceedingly satisfactory. The receipts have increased by no less than £13,700, being £92,210, as against £78,431 last year. The coal, as I before mentioned, is quite satisfactory, there being actually a saving of £2,384 on it. The net balance, as I say, is sufficient to meet the whole of the dividends on the preference shares with the exception of the £2,273 which I have already referred to. You probably will say that at present we have made no provision for depreciation in the City undertaking. That is perfectly true. We have not made it, and for two reasons. First, in our opinion the plant is absolutely brought up to date, and secondly, depreciation has got to be considered particularly in regard to the possibility of the business being taken over by the local authority, either at the end of the term or, in regard to the City undertaking, in 1913, but, if taken over in that year under our provisional order what we are entitled to receive is not the ordinary breaking up price which is provided under other provisional orders, but is absolutely the expenditure we made on the City undertaking, plus 10 per cent., and plus 4 per cent. if we have not earned 4 per cent. during the intervening years. Having regard to this we do not, at any rate at present, think we need make any depreciation in the City undertaking. After referring to the various power bills to come before Parliament and their probable effect upon the Company's business, the Chairman said: I should like to speak to the indefatigable industry of Mr. Seale, our secretary, and to the very great capability of Mr. W. H. Patchell, our engineer. I am glad to find that his services are again called in aid by the Board of Trade, who asked him to help in drawing up regulations before, and who, in asking for his aid again, are speaking of the high services he rendered to them. I now move the adoption of the report and accounts.

Mr. JOHN M. GATTI seconded the motion.

Mr. LAWRIE asked whether, with the means they already had, a very large additional number of lamps could be added, when required, without a great deal of capital expenditure? He also desired to know whether the competition was keener than before, and whether the amount which they saw due to the Charing Cross Co. was repayable to the parent Company after the interest was paid on the 4½ per cent. preference. He congratulated the Board on the enormous amount of work they had done in bringing the undertaking to its present state, and thought they could all look forward to the future without any misgiving whatever.

Mr. J. SQUIBB said that there was one thing in the accounts about which he desired information. A large sum was paid—he thought it was for energy in bulk. If the Company had all the ordinary and necessary machinery, &c., for generating more than they were at present called upon to supply for lighting purposes, why was it necessary to buy such a large quantity in bulk?

Mr. P. E. PILDITCH said, having regard to the competition of gas he desired to ask the Chairman whether he could give them some idea whether there was to be any further expenditure, and tell them what anticipations the management had made as to the demand coming up to their expectations when they made the expenditure on the City Co.?

Mr. W. A. MOORE said the amount for depreciation, £11,000, seemed to him to be very small. At one of the stations the Company had made alterations in machinery which had cost them £36,000, and they had taken from depreciation account previously £73,000—practically half on one station. Clearly £11,000 a year was not sufficient for the number of stations. In regard to the share premium account the auditors' advice was bad. The Board told the shareholders that they were going to Parliament again this year, and he presumed that they would have the same expenses again. Evidently with all the bother in London over electric supply the cost of opposition was an annual event and ought not to be taken from the share premium account.

Prof. AYRTON said they would all be very much reassured if the Chairman could give them some idea of what he thought was going to happen which would enable the Company's shares to regain something like the value on which the Company itself issued them to its shareholders.

The CHAIRMAN (in reply to the above and other questions) said: It is difficult to say exactly how many lights we expect to get further in the City, but we do rely with considerable confidence on getting a very much larger supply there to come upon our mains than we have at the present moment. We believe there is a very large area in the City not yet supplied with electric light, and when those persons who have not got it take to electric lighting we shall receive a dividend on our ordinary shares in the City undertaking, and shall be bringing back the dividend of the whole Company to the proportions which are longed for no less by you than by us. We shall then be in a position to make available for earning purposes that expenditure which has been made with the greatest care and is, at the present moment, lying idle. With regard to depreciation, we have seriously considered the question from time to time, and have come to the conclusion that £11,000 is sufficient for our purposes. The writing off of £36,000 is really the capital expenditure on that station which has gone out of use. We have put it at the most drastic figures we possibly could in order that there might be nothing which could be said in our accounts that we had not treated the matter with the greatest care we could possibly apply to it. One other question was: "How is it that notwithstanding the fact that there is an increased consumption of current in the West End the results are not so satisfactory?" The answer is a very simple one. It is decreased prices and competition with gas. We are dealing with this matter in the best way we can, and we do not think the results are unsatisfactory. As to the question about the purchase in bulk. We are obliged to keep the City undertaking and the West End undertaking accounts separate, and for economy of working we find it much best to buy for the West End undertaking a certain amount of current from the Bow station when further current is wanted in the West End, and similarly the City buys a certain amount from the West End for dual supply. To theatres we give an absolute dual supply, and that is the cause of our being able to get a certain amount of that work. One of the purposes for which we have our business is to show that we have actually two independent, but adequate stations, and the effect is that we can get a dual supply absolutely independent of the risk of fire or injury to station. It is more economical to work occasionally from one station and then from another, and thus there is interchange of current.

The motion was then carried unanimously, as were also resolutions approving the declaration of the dividends set out in the report, the re-election of the retiring Directors and auditors, and the remuneration of the Directors for the past year. A cordial vote of thanks to the Chairman terminated the proceedings.

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## London Electric Supply Corpn. (Ltd.)

The ordinary general meeting was held yesterday under the presidency of Mr. Robert H. Benson.

The SECRETARY (Mr. H. C. Carter) having read the notice calling the meeting and the certificate of the auditors,

The CHAIRMAN, in moving the adoption of the report, said: I shall leave to the managing director the task of dealing with details of generation and distribution and sale of current, confining myself to the financial points and broad questions of policy. The accounts show that, whereas nine years ago we sold 2,279,000 units, we last year sold 13,000,000 units; that the cost of the unit has gone down in the nine years from 3·55d. to 0·95d., or under 1d.; that the gross revenue has increased in the same period from £50,000 to £130,000; that the net revenue has increased from £16,570 to £78,721; and that the capital expenditure—which is a very interesting thing to put side by side with increase of net revenue, because the increase of net revenue is the only ultimate test of the legitimacy of the capital expenditure—was in 1897 £800,000, while last year it was £1,065,000, whereas, as I just said, the increase in the same period in net revenue has been from £16,570 to £78,721. Our power business, as distinguished from our lighting business, began in a small way in 1903. Now 59 per cent. of the units sold by us in the past year were sold for power as distinguished from lighting. In power supply our future lies, as you well know. We are prepared to meet any demand for power in our area as it arises; we have no desire to poach on any of our neighbours' areas as defined by Act of Parliament, but we shall strenuously defend our own. Coming to figures, last year we earned rather over 10 per cent. on our capital and paid 3 per cent. on the ordinary share capital, placing the balance to reserve, whereby our reserve account was made up to £25,000 and a contingency account was started of £5,000. This year we have earned rather over 13 per cent., out of which we propose to pay a dividend of 4 per cent. Moreover, after paying £1,946 of exceptional Parliamentary expenses, which we were put to last year, we propose to double both our reserve and contingency accounts, and leave them at £50,000 and £10,000 respectively. Finally, we carry forward £3,141 against £2,000 brought in. These results have been accomplished in the face not only of increasing competition, but of decreasing prices. We have no less than 11 different competitors within our area, of whom two are borough councils. Our rates this year are being raised; in fact, our assessment henceforward is to be on £25,000 a year, as against £8,000. Part of this huge increase goes into the pockets of borough councils to assist them in competing with us. In each of those cases we have offered to do their electric lighting business cheaper than they are doing it for themselves, but they have not accepted our offer. Some of you may wonder why we have felt it to be our duty to make such liberal provision for reserves, and may think that we might have spared another £3,000 and have paid a dividend of 5 per cent., instead of 4 per cent. · Those who urge that are entitled to refer to past sacrifices—that we had no dividend on our ordinary shares for 18 years, from 1887 to 1904, and that we have written down our capital by no less a sum than £227,000, making our ordinary shares £3 each instead of £5. These sacrifices fell to your lot because you were the pioneers in electric lighting in London. Those sacrifices, I may say, are constantly in the minds of your directors, and our great object is to retrieve them. The only way, in our opinion, to do that is to pile up our reserves now that at last we have got profits to do it with, to strengthen our position both physically and financially, to husband our resources, and improve our credit. Reference is made in the report to the London County Council's power contract and to other large power contracts being in progress. The negotiations for what I may say is the largest and most important power contract that has ever yet been let in the City of London are nearly completed. I had hoped to be able to make a definite announcement on that subject to-day. Though the agreement has not yet been signed, we have reason to believe that we are agreed with the other side on all points. When the agreement has been completed we shall make an issue of capital to provide the new plant which will be required. This will be offered to the shareholders, and I hope by the time the dividends are sent out we may be able to accompany them by a circular giving particulars of what I am unable to state to-day as to the terms of this contract to which I refer. You will see that we have renewed our contract with the London County Council for another three years from the date of the expiry of the present contract. That contract has not yet expired, and for the present they are taking more power from us than ever. Whenever their own generating station is ready they will take less, but we shall not lose them as customers for three years, and, perhaps, not even then. The fact is that we possess at Deptford the station where power can be generated cheaper than anywhere else in the county of London. That is the strength of our position. We are ready to sell power to-day at ¾d. per unit to any large and regular customer who will give us a sufficiently good load factor. Indeed, we will sell power at ½d. per unit to anyone who will keep our power running for 24 hours per day. Our total cost of production for 1904—that is, including the costs of distribution, management, rates and taxes, and everything—uponsales of 10,500,000 units was 1·21d. per unit against an average of all the London companies of 1·76d. I give you these figures to prove my statement that we have at Deptford the cheapest point of production. For 1905, upon sales of 13,000,000 units, our total cost is down to 0·95d.—under 1d.—which is the lowest of any company in London, while our works costs—that is to say, the generating costs only, without rates and taxes, distribution costs, &c.—is 0·62d. per unit sold, and our works costs per unit generated is under ½d. Whenever we get to selling power wholesale and reach sales of 20, 30, 40, or 50 million units, we shall cheapen our cost of production indefinitely and be able to supply the public at lower prices too. For the results so far achieved I want publicly—and I feel sure you will join me—to express our debt of gratitude to our managing director (Mr. Stewart Bain), to our chief engineer (Mr. Partridge), to our consulting engineer (Mr. Burstall) and to all the rest of the staff. Referring to the proceedings in Parliament last year, the chairman said: Nothing but an accident prevented the passing of the Administrative County of London Bill, and the pressure at the last was so great that we and every other company had to make terms with the invader. Fortunately the session closed before the bill could pass. The same bill is, however, coming up again this year, and two others of the same sort. We have got to have the same fight over again, but we are much stronger now. We can already supply power at ¾d., while they can only promise it in three years. The total present capacity of our station is 10,000 kw. The maximum use that we made of that plant at any one time last year was 6,000 kw. We have at present a load factor of only 26 per cent., which we hope to increase. We have, as you know, promoted this year a bill of our own. It is in our view of a non-controversial character, and is designed merely to give us the same powers which the Board of Trade have already intimated ought to be granted, and for which they themselves promoted a bill last year in the House of Lords. There was a time when we only sold 52 per cent. of the units we generated. We have now got up, last year, to selling 89 per cent. of the units that we generated. That is an extraordinary proportion, but science has still economies in store for us. I believe that, if Parliament gives us a fair chance and does not take away our heritage, what we have achieved in the last four years is only a small part of what we ought to achieve hereafter. I now move the adoption of the report and accounts.

Sir WILLIAM H. PREECE, K.C.B., F.R.S., seconded the motion.

In the course of a brief discussion, gratification was expressed at the progress of the company. A resolution was passed inviting the directors to resume the fees of £2,000 a year to which they are entitled by the articles of association (in place of the £1,000 a year which they had been voluntarily taking).

Resolutions approving the declaration of the dividends set out in the report, the re-election of the retiring directors, and the reappointment of the retiring auditors having been passed,

An extraordinary general meeting followed, at which the resolution passed at the meeting on the 1st inst. approving the company's bill in Parliament was confirmed.

A cordial vote of thanks to the chairman and directors terminated the proceedings.

## National Telephone Co. (Ltd.)

The thirty-seventh ordinary general meeting was held at Hamilton House, Victoria Embankment, E.C., on Thursday, Sir HENRY FOWLER, M.P., in the chair.

The SECRETARY (Mr. Albert Anns) read the notice convening the meeting.

The CHAIRMAN, in moving the adoption of the report, dealt first with the financial aspect of the company for the half-year, and pointed out that the income amounted to £1,125,978, an increase on the corresponding half of 1904 of £92,272. The Post Office royalty had increased from £95,195 last year to £105,866. They had paid in royalties since the original first licence was granted in 1881 over £2,000,000. He thought the true position of the company was best realised by dealing with the figures for the year as a whole, and if they did this they found that while the gross income of 1904 was £2,019,000, that for 1905 was £2,212,000 showing the satisfactoy increase of £193,280. For the same period the Post Office royalties were £256,504 being an increase of £20,000. The profit for the year was £730,743, against £678,346, and their reserve fund had been increased from £1,503,410 to £1,912,475. The number of their stations had been increased from 315,829 to 362,413, and the staff employed had risen from 13,844 to 15,702. The number of messages carried in 1904 was under 1,000 millions, and last year it was 1,053 millions. They would appreciate the significance of these figures when they learned that the number of inland telegrams sent through the Post Office in the same period was 88,000,000; so that the telephonic service was doing more than the postal telegraphic service. It should also be stated that the average rate per exchange telephone message was a fraction under ½d. The growth of their business in London had been remarkable. When the Post Office came into competition with them they had 47,053 stations, but now, although the Post Office had no fewer than 30,919 subscribers. the stations under the control of the National Telephone Co. had increased to 72,860, proving, as he had always urged, that there was ample room in Lonpon for a much larger telephone supply than existed at present, Having referred to the conditions of the agreement arranged for the purchase by the Post Office of the telephone undertaking in 1911, Sir Henry expressed gratification that a clause had been inserted granting liberal terms to their employés when the company came to an end—(hear, hear)—it being arranged that their officers and servants should enjoy the advantages and be subject to all the conditions of rank and grade as though they had been all along in the service of the Post Office. This undertaking did not, however, apply to officers of the company in receipt of salaries of £700 per annum or upwards. As regarded the limited number of the staff to whom the Postmaster-General's undertaking did not apply, and others not coming within that undertaking, the board proposed to forthwith establish a fund from the revenues of the company, applicable, in their discretion, to compensation in these cases. Then the question arose what were they to do as a company during the next six years? A telephone undertaking was one that could not stand still; if they did not go on they must go back, and it would be their aim when 1911 arrived to be able to knock at the door of the Post Office and hand over an undertaking which had improved between 1904 and 1911. The directors were fully determined to keep the concern up to date; they would not allow it to go down in a single department. Therefore, immediately the House of Commons sanctioned the agreement, they sent their general manager (Mr. W. E. L. Gaine) and their engineer-in-chief (Mr. F. Gill) over to America, to ascertain the most recent improvements in telephony in the United States. They had received a confidential report from these gentlemen which would be of the greatest value to them. Some people said that England was the worst country in the world in the matter of telephone supply. This was not so. We were not the best, we were the second best; and he would like to bring to their minds a contrast which was exceedingly instructive. Greater London had a population of 6½ millions; New York and greater New York a population of 5½ millions. Now, the number of telephone stations in London was something over 100,000. In New York, with a million less in population there were 280,000; in other words, nearly three times as many as in London, although he might say that the service in New York was not as cheap. The keeping of the service up to date would involve the expenditure of fresh capital, but the directors would take care that only reproductive expenditure should be undertaken. Having said so much concerning the company, he had to announce that, as he had accepted office in His Majesty's Government, he felt obliged to retire from the directorship of the National Telephone Co., and he asked the shareholders' assent to the proposition that during the period he had been associated with the board their interests had been carefully safeguarded. Taking the last five years alone, the capital had risen from £7,000,000 to £9,500,000, and the expenditure on capital account from £8,096,000 to £11,830,000, an increase of £3,750,000. Their reserve fund had risen from £883,000 to £1,912,000, entirely taken out of the profits of the company. The number of stations was, in 1900, 200,000; to day it was 362,000. The number of the staff was then 10,000; it was now 15,700. Their gross income for the year was in 1900 £1,432,000: it was now £2,212,000: while the Post Office royalty had risen from £140,000 to £206,000. As he had said, future expenditure on capital account would be only on reproductive undertakings, so that they might stand well when 1911 came. They could not have their cake and eat it too (laughter).

Mr. GEO. FRANKLIN seconded the adoption of the report, and expressed regret that Sir Henry Fowler was obliged to retire from the chairmanship of the company. He bore testimony to the diligence and assiduity with which he had discharged the duties of his office.

Mr. LEA SMITH, on behalf of the shareholders, also expressed regret at Sir Henry's withdrawal from the board. It would be unbecoming for him to say more about a Cabinet Minister; but, speaking as a Conservative, he felt they had, at any rate, one reasonable man in the Government (laughter).

Mr. HASTIE, as one who had given the general manager, Mr. Gaine, considerable trouble, bore testimony to the efficiency of the telephone service, and spoke of the advantages they had derived from private control. If they had been in the hands of the Post Office they would not have got the all-night service which was a great boon, especially to residents in the country, and was of great utility in other cases.

The report was adopted, as was a resolution declaring the dividends on the various stocks, and Mr. Franklin submitted a series of propositions giving power to the directors to issue ordinary shares to the extent of £6,000,000 and to convert these shares into stock.

A SHAREHOLDER hoped the new shares would be offered to the shareholders of the company.

Mr. FRANKLIN said the present intention of the board was to go to the shareholders.

On the proposition of Col. OTLEY PERRY, seconded by Sir THEODORE FRY, a very hearty vote of thanks was accorded to Sir Henry Fowler for the services he had rendered as chairman of the company.

## Buenos Ayres Grand National Tramways Co. (Ltd.)

An extraordinary general meeting of the Buenos Ayres Grand National Tramways Co. (Ltd.), was held on Monday, Mr. J. IRVING COURTENAY presiding. The business of the meeting was to consider a resolution approving a bill to be presented to Parliament intituled the Buenos Ayres Grand National Tramways Co. (Ltd.) Bill.

The SECRETARY (Mr. Fortescue Thursby) having read the notice calling the meeting,

The CHAIRMAN said the object of the proposed bill was the reorganisation of the company's capital. He might point out that without an Act of Parliament there was no means by which, within the present company, they could capitalise the arrears of preference dividend, which capitalisation must, they thought, form an essential part of any reasonable scheme that could be presented. They could accomplish the same result by a reorganisation or reconstruction, accomplished by means of the sale of the company's entire property and undertaking to a new company, the new company issuing capital not only in respect of the principal of the shares of this company, but also in respect of the arrears of dividend thereupon. Such a reconstruction, however, would involve great risks and enormous expense. We are advised that we cannot apply to the Court without first going into voluntary liquidation, which would make the whole of our debenture debt fall due and involve arrangements with our debenture holders, which we can avoid under our present plans. It is extremely difficult to say what effect the first-named course might not have upon our position in the Argentine, involving as it would the liquidation of this company. Finally, the expense of carrying out such a transaction, with the heavy stamp duties payable on the formation of the new company, and on the transfer of the properties to the new company, would be quite prohibitive. After full consideration, therefore, of the alternative, the directors have decided to proceed by bill in Parliament. There is a suggestion that this bill is premature, but in our view that is not so. It is intended that the changes proposed by the bill shall come into effect as from April 1 next—from the close of our current financial year. By that time we expect to have about one-half of our joint system completely electrified. I take it that it is everyone's wish, and especially of the preference shareholders, that we should begin payment of dividends on the preference shares at the earliest moment, and, after taking into account the returns which we have received from Buenos Ayres of the results of electrical working, and forming the best judgment we can, we believe we are justified in estimating that the profits of our next year's working—that is, from April 1, 1906, to March 31, 1907—will enable us to pay a dividend on the new preference shares which it is proposed to create. We think, therefore, we should be blameable, and incur the censure of the shareholders, if we left the company for one moment longer than necessary in its present disorganised condition in regard to its capital account. It is never possible to carry into effect a scheme of this kind without a certain amount of give and take between the different classes of shareholders. What the directors had to do was to set themselves to devise a scheme which they honestly consider to be in the interests of the company as a whole, and to be fair to every individual class of shareholders. In the circular we have issued we have set out at length the reasons why we consider our present proposals fair to the preference shareholders. I would repeat that we as directors, hold a very considerable stake in this company, distributed between all classes of shares, but, if anything, we have the greatest personal interest in the preference shares. The crucial point of the whole scheme, and probably the only one which will give rise to any controversy, is the question of the capitalisation of the arrears of dividend, and the mode by which such capitalisation is proposed to be carried into effect. I do not think anyone can quarrel with our proposals in this respect. The effect of our scheme is that, in lieu of a share which at present gives the holder a claim, large no doubt, but inevitably postponed for some years, against the future profits of the company, and which, even when the losses have been made good, it will take years to satisfy out of the annual profits of the company, it gives him first a new preference share—which, we believe, will begin to earn a dividend as from April 1, 1906, and will pay it regularly from that date—and, secondly, it gives him the whole of his arrears of dividend in a lump sum in marketable form, which he can realise on the Stock Exchange within a very few months after the issue is made. It also gives him, if he desires to retain his ordinary shares, as doubtless the great majority will do, an interest representing to the preference shareholders as a class more than one-half the entire reversion to the profits of the company. This is so far as the first preference shares are concerned. As regards the second preference they also are called upon to make some sacrifice, inasmuch as they surrender the whole of their arrears of dividend. But they receive £120 for every £100 of capital in common with the first preference shareholders, and are also put up into the front rank. As regards the ordinary shares, there is an important change: by the capitalisation of the arrears of dividend on the preference shares, instead of owning the entire reversion of the company, their interest is reduced to less than one-half. As regards the debenture-holders, all that the bill does is to pave the way for dealing with the debentures in the future. There is no absolute necessity for Parliamentary powers to enable us to deal with our debenture-holders, and, that being so, we do not wish to unnecessarily complicate the present measure. We have, however, made provision for the issue of an additional amount of preference shares, which will be fully sufficient to enable us, when the proper time comes, to absorb therein the existing issue of 6 per cent. debentures and income bonds, thus removing a large sum from in front of the preference shareholders. Later on it will no doubt be practicable to effect another consolidation which has been foreseen, and for which provision has been made—namely, the absorption of the prior lien debentures into the conversion debenture stock, so that when the scheme which we have in mind is fully carried into effect, there will be only three classes of securities in the company—first, conversion debenture stock; secondly, preference shares; and thirdly, ordinary shares. The chairman then explained a few modifications, the result of negotiations between the directors and some of the principal preference shareholders which had been agreed to since the directors' circular was prepared. He (the chairman) was advised that there would be no difficulty whatever in introducing these modifications into the bill. He then put the resolution, which was seconded and carried by 32 votes to 13.

The CHAIRMAN demanded a poll.

Other meetings of shareholders followed, at each of which it was necessary to take a poll. The results of the poll were declared as follows:—First meeting, 77,416 votes for the bill, 2,229 against; second meeting, 22,241 for, 5,183 against; third meeting, 13,721 for, 100 against; fourth meeting, 9,753 for, 100 against; fifth meeting, 31,598 for, 136 against.

The solicitor then declared that the resolution was carried by more than the necessary majority.

## Metropolitan District Railway Co.

The chairman (Sir GEORGE GIBB), at the meeting on Tuesday, said he saw with the eye of commercial faith beyond the difficulties of the initial introduction of electric traction, beyond the troubles and the discouragements of a transition period, which was bound to show adverse results, and saw a great future for the company's undertaking. They had a steep hill to climb, but they must face it with courage and determination. Doubtless every effort had been made to introduce the new form of traction with the minimum of inconvenience to the public, and quite recently there had been an undoubted improvement. Not only had the installation of automatic signalling been opened from Earl's Court to the Mansion House, but a substantially increased service of trains had been put on. The failures which were bound to occur for a time after the trains first began to work showed a tendency to become fewer in number. He trusted that with the assistance of the general manager (Mr. John Young) and the other officers of the company, they might shortly improve the train service and get into smoother working. Their success could only be based on punctual, reliable, adequate and satisfactory train service, which would attract the travelling public.

Mr. R. W. PERKS, M.P. (deputy-chairman) in moving the adoption of the report and accounts, said that during the last half-year they carried a record number of passengers. In 1901 they carried 7,824,000 workmen and last year (1905) 14,669,000. They had not been able until quite lately to put on an increased service of trains. At present they were running over the most crowded sections, between South Kensington and Mansion House, 24 trains an hour, against 18 trains per hour up to the middle of December last. They hoped to increase the number to 30 per hour on that crowded section by the end of March. They were endeavouring to get rid of the present congestion as rapidly as possible, and trusted that by putting on additional train service they might be able to give greater facilities to travellers than at present. The financial results at the present moment of the electrification were not what they had anticipated. The extra cost within the half-year of working, partly under steam and partly under electric traction, had been very heavy, and there had been the necessary but still costly wastage of current caused by their transition from one means of traction to the other, and to the necessity for educating the large number of drivers as to the economical handling of the new motive power on the line. The traffic expenses showed a large increase. In their train running they had seven men in charge of a train, against four men (driver, stoker and two guards) on the steam trains. The increased expenses were almost entirely due to the additional wages paid for the increased staff consequent upon electric traction. The cost of electrification up to the end of the year amounted to £1,677,000. The result of their working this half-year had been to show, after debiting everything that they could legitimately debit, a loss of £26,613.

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**ARIZONA COPPER CO.**—At the meeting on Monday the chairman (Mr. John Gill) said that the electrical uses of copper were increasing. They had not only the usual applications of electricity, but they had now a great industry coming upon them for the development of electric power. There was a scheme for taking power from the Victoria Falls, on the Zambesi, to the Transvaal. The Transvaal mines required about 3,000,000 H.P., and an expert had estimated that the copper line for the transmission of power from the Falls to the Transvaal mines would be in value upwards of £16,000,000. There were other schemes in the Transvaal for developing power at the coalfields and transmitting it to the mines. One or other of those schemes would certainly proceed, because electric power in the Transvaal mines would be very much cheaper than the present power, and it would be very advantageous to the mines to have electric working. They had before them a scheme for applying electric power to their own works and mines, and if they succeeded in making an arrangement of that kind, they would derive great benefit from it. It would save them £40,000 or £45,000 a year.

**BAKER STREET & WATERLOO RAILWAY CO.**—The report for the half-year ended Dec. 31 states that the capital expenditure during the period was £349,620. The line from Baker-street to Kennington-road will be opened for public traffic during March, and it is expected that the section from Kennington-road to the Elephant and Castle station will be opened in a few months. The works from Baker-street to Edgware-road are being actively pushed on. Beyond Edgware-road no work has yet been done. The company is promoting a bill to modify the arrangements for interchange with the Great Western system at Paddington. Satisfactory arrangements have now been made for the interchange of traffic, either by subway or footbridge, with the several companies whose lines the railway crosses.

**BRISTOL TRAMWAYS & CARRIAGE CO. (LTD.)**—At the meeting last week Sir George White said their receipts had decreased £3,058, but by careful regulation of cars they had saved £2,782, or nearly enough to balance the decrease. They had paid away £1,600 more in rates and taxes, compensation, &c., but had saved £500 in trading expenses and other general accounts. They had spent £7,485 more on permanent way, premises and electrical renewals, and they had erected many miles of new trolley wire. They were carrying out an experiment by putting on motor 'buses in outlying districts to feed the main tramway lines. If they had no main lines to serve they would, of course, hesitate before entering upon such a speculative class of business. The cost of working and depreciation of motor 'buses, as at present constructed, would swallow up receipts upon any ordinary traffic in provincial towns. In congratulating Sir J. Clifton Robinson upon the honour of knighthood recently conferred upon him, Sir George White said it was a peculiarly pleasant duty to him, because he saw before him many old friends who knew all about their operations for the last 30 years, and who remembered the early days of the company, when J. Clifton Robinson was their first general manager.

**CAMBRIDGE ELECTRIC SUPPLY CO. (LTD.)**—During 1905 there was connected the equivalent of 3,224 8 c.p. lamps, making the total 50,336, and 559,640 units were supplied, an increase of more than 36,000 units. After placing £1,743. 16s. 2d. to depreciation the accounts show a balance of £5,991. 1s. 9d., which, with £1,763. 18s. 7d. from 1904, makes £7,755. 0s. 4d. £2,120. 3s. 6d. has been paid as interim dividend, and after deducting interest (£1,332. 1s. 4d.) there remains £4,302. 15s. 6d. The directors recommend a further dividend of 3½ per cent., making 6 per cent. for the year.

**CENTRAL ELECTRIC SUPPLY CO. (LTD.)**—The report for 1905 states that energy has been supplied to the St. James' & Pall Mall Electric Light Co., and the Westminster Electric Supply Corpn., throughout the year, to an amount of 7,102,960 units. The bill promoted in the last session of Parliament, to enable the company to extend the works on the Grove-road site and to lay additional mains for the supply to the distributing companies, received the Royal Assent. The company is interested in the present year in the bill of the West London Electric Undertakers' Association promoted by the Westminster Corpn., the St. James' & Pall Mall, the Kensington & Knightsbridge and the Notting Hill Electric Lighting Companies. After making a full allowance for sinking fund and depreciation the net balance is £290. 15s. 3d., which with £7. 10s. from 1904 makes £298. 5s. 3d. to be carried forward.

**CHELSEA ELECTRICITY SUPPLY CO. (LTD.)**—The directors' report for the year to Dec. 31 last shows that the profit amounted to £36,030. 6s. 1d. (added £1,170. 7s. 6d. brought forward and £280. 15s. 7d. balance of interest), making £37,481. 9s. 2d. After deducting interest (£7,875), interim preference dividend (£900), interim ordinary dividend (£4,999. 1s.) and writing off suspense account £1,891. 5s. 9d. there remains £21,816. 2s. 5d., and the directors propose to credit renewals and depreciation fund with £10,918, to pay the balance preference dividend (£900), a final dividend on the ordinary shares at the rate of 7½ per cent. (making 6 per cent. for the year), £8,331. 15s., and a dividend of 3 per cent. on the 5,000 ordinary shares exchanged for founders' shares (£750), leaving £916. 7s. 5d. to be carried to next account. The number of lamps connected at Dec. 31 was 221,809, an addition of 11,150 during the year, and the total units sold was 3,222,038, being 9,626 more than the previous year. The smallness of this increase is due partly to a reduction in the demand by some of the large consumers and partly to a falling off in building operations in the district, which, it is believed will prove to be only temporary. Major Wm. F. Woods has been elected a director, in place of the late Mr. G. N. Marten.

**W. T. HENLEY'S TELEGRAPH WORKS CO. (LTD.)**—During 1905 the net profit was £50,099. 11s. 1d. After payment of directors' and auditors' fees, debenture interest and expenses of issuing new debenture stock, and making sufficient allowance for depreciation of buildings, plant, &c., there remains £40,186. 17s., making (with £26,511. 10s. 11d. from last year) a total of £66,698. 7s. 11d. The directors have transferred £5,000 to reserve and recommend the payment of a dividend on the ordinary shares of 15 per cent. (less tax), of which an interim dividend of 5 per cent. was paid on Sept. 1. These payments will, together with the year's preference dividend, amount to £44,000, leaving £22,698. 7s. 11d. to be carried forward. To meet the growing requirements of the business £300,000 new debenture stock has been created. £150,000 of this stock has been issued, and the former debenture stock has been redeemed. The construction of the Gravesend works is approaching completion, and it is expected that manufacturing will commence there in the course of a few weeks.

**KENSINGTON & KNIGHTSBRIDGE ELECTRIC LIGHTING CO. (LTD.)**—During the past year the number of houses and shops connected with the company's system has increased from 3,451 to 3,693, while the equivalent number of 8 c.p. lamps connected increased from 303,048 to 326,827. After providing for amount placed to renewal account, writing £346. 0s. 3d. off cost of purchase of South Kensington order and after paying the interim preference dividends and an interim dividend at the rate of 10 per cent. on the ordinary shares for the first half of the year, the balance is £15,774. 10s. 4d. Of this sum £2,125 has been appropriated for payment of the balance preference dividends and it is proposed to pay out of the balance (£13,649. 10s. 4d.) a further dividend on the ordinary shares at the rate of 10 per cent. making 10 per cent. for the year. The balance (£8,399. 10s. 4d.) has been carried forward. During the year further substantial reductions have been made in the charge for electricity supply.

**LANARKSHIRE TRAMWAYS CO.**—At Wednesday's meeting Mr. A. R. Monks said the directors recommended a dividend at the rate of 5 per cent. on the original capital and of 5½ per cent. on the new shares, while £898 would be carried forward. The undertaking had enjoyed continued progress, and in all probability at next meeting he would have to speak of future extensions.

**LONDON ROAD CAR CO. (LTD.)**—It was stated at the shareholders' meeting on Monday that the reduction in the receipts from the company's horse-drawn cars had been caused by the competition of the new motor omnibuses and by the electrification of the Metropolitan and Metropolitan District railways. The chairman (Mr. J. Howard Moore) made an interesting review of the action which had been taken by the directors during the last few years in regard to experimenting with mechanically-driven vehicles. It was not until 1904 that the directors came to the conclusion that the experimental stage of motor vehicles had been passed, and they had since placed large orders with the leading makers of these vehicles. It was clear to the directors that the horse-drawn vehicle had no chance against the swifter-running motor, and the substitution of the one for the other must, therefore, be carried through with the utmost possible expedition. He thought that by the end of the current year the greater proportion of the company's horse stock will have been superseded by the motor.

**MACKAY COMPANIES.**—The annual report of the trustees states that the companies now own part or all the capital stock of 74 cable telephone and telegraph companies in the United States, Canada and Europe, including the Commercial Cable and Postal Telegraph systems. The Mackay Companies are also one of the largest stockholders in the American Telephone and Telegraph Co., and during the past year have acquired control of the Northern American Telegraph Co. which for 20 years has owned and worked the telegraph system in Minnesota, Wisconsin, Iowa and Illinois. The Mackay Companies hold $40,645,600 preferred and $41,580,400 common stock. The laying of a fifth cable in the Atlantic Ocean, the establishment of cable communication with Newfoundland, and the laying of new cables to Japan and China are referred to in the report.

**NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY CO. (LTD.)**—At a special meeting on Thursday last the bill to extend the company's area of supply by taking over the Whitly and Monkseaton provisional order, 1901, and the Seghill, Eavedon, and Tynemouth (Rural) order, 1902, &c., was approved. The chairman (Dr. J. T. Merz) said that the bill was for the ratification of an agreement for taking over certain agreements of the Northern Counties Electricity Supply Co. to supply their districts, and (2) an agreement with the Durham County Electric Supply Co. to supply them with electricity in bulk. The bill also provided for working agreements with Durham Power and Durham Distribution Cos. and the Priestman Co. It also authorised the company to acquire and work generating stations, and to enter into agreements with the Newcastle and District Electric Lighting Co., and to supply electricity in bulk to the N.E. Railway beyond and outside the counties of Northumberland and Durham. It was not proposed to take over the Newcastle & District Lighting Co.

**NORTH LONDON RAILWAY CO.**—At the meeting on Thursday last the chairman (Lord Rathmore) said one cause of the reduction of dividend from 5 per cent. to 4½ per cent. was the competition from electrical conveyances. The result was that the company had lost in the last five or six years £23,000 per annum, and they had been obliged to lower their fares, on which head there was a further loss of £20,400 a year. The demon of electric competition was their principal enemy, and it grew closer and closer upon them every year. They had been told to electrify their line, but there were many difficulties in the way. Their trains ran over several other systems, and it would be useless to do anything until the other companies had come to some decision. Their position was such that it would be wiser to hold their hand at present.

**NORTH METROPOLITAN TRAMWAYS CO.**—At the meeting on Wednesday the chairman (Mr. G. Richardson) said that the long-pending arbitration between the company and Leyton Council in respect of the purchase by the latter of the lines and car works of the company had been held and the award of the arbitrator received. In January notice was received from East Ham Corporation for the compulsory acquisition of the lines and depots of the company in that district. The award of the arbitrator in the Leyton case was satisfactory to the company, but a legal point was reserved for the judgment of the court as to whether Leyton Council were compellable to purchase the car works, which they were advised they were not.

**OXFORD ELECTRIC CO. (LTD.)**—The profit for 1905 (including £898. 10s. 7d. from last year) was £12,823. 4s. 9d. After providing £2,103. 9s. 3d. for interest and writing off £696. 2s. 8d. on account of hire-purchase installations, the directors propose to appropriate the balance (£10,023. 12s. 10d.) in payment of a dividend of 7 per cent. (tax free) (2½ per cent. was paid in Sept.) £6,475, placing £2,500 to reserve and renewal account, leaving £1,048. 12s. 10d. to be carried forward. At Dec. 31 the equivalent of over 73,000 8 c.p. lamps was connected to the mains. The number of units of current sold during 1905 was 8 per cent. more than in 1904. The whole of the authorised capital having been issued, the directors have resolved to issue 10,000 cumulative 5 per cent. preference shares of £5 each.

**SHANGHAI ELECTRIC CONSTRUCTION CO. (LTD.)**—At the statutory meeting last week, Sir Alfred Dent said the share capital received was £63,400, of which £25,000 had been paid to the contractors. The success of the tramways would depend largely on the Chinese, and it was satisfactory to find how the Chinese flock to the railways wherever they are introduced. Negotiations had been going on for some time to extend the lines into the French concession, the Chinese city and the native quarter, but these were suspended while the authorities were dealing with disturbances, which had now ceased. About £60,000 worth of the plant had been shipped, although the directors only went to allotment six weeks ago. The tramway construction could be completed in 12 months.

**SOUTH METROPOLITAN ELECTRIC LIGHT & POWER CO. (LTD.)**—The revenue account for 1905 shows a profit of £22,131. 9s. 4d., and £6,706. 10s. 3d. brought forward, making £28,837. 19s. 7d. Deducting £7,965. 1s. 7d. for interest and £2,987. 17s. 8d. for interim preference dividend, there remains £17,885. 0s. 4d., and the directors recommend payment of the balance preference dividend (£3,459. 18s. 2d.), placing £4,000 to depreciation, paying a dividend on the ordinary shares at rate of 2½ per cent. (£2,676. 15s. 10d.), the balance (£7,748. 6s. 4d.) being carried forward. At the end of the year the equivalent of 125,674 8 c.p. lamps was connected (against 108,391 in 1904). The gross revenue was £35,421. 13s. 11d., against £28,796. 16s. 6d., and the expenditure £13,290. 4s. 7d., against £12,222. 0s. 3d. In order to deal with the rapidly-increasing demand for power, and to afford a supply of energy in bulk authorised by the company's act of 1903, the directors are erecting a further engine and boiler house, and are applying for power in the present session to make agreements for combination with other companies, and for the supply of energy in bulk to, and for taking energy from, one another. Mr. H. St. J. Winkworth has been elected chairman of the company, in succession to Sir John Willox, deceased.

**TELEGRAPH CONSTRUCTION & MAINTENANCE CO. (LTD).**—In the report for the year 1905 the directors express their deep regret at the death of Sir Robert Geo. W. Herbert, who had been a director of the company since Feb., 1893, and was chairman from Dec., 1896. Mr. William Shuter has been unanimously elected to fill the office of chairman, and Mr. Francis R. Lucas to the seat at the board vacated by the death of Sir Robert Herbert. The accounts for the year show a net profit of £73,911. 4s. 4d. after charging debenture interest. By adding £102,079. 13s. 2d. from last year, the total is £175,990. 17s. 6d., from which is deducted the interim dividend of 5 per cent. (£22,410), leaving £153,580. 17s. 6d. to be dealt with. The directors propose to distribute a dividend of £1. 4s. per share (absorbing £44,820), being at rate of 10 per cent., and making, with amount already paid, a total dividend for the year of £1. 16s. per share, or 15 per cent., tax free, leaving £108,760. 17s. 6d. to be carried forward. The business of the company has been satisfactory during the year, and the factories at Wharf-road and Greenwich have been fairly occupied in the manufacture of submarine telegraph cables and insulated wire. The company's steamships have been actively engaged in laying and repairing submarine cables. The "Colonia" met with an accident in striking a rock on the coast of Nova Scotia, while laying a new Atlantic cable for the Commercial Cable Co., but was fortunately got off, and was able to carry out the work on which she was employed without much delay. The "Colonia" has been thoroughly repaired and is now in as efficient condition as ever. The "Cambria" has done excellent service during the year, and has given general satisfaction. The works at Wharf-road and Greenwich are in efficient order, and are maintained in perfect readiness for any work that may come to hand. The retiring director (Sir James Pender, Bart.), being eligible, offers himself for re-election. The transfer books are closed from 19th to 27th inst. inclusive.

**WESTMINSTER ELECTRIC SUPPLY CORPN. (LTD.)**—The directors' report for the year 1905, just issued, states that the supply of current, which at Dec. 31, 1904, was the equivalent of 711,679 8 c.p. lamps, had increased by Dec. 31, 1905, to 764,930 lamps, and applications for supply continue to come in at a satisfactory rate. The length of roadway in which continuous-current mains have been laid now exceeds 77 miles (making about 293 miles of ways), into which upwards of 241 miles of copper (strip and cable) have been drawn. In addition, 3 miles of trunk mains (12 miles of ways) are laid to connect the stations with the Central Electric Supply Co.'s station at St. John's Wood, which has been working well during the year. The new transformer station at Duke-street-gardens is now completed and at work. By the Thames Embankment improvement scheme, London County Council have obtained powers to acquire the Corporation's generating station in Millbank-street, but have to reinstate the station on a new site. This matter has been referred to arbitration, which is now proceeding. The whole of the recent issue of 50,000 preference shares was taken up by the shareholders at a premium of 7s. 6d. per share, which has been taken into reserve, out of which the cost of conversion of the 5 per cent. preference shares and expenses of the issue of the new 4½ per cent. preference shares will be paid. The reduction in price of current, which came into force on Jan. 1, 1905, has resulted in the sale of an increased number of units, although for the present there has been a decrease in the year's revenue. To encourage the use of electricity for purposes other than lighting, and to obtain a day load, the charge for current used for power, heating and cooking has been further reduced to 1d. a unit from Jan. 1, 1906, and applications for current for these purposes have been very satisfactory. The continued increase in rates and heavy Parliamentary expenses have also contributed to the decrease in the balance available for dividend. The recent quinquennial valuation, even after successful appeal, has added to the rateable value of the company's undertaking by £20,000, a yearly increase of £7,000, or over 60 per cent. This large increase must, of course, hamper the board in their desire to make a further reduction to the consumer in the charge for electricity. Expenses amounting to £4,200 were necessarily incurred in defending the company's interests in connection with the Administrative County of London Bill. In the now ensuing session of Parliament similar bills are to be presented, and the directors consider that the powers and privileges they ask are considerably in excess of those which have been granted to companies supplying electricity in London hitherto, and, if confirmed by Parliament, would give them great advantages in competition with existing companies working under provisional orders. If further powers are granted they should (the directors hold) be given to the existing companies, and the proper way to deal with the question of the supply of electricity in London is to allow a grouping of adjacent companies for mutual assistance in providing bulk supply. In these circumstances, although the balance available is sufficient to pay a dividend at the same rate as last year, the directors consider it advisable to carry forward a larger amount than usual, and to pay a dividend of 13 per cent. for the year instead of 14 per cent., as in 1904. After allowing for depreciation, sinking fund and other charges, the net balance is £45,966. 10s. 9d. Deducting the interim dividends to June and the preference dividend now due, the balance is £42,623. 11s. 7d., and the board recommend a dividend at the rate of 13 per cent. (less tax), carrying forward £8,661.

**JAPAN.**—The underwriting, for a commission of 2 per cent., of an issue of £500,000 5 per cent. bonds of the Tokio Electric Light Co. has been completed. This company has a capital of about £715,000 (of which £500,000 is paid up), and has paid 12 per cent. dividend for the last three years.

## NEW COMPANIES, STATUTORY RETURNS.

### NEW COMPANIES.

**DEESIDE & DISTRICT ELECTRIC SUPPLY CO. (LTD.)**—(6,107). Reg. in Edinburgh on Feb. 16, capital £10,000 in £1 shares, to acquire from Lowdon Bros. & Co., land, buildings, plant and machinery of the Cults Electricity Supply Station, Aberdeenshire, and to carry on same and the business of electrical and mechanical engineers, &c. First directors, E. J. B. Lowdon, K. Lowdon and J. Laing. Reg. office, 129, Union-st., Aberdeen.

**FILTER BAND MACHINE CO. (LTD.)** (87,563.)—Reg. Feb. 12, capital £4,000 in £1 shares, to acquire the benefit of certain inventions relating to improved filtering apparatus for the extraction of liquid from finely-crushed minerals or the like, and improvements in and relating to the electrolytic extraction of metals from solutions, and the patents granted in respect thereof, and to develop and turn to account the said inventions. First directors: E. Coventry, Col. G. Clark and W. Norman-Bott. Reg. office, 16, St. Helen's-place, London, E.C.

**MUTUAL ELECTRICITY SUPPLY CO. (LTD.)** (87,621.)—Reg. Feb. 16, capital £20,000 in £1 shares, to carry on the business of electricians, engineers, producers of and dealers in electricity, &c. Subscribers: E. J. Cox (electrical engineer), J. Kimber (railway contractor), H. W. Everitt (electrical engineer), E. C. Bromley (engineer), A. Willett, H. J. King-Potter and J. Child. Reg. office, 39, Victoria-street, Westminster, S.W.

**RILEY Y CIA (LTD.)** (87,570.)—Reg. Feb. 12, capital £20,000 in £1 shares (15,000 preference), to carry on the business of electrical engineers and manufacturers, constructors, repairers, maintainers and runners of installations, wires, cables and other works for the supply and distribution of electricity, and for working railways, tramways, &c.

### STATUTORY RETURNS.

**ANGLO-SPANISH ELECTRICITY CO. (LTD.)**—In return to Jan. 14 capital is £100 in £1 shares, of which seven have been taken up. No calls have been made. Mortgages and charges nil.

**AUTOMATIC ELECTRICAL ADVERTISING SYND. (LTD.)**—The capital given in the return to Jan. 9 is £4,500 in £1 shares, all of which have been taken up. £3,000 has been received and £1,500 is considered as paid. Mortgages and charges nil.

**COSTA RICA ELECTRIC LIGHT & TRACTION CO. (LTD.)**—Return to Jan. 4 gives capital as £130,000 in £1 shares, all of which have been taken up. £7 has been received and £129,993 is considered as paid. Mortgages and charges £167,100.

**GILBERT ARC LAMP CO. (LTD.)**—In return to Jan. 12 capital is £2,000 in £1 shares, of which 1,405 have been taken up. £1 per share has been called up on 705, and £700 has been received, leaving £5 in arrears. 700 shares are considered as fully paid. Mortgages and charges nil.

**N.S. ELECTRIC STORAGE CO. (LTD.)**—In return to Dec. 31 capital is £21,100 in 20,000 A shares of £1 each, and 20,000 B and 2,000 C shares of 1s. each, of which 17,367 A, 16,835 B and 2,000 C have been taken up. £1 per share has been called up on 16,007 A, and 1s. per share on 15,475 B, and 2,000 C shares, and £16,630. 15s. has been received. £1,428 is considered as paid on 1,360 A and 1,360 B shares. Mortgages and charges £6,800.

**WESTINGHOUSE ELECTRIC CO. (LTD.)**—Return to Dec. 31 gives capital as £600,000 in 30,000 preference and 30,000 ordinary shares of £10 each, of which 18,955 preference and 27,500 ordinary have been taken up. £10 per share has been called up on 3,155 preference, and £31,550 has been received. £433,000 is considered as paid on 15,800 preference and 27,500 ordinary. Mortgages and charges nil.

## CITY NOTES.

**MEMORANDA** (Feb. 15).—Bank rate 4 per cent. (since Sept. 28, 1905). Price of silver 30 9/16d. per oz. Consols 90 5/16—90 1/16 for money, 90⅜—90½ for account; 2½ per cent. annuities 89⅛—89⅜. Consols Pay Day, March 1. Stocks and Shares Continuation Day, March 7; Ticket Day, March 8. Pay Day, March 9; Mining Share Carry-over Day, March 6.

**BOURNEMOUTH & POOLE ELECTRICITY SUPPLY CO. (LTD.)**—The directors have declared a dividend of 7 per cent. per annum on the ordinary shares.

**CHARING CROSS, EUSTON & HAMPSTEAD RAILWAY CO.**—For the half-year ended Dec. 31 the capital expenditure was £561,783, bringing the total to £3,934,477.

**CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)**—The directors have resolved (subject to completion of audit) to transfer £45,500 to reserve, and to recommend payment of the following dividends (less tax):—6s. per share on the preference shares (making 12s. for the year, or the full rate of 6 per cent.); 7s. per share on the ordinary shares (making 12s. per share, or 6 per cent. for year ended Dec. 31). The balance (about £22,000) is to be carried forward.

**COMPANIES STRUCK OFF.**—The "London Gazette" for 20th inst. contains a list of joint stock companies which have been removed from the Register, including the following:—Dumont Electric Ignition and Self-Starter Co., Great Western Electric Light & Power Co., King Arc Lamp Co., Lancashire & Yorkshire Electric Tramways, Snelgrove Electric Cash Register Till Synd., Taipo Accumulator Co., United Electric Tramways, West Riding Tramways & Electricity Supply Co., World's New Accumulator Co.

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. No. of weeks. | Aggregate. Amount. | Aggregate. Inc. or Dec. (a) |
|---|---|---|---|---|---|---|
| | | £ | £ | | £ | £ |
| **Aberdeen Corporation** | Feb. 17 | 1,141 | + 33 | 38 | 52,162 | - 898 |
| **Airdrie** | ,, 9 | 218 | + 11 | 6 | 1,279 | + 188 |
| Anglo-Argentine | ,, 18 | 14,610 | + 1,842 | 7 | 102,326 | + 10,416 |
| **Ayr Corporation** | ,, 17 | 176 | + 1 | 89 | 11,813 | - 94 |
| **Barnsley** | ,, 9 | 153 | - 2 | 6 | 847 | + 12 |
| **Barrow** | ,, 9 | 212 | + 25 | 6 | 1,181 | + 117 |
| **Bath Electric Trams, Ltd.** | ,, 14 | 559 | + 12 | 7 | 4,876 | + 648 |
| Birkenhead Corporation | ,, 18 | 921 | - 50 | 7 | 7,186 | - 23 |
| **Birmingham Corporation** | ,, 17 | 401 | + 33 | 46 | 17,202 | + 2,187 |
| *Birmingham & Mid. | ,, 9 | 1,309 | - 501 | 6 | 7,658 | - 1,843 |
| **Blackpool Corporation** | ,, 15 | 307 | + 4 | 7 | 47,562 | + 2,006 |
| **Blackpool and Fleetwood** | ,, 17 | 179 | - 7 | 7 | 1,221 | - 46 |
| **Bolton Corporation** | ,, 18 | 1,887 | + 207 | 47 | 89,741 | + 4,480 |
| **Bournemouth Corporation** | ,, 15 | 1,185 | + 290 | †46 | 64,648 | + 14,985 |
| **Bradford Corporation** | ,, 17 | 3,861 | - 20 | 46 | 199,965 | - 8,003 |
| **Brighton Corporation** | ,, 13 | 684 | - 76 | 47 | 45,945 | + 263 |
| **Bristol Trams & Carriage** | ,, 16 | 4,574 | + 148 | 1 | 4,574 | + 148 |
| **Buenos Ayres & Belgrano** | ,, 18 | 3,396 | + 517 | 7 | 24,578 | + 2,461 |
| Buenos Ayres Elec. Trms | Jan 20 | 1,194 | ... | 8 | 4,194 | ... |
| **Burnley Corporation** | Feb. 17 | 1,078 | - 114 | 46 | 60,556 | + 3,184 |
| **Burton Corporation** | ,, 18 | 264 | - 29 | §46 | 14,121 | - 1,604 |
| Bury Corporation | ,, 11 | 744 | ... | §45 | 34,201 | ... |
| **Calcutta Tramways Co.** | ,, 17 | R43,849 | + R4,286 | 7 | R327,175 | + R41,222 |
| **Camborne-Redruth** | ,, 17 | 92 | + 5 | 16 | 1,709 | + 81 |
| Cardiff | ... | ... | ... | ... | ... | ... |
| **Carlisle Tramways Co.** | ,, 17 | 145 | ... | 7 | 1,112 | + 90 |
| Cavehill | ,, 9 | 30 | - 8 | 6 | 170 | - 38 |
| **Central London Railway** | ,, 17 | 6,976 | - 216 | 7 | 48,748 | - 1,648 |
| **Chatham & Dist. Lt. Rys.** | ,, 15 | 532 | - 47 | †7 | 3,839 | + 24 |
| *City of Birm'gh'm Tram Co. | ,, 9 | 5,061 | - 473 | 6 | 29,472 | - 265 |
| **City & South London Rly.** | ,, 18 | 8,088 | + 222 | 7 | 21,204 | + 208 |
| **Colchester Corporation** | ,, 15 | 157 | ... | 27 | 5,819 | - 1,503 |
| **Cork Electric Trams Co.** | ,, 15 | 390 | - 60 | †7 | 2,715 | - 57 |
| **Devonport & Dist. Trams** | ,, 9 | 393 | - 52 | 6 | 2,370 | - 135 |
| **Dover Corporation** | ,, 17 | 173 | + 4 | ‡46 | 10,278 | + 62 |
| **Dublin & Lucan Railway** | ,, 16 | 87 | - 5 | §7 | 580 | - 68 |
| **Dublin United** | ,, 16 | 4,886 | - 18 | ‡7 | 30,727 | + 249 |
| **Dudley—Stourbridge** | ,, 9 | 740 | - 18 | 6 | 4,230 | + 285 |
| **Dundee Corporation** | ,, 14 | 921 | + 145 | §39 | 36,808 | + 3,150 |
| **East Ham Council** | ,, 17 | 742 | + 21 | 46 | 38,024 | + 5,278 |
| **Gateshead & Dist. Trams** | ,, 9 | 916 | + 23 | 6 | 5,248 | + 327 |
| **Glasgow Corporation** | ,, 17 | 15,123 | + 1,132 | 38 | 577,405 | + 57,854 |
| Glossop | ,, 17 | 122 | + 16 | 7 | 854 | + 123 |
| Gloucester Corporation | ,, 14 | 214 | - 2 | 47 | 13,223 | + 1,154 |
| **Gravesend—Northfleet** | ,, 9 | 187 | - 3 | 6 | 1,112 | + 68 |
| **Gt. Northern & City Rly.** | ,, 17 | 1,796 | + 36 | 7 | 12,619 | + 228 |
| **Greenock & Port Glasgow** | ,, 9 | 613 | + 23 | 6 | 3,198 | + 287 |
| **Halifax Corporation** | ,, 14 | 1,186 | - 26 | 46 | 71,392 | + 5,083 |
| **Hartlepool Tramways** | ,, 9 | 247 | - 6 | 6 | 1,448 | + 89 |
| Hastings Elec. Trams Co. | ,, 15 | 810 | ... | 7 | 2,481 | ... |
| **Huddersfield** | ,, 17 | 1,265 | + 71 | 46 | 62,741 | + 3,511 |
| **Hull Corporation** | ,, 17 | 2,060 | - 1 | 46 | 102,669 | + 2,002 |
| Ilford Dist. Coun. | ,, 17 | 372 | + 1 | 46 | 21,448 | + 950 |
| **Ipswich Corporation** | ,, 17 | 308 | - 81 | 46 | 19,424 | - 1,895 |
| **Isle of Thanet Co.** | ,, 17 | 215 | - 26 | 19 | 5,169 | - 494 |
| **Kidderminster & District** | ,, 9 | 89 | - 2 | 6 | 514 | + 4 |
| Kilmarnock Corporation | ,, 17 | 140 | - 8 | 40 | 6,258 | ... |
| **Kirkcaldy Corporation** | ,, 14 | 184 | - 13 | 24 | 4,889 | - 97 |
| **Lanarkshire Trams Co.** | ,, 15 | 797 | + 163 | †7 | 5,702 | + 1,303 |
| **Leamington** | ,, 9 | 112 | + 20 | 6 | 740 | + 220 |
| **Leeds Corporation** | ,, 17 | 5,428 | + 82 | 47 | 275,619 | + 8,622 |
| **Leicester Corporation** | ,, 17 | 1,948 | + 165 | 7 | 13,660 | + 1,916 |
| Leith Corporation | ,, 10 | 413 | + 203 | 38 | 14,049 | + 10,534 |
| **Liverpool Overhead Rly.** | ,, 18 | 1,361 | - 79 | 7 | 9,732 | - 608 |
| Liverpool Corporation | ,, 10 | 9,877 | - 153 | 6 | 60,277 | + 2,259 |
| ***London County Council** | ,, 10 | 13,329 | + 467 | 45 | 661,784 | + 88,050 |
| **Lowestoft** | ,, 17 | 111 | - 7 | 10 | 2,822 | - 29 |
| **Maidstone Corporation** | ,, 15 | 76 | - 20 | 47 | 5,518 | ... |
| **Manchester Corporation** | ,, 17 | 12,155 | + 487 | 46 | 591,067 | + 29,689 |
| **Mersey Railway** | ... | ... | ... | ... | ... | ... |
| **Merthyr** | ,, 9 | 173 | - 5 | 6 | 977 | - 2 |
| Metropolitan Dist. Railway | ,, 18 | 8,260 | + 105 | 7 | 56,838 | + 3,118 |
| ***Metropolitan Elec. Trams** | ,, 9 | 2,658 | + 639 | 6 | 15,612 | + 4,909 |
| **Middleton** | ,, 9 | 266 | - 6 | 6 | 1,586 | + 139 |
| **Nelson Corporation** | ,, 17 | 123 | + 16 | 47 | 6,137 | + 678 |
| **Newcastle-on-Tyne Corp.** | ,, 17 | 3,571 | - 8 | 46 | 175,083 | + 4,417 |
| **Newport (Mon.)** | ,, 17 | 534 | + 53 | 20 | 10,933 | + 828 |
| **Northampton Corporation** | ,, 16 | 846 | + 5 | 46 | 19,543 | + 5,241 |
| **Oldham, Ashton & Hyde** | ,, 9 | 503 | + 12 | 6 | 2,881 | + 152 |
| **Oldham Corporation** | ,, 18 | 1,560 | + 196 | 47 | 76,506 | + 17,499 |
| Perth (N.B.) Corporation | ,, 14 | 117 | ... | 15 | 2,219 | ... |
| **Perth (W. A.) Elec Trams** | ,, 16 | 1,498 | + 48 | ‡7 | 10,903 | + 569 |
| **Peterborough** | ,, 9 | 92 | - 13 | 6 | 550 | - 17 |
| Pontypridd Dist. Council | ,, 17 | 142 | ... | 46 | 7,861 | ... |
| Portsmouth Corporation | ,, 17 | 1,322 | - 40 | 46 | 88,830 | + 8,023 |
| **Potteries** | ,, 9 | 1,734 | + 73 | 6 | 9,864 | + 685 |
| **Preston Corporation** | ,, 14 | 559 | + 43 | 6 | 8,482 | ... |
| **Reading Corporation** | ,, 15 | 548 | + 8 | ... | ... | ... |
| **Rotherham Corporation** | ,, 15 | 414 | + 23 | 46 | 20,921 | - 153 |
| **Rothesay** | ,, 9 | 45 | - 1 | 6 | 805 | + 46 |
| **Salford Corporation** | ,, 13 | 4,023 | + 177 | 47 | 199,578 | + 11,554 |
| **Sheerness** | ,, 7 | 46 | - 10 | 6 | 288 | - 19 |
| **Sheffield Corporation** | ,, 18 | 4,581 | + 496 | 47 | 282,062 | + 13,670 |
| **Southampton Corporation** | ,, 14 | 785 | - 8 | 19 | 16,892 | - 40 |
| **Southend Corporation** | ,, 14 | 2 6 | + 8 | 46 | 16,962 | + 1,034 |
| **Southport Tramways** | ,, 9 | 220 | - 14 | 6 | 1,338 | + 71 |
| **S. Staffordshire Trams.** | ,, 9 | 725 | + 48 | 6 | 4,822 | + 755 |
| **Stockport Corporation** | ,, 16 | 757 | + 307 | 46 | 84,958 | + 25,064 |
| Sunderland Corpn. | ,, 18 | 1,133 | + 53 | 46 | 60,720 | + 2,737 |
| **Swansea Trams** | ,, 9 | 696 | + 240 | 6 | 4,073 | + 1,520 |
| Swindon Corporation | ,, 14 | 147 | - 15 | 46 | 8,921 | ... |
| Taunton | ,, 9 | 36 | - 4 | 6 | 241 | + 14 |
| **Tynemouth and District** | ,, 9 | 150 | - 29 | 6 | 928 | - 37 |
| **Tyneside Trams Co.** | ... | ... | ... | ... | ... | ... |
| **Wallasey District Council** | ,, 17 | 668 | + 87 | 46 | 35,577 | + 1,476 |
| **Warrington Corporation** | ,, 15 | 831 | + 23 | 46 | 15,734 | + 1,014 |
| **West Ham Corporation** | ,, 15 | 1,789 | + 710 | 45 | 84,519 | + 36,380 |
| **Weston-super-Mare** | ,, 7 | 25 | - 1 | 6 | 144 | - 1 |
| Wolverhampton Corpn. | ,, 14 | 696 | ... | 6 | 4,409 | ... |
| **Wolverhampton District** | ,, 9 | 870 | + 8 | 6 | 2,061 | + 161 |
| ***Worcester** | ,, 9 | 222 | - 40 | 6 | 1,868 | - 50 |
| **Wrexham** | ,, 9 | 91 | + 11 | 6 | 522 | + 5 |
| Yorkshire W.R. Trams | ,, 18 | 810 | + 275 | 7 | 4,467 | + 1,440 |
| **Yorkshire Woollen District** | ,, 9 | 801 | + 225 | 6 | 4,642 | + 1,688 |

(a) These comparisons are with the corresponding period last year. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days. ¶ Plus 3 days. * Partly electrical.

**COUNTY OF DURHAM ELECTRICAL POWER DISTRIBUTION CO. (LTD.)**—The directors recommend the following dividends for the year ended Dec. 31; 2½ per cent. (less tax) on amount called up on preference shares, making 5 per cent. for the year; and at the rate of 4 per cent. per annum (less tax) on the amount called up on the ordinary shares.

**DUNDEE & BROUGHTY FERRY DISTRICT TRAMWAYS CO.**—The difficulties in connection with the power station have been satisfactorily arranged. The directors are said to be in favour of extending the line to Monifieth.

**PEARSON FIRE ALARM** (LTD.)—The report for the 21 months ended Dec. 31 shows a debit balance. The board has decided to call up the remaining 2s. per share of the issued capital.

**STOCK EXCHANGE NOTICES.**—The Stock Exchange committee have appointed March 8 a special settling day in 56,000 £1 fully paid Vendors' shares of the *Electro-Peat Coal Co. (Ltd.)*, and have granted quotations to a further issue of 3,128 (fully paid) and 50,000 (£1 and 7s. 6d. premium paid) £5 4½ per cent. cumulative preference shares of the *Westminster Electric Supply Corporation (Ltd.)*. The Committee have been asked to grant quotations to 5 per cent. 1st mortgage debenture stock of the *Buenos Ayres Lacroze Tramways Co.* and 40,000 £5 fully paid ordinary and 46,261 £5 fully paid 6 per cent. cumulative preference shares of the *Yorkshire (West Riding) Electric Tramway Co. (Ltd.)*

**UNITED ALKALI CO. (LTD.)**—The profit for the past year, including £43,762 brought forward, was £128,000. The directors recommend payment of the 7 per cent. preference dividend, placing £40,000 to reserve and £50,000 to depreciation, carrying forward £38,000.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Feb. 21. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Feb. 21. Highest. | Business, Week to Feb. 21. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | £ s. d. | | | |
| 5 | 8/0 | Anglo-Argentine Ord. Shares | 8⅞—9⅛ | 4 7 9 | Ap, Oct | $9\frac{1}{16}$ | $8\frac{13}{16}$ |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞—6⅛ | 4 10 0 | — | $6\frac{3}{32}$ | $5\frac{15}{16}$ |
| St. | 6% | Do. Permanent 6% Deb. Stock | 141 —144 | 4 3 3 | — | .. | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 104 —106 | 4 14 3 | — | 105 | 104½ |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1 —1½ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 3⅞—4⅛ | 6 1 4 | — | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 93 —96 | 4 13 9 | — | 95 | — |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 120 —123 | 4 17 6 | — | .. | .. |
| St. | 5% | Do. Pref. Ord. Stk | 110 —113 | 4 8 4 | — | 111¾ | 111½ |
| 100 | 5% | Do. 5% Cum. Perp. Pref. Stock. | 108 —111 | 4 10 0 | — | .. | — |
| 100 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%—105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 101 —104 | 4 6 6 | — | .. | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | 3⅝—3⅞ | 5 3 0 | — | $3\frac{13}{16}$ | $3\frac{11}{16}$ |
| 5 | 8/0 | Do. 6 per Cent. "A" Cm. Pref | 5⅞—6⅛ | 4 13 0 | — | .. | .. |
| 5 | 8/0 | Do. "B" | 4¼—4¾ | 5 4 0 | — | . | .. |
| St. | 5% | Do. 5 per Cent. Debs. | 105 —107 | 4 13 6 | — | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102 —105 | 4 15 0 | — | .. | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 96 — 98 | 5 2 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 102 —106 | 5 4 3 | .. | .. | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 102 —106 | 5 13 0 | .. | .. | .. |
| 5 | 5/6 | Calcutta Tramways (Nos. 1 to 105) | 9½—10 | 4 5 0 | — | 9⅞ | $9\frac{11}{16}$ |
| 5 | 2/6 | Do. Nos. 105,001 to 137,610 | 9 —9½ | .. | .. | $9\frac{1}{16}$ | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 105 —107 | 4 4 8 | — | 106½ | 106 |
| 1 | 0/6 | Cape Electric Tram Shares | ¾—1 | 5 0 0 | — | .. | — |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 102 —104 | 4 16 0 | — | .. | .. |
| .. | 5% | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 96 —98% | 5 2 0 | .. | .. | .. |
| St. | .. | Kalgoorlie Elec. Trams 5% "A" Deb. Stock | 93 — 98 | .. | .. | .. | .. |
| St. | .. | Do. 6% "B" Ditto | 85 — 90 | .. | .. | .. | .. |
| 1 | .. | Lisbon Elec. Trams Ord. | $1\frac{7}{16}$—$1\frac{9}{16}$ | .. | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛—1⅜ | 4 7 4 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 100 —103 | 4 17 0 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 101 —103 | 4 17 0 | Ja, Jul | 102½ | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 102 —105 | 4 15 0 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102 —104 | 4 6 6 | — | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 105 —108 | 4 12 6 | .. | 105½ | .. |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 146 —148 | 5 8 0 | .. | .. | .. |
| .. | 5% | Do. 5% 1st Mt. $100 Dbs. | 99 %—100% | 5 0 0 | .. | 99¾ | .. |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | .. | Adelaide Elec. S'ply Co. 6% Cu. Pr. | 4¾—5¼ | — | .. | .. | .. |
| 5 | 3/8 | Calcutta Elec (1-50,000) | 9 - 9½ | 4 6 6 | — | 9¼ | 9⅛ |
| 100 | 5% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50 —52 | 4 16 0 | .. | .. | .. |
| . | 5% | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 94 —96 | 5 4 0 | .. | .. | .. |
| 1 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½— 3 | .. | .. | $2\frac{11}{16}$ | .. |
| St. | 5% | Do. 5% Debs. | 88 —92 | 5 9 4 | — | 89½ | .. |
| 10 | .. | Havana Electricity Co. Shares | 7¾ - 8¾ | — | — | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92 —94 | 5 6 8 | .. | .. | .. |
| St. | 26/2 | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. | 109 — 111 | 5 8 0 | .. | .. | .. |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞—1 | 6 0 0 | — | ⅞ | .. |
| 1 | 1/0 | Rand Electric | $1\frac{5}{16}$—$1\frac{7}{16}$ | .. | — | .. | — |
| 1 | .. | River Plate Electricity Co. Ord. | $\frac{19}{32}$ - $\frac{23}{32}$ | .. | .. | ⅝ | .. |
| 1 | 1/2⅞ | Do. 6% Non. Cum. Pref. | $\frac{15}{16}$—$1\frac{1}{16}$ | ... | .. | .. | .. |
| St. | 5% | Do. 5% Deb. Stock | 101 —103 | 4 17 0 | .. | .. | .. |
| 5 | 6/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5½—5¾ | 5 4 4 | .. | .. | — |
| 5 | 9·13d | Do. (12,001-20,000) | 5 —5½ | 8 8 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100 —103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 5% | Shawinigan Water and Power 5% Bds., Scrip | 102 —104 | 4 16 0 | .. | 101⅛ | .. |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Shre | Last Dividend | Name | Price Wed., Feb. 21. | Rate % Yielded £ s. d. | Dividend Due | Business, Week to Feb. 21. Highest | Lowest |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12½–12¾ | 6 8 0 | .. | .. | .. |
| 10 | 4/6 | † Do. 4½ per Cent. Cum. Pref | 10–10½ | 4 5 9 | .. | 10⅜ | 10 3/16 |
| 10 | 6/0 | † Do. 6% Cum. Second Pref. | 11–12 | 5 0 0 | .. | — | — |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 106–108 | 4 3 3 | .. | .. | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼–5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 103–105 | 4 5 0 | — | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 8¾–9¼ | 5 8 0 | — | .. | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 8½–9½ | 3 14 5 | Mar, Sept | 9 | 8⅞ |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 102–105 | 3 16 3 | — | 103½ | .. |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 5–6 | 6 4 0 | Feb, Aug | 5 17/32 | 5¼ |
| 5 | 2/3 | † Do. 4½ per Cent. Pref. | 5–5½ | 4 2 0 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 101–103 | 3 17 6 | — | 102¾ | .. |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4½–4¾ | 4 14 9 | — | .. | .. |
| 5 | 2/3 | Do. Do. (1903) | 4½–4¾ | 4 14 9 | .. | .. | .. |
| 5 | 2/8 | Chelsea Electric Supply Ord. | 5–6 | 5 0 0 | March .. | 5½ | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 108–110 | 4 1 6 | Jn, Dec .. | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 10¾–11¾ | 5 2 0 | Feb, Aug | 11 3/16 | 11⅛ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13¾–14¼ | 4 4 2 | Jan, July | — | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 123–126 | 3 19 4 | Jn, Dec .. | 126½ | 126¼ |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 100–102 | 4 8 3 | .. | 100⅞ | .. |
| 5 | .. | County of Durham Elec. P.D. Ord. £2pd. | 1¾–2 | .. | April, Oct | .. | .. |
| 5 | 5% | Do. Do. 5% non cum. pref. | 5¼–5⅝ | 4 13 0 | April, Oct | .. | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 8½–9½ | 4 6 6 | — | 9⅛ | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅝–12⅞ | 4 13 0 | Mar, Sept | 12 9/16 | 12½ |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 109–112 | 4 0 4 | .. | .. | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 101–103 | 4 7 6 | .. | 102½ | 101½ |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼–5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5–5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101–104 | 4 6 6 | — | .. | .. |
| 5 | 4 0 | Hove Electric Lighting Ord. | 8¼–8¾ | 4 17 2 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100–103 | 4 7 5 | — | .. | — |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 10–11 | 5 9 0 | — | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½–7 | 4 5 9 | Jan, July | — | — |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98–101 | 3 19 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 103–105 | 3 16 0 | — | 103¼ | .. |
| 8 | 1/9⅜ | London Electric Supply Ord. | 2¼–2¾ | 3 5 6 | — | 2 17/32 | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5⅝–5⅞ | 5 9 6 | — | 5¾ | 5 11/16 |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 98–101 | 3 19 2 | Mr, Jn, S, D | .. | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 9–10 | 5 0 0 | April, Oct | 9 7/16 | 9 5/16 |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5 5/16–5 9/16 | 3 17 9 | Jan. July | 5⅜ | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 109–113 | 3 19 6 | Jn, Dec .. | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 95–97 | 3 12 8 | — | .. | .. |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 101–103% | 4 7 4 | — | 102½ | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 12–12½ | 5 9 2 | Feb, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 102–104 | 4 6 6 | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8–8½ | 4 14 2 | Feb, Aug | .. | .. |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6¼–6¾ | 3 14 1 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99–101 | 3 19 7 | Jan, July | .. | .. |
| 1 | 3% | Northern Counties Elec. Sup. | 15/16–31/32 | 3 2 6 | Mar, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 101–102 | 4 7 6 | Jan, July | — | — |
| 10 | 6/0 | Notting Hill Electric Ord. | 13½–14½ | 4 16 8 | March .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98–100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6½–7 | 5 0 0 | March .. | — | — |
| St. | 4% | Do. 4% Deb. Stock | 99–101 | 3 19 0 | — | .. | .. |
| 5 | 5/0 | St. James' & Pall Mall Elec. Ord. | 11–12 | 6 5 0 | Feb, Aug | 11⅜ | 11¼ |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 7–8 | 4 7 0 | Feb, Aug | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 97–99 | 3 10 9 | — | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2½–3 | 7 10 0 | .. | .. | .. |
| St. | 4% | † Do. 4 per Cent. Deb. Stock | 76–80 | 5 0 0 | — | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 8¼–8¾ | 5 6 8 | .. | .. | .. |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | ¾–⅞ | .. | .. | .. | — |
| 1 | 0/8⅜ | Do. 7% Cum. Pref. | 1¼–1⅜ | 5 2 0 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105–108 | 4 3 8 | — | .. | — |
| 5 | 2/6 | Urban Electric Supply Ord. | 4½–4¾ | 5 5 0 | — | .. | .. |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5–5¼ | 4 15 8 | — | 5⅛ | .. |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 104–106 | 4 5 0 | .. | .. | .. |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 10¾–11¾ | 6 2 0 | Mar, Sept | 11 1/16 | 10 15/16 |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝–5⅞ | 4 9 0 | .. | 5 13/32 | .. |
| 5 | .. | Do. £1 and 7/6 premium paid | 1⅜–1½ | .. | .. | .. | .. |
| | | **ELECTRIC RAILWAYS, TRAMWAYS &c.** | | | | | |
| 1 | — | Bath Elec. Trams Pref. Ord. | 15/16–1 1/16 | .. | .. | 1 | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16–1 1/16 | 4 14 9 | .. | 1 | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 102–104 | 4 6 6 | .. | 103½ | 103 |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 101–103 | 4 7 9 | .. | 102⅝ | .. |
| 10 | 9% | † Bristol Tramways and Carriage Ord. | 16–17 | 5 6 0 | Feb, Aug | — | — |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10–10¼ | 3 18 0 | .. | .. | — |
| St. | 4% | Do. 4 per Cent. Debs. | 104–106 | 3 15 6 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 7½–8 | 7 10 0 | .. | 7⅞ | 7½ |
| 10 | 6/0 | † Do. 6 per Cent. Cum. Pref. | 10–10½ | 5 18 0 | Feb, Aug | 10 7/16 | 10⅛ |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 119–121 | 4 2 8 | .. | 120¼ | 119½ |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 98–100 | 4 10 0 | .. | 98¼ | .. |
| St. | 4% | † Central London Ordinary Stock | 93–95 | 4 4 0 | June, Dec | 94 | 93⅞ |
| St. | 4% | † Do. 4 per Cent. Pref. Stock | 103–105 | 3 16 0 | .. | 104½ | 103½ |
| St. | 4% | † Do. Deferred Stock | 83–86 | 4 13 0 | .. | 84 | 83 |
| 100 | 4% | Do. 4 per Cent. Debs. | 110–112 | 3 11 3 | .. | .. | .. |
| St. | 4% | Charing X, Euston & Hmpstd Per. Db. Stk. | 96–98 | 4 1 6 | .. | .. | .. |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 5⅛–5⅜ | 4 13 0 | .. | 5¼ | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 101–104 | 3 17 0 | .. | — | .. |
| St. | 1¾% | † City and South London Rly. Con. Ord. | 41–43 | 4 7 0 | Feb, Aug | 42⅞ | 42 |
| St. | 5% | † Do. 5 per Cent. Perp. Pref. (1891) | 120–123 | 4 1 4 | Feb, Aug | .. | .. |
| St. | 5% | † Do. (1896) | 115–118 | 4 4 8 | .. | .. | .. |
| St. | 5% | † Do. (1901) | 113–116 | 4 6 0 | .. | 114 | 113½ |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 106–109 | 3 13 4 | May, Nov | .. | .. |
| 10 | 6/0 | † Dublin United Trams. (1896) Ltd., Ord. | 13¾–14¾ | 4 1 6 | .. | .. | .. |
| 10 | 6/0 | † Do. 6 per Cent. Pref. | 14½–15½ | 3 17 8 | .. | .. | .. |
| 10 | 4/0 | † Gt. Northern & City Rly. Prf. Ord. (4%) | 4¾–5¼ | 7 12 0 | .. | 5 | 4⅞ |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8–9 | 4 8 11 | — | .. | .. |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 103–105 | 4 5 8 | .. | 104½ | — |
| 10 | 9% | †‡ Imperial Tramways Ord | 16–17 | 5 6 0 | Mar, Sept | .. | — |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 17¾–18¼ | 4 10 8 | Mar, Sept | .. | — |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 103–109 | 4 1 0 | Jan, July | .. | — |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼–2¾ | 9 8 6 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 82–87 | 4 12 0 | — | .. | .. |
| 10 | 1¾% | Liverpool Overhead Railway Ord | 8 11/16–8 15/16 | 3 13 0 | Feb, Aug | .. | — |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾–10¼ | 4 15 8 | Feb, Aug | .. | — |
| St. | 4% | Do. 4 per Cent. Deb. | 99–102 | 3 19 3 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9–9½ | 5 5 0 | — | 9⅜ | 9⅛ |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 94–97 | 4 2 6 | — | [illegible] | 95¼ |
| St. | .. | Mersey Con. Ord. Stock | 7–9 | — | — | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8–11 | — | — | — | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | [illegible] | .. | — | .. | .. |
| 1 | 0/6 | † Do. 5% Cum. Pref. | 1–1 1/16 | 4 14 1 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104–106 | 4 5 0 | — | .. | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum. Pref. | ½–1½ | .. | May | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾–9¼ | 5 5 8 | .. | .. | — |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9½–10 | 5 0 0 | Feb, Aug | .. | .. |
| St. | 4½% | † Do. 4½ per Cent. Deb. Stock | 103–106 | 4 5 0 | — | — | .. |
| 100 | 5% | Sunderland Dst. Elc. Trms. 5% 1st Mt. Db. | 93–96 | 5 4 0 | .. | .. | .. |
| — | 5% | Underground Elec. Rys. Co. of London | 98–99 | 5 1 0 | .. | .. | .. |
| St. | 3% | Waterloo and City Ord. | 99–102 | 2 19 8 | June, Dec | 101 | .. |
| St. | 4½% | Yorkshire W.R. El. Trs. Co. 4½% 1st Debs. | 95–97 | 4 13 0 | — | 96½ | 96¼ |

| Shre | Last Dividend | Name | Price Wed., Feb. 21. | Rate % Yielded £ s. d. | Dividend Due | Business, Week to Feb. 21. Highest | Lowest |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| | 6d. | † Alliance Elec. Co. 5% Cum. Pref. | ⅝–⅞ | 5 6 6 | — | — | .. |
| 1 | 10½d. | Aron El. Met. 6% Cm. Pf. | ½–⅝ | .. | — | .. | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3⅞–4⅛ | 4 11 5 | .. | 4 1/16 | 3 31/32 |
| 1 | 7½d. | Do. Pref | 1 1/16–1 3/16 | 3 16 10 | .. | .. | — |
| 5 | 4/0 | British Insulated & Helsby Cables Ord | 6¾–7¼ | 5 10 0 | July, Feb | .. | — |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾–6¼ | 4 16 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103–106 | 4 4 11 | .. | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db | 98–100 | 4 10 0 | .. | .. | .. |
| 5 | .. | British Westinghouse 6% Pref. | 1⅞–2⅛ | .. | .. | 2¼ | [illegible] |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 77–82 | 4 17 6 | .. | 80 | .. |
| 2 | — | Brush Electrical Engineering | ½–¾ | .. | March .. | ⅝ | .. |
| 2 | 2/4⅜ | Do. 6 per Cent. Pref. Non-Cum. | 1½–2 | 6 0 0 | Mar, Sept | 1 17/32 | [illegible] |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 98–100 | 4 10 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 82–84 | 5 7 4 | Jan, July | 81½ | 81¼ |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11–12 | 5 0 0 | Jan, July | 11⅛ | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅝–5⅞ | 4 5 0 | Jan, July | 5 11/16 | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 108½–110½ | 4 1 8 | Nov, May | — | .. |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1 1/16–1 3/16 | 5 1 0 | .. | 1 3/32 | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 95–100 | 4 10 0 | — | 98 | .. |
| 1 | 9⅜d. | Chadburn's (Ship) Telegraph Ord. | 1–1¼ | 8 0 0 | — | 1⅛ | — |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1–1⅛ | 5 7 0 | .. | 1 | .. |
| 3 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 2–2¼ | 3 9 0 | Jan, July | 2⅛ | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 97%–98% | 5 2 0 | Jan, July | .. | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8½–9 | 5 11 1 | Sept | [illegible] | [illegible] |
| 5 | 3/0 | Do. 6% Cum. Pref. | 6–6½ | 4 14 0 | Sept | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104–106 | 4 5 0 | .. | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅝–1⅞ | — | Feb, Aug | [illegible] | [illegible] |
| 5 | 2/6 | Do. (£5 paid) | 2½–3 | — | Feb, Aug | [illegible] | [illegible] |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 86–88 | 4 11 0 | June, Dec | 86½ | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92–97 | 5 3 1 | — | .. | .. |
| 5 | 2/6 | Edmundson's Elec. Corp. Ord. | 4½–5 | 7 0 0 | H'lf-yearly | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5¼–5¾ | 5 4 6 | .. | [illegible] | [illegible] |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 104–106 | 4 5 0 | .. | 104⅝ | 104¼ |
| 2 | 1/7½ | Electric Construction Co. | ½–¾ | 9 6 0 | July | — | .. |
| 2 | 2/9¾ | Do. 7 per Cent. Cum. Pref | 2–2½ | 5 12 0 | July | .. | — |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 89–92 | 4 7 0 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9¼–9¾ | 5 4 6 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96–99 | 4 1 0 | — | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 13–14 | 5 7 0 | Feb, Aug | 13½ | [illegible] |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼–5½ | 4 2 0 | Feb, Aug | [illegible] | 5¼ |
| 10 | 17/0 | India Rubber, Gutta Percha, &c., Wrks. | 18–19 | 2 12 6 | Feb, Aug | [illegible] | [illegible] |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99–102 | 3 18 5 | Mar, Sept | .. | — |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¾–12¼ | 4 1 8 | Mar, Sept | .. | — |
| 1 | 1/2⅔ | Richardsons, Westgarth & Co., Ltd. Ord. | 15/16–1 | 6 0 0 | .. | 1 1/16 | 1 |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1–1⅛ | 5 7 6 | .. | .. | .. |
| St. | 4½% | Do. 4½% Perp. Deb. Stock | 100–102 | 4 8 8 | .. | 102 | .. |
| 12 | 12/0 | Telegraph Construction & Mainten'ce. | 34–36 | 5 0 0 | Mar, July | [illegible] | 34 |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 100–102 | 3 13 6 | Jan, July | [illegible] | [illegible] |
| 1 | 1/0 | Vickers, Sons & Maxim, Ltd., Ord. | 2⅝–2⅞ | 4 9 6 | .. | [illegible] | .. |
| 1 | 6d. | Do. 5% Non-Cum. Preference | 1 3/16–1 5/16 | 3 16 0 | .. | .. | .. |
| St. | 5% | Do. 5% Non-Cum. Preferred | 122–126 | 4 0 0 | — | [illegible] | [illegible] |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock Red. | 104–106 | 3 15 6 | .. | [illegible] | [illegible] |
| 100 | 4½% | Do. 4½% 2nd Mort. Debs., Red. | 105–107 | 4 4 0 | .. | [illegible] | .. |
| 5 | — | Willans and Robinson Ord. | 2¼–2¾ | — | Apr, Oct | [illegible] | [illegible] |
| 5 | — | Do. 6 per Cent. Cum. Pref. | 4–4½ | — | Apr, Oct | .. | .. |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 82–87 | 4 12 0 | May Nov | .. | .. |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | * African Direct Tel. 4% Mrt. Deb. (red.) | 99½–101½ | 3 18 6 | Jan, July | [illegible] | .. |
| 10 | — | Amazon Telegraph | 3¾–4¼ | .. | Jn, Dec .. | [illegible] | .. |
| 100 | 5% | Do. 5% Debs. (red.) | 83–88 | 5 18 6 | .. | .. | .. |
| St. | 21/0 | † Anglo-American | 64–66 | 4 11 0 | F, My, Ag, N | .. | [illegible] |
| St. | 32/0 | † Do. Preferred | 111½–112½ | 4 17 6 | F, My, Ag, N | 112 | [illegible] |
| St. | 10/0 | † Do. Deferred | 18⅜–18⅝ | .. | F, My, Ag, N | [illegible] | [illegible] |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 97–99 | 4 1 0 | Jn, Ap, Jy, O | [illegible] | [illegible] |
| 10 | 5/0 | Cuba Submarine Ord. | 8½–9 | 5 11 0 | Feb, Aug | [illegible] | .. |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17–18 | 5 11 2 | Feb, Aug | [illegible] | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜–3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 8¼–8¾ | 5 14 0 | April, Oct | .. | .. |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 100%–102% | 4 8 0 | Jan, July | .. | .. |
| 20 | 3/6 | Direct United States Cable. | 14¾–15¼ | 4 5 0 | Ja, Ap, Jy, O | [illegible] | [illegible] |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 99–101 | 4 9 0 | Jn, Dec .. | .. | .. |
| St. | 25/0 | Eastern Ordinary | 149–152 | 4 12 0 | Ja, Ap, Jy, O | 150½ | 149 |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 91–93 | 3 15 8 | Ja, Ap, Jy, O | 92 | 91 |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 107½–108½ | 3 13 0 | May, Nov | 109 | [illegible] |
| 10 | 2/6 | Eastern Extension | 14¾–15¼ | 4 11 6 | Ja, Ap, Jy, O | [illegible] | [illegible] |
| St. | 4% | † Do. 4 per Cent. Deb. Stock | 105–107 | 3 14 8 | Feb, Aug | [illegible] | [illegible] |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb. 1909 | 99–101 | 3 19 3 | Feb, Aug | — | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101%–103% | 3 18 8 | May, Nov | .. | .. |
| 10 | 5/0 | G. N. (of Copenhagen) with coupon 65 | 87–89 | 6 2 0 | Jan, July | 88½ | [illegible] |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 100–102 | 4 8 0 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57–59 | 5 10 0 | May, Nov | — | .. |
| 100 | $1 | Mackay Companies Common | 61⅛ | 3 5 6 | Jan, July | — | .. |
| 100 | 4% | Do. Preference | 76 | 5 5 3 | Ja, Ap, Jy, O | .. | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1⅛–1⅜ | .. | .. | [illegible] | [illegible] |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 99–102 | 3 18 6 | June, Dec | .. | .. |
| 10 | 4/0 | West African Telegraph Shares | 9½–10 | 5 0 0 | .. | [illegible] | .. |
| 20 | — | West Coast of America | ⅝–¾ | .. | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100–102 | 3 18 3 | Jan, July | .. | .. |
| 10 | — | West India and Panama | ⅜–⅝ | .. | May, Nov | .. | .. |
| 10 | 6/0 | Do. 6% 1st Pref. | 8¼–8¾ | 6 6 8 | May, Nov | .. | .. |
| 10 | — | Do. 6 per Cent. 2nd Pref. | 6½–7½ | .. | May, Nov | .. | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 100–103 | 4 17 0 | Jan, July | .. | .. |
| 10 | 8/0 | Western Telegraph | 14½–15 | 4 18 0 | Mr, Jn, O, D | [illegible] | [illegible] |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 100–102 | 4 18 0 | June, Dec | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 102–104 | 3 16 10 | .. | .. | .. |
| | | **TELEPHONES.** | | | | | |
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 102–104 | .. | August | .. | .. |
| 5 | 8/0 | Chili Telephone (fully paid) | 8–8¼ | 4 17 0 | .. | 8 | .. |
| 1 | 0/9⅜ | Monte Video Telephone Ord. | ⅞–1 | 4 0 0 | — | .. | .. |
| 1 | 1/0 | Do. 5% Pref. | ⅞–1 | 5 0 0 | .. | .. | .. |
| St. | 6% | National Co. Pref. Stock | 113½–114½ | 5 5 8 | — | [illegible] | [illegible] |
| St. | 5% | Do. Def. Stock | 110–112 | 4 8 8 | — | [illegible] | [illegible] |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13–15 | 4 0 0 | Feb, Aug | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 11–13 | 4 12 4 | Feb, Aug | [illegible] | [illegible] |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅝–5⅞ | 4 5 2 | Feb, Aug | [illegible] | [illegible] |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 99–101 | 3 9 3 | June, Dec | [illegible] | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 102½–105½ | 3 16 0 | .. | [illegible] | [illegible] |
| 1 | 0/7½ | Oriental | 1½–1⅝ | 4 12 0 | April, Oct | [illegible] | .. |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1½–1⅝ | 4 7 0 | — | .. | .. |
| St. | 24/7⅜ | Do. 4% Red. Deb. Stock | 99–102 | 3 18 6 | .. | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 103–106 | 4 4 9 | .. | [illegible] | .. |
| 5 | 3/0 | United River Plate | 7¼–7½ | 5 6 8 | July | — | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5½–5¾ | 4 7 0 | June, Dec | .. | — |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 110–112 | 4 9 8 | June, Dec | 111½ | — |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 5–5½ | 5 9 0 | .. | .. | .. |
| 10 | 2/0 | Globe Telegraph and Trust | 11½–11⅝ | 4 16 6 | Ja, Ap, Jy, O | 11 11/16 | 11½ |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14⅝–14⅞ | 4 0 6 | Ja, Ap, Jy, O | 14⅞ | 14⅝ |
| 10 | 6% | Submarine Cables Trust (Cert.) | 127–130 | 4 12 0 | April, Oct | .. | — |

In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

## WHEATLEY KIRK, PRICE & CO.

*(Established 1850.)*

ELECTRICAL AND MECHANICAL VALUERS, ARBITRATORS AND AUCTIONEERS.

**TRAMWAY & ELECTRICITY SUPPLY VALUATIONS.**

Periodical Valuations, Stock-takings and Reports for DEPRECIATION, RENEWALS, &c., in conformity with the Acts.

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Telephones { 5077 Bank London. 3218 Central Manchester.

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## PLANT FOR SALE.

### CITY AND COUNTY OF THE CITY OF EXETER.

**SALE OF SURPLUS PLANT.**

The Exeter Corporation Electricity Department have FOR SALE the following PLANT in their Old Generating Station, New North-road :—

ONE 250 KILOWATT DIRECT-COUPLED STEAM ALTERNATTOR, consisting of a Vertical Compound Divided Engine by Hick, Hargreaves & Co., Bolton, with Ferranti Copper Type Flywheel Alternator, and Rope-Driven Exciter; for 2,000 volts and 100 cycles per second, with automatic lubrication; speed 188 r.p.m.

ONE 100 KILOWATT DIRECT-COUPLED STEAM-DRIVEN ALTERNATOR and EXCITER by Easton, Anderson & Goolden, for 2,000 volts and 100 cycles per second, with automatic lubrication; speed 300 r.p.m.

ONE 100 KILOWATT DIRECT-COUPLED ALTERNATOR, consisting of Raworth Universal Compound Engine and Mordey Victoria Alternator and Belt-Driven Exciter, for 2,000 volts and 100 cycles per second, with automatic lubrication; speed 300 r.p.m.

Orders to view may be obtained from the undersigned, to whom all communications should be addressed.

H. D. MUNRO, M.I.E.E., City Electrical Engineer.

184, Sidwell-street, Exeter.

## MISCELLANEOUS PLANT, &c., WANTED.

WANTED, TENDERS from Manufacturers for Direct and Alternating Current MOTORS for hiring out to consumers.—Particulars may be obtained on and after SATURDAY, 3rd March, 1906, from H. FARADAY PROCTOR, City Electrical Engineer, Temple Back, Bristol.

WE BUY for Cash to re-sell in Italy, INCANDESCENT ELECTRIC POCKET LAMPS, Novelties, Useful Articles, &c.—Address MONDO MEDICO, Naples, Italy.

WANTED, LAMP TOPS, with Platinum, Scrap Platinum, &c.—EDEY & Co., 29, Ludgate-hill, London, E.C.

## MISCELLANEOUS PLANT, &c., FOR SALE.

ELECTRIC LIGHT PLANT, two sets of 100 k.w., for power or traction, consisting of two sets of Belliss and Morcom triple expansion engines, coupled direct to Mather and Platt dynamos, 200 amps., 400 to 570 volts, at 550 revs. per minute. Each set complete, with surface condensers, air pumps, and circulating pumps, coupled to crank shaft. Sell cheap to save second removal.—WHITE BROS., and Co., Engineers, Stratford, London. Telephone 365 Stratford.

FOR SALE.—TWO 150 KW. "PARSONS" DIRECT-CURRENT (100 to 110 Volts) TURBO GENERATORS, Steam Pressure 150lb. These sets have been tested and are now ready for delivery, but, if necessary, can be rewound up to 250 volts. They are perfectly new and are for disposal owing to alterations in plans.—Apply, C. W. C., *Electrician* Offices, Salisbury-court, Fleet-street, London.

ELECTRIC PLANT, consisting of Vertical Cochran Boiler, 11 ft. by 5 ft.; Pair of Inverted Engines, 12 in. cylinders, by Browett, Lindley & Co.; Shunt Dynamo, 110 volts, at 450 revs., by Elwell Parker, Limited: all complete as recently worked. Apply Colosseum Theatre, Oldham.

TRANSFORMERS (3) to reduce 250 v. to 1 v. in 21 steps, with voltmeters complete.—JONES, Church-street, Islington, London, N.

FOR SALE, ELECTRIC MOTOR, 10 H.P., 500 v. 1,400 r. British Thomson-Houston, complete with rheostat and switchboard.—JONES, Church-street, Islington, London, N.

FOR SALE or HIRE, high-class Dynamos, Motors, Alternators, Cable and Electrical Apparatus.—PERCY HUDDLESTON & Co., 72, Finsbury Pavement, London, E.C.

ELECTRICIAN'S NON-MAGNETIC OXYDISED WATCH. Elegant appearance. Good timekeeper. 14s. 6d. post free.—WALLACE & FIELDS, 39, Old Hall-street, Liverpool.

**GAMBRELL BROS,**
MANUFACTURERS of ELECTRICAL TESTING INSTRUMENTS.
Durham House, North Side,
Clapham Common, London, S.W.
CATALOGUE ON APPLICATION.

Telegrams: Turnstile London.

**STANLEY**

GOLD MEDAL, St. Louis, 1904.

**SURVEYING & DRAWING INSTRUMENTS.**

*NOTICE OF REMOVAL OF THE RETAIL DEPARTMENT*
from GREAT TURNSTILE to
**286, HIGH HOLBORN, LONDON, W.C.** Price List post free.

## SALE BY TENDER.

**FOR SALE.—COPPER STEAM PIPES.**

THE Lord Provost, Magistrates and Council of the City of Edinburgh invite Tenders for the Purchase of a quantity of COPPER STEAM PIPE BENDS with wrought-iron flanges brazed on, the pipes ranging from 8 in. to 3 in. in diameter, the total weight of copper in the pipes being about 6 tons.

Tenders will be considered either for the pipes as they are, or as scrap copper with or without the wrought-iron flanges.

Full particulars can be obtained from the undersigned, to whom offers must be sent by 8th MARCH, 1906.

FRANK A. NEWINGTON, Engineer.

Dewar Place Electricity Supply Station,
Edinburgh, February 22nd, 1906.

## TENDERS INVITED, &c.

### BOROUGH OF TORQUAY.

The Electric Lighting Committee of the Torquay Town Council are prepared to receive Tenders for the supply of

**1,500 TO 2,500 TONS OF SMOKELESS THRO' STEAM COAL.**

Specification and Form of Tender may be obtained from the undersigned.

Tenders, endorsed "Tender for Steam Coal," must reach the undersigned not later than noon, MONDAY, March 19th, 1906.

The lowest or any Tender will not necessarily be accepted.

**FOR SALE BY TENDER.**—One 125 kw. Willans-Fynn ALTERNATING-CURRENT SET, in thorough working order, to be removed from the Corporation's Central Electric Lighting Station, to make room for a larger unit.

Further particulars may be obtained of the Electrical Engineer (Mr. P. Storey), and the plant seen at the above station.

Tenders, endorsed "Tender for 125 kw. Set," must reach the undersigned not later than noon on MONDAY, March 19th, 1906.

The highest or any Tender will not necessarily be accepted.

FREDK. S. HEX, Town Clerk.

Town Hall, Torquay, February 26th, 1906.

### BOROUGH OF FULHAM.

**GENERAL AND ELECTRICAL STORES.**

The Fulham Borough Council is prepared to receive TENDERS for the Supply of General Stores (including Engineering Goods, Packings, Jointings, &c., Tools, Castings, Cables, Incandescent and other Lamps, Carbons, Street Lighting Goods, &c., Oils, Paints, Brooms, Brushes, &c.) for the year ending 31st March, 1907.

Contractors may tender for all or any Section.

Tenders must be made on printed forms specifying Conditions of Contract provided by the Council, sealed and endorsed "Tender for General Stores," and delivered at the Town Hall, Fulham, by 4 p.m. on WEDNESDAY, the 14th March, 1906.

The Council does not bind itself to accept the lowest or any Tender.

By order.
R. M. PRESCOTT, Town Clerk.

Town Hall, Fulham, London, S.W.

### CITY OF DUBLIN.

The Corporation of Dublin is prepared to receive TENDERS for the Supply of **ARC LAMP CARBONS** to their Electricity Undertaking.

Specification, with Terms and Conditions, and Form of Tender, may be obtained from the City Engineer, City Hall, Dublin, on payment of the sum of One Shilling for each form.

Tenders, sealed and marked "Tenders for Carbons," must be addressed to me at my Office, City Hall, Dublin, and delivered not later than 12 o'clock noon on FRIDAY, 9th March, 1906.

Tenders which do not contain the genuine signatures of both the tenderer and his sureties will not be considered.

The lowest or any Tender will not necessarily be accepted.

By order,
HENRY CAMPBELL, Town Clerk.

Town Clerk's Office, City Hall,
Dublin, February 22nd, 1906.

TENDERS INVITED continued on next page.

**Royal Doulton Potteries.**

**INSULATORS**

AND ALL KINDS OF

**POTTERY FOR ELECTRICAL PURPOSES.**

**DOULTON & CO.,**
LIMITED,
Lambeth, LONDON, S.E.

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*Makers of all kinds of ELECTRICAL INSTRUMENTS,*
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## TENDERS INVITED—*continued.*

## METROPOLITAN BOROUGH OF ST. MARYLEBONE.

ELECTRICITY DEPARTMENT.

The Council of the Metropolitan Borough of St. Marylebone invite Tenders for the Supply and Delivery for a period of One Year of the following **STORES**:—

1. ENGINE-ROOM STORES.
2. CABLES.
3. CABLE-JOINTING MATERIALS.

General Conditions, Schedule and Form of Tender may be obtained from Mr. F. A. Wilkinson, Resident Electrical Engineer and Manager, Temporary Offices, 11, Manchester-street, London, W.

Sealed Tenders, endorsed "Tenders for Stores," must be addressed and delivered at the Town Hall to the undersigned before 4 p.m. on the 14th day of MARCH, 1906.

The Council will not be bound to accept the lowest or any Tender.

JAMES WILSON, Town Clerk.

Town Hall, Marylebone-lane, Oxford-street,
London, W., February 24th, 1906.

## BRITON FERRY URBAN DISTRICT COUNCIL.

**TO ELECTRICAL CABLE MAKERS.**

The Council of the Urban District of Briton Ferry are prepared to receive TENDERS for the Supply, Delivery, Erection and Laying of SUB-STATION SWITCHBOARD, NON-RUBBER FEEDER and DISTRIBUTOR CABLES, FEEDER PILLARS, JOINT BOXES, ARC STANDARDS, ARC LAMPS, &c.

Specifications, with General Conditions, Form of Tender, &c., and Plan of District, showing Cable Routes, &c., may be inspected on and after Monday the 5th day of March, 1906, at the Offices of the Consulting Engineers, Messrs. Herbert Lewis and Fletcher, Prudential Buildings, Cardiff, from whom a copy of the Specification with Form of Tender may be obtained on payment of Two Guineas, which will be returned on receipt of a bona fide Tender.

Tenders, addressed to me at the Council Offices, Briton Ferry, must be in my hands not later than noon the 26th day of MARCH, 1906.

TREVOR H. HUNTER, Clerk.

Dated February 26th, 1906.

## CORPORATION OF GREENOCK.

The Corporation are prepared to receive TENDERS for the Supply and Delivery of

**TWO D.C. STEAM GENERATORS OF 750 KW. EACH.**
**ONE 500 KW. D.C. MOTOR GENERATOR.**

Specification and Form of Tender may be obtained from the Burgh Electrical Engineer, at the Municipal Buildings, Greenock, on payment of a deposit of Two Guineas, which will be returned on receipt of a bona fide Tender by the date mentioned below.

Extra copies of Specification may be obtained on payment of 5s. each, which will not be returned.

Tenders, addressed to the undersigned and endorsed "Contract No. 20, Steam Generators, &c.," must be delivered to the undersigned not later than midday, MARCH 15th, 1906.

The Corporation do not bind themselves to accept the lowest or any Tender.

C. MACCULLOCH, Town Clerk.

Municipal Buildings, Greenock, February 27th, 1906.

## CITY AND COUNTY BOROUGH OF BELFAST.

TRAMWAYS AND ELECTRICITY DEPARTMENT.

The Tramways and Electricity Committee of the Belfast Corporation are prepared to receive TENDERS for

**ONE 400 KILOWATT STEAM DYNAMO.**

Specification, with Form of Contract, may be obtained from the undersigned, on payment of Two Guineas, which will be refunded provided a bona fide Tender has been sent and not withdrawn.

Sealed Tenders, endorsed "Tender for Steam Dynamo," shall be lodged with Sir Samuel Black, Town Hall, Belfast, not later than 11 a.m. on MONDAY, the 19th day of March, 1906.

The Council do not bind themselves to accept the lowest or any Tender.

VICTOR A. H. M'COWEN, M.Inst.E.E., M.I.Mech.E.
City Electrical Engineer, Belfast.

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## THE CITY OF LONDON ELECTRIC LIGHTING CO., LIMITED.

NOTICE is Hereby Given that the TRANSFER BOOKS and REGISTER of MEMBERS of the above Company will be CLOSED from the 28th February to the 14th March, 1906, both days inclusive.

By order,
J. CECIL BULL,
Manager and Secretary.

1 and 2, Great Winchester-street,
February 22nd, 1906.

## THE COUNTY OF LONDON ELECTRIC SUPPLY COMPANY, LIMITED.

NOTICE is Hereby Given that the TRANSFER BOOKS and REGISTER of MEMBERS will be CLOSED from 2nd to the 12th March, both days inclusive, preparatory to payment of the Final Dividends upon the Ordinary and Preference Shares of the Company for the half-year ended 31st December, 1905.

By order of the Board,
A. B. RENWICK, Secretary.

Moorgate-court, Moorgate-place,
London, E.C., February 26th, 1906.

## CIVIL SERVICE COMMISSION.—FORTHCOMING EXAMINATION.

ASSISTANT EXAMINERS in the PATENT OFFICE (20-25) 5th APRIL.

The date specified is the latest at which applications can be received. They must be made on forms to be obtained, with particulars, from the **SECRETARY**, Civil Service Commission, Burlington Gardens, London, W.

## WEST RIDING COUNTY COUNCIL.

The West Riding County Council offer FOUR TECHNOLOGICAL SCHOLARSHIPS each of the value of £60, open to residents within the Administrative Area of the West Riding of Yorkshire, and available for courses of instruction in connection with the following:—

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The awards will be mainly based on the results obtained at examinations of the Board of Education, South Kensington, and City and Guilds of London Institute.

Application Forms and full particulars may be obtained from the Education Department (Technical Branch), County Hall, Wakefield.

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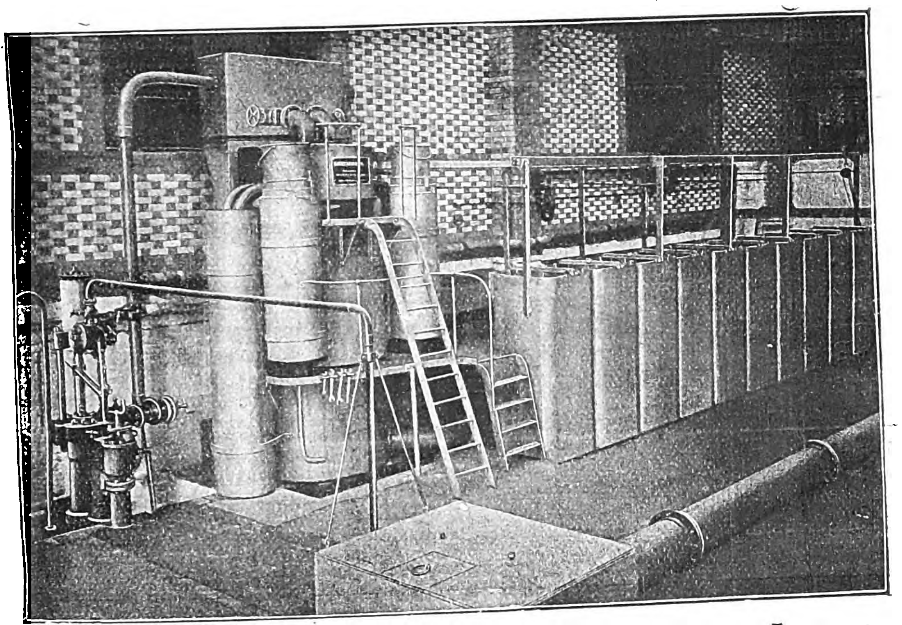

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Telegrams: WINDTIGHT GREENOCK. Telephone 127

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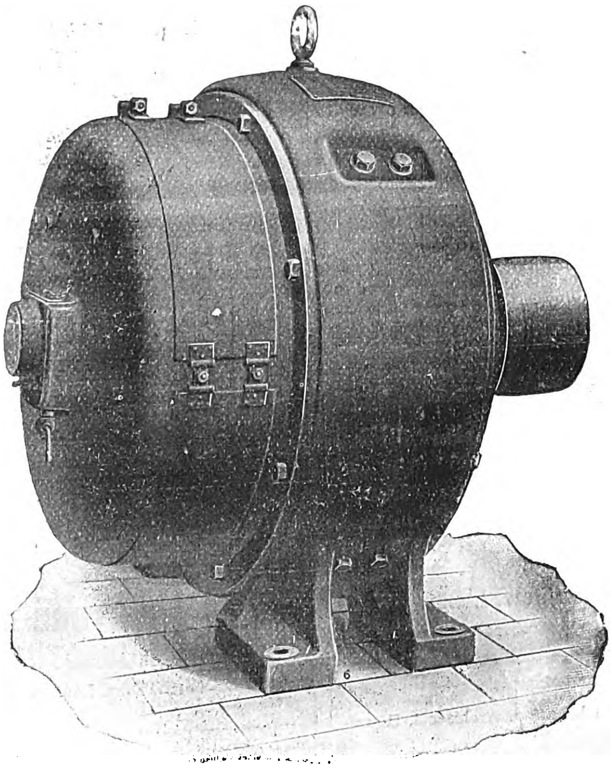

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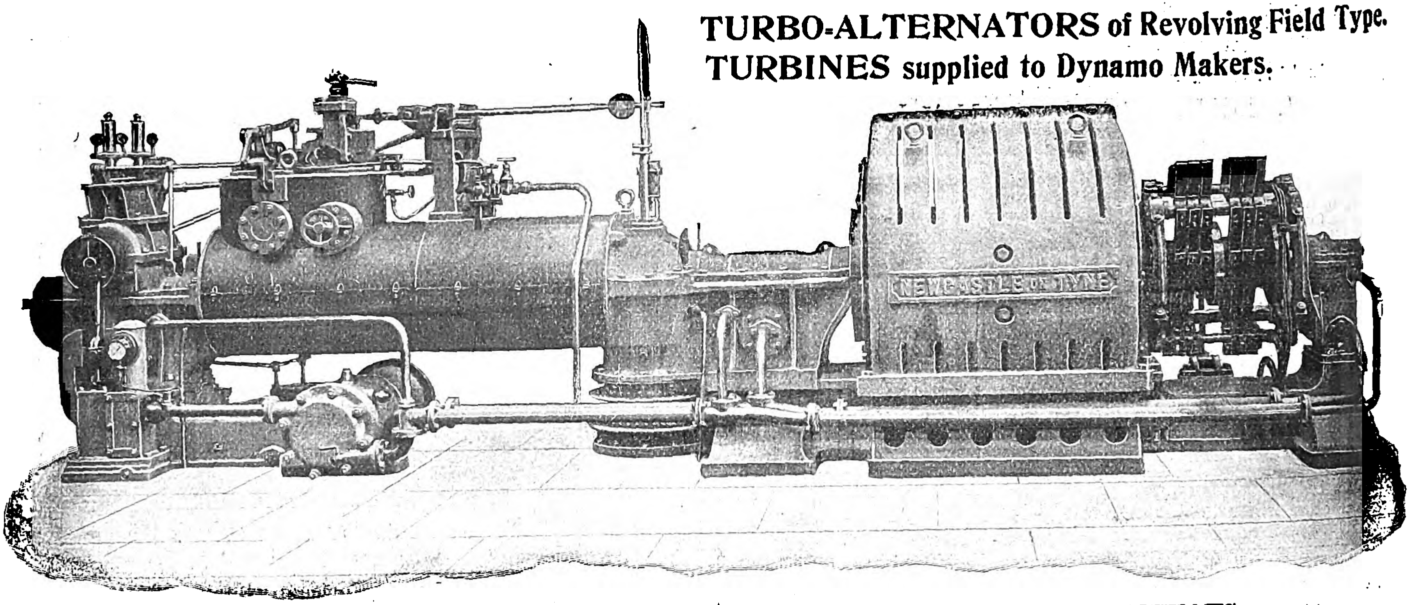

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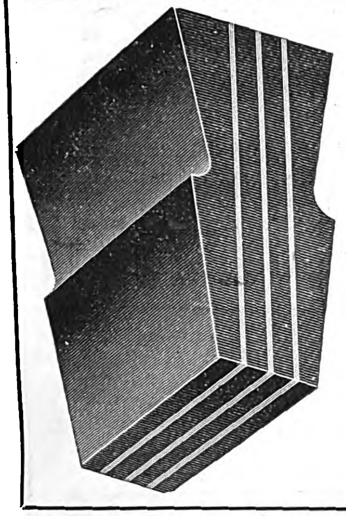

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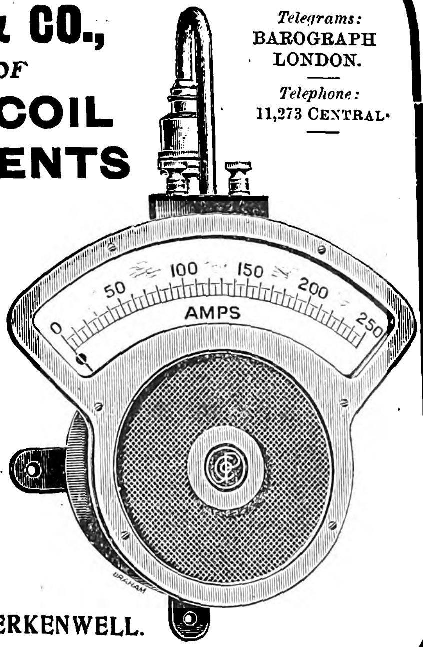

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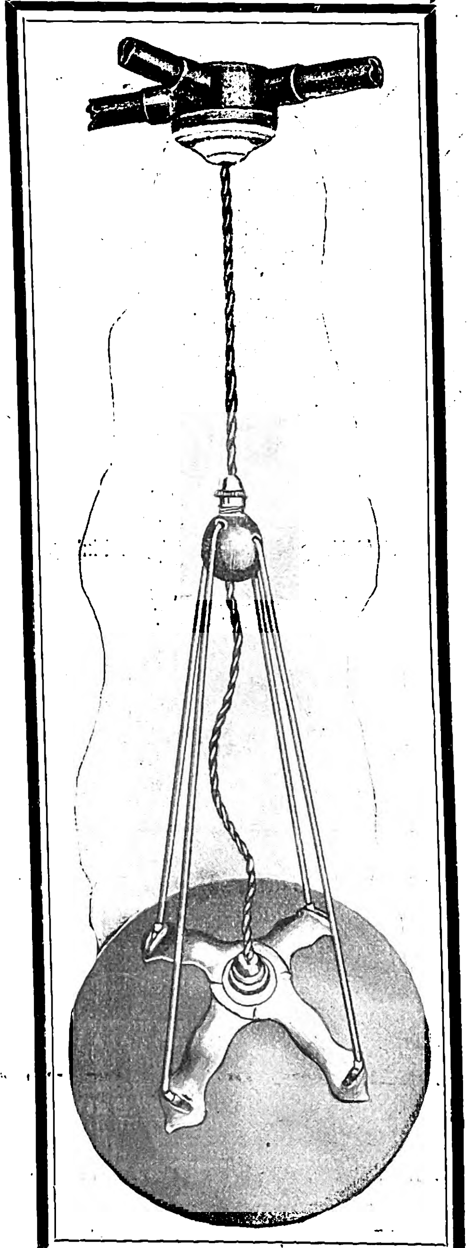

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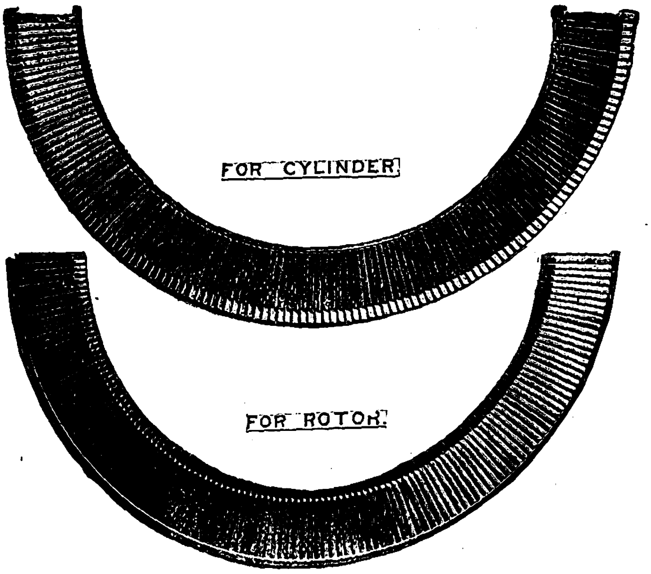
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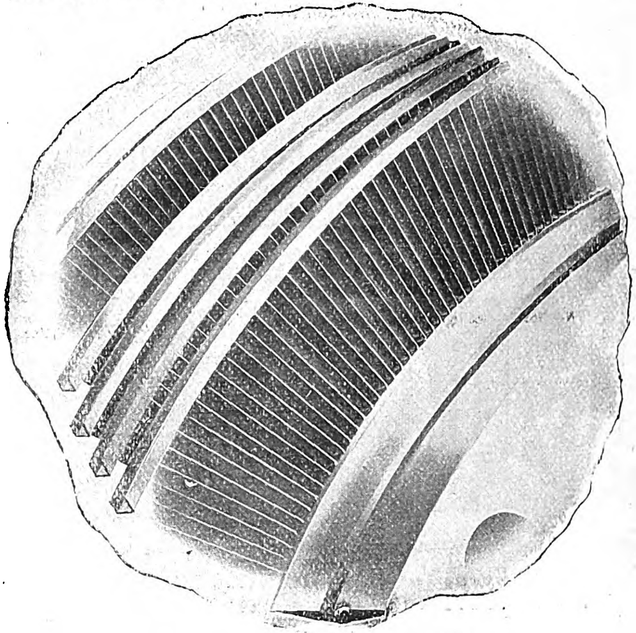

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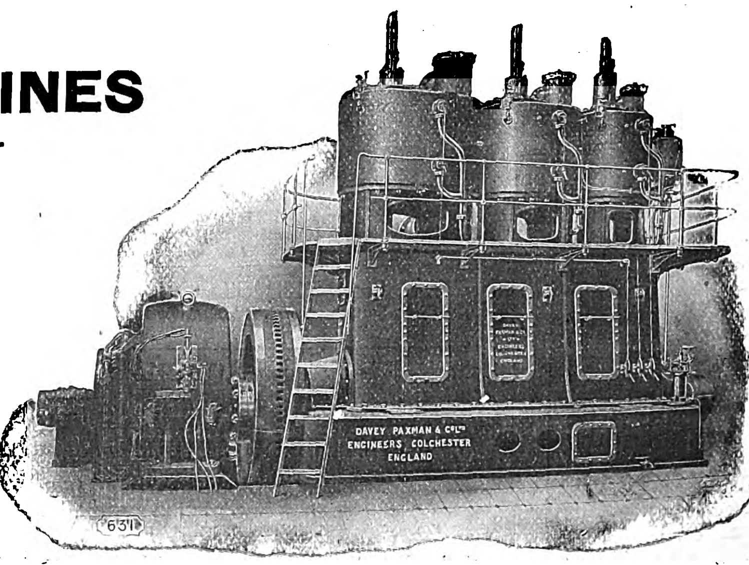
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# THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF
ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.
ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,450. [No. 20. Vol. LVI.] FRIDAY, MARCH 2, 1906. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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## NOTES.

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THROUGH the kindness of Mr. C. P. SPARKS, we are able to publish to-day some steam consumption tests on a 1,500 kw. Curtis turbo-alternator set, running at the electricity works of the County of London Electric Supply Co. Independent tests of this nature are always of great value, and in this case they are of more than usual interest, for they have been made on a standard make and size of machine that is now in use at several electricity works, and moreover, on a machine whose electrical design has been recently described in considerable detail in our columns. Mr. SPARKS has included in the particulars which he has given us the amount of energy absorbed by the auxiliaries, figures which are too often passed over in silence by experimenters. Perhaps more interesting than the low steam consumptions at full-load (17·25 lb. per kw.-hour, excluding auxiliaries, and 17·6 lb., including auxiliaries), is the fact that the consumption increases but very little down to one-third full-load. It is true, of course, that the tests were favoured by the extraordinarily high vacuum of 96·2 per cent. of the barometric pressure, and it will be interesting to note whether this vacuum can be maintained in ordinary service or not. On the other hand, however, the steam was superheated by 60°F. only, and the consumption figures might have been considerably reduced had it been possible to employ a higher degree of superheat. The test figures referred to do not represent the lowest steam consumption figures which have been recorded for turbo sets of about this size, although they approach them closely. In a 1,200 kw. Brown Boveri-Parsons three-phase set installed about two years ago at Rheinfelden, for instance (see *The Electrician*, Vol. LIII., p. 44), the steam consumed per kilowatt-hour ranged from 15·9 lb. at 1,440 kw. to 21 lb. at 378 kw. The vacuum was approximately the same as in the Curtis turbine sets referred to above, but the steam was superheated to no less than 250°C. on an average, and this quite accounts for the difference.

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PREVIOUS to the large electrical exhibition at Olympia last year, manufacturers of electrical engineering plant had been put to much trouble and expense by the obligation to send goods to numbers of small electrical exhibitions promoted in various parts of the country by the local electricity supply undertakers. Consequently the members of the National Electrical Manufacturers' Association, which was responsible for the organisation of the Olympia exhibition, agreed not to take part in any other exhibition in the near future. There was much to say in favour of this arrangement, but, on the other hand, it has been shown that there were drawbacks. Undoubtedly London may be taken to be the centre of a large branch of the electrical engineering industry, but there are other branches—notably electric power distribution—that have had a better opportunity for expansion in other cities, for instance, in Manchester and Newcastle. The success of the Olympia exhibition is indisputable, but electric power plant, especially the heavier sort, was not so fully represented as it might have been. There was room, therefore, for an exhibition of a "heavier" nature in one of the northern manufacturing centres, and it is to be regretted that the Newcastle exhibition, referred to in our Correspondence columns this week, should have been handicapped by lack of support by the members of the National Electrical Manufacturers' Association.

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ALTHOUGH London is behindhand with regard to electric power supply, there has been considerable improvement during the past year. It will be seen, for instance, in the report that we publish in another column, that the South Metropolitan Electric Light and Power Co. sells no less than 40 per cent. of its output for power purposes. Although at present the company ranks among the smaller London undertakings, this is soon to be remedied if we judge by the statement made by Mr. H. W. BOWDEN at the company's meeting on Monday. A large increase in the demand is anticipated in the near future, and extensions are to be made with 1,500 kw. sets, showing that the company is sanguine as to the productiveness of their large area, for at present the total connections amount only to about 3,500 kw. The area embraces Blackheath, Greenwich, Lewisham, Penge and the Crystal Palace district, and therefore it should certainly be possible to develop a large industrial load in addition to a lighting load with a good diversity factor. Evidently Mr. BOWDEN is of this opinion, as he is taking as a model the power-house at St. Denis, the capacity of which will be 60,000 kw. by the end of this year.

WE give in our Parliamentary columns this week a two clause Bill which has been introduced into the House of Commons by the Postmaster-General, Mr. SYDNEY BUXTON, relating to wireless telegraphy and was read the first time on Monday. It extends the Wireless Telegraphy Act of 1904, which in the ordinary course would have expired on September 30th of this year. Lord STANLEY, who was Postmaster-General in 1904, specially inserted the clause limiting the period of operation of the Act of 1904, and the Bill which is referred to above is ample evidence that the authorities have been satisfied with the result, for it will be observed that no modification or amendment of the Act of two years ago is made. It will be recalled that we expressed ourselves in complete agreement with the original Act in a leading article at the time. The Postmaster-General, it will be seen, intends to add a clause to the Bill limiting its operation to a further six years.

APART from engineering works, very little has hitherto been published on the most suitable form of electric driving of industrial works generally. A modest attempt to supply such information for a variety of works was made by Mr. W. J. BELSEY in a Paper recently read before the Dublin Local Section, and reported elsewhere in this issue. The author's recommendations as where to employ continuous-current motors and where to employ alternating-current motors appear sound, and call for no comment on our part. In quite a number of works it is undoubtedly advantageous, from the efficiency point of view, to employ more than one class of motors: motors with a rigidly-constant speed, motors with a variable speed characteristic, and motors with a large torque. Accordingly, the author proposes the adoption of induction motors, shunt motors, and continuous-current series motors. This implies, of course, both a continuous and alternating supply, and although this course has been followed with advantage in some large works, the increase in first cost and added complication in a small works would be a serious consideration and will limit its adoption. This brings us to another point not alluded to by Mr. BELSEY, and that is the possible replacement of continuous-current motors in this scheme by alternating-current commutator motors, which would then allow an alternating supply to be used exclusively in the shops. At present, of course, only alternating-current commutator motors possessing a "series" characteristic (such as required for traction purposes) have been commercially developed, but we have reason to believe that attention is now also being devoted to the evolution of a "constant speed" alternating-current commutator motor, resembling the shunt motor in its action. But there are a number of industrial establishments which do not require the latter type of motor, and which, therefore, can be driven with the utmost efficiency from an alternating supply by a combination of induction motors for constant speed, and single-phase commutator motors for large torques.

**National Electric Light Association.**.—The 29th Convention of the National Electric Light Association of America is to be held at Atlantic City, N.Y., from June 5th to 8th inclusive.

**Personal.**—Prof. John Perry, F.R.S., has been elected chairman of the Joint Scholarship Board of the College of Preceptors, Bloomsbury, in succession to Sir Philip Magnus, M.P.

**University Colleges.**—A permanent committee has been appointed by the Treasury to advise that department as to the distribution of the grant-in-aid of colleges furnishing education of a University standard. The committee consists of the following: The Rev. H. G. Woods, D.D., chairman, Sir Francis Mowatt, G.C.B., Sir William J. Collins, M.D., M.P., Prof. Henry Jackson, Litt.D., LL.D., and Prof. W. S. McCormick, M.A., LL.D., with Mr. R. G. Hawtrey, of the Treasury, as secretary.

| **Cable Interruptions.** | Date of Interruption: |
|---|---|
| Tarifa—Tangier | Jan. 18, 1904 |
| Jamaica—Colon | Jan. 10, 1905 |
| Cadiz—Teneriffe | July 20, 1905 |
| Puerto Plata—Martinique | Dec. 15, 1905 |
| Tangier—Cadiz | Feb. 17, 1906 |
| Santa Lucia—St. Vincent | Feb. 19, 1906 |
| St. Vincent—Grenada | Feb. 19, 1906 |
| Grenada—Trinidad | Feb. 24, 1906 |
| Porto Rico—St. Thomas | Feb. 26, 1906 |
| Porto Rico—St. Croix | Feb. 26, 1906 |
| Alexandria—Larnaca | Feb. 28, 1906 |

**The Construction and Maintenance of Overhead Equipment.**—In our report on the discussion on Messrs. R. N. Tweedy and H. Dudgeon's Paper on the above subject (p. 766 in our last issue), Mr. R. F. Browne's test figures on the Standard Committee's medium pole, 8⅝ in. × 0·34 in., 7½ in. × 0·31 in., and 6½ in. × 0·25 in., and of a weight of 875 lb., were wrongly quoted. The correct figures are: Temporary deflection with 1,250 lb. 5⅜ in., and permanent deflection with 1,750 lb. ¾ in.

**The Junior Institution of Engineers.**—Through the courtesy of Mr. A. P. Trotter, a visit was paid by the Junior Institution of Engineers to the Board of Trade Electrical Standardising Laboratory, Whitehall, on Monday, February 19th. The standard ampere-balances and voltmeters were shown, and the potentiometers by which small currents are measured. The standard resistances, kept in a small room at a constant temperature, were inspected, and the methods adopted for meter-testing were explained. Mr. J. Rennie and Mr. C. W. S. Crawley conducted the members round the laboratory.

**Wireless Telegraphy in Australia.**—Capt. Walker, of Marconi's Wireless Telegraph Co., recently applied to the Queenscliff (Victorian) Municipal Council for permission to erect upon Corporation ground an experimental plant for communicating with a station to be erected on the Tasmanian coast, and has been granted a lease for six months of a suitable plot situated half way between Queenscliff and Point Lonsdale. He has now proceeded to Tasmania to arrange for a temporary site at that end, and as the necessary plant is now in Australia, it is hoped that the stations will be at work at no distant date. In accordance with the arrangement with the Postmaster-General, the whole equipment will be worked under the supervision of Federal postal officials, in order that they may study the suitability of the system for Government use.

**St. Louis International Electrical Congress, 1904.**—The treasurer's audited financial report, closing the affairs of the International Electrical Congress of St. Louis, has been issued. The total expenditure of the Congress somewhat exceeded the amount of the membership fees, but when the probability of a deficit became evident, a canvass was instituted for the sale of copies of the *Transactions*, with the result that there is an unexpected balance to the credit of the Congress amounting to about £400. The Executive Committee of the Congress has decided to offer this balance to the library of the American Institute of Electrical Engineers, as a fund in perpetuity commemorating the Congress of 1904 the annual proceeds of which are to be applied to the purchase of international electrical literature. Mr. W. D. Weaver acted as treasurer.

**Electric Smelting.**—In a note on p. 377 of *The Electrician* of December 22nd we referred to one of the pig iron electric smelting works on the Heroult system which have been established by the Canadian Government, and we now learn from *Commercial Intelligence* that pig iron has been produced there from red hematite at less that $10 a ton. Experiments in electric smelting of steel are also being carried out on a laboratory scale in Canada by Mr. J. W. Evans, and an apparently good quality of steel was obtained from the titanium and sulphurous ores which are plentiful in Ontario. Another example of electric smelting is found in the furnace at Portland, Oregon, upon which Dr. T. Day, of the U.S. Geological Survey, has issued two reports. Here the smelting of magnetic iron ores is carried on, and during eight test runs the furnace yielded an average of 55 per cent. of metallic iron from the magnetite used and gave on the average 14 lb. of steel per horse-power day, a figure comparing favourably with results obtained on the Continent.

**Tramway Extensions in Surrey.**—The 7 miles of new routes in the Surrey suburbs which the London United Tramways Co. have just added to their system were opened for traffic yesterday. These lines are connected to the older part of the company's tramways by the line over Kingston Bridge, and include the following routes: (1) Winter's (or Window's) Bridge, Long Ditton, via Surbiton Station, Kingston Bridge, Teddington and Twickenham to Richmond Bridge; (2) Talworth, via Surbiton Station and Kingston Station to Richmond Park Gates; (3) Surbiton Station to Ham Boundary; (4) Winter's Bridge, via Surbiton Station to Kingston Hill; and (5) Kingston Hill to Hampton Court over Kingston Bridge. The further extensions to New Malden and Wimbledon are under construction, but the line from Wimbledon to Tooting, where a junction will be made with the London County Council system, has not yet been commenced. The Board of Trade inspection of the new lines was made by Col. Yorke on Wednesday. Power is obtained from the generating station of the Underground Railways Company at Lot's-road, Chelsea, and a special 11,000 volt main has been laid from Chelsea to the new sub-station in London-road, Kingston, a distance of some 10½ miles. Two separate paper-insulated, lead-covered, high-tension cables are provided and five feeders radiate from the sub-station to various parts of the line. This, we believe, represents the longest E.H.T. transmission by underground cable in this country.

**Dinner of the Manchester Students' Section of the Institution of Electrical Engineers.**—The second annual dinner of the Manchester Students' Section of the Institution of Electrical Engineers was held at the Grand Hotel, Manchester, last Saturday, Mr. S. L. Pearce, the President of the Manchester Section of the Institution, in the chair. The toast of "The Institution of Electrical Engineers" was proposed by Mr. C. D. Taite, who contrasted the facilities in the way of technical instruction and laboratories for students to-day with those in the days when he was himself a student. He thought it was generally understood that the Provincial Students' Sections, of which the largest was at Manchester, were doing good work. The best thing to do when a student knew nothing of a subject was to write a Paper on it. Mr. S. L. Pearce said, in reply, that all the students who could should hear President Gavey reply for himself at the Manchester Senior Section dinner the following Friday. He suggested that a longer time should be allowed at Senior meetings to give time for more discussion of the Papers in which students might take part. He complimented Mr. Jepson on his work in connection with the section. Mr. Jepson, who also replied, thought Mr. Roberts, as pioneer secretary, was entitled to a larger share of praise. Mr. Willis then proposed "Our Guests," and Mr. Taite and Mr. Miller responded.

**Serious Fire at a Cable Works.**—On Monday night, just about midnight, a fire broke out in one of the most important shops of Messrs. Johnson & Phillips' cable works at Old Charlton and, owing to the inflammable nature of the contents of the shop, the flames spread quickly and did considerable damage. The part of the cable works in which the fire occurred was the mechanical protection and tarry yarn department in which cables are lead-covered, armoured and covered with yarn serving, &c. By the prompt action of the officials, who were called to the scene immediately the outbreak was discovered, and the operations of the fire brigade, the fire was confined to one shop, so that the remainder of the cable works and the electric power and telegraph works, which cover an area of some 11½ acres, were not affected. Messrs. Johnson & Phillips are, therefore, able to continue the manufacture of cable without delay in their copper stranding and insulating departments, &c., and they anticipate having no difficulty in making arrangements for lead covering and armouring during the time that it will take to rebuild the shop in question and replace the lead presses. Immediate steps are being taken to start rebuilding, and the firm hopes that in 10 days the new **H** iron girders for the new shops will be in place. In addition to the lead presses and other machinery, a large stock of cable was destroyed by the fire, and the damage has been roughly estimated at £50,000, but we understand that the loss is entirely covered by insurance. It is not improbable that an indirect result of the fire will be the removal of part of the cable works to a site outside the metropolitan area. Messrs. Johnson & Phillips, as other manufacturing firms, find that their operations are considerably hampered by the London Building Act, which, among other things, limits the size of a building to 250,000 cubit ft., unless special consent is given, and even in the latter case the size is limited to 400,000 cubic ft., and the permission is only granted for a certain number of years. Other conditions are also enforced under the Act, such as a limit to the size of doors and openings, and it is thought that, taking all things into consideration, the works could be proceeded with under far better conditions if they were outside the London County Council area. It is, doubtless, considerations such as these that have induced W. T. Henley's Telegraph Works to build their new works at Gravesend. It is, therefore, quite conceivable that other manufacturers may adopt a similar course. Messrs. Johnson & Phillips have our fullest sympathy, and we are glad to learn that they have been able to make such prompt arrangements for the regular continuance of their cable manufacturing business in spite of the severe damage that has been done to their works.

**Central Technical College Old Students' Association.**—The annual dinner of this association was held at the Trocadero Restaurant on Friday last, Prof. W. E. Ayrton (dean of the college) in the chair. In proposing the toast of the evening, Sir Owen Roberts (chairman of the college committee), as one who had been associated with the college even before its birth, expressed his keen satisfaction with the progress that had been made, and with the proposals of Mr. Haldane's committee for the absorption of the Central Technical College and the other science schools at South Kensington into the comprehensive scheme for providing for the higher technical education of those destined to become leaders in the engineering profession. Although on the Senate of the London University, he was in favour of giving the new college a governing body of its own, distinct from that of the London University. The toast was responded to by Dr. E. F. Armstrong, one of the secretaries of the Old Students' Association. "The City and Guilds Institute" was next proposed by Dr. Moody and responded to by Mr. T. H. Blakesley. Col. R. E. B. Crompton, C.B., and Prof. W. J. Pope, F.R.S., proposed the next toast, "The Central Technical College." Col. Crompton referred to the work of the Electrical Engineers Volunteers. War, he said, was not a thing to be proud of, but a thing to guard against, and this could only be done by having able men to call upon—a real citizen army in which each man in the ranks thoroughly understood the work he had to do. He mentioned that there was no other corps in the world in which the juniors were so intelligent as in the Electrical Engineers Volunteers. Prof. H. E. Amstrong, F.R.S., replied. He spoke of the importance of discipline and of obeying the word of command. His own sons had been volunteers, and every Central student, he said, should feel it incumbent upon him to join Col. Crompton's corps. He also expressed in strong terms his opinion as to the unsuitability of the Senate of the London University as a governing body for the new college proposed by Mr. Haldane's committee. Mr. F. C. Raphael, who, with Prof. Pope, was the oldest "Old Student" present, proposed "The Visitors" in a short speech, in the course of which he said that the chief reason against making the London University the governing body of the new college in the first instance was that it would delay the realisation of the project, and it was important to the welfare of our engineering industries that there should be no delay. If governorship by the London University were insisted upon, it might mean the relegation of the whole matter to a Royal Commission, and the question would be shelved for a couple of years, just as had been the case with some measures for improving traffic facilities in London. Mr. James Holden (locomotive superintendent of the Great Eastern Railway) responded, and he was followed by Sir John Wolfe Barry, K.C.B., F.R.S. (chairman of the Executive Committee of the City and Guilds Institute), who, in proposing the toast of "The Chairman," referred to the subject matter of the speeches generally, and refused to rise to the fly cast by Mr. Raphael. In addition to the speakers, several other guests were present, including Prof. W. C. Unwin, F.R.S., Prof. W. E. Dalby, and Mr. T. Mather, F.R.S

**Visit of Foreign Scientific Institutions to Great Britain.**—We gave on p. 87 of our issue for Nov. 3 last, a few particulars concerning the visit to England, this summer, on the invitation of the Institution of Electrical Engineers, of a number of foreign engineering and scientific societies. We are now able to give some further information. The following societies have accepted the Institution's invitation :

Canada : Canadian Electrical Association ; France : Société Internationale des Electriciens ; Germany : Elektrotechnischer Verein, Verband Deutscher Elektrotechniker ; Italy : Associazione Elettrotechnica Italiana ; Switzerland : Schweizerischer Elektrotechnischer Verein ; United States : American Institute of Electrical Engineers.

Some of the leading continental electrical engineering firms will also be represented. A general reception committee has been appointed by the council, whose headquarters during the visit will be at the Hotel Cecil, Strand, London. This committee consists of the following gentlemen :

### General Reception Committee.

Chairman : John Gavey, C.B., President; Earl of Crawford and Balcarres, K.T. ; Lord Kelvin, O.M., G.C.V.O; Lord Alverstone, G.C.M.G., Lord Chief Justice ; Prof. W. Grylls Adams, F.R.S. ; Prof. W. E. Ayrton, F.R.S. ; F. Bailey, Prof. W. F. Barrett, F.R.S. ; Sir John Wolfe Barry, K.C.B., F.R.S. ; T. O. Callender, Albert Campbell, Sir Albert Cappel, K.C.I.E. ; Major P. Cardew, R.E. ; W. A. Chamen, G. von Chauvin, Col. R. E. Crompton, C.B. ; Sir William Crookes, F.R.S. ; H. H. Cunynghame, C.B. ; S. Dobson, B. Drake, W. Duddell, H. Edmunds, R. S. Erskine, W. B. Esson, S. Evershed, Prof. J. A. Ewing, F.R.S. ; A. L. C. Fell, S. Z. de Ferranti, Prof. J. A. Fleming, F.R.S. ; Prof. G. C. Foster, F.R.S. ; E. Garcke, Frank Gill, Dr. R. T. Glazebrook, F.R.S. ; Robert Kaye Gray, F. E. Gripper, Robert Hammond, H. E. Harrison, A. W. Heaviside, I.S.O. ; J. S. Highfield, Col. R. Hippisley, R.E. ; H. Hirst, Col. H. C. L. Holden, R.A., F.R.S. ; J. H. Holmes, Dr. E. Hopkinson, Walter Judd, Prof. Gisbert Kapp, Sir Alex. B. W. Kennedy, F.R.S. ; J. E. Kingsbury, Sir Oliver Lodge, F.R.S. ; P. V. Luke, C.I.E. : Sir Henry Mance, C.I.E. ; E. Manville, G. Marconi, LL.D. ; T. Mather, F.R.S. ; C. H. Merz, W. M. Mordey, A. B. Mountain, Dr. A. Muirhead, F.R.S. ; J. M. M. Munro, Hon. C. A. Parsons, C.B., F.R.S. ; W. H. Patchell, S. L. Pearce, Sir John Denison Pender, K.C.M.G. ; Prof. John Perry, F.R.S. ; Sir William Preece, K.C.B., F.R.S. ; J. S. Raworth, J. H. Rider, M. F. Roberts, Mark Robinson, Prof. Sir A. Rucker, F.R.S. ; R. P. Sellon, P. S. Sheardown, Alexander Siemens, Dane Sinclair, J. F. C. Snell. C. E. Spagnoletti, C. P. Sparks, A. Stroh, Sir J. Wilson Swan, F.R.S. ; James Swinburne, A. A. C. Swinton, Herbert Taylor, Prof. S. P. Thompson, F.R.S. ; Dr. W. M. Thornton. A. P. Trotter, J. C. Vaudrey, A. J. Walter, C. H. Wordingham, A. Wright.

The following members form the organising committee :—

Chairman, Robert Kaye Gray ; J. Gavey, C.B., President; S. Z. de Ferranti, R. Hammond, J. S. Highfield, H. Hirst, Prof. G. Kapp, Sir H. C. Mance, C.I.E. ; C. H. Merz, W. M. Mordey, A. B. Mountain, J. M. M. Munro, S. L. Pearce, Sir W. H. Preece, K.C.B , F.R.S. ; P. S. Sheardown, A. Siemens, Prof. S. P. Thompson, F.R.S. ; Dr. W. M. Thornton, J. C. Vaudrey, A. J. Walter.

A provisional programme has been arranged, of which the following is an outline :—

*June* 23 and 24. Central Committee Rooms at the Hotel Cecil will be open for registration of visitors and members.—*June* 25. Afternoon, a visit to the National Physical Laboratory may be arranged, to attend the ceremony of opening the new Electro-Technical Laboratory. In the evening, reception and banquet at the Hotel Cecil.—*June* 26. Visits to the General Post Office, Power and Electric Lighting Stations, Railway and Tramway Power Stations, Engineering Works, Telephone Exchanges, and other undertakings and places of interest. In the evening, Conversazione at the Natural History Museum.—*June* 27. Excursion up the Thames and visit to Windsor.—*June* 28. Leave London for Birmingham district. The programme will include visits to works in and near Birmingham, including Rugby and Stafford. Arrive Manchester in the evening.—*June* 29. Manchester District : Visits to Electricity Stations and Works in Manchester, Salford and the neighbourhood. Conversazione at the Town Hall in the evening.—*June* 30. Proceed to Liverpool. Visits to Electricity Stations, Works and Railways. Leave in the afternoon for the Lake District (Windermere).—*July* 1. Excursions in the Lake District. Proceed to Glasgow in the evening.—*July* 2. Glasgow District : Visits to Works and Reception by Lord Kelvin.—*July* 3. Visits and Excursions in the neighbourhood of Glasgow.—*July* 4. Leave Glasgow for Edinburgh. In the afternoon leave Edinburgh for Newcastle. *July* 5. Newcastle District : Visits to Works and Power Station.—*July* 6. Leave Newcastle for Leeds. Visit to Works and Excursions in the neighbourhood of Leeds.—*July* 7. Leave Leeds for London.—Entertainment will be provided in London and Local Centres for the ladies of the party and those of their friends who desire to accompany them.

**Radial Trucks.**—An interesting lecture on radial trucks was delivered by Prof. C. A. Carus-Wilson at the Tramways & Light Railways Association last Tuesday, the Hon. Arthur Stanley, M.P., in the Chair.

A miniature railway curve and truck were exhibited on the lecturer's table, and with the aid of these he demonstrated successively how a fixed truck, a car with two bogies, a flexible truck, &c., went round the curve. It was explained how the front wheels grind on the rails, and how the flange of the rear wheel is pressed against the rail. These actions, the lecturer proceeded, were not due entirely to centrifugal force, but in part also to the steering force—*i.e.*, the force required to turn the car when going round the curve. At low speeds this steering force (which was an inertia force) was large in proportion to the centrifugal force, while at high speeds the reverse held good. Its value depended on the weight and length of the car body, but not on the length of the wheel base. Since the wear depended on the angle of incidence between rail and flange, it behoved truck makers to reduce this angle as far as possible, and this was the real object of the radial truck. Of course, this angle could be reduced by the adoption of bogies, but these had well-recognised drawbacks in the direction of weight, cost, &c. The author then proceeded, with the aid of diagrams thrown on the screen, to explain the action of radial trucks. At the low speeds customary in tramway service it was the steering force which had to be depended upon to make the trucks take up a radial position, but this action was resisted by the friction between the car body and the radial truck. At such low speeds as two or three miles an hour, the steering force might easily be smaller than the friction between the car body and the truck. Hence the truck would not "radiate" in such conditions, and the two radial trucks behaved like a rigid two-axle truck. In order to reduce this friction, rollers and links had been tried. The lecturer's conclusion was that a thoroughly satisfactory radial truck for low speeds had yet to be invented. A number of diagrams of flexible and radial trucks, including the trucks designed by Mr. Conaty, Mr. Warner and Messrs. Mountain and Gibson, were then thrown on the screen and explained seriatim. Prof. Wilson also mentioned that radial trucks were also being tried on the London County Council tramways.

In the discussion which followed, Mr. G. Conaty said there was cutting action also in the case of a bogie. In Birmingham 108 cars with radial trucks had been running for more than 15 months, and had given satisfaction. One of the cars had been in service for $2\frac{1}{2}$ years. The cars could run smoothly through a 37 ft. curve at 12 miles an hour. His experience with rollers for reducing the friction between car body and truck had been disastrous, as the rollers cut through the plates, even if hardened, in a short time. Mr. F. Jenkin pointed out that the centrifugal force could be larger at high speeds than was necessary. There was no proportionality between the centrifugal force and the force required to make the trucks radiate. The steering force on a bogie was small. There was another force, not mentioned by the lecturer—viz., the rubbing friction of the wheel on the inner rail. Mr. R. L. Acland (Chesterfield) had used 12 cars with radial trucks for 15 months. They afforded steady riding, and did not "hunt" after passing round the curve, The greatest wear on the rails occurred some 6 ft. or 8 ft. in front of the curve, and he considered that harder rails ought to be used at these places. Mr. J. Bowden (London County Council tramways) referred to the Robinson three-axle truck, in which the middle axle was free to move laterally. Mr. F. Sutherland Warner explained his own type of truck at some length, and mentioned that he was making bogies for 45 ft. carriages, each bogie consisting of two radial one-axle trucks. Mr. R. J. Howley thought a good radial truck not an impossibility. The friction between car body and truck ought not to be too small. He also asked the lecturer to tell them more about the action of the rear wheels. Mr. E. Cook had not yet seen a radial truck that did actually radiate at two miles an hour. Experience had shown that the life of flanges and rails was as great with a radial car with an 8 ft. wheel base as with rigid trucks having a wheel base of 6 ft. Prof. Carus Wilson, in reply to the discussion, first referred to the Robinson truck mentioned by Mr. Bowden, and said that by this arrangement you got a perfect radiation on the outside trucks, and the steering force had to be entirely provided by the inner truck. (Mr. Peckham remarked here that the inner wheels had no flanges.) He agreed with Mr. Jenkin that you could have too much radiation at high speeds, and a truck that ran perfectly at, say, three miles an hour, would not act equally well at other speeds. The steering force on a bogie car was not as small as Mr. Jenkin thought, because the car body had necessarily to be slewed round. In the course of some experiments he had found that half the slip (in going round a curve) occurred on the inner wheels and half the slip on the outer wheels. Therefore, the rubbing friction was practically equal on inner and outer wheels.

**London Traffic.**—At the Society of Arts on Wednesday, Capt. G. S. C. Swinton, of the London County Council, read a Paper on the question of London traffic. Sir John Wolfe Barry presided.

The Paper was not of an engineering character, but was largely taken up with an interesting supposition of what a modern Haussmann would do to improve the street accommodation in London were he given carte blanche irrespective of cost, interference with existing property, &c.; but although the results would be of the most ideal character, such as roads 300 ft. wide, double-decked bridges, &c., Capt. Swinton carefully guarded himself from being understood to subscribe to such a method of procedure. Unlike many proposals to deal with the traffic problem in London, the Paper did more than outline what is necessary regardless of existing conditions, for it pointed out that a tremendous amount of relief could be obtained by certain small details in the shape of widenings here and there, the abolition of street obstructions such as lamp-posts, &c. The Paper referred to the Holborn to Strand thoroughfare as a most unimaginative improvement, for the result had been to tempt more traffic along the new route and to discharge it into the Strand at an already much overcrowded spot. The construction of the tramway subway was also criticised in so far as the ordinary double-deck car was precluded from being used therein, for he feared that congestion would not be minimised by the mingling of small single-deck cars with the usual type in the streets. A suggestion had been made that double-deck cars were to be abandoned in London, but "in the name of common sense" he protested, if only for the fact that the present congestion in the streets would be doubled thereby. Dealing with the question of the future passenger conveyance in the streets of London, Capt. Swinton expressed doubts as to the suitability of the tramcar, which, although the most comfortable mode of progression, was the most obstructive. Motor omnibuses were improving immensely, and he thought that a vehicle of this nature would be found to be most adaptable to the needs of the other traffic. Capt. Swinton also incidentally expressed the view that where costly street widenings were necessary in consequence of the tramways, then the whole cost of these widenings should be charged to the tramway account. This was the only way of running a tramway system on business principles. A report was in course of preparation by the Finance Committee of the London County Council as to the capital expenditure on street widenings and other incidental expenses connected with tramways. This report would, he thought, be a revelation, and would enable some opinion to be formed of what it will cost to build tramways through the far narrower streets and the more expensive property north of the River Thames. Adding to this expenditure a further colossal figure for the cost of installing the conduit system, he thought the moment had arrived when we should pause and quietly meditate. Capt. Swinton generally agreed with the recommendations of the Traffic Commission and especially the appointment of a Traffic Board. A tribute was also paid to the efforts of private promoters to improve the means of communication in London, the author not evidently having that antipathy to private enterprise which prevails so often. During the reading of the Paper several interesting views of Parisian streets were shown on the screen and also views illustrating the proposals made before the Traffic Commission by Messrs. Meik & Beer, which provided for a very complete system of overhead railways, surface tramways and underground means of communication.

Sir John Wolfe Barry, who opened the discussion, said that whatever might be said as to the recommendations of the Royal Commission on London Traffic, the Commission had published a mass of statistics and other information that had never been equalled in the history of England. There was a general misconception as to what London really consisted and how it was made up, but the reports of the Royal Commission had put this upon a scientific basis, and, having this in view, he felt bound to say that the question of the cost of the improvements recommended had not been properly considered by the average person. What was twenty or thirty millions of money compared to the many millions that were lost annually, both by individuals and in the carriage of goods, through delays which now characterised our present modes of locomotion with their slow speeds? Railway companies had spent 100 millions in 20 years with the same objects in view.

Mr. E. Benedict, secretary of the Tramways and Light Railways Association, disagreed with the author as to charging all street improvements to tramway account. The widenings were just as much necessary in the interests of other traffic. He also disagreed with Sir John Wolfe Barry as to placing a definite monetary value upon every hour of one's time, although in the carriage of goods, of course, money was lost by delay. He advocated the appointment of a traffic manager for the streets of London, with a staff, and to take this work out of the hands of the police.

Mr. A. A. Campbell-Swinton said he was rapidly coming to the conclusion that the place for tramways was out in the country, and that self-contained vehicles not running on rails were the best for crowded cities.

Mr. Maurice Fitzmaurice, chief engineer to the London County Council, said there were many advantages in single-deck cars, both as regards the speed of loading and unloading them and in the collection of fares. He thought the people of New York would have discarded them long ago had they not been found suitable for quick travelling. He thought the advantages that would accrue from the opening of the tube railways now under construction had not been fully appreciated, and that many other improvements could very well be left to private enterprise; the rates were already too high in London.

## ARRANGEMENTS FOR THE WEEK.

**(To-day) FRIDAY, March 2nd.**

Institution of Electrical Engineers: Manchester Local Section.

*6:45 p.m. for 7:15. p.m.* Annual Dinner at the Midland Hotel, Manchester.

Junior Institution of Engineers.

*7 p.m.* Meeting at the Westminster Palace Hotel. Papers to be read: (1) "Acceleration and Accelerometers," by A. P. Trotter; (2) "Gas Engine Indicators," by L. F. de Peyrecave.

**SATURDAY, March 3rd.**

Royal Institution.

*3 p.m.* Afternoon Lecture I. on "The Corpuscular Theory of Matter," by Prof. J. J. Thomson, F.R.S.

Institution of Electrical Engineers: Students' Section.

*3 p.m.* Visit to the Post Office Telephone Exchange, Addle-hill, London, E.C.

Glasgow Technical College Scientific Society.

*7:30 p.m.* Meeting at the Glasgow & West of Scotland Technical College, George-street, Glasgow. Paper to be read: "Portable Electric Tools and their Application to Industrial Purposes," by Andrew Stewart.

**TUESDAY, March 6th.**

Institution of Civil Engineers.

*8 p.m.* Ordinary Meeting. The discussion upon the two Papers on "Road Making" read at the last meeting will be continued, and, time permitting, the following Paper will be read: "The Widnes and Runcorn Transporter Bridge," by J. J. Webster.

**THURSDAY, March 8th.**

Institution of Electrical Engineers.

*8 p.m.* Ordinary General Meeting. Paper to be read: "A New Single-phase Commutator Motor," by V. A. Fynn.

Institution of Electrical Engineers: Dublin Local Section.

*8 p.m.* Meeting at the Royal College of Science, Dublin. Paper to be read: "Producer Plants for Electric Power Stations," by W. J. U. Sowter.

**FRIDAY, March 9th.**

Faraday House Old Students' Association.

*7 for 7:30 p.m.* Second Annual Dinner at the Florence Restaurant, Rupert-street, London, W. Mr. C. D. Taite, the President, will be in the chair.

Physical Society.

*8 p.m.* Meeting at the Royal College of Science, Exhibition-road, South Kensington. Agenda: (1) "The Velocities of the Ions of Alkali Salt Vapours at High Temperatures," by Prof. H. A. Wilson. (2) "Some Experiments on Earth Currents at Kew Observatory," by Dr. Harker.

Institution of Electrical Engineers: Manchester Students' Section.

*7:30 p.m.* Meeting at the Royal Technical Institute, Salford. Paper to be read: "Modern Primary Batteries," by E. Müller and J. Davies.

**SATURDAY, March 10th.**

Institution of Electrical Engineers: Students' Section.

*10 a.m.* Visit to Messrs. Elliott Bros.' Works at Lewisham.

Royal Institution.

*3 p.m.* Afternoon Lecture II. on "The Corpuscular Theory of Matter," by Prof. J. J. Thomson, F.R.S.

Junior Institution of Engineers.

*7 p.m.* Conversazione at the Westminster Palace Hotel. Reception by the President and Mrs. Dugald Clerk and the Chairman and Mrs. Adam Hunter.

Birmingham and District Electric Club.

*7:30 p.m.* Meeting at the Colonnade Hotel, New-street, Birmingham. Paper to be read: "Electricity in Mines," by R. G. Mercer.

## TEST ON A 1,500 KW. CURTIS TURBINE.

Two 1,500 kw. Curtis turbines have recently been supplied by the British Thomson-Houston Co., of Rugby, to the County of London Electric Supply Co. for their stations at City-road and Wandsworth, and the following particulars have been given us for publication by Mr. C. P. Sparks, the company's chief engineer :—

Turbines of the four-stage type are mounted on sub-base condensers as shown (Fig. 1). Each set, together with its air pump, occupies a floor space of 15 ft. by 14 ft., and the overall height from condenser base to governor is 19 ft. 6 in. and from engine room floor to top of governor 14 ft. 6 in. The alternators are two-phase 2,200 volts 50 periods 1,000 revs. per min., rated at 1,500 kw., with a temperature rise of 40°C. when running continuously at full load, with a further temperature rise of 15°C. when the machine is run for three hours at 2,250 kw. Owing to the proportioning of the turbine and the small $C^2R$ losses in the alternator, the set can be worked at 3,000 kw. for short periods when condensing.

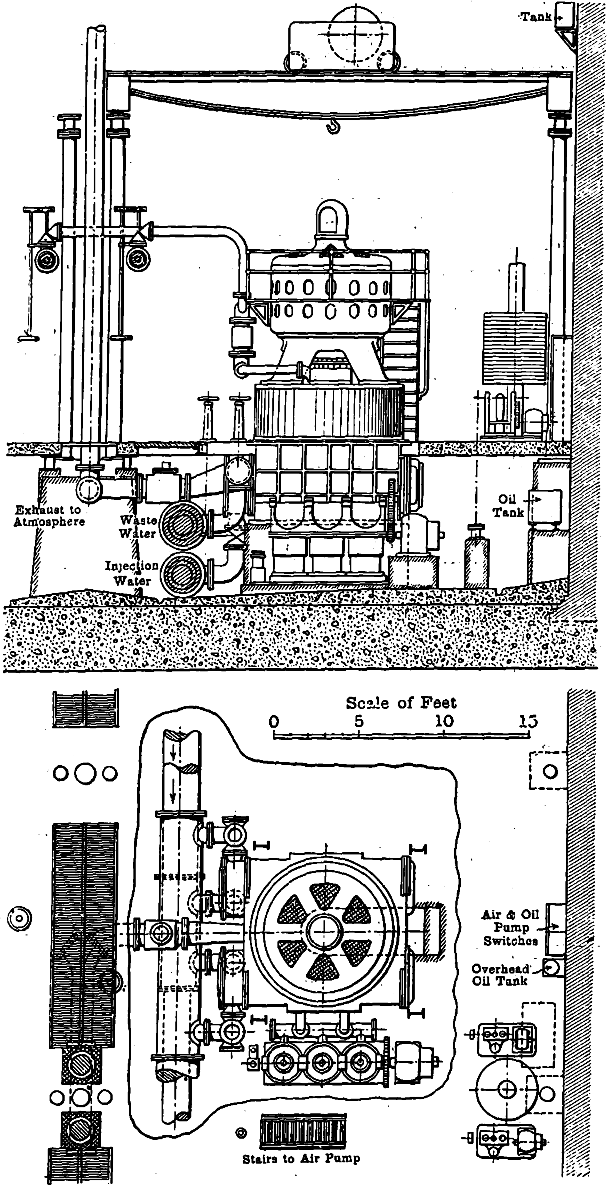


FIG. 1.

As the turbine is mounted directly upon the condenser, the back pressure on the last stage of the turbine is reduced to a minimum. When it is necessary to run non-condensing, the condenser tubes are flooded and water circulated through the sub-base. Each condenser has a cooling surface of 4,000 sq. ft., and is served by an Edwards three-throw air pump having 15 in. cylinders, 8 in. stroke, and a speed of 160 revs. per min. The pump is driven through raw-hide pinion by a 15 kw. two-phase motor running at 720 revs. per min. A Gwynne centrifugal pump directly driven by a 30 kw. two-phase variable-speed motor, running at 720 revs. per min., supplies the circulating water.

The turbine foot-step bearing is provided with water from the hot well at a pressure of 400 lb. per sq. in. by duplicate three-throw pumps driven by 2 kw. two-phase motors running at 720 revs. per min., the water pressure being maintained by an accumulator. These motors also drive the oil pumps for the alternator bearings. The auxiliary motors, together with the main and auxiliary switch gear, are all of the B.T.H. type.

The test conditions specified were 150 lb. steam pressure 60 deg. superheat, and the recorded result (Fig. 2), with a vacuum of 29 in. of mercury and barometer at 30·15 in., was 17¼ lb. of steam per kw. hour at 1,500 kw. (maker's full load rating). With this type of turbine the steam consumption per kw. hour increases slowly with falling load, and the set can be run at as low a load as 500 kw. before the steam consumption exceeds 20 lb. per kw. hour.

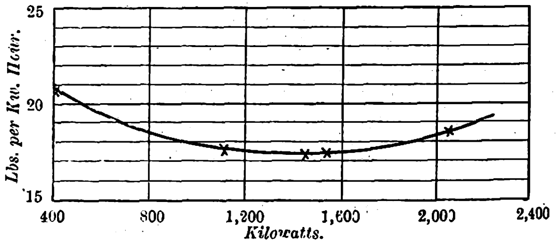


FIG. 2.

The power taken by the auxiliaries amounts to 33 kw. at one-quarter load (circulating water 21·5, excitation 5·7, air and foot-step pumps 5·75, total = 32 95), and 50 kw. at full load (circulating water 36, excitation 7·25, air and foot-step pumps 6·75 = 50), resulting in a total steam consumption of 17·8 lb. per unit when the set is delivering 1,500 kw.

Steam consumption tests were made during January at loads varying from 400 to 2,050 kw., the maximum load carried during the test being 2,200 kw. During the test the steam consumption was measured by weighing the hot-well discharge continuously in duplicate tanks holding six minutes discharge at full load. The test readings at each load, plotted in Fig. 2, were taken over 30 minutes, the reading at full load covering two hours.

The output was measured by integrating wattmeters checked by ammeter and voltmeter readings (the whole of the instruments being calibrated at the Board of Trade laboratory after the trial). The artificial load consisted of iron plates immersed in running water. During the test the superheat at the turbine varied from 48°F. to 62°F., the steam pressure from 146 lb. to 154 lb. per sq. in., and the temperature of the circulating water was 43°F.

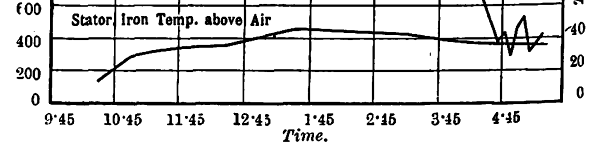


FIG. 3.

In order to shorten the temperature test (Fig. 3), after running two hours at full load normal pressure the load was increased to a maximum 2,200 kw. at 2,370 volts; the increased iron losses under these conditions gave a temperature rise of 44°C. for the stator iron at the end of four hours' run. The load and pressure were then reduced to normal full load, giving a temperature rise of 42°C. at the end of the fifth hour; at this time the corresponding temperature rise of the end windings of the armature was 34°C., while the field coils rose 12°C. measured by increase of resistance.

# THE GREENWICH POWER HOUSE OF THE L.C.C. TRAMWAYS.

(*Continued from page 745.*)

In the boiler house are two rows of Stirling boilers, 12 in each row, so that when the second half of the station is added there will be 48 boilers in all. The boilers are set in pairs and the chimney is in the middle of each row, with six boilers on either side. They are of the five-drum Stirling make, fitted with chain grate stokers (Fig. 5), and each boiler has an evaporative capacity of from 15,000 lb. to 16,500 lb. per hour. The heating surface of each is 3,650 sq. ft. and the grate area 60 sq. ft. The Stirling boiler with its vertical tubes is well known to our readers and no detailed description is necessary. A superheater is fitted between the first and second bank of vertical tubes, and this adds 150°F. of superheat. The boilers are run at a blow-off pressure of 190 lb. per sq. in. and an engine room pressure of 180 lb. per sq. in. The front of the boilers is of steel, and the other walls of fire-brick with glazed brick outside.

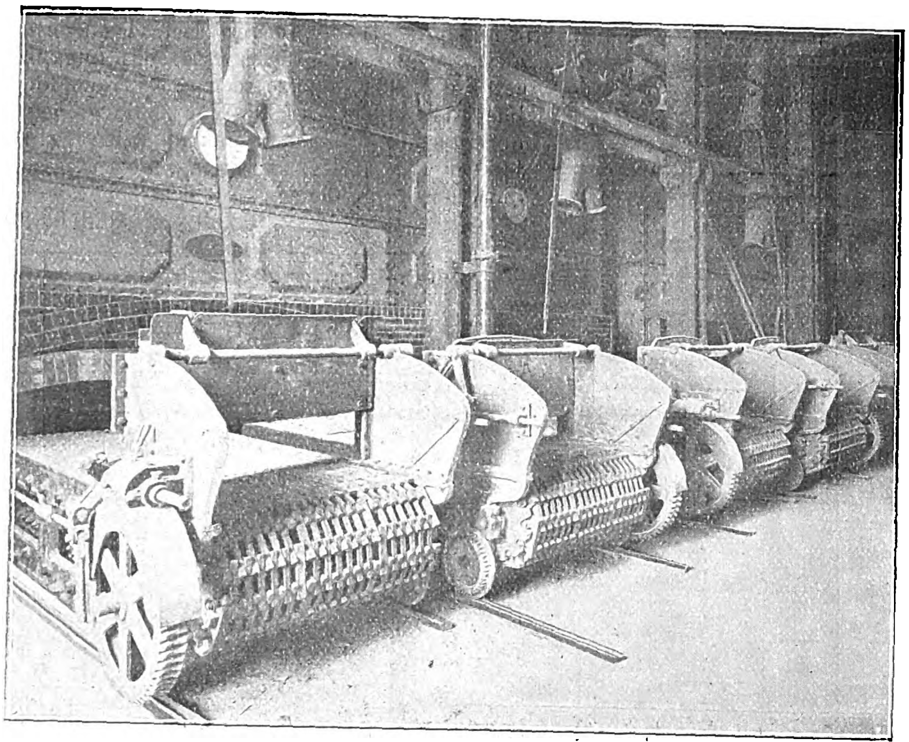


Fig. 5.—View of Boilers showing Chain Grate Stokers.

The gases from the boilers rise through steel up-takes to the floor above the boilers and pass through Green economisers. One economiser is provided for each pair of boilers, and the arrangement is seen in section in Fig. 6, which also shows the relative position of the boiler house and engine room, the various tiers of the switchboard gallery, the steel roof construction, &c. Each economiser has 320 tubes arranged in two sections and the scraper of each is driven independently by an induction motor through worm gearing. A spare motor is provided to replace any one of these small motors should it get out of order. As the economisers are on the floor above the boilers, there is a free space for the accumulation of soot at the base of the chimney. Each main flue has access doors, and the sub-division is such that any flue can be shut down for cleaning by shutting down one unit.

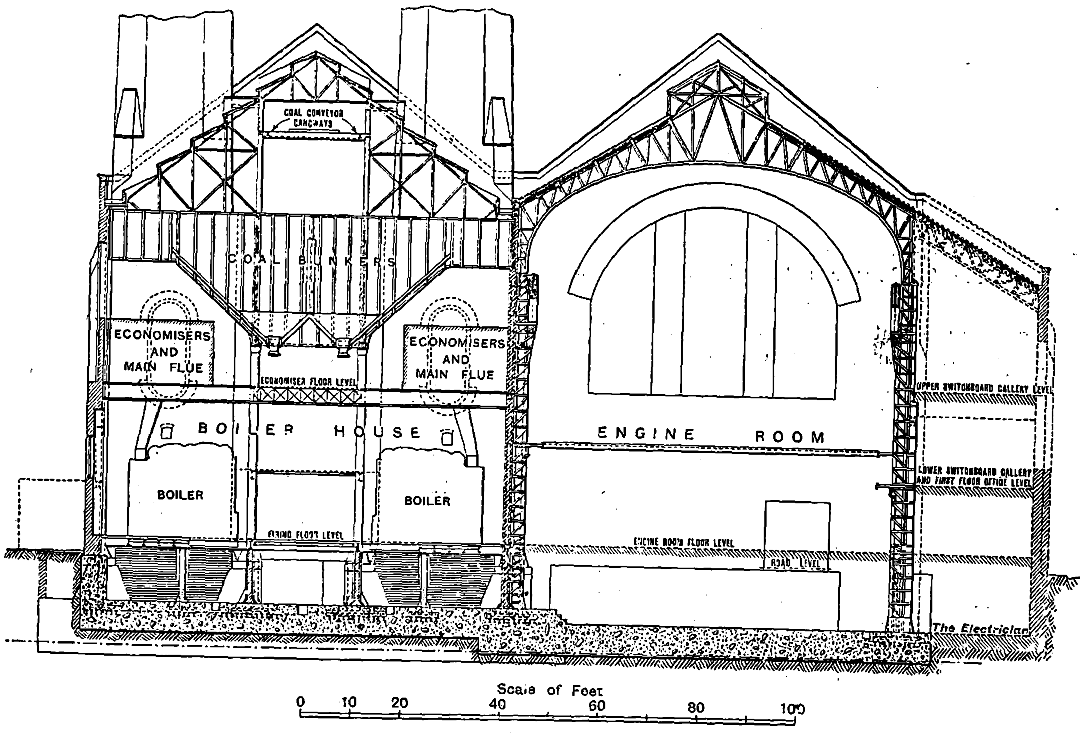
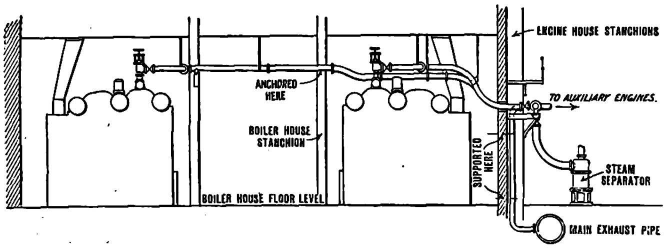

COAL CONVEYOR CANGWAYS
COAL BUNKERS
ECONOMISERS AND MAIN FLUE
ECONOMISERS AND MAIN FLUE
ECONOMISER FLOOR LEVEL
BOILER HOUSE
BOILER
BOILER
FIRING FLOOR LEVEL
ENGINE ROOM
UPPER SWITCHBOARD GALLERY LEVEL
LOWER SWITCHBOARD GALLERY AND FIRST FLOOR OFFICE LEVEL
ENGINE ROOM FLOOR LEVEL
ROAD LEVEL
The Electrician
Scale of Feet
0
10
20
40
60
80
100

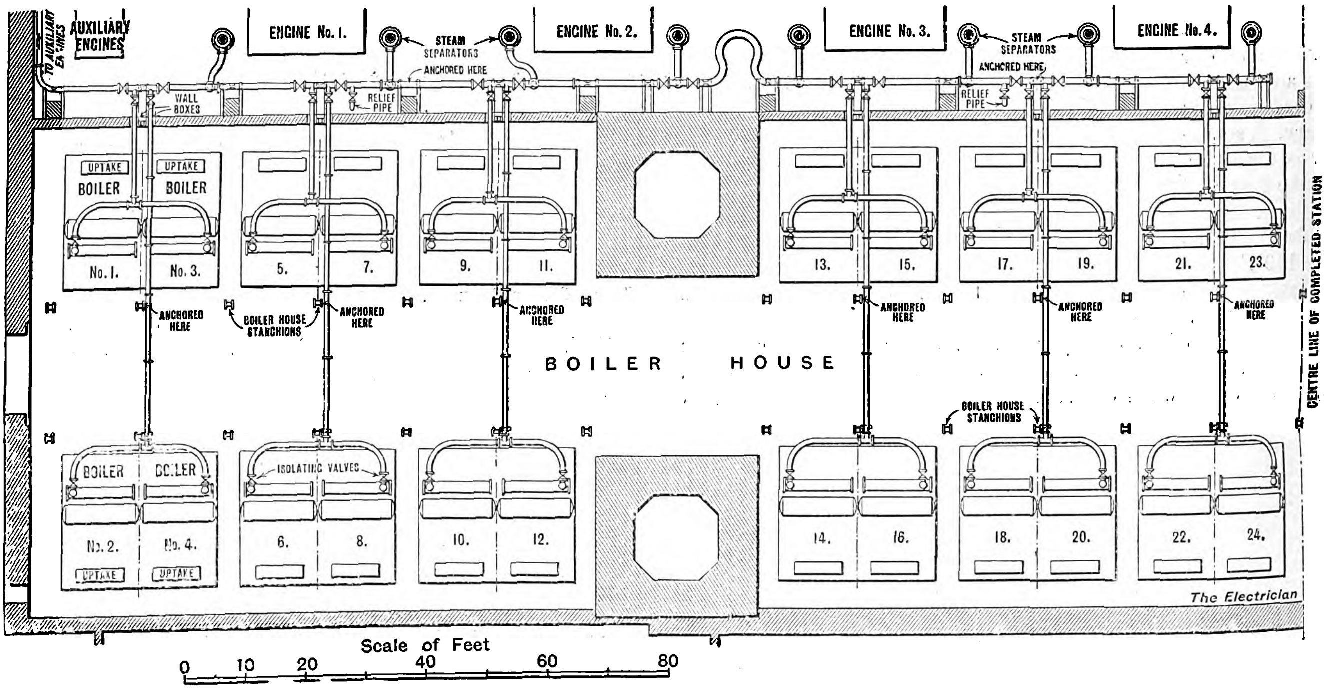
Fig. 6.—Outline Section of Generating Station.

Coal from the bunkers above the boilers is fed down through shoots and 5 cwt. measuring boxes into the hoppers of the stokers, and the ashes fall into brick-lined steel ash-pits beneath the boilers.

The feed pumps are placed in the basement under the boilers. They are divided into two separate sets, each consisting of three 3-throw horizontal pumps rated at 8,000 gallons per hour, against 220 lb. pressure. They have been supplied by

Messrs. John Cochrane and are driven by a 35 H.P. Bruce-Peebles series motor through worm gearing. The objection against electrically-driven pumps that there are considerable losses in the motor at low speeds is thus overcome; first, because there are six pumps over which the work is divided, and, secondly, by running the motors at two pressures—viz., 125 and 550 volts, so that the lower pressure may be used for the slower speed. There is a drum controller with a resistance in series with each motor, but it is not anticipated that this will be used much. The suction and delivery pipes are in duplicate. The water is drawn from tanks in the boiler-house basement which receive the water directly from the hot-wells of the condensers. The make-up water is supplied by an artesian well 8½ in. diameter and 350 ft. deep. This will furnish 3,500 gallons per hour. The make-up feed is passed through water softeners of the Harris-Anderson cold lime type (similar to the one used in the Metropolitan Railway power house at Neasden), and then passes to an overhead tank holding 30,000 gallons, from which the feed tanks in the basement are kept supplied, this latter having ordinary ball valves. A three-phase motor-driven Pearn pump lifts the water to the overhead tank. Should the condenser arrangements break down through any accident, arrangements are made by which all water can be taken from the mains of the Metropolitan Water Board. Special mains have, of course, been laid for this purpose. Two small tanks are provided for the town water to overcome any inequality there may be in the rate of supply, and these feed into the hot-well tanks, already mentioned, in case of emergency. The water is hard, but it has not been deemed necessary to fit softening apparatus in this case, as, of course, this arrangement will only come into use on emergency, and it will simply be a question of blowing out the boilers frequently.


ENGINE HOUSE STANCHIONS
ANCHORED HERE
TO AUXILIARY ENGINES.
BOILER HOUSE STANCHION
SUPPORTED HERE
STEAM SEPARATOR
BOILER HOUSE FLOOR LEVEL
MAIN EXHAUST PIPE


TO AUXILIARY ENGINES
AUXILIARY ENGINES
ENGINE No. 1.
STEAM SEPARATORS
ENGINE No. 2.
ANCHORED HERE
ENGINE No. 3.
STEAM SEPARATORS
ANCHORED HERE
ENGINE No. 4.
WALL BOXES
RELIEF PIPE
RELIEF PIPE
UPTAKE
UPTAKE
BOILER
BOILER
No. 1.
No. 3.
5.
7.
9.
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ANCHORED HERE
BOILER HOUSE STANCHIONS
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BOILER HOUSE
CENTRE LINE OF COMPLETED STATION
BOILER HOUSE STANCHIONS
BOILER
BOILER
ISOLATING VALVES
No. 2.
No. 4.
6.
8.
10.
12.
14.
16.
18.
20.
22.
24.
UPTAKE
UPTAKE
The Electrician
Scale of Feet
0
10
20
40
60
80

FIG. 7.—PLAN AND PART ELEVATION SHOWING GENERAL ARRANGEMENT OF STEAM PIPES.

The station is divided into units of 3,500 kw., each corresponding to one generating set. This is served by six boilers and has its own flue, there being a chimney for every two flues. The chimney is divided by a mid-feather up to a height of 90 ft. The total height of the chimney is 250 ft. The unit system is not carried out to the full extent which is in vogue in some works, for the arrangement is that all the boilers steam into one main header. The arrangements for drainage, and to take the expansion, are of considerable interest. The steam pipes fall all the way from the boiler stop valve to the engine separator, and the size of the steam pipes has been kept down as much as possible, so that there should be a rapid flow of steam, which tends to keep the steam dry. The steam range is not drained anywhere except at the separators, which is done through Geipel traps in the ordinary manner. Fig. 7 shows the general arrangement of the steam pipes. The boiler branches are 7 in., and, as is seen, each pair of boilers feed into a common 8 in. pipe, which is led to the main header, the latter having a diameter of 12 in. These 8 in. pipes are anchored at the centre only, as is marked in the illustration, and the expansion of these is taken up by the bends. The header for the present engine house is divided into two parts, with an expansion bend between, and each part is anchored at the centre, but is supported at intervals on rollers. Although there are expansion bends in the engine branches, arrangements have been made so that the separator itself can travel slightly to take up the expansion. This is arranged by mounting each separator on a special form of stand. As seen in Fig. 8, the system is, in this way, mounted on springs, and there is a clearance of ⅜ in. on either side of the separator in a direction parallel to the main header, so that sufficient lateral play is provided. Fig. 8 shows the stand only, and the separator and stand are seen together in Figs. 7 and 9. It will be noticed that the stop valve is up by the engine, and not down by the separator. The steam pipes in the boiler house are carried by suspension rods from the roof in the ordinary manner, and the main steam header is supported on steel brackets fixed to the stanchions of the engine house, and rests on rollers, as already explained. An isolating valve is provided between every engine and boiler junction on the main header. There are two 8 in. connections from the header to the atmospheric exhaust for relieving the boiler pressure in case of a stoppage.

The engine room is 236 ft. long by 80 ft. wide and the height up to the crane gantry is 50 ft. There are four generating sets; a plan and elevation of one of them is shown in Fig. 9. Each of the four sets includes in reality two engines with vertical high-pressure cylinders and horizontal low-pressure cylinders, and the alternator is placed between the two engines. The engines have been supplied by Messrs. J. Musgrave & Sons, and the alternators by the Electric Construction Co. These vertical-horizontal engines are the first that have been used in this country, although they have been employed in the power house of the Inter-Urban Rapid Transit Co., of New York,[*] and elsewhere in America. The arrangement is a very suitable one for reciprocating sets of a large size, but owing to the introduction of steam turbines it is hardly likely to meet with extended application in this country now. The set is rated at 3,500 kw. A feature of the engine is that the drainage is natural throughout, and there are no water pockets anywhere. The main dimensions are as follows: high-pressure cylinders 33½ in.; low-pressure cylinders 66 in.; stroke 4 ft.; speed 94 revs. per min. The connecting rods from the two cylinders drive on to the same crank pin; the high-pressure one is nearer the crank face, and the cranks of the two sides are placed 135 deg. apart. It will be seen that there are thus eight impulses every revolution, which materially assists parallel running. The valve gear is of the Musgrave standard Corliss pattern. It may be mentioned that the usual American practice in connection with these horizontal vertical engines is to make the low-pressure cylinders vertical and the high-pressure cylinders horizontal owing to the weight of the low-pressure piston, but this means bad drainage, as the steam has then to pass from the high-pressure cylinder at the bottom right up to the top of the low-pressure cylinder and leaves a pocket for the water. Mr. Rider, therefore, preferred the converse arrangement. The piston of the low-pressure cylinder is hollow, and the weight of the piston is supported by a tail rod. The vertical cylinder, seen in the drawing above the low-pressure cylinder, is the re-heater receiver in which the steam is re-heated with live steam on its way from the high-pressure to the low-pressure cylinders. This steam is not wasted, but exhausts in to the hot well and is included in the guaranteed consumption of the engine. The cylinders are fitted with specially hard cast iron liners, but in accordance with Messrs. Musgrave's standard practice they are not jacketted. There are only three eccentrics for each half of the engine, the exhaust eccentric serving both the high-pressure and the low-pressure cylinders. The guaranteed steam consumption is 11½ lb. of steam at the stop valve per indicated horsepower, at 180 lb. per square inch pressure and 26 in. vacuum, with steam superheated to 500°F. The engines are controlled by two governors driven by Hans Renold chain gear from the crankshaft. One of these is the ordinary governor acting on the cut-off, and the other is an emergency governor set 10 per cent. higher, and it trips a valve on the high-pressure cylinder, this acting only as an emergency knock-off. In addition to these two, there is an electrical gear on the switchboard, by means of which this emergency governor can be tripped. The button controlling this is under a glass case, and the glass has to be broken before the switchboard attendant can get at it. On the main governor there is a speeding-up gear which can be worked either at the

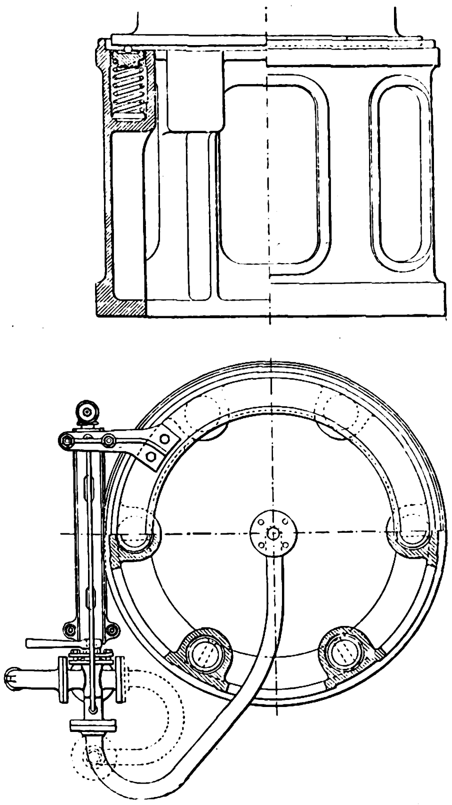

Fig. 8.—Stand for Steam Separator.

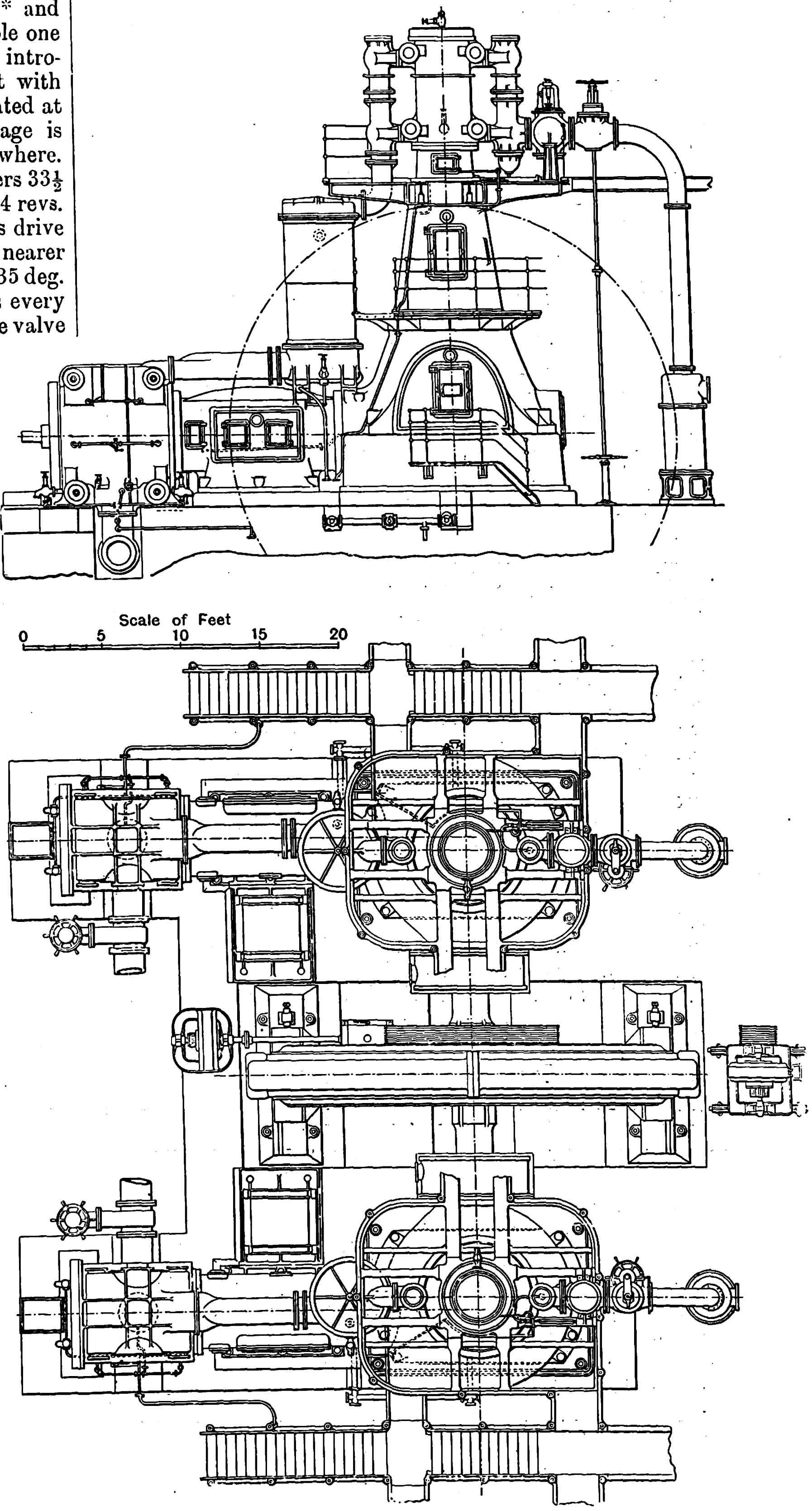

Fig. 9.—Plan and Elevation of Generating Set.

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[*] *The Electrician*, Vol. LIV., pp. 10, 168 and 208.

engine itself or from the switchboard. This electrical speeding gear consists simply of a three-phase motor which winds up a weight, and it is used for paralleling the engines. The engines are all enclosed, and lubrication is by force pumps at 35 lb. pressure, the oil being fed from a tank in the bedplate. The oil pumps are in duplicate, as is also the oil supply to the principal parts of the engines. Above the inspection door on each gallery level a bulkhead fitting is provided, which lights the inside of the engine to facilitate inspection.

Each of the high-pressure cylinders has its own steam inlet, separator, and stop valve, but the stop valves of the two halves are geared together, so that the engines are started simultaneously.

Each low-pressure cylinder has its own surface condenser in the basement below the engine room. The surface condensers have 4,500 sq. ft. cooling surface, and they were supplied by the engine builders. The air pumps are of the 3-throw Edwards pattern, also made by Messrs. Musgrave, and they are driven by three-phase motors, and these, as well as all the other alternating-current motors, are induction motors with squirrel-cage rotors. These pump sets have also a small force pump for pumping the condensed water into the hot-well tank, which is at a higher level. The steam, on its way to the condenser, passes through a Baker baffle plate oil separator to minimise the action of oil on the condenser tubes, and the water from the condenser passes through the well-known Harris-Anderson chemical purifiers, which have already been described in *The Electrician*, Vol. XLIX., p. 782. The capacity of each purifier is 4,000 gallons per hour, and there is one to each pair of condensers, not one to each condenser. We believe that the whole purifier installation, with the capacity of 32,000 gallons per hour, is the largest in existence. Experience has shown the great importance of removing the oil from the condensed water thoroughly before it is used again for feed purposes, and Mr. Rider only adopted the Harris-Anderson separators after having assured himself that they would accomplish the work satisfactorily. It is proposed to have a chemist on the works staff, among whose duties will be the inspection and keeping of the oil separators in order, and he will also test coal for calorific value, analyse flue gases, lubricating material, &c. Circulating water for the condensers is supplied from centrifugal pumps in the pump house, which is quite an independent building nearer the river bank, and will be described later. We shall deal next with the details of the alternators.

(*To be continued.*)

## THE OPERATION OF CIRCUIT BREAKERS AND FUSES.

BY PROF. E. W. MARCHANT, D.Sc. AND F. A. LAWSON, B.Eng.

It has long been known that when a fuse, designed to break circuit with a given current, was placed in series with a magnetic circuit breaker, set for the same or even for some larger current, it was possible to put the circuit breaker in action without blowing the fuse. In order to determine exactly what size of fuse it was possible to have in series with a given circuit breaker under these conditions, a number of experiments were carried out on a standard 500 ampere I.T.E. magnetic cut-out kindly lent by the electrical engineer to the Liverpool Corporation.

A sketch of this circuit breaker is given in Fig. 1. The operation is as follows:—The plunger C is drawn up into the coil B (which carries the main current) when this current exceeds a certain value, and hits the rod D. This releases the catch F, and the projection H gives a smart blow to the switch handle K. The handle is forced out by the spring I, and the current is broken at carbon contacts. The distance the plunger has to rise is adjusted by the screw M.

The coil of the circuit breaker was overwound with two layers of No. 18 wire, and this coil was used to work the iron plunger so as to reduce the operating current to about 45 amperes. Of course the arc at break was not as great as with the full current, and this reduced the time of breaking the circuit below that corresponding to normal working conditions.

I. *Circuit Breaker in Series with a Number of Paralleled Fuse Wires.*—A series of experiments was first made with the circuit breaker in series with a number of fuse wires in parallel with each other. The setting of the magnetic cut-out was adjusted until the wires fused simultaneously with the opening of the cut-out, when a current (just large enough to work the magnetic cut-out) was suddenly switched on to the circuit. The adjustment was first made, of course, without the fuse in circuit, with the aid of the change over switch shown in Fig. 2, allowance being made for the additional resistance introduced when the fuses were inserted. The object of these experiments was to determine how the time of operation of the circuit-breaker varied for different settings.

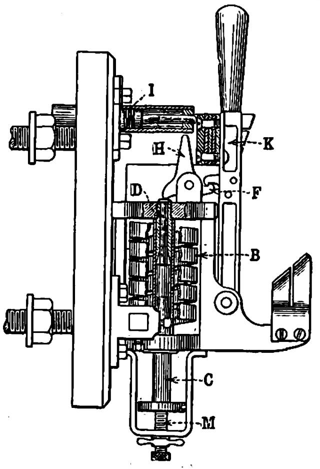

Fig. 1.

If $\bar{C}$ be the normal fusing current of a single wire, $n\bar{C}$ will be the fusing current of $n$ such wires in parallel, and if C denote the current that will just blow a single fuse wire in series with the circuit-breaker, then $nC$ will be the current that will blow $n$ wires in parallel if the time of operation is constant. If, however, the time of operation depend on the current flowing, the current that will just blow $n$ wires will not be $nC$, but will be either greater or less than $nC$, depending on whether the time of operation is less or greater than that for the current C. If, therefore, the relationship between $\bar{C}$, the normal fusing current, and the current C, which will just blow the fuse, when switched on to the circuit-breaker and fuse in series, is shown by a straight line passing through the zero point, $\bar{C}$ is proportional to C, and the time of operation would be constant.

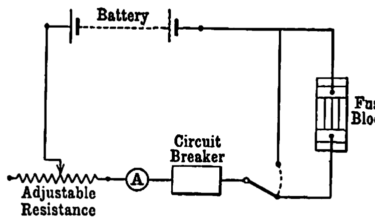

Fig. 2.

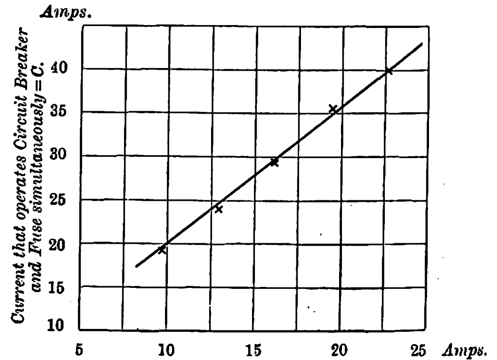

Fig. 3.—Relation between C and $\bar{C}$.

The relationship between $n$, the number of wires in parallel, and C′, the operating current (see Fig 3) is given very closely by $C' = 4{\cdot}5 + 5{\cdot}06n$ amperes for No. 43 copper wire. From this the relative time of operations may be estimated, and is given by $\frac{t}{t'} = \frac{1}{n^2}\left(\frac{C'}{C}\right)^2$, where $t$ and C are the time of operation and operating current for a single wire, and $t'$ and C′ the same quantities for $n$ wires. By substituting the value of C′ found above,

$$\frac{t}{t'} = 0{\cdot}28 + \frac{0{\cdot}50}{n} + \frac{0{\cdot}22}{n^2} \quad \text{or} \quad \frac{t}{t'} = 0{\cdot}28 + \frac{2{\cdot}52}{(C-4{\cdot}5)} + \frac{5{\cdot}4}{(C-4{\cdot}5)^2}.$$

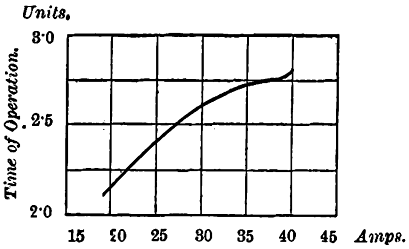

FIG. 4.—RELATION BETWEEN TIME OF OPERATION AND OPERATING CURRENT.
The ordinates of the curve are proportional to the time the cut-out takes to operate.

This relationship is shown by the curve in Fig. 4.

Direct experiments have been made on this point for very heavy overloads by Prof. B. Hopkinson* and also by Mr. H. A. Brown.†

II. *Circuit Breaker in Series with Tin Fuse Wire of various Diameters.*—The next series of experiments was made with ordinary tin fuse wires, the fusing current of which had been carefully determined, for fuses of such length that the cooling of the wire due to the terminal blocks was negligible in its effect on the fusing currents. The relationship between diameter and fusing current is shown in Fig. 5.

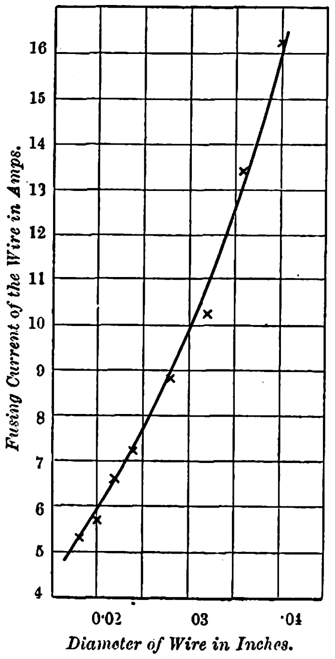

FIG. 5.—RELATION BETWEEN THE FUSING CURRENT OF A WIRE AND ITS DIAMETER.

The various wires were then each in turn put in series with the magnetic circuit breaker, as shown in Fig. 2, and the setting of the circuit breaker adjusted until the wire just fused, when a current, C, was suddenly switched on to the circuit, this current C being, as in the other experiment, just large enough to operate the circuit breaker. The relationship between the current C and the normal fusing current of the wire $\overline{C}$ is shown in Fig. 6, and it is at once seen how much larger this momentary current must be to blow the fuse, than when the current is a steady one.

A similar series of experiments was made in which the current C, which was suddenly switched on, was 25 per cent. greater than that required to just operate the magnetic circuit breaker, also for 50 and 75 per cent. greater current; these results are given in Fig. 7. It is evident from the curves shown for a 50 and 75 per cent. overload, that with a given fuse wire in series with the circuit breaker, the current which is suddenly switched on, and which will just blow the fuse, approaches a constant value, independent of the setting of the circuit-breakers.

From the curves in Fig. 6 it is found that the relationship between C and $\overline{C}$ is approximately given by the equation $C = 3{\cdot}05\,\overline{C}^{1{\cdot}18}$.

If C is the current suddenly switched on, $\rho$ = specific resistance of the wire, $l$ = the length of the wire and $d$ its diameter, then the heat developed with a momentary current C $\propto C^2\frac{\rho l t}{d^2}$ where $t$ is the time during which the current lasts.

This quantity must be greater than a certain value per unit volume of the wire to be fused.

Hence $C^2\rho\frac{l}{d^2}t$ must be $> K_1\frac{\pi d^2 l}{4}$ where $K_1$ is a constant.

$\therefore \quad C^2 t \propto d^4$, or $C \propto \frac{d^2}{\sqrt{t}}$ If $t$ is constant, $C \propto d^2$.

With a steady current, $\overline{C}$, the rate of heat production is $\propto \overline{C}^2\rho\frac{l}{d^2}$.

The rate of cooling is proportional to $\pi l d$, the surface exposed, and if the wire is to be fused $\overline{C}^2\rho l/d^2 > K_2\pi l d$ where $K_2$ depends on the physical constants (melting point, &c., of the wires).

Hence $\overline{C}^2 \propto d^3$ or $\overline{C} \propto d^{\frac{3}{2}}$.

For a given diameter of wire, $d$, it follows that $C \propto \overline{C}$. The fact that the relation between C and $\overline{C}$ actually found does not correspond with the theoretical value (on the assumption of constant time of operation of circuit-breaker) is obviously explained by the time of operation not being constant.

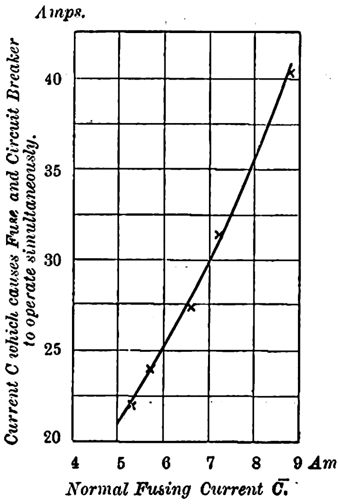

FIG. 6.—RELATION BETWEEN C AND $\overline{C}$.

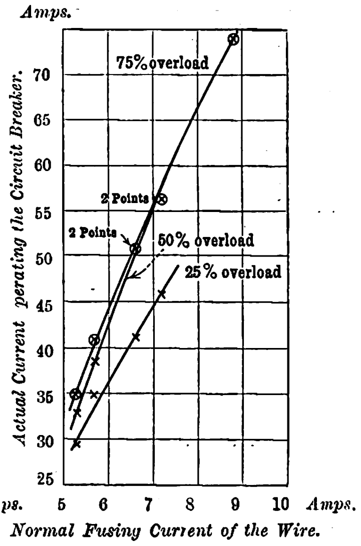

FIG. 7.—RELATION BETWEEN CURRENT THROUGH THE CIRCUIT BREAKER AND NORMAL FUSING CURRENT OF THE WIRE.

III. *Characteristic of the Circuit-Breaker.*—The experiments with tin fuse wires were next extended to get the necessary data for obtaining a curve showing the relationship between current through the magnetic circuit-breaker, and fusing current of wire in series with it, that will just not fuse for a given setting of the magnetic cut-out; a case which is, of course, one of great practical interest. The results of these tests are given in Fig. 8, and this curve may, perhaps, not unfitly be called the characteristic fusing-current curve of the circuit-breaker.

The whole area of it may be divided into two parts, one part shaded in the figure such that if the point corresponding to a given current through the circuit-breaker, and a given fuse in series with the circuit-breaker, lie in it, the wire will be fused, provided of course that the current flowing exceeds the steady fusing current of the wire. If the point lie within the second part (left clear in the figure) the current corresponding to it will operate the circuit-breaker without blowing the fuse. It is interesting to note that any fuse wire smaller than that which blows at 5·4 amperes for this particular setting, (25 amperes) will always be fused whatever the current flowing, provided, of course, it exceeds 5·4 amperes.

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* *Proc.* Inst. Civil Engineers, 1902, Vol. CLI., p. 3.

† *Electrical World and Engineer* of New York, February 9th, 1901, Vol. XXXVII., p. 229.

IV. *Effect of Various Kinds of Metal for the Fuse.*—The next series of experiments was with fuses of different materials. Wires (size No. 28 S.W.G.) of tin, platinoid, Eureka, German silver, copper, &c., were each in turn placed in series with the circuit-breaker, and the current found for which the cut-out and fuse would operate at the same instant.

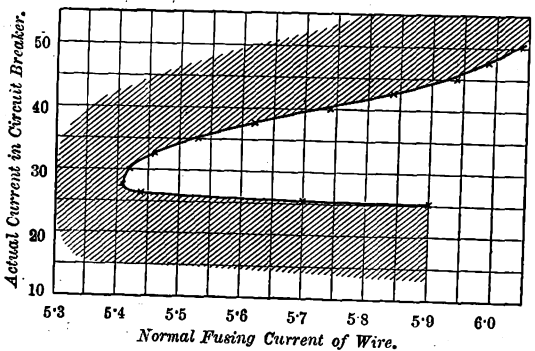

Fig. 8.—Circuit Breaker set for 25 Amperes.

The ratio of $C/\bar{C}$ was lower in all cases than for tin, showing that although tin is a good material to use for fuse wires on account of its low melting point, the time taken to melt it is much greater than for example with a copper fuse.

The comparative results for No. 28 wire are as follows :—

| — | Aluminium | Copper. | "Eureka." | German silver. | Platinoid. | Tin. |
|---|---|---|---|---|---|---|
| $\bar{C}$ …… | 17·0 amps. | 19·5 amps. | 9·1 amps. | 8·8 amps. | 9·1 amps. | 4·0 amps. |
| C …… | 45·0 | 52·0 | 26·3 | 27·3 | 25·9 | 16·7 |
| Ratio .. | 2·65 | 2·67 | 2·90 | 3·10 | 2·86 | 4·17 |

(These results point to the desirability of using fuses with high melting points, if the operation of circuit breakers due to local short circuits (say in a lighting system) is to be avoided. It is possible that the use of such fuses might obviate the necessity for the "time limit" circuit breaker in many cases).

## CRANE MOTORS AND CONTROLLERS.

The following is an abstract of the discussion which took place at the Institution of Electrical Engineers yesterday week in connection with Mr. C. W. Hill's Paper on the above subject. The Paper itself was published in our issues for February 9th, p. 663, and February 23rd, p. 747.

After reading his Paper, the author remarked that equations (14) and (15), given in the Appendix, could be written more conveniently as follows :—

$$\frac{dC_t}{dt}=\frac{M-C_t}{T} \quad . \quad (14) \qquad \text{and} \qquad f=\frac{\dfrac{C}{TK'}}{\dfrac{M-C_t}{T}+\dfrac{C_t}{TK'}} \quad . \quad . \quad (15)$$

Mr. ALEXANDER SIEMENS, referring to the common methods of specifying crane motors enumerated by Mr. Hill (see *The Electrician*, February 9th, p. 663), said he would like to point out that method 4 was manifestly not correct for small motors. This method was: "The horse-power required to lift or move the load, plus gearing losses, is taken as the brake horse-power of the motor. It is specified to maintain this power on a continuous run of ¼, ½ or 1 hour, as the case may be, with a rise of temperature of 75°F." A small motor, for instance, would attain the final temperature sooner than a large one, and the one hour's test might be the equivalent of a continuous test. On the other hand, the large motor would not attain its final temperature in the one hour, and might be far too large for the work required of it. The whole subject had been treated in a very thorough way by Mr. Oelschläger in the *Elektrotechnische Zeitschrift* of December 20, 1900. In this article it was shown that the question of the size of an intermittent motor depended on two things: First, the proportion of the time that the motor was doing work to the time that it was resting, and secondly, the length of time that it was doing work. The influence of this second factor could be gathered by considering first a motor which ran for 1½ minutes on load and then stood for 10½ minutes, and then a motor which ran for two hours continuously and then stood for 14 hours. The load factor was 1/8 in both cases, but the motors were very differently used. This demonstrated his point—viz., that is was not possible to be guided by the load-factor alone, but the length of time the motor was actually used must also be taken into account. Mr. Oelschläger, in his Paper, showed how to arrive at the correct length of the equivalent continuous run when the time (load) factor was given, provided the time of working was very short compared with T—the time constant. T was shown by Mr. Oelschläger to be the time in which the motor reached 0·633 of the final temperature of a continuously-running motor. With the formulæ given by Mr. Hill, it was necessary to add a constant here and a constant there, which had to be determined by experiment, and the formulæ were not practicable for this reason, Mr. Oelschläger came to the same conclusions that Mr. Hill did—viz., that by the combination of methods 1 and 4, set out in the Paper, it was possible to substitute for a test of intermittent working a run at a given horse-power for a given time varying as the load-factor, and if the machine did not attain the forbidden temperature during the run, it would also not obtain it in the intermittent work for which it was destined. The figures below had been worked out for the standard line of crane motors manufactured by Messrs. Siemens Bros. & Co. on the lines indicated in Mr. Oelschläger's Paper.

*Times in minutes, at horse-power stated, to reach 80°F. rise with equivalent load-factor rating given over each column.*

| Type. | 1/8 | | 1/6 | | 1/4 | | 1/3 | | 1/2 | |
|---|---|---|---|---|---|---|---|---|---|---|
| At medium speed. | Min. | H.P. | Min. | H.P. | Min. | H.P. | Min. | H.P. | Min. | H.P. |
| 6-C | 15 | 7 | 20 | 6½ | 30 | 5¼ | 40 | 4½ | 60 | 3½ |
| 8-C | 15 | 11 | 20 | 9 | 30 | 7 | 40 | 5½ | 60 | 4 |
| 9¾-C | 18 | 15½ | 25 | 13½ | 37 | 11 | 50 | 9 | 75 | 7 |
| 11-C | 22 | 23 | 30 | 20 | 45 | 16 | 60 | 13 | 90 | 10 |
| 13-C | 26 | 35 | 35 | 30 | 52 | 24 | 70 | 20 | 105 | 14 |
| 15·1-C | 30 | 50 | 40 | 43 | 60 | 33 | 80 | 27 | 120 | 20 |
| 15·2-C | 30 | 74 | 40 | 60 | 60 | 48 | 80 | 39 | 120 | 25 |

It would be noted that the same motor was rated at a lower horse-power as the load-factor increased, and that the duration of the run increased also with the load-factor. The table also showed that the larger motors, if rated in accordance with one hour's run, would overheat if used intermittently with a load-factor greater than one-third. Conversely, the one hour's test required larger motors than necessary in all other cases.

Mr. A. H. BATE thought the Paper was also of great interest in connection with electrically-driven machine tools. The overload temperatures given in Table I. were interesting, but he would like to know whether they had been calculated from some assumed data or the results of experiments. Some tests which he had made with the armature stationary—*i.e.*, simply passing current through it up to 10,000 and 15,000 amperes per square inch, gave very much smaller rises than Mr. Hill had given.

Mr. JAMES AITKEN first referred to the following sentence in the Paper: "It has been generally noted among crane makers that quarter-hour-rated motors had a habit of burning out with a facility which has been somewhat surprising to them." Speaking from the user's point of view rather than from the electrician's, he said that the maker of the crane seldom knew the exact work that the crane had to do, and seldom realised the enormous overloads that were placed on the crane in an ordinary day's work. As an instance he quoted a crane which was employed to unload barrels. But these frequently got jammed and the crane was consequently greatly overloaded. He would like to hear Mr. Hill's views as to the best voltages for crane and tool driving. In this connection he had had recently a rather curious experience. He was visiting an engineering works which was electrically driven where the voltage had previously been 220 but had been reduced to 110. The reason for this, he was told, was that with 110 volts if a fault developed it took, say, a fortnight before anything serious happened, and thus there was time to attend to it. With 220 volts, however, the fault became serious in a week. He would like to hear Mr. Hill's views as to the length of life of a crane motor. His experience under the usual rough conditions of workshops induced him to put this at seven or eight years.

Mr. STOKES said there was one matter which Mr. Hill had not referred to, and that was the crane driver. He remembered a case in which Mr. Hill himself made some elaborate arrangements for using a large number of stops, so that the motor should not be used too badly. They had, in addition, a sort of emergency arrangement, so that the current could be cut off instantly. He himself had had occasion to visit those works some time later, and found that the motor driver used to put his controller on to the speed he wanted, and by means of the emergency arrangement switched on the current at the right moment.

Mr. F. W. DAVIS (Cleveland Bridge & Engineering Co.), in a written communication read by Mr. F. E. Elmore, said that on the new high level bridge at Newcastle he employed a shunt motor and controller on a 5-ton derrick crane with a 70 ft. jib, and the same system on a 15-ton Goliath travelling crane. In their girder works at Darlington shunt motors had been used on a 30-ton overhead crane for nearly three years with very satisfactory results. The work of the driver was much simplified, and he had complete control over the load without having to use a brake as a means of slowing it down, this being the usual practice with series motors. The 5-ton derrick had been used constantly for setting granite ashlar in position, and this showed that the control over the speed of lifting and lowering was perfect. The acceleration was also found to be much steadier than with the other cranes with series motors. One important factor to be borne in mind, especially with large cranes erected at a great height from the ground, was safety in working, and he thought that with shunt motors and the provision of an electric brake in case of the current or the fuse failing, the working of the crane was perfectly safe. He was sorry he had not adopted the same system on the large 10-ton Blondin which had been erected over the river, as in lowering loads with this they had a large amount of trouble with the brakes, which were constantly getting too hot. Loads of 8 tons had to be constantly lowered for the distance of 120 ft., and with a shunt motor system a very considerable saving of electric energy would have been effected while the loads were being lowered.

Mr. C. W. HILL, in reply first of all to Mr. Siemens, said that he had specially avoided dealing with the question of motors that worked for more than a few minutes, the Paper being confined to crane motors. Mr. Siemens had stated that the formula given in the Paper would not enable one to calculate the temperatures, times of running and so on for crane motors unless experimental constants were obtained. But this was also the case with Oelschläger's method, for his constant which corresponded with that in the Paper had to be found by experiment. The two constants that had to be found by experiment were the constant T which Mr. Siemens had mentioned and which was given in the Paper both in formula 3 and formula 12, and the constant C in Mr. Esson's original formula. In answer to Mr. Bate, he said that the overloads on Table I. were calculated temperatures on the same basis as the rises of temperature on the curves shown in Fig. 9, and they were calculated on the assumption that the overload would last for such a short time that the whole of the heat generated during that short time would be confined to the armature winding. Of course, if the overload lasted for a longer time, the heating would spread and the rate of rise would be less. With motors driving machine tools the case was rather different to that of a crane motor. The former was put down to run continuously—*i.e.*, it might have to drive the tool all day long with a pretty good load on it, so that the motor driving the machine tool should be capable of carrying a very considerable overload above that when driving the tool. In the ordinary way a crane motor was an overloaded motor to begin with, so that if it were overloaded on the top of its original overload, its temperature naturally rose very rapidly. He quite agreed with Mr. Aitken's remarks as to the accidental overloading of cranes, for he had had similar experiences. With regard to the question of voltages, so far as outdoor works was concerned, such as bridge yards, &c., it was not found advisable to go beyond 220 volts, because earths and short-circuits could not be altogether avoided. The life of motors was a little difficult to determine. The Cleveland Bridge Co. had had motors at work for nine years, and very little had been done to them. In a written amplification of his reply which has been sent to us, Mr. Hill says that he had not seen Mr. Oelschläger's most interesting and valuable article at the time he wrote his Paper. Otherwise he would have referred to it. He (Mr. Hill) preferred to reverse the process, however, and instead of taking a given machine and finding what its temperature rise would be, he started with the temperature rise allowed and determined the size of machine necessary. His own Paper took into account the effect on temperature rise of the starting currents and this was a point which, as far as he knew, had not been previously treated.

Mr. W. M. MORDEY, who occupied the chair in the absence of the President, said the Paper dealt—at least by inference—entirely with direct-current motors, which were now very often used on cranes. But many of them had to put in motors where there was nothing but alternating current, and it was just as well to remember that they could drive cranes in that way, which was only a branch of the great subject of electric traction.

## SOME NOTES ON MOTOR DRIVING.*

BY W. J. BELSEY.

The object in bringing this Paper before you this evening is in special reference to the choice of a type of motor which is most suitable for the operation of various machines used in the various industries of these countries, and at the same time to describe a few novel applications of motor driving.

A problem which almost invariably confronts us in the laying out of an electrical drive is to determine whether the machines should be driven individually or in groups, and unless one has a most intimate knowledge of the working conditions which obtain, it is most difficult to say which is the best. As a general rule, individual driving is about 50 to 65 per cent. greater in the first cost than group driving. The advantages of individual driving are well marked, in that each machine is an independent unit, and can be run without respect to the other machinery. The liability to break down is considerably lessened, and full advantage can be taken of the stops or intermittent working of the machine, current being only taken when the machine is in use, and only in proportion to the work done. The advantage of a group drive is principally in the low first cost. In the majority of cases, however, the problem resolves itself into a compromise, the larger machines being driven by individual motors, and the smaller ones grouped together in small groups driven from short lines of shafting. The question of a proper grouping is one which merits very serious consideration, as on it very often depends the financial success of an installation. So many local and special features, such as the shape of the building and the position of the machinery to be driven, play a most important part in this question, that it would be futile to attempt to deal with it in detail, but the author may mention one instance which came under his notice where, in a furniture factory, by the rearrangement of the groups already driven by motors, a saving of £87 per annum was effected in the current bill with an outlay of only £29.

*Spinning Mills.*—One of the most essential conditions for the operation of all classes of preparing and spinning machinery, whether cotton, flax, jute or wool, is a predetermined constant speed. The rate of production of a given frame is governed by the number of broken ends which occur, and which can be picked up by the operator in a given time. The causes of these broken ends are: (1) irregularity of speed; (2) inequalities in the fibre: and (3) as an absolute limit the centrifugal force the fibre will withstand. From the above it will be apparent that an induction motor is undoubtedly the best suited for the operation of spinning frames, for its speed with a given load is constant with respect to the speed of the prime mover, and as the load on spinning frames varies but slightly whether empty or full, it may be said that if driven by an induction motor the speed of the frame will be constant with respect to the speed of the prime mover. The speed of a shunt-wound direct-current motor is not by any means solely dependent upon the speed of the prime mover, for it varies, depending upon whether the motor is hot or cold, and the difference in speed with a continuous-current motor, cold and hot, is generally about 5 to 10 per cent., say 8 per cent. as a fair average, and it takes from two to four hours (depending on the size) for a motor, starting cold, to reach its maximum speed. This means loss in production. Of course, these difficulties could be overcome if we fixed shunt regulators on to the motors and generators, but if the mill manager did this he would be taking the production out of the hands of the management and giving it to the operators, which, to say the least, would be unwise, and a condition which no mill manager would consider for a moment. Again, the atmosphere of a spinning mill is invariably charged with fine lint dust and fibre, which has a most deleterious effect on the commutators of direct-current machines, and this in itself is sufficient to preclude the adoption of direct-current machines for this class of work. Also, as every available square foot of floor space is occupied by producing machinery, the motor is generally located either on a platform hung from the ceiling, or is bolted direct to the ceiling in an inverted position.

A group system of driving is generally adopted for spinning mills. The motor is usually of a large capacity, ranging from 75 H.P. to 150 H.P., and is direct coupled to the line of shafting, from which are driven a number of machines by means of belts. The over-all efficiency of this method is equal to that of the individual drive, notwithstanding the use of belt transmission to the individual machines. This is due to the much higher efficiency of the larger motors, as compared with the efficiency of the smaller motor used on the individual drive system. A disadvantage of the group system, however, is that it is practically impossible to vary the speed of the individual frames whilst they are in operation. The same remarks as to the suitability of alternating-current induction motors apply in a somewhat lesser degree to the other operations in a spinning mill, such as carding, breaking, hackling, spreading, &c.

*Weaving.*—In weaving it is essential to have a maximum fixed speed, and this speed is fixed by the strength of the yarn and by the liability of the shuttle flying. In this case, again, an induction motor shows itself to be best suited for the driving of looms for the very same arguments which are advanced for spinning. It is a general rule to drive all weaving machinery in groups off short lengths of shafting. The power required by a loom is comparatively small, varying from about $\frac{1}{4}$ H.P. in the ordinary looms to about 2 H.P. in the very heavy carpet looms.

*Bleaching, Finishing, and Textile Printing.*—In these factories we find that it is desirable and convenient to have at our disposal an economical method of varying the speed of some of the machines we purpose driving, and as these machines are the largest power users in these works, continuous-current motors are undoubtedly the best suited for their operation. Moreover, the machines in these factories do not require, either for their output or finished product, the refinements of speed which are necessary in spinning and weaving, and a variation of speed of 8 per cent. does not affect them materially. As to the particular type of continuous-current motor used on the most important machines, we will deal with these as follows.

*Calendering Machines.*—Calendering machines require, according to size, motors from 12 H.P. to 50 H.P., and these are generally individually driven, the motors being spur geared to the machines. The motors should be capable of giving a speed variation of, at least, 2 to 1 on the shunt. The load on these machines is very heavy at the start, owing to the friction of the long train of gearing and the heavy cylinders, and it is generally figured that they take from 1½ to 2 full load torque at starting.

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* Abstract of a Paper read before the Dublin Local Section of the Institution of Electrical Engineers on February 8th.

*Dye Jigs.*—Dye jigs are generally driven in groups of from 10 to 20, as the power taken by each only averages about ⅓ H.P. The starting effort is very light, therefore a shunt-wound motor is quite suitable for driving these machines.

*Stenter, or Drying and Stretcher Frames.*—These machines consist of two members, the one being a fan and the other for stretching and drawing the cloth over the hot-air vents. It is usual to operate them by two motors—one for driving the fan and the other for operating the drawing and stretching mechanism. The load at the start being comparatively light, shunt-wound motors are used for both members. It is preferable that the motor operating the drawing mechanism should be capable of a speed variation of about 2 to 1, as according to the texture of the cloth the drying can be done rapidly or slowly.

*Beetling Machines.*—These machines are generally driven in groups, each beetle taking about 10 H.P. The machines are heavy at starting, and, therefore, compound-wound motors should be used.

*Calico-printing Machines.*—Calico printing machines are generally individually driven, owing to the intermittent nature of the work, and the motors are generally of fairly large capacity—from 20 H.P. to 45 H.P. The motors should be compound-wound, and it is very essential to have an economical range of speed variation of about 3 to 1.

*Engineering Works and Foundries.*—On the whole, the author thinks that the continuous-current motor is the best suited for the work, as variable speed may be desired, and is in some cases essential. It may be taken as a fair general rule that in an engineering works it pays to drive any machine requiring over 5 H.P. individually.

There has been rather an interesting development in the application of magnetic clutches for the operation of planing and other reversing machines. The use of a magnetic clutch obviates the necessity for belts and also obviates the reversing of the motor itself. and so saves the same from a constant shock, and, on the other hand, it utilises the momentum of the motor to overcome that of the machine on reversal. This magnetic clutch gear may be described as follows: On the main or driven shaft and spliced thereto is a hollow shaft provided at each end with a disc; opposite the outer face of these discs is a magnetic clutch which is rigidly attached to a gear wheel turning loosely on the shaft. The motor shaft is parallel to the main shaft, and is provided with two pinions which drive the above gears. At one side, however, there is an idle wheel, so that the gears on the main shaft, with their clutches, revolve in opposite directions. The clutches bear against shoulders on the main shaft, so that the distance between their faces is fixed. The space between the outer faces of the discs on the hollow shaft is less than this, so that the hollow shaft with its two discs is free to slide, and so engage with one or other of the revolving clutches. It will, therefore, be seen that while the motor shaft revolves always in one direction, the main or driven shaft can be made to rotate in either direction, according to which clutch is excited and engaging, and either clutch is excited by means of a switch operated by lever rod and dogs in exactly a similar manner as an ordinary striking gear for operating open and crossed belts.

A few tables as to the size and rating of motors used on the various machines in general use in engineering works may be of interest, and the author, therefore, gives the same below.

*Lathes for Screw-cutting and General Work.*

| Height of centre. Inches. | Distances between centres. Inches. | Rating of motor. B.H.P. |
|---|---|---|
| 4½ to 6 | 20 to 32 | ¼ |
| 7 to 8½ | 36 to 80 | ½ |
| 8½ to 12½ | 40 to 100 | 1 |
| 14 to 16½ | 100 to 140 | 1½ |
| 16½ to 19 | 140 to 175 | 2 |

*Face Lathes.*

| Diameter of face plate. Inches. | Largest working diameter. Inches. | Rating of motors. B.H.P. |
|---|---|---|
| 36 to 50 | 48 to 64 | 2 |
| 60 to 63 | 64 to 93 | 3 |
| 80 to 100 | 106 to 140 | 5 |
| 158 | 212 | 10 |

*Turbet Lathes (working with One Tool).*

| Height of centre. Inches. | Largest working diameter. Inches. | Greatest work in length. Inches. | Rating of motor. B.H.P. |
|---|---|---|---|
| 9 | 20 | 33 | 1 |
| 11½ | 24 | 43 | 3 |
| 11¾ | 25½ | 33 | 2 |
| 13 | 28 | 55 | 5 |
| 16¾ | 34 | 63 | 5 |

*Vertical Boring Machine.*

| Diameter of table. Inches. | Greatest working diameter. Inches. | Rating of motor. B.H.P. |
|---|---|---|
| 50 | 51 | 2 |
| 68 | 84 | 3 |
| 82 | 96 | 5 |
| 83 | 120 | 5 |
| 156 | 300 | 15 |

*Horizontal Boring Machines.*

| Greatest height of bar. Inches. | Largest working length. Inches. | Rating of motor. B.H.P. |
|---|---|---|
| 21 to 25 | 40 to 60 | 1½ |
| 33 to 35 | 80 to 140 | 2 |

*Drilling Machines.*

| Pattern. | Maximum diam. of work on table. Inches. | Greatest distance from spindle end to table. Inches. | Rating of motor. B.H.P. |
|---|---|---|---|
| Quick speed.... | 6 to 10 | 9 to 35 | ½ |
| Pillar ........ | 10 to 13 | 32 to 48 | 1 |
| Radial ........ | 40 to 72 | 46 to 80 | 2 |
| Three-spindle .. | 6 to 6 | 31 to 35 | 1 |

*Milling Machines.*

| Pattern. | Dimensions of table. Length. Inches. | Dimensions of table. Breadth. Inches. | Greatest distance from spindle to table. Inches. | Rating of motor. B.H.P. |
|---|---|---|---|---|
| Universal (medium).. | 30 | 5 | 12 | 1 |
| Ditto (heavy) ...... | 58 | 11 | 22 | 1 |
| Vertical and straight. | 70 | 14 | 22 | 3 |
| Ditto .............. | 120 | 52 | 44 | 5 |

Wheel-cutting machine for wheels of 20 in. to 48 in. diameter, 2 B.H.P.
Ditto for wheels up to 55 in. diameter, 3 B.H.P.

*Grinding Machines.*

| Diameter of emery wheel. | Rating of motor. |
|---|---|
| Up to 10 in. | ½ B.H.P. |
| 10 in. to 14 in. | 1 ,, |
| 14 in. to 22 in. | 2 ,, |

*Planing Machines.*

| To plane in length. Inches. | To plane in width. Inches. | To plane in height. Inches. | Rating of motor. B.H.P. |
|---|---|---|---|
| 40 | 26 | 26 | 1 |
| 72 | 24 | 24 | 1½ |
| 84 | 26 | 24 | 3 |
| 120 | 38 | 38 | 5 |
| 120 | 49 | 49 | 7½ |
| 168 | 60 | 60 | 10 |
| 192 | 73 | 73 | 10 |
| 206 | 105 | 105 | 10 |

*Shaping Machines.*

| Length of stroke. Inches. | Traverse of head. Inches. | Greatest distance from underside of ram to table. Inches. | Rating of motor. B.H.P. |
|---|---|---|---|
| 4¾ | 15 | 8 | ½ |
| 16 | 30 | 20 | 1 |
| 20 | 20 | 20 | 1 |
| 25 | 25 | 26 | 1 |

*Slotting Machines.*

| Length of stroke. Inches. | Width of slot. Inches. | Depth of slot. Inches. | Dimensions of table. Inches. | Rating of motor. B.H.P. |
|---|---|---|---|---|
| 5 | 14 | 12 | 12 × 12 | ½ |
| 6 | 12 | 9 | 20 × 16 | 1 |
| 8 | 20 | 24 | dia. 28 | 1½ |
| 8 | 30 | 30 | dia. 30 | 1½ |

*Drop Hammers.*

| Weight of tup. Lb. | Largest drop. Inches. | Number of strokes per minute. | Rating of motor. B.H.P. |
|---|---|---|---|
| 330 | 44 | 155 | 7½ |
| 550 | 50 | 126 | 7½ |

*Pneumatic Hammers.*

| Weight of tup with piston. Lb. | Length of Stroke. Inches. | Number of strokes per minute. | Maximum height of work. Inches. | Rating of motor. B.H.P. |
|---|---|---|---|---|
| 165 | 11¾ | 220 | 4¾ | 3 |
| 275 | 14½ | 200 | 7 | 4½ |
| 440 | 17¼ | 180 | 8¾ | 6½ |
| 660 | 19 | 170 | 10¼ | 8 |
| 1,000 | 21½ | 150 | 11¾ | 10 |
| 1,425 | 23 | 130 | 13¾ | 12-15 |
| 1,870 | 27 | 110 | 15¾ | 17-20 |

In foundries all the conditions which obtain are such that make it desirable to use induction motors. None of the machines used in a foundry require a variable speed; also the atmosphere is charged with a gritty dust, which acts very deleteriously on the commutators of direct-current motors.

*Punching and Shearing Machines.*—Undoubtedly, for punching and shearing machines, induction motors are the best suited, principally on account of their very robust construction, and also because an induction motor can exert a much higher torque than a direct-current motor when suddenly required—as in the case of the actual moment of shearing and punching—without an appreciable variation of speed. The speed of punching varies from about 28 strokes per minute in the larger punches for $1\frac{1}{2}$ in. thick plates, to about 40 strokes per minute in the smaller ones, $\frac{3}{4}$ in. plates. It is not generally considered good practice to exceed these speeds, as, if higher are used, the squad just miss a stroke, and therefore reduce the actual speed of punching by half. If direct-current machines are used, they should be compound-wound. Angle cutters and beam punches all have the same characteristics as the above.

*Plate Rolls.*—For plate-binding rolls and mast rolls the motors should have the same characteristics as a railway or crane motor—*i.e.*, they should be series-wound, and be capable of exerting a high torque when required Plate-roll motors are generally fitted with a brake attachment for convenience of adjusting the rolls. Although the series motor is undoubtedly the best suited for this class of machine, yet induction motors have been used with very considerable success for driving them, and on the North-East Coast nearly all machines are driven by three-phase motors.

*Plate Edge Planers and Scarfing Machines.*—These machines are generally driven individually, and neither alternating-current nor direct-current motors have any special advantage. If direct-current motors are used they should be compound wound, as these machines take a considerable amount of power at the reverse.

*Countersinkers, Radial Drills, &c.*—Most machines, such as these, are generally driven in small groups, and either alternating-current or direct-current motors would do equally well for driving them. There is nothing very special about a group drive of this description, and a shunt-wound motor would be quite suitable.

*Iron and Steel Works and Rolling Mills.*—A brief description of a method for driving a set of three mills may interest you, and from this you wi see the general conditions affecting the driving of rolling mills electrically. Assume the total estimated power required for three mills is about 1,200 kw., the power would vary between that amount and the energy required to drive the mills light. Assume the generating station has a capacity of 2,250 kw. This would be subjected to sudden shocks of the above magnitude unless some method of compensation is used. These sudden shocks would, of course, affect the regulation of the system to a serious extent. If this is to be obviated, some device for storing and giving out energy must be resorted to. This can be done in two ways—first, by having a battery of accumulators, or, second, by having a buffer machine for storing the energy in a heavy flywheel. This latter device has been adopted in some mills, and has been found to be both cheaper and more efficacious than the former. As stated above, the maximum total power required by the three mills equals 1,200 kw., but the mean power only equals 300 kw., and, therefore, the buffer machine will have to supply for the short periods the difference between these amounts—namely, 900 kw. This buffer machine consists of a dynamo having a variable speed from 250 revs. per min. to 500 revs. per min., and upon the shaft of which is fitted a flywheel having a weight of about 20 tons, and a peripheral velocity of 212 ft. per second when revolving at 500 revs. per min.; therefore, at that speed the storage of energy is 14,000 foot-tons, and if the flywheel is reduced in a speed from 500 revs. per min. to 250 revs. per min., the capacity of the flywheel is 14,000 minus 3,500 equals 10,500 foot-tons. If we assume a total loss in this buffer machine of 15 per cent., including friction and all electrical losses, then the power available in the flywheel equals 27,500 H.P. seconds or 21,000 kw. seconds; therefore, it will be seen that the buffer dynamo will give 21,000/60, equals 350 kw. for one minute, 700 kw. for half a minute, and so on. In actual practice, however, the pulsations of load will only last a few seconds, so that the flywheel will never be greatly reduced in speed.

A sketch is given (Fig. 1) showing diagrammatically how this machine is arranged, and from this you will see that a small motor-generator supplies the excitation for the buffer-dynamo. The generator for this set is usually excited by part of the current flowing from the generating station to the rolling mill, or perhaps a better way to put it would be that it has a shunted series winding, so that as the load increases the voltage of the exciting generator increases. By this means the excitation of the buffer dynamo is changed, which, in its turn, causes a corresponding change in speed, and corresponding to this decrease or increase in speed the buffer dynamo runs as a generator or as a motor.

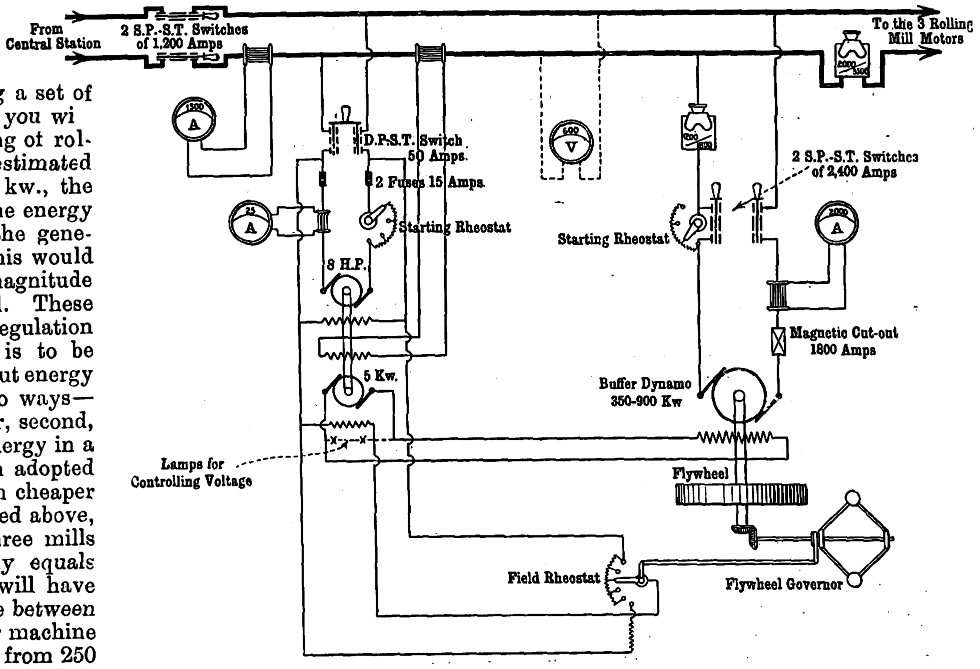

FIG. 1.

A very interesting feature recently adopted in one of the largest steel works in Scotland has been the using of the exhaust steam from the mill engine and steam hammers, &c., for driving a steam turbine. This is arranged by exhausting all the steam from the rolling-mill engines, steam hammers, &c., into a calorific reservoir, which consists, in some cases, of a covered steel tank which is loosely filled with pig iron or some other substance which will readily absorb heat. From this the steam is passed through a turbine, and exhausts into a very high vacuum. This idea has proved very successful in the utilising of hitherto waste steam, for, as you are aware, the steam which emerges under conditions of light load from rolling-mill engines and steam hammers is practically live.

*Paper Making.*—Paper-making machinery largely exhibits the characteristics of bleaching and finishing machinery, inasmuch that it is essential to have a wide range of economical speed control, and, therefore, continuous-current motors are generally used. Excepting in one or two instances, all the machines in a paper mill are individually driven, and it is a class of work which very readily and economically lends itself to this system, as the power required by each machine is generally fairly large and the work intermittent. In the majority of machines the load is of a variable character and liable to sudden shocks, and therefore compound-wound motors should be used.

*Printing Machinery.*—In the application of motors to the driving of printing machinery we have what may be considered one of the most interesting fields for the application of electricity, and one where electrical driving has shown itself to be pre-eminently the best over all other methods. The question of driving printing machines is very complex, owing to the large range of speed which the printers require to have at their disposal, and, therefore, printing machinery is generally operated by direct-current motors if the best and most economical results are to be obtained, and, even if an alternating-current supply were available, it would probably be best to convert it to direct current. For linotype and small jobbing machines of the stop-cylinder or flat-bed type, these are best to be arranged in small groups, so that each group may be driven from a short length of shafting. Owing to the rapid fluctuation of power required by all machinery having a reciprocating motion, and more especially flat-bed machines, it is desirable to use compound-wound machines. For guillotine shears, and other machines of the same nature, the motor should be heavily compounded. The medium-sized presses are generally individually driven, the motors having a variable speed of about 2 to 1 on the shunt. For very large presses provision has to be made for obtaining very slow speeds economically, such as when the paper is being threaded in or backing up and making ready for a run.

The author would like to express his indebtedness to Messrs. the British Thomson-Houston Co. (Ltd.) for allowing him to use their diagrams to illustrate this Paper.

## DISCUSSION.

Mr. W. J. U. SOWTER gave his experiences at Coventry, and alluded to the large losses in driving shafting often met with.

Mr. T. TOMLINSON agreed with the author that no general rule as to individual or group driving could be given. Alluding to the difficulty in persuading customers of the economy of electrical driving, he suggested that supply companies might with advantage keep in stock and loan to contractors motors of various powers, and give facilities for the temporary connection of these to their mains. He thought the buffer motor-dynamo a great improvement upon the simple flywheel which he had used himself with success.

Mr. EATON said his principal experience had been with polyphase motors for lift work; these, though subject to very rough usuage, gave practically no trouble.

Mr. CUMMINS said he had taken out a 3 H.P. gas engine and substituted a 2 H.P. motor; the gas engine had cost £3. 17s. per quarter, the motor cost £7. 17s. to do the same work, at a maximum demand price of 6d. and 1d. per unit after; on remonstrance, the energy was given at a flat rate of 3½d., when the cost fell to £4. 17s. In his opinion there was nothing to equal the three-phase motor.

Mr. FOSTER mentioned two cases where individual sewing machines and individual drills were independently driven; he also stated that the Manchester Steam Users' Association had informed a bleaching firm that steam was cheaper for his purpose unless electricity could be got at 1d. per unit. Was this, in the author's opinion, a fact? The requisite power was 400 H.P., and was used for 14 hours per day. He agreed with the author as to superiority of polyphase motors for work in dusty places, instancing his experiences in a Canadian cement works.

Mr. ELWALL said that many people had the idea that three-phase motors were readily pulled out of phase by overloading; this was not so. He had seen a Langdon-Davies 3 H.P. motor working at 7 H.P., and also two large motors working quite comfortably on a line shaft driven by a gas engine.

Mr. W. TATLOW pointed out that a factory buying electrical energy was enabled to run small sections of its work overtime with great economy. The squirrel cage motor was to be preferred—even at a sacrifice of a certain amount of economy—on account of its being such a good mechanical job. The induction motor had the enormous advantage over any form of direct-current motor that it could stand short-circuits for a few minutes. The advance of the steam turbine would, in his opinion, give an impetus to polyphase generation. As to the utilisation of the exhaust steam of reciprocating engines in turbines in preference to the use of condensers, he had recently seen that in a certain case 60 per cent. of power contained in the exhaust steam from the main engines had been recovered, compared with only 25 per cent. if condensers alone had been employed.

Mr. P. S. SHEARDOWN said that in cases where trouble was experienced with direct-current motors from the presence of dust, surely it would be possible to box in the commutator only. In cases where absolute regularity of speed was required he advocated the use of synchronous motors, whose speed depended solely on that of the well-governed prime mover.

Mr. BELSEY, in reply, advised that in all cases where electrical power was being substituted for steam or gas engine power the engines should be very carefully indicated to prevent future disputes as to power before and after the substitution. He gave the Glasgow price for power as ¾d. per unit for 500,000 units per annum and upwards, available at purchasers' discretion, and the same price for any quantity, however small, if not taken at the peak of the load, or a flat rate of a 1¼d. per unit. The extent of sub-division depended on the price of energy; he would not drive small engines individually. The question of the bleach works was complicated by the fact that a large amount of steam was necessary for heating; still, several large bleach works had adopted electrical driving with success and economy. The torque necessary to pull an ordinary polyphase motor out of phase was 100 to 120 per cent. that of full load, but in rolling-mill motors the figure might be as high as 250 per cent. He agreed with Mr. Tatlow as to the use of squirrel-cage motors provided they were under one-fifth of the full power of the generator.

During the evening Mr. Davies exhibited a model of a tramway lifeguard.

## CONDUIT WIRING FOR ELECTRIC INSTALLATIONS.*

It has been said that the practice of electric wiring has passed from the stone age to the wood age, from which during recent years it has merged into the metal age. In the days before the cable maker learnt his art, a porcelain or stoneware insulator was practically all that the electrician had to reply upon to separate his P.D., but with the advance in the art it became feasible to run the circuit wires in their rubber envelopes, either alongside each other, or separated by a small fillet of wood. Here the electrician began to rely upon his insulating covering and to dispense with an actual insulating support, but began to look out for mechanical protection and support for his vulnerable dielectric. We did not pass from the stone age to the iron age without an intermediate stage, and up to quite recently, wood casing was very extensively used, but it really afforded very little protection, either mechanically or chemically, to the insulation covering of the wires, and for this reason I consider its use was in reality a retrograde step.

Before coming to steel and iron conduits it would no doubt be in order to mention lead-covered cables. The lead sheathing offers a limited amount of mechanical protection, but the thin covering that is used will not stop the penetration of a nail, and this system is by no means free from leakage and electrolytic troubles. Another objection is the difficulty of satisfactory jointing.

During recent years a great impetus has been given to the use of iron and steel conduits for electric light installations. The first step in this country was the application of ordinary gas tubes and fittings; but great care was necessary in rodding the tubes, and otherwise cleaning out the interiors of gas fittings, which were never designed for the drawing through of insulating cables. This gas tubing did not make much headway, and it was not until the introduction of the light gauge steel conduit used in connection with specially designed malleable fittings that conduit wiring began to make any progress. The light steel tubes, with which all of you are familiar, run from about 20 gauge in the ½ in. to 16 gauge in the 2 in. It was found practically impossible to screw them on account of the longitudinal seam running through them, and also because there was not sufficient thickness of metal in the wall to permit of a reasonable depth of thread, which would yet leave the tube mechanically strong. Certain firms are supplying tubes of practically this gauge screwed, but in the seamless or brazed variety, and they are possiby able to do this by using a fine brass thread, and also because such tubes can be made to a very accurate diameter, and absolutely circular. The use of light gauge socket-joint tubing, however, is still increasing in this country at the present time, despite the large amount of heavier gauge screwed work.

Within the last year or two, devices have been brought out whereby electrical continuity may be secured with socket-joint tubing, but these necessitate the use of screwed fittings, which, although cheapening the cost as a whole in comparison with screwed work, increase the cost in comparison with ordinary socket work, but they provide for absolute metallic continuity and have the additional advantage that when tightening up, the tube and cables are not twisted, and the wire can be more readily withdrawn if occasion should subsequently arise. We take it generally that this class of tubing, under all ordinary conditions, affords complete metallic protection against light nails, panel pins and tin tacks; moreover, it has the undeniable advantage that its interior surface is of the smoothest possible description. There is no chance whatever, owing to the process of manufacture of these tubes, that the slighest burr or other obstruction can exist. Moreover, the diameter, and therefore the cable capacity, is the same at every point, and such tubes can be made with a degree of accuracy which is impossible of attainment with welded gas tubes. This exactness of diameter is a very important thing, as these tubes are used in combination with fittings having a bored socket, the depth of the bore being usually equal to or exceeding the diameter of the tube, and it is most essential that the tubing should be socketed well home in the fitting, and so fixed in position.

One of the principal causes of failure in connection with socket-joint tubing is undoubtedly due to carelessness in measuring up and not allowing sufficient length to allow the tube to socket well home in the fitting. The majority of faults attributed to the system are really more attributable to carelessness, and they are easily guarded against by the exercise of a moderate amount of care. The leading manufacturers of this class of material so arrange the bore of fittings in relation to the diameter of conduit as to secure an extremely tight fit, necessitating considerable pressure to drive the tube well home. The variation they allow in the extreme is not usually more than 0·005 in. or 0·0025 plus or minus from the normal.

I feel sure it is to the advantage of all that contractors should exercise reasonable supervision, especially with regard to concealed work, and that the undoubted advantages of the socket-joint system for rapid work should not be abused.

Light-gauge steel tubes, in common with all metal conduits, suffer to some extent from condensation, and in certain situations are acted on by acids and alkalies found in certain kinds of plaster, and especially in concrete where unwashed sea sand has been used. The first of these drawbacks is usually not very pronounced; moreover, it is quite practicable and usual to arrange the runs for draining, so as to reduce condensation to a minimum. Unfortunately chemical action is not so readily got rid of, but it can be guarded against in the great majority of cases, and after all it is not confined entirely to conduits, but other iron and steel metal work suffers to the same extent unless the cause is removed or the metal is very well protected.

Heavy gauge steel conduits in most general use in this country vary from about 16 gauge in the ⅝ in. to 14 gauge in the 2 in. size. The manner in which these tubes are constructed is either by rolling or drawing through dies, and brazing or welding the seam, or by drawing or rolling the tube by successive processes, both hot and cold, from a solid ingot of the metal. These tubes are commonly known as brazed, welded and solid drawn or seamless, and naturally, owing to the quality of the material and the expensive processes involved, the last is considerably the most expensive.

In a consideration of the points in connection with these conduits, we have in screwed brazed an absolutely uniform interior and exterior surface, with little or no obstruction possible. Such tube will screw readily, and although it is not advisable to attempt too much in the way of bends and sets, it can be used in connection with the standard fittings for conduit wiring which have been designed to eliminate as far as possible all unnecessary handling of the tubes, with the exception of cutting and screwing.

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* Abstract of a Paper read before the Electrical Contractors' Association on Tuesday, February 20th.

With regard to welded tubes, we can at once say that the heat necessary for the production of an efficient weld is injurious both to the internal and external surface of the tubes, and also to the maintenance of a uniform diameter. Moreover, welded tubes have to be made heavier than is either necessary or convenient for wiring purposes, and are subject, if the material is not homogeneous, to blistering and flaking, which causes serious trouble with the rodding process, and the interior surface of any welded tube can never approach to the ordinary rolled, brazed or solid drawn tube for smoothness and entire absence of burrs, fins and other obstructions. When a tube of this description is measured with a micrometer gauge, it is very seldom found to be of uniform diameter. Certain companies manufacturing welded tubes apply such processes as rodding and sand blasting, sometimes in conjunction with pickling, but the difficulty here lies that all these operations are costly, and that the satisfactory finished article could not be produced at less cost than a solid drawn tube, with which, of course, it cannot be compared in connection with conduit wiring.

Solid drawn or seamless tubes are made by processes which differ somewhat in detail, but they usually start with a square or circular billet of soft iron. The first two or three operations of rolling this down and making a tube of it are done at a white heat. The further processes in drawing down to smaller sizes are accomplished cold on powerful draw benches. The methods of the manufacture of weldless or solid drawn tube have vastly improved of late years, and the cost is now not much in excess of welded tube, but certain specifications which I have seen call for most exact gauges. Some even specify for 200 lb. per square inch which the tubing has to support by a hydraulic test previous to being selected, all of which appear to be unnecessary in electric conduits, and only have the effect of increasing price without corresponding advantage.

Some controversy has recently taken place in the electrical papers on the subject of standardisation of sizes, gauges and threads of conduit for electrical work, and an endeavour is now being made to standardise sizes, gauges and threads for conduit wiring, and rather than run the risk of prejudicing the committee's endeavours I will withhold my observations, believing this to be for the benefit of the trade.

We have yet to consider another grade which is commonly referred to as insulating conduit. This material was first imported from America, and consists of an impregnated papier-maché or bitumenised paper pulp tube. To afford this mechanical strength in its next stage it was brass cased, but in its present state it is covered by, or inserted into, a welded iron tube, and is known as steel-armoured. Some similar material to this is also in use on the continent. Insulated conduit has never found very much favour in this country, owing to a certain extent, no doubt, to its high and almost prohibitive initial cost. This type of conduit is looked upon by its adherents as giving increased insulation resistance to the circuit, and it is supposed to safeguard against damage through short circuits, internal arcs or electrolytic effects. The material, as far as I know it, is certainly not impervious to moisture, but absorbs it to an appreciable extent, and there is considerable difficulty presented, necessitating great accuracy in fitting if the insulating lining is to be made continuous throughout. We have also to bear in mind that the insulating lining has the effect of decreasing the capacity on any given size of metallic tubing.

I will now deal with some points in the conduit wiring of installations on which it appears to me that discussions would be most valuable, both from the manufacturers' and contractors' point of view, and should ultimately lead to the betterment of installation work as a whole. I would first direct your attention to an interim reissue of the rules of the Royal Insurance Co. These rules, embodied by consent of the Council, are uniform in requirements with the rules of the Institution of Electrical Engineers. On p. 18 we have the following: "In the opinion of this company the best general method of enclosing and protecting the conductors is by the use of stout metal conduits. It is important to note, however, that numerous fires have occurred through leakages of the current from such conduits to soft metal gas pipes, so that the security of such a system depends seriously upon the proper spacing apart of such conduits from soft metal gas pipes or from metal work in contact therewith." This note deals with one of the real risks in connection with the conduit wiring of buildings, and a risk that will remain just so long as we continue to permit the use of gas pipes of the compo description. Continuity and earthing are no doubt very advisable on high-voltage work from the point of view of protection from danger to life, but are really very little safeguard against fire risk unless care is taken to keep metal conduits spaced apart from such gas pipes, and of course from any metal work in connection with them.

The present chief engineer of Glasgow, Mr. W. W. Lackie, in his Paper on "Earthing" read before the Glasgow branch of the Institution of Electrical Engineers, in February last year, laid it down that conduits should be entirely insulated throughout a building. This is most desirable, and if it were possible in practice, I believe that it would at once remove the only real cause of uncertainty connected with the use of metal conduits.

I should like to refer to some points of importance which were brought out in that. First we had a report on fires having an electrical origin, and during three years, 1902-3-4, 35 fires were reported. On examination these were reduced to 33, or an average of 11 a year; this works out at one fire per 900 installations, and shows how essentially safe electric lighting is. Of these electrically-caused fires one half, 15, were due to the melting of compo gas tubes, where metal sheathed cables were used. Now eight of these jobs were carried out without being properly earthed, and seven were properly earthed; what the other causes were does not particularly concern us at the moment, but the point I want to emphasise is that continuity and earthing alone do not, as is commonly supposed, safeguard against fire. Suppose we have a leak on one of the outers of a three-wire system, the neutral of which is earthed, the tubing if continuous becomes alive throughout its length. Now the tubing may be earthed by an earth wire or not, it is quite possible that it may also be unintentionally earthed at one or more points by contact with compo piping; the result is that there is a large momentum rush of current to earth which splits up amongst the different earth paths in the ratio of their conductivities, and it is the arcing and consequent gas igniting effect of these earthing discharges which is the cause of danger. To entirely eliminate this we must insulate conduit runs, as far as practicable, from *all* metal work, or we must remove all compo gas tube from the building.

Now there are many thousands of socket-joint installations erected during the last eight years which are to-day working very satisfactorily, but these have been erected without any attempt being made to secure continuity or bonding, and consequently they are not intentionally earthed. The Institution of Electrical Engineers in their wiring rules do not demand continuity and earthing in jobs where the voltage of supply does not exceed 250 volts. Their rule dealing with this (Rule 12) is important: "Conductors conveying currents at pressures exceeding 250 volts must be completely encased in metallic sheathing or tubing efficiently connected to earth, and such sheathing or tubing must be electrically continuous throughout its length." We can draw the following deductions from this rule: First, that metallic sheathing continuous and earthed is the only method permissible with conductors on high voltage work; second, that it has not been deemed expedient to prohibit the use of socket-joint tubing on voltages below 250.

In dealing with this method of installing conduit, the question arises, "Is it desirable to use a brazed or solid drawn tube, or is it not actually advantageous to use an open seam and socket fittings?" I have it from more than one consulting engineer that for surface work they advocate the use of open seam conduit, and some of them go so far as to say that they would prefer to adopt tubing with even a more open seam than is now used, always provided that the seam is placed lowermost, so as to efficiently drain the tube; but it is reasonable to suppose, and is actually borne out in practice, that with such a well-ventilated tube there is absolutely no condensed moisture to drain, and it is for this reason more than anything else that, in my opinion, an open seam is desirable. In situations where there is steam or vapour about or humid atmosphere, such as in baths, laundries, boiler rooms, &c., the moisture from the outside is more to be feared than condensation, and in these cases the use of seamless screwed tube is desirable.

With regard to concealed work, switch runs, and the like, I think there is no doubt that open seam conduit is unsuitable wherever switch runs are buried in plaster or cement, and I do not think it has ever been recommended for this purpose. These runs, terminating very often in a switch wall plug or section box, act as natural drains for any condensation which may take place in the horizontal runs, and I think it is desirable that an outlet should be given to them, say by using a tee piece instead of a bend, so as to prevent this moisture draining into the switch box.

With regard to switches and ceiling roses and their mounting, I think it will be agreed that for the sake of continuity throughout the run it is most desirable that metal boxes should be used wherever an outlet is required. The circular conduit box is usually supplied with lugs which are drilled and tapped, and holding down metal screws are used to pass through the porcelain base, but owing to the proximity of these metal screws and the live terminals on the switch or ceiling rose, the leakage path to the conduit or earth is now very greatly reduced; in some cases it may not be more than ⅛ in., and on a large installation this has a very marked effect on the test. Good seating is also desirable to even up any inequalities in the china or porcelain base. Another method which reduces the projection is to use a ring provided with a lip, something after the nature of the cover of a paint tin. This would be put on the base of a ceiling rose with a small rubber washer, and after wiring the lid would be screwed home; this metal ring would then be gripped tight into the box, and to prevent subsequent loosening by vibration or any other cause, it is held in position by two screws on the outside.

It is pointed out that a great point in favour of a conduit is that it should be capable of being easily bent cold without flattening or splitting, that is, it must be well annealed and ductile; on the other hand, it must be of sufficient mechanical strength to resist penetration, and, unfortunately, these two requirements are not compatible.

In conduits and fittings a certain standard of workmanship and finish should be kept up, and for the production of an efficient article it should be recognized that certain processes in manufacture are essential, and I feel that I can safely leave it to electrical contractors as a body to say that what I venture to describe as the present satisfactory state of conduit manufacture shall not suffer by a demand for the cheapest article attainable irrespective of finish and general suitability.

### DISCUSSION.

Mr. STRODE mentioned that he had still a great regard for wood casing, for dry buildings, but admitted that in the present construction of fireproof buildings in our principal cities there were very many instances where only conduits could be used; he expressed his preference for solid-drawn material galvanised, and he did not approve of surface work.

Mr. JOHNSON asked a question in connection with the insulating of conduit runs through buildings. He had used mica for this purpose, but was not satisfied with the result. He referred to the care that had to be taken when screwing pipes, and mentioned the bad effect of oil on the insulation nipples, and asked for further particulars in connection with electrical fires.

Mr. LEWIN also touched on standardisation, and mentioned the difficulty of keeping tubes from rusting.

Mr. LESTER TAYLOR, the electrical expert of the Liverpool & London & Globe, and Royal Insurance Cos., mentioned that the fires reported in the Glasgow Paper as having an electrical origin were a very small proportion of the total fires from all causes. In the main he was in agreement with the Paper, although he thought it quite impossible and unnecessary to insulate conduit runs through buildings. With regard to earthing, he supported the lecturer's contention that continuity and earthing was no safeguard against fire, especially in buildings where compo gas pipe was to be found. He had found light-gauge socket-joint tubing quite satisfactory in a large number of installations. He referred to bushes and bell-mouth pieces wherever wires emerged from the free ends of conduits, and mentioned that certain forms in connection with conduit wiring to motors were very satisfactory.

Mr. TATE, the hon. secretary of the Association, asked for some information as to the rusting of iron and steel tubes; he expressed a preference for wood casing as against light steel tubing for surface work, and read some remarks from the electrical inspector of the Phœnix Fire Office in support of his views.

Another speaker referred to the absorption of moisture at the ends of lead-covered cables, and referred to the erroneous impression that had got about that the Fulham baths accident was occasioned by the use of non-continuous socket tubing, whereas in reality this was a screwed tube, but the tubing had not been earthed.

Mr. SCHMAHL thought that light-gauge tube was unsatisfactory for buried work, and asked for some tests on the continuity method that had been mentioned. He referred to hot and cold galvanising processes, and expressed the opinion that good enamelling was quite equal to this as a protective covering. He made comparisons between solid drawn and welded tubes, and he naturally favoured the latter.

Mr. WATERHOUSE, in reply, referred to the remarks at the opening of his Paper—viz., that this question was one on which great divergency of opinion exists, but he certainly held that light-gauge steel tube in conjunction with malleable fittings made the most satisfactory mechanical job where it was necessary to compete for the work to be done at the lowest possible cost. He sympathised with Mr. Johnson in the difficulty he had experienced in attempting to insulate conduit runs, and he had hoped that there would have been more suggestions from contractors as to the possibilities of this. In reply to the query in connection with electrical fires, an extract was read from Mr. Lackie's Glasgow Paper on "Earthing." With regard to rust, which had been mentioned by two or three speakers, he thought that the essential thing was that the tube should be absolutely clean before enamel or japan was applied, as, if rust had once started, it was very difficult to put on any protection that would be lasting.

In reply to Mr. Schmahl, it was pointed out that the continuity system mentioned had proved very satisfactory in working; the continuity of the trial run had not deteriorated in any way from the time it was first put down, and the output of these fittings was very large indeed.

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Practical Pattern Making." By Herbert Aughtie. 2nd edition. (Manchester: The Scientific Publishing Co.) 4s. net.

"Engineering Tables and Data." By W. W. F. Pullen. 2nd edition. (Manchester: The Scientific Publishing Co.) 2s. 6d. net.

"Brass and Iron Founding." By Joseph E. Dangerfield. No. 8 of "The Home Worker's" series of practical handbooks. (London: Dawbarn & Ward, Ltd.) 6d. net.

"La Télégraphie Sans Fil." By I. Van Dam. (Amsterdam: Scheltema & Holkema.) 5s.

## THE ELECTRIC WIRING OF SMALL BUILDINGS DURING COURSE OF ERECTION.*

BY R. ROBSON.

It is the author's purpose in this Paper to provoke discussion as to the best means of getting a thoroughly good installation for a low figure, more especially in small dwelling-houses.

Gas pipes in six and seven roomed houses can be put in for less than 7s. 6d. per point, good electric wiring in close-joint tubing at the very lowest for, say, 9s. or 10s. per point and switch for wiring only. Can we come down to anything like the price of gasfitting? The old bitumenised tubing, made by the General Electric Co. in very large quantities some years ago would do very well for this; the only drawback to this tubing is that a nail may be put through, but the same applies to light-gauge steel tubing. The writer has not tried this system for wiring in new houses commercially, but has adopted it in his own house twice, and also in the houses of one or two friends. These installations have been a success in every way, and the writer cannot see any drawback to this system except that the wires are not mechanically protected under floors—that is, out of sight—and, therefore, it is necessary to have special permission from the insurance companies interested; but what can possibly damage them except bad ventilation, accompanied by dampness or vermin—that is, rats and mice? In the first case, want of ventilation, accompanied by dampness, will affect any method of wiring except screwed tubing, and as for vermin in dwelling-houses, they are not worth taking into consideration. During the writer's experience of 13 or 14 years he has never seen any wiring so damaged except a little paraffined bell wire in one case.

Although he has used many miles of close-joint tubing, and is still compelled to use it in large quantities, the writer's opinion of this material is a very poor one, but as it is the method adopted in 99 cases out of every 100 for wiring this type of building, it is the system he will have to criticise considerably. Close-joint tubing laid into plaster has been referred to as a "streak of rust claiming a right of way," This is a very good definition, as the plasters used nowadays very often contain acid, and then it takes a very short time to eat away the tubing and leave no protection to the cables. Not only is condensation to be contended with, but the moisture in the brickwork and plaster drains through the *close joint* into the tubing, and so finds its way to the switches, and very often eats away the wire ends and causes the wood patrass to char or burn if the switches are mounted on wood blocks, as is usual in cheaper installations. This type of tubing is to a certain extent a mechanical protection, but it is by no means an uncommon occurrence to find nails driven right through the tubing and out again at the other side, and it does not take a large nail to do this—an inch oval brad is quite sufficient. The writer came across about 20 ft. or 30 ft. of such tubing damaged in no less than nine places by a joiner putting up picture beading, cutting right through the tubing and four or five wires, not even knowing he had gone through it. Builders and architects insist on having steel tubing, but will not pay for steel barrel, and think because they are getting a steel tube they are all right. Nine-tenths of the faults on tubing jobs would be done away with if one pole was not earthed, but as this cannot be avoided, we have it to reckon with.

There are many methods on the market for making close-joint tubing electrically continuous throughout; but for the type of installation in question they are not used, owing to the extra cost—probably 5 per cent. on the cost of the installation— and the slip joint has to be relied on to make a good enough electrical connection. This it does not do, especially when rusted. It is not an uncommon occurrence on tubing installations to find that no attempt at earthing has been made at all, and no draw-in system has been used, all the wires having been threaded in. Though no good firm will put joints in a tube, they are often found and cause no end of trouble. A great number of close-joint tubing jobs in this class of house have been rewired after a couple of years, sometimes less, owing to the above-named reasons. Frequently too many wires are drawn into a single tube, and the necessary drawing-in boxes not having been fixed, the wires cannot be drawn out owing to one wire being twisted round and round another, which prevents the replacing of any single wire without disturbing nearly the whole of the circuit or system.

The deterioration of the cable is a very common occurrence. If good cable is used it is more than half the battle won, but not many consumers ever bother about the class or make of cable when asking for tenders, although they seem now, after being circularised by supply companies and lamp makers, to be beginning to pay a good deal more attention to the make of lamp used. The use of a foreign instead of a C.M.A. cable will make 10 per cent. or more difference in the price of an installation, and naturally this is the first consideration, especially with builders. In fact, more than one builder has informed the writer "that we are building houses to sell, and we want the lowest price; after we have sold the house we have washed our hands of it." Could anything do more to encourage bad workmanship than this?

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* Abstract of a Paper read before the Newcastle Local Section of the Institution of Electrical Engineers, Monday, February 5th.

If there was any supervision of installations during erection, as there should be, most of the faults would not occur. Fire offices have their rules, but never on any account dream of inspecting small houses until a fire occurs; then sometimes they go, but if they do, they probably send a clerk out of the offices when it should be an expert. The supply authorities have their tests, and see to main switches, &c., but few of them have powers to enforce anything else, and probably it would be abused if they had, especially by corporations if they had a wiring department of their own. Companies usually work on different lines, and generally treat wiring firms as their best friends. Inspection there should be, but by a disinterested party. The fire offices are the responsible people, but they cannot afford to inspect every installation. The Institution might take this matter up with advantage. If the insurance people could afford a little more time and attention to go into the matter they would easily see that a good cable run on split insulators makes a thoroughly sound job. Such work cannot be scamped, as there is practically nothing to scamp in it. Everything can be seen at a glance by simply lifting a board or two, whereas tubing often hides many sins. What possible objection can there be to a good cable run on split insulators along the joists and through the joists in separate holes, and brought down in insulating tubing if inside the walls, or if outside, in a piece of casing? (In passing through the joists a ¼ in. hole is large enough for each wire, and this prevents the cutting and hacking of great pieces often over 1 in. deep, weakening the joists to an enormous extent.) Wires could even be jointed using this method, and make a first-class job that would easily compete with gas-pipes. If this were done, more than half our trouble would disappear.

Now turn to lead-covered cables. Paper-insulated cables are not advisable; they are too liable to be affected at the ends by dampness, and are very slightly cheaper than rubber-covered for small sizes. They also want very careful handling. A good job can be made with good lead-covered cables clipped to the joists and carried down the walls in casing, or protected with a metal shield. With the latter method you have earthing to see to again, and the lead, if let into the plaster, is often affected by it. There are some very good jointing devices on the market for lead-covered cables, but these add considerably to the cost of small installations.

It is not intended to recommend the Continental system of face wiring, using a wire something after the style of electrolier wire, or a flexible run on small insulators, as Englishmen would not have a face system in their houses, although if adopted originally it might have been popular. This method is used all over Switzerland with splendid results electrically. Insulator wiring does not seem to affect the decorations or artistic effects of the houses there, and electricity is far more popular than here among small consumers. The atmosphere in that country may perhaps help this kind of wire to last. The writer has recently run some miles of flexible on insulators in several hundred cottages; some of them have been in use nearly a year, and appear to be quite satisfactory. This arrangement would not do for the middle-class houses, but it is a system which can be done about 20 per cent. cheaper than casing in completed premises. Perhaps the writer has gone away a little from his subject, "Houses in Course of Erection," but he thought it as well to mention this system, as, of course, the house would have to be completed before such an installation could be installed.

He remembers once doing a batch of houses after reading a pamphlet published by a firm of electrical engineers, which proposed to point out how to do an installation of six lights in a cottage for 42s. The system was to be twin lead-covered, and switch lampholders were to be used with no wall switches. The lead-covered cable was clipped to the joists, and when run on brickwork the writer protected it with a semi-circular steel guard sold by the General Electric Co., although the pamphlet said nothing about this. He also put himself in correspondence with the writers of the pamphlet and got the particulars of cost from them which are given below:—

*Table of Costs with Lead-covered Wire.*

| | s. | d. |
|---|---|---|
| Six lamps | 2 | 9 |
| Six switch lampholders | 7 | 1 |
| Six ceiling roses | 1 | 9 |
| Six shades | 1 | 9 |
| 24 ft. flexible cord | 0 | 4 |
| Six blocks | 0 | 6 |
| 27 yds. $\frac{1}{18}$ twin lead-covered wire | 8 | 5 |
| Main switch | 2 | 6 |
| Fuses | 1 | 3 |
| Screws, nails, &c. | 0 | 3 |
| Labour 3s., wiring, 6d. fixing fittings | 3 | 6 |
| | £1 10 | 1 |

It is absurd to expect to get a decent job for anything like the above price. It will also be noticed the houses have to be done on piecework, which means the supervision would have to be about three times as great, and nothing is allowed for this. In the particular houses (about a dozen) which the writer tried the men were not put on piecework, but in other respects they were carried out as per the pamphlet, and they just cleared expenses, without allowing anything for supervision, at £2 10s. per house for five lights. Since then most of them have had wall switches fixed.

Further particulars given by the writers of the pamphlet read as follows:—

"*Wiring.*—As cottages of this size are without cellars the service will probably enter at the front room, where the main cut-outs and meter are fixed. At this point the contractor places his main switch (a five-ampere coupled link). To the same board are affixed two single-pole fuses, from which two pairs of 1/18 wire are run—one pair to the three lights on the ground floor and the other pair to the three lights on the first floor. These wires loop into the first two ceiling roses and terminate in the third; *no joints are made.* Where the rules and regulations permit, twin lead-covered wire should be used, otherwise close-joint tubing or casing must be substituted. In the latter instance the feeds for all the lights are run up to the ground-floor ceiling in the same casing or tube, the wires for the first three lights branching off at right angles and running straight down to each ceiling rose, while the two remaining wires are carried over the joists of the floor above and treated in a similar manner. The loops are left projecting through the ceiling until the floor boards are laid and the plastering is completed, when a lad can fix the ceiling roses. The success of cheap work such as this depends on a rigid system of supervision. The wire should be cut to the requisite length and handed to the lads ready to fix. Labour should be piecework—4s. 6d. a cottage for wiring and 6d. a cottage for fixing ceiling roses and pendants subsequently. Where lead-covered wire is permissible, 3s. a cottage will pay for *fixing of fittings*, a considerable saving being effected by dispensing with casing and tubing."

Lead-covered wire with the lead bared back and taken through wood blocks does not, in the writer's opinion, make a mechanical finish. Surface moisture is liable to creep between the lead and the insulation on the cables and causes them to give out quickly. The writer has tried piecework, but as the supervision has to be so much greater nothing is gained by it. It can only be done where there are a hundred or more similar installations.

If the split insulator system is satisfactory in works or large warehouses (and it is, the writer is certain of it), and since it is as safe a method as screwed tubing for all ordinary work, why can it not be adopted for housework? It only wants sanction and approval by the leading supply and insurance authorities. It would become the most generally-used system of any, and help a great deal to get the small householder, who is the best-paying consumer, as he is the most numerous. Twin lead-covered cable makes a very nice and cheap job for heating circuits in a house, as wall switches seldom are required. The switch is usually beside the plug, and if more than one plug is on a circuit it can be looped from the last one. This style can be done very cheaply, nearly as cheaply as split insulator work, and causes very little disturbance of the premises if put in after erection.

In addition to those already mentioned, the chief causes of breakdown on installations are the following: A fault that often occurs in tube wiring, but can be prevented with a little forethought, is the accumulation of water at the bottom of a long run down, and the tubing should be drained at the bottom bend to prevent this, by having one or two small holes drilled through, or by fixing a T-piece at the point instead of the usual bend. Faults are often caused by water used for washing purposes getting into the close-joint tubing and lodging there. If the cable is of decent quality, and the water dries away quickly, nothing will happen, but it is otherwise with inferior cable. The ends of the tubing often damage the wires if no insulating nipples are fixed, but this is only likely to happen on jerry work. Then there are faults due to nails driven through, and to rags in the tubing, other workmen cutting into the tubes, &c. Bad ventilation under floors plays havoc with tubing, and the writer had to take out the whole of the tubing on one floor of a large building, it being absolutely perforated all over in less than 12 months, through dampness due to lack of ventilation. This, perhaps, was an exceptional case, as the floors were absolutely rotten. Good ventilation will go a long way towards the preservation of an installation whatever method of wiring is adopted. Sea sand is much used in buildings in this district, and is very injurious to the pipe work.

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## DISCUSSION.

Mr. BUCKELL said that practically the only drawback of the split insulator system was that it gave no mechanical protection to wires under floors, but this was not very important. This system had worked very satisfactorily in works and factories for a number of years. He thought the C.M.A. cable would not make a difference of 10 per cent. higher cost, as this would mean that the cable itself would be about 40 per cent. more expensive than foreign cable. Lead-covered cable in small sizes was very unsatisfactory, the great disadvantage seemed to be that the comparatively thin layer of insulation between the conductor and the covering gave way during the handling and the copper shorted to the lead. It was a pity we did not start on the same system as on the Continent, and surface wiring would then not have been cried down by its unsightliness. He would like to hear insurance companies' opinions on surface wiring. Bitumenised tubing was very wasteful owing to its often breaking when cutting and erecting and often crushing when stored.

Mr. CLOTHIER said that not long ago, when endeavouring to have his house electrically wired, he was asked to pay more than half the rent of the house, and finally arranged matters by agreeing to pay 10 per cent. on the rent.

Mr. HANKS did not think surface wiring made a neat job, especially where the wires come down to switches. Tubing seemed to be of very little use as the wet plaster soon rotted it away. If tubing could be coated with some material which would last till the plaster was dry the tubing would probably then remain unaffected.

Mr. THORNTON considered that surface wiring was not unsightly if wires were covered when coming down to switches, and he thought that electric wiring should be run so that any wire could be replaced without unduly disturbing the remainder of the installation.

Mr. ROBSON, in reply, agreed with Mr. Buckell that bitumised tubing was wasteful, but, he thought, not to the extent which would exclude its use altogether. Lead-covered cables were very useful for radiator work, and he would not push their use for other work. Of course, split insulator work could not be made a neat job, but if down leads were covered it would be passable.

## A THREE-PHASE LEAKAGE INDICATOR.

A form of leakage indicator for use on three-phase circuits when the middle point is not earthed, which has recently been brought out by Messrs. Ferranti Limited, is illustrated in the accompanying figures. Fig. 1 shows the appearance of the complete instrument and Fig. 2 gives a diagram of connections. The apparatus consists of a milliamperemeter of the long-scale type working on the induction principle, a four-way switch provided with an automatic spring back arrangement to keep it normally on the first contact, and three incandescent lamps all mounted on one board. The lamps are connected in star fashion to the three phases, and the neutral point thus formed is connected to the first contact of the switch. When the switch is on the first position, the milliamperemeter will indicate the current passing to earth from the neutral point In the other positions of the switch one of the three phases is put to earth through the milliamperemeter and a resistance. If, when the switch is on position 1, the instrument reads a full scale deflection, it shows a dead earth on either phase 2 or 3. If the same result is obtained on position 2 it proves that the earth is on phase 3. If, instead of a full deflection, the instrument reads D milliamperes, the insulation resistance R of phase 3 can be calculated from the formula $\frac{V}{R'+R}=\frac{D}{1{,}000}$, where V is the voltage between phases and R′ the resistance of the instrument. It is intended that every day readings should be taken with the switch in all four positions. If there be no leakage the milliamperemeter will not read at all and the lamps will glow with equal dullness. A bad earth will put out the lamp on the earthed phase and cause the other two to light up more brightly, at the same time causing a large deflection on the milliamperemeter.

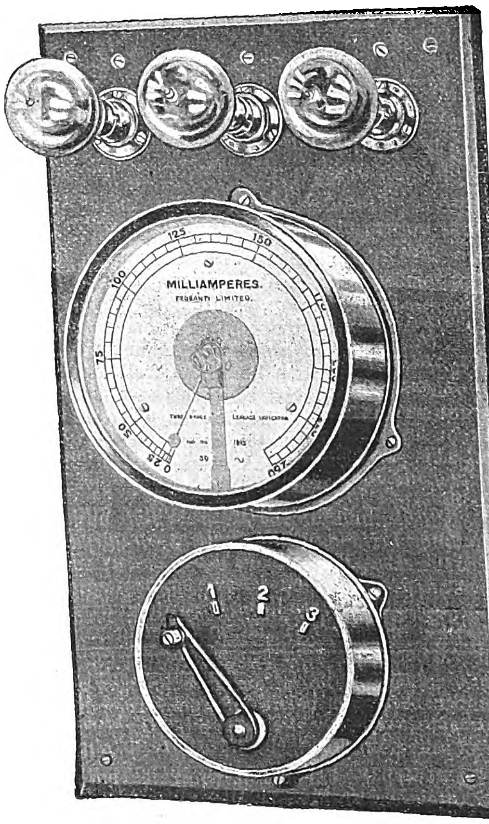
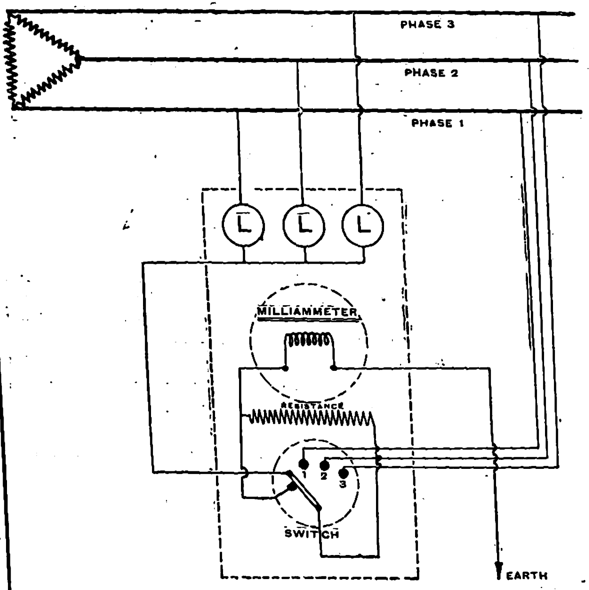


Fig. 1.—Three-phase Leakage Indicator.



CONNECTIONS TO CIRCUIT AS ABOVE

Fig. 2.—Diagram of Connections.

## THE ZOELLY STEAM TURBINE.

We learn that Messrs. Mather & Platt are now taking up the manufacture of steam turbines, and have decided to adopt the Zoelly type, which was introduced some time ago on the Continent by Messrs. Escher, Wyss & Co.

The Zoelly turbine is a multi-stage impulse turbine, with horizontal shaft, and its chief feature lies in the construction of the wheels. It is claimed by the makers that the design of the wheels enables them to withstand the stresses due to high rotational speeds so well that a relatively small number of wheels may be used. The turbine is generally constructed with two casings, a high and a low pressure, in each of which are placed about five complete elements. Steam is introduced into the first set of guides, in which it expands, in a five-chambered casing to approximately four-fifths of its initial pressure, and acts directly on the first wheel with a velocity corresponding to this drop; from thence it passes to the second guide and wheel, undergoing a further drop, and thus through the series. The two casings, high and low pressure, are separate and distinct from each other, but fixed on a common bedplate. They are split along the horizontal centre line, and the casing feet are placed as directly as possible under the line of division, so that no appreciable distortion takes place in the turbine when fully heated up, as compared with its position when cold.

The bearings are fixed on the bedplate quite independently of the casings, and are, therefore, in nowise affected by the heating of the latter. As a further precaution, they are cooled by water supplied under slight pressure, and are, moreover, lubricated by oil from a pump worked off the turbine shaft. Both oil and water are circulated over and over again. In the usual construction, three bearings are provided—one beyond each of the two casings and one between them. In the smaller sizes the shaft is continuous throughout; but in the larger it is made in two lengths and coupled between the casings with a double bearing, making four in all. In the smaller sizes the shaft is free to bend; but in the larger, the speed being below the critical for the material, the shaft is rigid.

On the shaft are keyed the wheels, which deserve special attention. They are forged in one piece with the boss from Siemens-Martin steel of the highest grade, and are polished all over. The blades of nickel steel are much fewer in number per wheel than in the reaction type, are secured by a special device to the periphery of the wheel, and are separated by accurately-cut distance pieces, the whole being backed by a grooved ring of forged steel riveted to the wheel. The cross-section of the blades decreases from the point of attachment towards the tip, to assist them in resisting the stresses set up by the high peripheral speed at which they run. The blades, like the wheels themselves, are highly polished, in order to minimise friction losses, while the nickel steel of which they are constructed enables them to retain their polished surfaces and clean-cut edges over lengthened periods of continuous operation. After assembling, the whole wheel is accurately and carefully balanced. The outside of the boss of each wheel is turned and is a neat but easily-running fit in the bore of its guide chamber, the boss of the latter containing several small grooves which trap any escape of steam from one section to the other.

Like the casings, the guide chambers are divided along the horizontal centre line, the joints being accurately made and fitted; the upper portion of the guide is secured to the upper half of the casing, and the lower half in like manner to the lower casing. Owing to this construction it is a very simple operation to lift the whole of the upper part of the casing with the attached halves of the guide chambers clear of the lower part, giving free access to the internal parts of the turbine.

The table contains the results obtained in some tests made in the beginning of last year with the plant at the electric power station in Mülhausen, which consists of a 550 B.H.P. Zoelly turbine, direct-coupled to two continuous-current dynamos. The results clearly show how nearly uniform was the steam consumption between 350 H.P. and 700 H.P.—*i.e.*, between half load and the maximum full load. This is stated to be an especial advantage of the Zoelly turbine.

*Table of Tests.*

| | | | | | |
|---|---|---|---|---|---|
| Useful output, kilowatts .......... | 132·19 | 208·21 | 291·52 | 391·13 | 463·22 |
| Revolutions per minute .......... | 3,061 | 3,050 | 3,040 | 3,030 | 3,020 |
| Pressure at inlet, lb. per sq. in. .... | 126·83 | 124·63 | 125·07 | 124·92 | 125·36 |
| Temperature °C.................... | 170·6 | 170·5 | 170·4 | 170·3 | 170·5 |
| Pres. before 1st guide, lb. per sq. in. | 39·83 | 55·85 | 73·48 | 95·97 | 111·84 |
| Vacuum per cent. ................. | 95·3 | 94·5 | 93·8 | 92·7 | 91·7 |
| Steam consump. per kw.-hour, lb. .. | 31·19 | 26·28 | 24·5 | 23·43 | 22·9 |

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. FOURNIER D'ALBE.]

*Magnetic Detectors.*—James Russell has measured the effects of parallel and transverse oscillations upon the magnetic properties of iron, with a view to explain the action of the various patterns of magnetic detectors of electric waves. He finds that Marconi's second instrument detects the *increase* of induction which occurs when electric space waves are superposed upon fields at or near a cyclic extreme, in precisely the same way as Rutherford's original apparatus detected, or rather measured, a *decrease* at another point of the cyclic process. The function of the moving band appears to be twofold: First, it supplies the hard iron or steel in a condition of lower permeability, in order that it may be raised to a condition of higher permeability when the signals are received from a distant station; and, second, it distorts the field in the direction of motion, the telephone thus tending to respond in a greater degree to signals received when the field is increasing near, but not at the cyclic extreme. For low field this is the most sensitive part of the cycle. The Ewing-Walter form of detector is essentially different. It is based upon Ewing's hysteresis tester, which measures the drag between field and iron when one of these is revolving. The best speed is stated to be from five to eight revolutions per second, while Marconi obtained good results at a speed of only half a revolution per second. The reason for this great difference is obvious. The Marconi instruments detect instantaneous induction change, while the Ewing-Walter form integrates.

[J. RUSSELL, *Proceedings*, Royal Society of Edinburgh, November, 20, 1905.]

*Spontaneous Ionisation.*—Madame Curie's supposition that radio-activity is due to an all-pervading radiation existing in the universe is now accepted in the converse sense that the radiation due to radio-active substances is present everywhere to a small extent, and accounts for the apparently spontaneous ionisation of gases left to themselves in closed vessels. H. Geitel discusses the kinds of radiation which may be made to account for this spontaneous ionisation. It may be due to traces of emanation contained in the gas itself, as is notably the case in subterranean vaults. The walls of the vessel play a prominent part. When they are incandescent they emit floods of ions, but even at ordinary temperatures many varieties of clay and other silicates emit ions. Even metals do so, and the recent experiments of Wood and Campbell have shown that this emission cannot be accounted for by superficial impurities. An analysis of the various radiations is necessary in order to decide the question as to whether all matter is radioactive. Thomson's observation that the alkali metals emit electrons not only when illuminated, but also in the dark, points towards a new phase of radio-activity.

[H. GEITEL, *Verhandlungen*, Deutsche Physikalische Gesellschaft, February 15, 1906.]

*Ionisation by Röntgen and Cathode Rays.*—J. Herweg has made a number of quantitative measurements in order to clear up doubtful points in connection with gaseous ionisation. One of these is as to whether the ionisation produced by Röntgen rays varies with the temperature, and another is as to whether it affects the simultaneous ionisation produced by an incandescent metal. The author answers both these questions in the negative. The ionisation is the same at all temperatures up to 400 deg. at all events, and the ionisations by Röntgen rays and incandescent metals are simply superposed. The author further made an attempt to determine the size of the ions, and was able to prove that they are positive atoms and electrons. This proof was furnished by determining the action of a magnetic field upon the dependent current through a gas ionised by Röntgen rays. It was found that the field increased the current density. Theoretical considerations showed that this is due to the strong deflection of the ions, which, owing to their increased path, have increased opportunities of producing secondary ionisation. These ions are free electrons. The author succeeded in making their cycloidal paths visible.

[J. HERWEG, *Annalen der Physik*, No. 2, 1906.]

*Velocity of Alpha-Rays.*—H. Becquerel has confirmed Rutherford's observation that when α-rays traverse a sheet of aluminium their speed is reduced. This applies both to radium itself and to the bodies giving out α-rays under the influence of radium emanation. The velocities were measured by noting the deflection produced by a strong magnetic field. The radius of curvature of the path described by the particles in a magnetic field was, contrary to previous observations, found to be uniform throughout. No magnetic dispersion could be detected, so that it must be concluded that the masses of the particles are all the same.

[H. BECQUEREL, *Comptes Rendus*, February 12, 1906.]

*Emission of Röntgen Rays.*—B. Brunhes has photographed the beam of Röntgen rays transmitted through an aperture in a turning disc, and compared the photograph with that of the light of the spark in the gap of the generating circuit, taking care to have only a single discharge. He finds that the spark records are not drawn out by the motion of the disc, whereas the Röntgen ray records are consistent with a duration of about a ten-thousandth of a second for the discharge of the rays.

[B. BRUNHES, *Comptes Rendus*, February 12, 1906.]

*Phosphorescence of Rare Earths.*—G. Urbain has studied the rare earths europium, gadolinium, terbium and dysprosium, and found that they all have a constant atomic weight, a characteristic spark spectrum and absorption spectrum, and also a phosphorescence spectrum when exposed to cathode rays. But the author finds that the oxides of these metals are not at all phosphorescent, or very slightly, when in a pure state. Mixtures of several of them are, however, highly phosphorescent. When one of them is added to another in increasing proportions, the phosphorescence passes through a maximum of brightness while the percentage is below one. Thus, in the case of a mixture of gadolinium and europium, the maximum phosphorescence is obtained when the europium oxide amounts to about 1 part in 250 of the mixture. The appearance of the phosphorescence spectrum is the same as if the gadolinium were replaced by calcium. Hence it is an atomic property of the europium, practically unaffected by the "solvent," whether calcium or gadolinium. The author has, by this principle, been able to identify several apparently unknown phosphorescent spectra as those of well-known bodies in a certain state of dilution.

[G. URBAIN, Société Française de Physique, *Résumé*, February 2, 1906.]

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## THE RATING OF CRANE MOTORS.

The subject of the suitable rating of motors intended for intermittent running at variable loads is one which is far more complicated than appears at first sight. The matter has been brought into prominence more especially in connection with crane driving, although the problem, with some slight modifications of conditions, embraces a very large field of electrical engineering, including, as it does, the whole range of traction, haulage, winding engine and lift work, and a very large branch of the subject of rolling mill and machine tool driving. The ideal method by which the choice of a suitable motor for working on intermittent and variable loads under any given conditions could be assured, is for the motor-designer to be supplied with a set of curves showing exactly the cycle of operations the motor will be called upon to perform, and for him to plot from them actual curves showing the losses in the various parts of the motor at every instant of the cycle at the various speeds and outputs. By integrating these losses over one or more complete cycles of operations he will be enabled to arrive at the probable temperature rise of his motor after running on the predetermined cycle for an extended period, and he will be able to check its suitability from the mechanical, commutation and other points of view by noting the maxima attained by the torque, reactance voltage and other quantities. Suitable as this elaborate method may be for special cases, it is obviously impracticable for application to everyday crane work. A system must be found which will enable the crane maker or the engineer who draws up the specification of the cranes to specify his requirements in a concise form and in such a manner as to ensure his obtaining the right motor from the motor manufacturer. Needless to say, the motor must be sufficiently large to perform its work satisfactorily, but a mistake may easily be made in the rating in view of the short periods during which the machine works at its maximum load, so that, if all the circumstances are not borne in mind, the result will be the specification of a motor far larger and more expensive than is really needed.

It is to this problem of finding a language through which the crane maker and the motor manufacturer can communicate that attention was given at the last meeting of the Institution of Electrical Engineers. Mr. C. W. HILL'S Paper on crane motors and controllers contained a praiseworthy attempt to arrive at a series of formulæ upon which a system of rating for this purpose can be based; but, as pointed out by Mr. ALEXANDER SIEMENS, his investigation is not absolutely complete. The formulæ given cover, no doubt, a large range of practice, especially with large motors, but the length of time of the individual runs is not taken sufficiently into account to enable the method to cover such cases occasionally met with, particularly in the case of motors of small size, where the length of the separate runs is in excess of the "time constant" of the motor employed. The number of variables which must be brought in is larger than would appear at first sight if the formulæ are to be capable of anything like universal application. Perhaps the most complete work that has been done in this direction is that of OELSCHLÄGER mentioned by Mr. SIEMENS in the discussion. His curves, showing how the relation of runs at various load-factors depends on the ratio that the time of each run bears to the time constant, are well known in most up-to-date designing offices; and the formulæ given in the article to which Mr. SIEMENS referred are as simple of application as Mr. HILL'S formulæ and yet show clearly the permissible load-factor at which a particular motor can be run under given conditions of working period and a given ratio of required overload to continuous rating for standard temperature rise. These formulæ bring out clearly the influence of the different variables and show how impossible it is to apply the same rule for rating in all cases. The very favourite system of specifying that the motor is to give a certain horse-power for an hour with a certain temperature rise, although convenient as being easily checked by tests, is not equally fair to motors of different sizes. And, on the other hand, the simple statement that a motor is to give a certain horse-power at a certain load-factor is incomplete if some mention of the length of the run is not made. A fuller specification of some sort is necessary, and it is only by wide experience of actual working that the most suitable compromise can be arrived at. Another point that must not be lost sight of is that the distribution of losses in a motor will not be the same for work consisting of a few short runs at a heavy load as for work including some longer runs at lighter loads and different speeds, even though the average load-factor may be the same in both cases. Some other interesting points were dealt with in the discussion, and Mr. DAVIS made a good case for the shunt motor, whose claims to usefulness in crane work are often neglected. He cited an example where shunt working was an undoubted advantage.

Even if a theoretically perfect system of rating could be arrived at, its value could only be utilised in cases where the exact amount of work the crane will be called upon to do are known to a nicety—a condition seldom, if ever, realised in practice. This vagueness of the requirements is strongly brought out by the widely different specifications which a motor manufacturer often receives from different crane makers who are tendering for the same crane contract.

The ideal system in cases where the crane maker does not manufacture his own motor would be for the crane expert to give to the motor designer full details of the exact duties which the crane is to perform, and let him, by utilising the methods of HILL or OELSCHLÄGER, select a motor suitable to fulfil the requirements, and thus avoid any attempt at specifying in terms of brake horse-power and minutes the size of motor required. The objection that may be raised is that there would be no easy way of checking, by means of a test run, that the motor supplied was really suitable for the work it is intended to do before it is actually in operation on the crane. In the case of foreign and colonial contracts particularly, this objection holds good, as consulting engineers find it essential to have a ready means of testing the motors before they are exported. Moreover, the great difficulty still remains—viz., that of ascertaining with any degree of exactitude what will be the actual work of the crane.

In ordinary circumstances a crane never goes through the same cycle of operations twice running, and probably at busy times will be working far harder than was ever predicted. In the hands of careless drivers also, it will experience overloads not dreamt of by the engineers who drew up the specification. Some amusing examples of the treatment some cranes have to stand were mentioned by speakers in the discussion. A large factor of safety in the design is thus rendered necessary by the large factor of uncertainty of the specification. The aim should be to combine the practical experience of the crane expert, who has to predict the worst conditions the crane will have to fulfil, with the knowledge of the skilled electrical designer, who can determine with certainty by what motor these conditions can satisfactorily be met. Both must act in accordance with the familiar definition of an engineer's business as common sense applied to the use of materials.

## THE KINGSWAY SHALLOW-TUNNEL RAILWAY.

*(Concluded from page 621.)*

The first part of our article on the Kingsway Subway was devoted to the electrical and general engineering features of the tunnel and the track, and we shall now deal with the cars. These are of the single-deck type, and are constructed of non-inflammable material throughout, in accordance with the Board of Trade regulations for the construction of cars for tube railways. They are the first cars of the kind constructed in this country for tramway purposes. The contractors for the first 16 are Messrs. Dick, Kerr & Co., who have made them to the designs of Mr. A. L. C. Fell, Chief Officer of Tramways. Some of the leading dimensions are: Overall length (over collision fenders) 33 ft. 6 in., overall width 6 ft. 10 in.; overall height 10 ft. 11¼ in., lengths of platforms 3 ft. 8½ in.; seating accommodation 36.

The main floor frame of the car (see Fig. 5) is constructed of rolled steel angle and channel bars, strongly put together with steel knees and gussets. Side pillars are built up of two channel bars placed back to back, supporting the angle steel cant rail and the steel carlines. The outer roofing is of mild-steel plate. Inside the cars are finished with aluminium sheet panels and mouldings, which give to the interior a bright appearance. The windows are furnished with spring roller blinds, and the ventilators above the windows can all be opened or closed simultaneously by turning a small handle at one end of the car. By this means the air is driven into the car from the front end and is expelled at the back.

The floors are constructed of steel plates, on the upper surface of which there is a covering of "Litosilo." As will be seen from the drawing, the seats are of the longitudinal type. They are formed of oak slats fixed to angle steel supports. The oak and all timber used in the car is rendered non-inflammable by a special process. There are altogether 20 16 c.p. lamps on the car, 12 of which serve to light the interior. Groups of five lamps in series are connected across the 500 volt supply. Communication between the conductor and driver is effected by means of the familiar mechanical bell and cord running along the whole length of the car from platform to platform, this arrangement having been adopted in preference to the electric bell system, which always requires a certain amount of attention.

The car rests on two trucks of the maximum traction type, which have been specially designed to give a steady riding motion under the varied conditions of service. Steel-tyred wheels are used on these, as on all other cars belonging to the Council. The electrical equipment, the whole of which has also been supplied by Messrs. Dick, Kerr & Co., includes two 39 B.H.P. motors to each car, controllers of standard design and over-load cut-outs on the driver's platform. Non-inflammable cables are used throughout and are carried in steel casings.

Magnetic track brakes of an improved type are employed. These brakes are applied by causing the motors to act as generators and to send current through the brake magnets. (For a description of and tests on electromagnetic track brakes see Mr. A. L. C. Fell's recent Paper on "Brakes," read before the Tramways and Light Railways Association, and reported in *The Electrician* for January 19th, p. 543, January 26th, p. 586, February 2nd, p. 635, and February 16th, p. 719.) The motors are disconnected from the supply and connected up as generators for braking by moving the controller handle backwards beyond the "off" position. When the brake is drawn down on the track rails by electromagnetic action, the ordinary brake shoes are automatically applied, this being achieved by connecting mechanically the track brake to the hand-brake gear. Although the cars are fitted with the customary hand-operated brake, the latter is only used in case the electromagnetic brake should fail. On a trial spin in the subway we were afforded an opportunity of witnessing the efficiency and smoothness of the braking equipment.

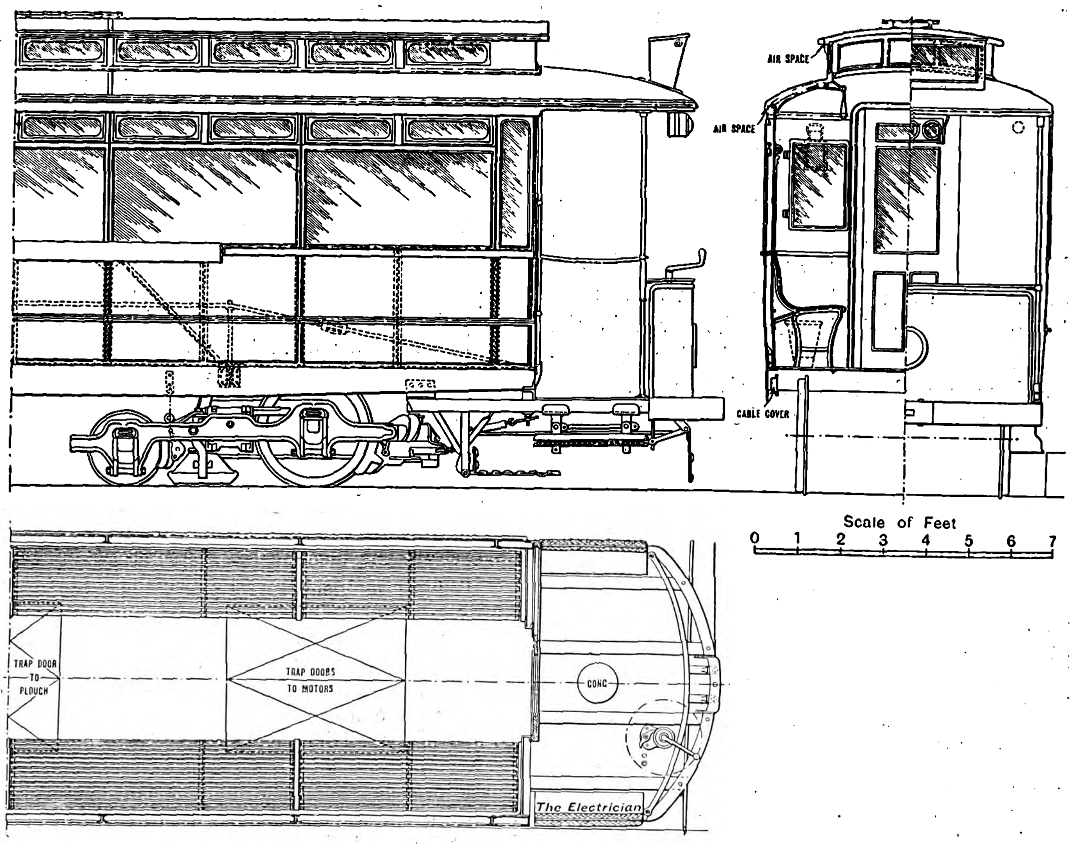

Fig. 5.—Single-Deck Steel Car used in the Kingsway Shallow-Tunnel Subway.

Sand is dropped on to the metals by depressing two foot pedals on the driver's platform, one for each side of the car. The lifeguards fitted under the platforms are of the Hudson-Bowring swinging-gate pattern, of an improved type, and come into action when the hinged tripping gear in front is pressed backwards about 3in. Folding steps are fitted to the cars, and when "up" the height of the step above the subway platforms (about 13 in.) is the same as the height of the step—when down—above the road. Passengers, therefore, step into the car from the subway platforms just as they would from the road. The cars weigh some 14 tons each. The exteriors are finished in brown and yellow similarly to the other cars on the London County Council tramway system. Special efforts have been made to use, as far as possible, the Council's standard parts and fittings, and the interchangeability thus ensured will facilitate the work of maintenance.

At present the conduit does not extend right down to the Strand end of the subway, but the latter part is equipped with running rails, and is to serve for the time being as a car depot. In order to run the cars into this temporary depot the ploughs are removed at a point where the conduit terminates (a short distance beyond the Aldwych station), and a flexible cable is plugged into the current collecting gear in place of the plough. This flexible cable emerges between the bogies at one side of the car, and leads up to a pair of wheels which run on two trolley wires, supported by suitable brackets from the side of the tunnel.

It will be remembered that the cars, after leaving the Holborn station, have to run down a gradient of 1 in 10, and to rise again to the surface at Theobald's-road on an equally severe incline. To avoid accidents on this portion of the line, the following signalling arrangements have been installed. Shortly after leaving the Holborn station en route to Theobald's-road, a projection on the car strikes a lever suspended from the roof of the tunnel, and this causes by electrical means a signal lamp in front of the Holborn station to show a red light. When the same car emerges from the tunnel at Theobald's-road it is checked by an official, who presses a button and causes the signal lamp at the Holborn station to show green. The next car may then proceed from this station.

A regular tramway service between the Aldwych station of the subway and the Angel, Islington, was commenced last Saturday at noon. The distance is some 1½ miles, and is covered in about 12 minutes.

Our thanks are due to Mr. A. L. C. Fell and Mr. Maurice Fitzmaurice for giving facilities to our representative to inspect the system, and for information embodied in this article.

## THE "PIEPER" PETROL-ELECTRIC SYSTEM OF AUTOMOBILES.

Many attempts have been made at various times to devise a satisfactory system of automobile propulsion wherein an electrical method of transmission between the engine and the road wheels replaces the somewhat crude mechanical system of sliding spur gears for three or four different gear ratios. In some cases the transmission is purely electrical, the engine simply driving a dynamo which supplies current to the motors which drive the road wheels, either with or without accumulators for storing energy when the engine is running light. The disadvantage of these systems is the excessive weight of the electrical equipment, as both the dynamo and motor have to be of sufficient size to develop the whole power of the engine. In the "Pieper" system, however, which is described in a recent number of *L'Industrie Electrique*, the number of organs is reduced and only one electric machine is employed, this serving either as dynamo or motor as required, thus considerably simplifying the construction and reducing the weight. A small battery of accumulators is carried, which supplies reserve power for starting the car and hill climbing, and also is used for starting the engine, working the ignition, lighting the lamps and other auxiliary purposes. A combined electric clutch and brake is provided, and, as will be seen from the description below, the control of the vehicle is remarkably simple. Mr. Pieper has for some years been experimenting on this system, and one of his latest carriages was shown at the Paris Exhibition last December.

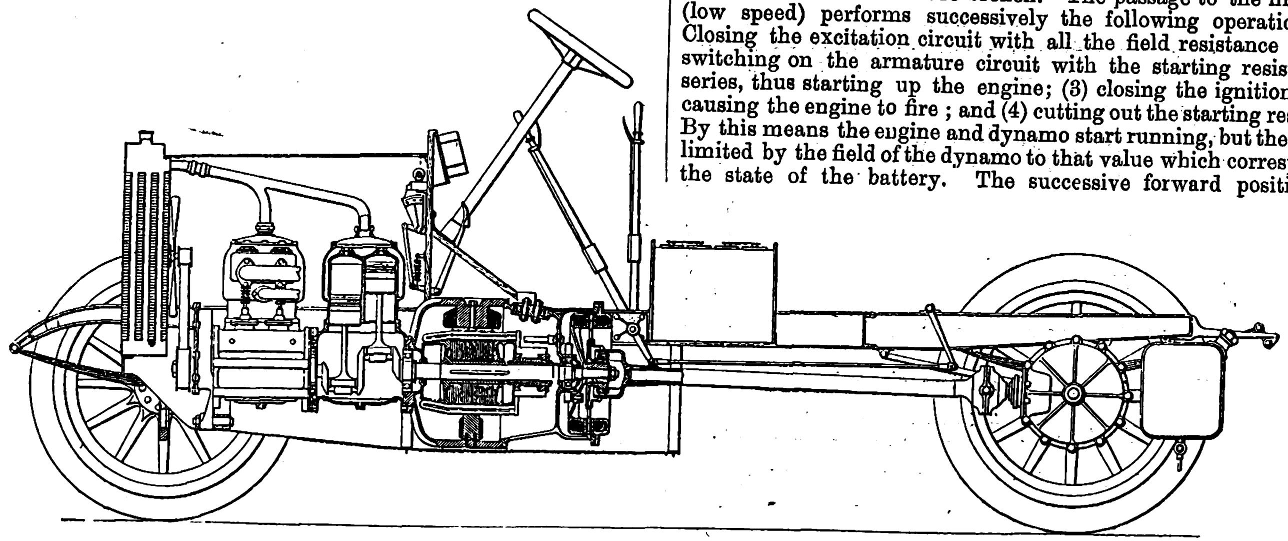

FIG. 1.—SECTIONAL ELEVATION OF CHASSIS.

A sectional elevation of the chassis is shown in Fig. 1. The engine is the usual vertical type, with four cylinders, each 10 cm. diameter by 10 cm. stroke, with mechanically operated inlet valves and low-tension ignition, with a variable self-induction in series with the breaks inside the cylinders, so that a more powerful spark is produced at the higher engine speeds, ensuring more rapid ignition. This arrangement replaces the usual system of altering the timing. Cooling is effected by radiator and fan in the ordinary way. The carburettor is of the "Longuemore" type, and the throttle is electrically governed, as explained below, so that the power developed by the engine is regulated automatically.

The engine is coupled directly to the dynamo, and the electromagnetic clutch is placed on the same shaft, and also serves as a flywheel. The clutch connects the engine and dynamo system through the usual cardan shaft to the bevel pinion which drives the differential on the live back axle. The general idea of the arrangement is that one direct gear only is provided, the extra torque required for starting and hill climbing being supplied by the electric motor drawing current from the accumulators instead of by mechanical changes of gear ratio. This is only rendered possible by the extreme flexibility of the modern petrol engine, as the variations of speed called for are very large. The advantage of not having the engine running at high speeds when starting or climbing a steep hill slowly is very great, not only on the score of quietness, but also on account of the saving in petrol consumption.

The dynamo is of the four-pole type separately excited from the battery and provided with auxiliary commutation poles in order to prevent sparking troubles when running on heavy currents with a weak field. The machine, as we have seen, acts as a motor when a large torque is called for and acts as a dynamo at all times when the full power of the engine is not required to propel the car. It can also be used as an electric brake and to drive the car backwards when required without the assistance of the engine, all these functions being controlled by variations in the strength of the field and direction of the armature current. The battery consists of 24 Tudor cells capable of discharging at 200 amperes for short periods, a large capacity is, of course, not required, so that the weight can be kept under 150 kg.

The throttle valve regulating the admission of gas from the carburettor to the engine is governed by the movement of an iron core controlled by a solenoid with a double winding. One of these windings is connected across the terminals of the battery while the other carries the main current between the dynamo and the accumulators. The tension of the spring from which the moving core is suspended is so adjusted that when the battery is well charged the engine produces just sufficient power to drive the carriage at the speed required and supply the losses in the generator and the small current necessary for ignition, excitation and auxiliaries. When the car is starting, however, or when ascending hills, the discharge current passing through the thick wire winding of the solenoid opposes the flux due to the fine wire winding and increases the admission of gas to the engine. If, on the contrary, a current in the charge direction passes through the solenoid, its action assists that of the fine wire winding and tends to close the throttle.

The whole of the speed regulation of the car is effected by the action of the combined clutch and brake pedal and the controller worked by a lever at the side, no other control levers being required. The action of the controller is as follows: In the neutral position all the circuits are broken. The passage to the first notch (low speed) performs successively the following operations: (1) Closing the excitation circuit with all the field resistance out; (2) switching on the armature circuit with the starting resistance in series, thus starting up the engine; (3) closing the ignition circuit, causing the engine to fire; and (4) cutting out the starting resistance. By this means the engine and dynamo start running, but the speed is limited by the field of the dynamo to that value which corresponds to the state of the battery. The successive forward positions put resistances into the field circuit and thereby regulate the speed at which the set runs. Each of these steps, which are 10 in number, corresponds to a speed higher than the last. In passing from one speed to another and accelerating the car, energy is taken from the battery which causes the dynamo to act as a motor and reinforce the engine until the speed reaches the value corresponding to the new field strength and a balance is attained between the battery and dynamo voltages. Conversely, in changing to a lower speed the dynamo voltage increases and sends back a charging current into the accumulators. Behind the neutral position there are three notches, the first position acts as an electric brake by short-circuiting the armature with full field. The second backward notch reverses the armature connections, and places the starting resistance in circuit, while at the same time the ignition circuit is interrupted, so that the engine and dynamo start to revolve in the reverse direction, all the power being in this case taken from the accumulators. The third backward position cuts out the starting resistance, so that the car can be driven in the reverse direction at a slow speed by actuating the clutch.

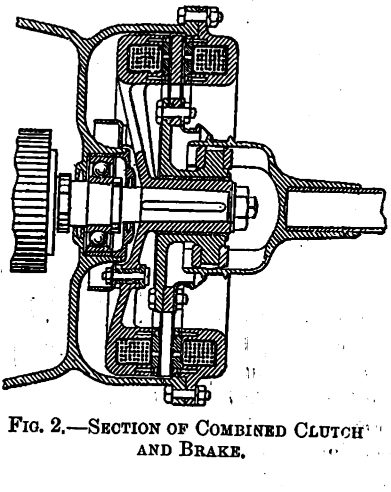

FIG. 2.—SECTION OF COMBINED CLUTCH AND BRAKE.

With the arrangement of a permanent direct drive on a high gear it is particularly necessary to have a clutch allowing a considerable amount of slip in order to avoid an undue slowing down of the engine and dynamo when starting. The electromagnetic clutch used is very smooth in action, and is combined with a most effective electromagnetic brake. A section of the clutch is shown in Fig. 2. It consists of an iron disc, mounted on the driven shaft connected to the differential, situated between two iron rings each carrying a magnetising winding, one mounted on a prolongation of the engine and dynamo shaft, and the other fixed to the frame of the car. The current in these windings is controlled by the combined clutch and brake pedal, which works a small controller and causes current to be supplied to either the fixed or moving ring, or cut it off altogether for running light. A great part of the braking can, however, be done by the main controller, so that this brake is only used for actual stopping. The pedal controller is provided with several resistance steps, so that the current can be applied gradually. A fusible cut-out is provided for the protection of the battery, and a plug is provided on the steering column by means of which the clutch current can be interrupted. A voltmeter and a centre-zero ammeter are provided, which show the state of the battery and the current passing in or out. Mechanical brakes are of course fitted to the back wheels in addition to the electric brakes.

The control of the vehicle is very simple. The engine is set running by placing the speed-control lever in the first notch and the car started by slowly releasing the clutch pedal so as to send a gradually increasing current through the clutch coils. By this means the speed of the car is brought up to that corresponding to the lowest speed of the engine, further changes in speed being obtained by manipulating the main controller alone, the clutch not having to be touched. Braking down long hills may be effected by the speed lever, and the car is stopped by means of the pedal.

The conditions under which the battery works are particularly favourable to long life, as its load consists of short discharges alternating with short periods of charge. The method can be applied to cars of all sizes, and a shunting engine working on this system to draw a 250-ton load has been ordered by the Belgian Government. In addition to the advantage of the engine being self-starting, the use of a battery renders it possible to still drive the car for a fair distance on the accumulators alone in the event of a breakdown of the engine. We understand that the British rights of the system have been acquired by Messrs. Johnson & Phillips, and that a company is being formed to place motor omnibuses and touring cars on the market in this country.

## THE "CROMPTON" ELECTRICAL PYROMETER.

The "Crompton" direct-reading pyrometer is used without any batteries, and indicates the temperature continuously on the scale, no corrections being necessary. It is of the thermo-electric type and consists of three essential parts—viz., the thermo-electric couple, the indicating instrument and the leads connecting the instrument to the couple. The thermo-electric couple is placed at the point the temperature of which is to be determined, while the indicating instrument can be placed at any convenient position, even at a reasonable distance from the couple.

When two dissimilar metals are joined together, as shown in Fig. 1, and the temperature of one joint is raised, a difference of potential is set up and a current flows in the circuit. The value of this current depends chiefly on the metals used, the resistance of the circuit and the difference in the temperatures of the two junctions. By inserting an amperemeter in the circuit the current can be measured, and after a simple series of calibrations the readings of the instrument may be used for determining the difference in the temperatures of the two junctions. For example, the junction B may be placed in a furnace or flue at a high temperature (Fig. 2), while the junction A is outside at atmospheric temperature The temperature at A being known, that of the joint B can be determined from the readings on the amperemeter.

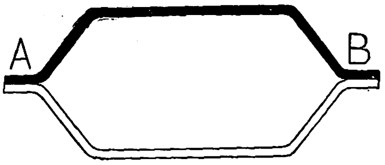

Fig. 1.—Thermo-couple.

The couple is formed by welding together at one end two rods or wires of dissimilar metals. The welded end forms the hot junction, and the other ends of these rods are provided with terminals, from which leads are taken to the indicating instrument, which forms the cold junction of the circuit. Fig. 3 is an illustration of the complete pyrometer. For temperatures up to 1,000°C. or 1,100°C. the couple is constructed of nickel and steel. A nickel rod runs down the centre of a steel tube without touching it, and at one end the two materials are welded together. At the other end terminal clamps for the connecting leads are brazed to the rod and tube. For measuring temperatures of boiler flues, superheated steam, and in other cases where the temperature does not exceed 500°C., a constantan copper couple is used. The welded end of the couple is placed at the point where the temperature is to be measured. The temperature of the rest of the couple does not materially affect the readings of the instrument.

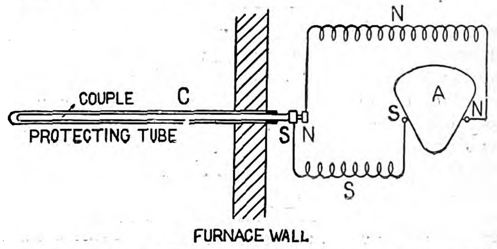

Fig. 2.—Arrangement of Pyrometer Circuits for measuring Furnace Temperatures.

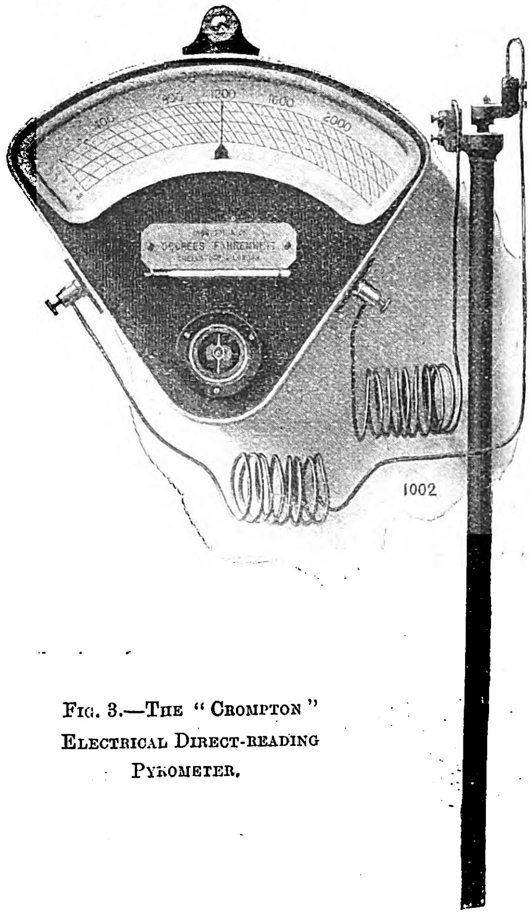

Fig. 3.—The "Crompton" Electrical Direct-reading Pyrometer.

Various designs are adopted to meet the requirements of different cases, but the following diagrammatic illustrations show a few typical forms. For measuring temperatures at various parts of a steam system, such as valve boxes, steam chests and different points of the pipe line, small wells or pockets are fixed at the points where the temperature is to be measured, as indicated in Figs. 4 and 5.

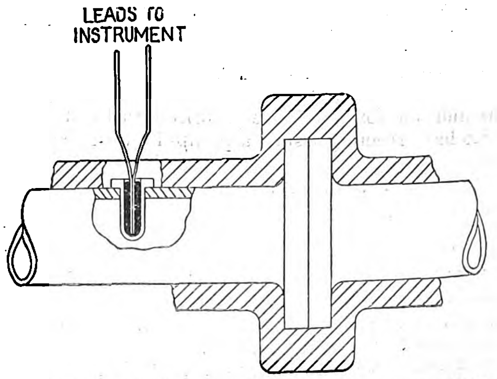

Fig. 4.—Arrangement of Thermo-couple for measuring Temperatures in Steam Pipes of Large Diameter.

In cases where the steam pipes are too small to admit of a pocket, and where there is no convenient flange joint, the couple should be fastened to the pipe and heavily lagged. The lower the temperature to which the couple is continuously subjected, the longer it will last, and copper-constantan couples, when measuring temperatures up to 500°C., are said to have a very long life. The life of the couple is considerably increased by protecting it with a renewable steel sheath or a porcelain cover, or by embedding it in a shallow trough containing silica. Platinum-wire pyrometers resist the action of the furnace gases permanently if protected by a porcelain tube, but couples of this description are costly and easily broken.

As a rule the indicating instrument is of the sector pattern and has a scale about 10 in. long (Fig. 6). A smaller instrument can be supplied for portable pyrometers and for special cases, such as the instruments used in measuring continuously the temperature of the superheated steam in a steam motor car.

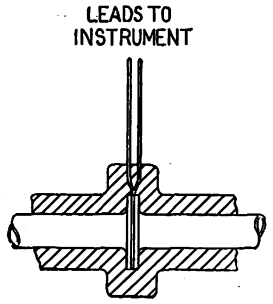

Fig. 5.—Arrangement of Thermo-couple for measuring Temperatures in Pipes of Small Diameter.

The scale of the instrument is constructed to take into account variations in the temperature of the indicator, these variations being measured by a small thermometer attached to the face of the instrument. The several arcs are calibrated for different temperatures of the indicating instrument, and the reading should be taken on that arc which corresponds with the thermometer reading. For this purpose the end of the pointer is finished to a knife edge, which crosses radially the whole depth of the scale. Since close proximity of iron may alter the readings to some extent, the instrument should not be fixed in close contact with an iron mass such as a pillar, but where possible it should be fixed to a wooden support or brick wall.

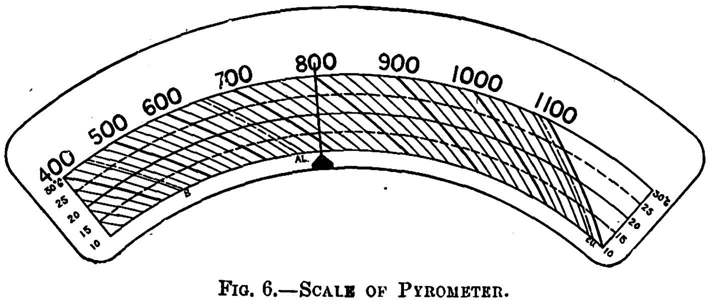

Fig. 6.—Scale of Pyrometer.

The connecting leads may be of any length within reasonable limits, and in ordinary circumstances are of the same material as the rods forming the couple. With the nickel and steel couple stout wires of nickel and steel are used; nickel wire from the nickel rod, and steel wire from the steel tube, so that the materials of the couple are continuous up to the indicating instrument. In the copper-constantan couple the connecting leads are generally of copper and constantan.

We are indebted for the above information to Messrs. Crompton & Co., who have recently issued a pamphlet on these instruments.

**Electrically-driven Boat for Dispersing Floating Ice.**—A boat has been constructed by the Niagara Falls Power Co. for the purpose of creating a surface current in the inlet canal of their station, so that floating ice may be driven towards the overflow. The boat is 25 ft. long, 10 ft. beam, with a draught of 3½ ft. Current is supplied by a trolley wire over the canal at 220 volts single-phase and a Westinghouse single-phase railway motor taking about 75 kw., and running at about 1,000 revs. per min., drives the propeller on the boat through gearing at speeds up to 275 revs. per min. The double trolley wire is 40 ft. above the water, and runs over about 400 ft. of the canal.

# CORRESPONDENCE.

## BLONDLOT'S "N" RAYS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: It would be interesting to ascertain whether anyone has been able to successfully repeat the experimental proof of the objective existence of M. Blondlot's "N" rays and their influence on an electric spark, very fully described by M. C. Gutton in *Comptes Rendus* for January 15th last and abstracted in your issue for the 2nd instant.

The writer has been at much pains to repeat M. Gutton's experiment, but in this case he has met with no more success than he has obtained in repeating M. Blondlot's own experiments, most of which he has tried with purely negative results, provided due care was taken to avoid effects caused by temperature, &c.

In M. Gutton's experiment, the effect of the "N" rays falling upon a spark in a primary circuit is stated to be a marked diminution in the brilliancy of another spark in a secondary circuit. Under these conditions one would suppose that the observed effect must be due to some change in the amount of electric energy in the secondary circuit, but the writer has ascertained that a very sensitive Duddell thermo-galvanometer, which would show a very small percentage of alteration in the amount of this energy, gives no indication of any such alteration whatever.—Yours, &c., A. A. Campbell Swinton.

Westminster, Feb. 24.

## THE EXHIBITION AT NEWCASTLE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: You have already, I think, announced in your paper that an Electrical Exhibition is to be held in the Exhibition Buildings, Newcastle-upon-Tyne, during part of the months of March and April. The opening day is fixed for March 24th, and the exhibition will run for one month.

From the support which has been given to it by the electric supply companies and the various contractors and engineering firms in this district and elsewhere the exhibition is likely to be thoroughly successful. Four first-class bands have been engaged and arrangements are well in hand for inviting the various local authorities, engineering and colliery societies to visit the exhibition.

Throughout the negotiations which have taken place between the representative electrical manufacturing companies of the country and those responsible for the management of the exhibition, it has been very marked that many firms would have been only too glad to have availed themselves of the opportunity this exhibition affords for placing their manufactures before what one may call "an electrical public," for, as is well known, nowhere else in the country has electricity been so widely adopted as in Newcastle-upon-Tyne and the surrounding districts. Apparently many of the manufacturers would have exhibited but for the ill-considered resolution, under which many of them bound themselves, which was adopted by the Manufacturers' Association. That this resolution was ill-timed and ill-advised is becoming more and more apparent.

It has been said, and truthfully said, that the reason why the gas authorities are still putting up such a good fight against their electrical foes is that they are much more businesslike and progressive. There is no doubt that gas engineering firms would never have bound themselves to refrain from exhibiting at any exhibitions of importance. Manufacturers of electrical machinery and apparatus are never likely to exhibit unless they can see some prospect of gaining advantage thereby. In their own interests and in the larger interests of the electrical industry throughout the country, they should be free to exhibit or not as they think fit.

It must be remembered that there are numerous manufacturers not affiliated to the Association who are not slow to take advantage of the absence of their more formidable competitors, whose wares, under ordinary circumstances, would be exhibited under the same roof. That this is so is exemplified in the case of the forthcoming exhibition at Newcastle-upon-Tyne, the success of which, notwithstanding the absence of some of the better known firms, is assured.

No doubt the enterprise of the firms who have not been so shortsighted as to be bound by the resolution complained of will reap its own reward.—Yours, &c.,

ARNOLD B. GRIDLEY,
Newcastle-upon-Tyne Electric Supply Co. (Ltd.)

Newcastle-upon-Tyne, Feb. 21.

## ELECTRIC ORGANS.

Messrs. Norman & Beard, the well-known organ builders, are at the present time converting the pneumatically-operated organ at Wesley's Chapel, City-road, to electric control. Hitherto the manuals in the body of the chapel were connected to the two halves of the organ in an elevated position at either side of the chapel by means of pneumatic tubing. This system, although perfectly suitable for moderate distances, introduces a disturbing interval between the pressing of a key and the action of the organ pipes if the intervening distance is as much as 120 ft., as is the case at Wesley's Chapel. It may be of interest to note that the builders had to remove during the process of conversion several tons of pneumatic tubing, most of which was of about $\frac{5}{16}$ in. outside diameter. The electric installation acts as follows: The depression of a key causes a small nickel-plated phosphor bronze bar to wedge in between two springy wire contacts of a special alloy, and an electric current, under a pressure of about 6 volts, flows through its line wire to a small horse-shoe electromagnet on the organ fixed vertically with its poles uppermost. A soft-iron disc-shaped armature is free to move between the electromagnet and the lid of the wooden compartment in which the electromagnet and the auxiliary pneumatic motor (to which reference will be made directly) are enclosed. The range of movement of the armature is only about $\frac{1}{100}$ in. As long as the key is not depressed, this miniature armature is held tight against a valve seat in the lid by the pressure of air within. But when the electromagnet is energised, the disc armature is drawn down by the magnet, and the compressed air can pass through the opening. This occasions a small pneumatic bellows to collapse, which causes the pallet to be pulled down and wind to be admitted into the organ pipe. When the key on the keyboard is released, the disc armature is pressed once more against the valve seat and the air is cut off from the pipe. The three manuals have 61 keys each, and the 183 contacts are arranged in three tiers behind the keyboards. There are 34 drawstops, of which five are electrical manual couplers and three mechanical pedal couplers. There are also 30 pedals. When a drawstop is pulled, an electromagnet is caused to act in the way described above, and the required combination of pipes comes into play. When the drawstop is pressed back again, the phosphor bronze bar makes contact with another pair of wires, another magnet is energised, and the previous state of things is restored. The coupler board for coupling the three manuals is in the basement of the chapel. It consists essentially of five long barrels with a number of radial contacts. When a manual drawstop is pulled, the corresponding barrel is rotated by electromagnetic means and the radial bars make contact with a row of springy wire contacts and the required combination is effected. A special device is provided to enable the organist to prepare his combinations beforehand, a single touch of the "stop-switch" enabling him to bring the new combination into play just when it is required. It is stated that the touch of the keys, even when the whole organ is being used coupled together, is as light as that of a piano, since all the organist has to do is to work the electrical contacts. We were afforded the opportunity of verifying this statement ourselves, and were particularly struck with the instantaneous action of the organ and the way in which it responded when the same note was struck and repeated in rapid succession.

Altogether there are 1,630 organ pipes, which are controlled by some 365 electromagnets. The electric energy required to operate an organ is surprisingly small and we were told that three or four dry cells are sufficient. As a rule, however, accumulators are preferred. The organ in question is blown by water power and the pressure in the wind chest is about 6 lbs. per square inch. But at the Leysian Mission, City-road, where an electric organ has been installed by the same firm, the wind is provided by a "Kinetic" blower (of the centrifugal type) driven at 940 revs. per min. by a 3½ H.P. 530 volt motor. An automatic starting rheostat is provided, so that the motor is simply started by cutting in the main switch, the resistances being automatically cut out as the motor speeds up.

# PARLIAMENTARY INTELLIGENCE.

## SECOND READING OF ELECTRIC POWER BILLS.

The second reading in the House of Commons of the London County Council (Electric Power) Bill and the Additional Electric Power Supply Bill has been fixed for Monday next. Mr. Pickersgill (Bethnal Green) will move the rejection of the latter measure and also the rejection of the Administrative County of London & District Electric Power Supply Bill when it comes up for second reading in the House of Commons. Mr. Summerbell (Sunderland) has given notice that he will move the rejection of the Newcastle-upon-Tyne Electric Supply Bill and the County of Durham Electric Power Supply Bill, on second reading, and Mr. Toulmin (Bury) has given a similar notice with regard to the Lancashire Electric Power Bill.

## THE WIRELESS TELEGRAPHY ACT.

Mr. SYDNEY BUXTON, the Postmaster-General, introduced a bill in the House of Commons on Monday "to continue the Wireless Telegraphy Act, 1904." The bill was read a first time. There are only two clauses and they are as follows:—

1. The Wireless Telegraphy Act, 1904, shall continue in force until Parliament otherwise determines, and sec. 6 of that act is hereby repealed.

2. This act may be cited as the Wireless Telegraphy Act, 1906, and may be cited with the Telegraph Acts, 1863 to 1904.

On Wednesday, the POSTMASTER-GENERAL moved the second reading of the bill, and in doing so said that in deference to one or two objections he proposed to insert a clause limiting the period of its duration to Dec. 31, 1912.

After a brief discussion, the second reading was agreed to.

[We refer to this matter in our Editorial columns.]

## ROYAL COMMISSION ON CANALS.

In the House of Commons on Tuesday, in answer to Mr. C. Edwards,

The CHANCELLOR OF THE EXCHEQUER stated that the formation of a Royal Commission to inquire into the working of British canals was in a forward state, and that the Prime Minister hoped soon to make the necessary arrangements for securing the King's sanction thereto.

*The Times* of Tuesday stated that it is understood that the terms of the reference to the Royal Commission on Canals now in course of constitution will be so comprehensive as to warrant the belief that the inquiry will extend over a prolonged period. In addition to weighing carefully all the arguments that may be adduced for and against the acquisition for the national benefit of the canals in the United Kingdom, the Commissioners will probably find it necessary to take evidence with regard to the disused waterways owned by railway companies, and to the possibility of resuscitating canal traffic by the employment of petrol or other power for mechanical propulsion on board the barges or for motors on the towing paths. In view of the variety of interests concerned, the Commission will be an exceptionally large one, various bodies of traders being represented upon it, as well as the railway and other carrying undertakings, the total number of its members being in all probability nearly 20. The King's sanction of its appointment is expected to be gazetted in about three weeks.

## ROYAL COMMISSION ON LONDON TRAFFIC.

In the House of Commons on Monday, in reply to a question by Sir John Dickson-Poynder,

The CHANCELLOR OF THE EXCHEQUER said it was impossible to give any undertaking as to the introduction of legislation during the present session consequent upon the recommendations contained in the report of the Royal Commission on London Traffic. The Government had not yet had time to consider the recommendations in question.

## HIGHER TECHNICAL EDUCATION.

In answer to Sir William Collins in the House of Commons on Monday,

Mr. BIRRELL (President of the Board of Education) said that the report of the Departmental Committee on the Royal College of Science and the School of Mines was receiving the careful consideration of the Board of Education. A communication was now being awaited from the Senate of London University on the subject, and for the present no more definite statement could be made.

## TRADES DISPUTES BILL.

A Trades Disputes Bill has been introduced by Sir Charles Dilke, and is supported by Mr. Keir Hardie, leader of the Labour Party. It is a private member's bill, and not the measure promised by the Government in the King's Speech. The bill contains four clauses, which are as follows:—

"1. Where an act is done in contemplation or furtherance of a trade dispute, the person doing the act shall not be liable to an action on the ground that by that act he interfered, or intended to interfere, either with the exercise by another person of his right to carry on his business, or with the establishment or continuance of contractual relations between other persons, provided that nothing in this section shall exempt such person from liability on any other ground.

"2. An agreement or combination by two or more persons to do or procure to be done any act in contemplation or furtherance of a trade dispute shall not be a ground for an action, if such act when done by one person is not a ground for an action.

"3. An action shall not be brought against a trades union, or against any person or persons representing the members of a trades union, in his or their representative capacity.

"4. It shall be lawful for any person or persons, acting either on their own behalf or on behalf of a trades union or other association of individuals, registered or unregistered, in contemplation of or during the continuance of any trade dispute, to attend for any of the following purposes at or near a house or place where a person resides, or works, or carries on his business, or happens to be—namely, (1) for the purpose of peacefully obtaining or communicating information; (2) for the purpose of peacefully persuading any person to work or to abstain from working."

## MISCELLANEOUS.

**Post Office Telephone Service.**—Mr. Nield (Ealing) has given notice of the following two questions: (1) To ask the Postmaster-General, upon what principle the official charges for the telephone service in the suburbs of London are based; and why the department are making a fixed charge of £15 per annum or thereabouts, plus message rate, for the use of a telephone in part of the northern postal district, and within six miles of Charing Cross; and whether there is any prospect of this charge being reduced, with a view to popularise the service. (2) To ask the Postmaster-General, whether he is aware that considerable dissatisfaction exists among subscribers to the Post Office telephones in connection with the working of the central exchange of the Post Office telephone system; and whether he will institute an inquiry for the purpose of ascertaining the cause of such complaints, and take steps to remedy any matter appearing to call for alteration or amendment.

**Standing Orders.**—The following Scotch Bills were partly considered for compliance with Standing Orders on Tuesday, but were postponed with the object of allowing the promoters to endeavour to secure further consents: Ardrossan, Saltcoats & District Tramways, Dunfermline & District Tramways and Falkirk & District Tramways.

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The following Bills were read a first time in the House of Lords on Monday:—Cumberland Electricity & Power Gas, Wallasey Tramways & Improvements, Buenos Ayres Grand National Tramways, County of Durham Electric Power Supply, Crediton Lighting & Power, Folkstone & District Electricity Supply, Kent Collieries Electricity Supply, Kent Electric Power, Newcastle-upon-Tyne Electric Supply, Nottinghamshire & Derbyshire Tramways, Preston, Chorley & Horwich Tramways, Shropshire, Worcestershire & Staffordshire Electric Power, South Lancashire Tramways (Extension of Time), Southport & Lytham Tramroad (Extension of Time).

The Bacup Corporation Bill and the Corporation of London (Blackfriars and other bridges) Bill were read a second time in the House of Commons on Monday.

The London County Council (General Powers) Bill and the Macclesfield & District Tramways Bill were read a second time in the House of Commons on Tuesday.

The London Outer Circle Railway Bill and the Manchester Corporation Bill were read a second time in the House of Commons on Wednesday.

The consideration of the West Yorkshire Tramways and the two Sandgate, Folkestone & Hythe Tramway Bills at this stage, has been postponed until Tuesday, March 6.

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**Petrol-Electric Car on the Delaware & Hudson Railway.**—Following the lead of the North-Eastern Railway, who some time ago experimented with a self-contained petrol-driven railway car with electric transmission, the Delaware & Hudson Railroad Co. have had a somewhat similar car constructed, which completed a trial trip from Schenectady to Saratoga on February 2nd. The power is derived from a horizontal petrol engine built in England by the Wolseley Tool & Motor Car Co., of Birmingham. The engine has six cylinders, 9 in. diameter by 10 in. stroke, and develops 160 B.H.P. at 450 revs. per min., and the peculiar plan of firing charges of black powder inside one cylinder is adopted for starting. Both high and low-tension ignition are provided. A six pole 120 kw. generator by the General Electric Co. with auxiliary commutating poles is coupled directly to the engine, and is excited by a 5½ kw. two-pole compound-wound exciter working at 110 volts and driven by a Morse silent chain. The two motors are standard G.E. 69 railway motors. Speed regulation is effected by alteration of the generator voltage by varying the excitation in addition to series parallel control. The controller is semi-automatic and can be set for any predetermined maximum acceleration. The reversing handle has five positions—namely, series ahead, parallel ahead, off, series reverse and parallel reverse. Arrangements are provided to prevent the motor connections from being changed from series to parallel until the resistance is put in the field circuit of the generator. According to the *Street Railway Journal* the trial trip was most successful. The acceleration was smooth and rapid, and a maximum speed of 40 miles per hour was attained.

# LEGAL INTELLIGENCE.

## Cooper Patent Anchor Rail Joint Co. (Ltd.) v. London County Council.

Before Mr. Justice Swinfen Eady, on Tuesday, plaintiffs claimed an injunction to restrain defendants and their agents from infringing plaintiffs' letters patent (23,578 of 1898 and 14,941 of 1899). Damages were also claimed.

Defendants in 1904 used plaintiffs' patent rail joints in the construction of the Brixton electric tramways. The validity of the patent was disputed, defendants alleging it had been anticipated by the publication of a number of British and foreign patent specifications and other publications. Defendants further said that, having regard to the published knowledge at the date of plaintiffs' patent with respect to methods of jointing rails of railways, electric tramways, &c., by bolting, riveting or welding a short length of inverted rail or T-iron to the undersides of the end of the rails to be jointed, and sinking the same in earth or concrete, no invention was required to produce the joints described in plaintiffs' claim, and that the letters patent was invalid for want of subject matter.

Mr. CRIPPS, K.C., for plaintiffs, said the invention related to a joint or method of jointing rails where a tramway or light railway was laid on a bed of concrete. In modern tramway construction the rails were laid on a bed of concrete. As soon as that method of construction became general, and more particularly after the introduction of electric cars which were of great weight and went much faster than the ordinary horse cars, one of the main difficulties was found to be how to join the rails to one another so as to get a joint satisfactory as to cost and life. It was an extremely difficult problem in tramway work, and Mr. Cooper was the first to solve it. Since Mr. Cooper's invention substantially all tramways had been laid with joints of the character described in plaintiffs' specification. The invention was one of immense utility, and removed a difficulty which had been in the way of tramway engineers for a number of years. The extensive use of the joint had led to Mr. Cooper and the company securing the advantage of a large number of royalties. Except at Swindon the present was the only instance where the right to royalty had been refused and the patent rights called in question. The London County Council had paid plaintiffs' royalties in respect of user, but after a time they thought they could upset plaintiffs' patent, and this was the reason why the present action was brought. Plaintiffs' rail joint was admirably adapted for preventing loss of electric current. The method of attachment was such that no current was lost by leakage. By fastening the piece of rail underneath the current was allowed to pass the joint without loss. In some tramways a bonding piece of copper was used, but with plaintiffs' joint the copper bond was no longer necessary. Tramways laid with plaintiffs' joint without any provision for bonding, except that obtained from the joint itself, had so far been found to work perfectly satisfactorily. Bonding, however, might be used in connection with plaintiffs' joint, but having regard to experiments and to the experience of plaintiffs they considered that the copper bonding was not necessary. The Anchor rail joint really provided a continuous rail. It combined the advantages of a welded joint without any of its disadvantages and with the addition of anchorage to the concrete underbed. The defence raised, in substance, was lack of novelty. All the American specifications which defendants relied upon, so far as he (Mr. Cripps) could see, referred to old railway construction as apart from the new tramway construction, and instead of assisting the tramway engineer they diverted his attention to the old railway method, which could not be applicable as regarded tramways laid upon concrete. With regard to the allegation of prior user, Kincaid's chair joint was not one which was applicable at all to what was required as a result of electric traction. It was a joint which was neither anchored nor rigid. In the specifications defendants relied upon there was nothing approaching the rigid anchor joint which was the subject of plaintiffs' claim. There was no greater test as to whether there was invention than that of utility. It was a strong element to find that the invention claimed provided something which was much wanted, but previously could not be obtained, and plaintiffs' invention soon came into universal use. Apart from that there was the combination applied for a new purpose and under new conditions.

Mr. JAMES SWINBURNE said he had studied plaintiffs' specifications as well as the alleged anticipations. The subject of joints at the date before plaintiffs' patent presented a problem. Plaintiffs' anchor joint solved that problem. What the inventor did was to make an exceedingly rigid joint which also had the property of being anchored down in the concrete so that it never came away and there was nothing to fall down when the car came over it. The result is that the rail becomes practically rigid. Apart from anchoring, plaintiffs also made a joint for electric railways which was a good conductor electrically. If you got a joint so strong that there was no movement between the parts it was possible to get good electrical conductivity. The irregular shape which the joint possessed was necessary for anchoring. The anchoring in the concrete was part of the invention and necessary in order to get the result. The practice of tramway engineers with reference to rails through which a current of electricity might have to be passed was to use fish plates, but fish plates did not make a good electrical contact because there was always some working between the fish plates and rails. They had a copper bond which stretched from one side to the other and made a good contact. It was flexible in itself, so it stretched when the rail stretched.

Sir ROBERT FINLAY: I may say there is no question about infringement; but we do not use this for conducting electricity at all. That we use the inverted rail at the joint there is no doubt, but we have a different system so that the electricity does not return.

As to the Anthony specification, WITNESS said that what that inventor wanted to do was to get a joint as flexible as the railway line. To make an ordinary tramway like a railway would simply smash the concrete up. Tramway engineers started by copying the railways and got into difficulties, and now the way of solving the difficulty was to depart radically from railway practice. Cooper not only anchored the joint, which was what he claimed, but he also anchored the whole rail, and that part of the invention which was not claimed was used by other people, who anchored the middle of the rail in addition. He thought the whole idea of anchoring down of the tramway joins was due to Mr. Cooper, and it was clearly expressed in the specification.

Cross-examined by Sir ROBERT FINLAY. Apart from the tram rails being at the same level as the street elasticity would be just as desirable for a tramway as for a railway, would it not?—No, because it is possible, and, in fact, easy to make the tram rails rigid. Elasticity in a railway means burning more coal. It would be better to avoid that if you could, but you cannot.

Do you say that, in your view, rigidity would be a good thing in railways themselves? Yes, I think so, if you could get it. At any rate, it would be a good thing as far as the coal bill goes.

Plaintiffs complete specification says:—"My said invention relates to the method of jointing rails for railways, tramways and the like." Where do you get in this specification anything to confine it to tramways?—A tramway means a street railway or light railway. I confine this specification to concrete tramways.

Then the novelty in plaintiffs' patent is in bedding the joint in the concrete?—Yes, the novelty is taking an old joint, if you like to put it so, and embedding it in the concrete, but you use the joint to some extent in a different way. All these joints mentioned in the defendants' particulars have been rail joints of the same mechanical principle so far as the iron goes as Cooper's, but they are working to different circumstances because there is expansion and contraction in them, and they are not supported underneath.

You agree with me that the process of anchoring supports for the rails into cement is old?—No, I do not think it is.

It is as old as De Féral?—No, his rails are very thin things at the top, and he has simply put sorts of chairs. They only go down about the depth of the setts. That is no more anchoring than the plates.

Re-examined by Mr. BOUSFIELD: Leslie's joint was not one which could be made absolutely rigid like plaintiffs'.

Mr. E. M. LACEY, M.I.C.E. (of Lacey, Sillar and Leigh) said he had advised the Corporations of Rochdale, Barry, Colchester, Batley, Belfast, Swindon and Trafford Park, with regard to their tramways, and in 1897 he was concerned with the Blackburn tramways. In the work that was done with the Blackburn tramways in 1897 they used a six-hole fish-plate on a portion of the section and the six-hole fish-plate and a sole-plate on another portion. It became necessary to relay the tramway about two or three years afterwards. In that time the tramways got into a very bad condition. Of course, the rail used was rather a light one and that had also to do with the trouble, but using heavy cars, the old form of joint, the fish-plate joint or the sole-plate joint was absolutely no good. The trouble was mainly at the joints, because at that time they were using a 45 ft. rail only, now they were often using a 60 ft. rail and they found it necessary to anchor it at intermediate places. The water action underneath the joint was the result of using only a fish plate or sole plate which gradually made a cavity. The concrete was worn away and the pumping action displaced the setts. A hammering action was also created at the point owing to the jumping of the car. The leap-frog action of the car tended to flatten the wheels and heavy costs were occasioned in maintenance. Before date of plaintiffs' specification there most decidedly was a want for a rail joint suitable for tramway work. At first he was not at all satisfied as to whether or not the anchor joint was one that would meet the difficulties. He tried it experimentally at Blackburn about 1899 or 1900, and they found it so satisfactory that they had used it ever since.

Have you in any of your works used the Cooper anchor joint alone, omitting altogether the bonding?—Yes. I had some done at Blackburn as a trial, and I found on testing that we got as good a conductivity over the rail joint as over an equal length of rail.

Were some of them actually laid down in that way without bonding?—Yes. I believe they are there now. I do not know that they have been bonded. As regards the laying down of any system of tramways he should certainly advise the use of the anchor joints.

Cross-examined by Sir ROBERT FINLAY: He did regularly dispense with copper bonding. Engineers always liked to have a good factor of safety, so he preferred to put in either a single or a double bond in addition.

Mr. JOHN NICHOLLS, Clerk of the Works to Wigan Corporation since 1888, also gave evidence for plaintiffs.

For the defence, Mr. DUGALD CLERK said he had carefully considered plaintiffs' specification and he saw nothing new in it. Looking at the patent he did not find that anchoring was part of the invention claimed or as the invention. His view was that the invention was clearly applicable first to railways and then to tramways.

It was applicable both where the rail was above the level and where the the rail was below the level. The invention had nothing whatever to do with the setting in concrete. He could hardly think of engineering construction that did not have anchoring. Leslie in his patent specified an inverted rail as one method of making a joint. It had long been known that a tramway must be a rigid construction, not because it was best for running smoothly, but because if there was not rigid construction it would throw up the roadway. Granite beds for tramways had been in use for at least ten years before date of plaintiffs' patent. Kincaid had a series of holes dug in the track, then he put in his chair and filled up with concrete, leaving room for the setts. Witness could see no novelty whatever in anchoring. Leslie, McNair and other specifications had the same object as Mr. Cooper—to produce a strong and rigid joint. Very few engineers would rely solely on plaintiffs' joint for conductivity. They tried to supplement even a copper bond. One could not be too careful with regard to conductivity in connection with tramway construction.

Mr. I. E. WINSLOW, tramway engineer, also gave evidence for defendants.

Sir ROBERT FINLAY, in summing up the case on behalf of defendants, submitted that there was no novelty in the anchoring, the point to which the patent was then reduced, and that it was not claimed in the patent. If that was the point of the patent the patentee ought to have expressed himself in very different terms. No one reading the specification would have supposed that the claim related to the form of the joint and to the superior advantages to be got from the inverted rail bolted or riveted to the rail on which the tram ran. It was impossible to treat the patent as only applicable to tramways; it was applicable to railways as well as tramways. Embedding the rail into concrete was an incidental advantage you would get in dealing with tramways, but it was not claimed in the specification. The claims were confined to the nature of the joint, the inverted piece which might be bolted, riveted, or welded to the foot of the rail. He submitted that the claim was entirely confined to the joint, which was admitted by plaintiffs' witnesses not to be novel. The case was reduced to this, that on the reading contended for by plaintiffs the patentee only pointed out one process for carrying out Leslie's patent. On the other part of the case he asked his lordship to say that there was no novelty in anchoring in concrete.

Mr. CRIPPS, K.C., replied, and his lordship reserved judgment.

## Fox v. Birmingham Corporation.

At Birmingham County Court on Thursday last Thomas Fox, labourer, applied to Judge Bray for compensation under the Workmen's Compensation Act for injuries alleged to have been caused whilst doing work in defendants' service in connection with the construction of a tramway. The construction work had been carried out by Messrs. Wm. Griffiths & Co. prior to the accident, which occurred while applicant was engaged in levelling up the road. For defendants it was submitted that applicant was not engaged in employment to which the act referred; he was not in the employ of the firm undertaking the engineering work, and the tramways had been completed.

His HONOUR said the expression "engineering work" indicated a physical area on, in or about which the workman must be employed in order that the case might come under the act. Where applicant was employed was not within such a physical area, and levelling-up work was independent of the work of construction. He was not, therefore, entitled to compensation.

## J. Defries & Sons (Ltd.) and the Helios Mfg. Co. v. the Electric & Ordnance Accessories Co. (Ltd.)

This case came before Mr. Justice Joyce in the Chancery Division yesterday.

Mr. Younger, K.C., and Mr. J. D. Israel, appeared for the plaintiff, and Mr. A. J. Walter and Mr. J. C. Gray for the defendants.

Mr. YOUNGER, K.C., in opening the case, said it was an action brought by plaintiffs for an injunction to restrain defendants from selling and passing off arc lamps under the name of "Stewart Arc Lamps" without properly distinguishing, and the case was somewhat peculiar in its facts, and raised one or two interesting questions of law.

Counsel proceeded to outline the case, and was addressing the Court when the hearing was adjourned.

[A full report of this action will appear in our next issue.]

# MUNICIPAL, FOREIGN & GENERAL NOTES.

## APPOINTMENTS VACANT AND FILLED.

The Cambridge Scientific Instrument Co., Carlyle-road, Cambridge, require a good mechanic accustomed to suspending delicate galvanometers; also a junior test-room assistant to assist in the manufacture and adjustment of electrical instruments. See advertisements.

London County Council require an electrical and mechanical engineer and an assistant electrical engineer to be responsible, under the chief officer of the Fire Brigade, for matters connected with electric lighting and heating at places of entertainment. The salaries are £400 and £200 a year respectively. Applications by 10 a.m. March 12.

Ferranti Limited, Hollinwood, Lancs., require a first-class draughtsman, accustomed to l.t. and h.t. switch-gear work. See an advertisement.

A chief of test room is required, up to date in testing of three-phase direct-current machinery. See an advertisement.

A telegraph operator is wanted for wireless telegraph installation, expert in reading by sound and European and American Morse. Applications to Messrs. Abel & Imray, Birkbeck Bank chambers, Holborn, London, W.C. See an advertisement.

Barking District Council require a meter superintendent inspector. Applications by noon March 8.

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Southend Council have appointed Mr. G. Parry, West Ham, charge engineer at £3 per week, and Mr. A. Wiseman, Southend, as switchboard attendant.

Mr. E. Fenton, of York, has been appointed, at a salary of £100 per annum, assistant electrical engineer at Bridlington Corporation electricity works, in succession to Mr. Simpson. There were 180 applicants.

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**Beckenham.**—The salary of the electrical engineer (Mr. J. E. Tapper) has been fixed at £275 per annum as from Nov. 22 last.

**Blackrock (Ireland).**—Last week the Council decided to entertain a proposal to form a syndicate to take over the Council's provisional order of 1901 and to undertake the supply of electricity in the district.

**Bradford.**—At the meeting of the Electricity committee on Friday last, the electrical engineer (Mr. A. S. Blackman) submitted a return as to "motors and arc lamps let on hire at March 31, 1905." This scheme was inaugurated in Nov., 1896, but depreciation was allowed for the first time for the year ended March 31, 1903, and since that date depreciation has been regularly allowed. Particulars are as follows:—

| | | *Motors.* | *Arc Lamps.* |
|---|---|---|---|
| On the supply and in stock | | £44,305 7 9 | £2,569 3 9 |
| In use at works | | 1,355 10 10 | 427 8 7 |
| Original cost | | £45,660 18 7 | £2,996 12 4 |
| Less depreciation, viz.:— | | | |
| Year to March 31, 1903 .. | £2,507 7 3 | | |
| Do. 1904 .. | 2,701 17 2 | | |
| Do. 1905 .. | 2,739 13 1 | | |
| | | £7,948 17 6 | |
| Net cost | | £37,712 1 1 | |
| Stock of tools, fittings and accessories | | 677 2 2 | |
| Less depreciation, viz.:— | | | |
| Year to March 31, 1903 .. | £248 13 5 | | |
| Do. 1904 .. | 295 15 5 | | |
| Do. 1905 .. | 299 13 3 | | |
| | | | £844 2 1 |
| Net cost | | | £2,152 10 3 |
| Stock of tools, fittings and accessories | | | £86 18 11 |
| Total | | £38,389 3 3 | £2,239 9 2 |
| Engineer's valuation at March, 1905 | | £30,441 0 0 | £1,498 0 0 |

The receipts of the electricity department for the past year were £94,958 and the working expenses £45,022, leaving gross profit £49,936, the net profit being £8,710.

**Callender's Cable Works in Germany.**—A number of statements have appeared as to the probability of Callender's Cable & Construction Co. (Ltd.) establishing works in Germany for the manufacture of Callender cables. The report (which is, however, unconfirmed) further states that if works are established in Germany, the company's fine works at Erith will be unaffected.

**Cambridge.**—The Paving, Drainage and Lighting committee having recommended that consent be given to the National Telephone Co.'s application to lay their wires underground in the borough, on condition that the company pay the Corporation a rent of 1½d. per yard per annum until September, 1908, and 2d. per yard from that date until the termination of the agreement (January, 1912), the recommendation has been adopted by the Council.

**Chile.**—A concession has been granted to the Tabolan Electric Co. for the supply of electricity for lighting and power in the towns of San Francisco de Limache and Limache.

**Croydon.**—The proposal to appoint Mr. T. B. Goodyer, general manager for the present lessees of the tramways (the British Electric Traction Co.) as general manager of the Corporation tramways at £600 per annum was further discussed by the Council on Monday. It was ultimately decided to refer the whole question back, with instructions to bring up a complete report as to the management of the tramways.

**Customs Decisions.**—The customs authorities of the Argentine Republic have decided that, amongst articles admitted free of duty, the following shall be included: Rails of iron or steel, ties of iron, couplings for railways and steam or electric tramways and plant destined for the installation of electric tramways and electric traction (including cars and motors, cables, trolleys, wire reels, brakes, wheel tyres, lightning conductors, fuse boxes, springs, insulators, controllers, wheels, rosettes, intersections and switches).

Under the new import duties levied on goods entering British India electrical, electric lighting, galvanic and telephonic instruments are subject to a duty of 5 per cent. ad val.

**Dartford.**—The Council have reduced the price of current for power to 1½d. per unit where the demand exceeds 15,000 units per annum.

**Dundee.**—The Corporation contemplate the promotion of a provisional order to authorise (inter alia) the construction of two new tramway routes. It is also proposed to obtain authority to run motor vehicles as feeders of the tramway system.

The Tramway committee have decided to recommend the Council to acquiesce in a proposal made by the Dundee & Broughty Ferry Tramway Co. in regard to certain division of fares over the combined routes of the Council and the company, and that the same conductors and drivers shall be in charge of the respective cars from end to end of the route.

**Electric Launches.**—Cardiff Parks Committee have decided to purchase an electric launch, 30 ft. in length and capable of carrying about 40 passengers, for use on Roath Lake.

**Electric Traction in Switzerland.**—A concession has been granted to a syndicate, including M. J. E. Dunand, of Geneva, for an electric tramway from Versoix to the Sauverny Bridge on the French frontier. The estimated cost of the tramway, which is to be a single line of 1 metre gauge and 5·2 km. in length, is £38,000, of which £7,900 will be for rolling stock.

**Electrolytic Refining of Lead.**—Messrs. Locke, Blackett & Co., Newcastle-on-Tyne, have decided to adopt the Heroult electrolytic method of refining lead. The fact that electric energy can be obtained at a very low rate in Newcastle has induced Messrs. Locke, Blackett & Co. to adopt the process.

**Exeter.**—The Electric Lighting committee recommend the Council to apply for sanction to borrow £15,500 for extension of mains.

**Falmouth.**—The erection of the electricity works has been commenced.

**Faversham.**—The salary of the electrical engineer (Mr. G. Somerville) has been increased to £200 per annum.

**Great Eastern Railway.**—The directors are considering the question of running an electric motor train between Clacton, Frinton and Walton.

**Harwood (Lancs.)**—The Board of Trade propose to remove the Rishton, Great Harwood and Clayton-le-Moors electric lighting order.

**Heywood.**—The Corporation's electric tramways, which will form a link in the projected tramway route from Halifax to Liverpool, were officially inspected yesterday (Thursday).

**Hoylake and West Kirby.**—The salary of the electrical engineer (Mr. H. G. McHaffie) has been increased to £320 per annum.

**Islington (London).**—This evening the Council will further consider the recommendation by the Lighting committee to supersede 714 incandescent gas lamps in 15 miles of street by 245 flame arc lamps at an estimated cost of £21,011.

**Italy.**—The Italian Electric Tramways Union have been authorised by the Italian Government to construct and work an electric tramway between San Martino d'Albaro and Borgoratti.

**Jerusalem.**—It is reported that the Sultan has granted an electric lighting concession for this city and for the construction of electric tramways through the city to Bethlehem, Bethany and probably to Jericho.

**Lancaster.**—A special Council meeting is to be held to consider a recommendation to reject the proposal to lease the electric lines in the borough to a company, but to give facilities to the company for acquiring the horse tramway and so end the difficulty as to carrying the municipal tramways to Skerton.

**Leicester.**—The Chairman of the Tramways committee (Councillor Flint) stated at the Council meeting on Tuesday that during 1905 the tramways carried nearly 26,000,000 passengers, the total receipts being £109,540.

Working expenses were £63,827, and of the balance (£45,712) £21,826 had been paid as interest, £12. 1s. 7d. as income-tax, and £10,661 as sinking fund, leaving £14,063, which they purposed putting to reserve. Councillor Flint said he had no objection to create a depreciation fund, but the time had not come yet for that. What they wished to do was to lay by all their profits until they had a reserve equal to any emergency which might arise. If, after they had a reserve of £100,000, the committee desired to dispose of the profits in any other way, it would be for the Council to say what that should be. Since they had altered their system of instruction of motormen they had had fewer accidents. They had put down new automatic points, which would be a saving, and their power costs were the lowest in the kingdom with the exception of Leeds and Huddersfield. They had confidence in their manager and also in their electrical engineer. With regard to the proposed increase in the salary of their manager, Mr. Lucas received £350 when they took over the tramways five years ago, and it was now proposed to increase it to £400. The duties of the office had greatly increased and the salary was the lowest in the kingdom, having regard to the undertaking.

Several members congratulated the committee, the electrical engineer, and the manager upon the successful working of the undertaking. The report was then adopted.

**Light Railways.**—The Board of Trade have confirmed the Ryhope, Seaham, Murton and South Hetton Light Railways Order, 1906.

The Light Railway Commissioners held an inquiry on Thursday last at Middlesbrough into the application for an order authorising the construction of the Middlesbrough and West Hartlepool light railway and a transporter bridge over the river Tees.

The engineer (Mr. G. G. Eady) said the proposed light railway would be 7½ miles in length, and the novel feature of the scheme was the bridge. The line would be of 3 ft. 6 in. gauge and single-deck cars would be used. The span of the conveyor bridge would be 500 ft. and the conveyor carriage would accommodate 600 passengers on a single journey.

The Chairman of the Commissioners said Middlesbrough Corporation (who own a ferry and opposed the scheme on this ground) had no monopoly in regard to a ferry, and so far as local evidence was concerned the Commissioners were satisfied on this point. Unless, however, the promoters came to terms with Middlesbrough Corporation in the meanwhile, the Commissioners would sit in London next month to hear engineering evidence on behalf of the Corporation.

The Board of Trade have granted an extension of one month (from Feb. 23) to permit of the negotiations being completed for the construction of the Llandudno & Colwyn Bay Light Railway. Messrs. Bruce Peebles & Co. have entered into a provisional agreement to take over and complete the line.

The Light Railway Commissioners will grant an order for the construction of the Clayton West and Darton light railway, referred to in our last issue.

**Llanelly.**—The South Wales Electrical Power Distribution Co. have paid the Council £1,000 in accordance with the terms of the agreement as a contribution towards the costs incurred by the Council in obtaining their provisional order, &c. The Corporation have sought the advice of the Local Government Board as to the allocation of this money, and have now asked that taxed bills of all the cost be forwarded to them.

**London County Council.**—At Tuesday's weekly meeting the Highway's committee submitted a report dealing with the organisation of the Council's tramway staff.

In view of the agreement with the North Metropolitan Tramways Co., which was to come into effect on April 1, the committee had considered a report by the chief officer of the tramways. Dealing first with the North Metropolitan tramways, the committee stated that the total amount of the present salaries of the officials of the company (apart from the employés) whom it was suggested should be temporarily engaged by the Council was £8,000. It was not proposed to transfer the services of the managing director, the consulting engineer and certain other officials. There were, however, certain new posts of a permanent character which it was considered it would be desirable to create in connection with the electrification of the lines, as experience had shown in the case of the southern tramways that it was desirable that the work from its inception should be under the direct supervision of the officials who would afterwards be responsible under the chief officer for the working of the system. The posts, for which it was suggested that applications should at once be invited by public advertisement, were as follows: One resident electrical superintendent for the Council's northern tramways, proposed salary £300 a year, rising by two annual instalments of £25 to £350 a year; one district traffic superintendent at £300 a year, rising to £350; one assistant rolling-stock superintendent at £250 a year; and one permanent-way engineer at £250 a year. To provide the chief officer of tramways with additional assistance of a general character, the committee recommended that Mr. Farquharson, general secretary of the North Metropolitan Tramways Co., be appointed general assistant in the department at a salary of £400 a year, rising to £500. Agreed.

The committee further recommended the following increases of salaries in the tramways department: Mr. J. H. Rider, electrical engineer, from £1,000 to £1,100 a year on April 1, 1906, and to £1,200 a year on April 1, 1907: Mr. J. K. Bruce, traffic manager, from £800 to £850 a year on April 1, 1906; Mr. J. Shepherd, assistant electrical engineer, from £500 to £550 a year on April 1, 1906, and to £600 a year on April 1, 1907. Mr. C. R. Johnson to be district traffic superintendent, and his salary to be increased from £250 to £265 a year; Mr. G. Dickens, superintendent of stores, from £220 to £235 a year; Mr. J. Terry, to be assistant district traffic superintendent, and his salary increased from £185 to £200 a year; Mr. W. J. Crane, clerk, from £150 to £160 a year; and Mr. J. Brown, traffic time-table clerk, from £145 to £155 a year.—Consideration of these recommendations postponed.

**Lucan-Leixlip Tramway.**—On Friday last the Judicial Committee of the Privy Council made a provisional order for the construction of this line (1 mile in length), which will practically be an extension of the Dublin and Lucan tramway. It is proposed to form a company with a capital of £3,000 to carry out the construction work and the electrical equipment.

**Malta.**—In 1904-5 the total number of units generated at the Government electricity works was 1,111,174, against 1,062,744 in the previous year. There was a saving in 1904-5 of 1·57 lb. of coal per unit compared with 1903-4. The revenue was £17,020 in 1904-5 compared with £17,121 in the previous year, a decrease of over £100. Working expenses (including interest on capital, reserve fund, &c.) amounted to £12,654. The total capital expenditure at March 31, 1905, was £62,943.

**Marylebone (London).**—Customers who so desire are to be charged for current upon the following provisional scale: Ordinary lighting 8d. for 500 hours on maximum demand and 1d. after; power 2d. and 1d; basement lighting 2d.

**Motor Omnibuses and Garage Lighting.**—The car house (accommodating 150 double-deck vehicles) and yard of the London Power Omnibus Co. at Cricklewood are lighted electrically, as are also the vehicles themselves, the batteries for lighting and ignition being charged at a station on the company's premises.

**Municipal Telephony.**—Swansea Telephone committee held a meeting last week to discuss the offer of the Government to take over the Corporation Telephone system. It was decided to confer with Brighton and Portsmouth municipalities, who have received similar offers.

The general manager of the Glasgow municipal telephone department (Mr. J. Macfee) recently submitted to the Telephone committee a statement showing that £690 had been expended in connection with the representations made and the evidence given on behalf of the Corporation before the Select Committee of the House of Commons which considered the agreement between the Postmaster-General and the National Telephone Co. for the purchase of the Company's undertaking. As the action taken was in the interests of the community, the committee are of the opinion that the expenditure should be paid by the Corporation out of the Common Good.

**Obituary.**—Mr. Ernest Tumber, electrical engineer, Thirsk, died on Friday, at the early age of 27 years.

**Ossett (Yorks.)**—An inquiry was held on Tuesday into the Council's application for sanction to borrow £3,500 for electricity supply.

It was stated that it was proposed to put down a small plant at the destructor works in order to utilise the steam of the refuse destructor.

The question of obtaining a bulk supply having been raised by the inspector (Mr. M. K. North), the consulting electrical engineer (Mr. W. Emmott) stated that he had gone into the matter, and he had a quotation from the Yorkshire Electric Power Co., but there was a difference of only £15 between purchase in bulk and generation by the Corporation. The greater the consumption, however, the greater was the advantage in favour of generation by the Council.

**Personal.**—Mr. J. Archibald Kyle, A.I.E.E., has taken up a position with the Westminster Electric Supply Corpn. as from March 1.

**Plymouth.**—An inquiry was held here on Wednesday into the application of the Council for permission to borrow £3,000 for electric lighting extensions.

**Poplar.**—The borough electrical engineer (Mr. J. Horace Bowden) recently recommended the installation of coal-handling plant, at an estimated cost of £3,000.

It is of the utmost importance (reports Mr. Bowden) that the cost of production should be cut down. The current year's costs showed that coal had been reduced from 0·47d. to 0·4d. which was the greatest reduction in any one year. With overhead coal bunkers the coal per unit generated could, he believed, be lessened from 4·5 lb. to 4 lb. 30 tons were at present used per day and the coal was handled no less than four times. He estimates the saving to be effected at £155 per annum.

The Council have adopted the scheme.

During the last three months there has been connected for power supply 153·7 kw., making a total for the last nine months of 383·8 kw.

Application is to be made for a loan of £5,927 for the electricity undertaking.

**Presentations.**—A service of plate has been presented by the Sussex staff of the National Telephone Co. to Mr. F. W. Taylor, district manager for Sussex.

The Royal Humane Society's certificate has been presented to Mr. R. C. Leslie, of the electrical staff of the Lancashire Electric Power Co., for saving a drowning bather at Grassington in June last.

**Pudsey.**—A committee has been appointed to confer with the Yorkshire Electric Power Co., who have offered to light the public lamps at a cost not exceeding the present cost of gas.

**Romford.**—The Council have resolved to oppose the Romford & District Tramways Co.'s bill.

**St. Petersburg Tramways.**—The Westinghouse Electric Co., of Pittsburg, have secured a contract from the town council for conversion of the tramways in the city to electric traction at a cost of 3,359,677 roubles, of which 1,802,438 roubles is for reconstruction of roadways and laying a track, and 1,133,045 roubles for rolling stock and electrical equipment.

**Stoke-on-Trent.**—From April 1 the charge for electric energy for power and heating is to be 1½d. per unit up to 7,000 units per annum, 1¼d. up to 15,000 and 1d. beyond.

On the recommendation of the electrical engineer (Mr. P. J. S. Tiddeman) application is to be made for sanction to borrow £5,748 for additional plant for the electricity works, including steam generator (£1,950), condensing plant (£630), thermal storage (£534), piping and covering (£250), feeder, booster and balancer (£320), switching apparatus (£110), sundries (£100), foundations, &c. (£200), 5 per cent. for contingencies (£205), overspent on last loan (£449) and mains, services and meters (£1,000).

**Sunderland.**—An inquiry will be held here on Wednesday into the application of the Council for permission to borrow £18,000 for electric lighting extensions.

**Telegraphic Communication in Italy.**—A new direct telegraph service is to be put in hand forthwith between Naples and Turin and Naples and Reggio (Calabria).

**Train Lighting, &c.**.—Three new Pulman cars built at the L.B. & S.C. railway shops are lighted electrically on the Stone system, each car being fitted with four central electroliers and a small bracket over each window. The cars are also fitted with electric fans.

**Tramcar Speeds in London**—The Board of Trade have notified the London County Council that they are prepared to approve alterations in speed over certain sections of the Greenwich (via Old Kent road) tramway route. 16 miles an hour is to be permitted on one section and 12 miles on another. Increases of speed on other sections of this line will probably be authorised after certain road widenings have been effected.

**West Ham.**—With the consent of the Board of Trade the total sum to be borrowed for tramways under sec. 73 of the Corporation's Act of 1900 has been increased from £154,240 to £184,740. The additional sum is required to complete the original scheme.

**West Yorkshire Tramways.**—Brighouse Corporation have decided to support the West Yorkshire Tramways Co.'s bill authorising the construction of electric tramways between Halifax and Huddersfield, via Elland, Rastrick and Brighouse.

**Dinner.**—The second annual dinner of the Faraday House Old Students' Association will take place at the Florence Restaurant, Rupert-street, W., on March 9, with the president (Mr. C. D. Taite, borough electrical engineer of Salford) in the chair.

## TRADE NOTES AND NOTICES.

### NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1906 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is even more complete and accurate than in previous issues, and has been revised up to Feb. 12, 1906. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Traders' purposes. The valuable large sheet Tables, &c., have been very carefully revised and extended, making the 1906 Edition of this indispensable work the most complete book of the kind ever published.

A full Digest of Contents will be sent post free on request.

### TENDERS INVITED.

*Briton Ferry* Urban District Council invite tenders for supply, delivery, erection and laying of sub-station switchboard, non-rubber feeder and distributor cables, feeder pillars, joint boxes, arc standards, arc lamps, &c. Specifications (with general conditions, &c.) may be inspected after the 5th inst. at the offices of the consulting engineers (Messrs. Herbert Lewis & Fletcher), Prudential-buildings, Cardiff. Tenders to the clerk (Mr. Trevor H. Hunter), Council Offices, Briton Ferry, Glam., by noon, March 26. See also an advertisement,

*Fulham* (London) Council invite tenders for supply of general stores (including engineering goods, packings, jointings, &c., tools, castings, cables, incandescent and other lamps, carbons, street lighting goods, &c., oils, paints, brooms, brushes, &c.) for year ending March 31, 1907. Tenders (on printed forms) to the Town Hall, Fulham, S.W., by 4 p.m., March 14. See also an advertisement,

*St. Marylebone* (London) Borough Council invite tenders for supply and delivery of stores for 12 months, including engine room stores, cables and cable-jointing material. Conditions, &c., from the resident electrical engineer (Mr. F. A. Wilkinson), 11, Manchester-street, W. Tenders to the town clerk (Mr. Jas. Wilson), Town Hall, Marylebone-lane, W., before 4 p m. March 14. See also an advertisement.

*Greenock* Corporation invite tenders for supply and delivery of two d.c. steam generators of 750 kw. each and one 500 kw. d.c. motor generator. Specifications from the burgh electrical engineer (Mr. James A. Robertson), Municipal Buildings, Greenock. Tenders to the town clerk (Mr. C. MacCulloch), Municipal Buildings, Greenock, by midday March 15. See also an advertisement.

*Bristol* Corporation want tenders from manufacturers for direct and alternating-current motors for letting out on hire. Particulars from the city electrical engineer (Mr. H. Faraday Proctor), Temple Back, Bristol. See an advertisement.

*Belfast* Tramways and Electricity committee invite tenders for one 400 kw. steam dynamo. Specification from the city electrical engineer, Mr. Victor A. H. McCowen. Tenders to the town clerk (Sir Samuel Black), Town Hall, Belfast, by 11 a.m. March 19. See also an advertisement.

*Dublin* Corporation invite tenders for supply of arc lamp carbons. Specifications, &c., from the city electrical engineer (Mr. Mark Ruddle), City Hall. Tenders to the town clerk (Mr. Henry Campbell) by noon March 9. See also an advertisement.

*Torquay* Electric Lighting committee invite tenders for supply of 1,500 to 2,500 tons of smokeless thro' steam coal. Specifications, &c., from the town clerk (Mr. Frederick S. Hex), to whom tenders by noon March 19. See an advertisement.

*Manchester* Tramways committee invite tenders for the supply of various stores, including motor parts and accessories, controllers, resistances, fuses, switches, trolley poles, arc and incandescent lamps, telephones, lighting material and bells, insulating material, carbon brushes and carbons, cable, copper, brass and steel wire, overhead line material, oils, lubricants, lamp glasses, globes, porcelain and brown ware insulators, crucibles, rubber goloshes, gloves, &c. Tenders to chairman of Tramways committee by 1 p.m. March 3.

*Leeds* Electricity committee invite tenders for one or two sets of electric generating and condensing plant, each comprising a steam turbine, two-phase alternator and exciter of 3,000 kw. capacity, electrically-driven surface-condensing plant, and the necessary pipes and valves. Preference will be given to tenders for plant of British manufacture. Tenders to town clerk (Mr. Robert E. Fox) by 10 a.m. April 9.

*Leeds* Tramways committee want tenders by March 12 for 12 months' supply of electrical sundries, ironmongery, iron and steel, castings, oils, engineers' furnishings, coals, &c.

The *Great Central Railway Co.* invite tenders for supply, during 12 months, of various stores and materials, including telegraph materials, asbestos, &c., packing, brass sheets and tubing, glass, hardware, indiarubber, iron and other metals, screws, signal materials, &c. Tenders to the secretary (Mr. Oliver S. Holt), Marylebone station, London, N.W., by 10 a.m. March 6.

The Asylums committee of *London County Council* invite tenders for the installation of electric lighting and power (including generating plant) at Long Grove Asylum, Epsom. Tenders to the offices of the committee, 6, Waterloo-place, London, S.W., by March 26.

*Shoreditch* (London) Borough Council invite tenders for stores for one year ending March 31, 1907, including electric cables and sundries, gas pipe and fittings, and engineers' stores. Tenders to town clerk (Dr. H. Mansfield Robinson), Town Hall, Old-street, E.C., by 3 p.m. March 13.

*Barnes* Urban District Council invite tenders for supply, delivery and erection of one straight-tube type water-tube boiler, surface condenser, feed pump and pipe work. Tenders to the Clerk, Council House, High-street, Mortlake, by March 12.

*Edinburgh* Corporation invite tenders for stores for 12 months from May 16, 1906, including arc lamp carbons, cast-iron pavement boxes and pipes, electricity meters house service fuse boxes and bitumen. Tenders to the town clerk (Mr. T. Hunter, W.S.) by March 12.

*Erith* District Council want tenders by 10 a.m. 12th inst. for six months' supply of stores for the electricity department, including carbons, meters, lamps, cables, joint boxes, motors, &c.

*Swindon* Corporation want tenders by noon March 12 for 12 months' supply of electrical and tramway equipment accessories, fuse and service boxes, incandescent lamps, cables, meters, &c.

*Huddersfield* Tramways committee want tenders by 10 a.m. March 9 for supply of steam engine and piping, 750 kw. traction generator, switchboard extension, cables, &c.

*Halifax* Tramways and Electricity committee want tenders by March 12 for 12 months' supply of smudge coal and slack.

*Middleton* Corporation invite tenders for about 1,000 yds. of distributor cable. Tenders by March 13.

Tenders will be received up to 30th April by the Director-General of Ports and Lighthouses, Cairo, for supply and erection of an electric lighting installation on board H.H.S. "Aida," at Alexandria. Conditions of tender and specification at Central Office, Ports and Lighthouses Administration, Cairo. The plant is to consist of direct-coupled generating set, switchboard, instruments, fittings and accessories.

The *East Indian Railway Co.* (Nicholas-lane, London, E.C.) want tenders by noon March 7 for electrical equipment for transformer house.

## TENDERS RECEIVED AND ACCEPTED.

London County Council have accepted the tender of Edmundson's Electricity Corpn. at £5,565 for extending and making additions to the generating plant at the electricity supply station of Longgrove Asylum.

The following tenders for the reconstruction of about 22½ miles of single tramway track from Shoreditch to Stamford-hill, and from Bloomsbury to Poplar, were submitted to London County Council on Tuesday:—

*Shoreditch to Stamford-hill route.*

| | | | |
|---|---|---|---|
| J. G. White & Co. | £141,399 | 6 | 9 |
| Robert W. Blackwell & Co. | 147,887 | 5 | 5 |
| John Mowlem & Co. | 147,717 | 0 | 0 |
| William Griffiths & Co. | 145,501 | 9 | 2 |
| Dick Kerr & Co. | 143,105 | 6 | 0 |
| Engineer's estimate | 135,980 | 9 | 9 |

*Bloomsbury and Poplar route.*

| | | | |
|---|---|---|---|
| Dick Kerr & Co. | £238,045 | 12 | 8 |
| John Mowlem & Co. | 243,190 | 10 | 0 |
| William Griffiths & Co. | 242,425 | 12 | 8 |
| J. G. White & Co. | 239,995 | 5 | 6 |
| Engineer's estimate | 226,831 | 18 | 8 |

The lowest tender in each case was recommended for acceptance, with liberty to sub-contract as follows: J. G. White & Co. to sublet to the Lorain Steel Co. the manufacture of the special work (consisting of points, crossings, &c.), Anderston Foundry Co. the manufacture of yokes and castings, and the Associated Portland Cement Manufacturers for cement.

Messrs. Dick, Kerr & Co. to Hadfield's Steel Foundry Co. the manufacture of the special work (consisting of points, crossings, &c.), Anderston Foundry Co. the manufacture of the yokes and castings, Doulton & Co. the manufacture of insulators, Bayliss, Jones & Bayliss the manufacture of the tie-bars, &c., and to the Associated Portland Cement Manufacturers the supply of cement.

The consideration of the tenders was postponed for a week.

The "Australian Mining Standard" states that the Postmaster-General (Sydney) has accepted the following tenders:—

British Insulated & Helsby Cables for hard-drawn copper wire, insulated wire, office wire, c.c. paraffined wire and cord for switchboards; the India Rubber, Gutta Percha & Telegraph Works Co. for porcelain insulators, Leclanché porous pots, chemicals for batteries, steel staples and fuse wire; Siemens Bros. & Co. for soldering solution in bottles; Lawrence & Hanson for indiarubber-covered wire, iron shackles, battery zincs and leads, office wire, bells, switches, telephone diaphragms, receiver cords, cords for switchboards, terminals, battery boxes, fuses, &c.; Rabone, Feez & Co., for galvanised iron and galvanised steel wire, seven-wire galvanised steel cable, double flexible cord and cross-connecting wire; Noyes Bros. for galvanised iron telegraph wire; J. A. Newton & Co. for insulated copper wire and metallic return lead-cased telephone cable; Zwicker, Todd & Co. for porcelain insulators, screws and Leclanché zincs; F. G. King for iron bracket and top pins; Federal Flint Glass & Bottle Works Co. for battery cells, cups and balloons; S. Zollner for battery zincs; J. W. Broomhead & Sons for battery coppers and battery suspenders; H. C. Martyn for Morse instrument ink; Paton and Russell for complete Ericsson telephones, Ericsson table sets, slot attachments, extension bells, &c.; R. B. Hungerford for metallic return lead-cased telephone cable, complete telephones, switchboards, switches, &c.; Staerker and Fischer for metallic return lead-cased telephone cable; Gibson, Battle & Co. for brass-sheathed rubber telephone cable; T. K. Steanes for spares for Willans engine, incandescent lamps and arc lamp carbons; and the Australian General Electric Co. for inner globes for General Electric arc lamps.

The Postmaster-General's Department (Brisbane) has accepted the tenders of W. T. Henley's Telegraph Works Co. for 52 pair cable and 20 lb. conductor, and of the Brisbane Electrical Co. for 208, 104, 78 and 39 pair cables and 20 lb. conductor.

Walthamstow Council have accepted the following tenders for annual stores:—

Electrical Co., rheostats and lamps (including Nernst lamps); Beam Co., shades and ironclad switches; Sunbeam Co., opal and iron enamelled shades; Reason Mfg. Co., house service and fuse boxes, ironclad cutouts; Edison & Swan Co., cutouts, holders, ceiling roses, wall plugs, adapters, key switch-holders, switches, casing, &c.; R. F. Coulston, binding and fuse wire, tinned wire, distributing boards, indiarubber solution, wood blocks, white cotton waste, and engine wipers; Connolly Bros., Para rubber strip, black adhesive tape, Blackley tape, vulcanised i.r. cables, flexible and telephone wire; British Thomson-Houston Co., splicing gum; General Electric Co., fittings, phosphor bronze and copper wire, orange shellac varnish, enamelled steel conduit, enclosed arc lamp carbons and telephone sundries; Croager Bros., sponge cloth; I. Bentley & Co., lubricant; W. T. Henley's Co., armoured and lead-covered cables; London Lamp Works, carbons; London Electric Wire Co., copper wire brushes; Good Bros., steam and gas barrel; and Applebee Bros., linen tape.

Marylebone (London) Council have accepted the following tenders: Ernest Scott & Mountain, for a centrifugal pump at £62. 10s. (three tenders, ranging from £60 to £81). R. S. Robertson, for wiring electricity department offices at £88 (four tenders varying from £88 to £191). Craig, Sharp & Co., for annual supply (at £22. 10s. per ton) of box compound. British Electric Trades Co., for annual supply of pitch at £2. 5s. per ton.

Islington (London) Council have accepted tenders from the following firms for annual stores, &c., for the electricity department: John Knowles & Co., pipes; Robertson Electric Lamps, incandescent lamps; Berry, Skinner & Co., terminal boxes; Alex. Duckham & Co., oils and lubricants; Middleton Bros., waste, &c.; Pryke & Palmer, belting, engineers' sundries, &c.; and H. Edmonds & Co., rubber and asbestos. The contracts for meters, carbons and globes have not yet been let.

Battersea (London) Council have accepted the tender of Mather & Platt for steam generating plant of 850 kw. capacity (with Belliss engines) at £6,446, Körting condenser £140, spare armature £800, drains £6; total £7,392.

Grimsby Corporation have accepted the tender of Johnson & Phillips, Old Charlton, Kent, for cable supplies for 1906, and also for supply of a switchboard.

West Ham Corporation have accepted the tender at £7,429 of Willans & Robinson for a 1,500 kw. turbo-generator (Dick-Kerr generator). There were 15 tenders.

The British Westinghouse Co. have received the order to equip with magnetic brakes 200 cars now being delivered to Birmingham Corporation by Dick, Kerr & Co.

London County Council have accepted the tender of Darracq & Co. for two motor cars at £489. 10s. for the use of the tramways department.

Southend Council have accepted the tender of Crompton & Co. for a steam dynamo (Belliss engine) at £2,857, and that of F. Pratt & Co. for a large wheel lathe at £145. 10s.

Thos. Piggott & Co. have received an order for cast-iron steam pipes for Birmingham Corporation electricity works.

**Ship Lighting Contracts.**—J. H. Holmes & Co., Newcastle-on-Tyne, have contracts in hand for the electric lighting of 38 steamships building in the United Kingdom and abroad.

Included amongst these are vessels for carrying Russian troops, petroleum oil in bulk, for the Newfoundland sealing trade, New Zealand and South African trade, Nile tourists, two for the L. & Y. Railway Co., one for the G.C. Railway Co. and a large number of passenger and general cargo boats. In addition to these the firm have in hand several large private yachts, and they are also overhauling the installation on the ss. "Smolensk," now lying in the Tyne, and which was engaged in the recent Eastern war. Messrs. Holmes & Co. equipped this boat with generating plant and complete installation when she was built at Messrs. Hawthorn, Leslie & Co.'s yard, Hebburn-on-Tyne. The foregoing list brings the number of vessels up to 800 for which the firm have manufactured the generating plant and fitted the installations.

## BANKRUPTCIES, LIQUIDATIONS, &c.

A. P. Jones and C. Hellyar (trading as A. Parker & Co.), electrical engineers, 130, Upper Richmond-road, East Sheen, Surrey, have been adjudicated bankrupt. The first meeting of creditors will take place on March 8, at 132, York-road, Westminster Bridge-road, London, S.W., and the public examination on March 22, at the Court House, Wandsworth, London, S.W.

A dividend of 5s. 2d. has been paid in the liquidation of Walker and Hodgetts (Ltd.).

On Feb. 1 and 20 respectively resolutions were passed and confirmed to wind up the Crystal Palace District Electric Supply Co. (Ltd.), whose undertaking has been acquired by the South Metropolitan Electric Light & Power Co. (Ltd.), and to appoint Mr. Jas. Gray, Dashwood House, New Broad-street, London, E.C., as liquidator.

An immediate discharge has been granted to Albert John Harris, electrical engineer, Borough Mills, Bradford, debtor's assets greatly exceeding his liabilities.

**Plant for Sale.**—Exeter Corporation have plant for sale, including a 250 kw. direct-coupled steam alternator (Hick, Hargreaves engine, Ferranti alternator), one 100 kw. steam-driven alternator and exciter (Easton, Anderson & Goolden) and one 100 kw. direct-coupled alternator and belt-driven exciter (Universal engine and Mordey Victoria alternator). Orders to view from the city electrical engineer (Mr. H. D. Munro), 184, Sidwell-street, Exeter, to whom communications are to be addressed. See also an advertisement.

Edinburgh Corporation invite tenders for the purchase of a quantity of copper steam pipe bends, with wrought-iron flanges brazed on. Particulars from the chief electrical engineer (Mr. Frank Newington), Dewar-place Electricity Supply Station, Edinburgh, to whom offers by March 8. See an advertisement.

Torquay Corporation offer for sale one 125 kw. Willans-Fynn alternating-current set, which is to be removed to make room for a larger unit. Further particulars from the borough electrical engineer (Mr. P. Storey). Tenders to the town clerk (Mr. Frederick S. Hex) by noon March 19 See an advertisement.

Two new 150 kw. Parsons d.c. turbo-generators are advertised for sale in another column.

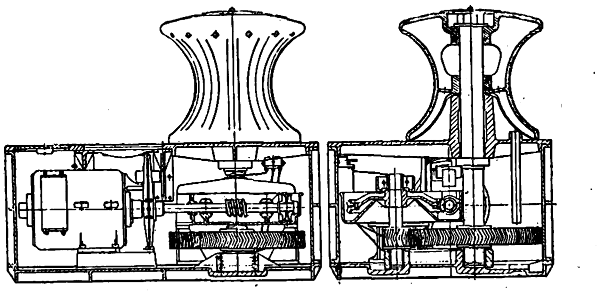
Messrs. White Bros. & Co., engineers, Stratford, London, E., have for sale some electrical plant, particulars of which are set out on another page.

Some electric lighting plant (consisting of a Cochran boiler, pair of Browett-Lindley engines and Elwell Parker shunt-wound dynamo) is advertised for sale by the Colosseum Theatre, Oldham.

**Blackman Electric Fans.**—The popular electric Blackman fans, single-phase, two-phase and series type (alternating-current), are described and illustrated in a sheet just issued by the James Keith & Blackman Co., 27, Farringdon-avenue, London, E.C., the illustrations showing the latest form of these fans, which are exactly the same in pitch and construction as those fitted to the company's continuous motors. The series type of motor is used where a very quiet fan is necessary, and is wound for slow speed. All these motors have commutators and brushes, and the speed can be regulated by a choking coil and switch of special construction supplied by the company. The same list describes the Blackman fan and steam engine combined, which has been previously illustrated in these columns.

**Measuring and Testing Instruments.**—Two new pamphlets have recently been issued by Messrs. Elliott Brothers. The first describes Prof. J. A. Ewing's well-known "Permeability Bridge" for rapidly and easily measuring the magnetic permeability of sample bars of iron and steel by comparing them with standard specimens, and giving a clear description of its functions. The second pamphlet contains an illustrated description and price list of the firm's series transformers for use with their standard indicating and recording alternating-current ammeters and wattmeters. These are made in three styles for pressures up to 600, 6,000 and 12,000 volts, and are suitable for any frequency. The 12,000 volt type is oil immersed, but the others are simply supported on porcelain insulators. Portable as well as switchboard type are listed.

**Catalogues, &c.**—An excellent list of electric winches, capstans, haulage gears, &c., has been issued by Clarke, Chapman & Co., Gateshead-on-Tyne, forming a comprehensive catalogue of ship deck and dock machinery. The motors for winches and capstans can be supplied of either continuous current or multiphase alternating type, be wound for any usual voltages, and in the case of multiphase motors, for any usual periodicities. The list sets out in full particulars of construction and operation, and the leading types of machines for both general and special work are well illustrated. A single speed capstan is shown in the accompanying illustration, in which the barrel is driven by the motor through a combination of worm and spur gearing. The worm gear is enclosed in an oil bath. The spur gear is cast steel with machine-moulded teeth, the wheel keyed to the capstan spindle. This machine is of massive design, and suitable for handling large steamers for docking. The controller supplied with these capstans can be fitted with either hand lever or foot pedal (either is removable). Nearly thirty fine machines are illustrated in this up-to-date list.



Messrs. Clarke, Chapman & Co.'s Single Speed Electric Capstan.

Ferranti Limited have three new lists ready, Nos. 73, 78 and 89, dealing with standard cast-iron regulating pillar and hand wheel for rheostats and motor starters, standard voltmeter and synchronising plugs and sockets and three-phase oil-break automatic and non-automatic switches ranging from 300 amperes, 3,000 volts to 100 amperes, 10,000 volts.

A new list of semi-enclosed motors has been prepared by Laurence, Scott & Co., Gothic Works, Norwich, and copies can be obtained on application. A large number of windings have been arranged for each of the company's standard size motors, and outputs and speeds are given in the list for the voltages in general use. The ratings of these motors are based on continuous-current working.

Pamphlet No. 191, issued by the British Thomson-Houston Co., deals with automatic circuit-breakers, and illustrates and describes various forms of type C of this apparatus.

The Howard Asphalt Troughing Co. have prepared a booklet describing the best method of laying and joining Howard troughing. Copies of the booklet can be obtained on request.

The Sun Electrical Co., Charing Cross-road, London, W.C., has ready a new catalogue (section M) of motors and dynamos.

Messrs. Hunt & Hess have ready two new hanging sheets relating to litholite insulating handles, spanners and bushes. The sheets illustrate a number of these articles. The second edition of the same firm's catalogue is now ready and includes several important alterations and additions, bringing it up-to-date and increasing its value to the manufacturing electrical engineer.

R. & J. Beck, 68, Cornhill, London, E.C., have placed on the market a new metallurgical microscope (by Rosenhain), designed on entirely new lines for the special work of metallurgy.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Feb. 21 to Feb. 27, with the ports of destination:—

*Aden*, £20 (telegraph material). *Africa*—Alexandria, £743; Cape Town, £494; Delagoa Bay, £51; Durban, £2,803 (including £1,404 telegraph material); East London, £140; Port Elizabeth, £128; Port Said, £74. *Argentina*—Buenos Ayres, £151. *Australasia*—Auckland, £42; Fremantle, £140; Hobart, £20; Lyttelton, £77; Melbourne, £194 (including £170 telegraph material); Napier, £10; Sydney, £752 (including £580 telegraph material); Wellington, £46. *Belgium*—Antwerp, £39; Ghent, £32; Ostend, £199. *Brazil*—Santos, £98. *Canada*—St. John (N.B.), £10. *Ceylon*—Colombo, £15. *China*—Canton, £227; Shanghai, £8,890 (including £8,850 telegraph cable). *France*—Paris, £106. *Germany*—Bremen, £125 (telegraph material); Hamburg, £34. *Gibraltar*, £36 (telegraph material). *Greece*—Piræus, £21 (telegraph materials). *Holland*—Amsterdam, £263 (including £27 telegraph material); Rotterdam, £10. *Hong Kong*, £113. *India*—Bombay, £576; Calcutta, £3,136 (including £216 telegraph material); Madras, £9. *Japan*—Kobe, £4,730; Nagasaki, £1,130; Yokohama, £1,922. *Malta*, £4,300 (telegraph material). *North Atlantic*, £1,500 (telegraph cable). *Peru*—Callao, £30. *Philippines*—Manila, £11,196 (including £768 telegraph material). *Portugal*—Lisbon, £115. *Russia*—Kurch, £33; Riga, £236; St. Petersburg, £202. *Siam*—Bangkok, £322. *Straits Settlements*—Penang, £759 (including £510 telegraph instruments); Singapore, £154. *Sweden*—Stockholm, £73 (telegraph material). *U.S.A.*—New Plymouth, £109; New York, £250. Total, £46,885, against £16,621 in the corresponding week last year (Feb. 22 to 28).

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

Note.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specification Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

January 16, 1906.

1,207 Lake. (Steiner Investment Co., U.S.) Automatic signalling systems.*
1,218 Hunter. Electrically indicating target.
1,221 Arno. Indication, measuring and recording of currents. (Date applied for, Jan. 17, 1905.)*

January 17, 1906.

1,230 Fowkes. Mechanism for electrically lubricating shafts of machinery.
1,242 Veritys Limited & Gott. Switches.*
1,252 Chadburn's (Ship) Telegraph Co. & Grant. Ship's telegraphs.
1,259 Turner. Switch for increasing or decreasing the number of lamps or appliances.
1,289 Küppers. Electrical welding of chains.
1,307 and 1,308 B.T.-H. Co. & Murphy. Arc lamps.
1,309 B.T.-H. Co. (A.E.-G., Germany.) Electric safety spark-gap devices.
1,316 Juhel. Bell-push mechanisms.
24,452A/05 Harrison. Switches for incandescent lamps. (Date applied for, Nov. 27, 1905).*†

January 18, 1906.

1,389 Kingsbury. (Western Electric Co., U.S.) Cables.
1,394 Neyret. Electric couplings. (Date applied for, Jan. 31, 1905.)*†

1,396 Strohmenger. Secondary batteries.
1,400 Young. Construction of tramway and railway permanent way.
1,404 Dupré. Insulators for conductor or "live" rails.
10,400A/05 Birnbaum & Bell. Combined fire alarm and telephone systems. (Date applied for, Oct. 20, 1905.)*†

January 19, 1906.

1,453 Morris. Supports for trolley wires.
1,469 Pattison. Combination of apparatus for calling attention electrically and automatically at any desired time at a distance from time indicator.
1,481 Bradshaw. Alternating-current motors. (Date applied for, Feb. 1, 1905.)*†
1,487 Bláthy. Electricity meters.*
1,507 Simms & Bosch. Magneto-electric ignition apparatus.*
1,509 Beaumont, Still & Mackie. Electric lighting of railway vehicles.

January 20, 1906.

1,541 Westwood & Jones. Brush holders for dynamo-electric machines.
1,564 B.T.-H. Co. (G.E. Co., U.S.) Signalling systems.
1,569 Wilderman. Accumulators.*
1,576 Fellows, Pickup & Tice. Secondary batteries.
1,578 Cowper-Coles. Electrolytic manufacture of copper wire, strip, &c.

January 22, 1906.

1,628 Schmitz. Electrolyte metal-plating.*

January 23, 1906.

1,688 Barr. Electromagnet cork extractor.
1,691 Von Ammon. Dynamo-electric machines.
1,695 Spencer. Automatic electric signalling.*
1,699 Pieper. Electrically-fired internal-combustion engines. (Date applied for, Jan. 24, 1905.)*†
1,701 Fleetham. Safety guard for tramcars or other vehicles.
1,712, and 1,713 Graham. Telephonic apparatus.
1,714 Graham. Apparatus for supplying current to telephonic apparatus.
1,716 Finlay & Finlay. Electrolytic cells.
1,723 Winby. Securing rails and rail joints in railways and tramways.
1,727 Webb. Automatic fuse indicator for showing blown fuses.
1,728 Loebl. Electric alarm devices.*
1,738 Allison. (Empire Electric Stage Lighting Co., U.S.) Switches.*
1,763 Fellows, Pickup & Tice. Batteries.
1,766 Konitzer. Electrode for arc lamps. (Date applied for Jan. 23, 1905.)†
1,783 Aldigier. Protecting-cap for the electrodes of sparking plugs.*
1,785 Séguiniol. Sparking plugs.*
1,793 Middleton. Anode suspender for use in electro-deposition of metals.
1,796 Livesey. Fuses.
1,804 Haigh, Wheeler & Appleyard. Rendering certain materials waterproof, non-inflammable and non-conductive of electricity.*
1,818 Brown. Switches for surface contact electric traction.
1,830 Raworth. Control of circuits in systems of electric traction.
1,847 Westmacott & Thomas. Ignition apparatus for internal combustion engines.
1,852 Siemens Bros. & Co. & Gordon. Measuring temperatures by electric resistance thermometers.*
1,858 Simpson. Generating and utilising electric energy.
1,867 Allgemeine Elektricitats-Ges. Electric signals for railways, &c. (Date applied for Jan. 25, 1905.)†
1,868 Stallibrass. Submarine telegraph cables.

January 24, 1906.

7,286A/05 Pfatischer. Variable-speed motors. (Date applied for, April 7, 1904; invention comprised in 7,286 of April 6, 1905.)*†

January 25, 1906.

1,878 Moone. Ammeter switch.
1,881 Veritys Limited & Gott. Electrical fuses and boxes therefor.
1,901 and 1,902 Barter & Light Motors (Ltd.) Electrical ignition of internal-combustion engines.
1,914 Fuller & Fuller. Protecting telegraph and like lines from lightning.
1,924 Edison. Electrode for storage batteries. (Date applied for, Nov. 2, 1905.)*†
1,925 Edison. Storage battery electrode. (Date applied for, 30/4/1905.)*†
1,927 Edison. Electrode mass for storage batteries. (Date applied for, March 30, 1905.)*†
1,928 Edison & Aylsworth. Storage battery electrodes. (Date applied for, April 28, 1905.)*†
1,934 Ohnesorge. Telephone service systems and methods of operating same. (Date applied for, Jan. 28, 1905.)*†
1,935 Claremont & Stratton. Carriages for carrying cable drums.*
1,944 Highfield. Systems of laying electric conductors.
1,945 Highfield. Safety devices for high-tension direct-current systems.
1,946 Highfield. High-tension direct-current systems.
1,947 Highfield. Systems of direct-current supply.
1,961 Kastler. Pole for supporting electricity transmission lines and the like. (Date applied for, April 1, 1905.)*†
1,963 Mordey & Fricker. Electricity meters.

January 26, 1906.

1,968 Cowper-Coles. Electro-deposition of alloys.
1,983 Pessell. Sparking devices of internal-combustion engines.
1,987 Fawcett. Ignition plugs for internal-combustion engines.
1,989 Brown. Self-recording electricity meters.
1,992 Nehmer. Electrical apparatus for lighting gas.
2,014 Mantle. Arc lamps.
2,019 Sullivan. Electric relays and recorders.
2,027 Jacoby. Controlling electromagnets and the like.
2,031 Beale. Automatic switch.
2,037 Hey & Broadbent. Trolley wheels for electric vehicles.
2,064 B.T.-H. Co. (G.E. Co., U.S.) Signalling systems.
2,065 B.T.-H. Co. (G.E. Co., U.S.) Electric controllers.
2,066 Berry. Insulated conductors and windings for use in transformers, dynamos, &c.
2,067 Berry. Construction of electromagnets.
2,072 Cowper-Coles. Electric radiators or heaters.

January 27, 1906.

2,100 Newton. Electroscope for measuring X-ray radiation.
2,129 Boult. (Albert L. Marsh, U.S.) Resistance elements.*
2,151 Parsons, Stoney & Law. Rotating magnets for dynamo-electric machines.
2,153 Neu. Hoisting apparatus for electric arc lamps.
2,156 Zelensky. Poles for wireless signalling.*
2,158 B.T.-H. Co. & Holden. Electric measuring instruments.

January 29, 1906.

2,174 Kingston. Electric bells indicating opening of railway carriage doors while trains in motion.
2,184 Smith. Electric fuse boxes.
2,185 Mair. Electric controller for lifts, hoists and cranes.*
2,194 Braunehjelm. Wireless telegraphy. (Date applied for Feb. 3, 1905.)*†
2,196 Edwards. Switches.
2,209 Leake. Trolley wheel guides.
2,218 Bastian Meter Co., Calvert and Abraham. Electricity meters.
2,236 Redfern. Shades for incandescent lamps. (Heilbrun & Pinner, Germany.)

## SPECIFICATIONS PUBLISHED.

### 1904 Specification.

28,147 Bastian. Electric vapour apparatus.

### 1905 Specifications.

1,221 Atkinson. Electricity meters.
1,321 Huff. Railway electric signals.
1,482 Noble. Electrical contact makers and breakers.
1,482A Noble. Electrical contact makers or breakers. (Date applied for, Jan. 25, 1905.)
2,299 Schilvock. Electroliers and electric wall brackets.
2,691 B.T.-H. Co. (G.E. Co., U.S.) Electric signalling systems and apparatus.
4,075 Wise. (Thomson Electric Welding Co.) Transformer for electric metal working apparatus.
4,497 Hunt. Brakes for electrically-driven machinery.
6,781 Hanscotte. Obtaining adhesion for traction on steep inclines. (Date applied for, March 31, 1904.)
7,111 Gianoli & Persin. Magnetoelectric generators. (Date applied for, April 14, 1904.)
9,783 Diamant & Chiesa. Construction of electric arc lamp.
10,265 Griffin. Switches.
11,012 Codd. Terminals for electric cables.
13,660 Moss. Coin-freed apparatus for franking letters, telegrams, &c.
14,782 Lake. (Clinton Wire Cloth Co.) Electric-welding apparatus.
14,889 Coridori. Insulating sleeves for electric wires at high potential.
15,819 Lionel Robinson & Co. & Adams. Automatic circuit breakers.
16,300 Siemens Bros. & Co. (Siemens-Schuckertwerke G.m.b.H.) Enclosed dynamo-electric machines for effecting the ventilation thereof.
20,728 Brown. Means for facilitating the erection of telegraph poles and the like.
21,162 Bumiller. Telephone receivers and the like.
21,833 McIntyre. Electromagnetic coils for treating live animal, vegetable or other objects. (Date applied for, Oct. 29, 1904.)
22,820 Jacobs. Omnibus signalling circuits, particularly for telephony.

# COMPANIES' MEETINGS AND REPORTS.

## Telegraph Construction & Maintenance Co. (Ltd.)

The forty-second ordinary general meeting was held on Tuesday at the offices, 38, Old Broad-street, London, E.C., Mr. William Shuter (chairman and managing director) presiding.

The SECRETARY (Mr. E. Dickens) read the notice convening the meeting, the report of the auditors, and the minutes of the previous ordinary general meeting.

The CHAIRMAN then said: Gentlemen, at the half-yearly meeting in July last, it was my sorrowful duty to report the rather sudden death of Sir Robert G. W. Herbert, and I am sure you will understand that this sorrow is still fresh in our minds, and that you will deplore with us the loss the company has sustained. I am sure, too, you will greatly regret, as we do, the absence of Sir Robert Herbert's always genial and amiable presence at our meetings. I must not dwell on this sad subject, but will proceed to inform you that the directors have done me the honour to select me to fill the vacant chair. (Hear, hear.) I quite feel that it is not easy for me to follow in the footsteps of so distinguished a predecessor, but I can assure the shareholders that I shall continue to be as devoted to its interests and its welfare as I have always been during the many years of my service with the company. It is a real pleasure and satisfaction to me to confirm what I briefly intimated to you at the July meeting, that Mr. Francis R. Lucas has been unanimously elected to a seat at the board. I am equally pleased to add that I shall have Mr. Lucas's valuable assistance as a joint managing director. He, like myself, has been one of us since the earliest days of our company, and his vast and varied experience in the manufacture of cables, and in cable laying and repairing in every part of the globe, is of quite a unique character. I can assure you, gentlemen, that it is a great advantage to me to know that I have one by my side whose ability and high character are so well known to myself and to those who have worked with him for a long series of years. (Cheers.) As you probably are aware, the year which has just come to a close has been one of exceptional difficulty. The accident which happened to the "Colonia," when she got on to a rock on the coast of Nova Scotia, was at first a grave anxiety. Fortunately, the efforts of our officers were successful in getting her off, and the damage did not prove to be so serious as was at first anticipated. The repairs carried out in the dry dock at Halifax were sufficient to enable the "Colonia" to complete the laying of the Atlantic cable, and after her return she went into dry dock in London and was thoroughly repaired. She is now re-classed by the Board of Trade, and stands the same at Lloyds as she did after her launch. Although the greater part of the loss will be covered by insurance, the company will have to bear some portion of it. This does not appear in the profit and loss account, as it is a charge against the company's insurance fund. The accounts for the year are on the whole satisfactory, and compare favourably with those of 1904. In that year the net profit was £48,825, whilst on this occasion it amounts to £73,911. Then the disposable balance was £146,900, whilst our present account shows £153,580. We now propose to declare a dividend of 10 per cent., making, with the 5 per cent. already paid in July, a total of 15 per cent., carrying forward £108,760, as against £102,079 in the previous year. I do not think I have anything further to tell you, but if shareholders desire to ask any questions I shall be glad to hear them. I will now move

"*That the report and accounts to Dec.* 31, 1905, *submitted to this meeting, be and the same are hereby adopted, and that a dividend of* 24*s. per share (in addition to the* 12*s. per share, interest or interim dividend, paid to June* 30, 1905) *be paid on all shares of the Company for the year ending Dec.* 31, 1905, *and that such dividend be paid free of income tax.*"

Sir JAMES PENDER, Bart., seconded the resolution.

Mr. T. CROFT said that he felt sure the shareholders would desire to associate themselves with the board in the expression of regret to which the chairman had given utterance at the death of their late chairman, Sir Robert Herbert. (Hear, hear.) He had been connected, as a shareholder, with this company for a great many years, and he thought he had attended all, or nearly all, the general meetings at which their late chairman presided, and if he could do nothing else he could at least testify to the unfailing courtesy Sir Robert Herbert always displayed to him and the other shareholders in answering questions put to him, and he could also testify to the great ability he displayed in expounding the business of the company. It was in the year 1897 that Sir Robert Herbert first occupied the chair, and it was in the speech he then made that he alluded to the serious losses the company had then sustained by the death of distinguished members of it, and notably the death of his predecessor, Admiral Richards, who had been managing director for a period of 20 years. Admiral Richards, they all knew, was a distinguished naval officer, and through his long association with the company he must, of course, have acquired a great deal of technical knowledge. Sir Robert Herbert entered upon his duties as chairman at a time when the post was naturally a difficult one, and the position was one that any ordinary man might well have shrunk from. It would be presumptuous on his part to attempt to gauge the extent of Sir Robert Herbert's abilities, but they knew that, before he joined the board of this company, he had already achieved distinction in a department of the State where the qualities he possessed, and which had gained him success there, were sure to bring him success in the chair he occupied at the board of this company. He (Mr. Croft) did not suppose that Sir Robert Herbert, when he joined the board, was a man who possessed the technical knowledge of his predecessor. In the first place, Sir Robert was not a naval officer, and, moreover, he had not a special knowledge of cable laying, but he devoted himself with the greatest industry and ability to the work of the company, and one of the first objects to which he devoted himself, and an object which would endear his memory to the employés of this company, was the establishment of the pension fund. That pension fund was first started with only the modest sum of £5,000. In the year 1903, as it appeared in the accounts, the sum had grown to £67,000. For some reason or other the amount of the pension fund did not appear in the accounts for the year now under review, but the amount in 1903 was £67,000. Sir Robert Herbert, when that fund was started, expressed the view that he would not be satisfied until it had been placed in such a state as would enable all the employés of the company, when they retired, after a long service to the company, to enjoy the pension to which they were undoubtedly entitled. That was one of the objects to which Sir Robert Herbert had devoted himself, but he also had the satisfaction during his occupancy of the chair to witness the laying of the largest amount of cable—a cable which encircled the globe. He also told them that part of the Pacific cable had been laid in the deepest water that any cable had or was likely to be laid. Both these objects were achieved under his direction. Of course, it was not to be supposed that he, personally, was entitled to the credit for the ability with which the cable had been laid by those people engaged in the actual work of laying it. That work devolved on the naval portion of the company's staff, but the work was all done during his chairmanship, and they might well believe that he devoted a great deal of his time and attention to the supervision of that business. It was, moreover, during his tenure of office that the two cable-laying ships were launched—first the "Colonia," which was employed in laying the Pacific cable, and then the "Cambria." These works were all achieved under the presidency of their late chairman. Although, as he had said, Sir Robert Herbert could not have brought to the office, in the first instance, the same amount of technical knowledge some of his predecessors possessed, it was perfectly obvious to all of them that he conducted and supervised the business of the company with such ability that any man might envy. (Hear, hear.) He concluded by congratulating Mr. Shuter on being elected to the post of chairman.

The CHAIRMAN: I have to thank you, gentlemen, very sincerely for the kind words you have spoken. With reference to the pension fund, I may mention that it has been taken out of the company's accounts, and that it now stands on its own merits. The additions made to it are represented by the interest which the capital item brings. This interest is always added to the amount of the fund.

General TREVOR said that the figures submitted to them were very interesting, more, perhaps, from what they did not disclose than from what they did disclose. The debts owing by the company could not be compared in amount with the debts owing to the company, because the debts which were owing to the company had always been stated at a certain figure, but the debts owing by the company were lumped together with reserves for insurance and contingencies. How much of this was really reserves and how much represented debts due by the company was not disclosed. There might be good reasons for not disclosing these particulars. If there was not any good reason, he would suggest that the two items should in future accounts be separated. Then the reserve fund of £50,000 was, he presumed, employed in the business, because it was not stated to be invested in any other way. That would have to be added to whatever proportion of the sum of over £1,000,000 which stands just above it, was put down in their books to reserve. Therefore, it was impossible to state how much of the reserve was employed in the business. As to the directors' remuneration, that was stated at a minimum of £2,000, and an extra sum of £1,010. In every manufacturing company with which he had been associated, and he was a shareholder in a good many, the managing director had a very much larger remuneration than the other directors, and properly so, because a managing director had more work and responsibility than an ordinary director. The management expenses were not shown. They did not even know the amount of the auditors' fees. That was not shown. There might be very good reasons for not revealing these things, because the company had many competitors in the trade, and if the chairman, in his reply, declined to give any reason he was at perfect liberty to do so. He should not withdraw his remarks in that case, but he should take no further notice of the matter. The value of their property, freehold and leasehold premises, &c., was put down at £332,000. Was that valuation a recent one, or was it taken some years ago? If taken, say, ten years ago, it must be subject to a good deal of depreciation. They did not know from these accounts whether 10 per cent., or indeed any percentage, has been deducted for depreciation. On the other hand, the property and other items might have improved in value. It is impossible to tell from the accounts whether the management expenses were increasing or diminishing.

The CHAIRMAN: Perhaps you will allow one of the accountants to answer these questions. I will ask Mr. Plender to address you.

Mr. PLENDER said that the amount of debts actually owing by the company included in the figure of £1,060,816 was small. The directors had always adopted the policy of not setting out the reserves, and that policy had always been approved by the shareholders at each meeting. Speaking on behalf of the board, he might say that they thought it would be much to the injury of the company if its reserves were too freely disclosed. (Hear, hear.) As regarded the reserve, that was invested specifically, and included in the item of sundry securities on the other side of the balance-sheet, totalling at £1,022,000. The reserve was represented by Consols. The remuneration of the managing director was not included in the directors' fees, which were disclosed in the profit and loss account, but they were properly provided for, as well as the auditors' fees, before the net profits of £76,876 were arrived at. There had been no recent valuation of the premises, but he could assure them from his knowledge of the accounts that the most ample provision had been made for depreciation and renewals of leases. The company had been always liberal in making most ample provisions for every possible contingency. (Cheers.)

The resolution was carried unanimously.

Mr. COLIN F. CAMPBELL proposed the re-election of Sir James Pender, the retiring director.

Mr. PAGET V. LUKE, C.I.E., seconded the proposition, and it was unanimously agreed to.

On the motion of Mr. BUNNING, seconded by Mr. ROBERTS, Mr. John Gane and Mr. Patrick A. Glegg were re-appointed auditors.

A vote of thanks to the chairman and the other members of the board, proposed by General TREVOR, and seconded by Mr. CROFT, terminated the proceedings.

## London Electric Supply Corpn. (Ltd.)

In our report of the proceedings at the ordinary general meeting of this Corporation in our last issue, we were only able to give the very interesting statement made by the chairman (Mr. Robert H. Benson), in whose opening remarks it was stated that the managing director (Mr. R. Stewart Bain) would deal with the details of the generation and distribution of current. We give below a report of the proceedings following the account appearing in our last issue :—

The CHAIRMAN : The managing director has a few interesting figures which I think should be recorded.

The MANAGING DIRECTOR : The capital expenditure for the year was £42,000. That has been almost entirely used for the purpose of installing two new direct-current stations and the mains in connection therewith. For many years this corporation was heavily handicapped because it could not supply continuous current for power purposes, and it was largely owing to that fact that, although we were the pioneer company in London, our business in the West End has not developed as rapidly as other companies who used the continuous current. Last year we asked the Board of Trade for power to supply on both systems, and although we were opposed by our municipal competitors, the Board granted us that permission, and we have erected a new station in Southwark from which we are now supplying direct current in the boroughs of Southwark, Bermondsey and Camberwell. We have also erected a new station at Deptford, where we are also supplying direct current in Deptford and Greenwich. We have further acquired a valuable site near Bond-street, which can be utilised for a similar station in the West End of London if we think it desirable. We have laid during the year 12 miles of mains, bringing the total length of mains laid up to 244 miles. This is a business where we cannot afford to wait until things happen; we have to try and anticipate them. Last year I told you that a large portion of our capital expenditure had been used in laying a new trunk main route from our Deptford station to the West End of London, our previous trunk main route coming over the Charing Cross bridge, and we had used that route for 16 years. Very shortly after our other route was opened and working the serious accident took place at Charing Cross railway station, where part of the roof fell down. When that roof fell it carried away the wall of the station to which our four trunk mains were attached and buried those mains under thousands of tons of debris. Our engineers were *not* allowed to go near our mains because of the danger of other portions of the roof falling, and but for this alternative route we could not have supplied any current to the West End *until* those mains were repaired. As *it* was, we had no interruption—our lighting was not interfered with at all. The chairman has told you about our average price. That is steadily diminishing, increased this year by the agitation which was raised by the bill of the Administrative County of London Co. The average price we received during the year from our lighting customers was 3·90d. That is a low price when you remember that not so many years ago it was 6d. I am glad to say, however, that we have been keeping pace with the decreased cost by the largely decreased expenses. As the chairman told you, we have decreased our cost per unit sold this year from 1·21d. to 0.95d., or over 20 per cent., making it, I believe, the lowest of any company in London. The principal decrease was in our coal bill. Our consumption last year was 30,065 tons, compared with 29,425 tons in 1904, but in 1904 we sold 10,500,000 units, whereas this last year we sold 13,000,000 units, the saving in consumption per unit being over 18 per cent. To put it in another way, while in 1904 every unit we sold took 6·26 lb. of coal, last year it had decreased to 5·16 lb. The cost of coal shows a decrease of 33 per cent.—namely, from ½d. per unit during 1904 to 0·34d. during 1905. Our percentage of units sold to units generated has also, I am glad to say, been gradually increasing. Another very pleasing thing is that the units we are selling for power purposes are increasing very satisfactorily. Within the last few days we have secured an order from a large manufacturer for 400 H.P. The development of this power business, to which our continued success to a great extent depends, is receiving the energetic attention of our staff, in whose praise I cannot speak too highly, and we look to the future with confidence and hope.

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## W. T. Henley's Telegraph Works Co. (Ltd.)

The 27th ordinary general meeting was held yesterday under the presidency of SYDNEY GEDGE, Esq.

The SECRETARY (Mr. A. E. Salmon) read the notice calling the meeting.

The CHAIRMAN said : This year may be called our silver wedding, for although this company was incorporated on Feb. 21, 1880, and is therefore just 26 years old in a sense, yet we hardly recognise the first broken year as anything; it is a sort of period when things are in embryo. There have been 25 full years of the company's existence up to the 31st of December last. Again, Mr. Sutton, our energetic and most valuable managing director, entered the company's service in the month of March, 1881—exactly 25 years ago—and you know how much we are indebted to the energy, knowledge, zeal and attention that Mr. Sutton has brought to the business, and how much it is owing to him that we have emerged from the poor state we were in when he entered the company's service to the state in which we are happy to be in now. We all know how glad we are that Mr. Sutton has lived to render us these services, and how heartily we can congratulate him on his silver wedding with the company. People tell us, You show too good a balance-sheet. You are paying a dividend of 15 per cent. You did pay 20 per cent. for three years, but you have wisely given that up, because, with an industrial company engaged in electrical manufacturing work, such a return as that is an inducement for the speculative loafers who are looking around to form some rival company. Well, that being so, I think that all such capitalists should know exactly how the matter really stands. In the first place, we must remember that when this Company was formed we took over existing ready-made works, with the machinery, and we also took over a very valuable asset in the shape of Mr. Henley's goodwill, Mr. Henley being known as a first-class telegraph manufacturer all over the world, and having a good connection all round. No new company would start with an advantage of that kind. In the next place we must remember that for the first 11 years of the company's existence it paid no dividend. Now let us take it that the shareholders put in their money with the reasonable expectation that it would earn 7 per cent. for them. That 7 per cent. for 11 years amounts to 77 per cent., and at compound interest this brings the capital of £70,000 up to £120,000. But the original shareholders only get their dividend now on the £70,000, not on £120,000. Then it has to be remembered how, as by degrees our credit has risen in the market, we have been able to borrow money at a very low rate; and although we pay 15 per cent., we are not paying that rate upon the capital in the business. We are only paying 15 per cent. on the ordinary share capital, which is £200,000, as against the total capital of ordinary shares, preference shares—another £200,000—and debentures £150,000. Our dividend has to be divided, therefore, on £550,000, not only on £200,000, if people want to see what return may be expected from an investment of this description, and that comes out at about 8 per cent. only instead of 15 per cent. Therefore, although we may, as ordinary shareholders congratulate ourselves that we get 15 per cent. for our money, it by no means follows—and there is nothing to induce people to believe it—that by planking down half a million of money they will be able to get a return of 15 per cent. on it or anything like such a return. Having regard to our small beginnings and our very uphill work we had very nearly come to grief, and we might have done so but for some of our friends. My firm and one or two other friends came forward and assisted, or else the company would have come to grief. We all had faith in the concern and its management, and we believed in the future of electricity, and I think you will say that our confidence has been amply justified. Last year was a record for the amount of orders which we received. For obvious reasons I do not state what the amount was; no company ever does that, as they do not want others in the business to know too much. I may, however, say that the amount of our orders exceeded by 10 per cent. the highest amount that we had ever previously had. "How is it," you may therefore say, "that you are only paying 15 per cent. when on previous occasions, when the orders were not so large, you paid 20 per cent.?" The reply to that is that we had to do more in return for the orders. There is very keen competition for the work at the present time, and therefore the profits on the orders are not quite so large as they used to be—a fact which renders economy in administration and in management of very great importance. Now this increase of business and the keen competition we are experiencing necessitated an increase in our works, and you are aware, from what you have been told on a former occasion, that we bought some 12 acres of land at Gravesend, on the river, and we have there erected very fine works indeed. I do not profess to be an engineer, or a mechanician, or an electrician, but one does know something about works, and I have been over a great many works in my time, but I think I never went over or saw a finer shop than the great factory which we have erected there. I have full details, which have been supplied to me by our capable manager at those works, Mr. Wright. He tells me that there is a wall all round, 1,941 ft. long and 8 ft. high, that the factory I spoke of covers an area of more than two acres, and that it is 700 ft. long by 144 ft. wide and roofed in with glass. I think that anyone who visited those works would see that the whole arrangements there for doing the work in an economical and efficient manner are as admirable as could be conceived. We make our own gas, and with that gas we make our own electric power both for heating, for lighting, and for mechanical work, so we are almost self-sufficient in ourselves. We do not possess coal mines—we buy our coal, but having the coal we can transmute the energy of that coal into electrical and mechanical energy. The works have not yet opened, but we are told that it is hoped to open them next week and then they will begin to earn money. It has, of course, been a considerable drag on us as a charge upon our profits, for up to the present this capital, both the amount expended on the purchase of the land and on the erection of the works, has not yet earned a shilling. Yet we are, nevertheless, able to pay a dividend of 15 per cent. The large sum we have sunk on those works by no means exhausts their value, because we are going to remove a considerable amount of valuable machinery from North Woolwich to Gravesend. We have to raise money to pay for all this outlay, and last year we obtained powers from you to issue £300,000 of debenture stock, of which we have raised £150,000, out of which the former £50,000 of debenture stock has been repaid. You may ask why it was that when we only wanted £150,000 we took powers to raise as much as £300,000. Well, the reason is this—that when we came to deal with the £50,000 we found that it was issued without our having any power to add more to it for it to rank pari passu with that £50,000. We found also, when we came to deal with the debenture stockholders, that we were not entitled to pay them off against their consent. At the time when that £50,000 stock was issued the company's credit was not as good as it is now, and in order to get the debenture money subscribed, we were advised that there must be an annual sinking fund by which the stock should be redeemed in 30 years. The necessity for that has not arisen, and with respect to the new stock, we had to take care that it should not arise. We had to go to those who held the £50,000, less the £5,000 odd that had been redeemed by the sinking fund, and to ask them to take their money. But why should people who come first with £50,000, having a first charge on the property, agree to be merged in a much larger amount of £150,000 or £300,000? Clearly by doing that they would to a certain extent be worsening their position. We, therefore, had to give them an inducement to do what we asked them to do. We, therefore, offered them a premium of 10 per cent., to be paid either in debenture stock or in cash, if they would allow us to pay off their debenture stock at once, or if they would take up the new debenture stock. They behaved exceedingly well. No single debenture holder stood out, as one or two sometimes do, to the last moment, for better terms, and they very nearly all of them took the new debenture stock, an almost inappreciable number only taking cash. There is no intention of issuing any more debenture stock, and more of it will only be issued if the expanding nature of the business should require it. I may tell you, however, that the stock was subscribed for seven or eight times over when we closed the books.

Going through the balance-sheet and accounts, you will see the amount of debenture stock to-day compared with what it was last year; only £105,000 had been paid up to Dec. 31 last, but the balance will very shortly be coming in. You will find an increase of £53,000 in the item of freehold land. The value of freehold land, with buildings, &c., after writing off depreciation, and the annual sum in lieu of rent for these offices, is put up by £53,000 more than it stood at last year. The reserve account, which was only £100,000 in the balance sheet last year, is now £125,000, including the £5,000 transferred to profit and loss account this year to it. The only other thing I wish to mention is in connection with the profit and loss general account—that we brought forward a balance from 1903 of £27,585, and from 1904 we brought forward £26,511, while we now carry forward £22,698; but if you add the £5,000 which we transfer to the reserve account this year from profit and loss (whereas in the previous balance sheet there was no corresponding amount transferred to reserve) the £22,698 is increased to £27,698, whereas the balance brought forward from 1904 was only £26,511. We are, therefore, really carrying forward more instead of less than we did last year. I now move the adoption of the report and balance-sheet.

The MANAGING DIRECTOR (Mr. George Sutton) said: In seconding the motion for the adoption of the report, as has been my custom at these annual meetings for the last eight or ten years, it is usual for me to make some comments on the business of the year. The ground has been very admirably covered by the Chairman, so that it leaves me little to do, and I am in the unfortunate position of the second speaker who frequently has nothing fresh upon which he can comment. The year has been one of steady progress, the balance sheet shows that, and we have done a fair amount of uniform work during the year, which is the kind of work we like because it gives regular employment to our workpeople. In that sense—and this matter has been referred to by the Chairman—the accounts are really more satisfactory than any which we have hitherto brought before you. This is not apparent to the shareholders from the balance-sheet itself, but I would remind you that the Chairman referred to the fact that last year produced us the largest number of orders the Company has hitherto received, but more than that, the 12 months not only produced us the largest number of orders, but also gave us a larger amount of work. It is true the percentage of profit, owing to the competition and the course of markets for raw material, which during the whole year has been against us, has been smaller; and some gratitude is due from the shareholders for the way in which the buying has been done for this business and the careful way in which markets have been watched, so that the Company have not suffered loss from the purchase of material, and, indeed, in some cases have made profit—necessarily small, for we do not speculate. The competition and the course of markets have reduced the percentage of profits to the turnover, but we have been able, notwithstanding, to maintain our 15 per cent. dividend without encroaching on the reserve. That is very satisfactory in two ways. It is satisfactory, of course, to the shareholders to get a dividend of 15 per cent. The maintenance of such a handsome dividend as that must give them satisfaction. But it is also a satisfaction to your manager and workpeople employed in the factory. It means that we have spent a very much larger sum in wages down at Woolwich during the past year than we have hitherto spent. We had constant work for a large number of people throughout the year, and this means that during this winter, when we heard so much about such a large number of people being unemployed, that Henley's Telegraph Works increased its employment and paid more wages in the district of Woolwich than ever before. That is very satisfactory to your workpeople. I am sure that the shareholders of this Company are satisfied with a dividend of 15 per cent., and that they do not wish the Directors to screw every penny of profit out of the workpeople to enlarge their dividend. I mention this because I read in one of the morning papers an account of an industrial company in which it was stated that the shareholders were quite careless and reckless about the workpeople—that all the thought of was to get as large a profit as possible paid to them in dividend, and that that is the object for which directors and managers were appointed. I do not believe that you appoint your directors and managers for that purpose. I would just mention that the business of last year which would have been carried out at Gravesend has been largely power work for cables and for the extension and construction of new tramways. Of course that tramway work is feeder and distributor work. We have done a good deal of cable work in that direction during the year, and to-day there are openings in the West End for large extentions of tramways. For the London United Tramways Co. the whole of the cable work for the Kingston and Wimbledon lines was constructed by this Company. Probably this was the largest order ever placed, and not the least difficult of orders, and those who have knowledge of electrical work—the fact will appeal to them—will be interested when I tell them that the test made of our cables last week through 28 miles of cable, upwards of 300 joints, and a pressure of 22,000 volts upon them, was entirely satisfactory. It gave satisfaction to the representatives, Sir Clifton Robinson and other gentlemen connected with the London United Tramways Co., and to other electrical engineers who were there, and, in fact, some of them expressed surprise that such a good result was obtained under such high pressure and with so many joints. This is an experience not always obtained by those who order high-tension cables. I have nothing else of interest to bring before the shareholders, and I will conclude by seconding the adoption of the report.

Mr. DRYSDALE expressed satisfaction at the statement made by Mr. Sutton, and said he regarded it as a good investment to look after workpeople, as in many ways the employers reaped the benefit of so doing. He desired also to congratulate Mr. Sutton on his silver wedding with the company.

The motion was then carried unanimously, as was a resolution approving the dividend on the ordinary shares. The retiring directors were then re-elected.

Sir A. C. LYALL proposed a cordial vote of thanks to the managing director, the secretary and the staff in London and at the branches at home and abroad, and also to the chief engineer and staff at the works, for their valuable services during the past year.

This was seconded by Mr. LAMONT and carried unanimously.

A hearty vote of thanks to the Chairman brought the proceedings to a close.

## Chelsea Electricity Supply Co. (Ltd.)

The annual ordinary general meeting was held on Wednesday, Mr. J. Irving Courtenay in the chair.

The SECRETARY (Mr. S. J. Cluer) read the notice calling the meeting and the auditors' certificate.

The CHAIRMAN, after referring to the death of Mr. G. N. Marten and the selection of Major W. F. Woods as his successor on the board, said: The expenditure on capital account has been comparatively small. The chief item of £13,138 is mainly the outlay on the extension of the generating station, including a new chimney shaft. The plant to equip this will be added as the demand for current increases. Expenditure on mains is small, and this is due partly to the increased capacity of the existing mains resulting from the change to the higher pressure initiated a few years ago. The cost of the change has amounted in all to about £9,000, and during the past three years more than £5,000 has been written off direct from profits, and the balance is now extinguished through the depreciation fund. Notwithstanding that the progress in the past year has not been as great as in the years immediately preceding, we cannot regard the position as altogether unsatisfactory. Although the gross takings are about the same as in 1904 the net profits are £1,000 more, and while paying £687 more on debentures, which were not fully subscribed until the end of 1904, putting a slightly increased amount to depreciation (£10,918), and with a share issue larger by £25,000—the amount issued in exchange for the founders' shares—we are able to recommend the same dividend as for 1904. The expenses are considerably less, partly owing to the fact that in 1904 there was a special overhauling of the plant and mains, periodically found to be necessary beyond the annual maintenance. Considering the relative smallness of our output as compared with some of the large electric supply undertakings in London, it is satisfactory to note that our total costs per unit do not compare unfavourably with those of other undertakings more fortunately situated as regards cheap production of the current. As regards the future, there are distinct signs of a revival in building operations in Chelsea, and with more activity generally and an improvement in trading conditions, the company should benefit by an increase of custom resulting therefrom. But you must bear in mind that we have the rates always with with us, and invariably increasing. Surely, the basis upon which we are rated is inequitable. Probably you will be surprised to learn that 25 per cent. of our divisible profits go to the rates; in other words, an amount equal to one-third of the dividend we pay goes to the rate collectors. I hope that some united effort will be made in the near future to put these rates and charges upon a more equitable footing. The increase in the output of current during the past year was only small, but there was a remarkable absence of fogs in London in 1905. In the previous year our output was considerably increased in consequence of the prevalence of fog during November and December. The proceedings in Parliament this session will considerably interest us. There are several bills being promoted for supply of electricity in bulk, and these we shall have to watch closely, as we did last year, in order to see that our interests are safeguarded. A great deal of misapprehension has arisen in regard to the benefit which may be derived from these schemes by the individual consumer, and I venture to think that somewhat exaggerated ideas prevail on this point. I incline to think that even should any of the bills pass, the small individual consumer for lighting would receive comparatively but little benefit. If the prices at which such bulk companies could supply were sufficiently low, we should take a supply from them and save capital expenditure on further extensions, and to that extent both consumers and shareholders would be benefited. At present, however, no price appears to have been put forward which would justify us in risking a supply wholly from an outside producer. By far the larger portion of the cost of a supply lies in the distribution expenses—the cost and maintenance of mains, meters and apparatus, the interest on such capital expenditure, and the general supervision and expenses attendant upon dealing with a number of individual consumers. I may add that we do not anticipate any harmful competition in our district from these bulk supply companies; it does not appear to be contemplated in their bills. Although the use of electricity for heating and cooking purposes is only just commencing, a considerable number of units were sold for this purpose, more especially in the last quarter of the year. Great improvements have lately been introduced in the manufacture of electric cooking apparatus. At the present time it is being tried in some of the large private houses as an adjunct to the ordinary coal-fired kitchen range, and we believe that it will gradually come into more general use as the advantages of electric cooking become appreciated. The new section of building to provide for further machinery at our generating station is now practically completed, and it will be equipped with suitable plant as soon as the necessity arises. The alteration in our system of distribution to which reference was made last year has given most satisfactory results, and I think I can safely say that our customers in Chelsea have been well satisfied with the supply of electricity and the general attention which has been given them by Mr. Percy Still, our chief engineer, and the secretarial staff. I now move the adoption of the report and accounts, and the dividends as recommended.

Mr. WILLIAM PAGE seconded the motion, which was carried nem. con.

The retiring directors and auditors having been re-elected, a vote of thanks to the chairman and directors brought the proceedings to a close.

## Westminster Electric Supply Corpn. (Ltd.)

The ordinary general meeting was held on Wednesday, Mr. EDMUND BOULNOIS presiding.

The SECRETARY (Mr. Frank Iago) read the notice convening the meeting.

The CHAIRMAN said: I regret Lord Suffield is unable to be present, as he is suffering from a chill. Sir Alexander Kennedy, our engineer-in-chief, is suffering, I am sorry to say, from an attack of laryngitis. We shall all regret that he cannot be present, as he has been, I think, on every annual occasion since the Company was started. As you will have seen from the report, there is a reduction in the profits. Three factors have primarily conduced to this diminution—viz., the reduction in our charges, which has temporarily lowered our income, the increase of rates and Parliamentary expenses. There is an increase in rates of not less than £7,000 a year, or over 60 per cent. This takes effect from March 31 next, so that we shall have to pay over £5,000 more this year than last, which is equal to 1 per cent. dividend on the ordinary shares. Ten years ago our rates were 5s. 3d. in the £; they are now 6s. 10d. on a very much higher assessment. These increasing rates are a serious factor in any business concern, and I fear we cannot look for any improvement considering the extravagant manner in which local authorities throughout the country are spending money. This handicap must, of course, have an appreciable effect on the possibility, however much desired by the Directors, and by all the shareholders, to make further reductions in the charge for supply. In the last few years there has been a great increase in the demand for current for purposes other than lighting, and this demand we have done everything we can to encourage and develop. As showing the increase in our business in this direction, I may mention that we sold last year for these purposes more units than we sold 11 years ago for all purposes combined, and we hope to be as successful in competing with the gas companies in this class of business as we have been in lighting. Our charge of 1d. a unit for this description of supply came into force on Jan. 1, and will, I am sure, compare favourably with any of the complex charges proposed by those companies who are seeking to obtain powers to supply for similar purposes in the county of London. The fight in Parliament over electricity supply is to be continued this session, and the London County Council have now entered the lists. The bill we are promoting jointly with other West End companies does not seek to trench upon the rights or powers of any other company. The question arises whether such a matter as the supply of electricity to the metropolis, which is of importance not only to the supply companies, but to the users of electricity and the ratepayers of London, can be properly dealt with piecemeal by means of competing bills before a Parliamentary Committee, or whether the time has not arrived for the whole subject to be referred to some authority with a wider reference. That companies who are satisfactorily carrying out their duties under powers granted them by Parliament, and under the supervision of the Board of Trade, should year after year be put to heavy expense in defending their position cannot be considered equitable. We, and other companies also, have made full provision for and are capable of supplying any demand we are likely to be called upon to supply in bulk or otherwise. The sanguine estimates of promoters as to the cost at which they could generate electricity under the most favourable conditions is not the only factor which should be taken into consideration in dealing with the supply of electricity in London. The capital which has been already expended under the authority of Parliament, the restrictions under which the existing systems of supply are working, the effect on consumers of the competition which has been allowed in some districts in London and disallowed in others, and the increased cost due to the purchase clauses, are at least as important. The problem of providing the cheapest and most reliable supply to consumers can never be properly solved unless these factors also are carefully inquired into. Any hasty and partial legislation is quite likely to make matters worse instead of better. Another matter I wish to refer to is our Millbank-street station. Under the Thames Embankment Improvement Scheme the London County Council obtained powers to acquire the land on which this station stands, but they are bound to reinstate us. This matter has been referred to arbitration, which is now proceeding. As stated at the extraordinary general meeting, held in October last, your Directors, after full and careful consideration, were of opinion that it was desirable to take steps to provide for the raising from time to time in the cheapest way the capital estimated to be necessary for the remainder of our term. The scheme for the conversion of the 5 per cent. preference shares and the issue of 4½ per cent. preference shares has now been carried through. The whole of the issue of 50,000 new 4½ per cent. preference shares was subscribed at a premium of 7s. 6d. per share, and the Board think they can congratulate the shareholders upon the result of a somewhat unique scheme for carrying out the necessary increase in the Company's capital. I now move the adoption of the report and accounts.

Mr. J. BROWNE MARTIN seconded the motion, which was carried unanimously, as were resolutions approving the dividend and re-electing the retiring directors.

## Notting Hill Electric Lighting Co. (Ltd.)

The annual general meeting took place on Tuesday under the presidency of Sir WILLIAM CROOKES, F.R.S.

The SECRETARY (Mr. R. G. Rawkins) read the notice calling the meeting and the auditors' report.

The CHAIRMAN then said: Gentlemen, It gives me pleasure to preside at another of our annual meetings, and to present an account of our stewardship for the past year. I have done so on every similar occasion since the incorporation of the Company in 1888, except in the year 1896, when I was absent in South Africa. In the report and accounts which I shall ask you to adopt you will see that, as last year, we have unissued share capital amounting to £56,000, and remaining borrowing powers of £8,000. On capital account £4,092. 14s. 9d. was added to the expenditure during the year. This is the lowest amount the Company has expended for many years, and £2,302. 8s. 4d. (more than half the total) was upon new mains, and £1,157. 3s. for new machines. The total mileage of mains now laid is 32. Revenue shows, I think, a very satisfactory result, and it would have been even better but for an almost total absence of fogs during December. Although we who live in the neighbourhood would rather be without it, it is an interesting fact that a few days of fog soon swells the revenue to the extent of £1,000. We have sold 66,000 more units, and the revenue had increased by £750, whereas the total costs, but for two special items which I will refer to, were actually less than the previous year. The first special item of extra cost was £785 for Parliamentary expenses. These were incurred in opposing measures brought before Parliament last session, measures which, in the opinion of your Directors, would have injuriously affected your interests. The opposition to the bills was successful, but it seems to us a genuine grievance that the Company should be put to this expense in protecting what we consider its statutory rights. I am sorry to say that many measures have again been introduced into the present Parliament dealing with electricity supply in London, including an application for the right to supply in bulk and for motive purposes in the Company's area, but as we have received assurances from the promoters of most of these bills that it is not intended to interfere with our rights, I hope that the amount against the heading of "Parliamentary Expenses" will be considerably reduced this year and altogether disappear in the near future. In connection with this subject I would specially mention that both the general public and the shareholders of the electric supply companies are suffering considerably through these continued attempts to interfere with existing Parliamentary powers. The direct effect is that the general public suffer owing to the expense the companies are put to in maintaining their rights, whilst the uncertainty as to competitive powers being granted prevents a general reduction in the charge for current. The shareholders also suffer, as they would undoubtedly reap benefit from the increase in the demand for current which would arise immediately prices were reduced. The expenditure for the year was only £650 more than in 1904, so that this one item of Parliamentary costs more than covers the increase. Another item I must specially refer to is the £76. 11s. spent in opposing the increase in the rating assessment. I am sorry to say that we were unsuccessful, although we employed one of the most eminent valuers in London, and we have been advised not to carry the appeal further. The assessment was increased from £4,598 to £7,656, which will result in the Company having to pay an additional £1,000 per annum for rates, and it may not be generally known that as the law at present stands we are assessed on our profits, or upon a similar basis to the income tax. The assessment of our Wood-lane works also was increased considerably at the recent quinquennial valuation, so that in addition to the large increase on the Company's individual property we shall be called upon to pay a further £300 a year in respect of our share in the joint works. We shall, therefore, in future be paying the enormous sum of about £3,600 a year for rates, and I hope our consumers will not overlook this fact when considering the cost of electric light, as over 10 per cent. of the total revenue is contributed to the local authority. After providing for depreciation, debenture interest, and our proportion of the interest and sinking fund on the Wood-lane debenture stock, the balance of profit remaining for division is £11,558. 12s. 9d., or about £100 less than in 1904. The depreciation fund now stands at £23,500, or rather more than 10 per cent. of our total capital expenditure, and we have not had occasion to trench upon it during the year to meet any unusual expense for renewing plant. The following table explains the Company's progress from the first year's working to date:—

| Year | Houses conn'ct'd | Lamps connected | Units sold. | Revenue. | Expenses | Profit or loss. | Div. on ord. shrs. |
|---|---|---|---|---|---|---|---|
| 1891 | 77 | 6,056 | 30,162 | £1,623 | £2,178 | Loss £554 | nil |
| 1892 | 124 | 9,438 | 75,667 | 3,513 | 3,301 | Profit 112 | nil |
| 1893 | 173 | 12,153 | 107,580 | 4,329 | 2,848 | do. 1,481 | nil |
| 1894 | 234 | 15,669 | 130,266 | 5,123 | 3,021 | do. 2,101 | 1% |
| 1895 | 307 | 20,307 | 182,327 | 6,940 | 3,712 | do. 3,227 | 2% |
| 1896 | 396 | 25,716 | 230,787 | 8,552 | 3,816 | do. 4,736 | 4% |
| 1897 | 571 | 33,000 | 354,969 | 11,625 | 4,771 | do. 6,854 | 6% |
| 1898 | 816 | 46,066 | 455,871 | 13,571 | 6,320 | do. 7,251 | 6% |
| 1899 | 1,012 | 59,154 | 665,129 | 17,935 | 7,574 | do. 10,360 | 7% |
| 1900 | 1,191 | 68,505 | 782,215 | 19,963 | 10,107 | do. 9,856 | 7% |
| 1901 | 1,445 | 82,054 | 947,491 | 24,195 | 11,149 | do. 13,046 | 6% |
| 1902 | 1,784 | 99,497 | 1,148,991 | 28,837 | 14,228 | do. 14,609 | 6% |
| 1903 | 2,052 | 116,360 | 1,372,642 | 29,443 | 14,425 | do. 15,018 | 6% |
| 1904 | 2,267 | 132,132 | 1,645,492 | 34,563 | 14,718 | do. 19,845 | 7% |
| 1905 | 2,486 | 143,102 | 1,711,955 | 35,314 | 15,367 | do. 19,983 | 7½% |

I must specially refer to our Wood-lane works in order to congratulate the managing and engineering staff of that station upon its successful working, which has so direct a bearing upon our increased prosperity. The cost of generating current at those works has been reduced from year to year, and I believe it is now lower than any other similar station in London. The economies which have been effected have reduced the generating costs to such an extent as to allow our taking over 200,000 additional units, whilst the total cost was £44 below that of the previous year. Notwithstanding the energetic manner in which the gas companies are working, our rate of progress continues satisfactory, and applications from new consumers show no sign of diminishing. Our area of supply continues to improve by the considerable rebuilding which is taking place, and it follows that owing to the many known advantages electric light possesses, it is being installed in place of gas. We have instituted a new tariff dealing with the supply for power, heating, cooking, &c., but your Directors have not felt justified in following the example set by several of the London companies which have reduced the charge for this class of business to a flat rate of 1d. per unit, as we feel that it will then be unprofitable. Our new scale varies from 3d. per unit for use during one hour a day, to ½d. per unit provided the maximum current is taken 20 hours per day. There is very little demand for power supply in our district owing to the few manufactories which exist, I do not anticipate that we shall require any heavy capital expenditure for the present, so that any increased profit which should accrue will allow a still higher rate of dividend to be paid to shareholders. There appears to be some alarm with regard to electric lighting prospects in London, and the unsettled state of affairs may have depreciated the value of electric lighting securities. I see, however, no serious reason for this alarm, as I feel we are quite able to cope with the competition of the gas companies; and with regard to the measures which are being brought before Parliament this session I do not think that Parliament will grant powers which would materially injure those already possessed by companies in which so many millions of money have been invested by the public on the moral understanding that they would not be interfered with. It has been suggested that the electric lighting question, as affecting London, should be referred to a Royal Commission, and I should welcome this course, as it would no doubt settle matters definitely, and prevent the continued attempts to injure the existing undertakings, which have carried out their obligations in a proper manner, and are quite ready to meet all demands for a supply of electricity and to charge a reasonable price. I now move the adoption of the report and accounts and the payment of the dividends as recommended.

Sir RICHARD B. MARTIN, Bart., seconded the motion.

In reply to questions the CHAIRMAN said: The question of the reserve has cropped up on very many occasions and the answer has been given. It is considered cheaper to invest the money in our own business and to get a considerable revenue from it—7½ per cent., we will say—than to make a call on the shareholders for money—a proceeding which might, perhaps, be inconvenient. This point has been gone into, and, after considerable thought, this plan has been adopted, and I think it has met with the approval of the shareholders on many previous occasions. As regards the founders' shares, the matter has been under discussion for some time, but I think there are certain difficulties, which, however, may be got over. At present I do not think there is any intention of doing anything.

The resolution was then carried unanimously.

The retiring directors and auditors having been re-elected, a cordial vote of thanks to the chairman, directors and staff terminated the proceedings.

## Kensington & Knightsbridge Electric Lighting Co. (Ltd.)

The ordinary meeting was held yesterday, Lieut.-Col. R. E. CROMPTON, C.B., presiding.

Mr. R. S. ERSKINE (the secretary) read the notice calling the meeting.

The CHAIRMAN said: Gentlemen, although we continue to pay the 10 per cent. dividend, the directors, as you will see, do not this year propose to add the bonus which has been distributed for two years past. I have already, in my annual review of the accounts, twice pointed out to you that, in the nature of our business, there must be considerable fluctuations in our earning power, and that each reduction in price which we find it is advisable from time to time to give to the public will be naturally followed by a temporary reduction in the net revenue of the year following the reduction. This has been the case during the year under review, and has unfortunately coincided with several considerable increases in our expenditure, which are temporary and are not likely to recur. During the year, although we sold a quarter of a million units in excess of our output of 1904, owing to the fact that we have reduced our price to the public by approximately 6 per cent., the total gross income we have received is less than last year, and on the other side of the account, as mentioned above, our outgoings have increased, so that, including the sums allowed for depreciation, the total outgoings work out at £51,715, as against £50,184 in 1904, and for this reason the balance we are able to carry to net revenue account is £2,307 less than that of last year. We should have had little or no decrease in the sum received from the sale of electricity if it had not been that during this year the work of the contractors on the underground railways in our district has been reduced to such an extent that we have lost a considerable output, which during the previous years we had sold to them for power purposes, and we have not yet had time to make up for this loss in other directions.

Apart from these temporary fluctuations in the demand, the general increase in our output caused by reductions in prices and improvement in the district is going on in a satisfactory manner, and, we think, will continue to do so. During this year we, in common with other electric supply companies, have issued a circular to our public stating that we are prepared to supply them with electricity for heating, cooking and power purposes at the extremely low price of 1d. per unit, and we believe that at no distant period we shall by this means secure a satisfactory day load, and so get a largely increased output from our plant without a corresponding increase in the cost of producing the electricity. Turning to the other side of the account, the exceptional items of cost which I have above referred to are the following: That of generating the electricity itself has not been so low as we had hoped it would be, owing to the large fraction of our supply which we take from the joint works at Wood-lane having been produced approximately at the same cost as last year, but we hope in future years to see this part of the cost considerably lowered. But in regard to those items of the account which are directly under our control, I am glad to point out that we have succeeded in distributing an output a quarter of a million units greater than last year at practically no increase in salaries and wages. The sum spent on repairing and maintaining our plant and keeping it in all respects up to date is a large one. We have spent this advisedly, pursuing the policy which we have followed throughout of making every repair and renewal of each portion of our plant in turn so complete that it becomes practically as good as new. We believe the shareholders will agree with us and support our policy of maintaining our plant to the high standard that we have always laid down for our guidance as necessary to efficiency. On management expenses about £1,000 additional has been spent, and the year shows a heavy increase on law and Parliamentary expenses. We have written off £346 from the balance of the South Kensington order, and have provided the usual sum for renewals and maintenance of buildings, plant and mains, from which, after having deducted the sum spent on repairs, we have carried the sum of £5,376 to the credit of our renewal account, which is thereby brought up to the very substantial figure of £57,670, equal to 16 per cent. on our present capital expenditure. Turning to the last matter referred to in the report—*i.e.*, the remuneration of the directors, as the question has been raised by the action of one of your shareholders, the directors think it best to set the case out fully in the report and in a letter which has been addressed to the ordinary shareholders, and they now leave the matter in your hands for settlement. I now move the adoption of the report and accounts.

Mr. R. W. WALLACE, K.C., seconded the motion, which, after a brief discussion, was carried and the dividend declared.

The retiring director (Mr. R. W. Wallace, K.C.) and the retiring auditors were re-elected.

On the question of the confirmation of the increase of the directors' fees to £1,750 per annum, Mr. H. J. MAKINS moved an amendment, which was defeated on a show of hands, and a poll demanded. The original resolution was then carried, and a poll demanded. The result of the poll was that the amendment was defeated, there being only 209 votes for it and 1,522 against. The original resolution was then carried by a corresponding majority.

**BROMPTON & KENSINGTON ELECTRICITY SUPPLY CO. (LTD.)**—The balance profit for 1905 is, with the amount brought forward, £35,924. Deducting interest and interim dividends the directors recommend that £8,000 be placed to depreciation, that the final preference dividend and a dividend on the ordinary shares at the rate of 11 per cent. (making 10 per cent. for year) be declared, leaving £8,684 to be carried forward.

**CROSSLEY BROS. (LTD.)**—Mr. H. D. Irwin stated at the meeting on Wednesday that the year just passed had been a very difficult one. They had to face a drop in prices and greatly increased competition. The gas plant works had done well, and they had doubled their area since last year. They were making a new departure in large power gas engines working with their own gas-producer plant and increasing their output of vertical engines to meet the demand of electrical engineers for that class of engine.

**PEARSON FIRE ALARM (LTD.)**—At the meeting on Monday, the chairman (Mr. Walter Chamberlain, J.P.), gave an account of the progress of the company, and stated that numerous agencies and branches had been established throughout the country, and they had also connected up their installations, or had permission to do so, with a great many of the chief fire brigade stations. After nearly three years of strenuous work they had obtained the recognition of the highest fire insurance authorities of the United Kingdom.

**SCARBOROUGH ELECTRIC SUPPLY CO. (LTD.)**—The report for 1905 states that electrical energy has been taken by the tramway company during the year beyond the minimum figure agreed upon. The receipts for lighting had suffered from a bad season in the town, and also from the reduced scale of charges. Capital outlay during 1905 was £4,636, against £16,368 for 1904. After placing £1,000 to depreciation the balance is £4,909, and the directors recommend a dividend at the rate of 5 per cent. for the year.

**SMITHFIELD MARKETS ELECTRIC SUPPLY CO. (LTD.)**—Presiding at the meeting on Friday, Mr. H. S. Leon said the adoption of automatic stokers would not only reduce the smoke nuisance, but effect a considerable saving in working expenses. The cost of generating had been reduced by ¼d. per unit, which had gone to benefit their customers. A dividend of 4 per cent. was declared, and the chairman announced that the board would, in the near future, consider what provision was to be made for the year 1913, when the contract with the Corporation for the supply of electric light to the markets would come to an end.

**SOUTH METROPOLITAN ELECTRIC LIGHT AND POWER CO. (LTD.)**—Mr. H. St. J. Winkworth stated at the meeting on Monday that the lamp connections had increased by 17,283 8 c.p., which, with the exception of last year, when the Crystal Palace area was taken over, was the largest increase they had had, and brought the total 8 c.p. equivalents to 125,674. The number of consumers had increased to 2,858, and the net revenue £16,574 to £22,131. The directors recommended a final dividend of 2½ per cent. on the ordinary shares. Negotiations are proceeding for several extensions of existing orders and other large contracts for power, which render necessary additions to their generating machinery. The Company's new power house combines all the most up-to-date improvements. The managing director (Mr. H. W. Bowden) referred to the power bills, and claimed that it could not be said of the company that it had not cultivated a power demand. The units sold for power in 1904 were 38·5 per cent. of the total (for the northern area about 50 per cent.), and for last year 40·5 per cent. That was the highest percentage of any London company, exclusive of the special supply given by two companies for the London County Council tramways. They had negotiations pending for nearly 1,000 kw., part of which would be for new consumers, part for extensions to existing installations and part for supply in bulk (under their 1903 Act) at the boundary. In addition they had been asked to quote for a supply of 1,000 kw. to two consumers, making a total of 2,000 kw. The board had decided to extend the present station. Having this object in view, he had visited several stations, and it had been decided to extend on the lines of the new St. Denis power house, Paris, which was, he believed, one of the very latest and most up to date, erected for the purpose of supplying cheap electric energy for the Metropolitan Railways of Paris, and to afford a supply in bulk to the electric lighting stations as their concessions run out. The first instalment for their new building was two 1,500 kw. turbo-generators, and the next instalment should be two 3,500 kw., making a total of 10,000 kw. That would complete the first portion, or north section, of a 30,000 kw. (normal) power-house having a maximum of 60,000 H.P. The capital cost for the first instalment—namely, two 1,500 kw.—was about £16 per kw., which included two 42 in. river circulating water pipes sufficient for the first portion—namely 10,000 kw.—for which the capital cost will be approximately £11 per kw. For the combined stations the comparison was as follows per unit sold:—Coal for 1905 was 0·54d. against 0·7d. in 1904; works cost, 0·85d. against 1·06d.; total costs, 1·48d. against 1·8d.; the efficiency of distribution was 80 per cent. against 72 per cent.

**SOUTH WALES ELECTRICAL POWER DISTRIBUTION CO.**—The directors' report for 1905 states that the revenue from sale of current and meter rents was £11,413; the horse-power connected to Dec. 31 was 6,139. Customers are slow in getting their arrangements completed, and, consequently, in getting connected to the mains. There is, however, a steady increase going on. Up to the end of the year some of the company's largest and most important consumers had not commenced to take supply. Among the larger consumers in this position are Locket's Merthyr Collieries, at Mardy (399 H.P.), D. Davis & Sons, Ferndale (1,463 H.P.) and at Bodringallt (80 H.P.), Gt. Western Colliery Co., Pontypridd (267 H.P.), Penrikyber Navigation Colliery Co. (680 H.P.) and Tirpentwys Steam Coal Co. (525 H.P.) These have all actually ordered the complete electrical equipment necessary for electric driving. The generating plant which the company have in position and in actual working order, together with two engines of 1,250 H.P. each, which are now about to be delivered, is sufficient to deal with a total of some 16,000 H.P. connected. It is generally found that at a maximum not more than half of the horse-power connected is at work at any one time. At present the revenue is at the rate of £2. 10s. per annum per horse-power connected to the mains. In order to meet the prospective and ever-increasing demand for power it has been found necessary to spend a larger amount of capital than was expected a year ago, and further extensions will from time to time be needed to authorise the creation and issue of further capital for the purpose of the Carmarthenshire undertaking and for the general purposes of the company.

**YORKSHIRE ELECTRIC POWER CO.**—At the meeting on Tuesday the chairman (Mr. Arnold G. Lupton) said that more than half the capital expenditure to date was on mains, and the remainder was for equipment and sub-stations. The company had now given a supply for one year, and at first customers had waited to instal their motors until the mains had been brought to the doors. Accordingly, for the first half-year the sales of current amounted to only £149. In the third quarter of the year, however, the amount was practically doubled, and in the fourth quarter it was doubled again. The number of consumers was increasing, and one of the most hopeful signs was that customers who took the power at first tentatively were now increasing the number of their motors. Local authorities had been afraid of the company, as though something was to be taken from them, but he thought that that fear was now being overcome, and that the authorities were realising that under the large scale on which the company worked they could obtain better facilities than they could provide for themselves. With the exception of the third set of turbines their generating station was now practically complete. The contractors had tendered for 4,500 kw., but instead of that they could safely rate the capacity at 6,000 kw.

## NEW COMPANIES, STATUTORY RETURNS.

### NEW COMPANY.

**LIMIA CO. (LTD.)** (87,734.)—Reg. Feb. 24, capital £10,000 in £1 shares, to acquire and take over the concession granted by the King of Spain to Doña Carlota Partington y Cárcer, Marquesa de Longueville for the reclamation of certain lands in the valley of the River Limia (Orense, Spain) and for the installation of electric generating plant for supplying electrical energy for traction and industrial purposes in the province of Orense, and to carry on the business of constructors of roads, railways, tramways and other works, electricians, engineers, manufacturers of and dealers in electrical apparatus. First directors, T. Greehill, L. E. Chagniat, A. L. Lambert, T. F. Turner, A. Ireland, T. M. de Bingham and H. H. Sims. Reg. office, 11, Queen Victoria-street, London, E.C.

### STATUTORY RETURNS.

**BATH & DISTRICT LIGHT RAILWAY CO. (LTD.)**—Return to Dec. 31 gives capital as £225,000 in £1 shares, of which 11,270 have been taken up and paid for in full. Mortgages and charges nil.

**BRITISH RAILWAY TRAFFIC & ELECTRIC CO. (LTD.)**—The capital is given in return to Jan. 11 as £100,000 in £1 shares, of which 60,000 have been taken up. £1 per share has been called up on 7, 10s. per share on 5,000 and 6s. per share on 54,993 shares, and £19,004. 18s. has been received. Mortgages and charges nil.

**BRYANT TRADING SYND. (LTD.)**—Return to Jan. 13 gives capital as £25,000 in 20,000 ordinary and 5,000 preference shares of £1 each, of which 17,252 ordinary and 60 preference have been taken up. £1 per share has been called up on 13,812 shares and £10,779. 11s. has been received, leaving £3,032. 9s. in arrears. 3,500 shares are considered as fully paid. Mortgages and charges, £2,389. 13s. 4d.

**GARDNER ELECTRIC DRILL & RAMMER CO. (LTD.)**—According to return to Jan. 14 capital is £40,000 in £1 shares, all of which have been taken up. £2,000 has been received and £38,000 is considered as paid. Mortgages and charges nil.

**GENEVA TRAMWAYS CO. (LTD.)**—The capital in return to Dec. 29 is £850,000 in £1 shares, all of which have been taken up. £2,507 has been received and £847,493 is considered as paid. Mortgages and charges £889,692. 7s. 9d.

**NATIONAL ELECTRIC ENGINEERING CO. (LTD.)**—According to return to Dec. 30 capital is £5,000 in £1 shares, of which 2,659 have been taken up. £654 has been received, and £2,005 is considered as paid. Mortgages and charges nil.

**SIMPLEX STEEL CONDUIT CO. (LTD.)**—In return to Feb. 7 capital is £25,000 in £1 shares, all taken up and paid for in full. Mortgages and charges nil.

**THOMPSON, RITCHIE & CO. (LTD.)**—Return to Dec. 31 gives capital as £5,000 in 200 preference and 300 ordinary shares of £10 each, of which 200 preference and 140 ordinary have been taken up. £10 per share has been called up on 170 shares, and £1,700 has been received. 170 shares are considered as fully paid. Mortgages and charges £1,900.

## CITY NOTES.

**MEMORANDA** (March 1).—Bank rate 4 per cent. (since Sept. 28, 1905). Price of silver $30\frac{7}{16}$d. per oz. Consols $89\frac{13}{16}$—$89\frac{15}{16}$ for money, $90\frac{1}{8}$—$90\frac{1}{4}$ for account; $2\frac{1}{2}$ per cent. annuities $89\frac{1}{8}$—$89\frac{3}{8}$ (x.d.). Consols Pay Day, April 4. Stocks and Shares Continuation Days, March 7 and 26; Ticket Days, March 8 and 27. Pay Days, March 9 and 28; Mining Share Carry-over Day, March 6.

**CANADIAN PACIFIC RAILROAD CO.**—The directors intend to commence at an early date experiments in electric haulage. The board have under consideration the question of converting their Quebec-Montreal line to electric traction and subsequently other lines also. It is proposed to obtain electrical energy from Shawinigan Falls, and if electric traction be decided upon for the eastern end of the system power will be obtained from Niagara. In any case, it is probable that electricity will be adopted for the eastern urban passenger traffic of the C.P.R. The company already own an electric street railway between Galt and Waterloo (Ont.).

**CITY OF CARLISLE ELECTRIC TRAMWAYS CO. (LTD.)**—A dividend of $1\frac{1}{4}$ per cent. has been declared.

**CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)**—The transfer books and register of members are closed from Feb. 28 to March 14 inclusive.

**COUNTY OF DURHAM ELECTRICAL POWER DISTRIBUTION CO. (LTD.)**—A dividend of 4 per cent. has been declared on the ordinary shares.

**COUNTY OF LONDON ELECTRIC SUPPLY CO. (LTD.)**—After placing £2,000 to revenue for depreciation, and carrying forward over £4,000, the directors recommend a final dividend on the ordinary shares at the rate of 6 per cent. per annum, less tax, for the half-year ended Dec. 31, making 5 per cent. for the year. The transfer books and register of members will be closed from 2nd to 12th inst. inclusive, preparatory to payment of dividends on the ordinary and preference shares.

**DICK, KERR & CO. (LTD.)**—At a special meeting last week the resolution for the subdivision of the £5 preference and £5 ordinary shares into shares of £1 each was confirmed.

**LONDON UNITED TRAMWAYS (1901) (LTD.)**—The gross receipts during 1905 were £301,350. 4s., and working and general expenses and renewals £175,313. 14s. 1d., leaving (with balance forward) a net revenue of £126,600. 1s. 2d. After payment of interest and yearly preference dividend, there remains £30,447. 1s. 2d. Allowing for interim dividend paid in August the available balance is £18,234. 8s. 3d. It is proposed to pay a final dividend on the ordinary shares for the half-year ended Dec. 31 at the rate of 2 per cent. (less tax) (making 3 per cent. for the year), to place £10,000 to reserve, and to carry forward £1,116. 0s. 6d. Gross receipts show an increase of £5,114. 12s. 10d., whilst operating expenses have decreased by £874. 11s. 9d. The total number of passengers carried was 49,157,139, an increase of 1,030,412. Since the last meeting the construction of the authorised tramways in Kingston, Surbiton and New Malden, and between Brentford and Hanwell, has been undertaken. The works are practically complete, and it is anticipated that the lines will be

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. No. of weeks | Aggregate. Amount. | Aggregate. Inc. or Dec. (a) |
|---|---|---|---|---|---|---|
| | | £ | £ | | £ | £ |
| **Aberdeen Corporation** | Feb. 21 | 1,135 | + 57 | 39 | 53,296 | − 841 |
| **Airdrie** | ,, 16 | 206 | + 12 | 7 | 1,485 | + 145 |
| Anglo-Argentino | ,, 25 | 14,651 | + 1,506 | 8 | 116,980 | + 11,922 |
| **Ayr Corporation** | ,, 24 | 178 | + 12 | 39 | 11,813 | − 95 |
| **Barnsley** | ,, 16 | 152 | − 6 | 7 | 999 | + 7 |
| **Barrow** | ,, 16 | 198 | + 10 | 7 | 1,329 | + 127 |
| **Bath Electric Trams, Ltd.** | ,, 21 | 515 | + 84 | 8 | 4,992 | + 727 |
| Birkenhead Corporation | ,, 25 | 917 | + 24 | 8 | 8,103 | + 1 |
| **Birmingham Corporation** | ,, 24 | 388 | + 46 | 47 | 17,580 | + 2,233 |
| ***Birmingham & Mid.** | ,, 16 | 1,316 | − 449 | 7 | 8,967 | − 2,592 |
| **Blackpool Corporation** | ,, 22 | 832 | + 22 | 8 | 47,894 | + 2,0[illegible]0 |
| **Blackpool and Fleetwood** | ,, 24 | 190 | + 12 | 8 | 1,411 | − 34 |
| **Bolton Corporation** | ,, 25 | 1,750 | + 184 | 48 | 91,492 | + 4,654 |
| **Bournemouth Corporation** | ,, 26 | 1,308 | + 469 | †47 | 65,956 | + 15,414 |
| **Bradford Corporation** | ,, 24 | 3,977 | + 421 | 47 | 203,918 | + 2,579 |
| **Brighton Corporation** | ,, 25 | 714 | + 48 | 43 | 46,659 | + 478 |
| **Bristol Trams & Carriage** | ,, 23 | 4,657 | + 571 | 2 | 9,214 | + 517 |
| **Buenos Ayres & Pelgrano** | ,, 25 | 3,256 | + 174 | 8 | 27,834 | + 2,579 |
| Buenos Ayres Elec. Trms | Jan. 27 | 1,373 | ... | 4 | 5,567 | ... |
| **Burnley Corporation** | Feb. 24 | 1,046 | + 161 | 47 | 61,002 | + 3,380 |
| **Burton Corporation** | ,, 25 | 247 | − 27 | §47 | 14,368 | − 1,691 |
| **Bury Corporation** | ,, 18 | 789 | ... | §46 | 34,959 | ... |
| **Calcutta Tramways Co.** | ,, 24 | R43,651 | + R4,287 | 8 | R360,826 | + R45,509 |
| **Camborne-Redruth** | ,, 24 | 94 | ... | 17 | 1,803 | ... |
| Cardiff | ,, 17 | 1,608 | − 39 | 47 | 95,475 | + 211 |
| | ,, 24 | 1,832 | + 147 | | | |
| **Carlisle Tramways Co.** | ,, 24 | 146 | − 17 | 8 | 1,258 | − 107 |
| Cavehill | ,, 16 | 60 | + 12 | 7 | 220 | − 21 |
| **Central London Railway** | ,, 24 | 7,017 | − 231 | 8 | 56,765 | − 1,874 |
| **Chatham & Dist. Lt. Rys.** | ,, 22 | 631 | − 33 | †8 | 4,370 | − 57 |
| ***City of Birm'gh'm Tram Co** | ,, 16 | 5,675 | − 317 | 7 | 34,547 | − 582 |
| **City & South London Rly.** | ,, 25 | 9,978 | − 20 | 8 | 24,182 | + 188 |
| **Colchester Corporation** | ,, 22 | 156 | + 5 | 28 | 5,475 | − 1,495 |
| **Cork Electric Trams Co.** | ,, 22 | 394 | + 19 | †8 | 3,110 | − 87 |
| **Devonport & Dist. Trams** | ,, 16 | 380 | − 44 | 7 | 2,751 | − 178 |
| **Dover Corporation** | ,, 24 | 165 | + 8 | ‡47 | 10,489 | + 71 |
| **Dublin & Lucan Railway** | ,, 23 | 89 | − 2 | §8 | 669 | − 70 |
| **Dublin United** | ,, 23 | 4,456 | + 802 | ‡8 | 35,164 | + 1,229 |
| **Dudley—Stourbridge** | ,, 16 | 716 | − 25 | 7 | 4,946 | + 260 |
| **Dundee Corporation** | ,, 21 | 951 | + 174 | §40 | 37,755 | + 3,225 |
| **East Ham Council** | ,, 24 | 768 | + 139 | 47 | 38,767 | + 5,417 |
| **Gateshead & Dist. Trams** | ,, 16 | 597 | + 36 | 7 | 6,145 | + 862 |
| **Glasgow Corporation** | ,, 24 | 15,039 | + 1,553 | 39 | 592,495 | + 38,907 |
| Glossop | ,, 24 | 122 | + 26 | 8 | 976 | + 149 |
| **Gloucester Corporation** | ,, 23 | 221 | + 12 | 48 | 13,444 | + 1,166 |
| **Gravesend—Northfleet** | ,, 16 | 192 | + 6 | 7 | 1,304 | + 74 |
| **Gt. Northern & City Rly.** | ,, 25 | 1,853 | + 88 | 8 | 14,472 | + 316 |
| **Greenock & Port Glasgow** | ,, 16 | 594 | + 41 | 7 | 3,787 | + 351 |
| **Halifax Corporation** | ,, 21 | 1,382 | + 205 | 47 | 72,797 | + 6,305 |
| **Hartlepool Tramways** | ,, 16 | 243 | + 13 | 7 | 1,692 | + 101 |
| Hastings Elec. Trams Co. | ,, 22 | 335 | ... | 8 | 2,816 | ... |
| **Huddersfield** | ,, 24 | 1,287 | + 173 | 47 | 64,027 | + 3,684 |
| **Hull Corporation** | ,, 24 | 2,126 | + 135 | 47 | 104,796 | + 2,188 |
| Ilford Dist. Coun. | ,, 21 | 577 | + 31 | 47 | 21,826 | + 981 |
| **Ipswich Corporation** | ,, 24 | 509 | + 6 | 47 | 19,733 | − 1,895 |
| **Isle of Thanet Co.** | ,, 24 | 238 | + 8 | 20 | 5,399 | − 486 |
| **Kidderminster & District** | ,, 16 | 87 | − 5 | 7 | 600 | − 1 |
| Kilmarnock Corporation | ,, 21 | 135 | + 4 | 41 | 6,388 | ... |
| **Kirkcaldy Corporation** | ,, 21 | 192 | + 4 | 25 | 4,889 | − 93 |
| **Lanarkshire Trams Co.** | ,, 22 | 865 | + 260 | †3 | 6,557 | + 1,562 |
| **Leamington** | ,, 16 | 115 | + 25 | 7 | 855 | + 215 |
| **Leeds Corporation** | ,, 24 | 5,532 | + 291 | 48 | 281,152 | + 8,848 |
| **Leicester Corporation** | ,, 24 | 1,950 | + 223 | 8 | 15,610 | + 2,118 |
| Leith Corporation | ,, 17 | 416 | + 202 | 39 | 11,465 | + 10,786 |
| **Liverpool Overhead Rly.** | ,, 25 | 1,366 | − 43 | 8 | 11,098 | − 651 |
| Liverpool Corporation | ,, 17 | 9,995 | + 223 | 7 | 70,273 | + 2,483 |
| ***London County Council** | ,, 17 | 18,393 | + 515 | 46 | 675,178 | + 68,565 |
| **Lowestoft** | ,, 24 | 107 | − 18 | 21 | 2,920 | − 43 |
| **Maidstone Corporation** | ,, 22 | 76 | − 15 | 48 | 5,595 | ... |
| **Manchester Corporation** | ,, 24 | 12,884 | + 1,375 | 47 | 608,401 | + 50,552 |
| **Merthyr** | ,, 16 | 169 | − 10 | 7 | 1,145 | − 12 |
| Metropolitan Dist. Railway | ,, 25 | 8,835 | + 548 | 8 | 65,178 | + 8,661 |
| ***Metropolitan Elec. Trams** | ,, 16 | 2,608 | + 629 | 7 | 18,220 | + 5,538 |
| **Middleton** | ,, 16 | 254 | − 15 | 7 | 1,840 | + 124 |
| **Nelson Corporation** | ,, 24 | 125 | + 29 | 48 | 6,268 | + 707 |
| **Newcastle-on-Tyne Corp.** | ,, 24 | 3,603 | − 12 | 47 | 178,685 | + 4,444 |
| **Newport (Mon.)** | ,, 24 | 519 | + 76 | 21 | 11,462 | + 904 |
| Northampton Corporation | ,, 23 | 840 | + 18 | 47 | 19,853 | + 5,259 |
| **Oldham, Ashton & Hyde** | ,, 16 | 483 | − 8 | 7 | 3,865 | + 143 |
| **Oldham Corporation** | ,, 25 | 1,486 | + 168 | 48 | 77,993 | + 17,667 |
| Perth (N.B.) Corporation | ... | ... | ... | ... | ... | ... |
| **Perth (W. A.) Elec Trams** | ,, 23 | 1,467 | + 19 | ¶3 | 12,370 | + 588 |
| **Peterborough** | ,, 16 | 93 | − 10 | 7 | 612 | − 27 |
| Pontypridd Dist. Council | ... | ... | ... | ... | ... | ... |
| Portsmouth Corporation | ,, 24 | 1,308 | + 45 | 47 | 50,189 | + 1,705 |
| **Potteries** | ,, 16 | 1,698 | + 82 | 7 | 11,562 | + 718 |
| Preston Corporation | ,, 21 | 596 | + 100 | 7 | 4,078 | ... |
| **Reading Corporation** | ,, 22 | 524 | + 15 | ... | ... | ... |
| **Rotherham Corporation** | ,, 22 | 426 | + 44 | 47 | 21,847 | − 109 |
| **Rothesay** | ,, 16 | 58 | − 2 | 7 | 843 | + 43 |
| **Salford Corporation** | ,, 23 | 3,967 | + 368 | 48 | 203,545 | + 11,922 |
| **Sheerness** | ,, 14 | 45 | − 10 | 7 | 318 | − 29 |
| **Sheffield Corporation** | ,, 25 | 4,829 | + 531 | 48 | 236,911 | + 14,201 |
| **Southampton Corporation** | ,, 21 | 821 | + 58 | 20 | 17,721 | + 17 |
| **Southend Corporation** | ,, 21 | 2[illegible]5 | + 7 | 47 | 17,187 | + 1,011 |
| **Southport Tramways** | ,, 16 | 210 | − 29 | 7 | 1,518 | + 42 |
| **S. Staffordshire Trams.** | ,, 16 | 773 | + 100 | 7 | 5,095 | + 855 |
| **Stockport Corporation** | ,, 23 | 767 | + 318 | 47 | 35,723 | + 10,240 |
| Sunderland Corpn. | ,, 25 | 1,176 | + 101 | 47 | 61,896 | + 2,888 |
| **Swansea Trams** | ,, 16 | 706 | + 230 | 7 | 4,778 | + 1,759 |
| **Swindon Corporation** | ... | ... | ... | ... | ... | ... |
| Taunton | ,, 16 | 39 | + 1 | 7 | 260 | + 16 |
| **Tynemouth and District** | ,, 16 | 145 | − 19 | 7 | 1,067 | − 56 |
| **Tyneside Trams Co.** | ,, 14 | 336 | + 8 | 7 | 2,185 | + 45 |
| **Wallasey District Council** | ,, 24 | 663 | + 61 | 47 | 36,241 | + 1,528 |
| **Warrington Corporation** | ,, 22 | 839 | + 50 | 47 | 16,074 | + 1,064 |
| **West Ham Corporation** | ,, 22 | 1,831 | + 782 | 46 | 86,351 | + 37,162 |
| **Weston-super-Mare** | ,, 14 | 22 | − 6 | 7 | 167 | − 8 |
| Wolverhampton Corpn. | ... | ... | ... | ... | ... | ... |
| ***Wolverhampton District** | ,, 15 | 376 | + 29 | 7 | 2,437 | + 191 |
| **Worcester** | ,, 16 | 225 | − 29 | 7 | 1,558 | − 79 |
| **Wrexham** | ,, 16 | 80 | − 15 | 7 | 608 | − 10 |
| Yorkshire W.R. Trams | ,, 25 | 736 | + 215 | 8 | 5,203 | + 1,655 |
| Yorkshire Woollen District | ,, 16 | 770 | + 207 | 7 | 5,412 | + 1,896 |

(a) These comparisons are with the corresponding period last year. † Minus 8 days. ‡ Minus 2 days. § Plus 2 days. ¶ Plus 8 days. * Partly electrical.

opened for traffic on March 1. (The opening of these lines is referred to on page 785). The directors intend to proceed immediately with the construction of the tramways from New Malden to Wimbledon, Merton and Tooting.

**METROPOLITAN ELECTRIC SUPPLY CO. (LTD.)**—The directors recommend a final dividend for 1905 of 5s. per share on the ordinary shares, making 10s. for the year, or 10 per cent., the carry forward being £2,219.

**NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY CO.**—The directors recommend a further dividend of 5½ per cent., making 8 per cent. for 1905.

**STOCK EXCHANGE NOTICES.**—The Stock Exchange Committee have appointed March 8 a special settling day in £41,978 4½ per cent. first mortgage debenture stock, and March 9 a special settling day in £108,022 scrip for 4½ per cent. first mortgage debenture stock (fully and partly paid) of *W. T. Henley's Telegraph Works Co. (Ltd.)*, and have ordered same to be quoted. The Committee have also appointed March 14 a special settling day in 317 £1,000 shares (£200 paid) of the *Shanghai Electric Construction Co. (Ltd.)*, and have granted a quotation to 10,000 £5 fully-paid ordinary shares of the *United River Plate Telephone Co. (Ltd.)* The Committee have been asked to appoint a special settling day in 7,362 £1 fully-paid 6 per cent. cumulative preference shares of the *Sir Hiram Maxim Electrical Co. (Ltd)*, and to allow a further issue of 5,000 £5 fully-paid ordinary shares of the *Chelsea Electricity Supply Co. (Ltd.)* to be quoted.

**VICKERS, SONS & MAXIM (LTD.)**—The directors recommend a final dividend of 2s. per share, tax free, on the ordinary shares, making, with interim dividend, 15 per cent. for the year.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Feb. 28. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Feb. 28. Highest. | Business, Week to Feb. 28. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | £ s. d. | | | |
| 5 | 8/0 | Anglo-Argentine Ord. Shares | $8\frac{13}{16}-8\frac{15}{16}$ | 4 8 0 | Ap, Oct | $9\frac{1}{32}$ | 8⅞ |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞—6⅛ | 4 10 0 | — | $6\frac{3}{32}$ | 6 |
| St. | 6% | Do. Permanent 6% Deb. Stock | 141—144 | 4 3 3 | — | 142½ | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 104—106 | 4 14 3 | — | 105¼ | 105 |
| 5 | .. | Brisbane Electric Trams. Invest Ord. | 1—1½ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 3⅞—4⅛ | 6 1 4 | — | [illegible] | $4\frac{1}{16}$ |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 13—16 | 4 13 9 | — | .. | .. |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 120—123 | 4 17 6 | — | [illegible]2½ | .. |
| St. | 5% | Do. Pref. Ord. Stk | 110—113 | 4 8 4 | — | 111 | .. |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock | 108—111 | 4 10 0 | — | . | — |
| 4[illegible] | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%—105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 102—105 | 4 5 0 | — | 104¾ | [illegible] |
| [illegible] | 2/6 | Buenos Ayres and Belgrano Ord. | 1⅝—2⅞ | 5 3 0 | — | [illegible] | [illegible] |
| [illegible] | 8/0 | Do. 6 per Cent. "A" Cm. Pref. | 5⅝—6⅛ | 4 18 0 | — | 5⅞ | .. |
| [illegible] | 8/0 | Do. "B" | 5¼—5¾ | 5 4 0 | — | .. | .. |
| St. | 5% | Do. 5 per Cent. Debs. | 105—107 | 4 13 6 | — | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102—105 | 4 15 0 | — | .. | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 99—101 | 4 19 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 102—106 | 5 4 3 | .. | .. | .. |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 102—106 | 5 13 0 | .. | .. | .. |
| [illegible] | 8/6 | Calcutta Tramways (Nos. 1 to 105) | 9½—10 | 4 5 0 | — | [illegible] | [illegible] |
| 5 | 2/6 | Do. Nos. 105,001 to 137,610 | 9—9½ | .. | .. | .. | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 105—107 | 4 4 8 | — | .. | .. |
| 1 | 0/6 | Cape Electric Tram Shares | ⅝—⅞ | 5 14 0 | — | ¾ | — |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 102—104 | 4 16 0 | — | .. | .. |
| .. | 5% | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 96—98% | 5 2 0 | .. | 9[illegible] | .. |
| St. | .. | Kalgoorlie Elec. Trams 5% "A" Deb. Stock | 93—98 | .. | .. | .. | .. |
| St. | .. | Do. 6% "B" Ditto | 78—82 | .. | .. | .. | .. |
| 1 | .. | Lisbon Elec. Trams Ord. | $1\frac{7}{16}-1\frac{9}{16}$ | .. | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛—1⅜ | 4 7 4 | .. | . | .. |
| 100 | [illegible]% | Do. 5% Reg. Mort. Debs. | 100—103 | 4 17 0 | .. | [illegible]0½ | [illegible]1 |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 101—103 | 4 17 0 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 102—105 | 4 15 0 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102—104 | 4 6 6 | — | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 105—108 | 4 12 6 | .. | . | .. |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 146—148 | 5 8 0 | .. | .. | .. |
| .. | 5% | Do. 5% 1st Mt. $500 Dbs. | 99%—101% | 4 19 0 | .. | [illegible]0¾ | [illegible]9¾ |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| [illegible] | — | Adelaide Elec. S'ply Co. 6% Cu. Pr. | 4¾—5¼ | . | .. | . | .. |
| [illegible] | 8/8 | Calcutta Elec. (1-30,000) | 9—9½ | 4 6 6 | — | .. | .. |
| 10 | [illegible]% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50—52 | 4 16 0 | .. | .. | .. |
| .. | 5% | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 94—96 | 5 4 0 | .. | .. | .. |
| [illegible] | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½—3 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Debs. | 88—92 | 5 9 4 | — | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | 7¾—8¾ | — | — | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92—94 | 5 6 8 | .. | .. | .. |
| St. | £6/2 | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. | 109—111 | 5 8 0 | .. | 111 | 110¾ |
| 1 | 5·88d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞—1 | 6 0 0 | — | .. | .. |
| 1 | 1/0 | Rand Electric | $1\frac{5}{16}-1\frac{7}{16}$ | — | — | .. | — |
| 1 | .. | River Plate Electricity Co. Ord. | [illegible] | .. | .. | ⅝ | .. |
| 1 | 1/2⅖ | Do. 6% Non. Cum. Pref. | $1\frac{1}{8}-1\frac{3}{16}$ | .. | .. | .. | .. |
| St. | 5% | Do. 5% Deb. Stock | 101—103 | 4 17 0 | .. | 101¾ | .. |
| 5 | 8/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5½—5¾ | 5 4 4 | .. | .. | — |
| 5 | 9·23d | Do. (12,001-20,000) | 5—5½ | 3 8 0 | .. | 5½ | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100—103 | 4 7 5 | Ap, Oct | — | ... |
| .. | 5% | Shawinigan Water and Power 5% Bds., Scrip | 102—104 | 4 16 0 | .. | 103⅛ | .. |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Shre. | Last Divi-dend | Name. | Price Wed., Feb. 28. | Rate % Yield-ed. | Dividend Due | Business, Week to Feb. 28. Highest | Lowest |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | £ s. d | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12¼–12¾ | 6 8 0 | .. | .. | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10 –10½ | 4 5 9 | .. | 10⅜ | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11 –12 | 5 0 0 | .. | .. | – |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) ... | 106 –108 | 4 8 3 | .. | .. | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼–5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 103 –106 | 4 5 0 | – | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec.Sup.Ord. | 8¾–9¼ | 5 8 0 | – | .. | .. |
| 5 | 8/6 | Do. 7 per Cent. Pref. | 8½–9½ | 3 14 5 | Mar, Sept | .. | .. |
| St. | 4% | Central Elec. Sup.Co.4%Guar.Db.Stock | 102 –105 | 3 16 3 | – | 104 | 103¼ |
| 5 | 2/6 | †CharingCross(W.End&City)El.Sup.Co. | 5 –5¼ | 6 16 0 | Feb, Aug | 5 7/16 | .. |
| 5 | 2/8 | Do. 4½ per Cent. Pref. | 5 –5½ | 4 2 0 | Feb, Aug | 5 1/16 | 5 |
| St. | 4% | Do. 4% Deb. Stock (red.) | 101 –103 | 3 17 6 | – | .. | .. |
| 5 | 2/8 | Do. City Undertaking 4½% Cm. Pref. | 4½–4¾ | 4 14 9 | – | .. | .. |
| 5 | 2/8 | Do. Do. (1903) | 4½–4¾ | 4 14 9 | .. | .. | .. |
| 5 | 2/8 | Chelsea Electric Supply Ord. | 5¼–5¾ | 5 4 6 | March .. | .. | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) ... | 108 –110 | 4 1 6 | Jn, Dec .. | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 10¾–11¾ | 5 2 0 | Feb, Aug | 11 | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13¼–14¼ | 4 4 2 | Jan, July | 13½ | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 123 –126 | 3 19 4 | Jn, Dec .. | – | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 100 –102 | 4 8 3 | .. | .. | .. |
| 5 | .. | County of Durham Elec.P.D.Ord. £2pd. | 1¾–2 | .. | April, Oct | .. | .. |
| 5 | 5% | Do. Do. 5% non cum. pref. | 5¼–5⅝ | 4 13 0 | April, Oct | .. | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. .. | 8½–9½ | 4 6 6 | – | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅜–12⅞ | 4 13 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 109 –112 | 4 0 4 | .. | .. | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs.. | 101 –103 | 4 7 6 | .. | 101½ | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼–5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5 –5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101 –104 | 4 6 6 | – | – | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8¼–8¾ | 4 17 2 | .. | .. | .. |
| St. | 4½% | I.of W.Elec.Lt.&Power4½%Db.St.(red.) | 100 –103 | 4 7 5 | – | .. | – |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 9½–10½ | 6 4 0 | .. | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½–7 | 4 5 9 | Jan, July | – | – |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) .. | 98 –101 | 3 19 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg.Co.&NottingHill Co. (Joint Station) 4% Deb. Stck.(red.) | 103 –105 | 3 16 0 | .. | .. | .. |
| 3 | 1/9⅜ | London Electric Supply Ord. | 2⅝–2⅞ | 3 2 6 | .. | 2⅝ | 2 9/16 |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5⅝–5⅞ | 5 9 6 | .. | 5½ | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 98 –101 | 3 19 2 | Mr,Jn,S,D | .. | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 9 –10 | 5 0 0 | April, Oct | .. | .. |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5⅜–5⅝ | 4 0 0 | Jan. July | 5½ | 5⅜ |
| St. | 4½% | Do. 4½ per Cent.Deb. Stock 1st Mort. | 110 –114 | 3 19 0 | Jn, Dec .. | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 95 –97 | 3 12 3 | – | 95 | .. |
| 100 | 4½% | MidlandElec.Corp.for P.D.1stMort.Db. | 101 –103% | 4 7 4 | – | 102¼ | .. |
| 10 | 7½% | Newcastle & Dist.Elec.Ltg.Ord.£9 paid | 12 –12½ | 5 9 2 | Feb, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 102 –104 | 4 6 6 | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8 –8½ | 4 14 2 | Feb, Aug | .. | .. |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. .. | 6½–6¾ | 3 14 1 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99 –101 | 3 19 7 | Jan, July | .. | .. |
| 1 | 8% | Northern Counties Elec. Sup. | 15/16–31/32 | 3 2 6 | Mar, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 101 –102 | 4 7 6 | Jan, July | – | – |
| 10 | 6/0 | Notting Hill Electric Ord. | 13½–14½ | 4 16 8 | March .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98 –100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6½–7 | 5 0 0 | March .. | .. | .. |
| St. | 4% | Do. 4% Deb. Stock | 99 –101 | 3 19 0 | – | .. | .. |
| 5 | 7/6 | †St. James' & Pall Mall Elec. Ord. | 10½–11½ | 6 10 6 | Feb, Aug | 11⅛ | 11 |
| 5 | 3/6 | † Do. 7 per Cent. Pref. | 7 –8 | 4 7 0 | Feb, Aug | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) ... | 97 –99 | 3 10 9 | – | .. | .. |
| 5 | 4/0 | †Smithfield Markets Electric Sup. Ord... | 5¼–5¾ | 8 4 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76 –80 | 5 0 0 | – | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord ... | 3¼–3¾ | 5 6 8 | .. | .. | .. |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | ¾–⅞ | .. | .. | 13/16 | – |
| 1 | 0/8¾ | Do. 7% Cum. Pref. | 1¼–1⅜ | 5 2 0 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105 –108 | 4 3 8 | – | .. | – |
| 5 | 2/6 | Urban Electric Supply Ord. | 4½–4¾ | 5 5 0 | – | .. | .. |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5 –5¼ | 4 15 8 | – | 5 7/16 | – |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 104 –106 | 4 5 0 | .. | 105¾ | .. |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 10¾–11½ | 6 2 0 | Mar, Sept | 11⅛ | 10⅞ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⅜–5⅝ | 4 9 0 | .. | 5½ | .. |
| 5 | .. | Do. £1 and 7/6 premium paid | 1⅜–1½ | .. | .. | .. | .. |
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| 1 | – | Bath Elec. Trams Pref. Ord. | 15/16–1 1/16 | .. | .. | 31/32 | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1 1/16–1⅛ | 4 14 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) .. | 102 –104 | 4 6 6 | .. | 101 | 103 |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 101 –103 | 4 7 9 | .. | .. | .. |
| 10 | 9% | †Bristol Tramways and Carriage Ord. ... | 16 –17 | 5 6 0 | Feb, Aug | – | – |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10 –10¼ | 3 18 0 | .. | .. | – |
| St. | 4% | Do. 4 per Cent. Debs. | 104 –106 | 3 15 6 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 7⅜–7⅞ | 7 12 0 | – | 7 13/16 | 7 17/32 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 10 –10½ | 5 13 0 | Feb, Aug | 10 7/32 | 10⅛ |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 119 –121 | 4 2 8 | .. | 120¼ | 119 |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 98 –100 | 4 10 0 | .. | 98½ | 98¼ |
| St. | 4% | Central London Ordinary Stock | 92 –94 | 4 5 0 | June, Dec | 93⅜ | [illegible] |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 103 –105 | 3 16 0 | .. | 104½ | .. |
| St. | 4% | Do. Deferred Stock | 81 –84 | 4 15 0 | .. | 82½ | 82¼ |
| 100 | 4% | Do. 4 per Cent. Debs. | 110 –112 | 3 11 3 | .. | 111¾ | .. |
| St. | 4% | Charing X, Euston & Hmpstd. Pfr Db. Stk. | 96 –98 | 4 1 6 | .. | 96⅝ | 96 |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 5⅛–5⅜ | 4 13 0 | .. | 5 5/16 | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 101 –104 | 3 17 0 | .. | 102½ | .. |
| St. | 1¾% | City and South London Rly. Con. Ord. | 41 –43 | 4 7 0 | Feb, Aug | 42¾ | .. |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) ... | 120 –123 | 4 1 4 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 115 –118 | 4 4 8 | .. | .. | .. |
| St. | 5% | Do. (1901) | 113 –116 | 4 6 0 | – | .. | – |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 106 –109 | 3 13 4 | May, Nov | 108½ | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13¾–14¾ | 4 1 6 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½–15½ | 3 17 8 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 4½–5 | 8 0 0 | .. | 4¾ | .. |
| 10 | 4/0 | †Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8 –9 | 4 8 11 | .. | .. | .. |
| St. | 4½% | Hastings&Dist.Elec.Trams.Co.4½Db.St. | 103 –105 | 4 5 8 | .. | 104 | 103¾ |
| 10 | 9% | †‡Imperial Tramways Ord | 15½–16½ | 5 9 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 12¾–13¼ | 4 10 8 | Mar, Sept | – | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 101 –103 | 4 8 0 | Jan, July | – | – |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼–2¾ | 9 8 6 | – | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 80 –85 | 4 14 0 | – | 80 | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8 11/16–8 15/16 | 3 13 0 | Feb, Aug | .. | – |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾–10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99 –102 | 3 19 3 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9 –9½ | 5 5 0 | – | 9⅜ | 9 3/16 |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 93 –95 | 4 3 8 | – | 95¼ | 95 |
| St. | .. | Mersey Con. Ord. Stock | 7 –9 | – | – | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8 –11 | – | – | – | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 3/32–5/32 | .. | – | 7/32 | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1 –1 1/16 | 4 14 1 | – | 1 1/32 | 31/32 |
| St. | 4½% | Do. 4½% Deb. Stock | 104 –106 | 4 5 0 | – | 104½ | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½–1½ | .. | May .. | 31/32 | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8¾–9¼ | 5 5 8 | .. | .. | – |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9½–10 | 5 0 0 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103 –106 | 4 5 0 | – | – | .. |
| 100 | 5% | Sunderland Dst.Elc.Trms.5%1stMt.Db. | 93 –96 | 5 4 0 | .. | .. | .. |
| .. | 5% | Underground Elec. Rys. Co. of London | 98 –100 | 5 0 0 | .. | .. | .. |
| St. | 3¾% | †Waterloo and City Ord. | 101 –104 | 3 7 8 | June, Dec | 101 | 99 |
| St. | 4½% | Yorkshire W.R. El. Trs.Co.4½% 1st Debs. | 95 –97 | 4 13 0 | .. | 96½ | 96¼ |

| Shre. | Last Divi-dend | Name. | Price Wed., Feb. 28. | Rate % Yield-ed. | Dividend Due. | Business, Week to Feb. 28. Highest | Lowest |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC MANUFACTURING, &c.** | | £ s. d. | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝–⅞ | 5 6 6 | – | – | .. |
| 1 | 10½d. | Aron El.Met.6%Cm.Pf. | 1 7/16–1 9/16 | .. | .. | .. | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3⅞–4⅛ | 4 11 8 | .. | [illegible] | [illegible] |
| 1 | 7½d. | Do. Pref | 1 7/16–1 9/16 | 3 16 10 | .. | .. | .. |
| 5 | 4/0 | British Insulated & Helsby Cables Ord | 6½–7 | 5 14 0 | July, Feb | [illegible] | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾–6¼ | 4 16 0 | Jan, July | [illegible] | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103 –106 | 4 4 11 | .. | 104½ | [illegible] |
| St. | 4½% | British Thoms'n-Houst'n4½%1stMt.Db | 98 –100 | 4 10 0 | .. | .. | .. |
| 5 | .. | British Westinghouse 6% Pref. | 1⅞–2⅛ | .. | .. | [illegible] | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock ... | 78 –83 | 4 16 0 | .. | [illegible] | .. |
| 2 | – | Brush Electrical Engineering | ⅝–⅞ | .. | March .. | [illegible] | .. |
| 2 | 2/4⅘ | Do. 6 per Cent. Pref. Non-Cum. | 1½–2 | 6 0 0 | Mar, Sept | [illegible] | .. |
| St. | 4½% | † Do. 4½ per Cent. Perp. 1st Deb. Stock | 97 –99 | 4 11 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 82 –84 | 5 7 4 | Jan, July | .. | .. |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11 –12 | 5 0 0 | Jan, July | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5¾–6 | 4 3 4 | Jan, July | [illegible] | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs.(rd.) | 108½–110½ | .. | Nov, May | – | .. |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1 1/16–1 3/16 | 5 1 0 | .. | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 95 –100 | 4 10 0 | – | .. | .. |
| 1 | 9⅜d. | Chadburn's (Ship) Telegraph Ord. | 1⅛–1¼ | 8 0 0 | .. | .. | .. |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1 3/16–1¼ | 4 16 0 | .. | [illegible] | .. |
| 3 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) ... | 2 –2¼ | 3 9 0 | Jan, July | .. | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 96%–98% | 5 2 0 | Jan, July | [illegible] | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8¾–9¼ | 5 8 0 | Sept .. | .. | .. |
| 5 | 3/0 | Do. 6% Cum. Pref. | 6 –6½ | 4 14 0 | Sept .. | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104 –106 | 4 5 0 | .. | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.)(£3 pd.) | 1⅝–1⅞ | – | Feb, Aug | [illegible] | .. |
| 5 | 2/6 | Do. (£5 paid) | 2½–3 | .. | Feb, Aug | [illegible] | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb.Stock(rd.) | 86 –88 | 4 11 0 | June, Dec | .. | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92 –97 | 5 3 1 | .. | .. | .. |
| 5 | 2/6 | Edmundson's Elec. Corp. Ord. | 4½–5 | 7 0 0 | H'lf-yearly | [illegible] | [illegible] |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5½–5¾ | 5 4 6 | .. | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 104 –106 | 4 5 0 | .. | [illegible] | [illegible] |
| 2 | 1/7½ | Electric Construction Co. | ½–¾ | 9 6 0 | July .. | [illegible] | .. |
| 2 | 2/9⅗ | Do. 7 per Cent. Cum. Pref | 2 –2½ | 5 12 0 | July .... | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 89 –92 | 4 7 0 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref... | 9¼–9¾ | 5 4 6 | .. | [illegible] | [illegible] |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 95 –99 | 4 1 0 | – | [illegible] | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 13 –14 | 5 7 0 | Feb, Aug | [illegible] | [illegible] |
| 5 | 2/3 | † Do. 4½ per Cent. Pref. | 5¼–5½ | 4 2 0 | Feb, Aug | .. | .. |
| 10 | 15/0 | India Rubber, Gutta Percha, &c., Wrks. | 18 –19 | 2 12 6 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99 –102 | 3 18 5 | Mar, Sept | .. | .. |
| 10 | 5/0 | †Mather & Platt 5 per Cent. Cum. Pref. | 11¾–12¼ | 4 1 8 | Mar, Sept | .. | .. |
| 1 | 1/2⅖ | Richardsons, Westgarth & Co., Ltd. Ord. | ⅞–1 | 6 0 0 | .. | [illegible] | 1 |
| 1 | 7⅕d. | Do. 6% Cum. Pref. | 1 –1⅛ | 5 7 6 | .. | .. | .. |
| St. | 4½% | Do. 4½% Perp. Deb. Stock | 100 –102 | 4 8 3 | .. | [illegible] | [illegible] |
| 12 | 12/6 | Telegraph Construction & Mainten'ce. | 34 –36 | 5 0 0 | Mar, July | [illegible] | [illegible] |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 ... | 100 –102 | 3 18 6 | Jan, July | [illegible] | [illegible] |
| 1 | 1/0 | Vickers, Sons & Maxim, Ltd., Ord. | 2 1/16–2 3/16 | 4 8 10 | .. | [illegible] | .. |
| 1 | 6d. | Do. 5% Non-Cum. Preference | 1 3/16–1 5/16 | 3 13 0 | .. | [illegible] | .. |
| St. | 5% | Do. 5% Non-Cum. Preferred | 122 –126 | 4 0 0 | – | .. | .. |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock Red. .. | 105 –107 | 3 14 8 | .. | [illegible] | .. |
| 100 | 4½% | Do. 4½% 2nd Mort. Debs., Red | 106 –108 | 4 3 8 | .. | [illegible] | .. |
| 5 | – | Willans and Robinson Ord. | 2½–2¾ | – | Apr, Oct | [illegible] | .. |
| 5 | – | Do. 6 per Cent. Cum. Pref. | 4 –4½ | – | Apr, Oct | [illegible] | .. |
| .. | 4% | Do. 4 per Cent. 1st Mort. Debs. .... | 82 –87 | 4 12 0 | May Nov | [illegible] | .. |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | *African Direct Tel. 4% Mrt. Deb. (red.) | 98½–101½ | 3 18 6 | Jan, July | .. | .. |
| 10 | – | Amazon Telegraph | 3¾–4¼ | .. | Jn, Dec .. | .. | .. |
| 100 | 5% | Do. 5% Debs. (red.) | 83 –88 | 5 18 6 | .. | [illegible] | [illegible] |
| St. | 21/0 | Anglo-American | 66 –67 | 4 0 9 | F,My,Ag,N | [illegible] | [illegible] |
| St. | 32/0 | Do. Preferred | 113½–114½ | 4 16 0 | F,My,Ag,N | [illegible] | [illegible] |
| St. | 10/0 | Do. Deferred | 18⅞–19¼ | .. | F,My,Ag,N | [illegible] | [illegible] |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 97½–98½ | 4 0 6 | Jn,Ap,Jy,O | [illegible] | .. |
| 10 | 5/0 | Cuba Submarine Ord. | 8½–9 | 5 11 0 | Feb, Aug | .. | .. |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17 –18 | 5 11 2 | Feb, Aug | .. | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜–3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 8¼–8¾ | 5 14 0 | April, Oct | .. | .. |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 99%–102% | 4 8 0 | Jan, July | [illegible] | [illegible] |
| 20 | 2/6 | Direct United States Cable | 15 –16½ | 4 8 9 | Ja,Ap,Jy,O | .. | .. |
| 100 | 4½% | Direct West India Cable 4½% Rg.Db.(rd.) | 99 –101 | 4 9 0 | Jn, Dec .. | [illegible] | [illegible] |
| St. | 25/0 | Eastern Ordinary | 149 –152 | 4 12 0 | Ja,Ap,Jy,O | [illegible] | [illegible] |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 91 –93 | 3 15 8 | Ja,Ap,Jy,O | [illegible] | [illegible] |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 107½–108½ | 3 13 0 | May, Nov | [illegible] | [illegible] |
| 10 | 2/6 | Eastern Extension | 14¾–15¼ | 4 11 6 | Ja,Ap,Jy,O | [illegible] | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 105 –107 | 3 14 8 | Feb, Aug | – | .. |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb. 1909 | 99 –101 | 3 19 3 | Feb, Aug | .. | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101%–103% | 3 18 3 | May, Nov | .. | .. |
| 10 | 5/0 | G. N. (of Copenhagen) with coupon 65 | 17½–18½ | 6 2 0 | Jan, July | .. | .. |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 98½–101½ | 4 8 9 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57 –59 | 5 10 0 | May, Nov | .. | .. |
| 100 | $1 | Mackay Companies Common | 62⅛ | 3 8 9 | Jan, July | .. | .. |
| 100 | 4% | Do. Preference | 70½ | 5 5 3 | Ja,Ap,Jy,O | .. | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1 –1¼ | .. | .. | .. | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 99 –102 | 3 18 6 | June, Dec | .. | .. |
| 10 | 4/0 | West African Telegraph Shares | 9½–10 | 5 0 0 | .. | – | .. |
| 5 | – | West Coast of America | ⅛–¼ | .. | – | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100 –102 | 3 18 3 | Jan, July | [illegible] | [illegible] |
| 10 | – | West India and Panama | ⅜–⅝ | .. | May, Nov | .. | .. |
| 10 | 6/0 | Do. 6% 1st Pref. | 8¼–8¾ | 6 6 8 | May, Nov | .. | .. |
| 10 | – | Do. 6 per Cent. 2nd Pref. | 6½–7½ | .. | May, Nov | .. | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 100 –103 | 4 17 0 | Jan, July | [illegible] | [illegible] |
| 10 | 3/0 | Western Telegraph | 14½–15 | 4 13 0 | Mr,Jn,O,D | .. | .. |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 100 –102 | 4 18 0 | June, Dec | 1 | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 102 –104 | 3 16 10 | .. | .. | .. |
| | | **TELEPHONES.** | | | | | |
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt.Db.Stk. | 103 –105 | .. | .. | [illegible] | .. |
| 5 | 8/0 | Chili Telephone (fully paid) | 8 –8½ | 4 17 0 | August – | .. | .. |
| 1 | 0/9⅜ | Monte Video Telephone Ord. | ⅞–1 | 4 0 0 | – | .. | [illegible] |
| 1 | 1/0 | Do. 5% Pref. | ⅞–1 | 5 0 0 | .. | [illegible] | [illegible] |
| St. | 6% | National Co. Pref. Stock | 114 –115 | 5 4 6 | – | [illegible] | .. |
| St. | 5% | Do. Def. Stock | 110 –112 | 4 8 8 | – | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13 –15 | 4 0 0 | Feb, Aug | [illegible] | [illegible] |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 11 –13 | 4 12 4 | Feb, Aug | [illegible] | .. |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref... | 5⅜–5⅞ | 4 5 2 | Feb, Aug | [illegible] | [illegible] |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) ... | 99 –101 | 3 9 3 | June, Dec | [illegible] | [illegible] |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 103 –105 | 3 16 8 | – | – | .. |
| 1 | 0/7⅕ | Oriental | 1½–1⅝ | 4 12 0 | April, Oct | .. | .. |
| 1 | 0/7⅕ | Do. 6 per Cent. Cum. Pref. | 1½–1⅝ | 4 7 0 | – | .. | .. |
| St. | 24/7⅔ | Do. 4% Red. Deb. Stock | 97 –99 | 4 1 0 | .. | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db.Stk.Rd. | 103 –106 | 4 4 9 | .. | .. | .. |
| 5 | 3/0 | United River Plate | 7¼–7½ | 5 6 8 | July | – | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5½–5¾ | 4 7 0 | June, Dec | [illegible] | [illegible] |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) ... | 110 –112 | 4 9 8 | June, Dec | .. | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 5 –5½ | 5 9 0 | .. | [illegible] | [illegible] |
| 10 | 2/0 | Globe Telegraph and Trust | 11⅛–11⅜ | 4 16 6 | Ja,Ap,Jy,O | [illegible] | [illegible] |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14¾–15 | 4 0 0 | Ja,Ap,Jy,O | .. | – |
| 10 | 6% | Submarine Cables Trust (Cert.) | 127 –130 | 4 12 0 | April, Oct | .. | .. |

In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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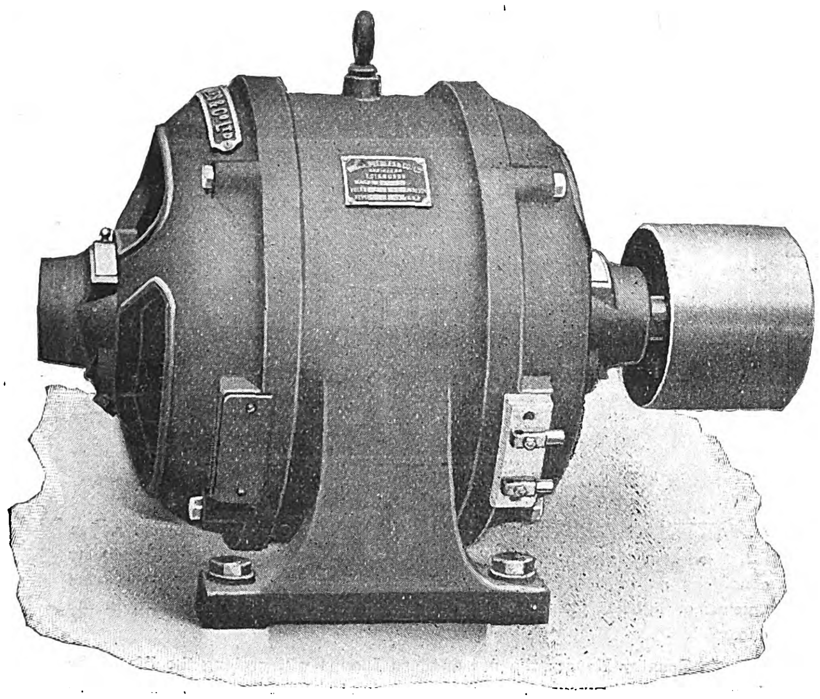

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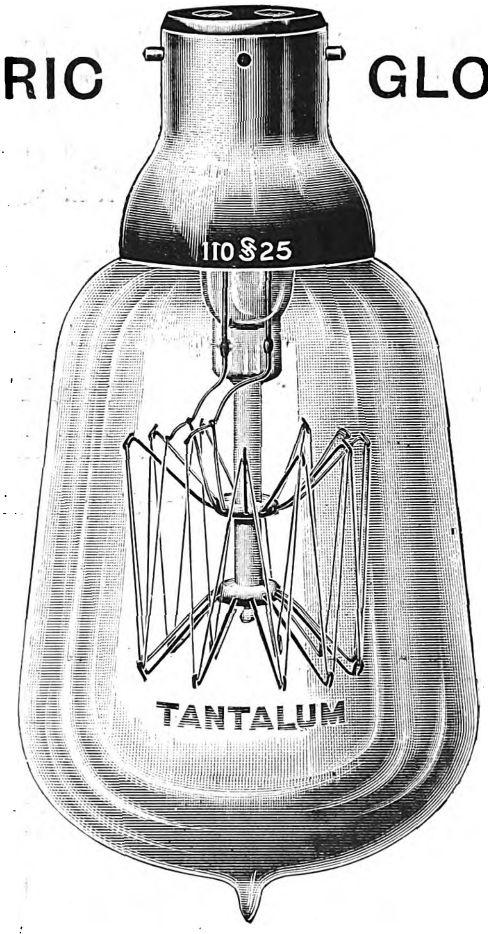

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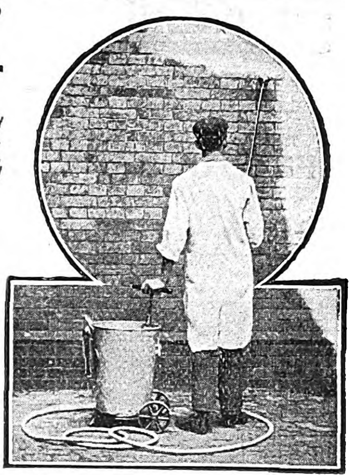

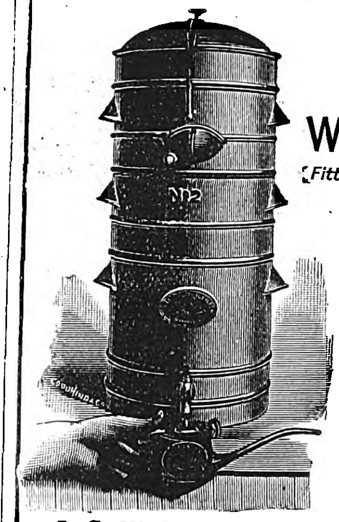

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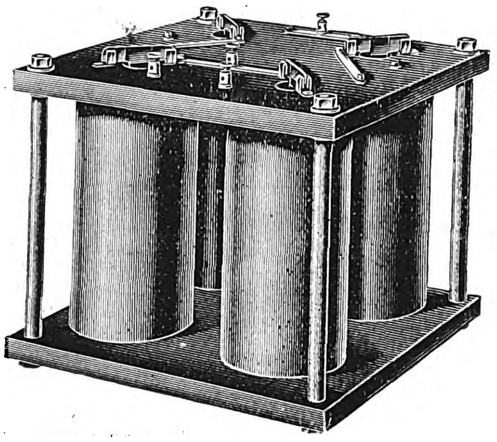

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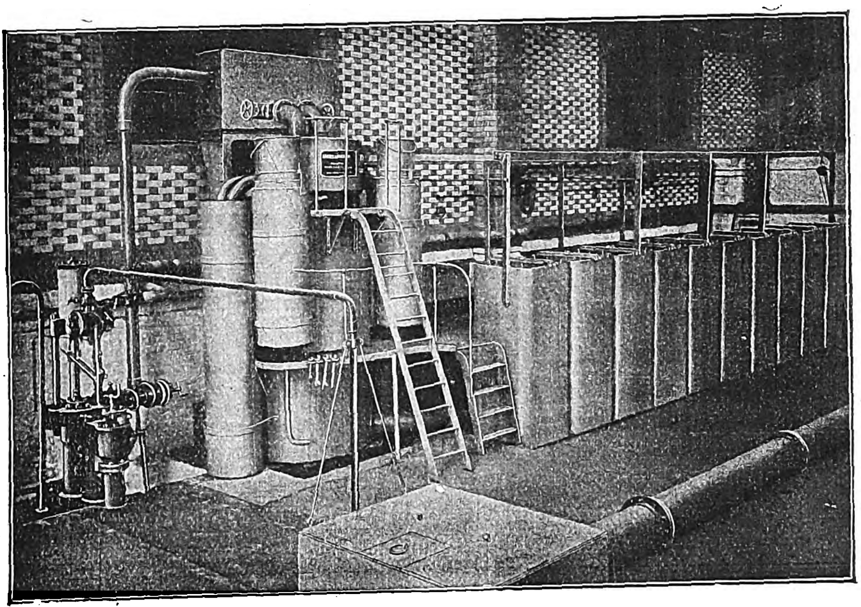

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# THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,451. [No. 21. Vol. LVI.] FRIDAY, MARCH 9, 1906. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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## NOTES.

THE acquisition of Electric Lighting Orders by gas companies has wisely been discouraged by the Board of Trade, for, once a gas company have obtained an Electric Lighting Order and have blocked the way for other people who might subsequently apply for one, there is little incitement for them to develop electric lighting in competition with their existing business. Attempts are constantly being made to evade this, however, and one of these is recorded in our Parliamentary columns this week. In this case a private company deposited with the Board of Trade, last July, an application for an Electric Lighting Order for the Ascot district. In the ordinary course, the Provisional Order will be granted next March. The local gas company, however, wished to retain the lighting of the district, and gave notice of a Special Bill in November to extend their own powers so as to authorise them to supply electricity. Naturally the electrical firm are opposing this, but the gas company cleverly argued that this firm had no *locus standi* in accordance with Parliamentary procedure as they did not yet possess any powers to supply electricity in the district. We are glad to report that the contention of the gas company was not upheld by the Court of Referees.

◆

THE Wright maximum demand system of charging has done good service to the electricity supply industry. In addition to affording a means of arriving at equitable tariffs it also did much in the earlier days of its development to educate the central station engineer as to the true significance of the load factor and its influence on the cost of generation. So valuable was the system, in fact, that, in spite of the difficulty of explaining it to consumers and the consequent suspicion with which the method of charging was sometimes regarded by those who had failed to understand the system, it was adopted by a very large number of electricity works. Thanks to the knowledge brought by its application, many central station men have now substituted for the maximum demand system flat rates of charging, with discounts which make sufficient allowance for the character of the load of individual consumers, and there are now comparatively few towns in which the Wright system is the only tariff in use. In some it has been abandoned altogether, while in others flat rates are offered as an alternative method of charging. Brighton, the town in which the maximum demand system was born, has hitherto been among those in which every consumer was charged on the maximum demand system, but the Brighton Corporation have now decided to give every consumer the option of being charged at a flat rate of 4d. instead of on the Wright system at 7d. for the first hour and 1d. after. As it requires a two hours' user of the maximum demand per day at 7d. and 1d. to bring the average charge down to 4d. per unit, it is probable that a large number of consumers will adopt the alternative.

◆

MR. BARKLA read an interesting and suggestive Paper at the last meeting of the Physical Society. He described the experiments by which he has discovered that the secondary radiation obtained from an element by submitting it to the direct action of Röntgen rays has a capacity for being absorbed that is a periodic function of the atomic weight. Now the "hardness" or penetrating power of the secondary radiation probably depends mainly on the amount of freedom possessed by the electrons of an atom. A corpuscle loosely held will be easily accelerated by the Röntgen pulse passing over it, and will, therefore, emit radiation more penetrating than will a corpuscle more stably bound in its atomic orbit. Thus this secondary radiation from the elements is an index of the stability of atomic system. And the conclusion pointed by Mr. BARKLA'S experiments is a remarkable confirmation of Prof. J. J. THOMSON'S well-known theory of the atom, which, to account for the electro-positive to electro-negative gradation of the elements in each group of the periodic table, postulates exactly this looseness or tightness of coupling within the atomic orbit now, we may almost say, demonstrated by Mr. Barkla. We publish the official abstract of the Paper in another column.

◆

It is interesting to note the attitude of the General Hydraulic Power Co. towards the electric power schemes which promise London a cheaper electric power supply than at present. As is well known, electric lifts are far more economical than hydraulic lifts, and the General Hydraulic Power Co. have felt the competition keenly, so that any further reduction in the price of electric power, one would suppose, would not be welcomed by them. At the Company's annual general meeting last week, however, it was actually suggested that the Company would be gainers and not losers by the advent of cheap "bulk" supply. At present the central station engineer, it was said, does not care much for a lift load, presumably because of the large amount of power required for short intervals of time. The argument is, therefore, that he only supplies lifts in order to improve his load factor and to cheapen his general costs, and that he supplies them at a loss. When the central station engineer can obtain his electrical energy "in bulk" at a cheaper rate, he will no longer need to have recourse to this method, and will therefore leave the lift load to the Hydraulic Power Company. But this is not the whole of the plausible case put forward by the Company. As pioneers in power distribution, with large vested interests, they propose to obtain from Parliament a clause directing the electric power companies to give them "most favoured treatment." They will then be able to displace the steam engines by electric motors, and drive their pumps at a lower cost than at present, and they hope thus to gain a double advantage from the new condition of affairs. Far be it from us to discourage these sanguine hopes of the General Hydraulic Power Co.; we can only congratulate them on their ready adaptability to the new circumstances. But at the same time we congratulate electrical engineers on the popularity of electric lifts, which is increasing now at a greater rate than ever.

◆

Lieut. Tissot, in the short Paper which we publish this week, does well to point out that in his experiments of 1902 to 1904, he obtained results similar to those of Duddell and Taylor bearing on the propagation and spreading of the Hertzian waves used in wireless telegraphy. At the time his experiments were published they were regarded as having the special aim of comparing the efficiencies of tuned and untuned simple air wires, and were, in fact, not set out in a form to exhibit clearly the inverse square law demonstrated by the English experimenters. He now shows, however, that his observations included data sufficient to establish this law; and thus we may now feel that we possess, altogether, very strong evidence that up to distances of 40 miles, at any rate, the radiant energy is propagated in three dimensions. As in Duddell and Taylor's experiments, a thermal detector was used in the measurements by Tissot; and it is interesting to observe that the later forms of Tissot's bolometer approach in delicacy Duddell's adaptation of the radio-micrometer. Instruments based on these two principles have always been close rivals.

But perhaps the point of greatest importance is the close accord between the French and English experiments in the matter of the best resistance for the measuring instrument in the receiving circuit. In both sets of observations this best value appears to be of the order of 60 ohms; which implies, of course, that the rate of loss of energy in the other parts of the receiver system is as if due to a resistance of about 60 ohms. In both cases the observers suggest that this loss may be attributable, at least in part, to radiation taking place from the receiver air wire. The striking agreement in the figure is very probably explainable by the fact that similar lengths of air wire were used in both sets of experiments.

**Circuit Breakers and Fuses.**—A misprint occurred in the article by Messrs. Marchant and Lawson on p. 793 of our last issue. The second line above Figs. 6 and 7 should read: "For a given diameter of wire, *d*, it follows that $\mathrm{C} \propto \bar{\mathrm{U}}^{\frac{4}{5}}$," and not ". . . . $\mathrm{C} \propto \bar{\mathrm{U}}$."

**The Electric Production of Nitric Acid.**—According to *Nature*, the Badische Anilin- und Soda-Fabrik, of Ludwigshafen, proposes to lay down a hydraulic power plant for the preparation of nitric acid from atmospheric nitrogen by the Birkeland process. Instead of preparing calcium and sodium nitrate for artificial manures however, as in the Norwegian installations, it is intended, in the first place at least, to make potassium nitrate for explosive purposes.

**"De Magnete."**—Messrs. Maggs Bros., of 109, Strand, are offering for sale a copy of Gilbert's "De Magnete," the first folio edition of 1600, a remarkably fine copy in a perfect state of preservation. There are only about 70 copies known to exist, most of them in public libraries.

**Cable Interruptions and Repairs.**

| | Date of Interruption. | Date of Repair |
|---|---|---|
| Tarifa—Tangier | Jan. 18, 1904 | — |
| Jamaica—Colon | Jan. 10, 1905 | — |
| Cadiz—Teneriffe | July 20, 1905 | — |
| Puerto Plata—Martinique | Dec. 15, 1905 | — |
| Tangier—Cadiz | Feb. 17, 1906 | — |
| Santa Lucia—St. Vincent | Feb. 19, 1906 | — |
| St. Vincent—Grenada | Feb. 19, 1906 | — |
| Grenada—Trinidad | Feb. 24, 1906 | — |
| Porto Rico—St. Thomas | Feb. 26, 1906 | Mar. 8, 1906 |
| Porto Rico—St. Croix | Feb. 26, 1906 | — |
| Alexandria—Larnaca | Feb. 28, 1906 | — |
| Guadaloupe—Dominica | Mar. 8, 1906 | — |

**Strange Result of a Short-Circuit.**—Between three and four o'clock on Wednesday morning a short-circuit occurred on the distributing cables of the East Ham Corporation network in front of a house in Green-street, near Upton Park railway station. The fault was right across from the positive to the negative cable, and as the current was well within the capacity of the machines the fault was allowed to burn out and the section was then cut out. About an hour after this, however, it was found that a number of people in an adjoining house were in a state of partial suffocation, some of whom were promptly taken to the hospital, but soon recovered. On taking up the footpath to repair the fault it was found that a gas pipe crossing over the cable troughing was leaking badly. The fumes from the burning fault, mixed with the escaping gas, had found a way into the cellar through a hollow which had been left by a disused gas service, and ascending to the top of the house, had overcome the persons sleeping in the attics.

**30-ton Electric Crane in Breslau.**—A 30-ton travelling crane has recently been erected at the Breslau harbour for loading ships expeditiously with coal. According to *Elektrotechnik & Maschinenbau*, the traveller, whose span is 46 ft., runs on an overhead girder structure (230 ft. long) supported by four pairs of columns. Coal is transported in huge buckets which discharge automatically, and for lifting ordinary objects a hook is fixed in lieu of the bucket. Electro-pneumatic brakes are provided, and the transmission is partly spur gearing and partly worm gearing. The motors employed for the various operations are as follows: A 70 H.P. motor for hoisting (which is done at the rate of 3·8 ft. per minute), a 20 H.P. motor for tilting and discharging the bucket, a 2·5 H.P. motor for slewing, a 3·6 H.P. motor for the cross traverse (speed 5½ ft. per second) and a 14·5 H.P. motor for the longitudinal traverse (speed 21·8 ft. per second). Including foundations, the whole plant as outlined is stated to have cost 175,000m. (£8,750).

**Institution of Mechanical Engineers.**—The annual dinner of the Institution of Mechanical Engineers will take place on Thursday, April 26th, at the Hotel Cecil, at 7:30 for 7:45 p m. The annual general meeting of the association was held a fortnight ago, and the officers and council are now constituted as follows:—

President, Edward P. Martin; Past-Presidents, Samuel Waite Johnson, Sir Alexander B. W. Kennedy, LL.D., F.R.S., William H. Maw, E. Windsor Richards, Percy G. B. Westmacott, Sir William H. White, K.C.B., LL.D., D.Sc., F.R.S., J. Hartley Wicksteed; Vice-Presidents, John A. F. Aspinall, Edward B. Ellington, Arthur Keen, Sir William T. Lewis, Bart., T. Hurry Riches, A. Tannett-Walker; Members of Council, Sir Benjamin Baker, K.C.B., K.C.M.G., LL.D., D.Sc., F.R.S., Sir J. Wolfe Barry, K.C.B., LL.D., F.R.S., Henry Chapman, George J. Churchward, Henry Davey, H. F. Donaldson, H. Graham Harris, Edward Hopkinson, D.Sc., J. Rossiter Hoyle, Henry A. Ivatt, Henry Lea, Michael Longridge, the Right Hon. William J. Pirrie, LL.D., Sir Thomas Richardson, John F. Robinson, Mark H. Robinson, James Rowan, John W. Spencer, Sir John I. Thornycroft, LL.D., F.R.S., John Tweedy, Henry H. West; Hon. Treasurer, Harry Lee Millar; Auditor, Robert A. McLean, F.C.A.

**Electricity v. Gas for Train Lighting.**—In a report by Lieut.-Col. P. G. von Donop on the derailment of a train in the Catesby tunnel on the Great Central Railway, it is stated that the accident furnishes another instance showing the undesirability of the employment of gas as an illuminant for trains and the superiority of electricity for that purpose. After referring to the extinguishing of the lights on three of the carriages and the consequent escape of gas, the report continues:

> It is terrible to contemplate what might have been the results of this accident if an explosion had occurred or a carriage had caught fire in the tunnel. The leading and rear vehicles of the train were both lighted by electricity; the lights in the latter were extinguished, but in the former vehicle they remained alight throughout, and were of the greatest assistance in rescuing and controlling the passengers. This accident furnishes, therefore, another instance showing the undesirability of the employment of gas as an illuminant for trains, and the superiority of electricity for that purpose.

It may be recalled that this same Board of Trade inspector made a similar recommendation in his report concerning the accident at Witham, on the Great Eastern Railway, last year.

**Gas-engine Indicators.**—A Paper on gas-engine indicators was read at the meeting of the Junior Institution of Engineers on Friday last by Mr. L. F. de Peyrecave. He described the methods adopted for testing and calibrating indicator springs and indicators, and dealt with the effects of variations of temperature on the calibration curves, and precautions to be taken to avoid other sources of error. The results of a series of comparisons, carried out by the author and Mr. F. White, of various types of indicator with a standard indicator on a gas engine were given, and a few special devices, such as Elliott Bros.' differential spring and the Mahot recording drum, were described. In his conclusions, the author expressed a decided preference for the outside spring type of instrument for gas-engine work. A representative collection of indicators was shown, and a lively discussion followed the Paper, in which Prof. Dugald Clerk took part, giving an interesting account of a method of measuring heat losses in a gas engine, by causing the exhaust valve to remain closed for several strokes after an explosion, and obtaining a record by means of an indicator of the alternate compression and expansion curves of the gradually cooling imprisoned gases.

**Municipal Accounts.**—On Monday a conference was held in London at the instance of the Municipal Trading Committee of the London Chamber of Commerce with the object of discussing the recommendations of the Joint Committee on Municipal Trading of 1903 (*The Electrician*, Vol. LI., p. 709), and the best means of securing the independent professional audit of municipal accounts and the standardisation of such accounts. Mr. Felix Schuster was in the chair, and altogether 48 Chambers of Commerce, 18 industrial and other associations and 20 municipal authorities were represented. A series of questions had been submitted to all who had been invited, and 91 replies had been received in favour of the recommendations of the Select Committee, 21 conditional, and 29 against; 107 favoured the prescription of a standard form of accounts, 11 conditional and 18 against. Practically all the answers in the negative to both questions were from local authorities. The chairman, in the Course of a short speech, said that the sole object of the conference was to discuss the question of the proper keeping of municipal accounts. A resolution was moved expressing regret that effect had not been given to the recommendations of the Joint Committee of 1903. An amendment to this resolution was moved by the town clerk of Fulham, having for its object the possibility of another form of independent audit to that laid down by the Select Committee. This amendment was defeated and the original resolution passed. Another resolution was also passed urging the desirability of the standardisation of municipal accounts on business lines, and it was further resolved that a deputation should wait upon the President of the Local Government Board urging both the necessity for giving effect to these resolutions and also the addition of independent members connected with accountancy to the Departmental Committee which has just been appointed to deal with this matter.

**The Royal Commission on Canals.**—In an Editorial note on page 415 of our issue of December 29th we welcomed the appointment of a Royal Commission on Canals and Waterways which was promised in a speech by Sir Henry Campbell-Bannerman, and we are glad to learn that the King has been pleased to appoint such a Commission. The chairman will be Lord Shuttleworth, whose business capacity has been well proved in his distinguished public career, and who has acted as chairman of a Parliamentary Committee dealing with the same subject. The other members of the Commission are Lord Kenyon, Lord Brassey (chairman of the Associated Chambers of Commerce), Lord Farrer, Sir John Dorington (chairman of the County Councils Association), Sir John Brunner, M.P., Sir Francis Hopwood (permanent secretary to the Board of Trade), Mr. W. J. Crossley, M.P. (who will represent the interests of the Manchester Ship Canal), Mr. Russell Rea, M.P., Mr. J. F. Remnant, M.P., Mr. P. Snowden, M.P., Mr. Henry Vivian, M.P., Mr. L. A. Waldron, M.P. (who appears for Ireland and her largest canal), Mr. R. C. H. Davison (well known in civil engineering circles), Dr. A. J. Herbertson (reader in geography at Oxford), Mr. J. P. Griffith (an engineering representative from Ireland), Mr. J. C. Inglis (the general manager of the Great Western Railway), Mr. H. F. Killick (representing the canal industry generally and Liverpool in particular) and Mr. John Wilson, formerly M.P. for Falkirk. Mr. W. B. Duffield will act as secretary to the Commission. It will be seen that a variety of interests are represented, and we look forward with interest to the proceedings and subsequent report. The Royal Commission will deal not only with the engineering problem presented of how the much-needed improvement in efficiency of transport may be obtained, but will also consider how the funds for the purpose can be obtained and secured, and the expediency of canals being made or acquired by public bodies or trusts.

**Metallic Filament Incandescent Lamp.**—We have now received some further particulars of the new metallic filament lamp of Dr. Kuzel's invention, to which we referred in pp. 655 and 679 of our issue of February 9th. The process by which the filaments are made has already been outlined in an Editorial Note in our issue referred to above. The metals are reduced to a colloidal state wherein their properties are somewhat modified by their very finely-divided condition and Dr. Kuzel forms his filaments by forcing his colloidal preparation through a die. This, it is said, produces a much more durable filament than the ordinary wire-drawing method. Dr. Kuzel finds that by employing a mixture of different colloidal substances he obtains alloys with properties more suitable for filament construction than the components used separately, however high their fusing points. The lamps are exactly similar in appearance to the carbon filament type and the size of the bulbs identical. Two horse-shoe filaments in series are used and the lamps can be made up to 110 volts. It is hoped, however, to extend the limit up to 220 volts. The actual mounting of the filament and exhausting of the bulb is precisely the same as for the carbon lamp, so that beyond establishing a new filament department, no alterations are necessary in the equipment of an existing lamp factory. The efficiency claimed for the filaments for low voltage lamps is indicated in the tests which were published in *The Electrician* of February 9th, p. 679, and it should be explained that the candle-powers given are mean horizontal, the Hefner unit being used. It has been found from a number of tests that a useful life of about 3,500 hours may be expected with a loss of candle-power varying from 2 per cent. to about 11 per cent. for lamps with an efficiency in the neighbourhood of 1 watt per candle, and that they will last as long as 5,000 hours with a diminution in light of 20 per cent. Lamps working at an efficiency of about 0·75 watts per candle have been run for 1,000 to 1,100 hours with a loss of 3-5 per cent., and for 1,600 hours with a loss of 20 per cent. The lamps remain remarkably cool in use, as a very small portion of the radiation consists of infra red rays. The lamps are equally suitable for alternating and continuous-current circuits, and can be over-run as much as 300 per cent. without damage. The inventor looks forward to producing lamps with an efficiency as high as 0·5 watts per candle-power. The above particulars are on the authority of Messrs. Fahn & McJunkin, who have the sole selling rights under the patents, and we look forward to their confirmation by independent tests made in this country.

**The Corpuscular Theory of Matter.**—Prof. J. J. Thomson devoted the first of his series of Saturday afternoon Royal Institution lectures on "The Corpuscular Theory of Matter" to a description of the genesis and the properties of cathode rays. He expounded carefully the main reasons for regarding the cathode beam as a stream of moving particles. These reasons are, first, that the rays are deflected by a magnetic field; second, that they give a negative charge to any metal vessel they enter, and third, that they are deflected by an electric field, all the effects being of such a nature as to indicate that the particles are to be regarded as negatively-charged bodies. The phenomena described were fully illustrated by experiments, the demonstration of the magnetic and electric deflections being made especially clear by the use of the slowly-moving cathode rays given off, as was discovered by Wehnelt, from a speck of lime on a heated platinum cathode. The electric deflection of these slow rays was particularly striking; for when in a large tube the beam was directed towards a metal plate charged negatively it was seen to be completely bent back by the electrical repulsion and to follow a parabolic path. The cathode rays possess, however, the disquieting property of penetrating thin sheets of metal—a property that seemed at first to favour the views of the German physicists, who held at one time that the cathode beam was, like ultra-violet light, undulatory in nature. This penetrating power must now be regarded, however, as merely widening our estimation of the closeness of the packing of the molecules of matter. Prof. Thomson then went on to describe how the various constants of the cathode rays have been measured. The speed of the particles was first measured by balancing the magnetic against the electric deflections, with the result that in different tubes speeds of from 1,000 to 60,000 miles per second were recognised. Next the ratio of charge to mass for a single particle was measured by the deflection in an electric field. This ratio has been found the same in all cases, being independent of the speed of the particles and of the nature of the gas and the electrodes, and appears to be about 1,700 times the similar ratio for the hydrogen atom in electrolysis. An application of the fact that ions can serve as nuclei for water condensation in dust-free air showed later that the charge carried by the cathode particle is the same as that carried by the hydrogen atom in electrolysis, and thus that the mass of a corpuscle is more than a thousand times smaller than the mass of the lightest known atom.

**Royal Commission on London Traffic.**—Vols. V. and VI. of the report of the Royal Commission on London Traffic were published last week. They consist of an exhaustive analysis of about 100 plans, diagrams and drawings, selected from those furnished by witnesses during the course of the Commission's inquiry, other than American and Continental witnesses, and others specially prepared by the Commission. The plans and diagrams furnished by witnesses in the United States and abroad will be published as part of Vol. IV. The remainder of the plans and diagrams now in the Commission's possession are being preserved to form the stock-in-trade of the new Traffic Board for London,—when it comes into existence. The social aspects of the traffic problem are graphically demonstrated, and the volumes under notice purport to present this section of the Commission's labours in a crystallised form for the future benefit of a permanent Traffic Board, which the Commission hopes will be formed to take up the problem where it has now been left. In this connection two plates that have been prepared by Sir Henry Oakley, Chairman of the Central London Railway Co., are of interest, for they show all the various London railway proposals that have been submitted to Parliament since 1885, scattered without system broadcast over London. These plans show in an interesting way the early partiality of promoters for certain routes still unprovided for, and their kaleidoscopic effect affords the readiest proof of the necessity for the establishment of a Traffic Board with co-ordinating powers. Other plans deal with streets and street improvements, and traffic in the streets. Under this latter heading, the report inveighs against the practice of placing tramway and electric lamp columns down the centre of roadways, and this is regarded as a matter which should be the subject of immediate regulation. Several designs for shallow tramway subways and pipe subways, and a number of plans giving proposals for new thoroughfares are included, the latter having been prepared by Mr. Maurice Fitzmaurice, chief engineer to the London County Council. Mr. Stephen Sellon's proposals for a connected system of tramways throughout London, including connections across all bridges and also through the City, most of which were endorsed by the Advisory Board of Engineers to the Commission, are included. All the most important schemes and proposals which, in the opinion of the particular witnesses, would relieve or cure the congestion of traffic in particular localities in London are dealt with, and not the least interesting is a plate submitted by Mr. Edgar Speyer showing for a number of years past the fluctuations in the price of money, stock, &c., and the adverse financial difficulties to which promoters of tube railways have been subject, apart altogether from those incidental to the special character of the enterprise. The publication of the present volumes leaves only one further volume—Vol. IV.—to be issued by the Commission, containing the evidence taken by, and documents and information furnished to, the Commission, in the United States and on the Continent. Vols. V. and VI. are the work of Mr. Lynden Macassey, secretary to the Commission, and Mr. R. B. Dunwoody, its engineer.

**Manchester Local Section of the Institution of Electrical Engineers.**—The annual dinner of the Manchester Local Section of the Institution of Electrical Engineers was held at the Midland Hotel on Friday last. After the loyal toasts had been proposed by the chairman, Mr. S. L. Pearce, and had been duly honoured, Mr. S. Z. de Ferranti proposed "The Corporations of Manchester and Salford." To him, he said, the Lord Mayor of Manchester and the Mayor of Salford appeared simply as the heads of two vast electrical undertakings. He had been given to understand that the sum invested in their electricity works and tramways was about £4,000,000, and he reminded those present of the competition of suction gas plants and motor omnibuses, which made it necessary that no effort should be spared to improve and develop their own undertakings. The Lord Mayor of Manchester (Mr. J. H. Thewlis) and the Mayor of Salford (Mr. I. Frankenburg) replied, the latter referring to the fact that his own borough, in contra-distinction to Manchester, had bought all the plant for their electricity works from British firms. Dr. A. Hopkinson, vice-chancellor of the University of Manchester, in proposing the Institution of Electrical Engineers, spoke of the early days of electricity, and recalled the time when he had first read of the telephone in a newspaper and had turned the page over with the remark that people who would believe that would believe anything. Since he had found that the discovery of the telephone was a fact, he would not even venture to express his disbelief in psychical research. He concluded with a tribute to the work of the Post Office Telegraph Department and to its distinguished engineer-in-chief. Mr. John Gavey, C.B., president of the Institution of Electrical Engineers and engineer-in-chief of the Post Office, in replying on behalf of the Institution, spoke of the excellence of the Papers read at the Manchester Local Section and to the successful formation of the Manchester Students' Section. Incidentally he mentioned that Manchester carried on a brisker telephone traffic over the trunk lines than any business centre he knew of. Mr. Gavey concluded with a reference to the coming visit of the foreign electrical societies to this country, and invited the co-operation of the local centres in the entertainment of their guests. Mr. R. Kaye Gray (past-president) gave the next toast, "The Local Sections," of which he said Manchester was certainly not very far from the top, and Mr. S. L. Pearce, in responding, said that the number of the Manchester members was 800, and that at the last meeting there had been a record attendance of 350. He also alluded to the desirability of discussing Local Section Papers in London more frequently. Mr. T. L. Millar then proposed "The Visitors," for whom Mr. Dane Sinclair (general manager of the British Insulated & Helsby Cables) returned thanks.

**The Baker Street & Waterloo Railway.**—A large party of representatives of the Press inspected the Baker Street & Waterloo Railway on Wednesday last, and were afterwards entertained at lunch by the directors of the Underground Electric Railways Co. of London at the Hotel Great Central. The portion of the line from Baker-street to Kennington is now quite complete, and the party travelled over the whole of this section, and had an opportunity of examining a number of interesting details of the line. The principal features of the railway have already been described in our columns (see *The Electrician*, February 16th, p. 703, and February 23rd, 745). It has now been decided to arrange the standard six-car trains so that they can be divided at times of comparatively light traffic into two halves, consisting of one motor-car and two trailers each. In order, therefore, that these half-trains can be driven from either end, some of the trailer cars have been fitted with controllers, although they do not carry motors. Particular attention was paid to the signalling arrangements at Kennington. Here, owing to the junction and cross-over roads, there are a number of points to be worked, so that the system cannot be entirely automatic as it is on the straight-away portions of the line. The operator in the signal box has in front of him an illuminated diagram of the whole section under his charge which is so arranged that all portions where the line is clear are lighted up by lamps behind the glass, while on portions which are occupied by trains the lamps are extinguished. The lever frame consists of a row of miniature levers about 9 in. long, which open and close the electrical contacts controlling the electro-pneumatic mechanism operating the points and signals, all being fully interlocked. The trains automatically put the signals at danger as soon as they pass them, in the same way as on the fully automatic sections, and they are reset to "line clear" by the levers. The line will be opened for traffic to morrow, and the following service will be run on weekdays: from 5:30 a.m. to 7:30 a.m., every five minutes; from 7:30 a.m to 11:30 p.m., every three minutes; and from 11:30 p.m. to 12:30 a.m., every six minutes. The Sunday service will be: from 7:30 a.m. to 11:0 a.m., every six minutes; and from 11:0 a.m. to 12:0 p.m., every three minutes, a uniform fare of 2d. for all distances being charged. The average speed, including stops, will be 14 miles per hour, and this can be maintained with a maximum speed of 30 miles per hour. The trains are, however, capable of attaining a maximum speed of 35 miles per hour, so that time can be made up if necessary. Opportunity was also given to inspect the sub-station at Baker-street, which closely resembles that at Charing Cross (described in *The Electrician*, Vol. LIV., p. 615), except that only one set of 'bus bars is used. The lift equipment was also examined.

At the lunch which followed, Sir George Gibb, managing director of the Underground Railways Company was in the chair. In a short speech he referred to the nature of the undertaking, which was the first to provide for a north and south route and whose object was not to compete with other lines, but to assist them and enable full advantage to be taken of their facilities to the mutual advantage of all concerned. Mr. Edgar Speyer, chairman of the Underground Railways Company also spoke and expressed regret that the late Mr. Yerkes had not lived to see even the commencement of his scheme an accomplished fact. The Baker Street & Waterloo line was but a beginning, but he hoped that the whole system would be at work during the early part of 1907.

**Acceleration and Accelerometers.**—Mr. A. P. Trotter read a Paper dealing with acceleration and methods by which its value could be measured before the Junior Institution of Engineers on Friday last. Commencing with a quotation from *Punch*, Mr. Trotter dealt in a particularly happy way with the aspects of the subject more especially met with in connection with railway trains. Most of his remarks were based on the conception of the alteration of the "dynamical vertical" produced by the interaction of the forces of acceleration and gravity. The various units employed in the quantitative statement of acceleration were explained, and the simplest of all methods of measuring horizontal accelerations by the deflection of a plumb bob was experimentally demonstrated. The recording pendulum instruments of Mr. A. Mallock and Mr. F. W. Lanchester were mentioned and actual records taken by the former were shown. Other types of accelerometers described were those depending on the alteration of levels of a liquid, of which one example is that of Prof. G. Kapp (described in *The Electrician*, Vol. XLV., p. 641), in which a long tube with upturned open ends is used, fitted partly with mercury and partly with water, and the alteration in level in the longer branch is observed. Another form which he had himself often used consisted of a bent tube nearly full of liquid, similar to a spirit level. This was particularly convenient for use in railway trains, and some examples recently made by Messrs. Everett and Edgcumbe were shown. The indications of these instruments are, of course, affected by gradients as well as by acceleration, so the result obtained is rather a measure of the force acting on the train than of the acceleration. Thus, when a train is "coasting" down a grade, the bubble remains stationary at the zero, except for the small deflection due to friction, even though the speed is fast increasing. Again, when a car is standing on a grade, the bubble shows a considerable deflection, which is in reality a measure of the force of the brakes holding the car up. This somewhat detracts from the use of these accelerometers from a passenger's point of view, but for investigation of the actual power required for traction the accelerometer ignores the effects of gradients and attends to the propulsive power in a remarkable way. A clear explanation of the forces acting on passengers walking along a train during acceleration or retardation was given when the sensation as of walking up or down a hill is felt. Reference was also made to vertical accelerations in lifts and the like, and, as an example, the new lifts on the Baker Street & Waterloo Railway were mentioned, in which oil buffers are provided, so that if the attendant does not switch off in time the lifts, when travelling their full speed of 350 ft. per minute, can be pulled up in 8 in. In the discussion which followed Mr. K. Edgcumbe asked what methods could be adopted to differentiate between gradient and acceleration effects, and referred to an instrument he had seen in which a pencil driven by a gearing from the wheels of the car moved over a strip of paper driven at uniform speed by a clock, the pencil springing back to zero at intervals, so that a sort of saw-tooth diagram was obtained, the slope of the sides of the teeth indicating the acceleration. Mr. P. V. McMahon congratulated Mr. Trotter on the clearness of his Paper, and wished he had had it before him when making some of his early experiments on the City & South London Railway. He did not quite see how accelerometer observations could replace actual measurements of draw-bar pull with a dynamometer car. Mr. Trotter, in reply, stated that he knew of no way in which the gradient effect could be eliminated except by some such instrument as Mr. Edgcumbe has mentioned, and referred to Prof. Kapp's article in *The Electrician* for further treatment of the subject. He agreed with Mr. McMahon that for many purposes the actual measurement of draw-bar pull by a dynamometer was the most suitable method. In connection with this subject the electrical accelerometer recently described by Prof. R. B. Owens before the Canadian Society of Civil Engineers is of interest, as its action is entirely independent of the effect of gradients, only the rate of change of the speed affecting the instrument (see *The Electrician*, January 12th, p. 495). This apparatus was not, however, alluded to by any of the speakers.

**International Congress on Electrical Units.**—It will be remembered that as a result of the International Electrical Congress at St. Louis in 1904, it was determined that steps should be taken towards arriving at an agreement with regard to electrical units and standards by the constitution of an International Commission representing the Governments concerned. As a preliminary move a meeting of representatives of Government laboratories was convened, and was attended by the following delegates :—

*U.S. of America* : H. S. Carhart, professor at the University of Michigan. *Belgium* : Eric Gerard, president of the Commission des Unités Electriques, and P. Clément, secretary of the Commission. *Germany* : Dr. Th. Lewald, president of the Kuratorium of the Physikalisch-Technische Reichsanstalt ; Prof. Dr. F. Kohlrausch, formerly president of the Reichsanstalt ; Prof. Dr. E. Warburg, president of the Reichsanstalt ; Prof. Dr. E. Hagen, director at the Reichsanstalt ; and Prof. Dr. W. Jaeger and Prof. Dr. St. Lindeck, members of the Reichsanstalt. *England* : Dr. R. T. Glazebrook, F.R.S., director of the National Physical Laboratory. *France* : E. Mascart, director of the Bureau Central Météorologique. *Austria* : V. v. Lang, president of the Normal-Eichungskommission, and Dr. L. Kusminsky, referee for electrical measures at the Normal-Eichungskommission.

Meetings were held in Berlin on October 23rd, 24th and 25th last, and the official report of the proceedings has now been published. The following decisions were arrived at :—

### Formal Decisions.

That only two electrical units shall be chosen as fundamental units.

The international ohm defined by the resistance of a column of mercury, and the international ampere defined by the deposition of silver are to be taken as the fundamental electrical units.

The international volt is that E.M.F. which produces an electric current of one international ampere in a conductor whose resistance is one international ohm.

The Weston cadmium cell shall be adopted as the standard cell.

The conference recommends the following procedure for the realisation of the ohm :—

1. The method which avoids the end correction (Ausbreitungswiderstand) should not be employed (*Wissensch. Abh. der Phys.-Techn. Reichsanstalt*, 2, S. 383, 1895 ; *Phil. Trans. Roy. Soc.* London 204, S. 81, 1904).
2. The Reichsanstalt will put itself in communication with Messrs. Schott & Co., of Jena, in order to determine whether glass tubes of sufficiently uniform section can be produced of the glass $59^{III}$.
3. The glass tubes used in setting up mercury resistances are to be carefully annealed.
4. The tubes are to be filled in vacuo without heating.
5. In determining the weight the mercury column is to be bounded by planes at the terminal cross sections of the tube and to be at a temperature of 0°C.
6. The length measurements are to be made as far as possible at 0°C. with the aid of contact pieces.
7. The electrical measurements are to be carried out at 0°C. and a method is to be employed which avoids the use of thick connecting wires. Among such methods the Kohlrausch differential galvanometer method, the Thomson double bridge method, and eventually the compensation method are recommended. The current employed in measurement shall be limited by the condition that the mercury shall not be warmed sufficiently to produce appreciable error.
8. The mean of at least three fillings shall be taken as the value of the resistance of a tube.
9. The mean of at least five tubes must be taken to determine the value of the mercury unit.
10. The mercury standards shall have a resistance of approximately one ohm.
11. As the value of the wire standard the mean of at least five resistances of one ohm shall be taken.
12. A comparison of the wire standard with the mercury units shall be carried out at appropriate intervals of time.

The Weston standard cell shall contain solid hydrated cadmium sulphate ; the strength of the cadmium amalgam shall be 12 to 13 per cent. of cadmium.

In the form of the normal element of the standard cell to be finally specified, sources of disturbance at the negative pole are to be avoided.

### Resolutions.

The conference expresses the wish that an International Convention should be summoned in order to arrive at agreement in the electric standards which are in use in the different countries.

The following resolution was further adopted : "In view of the fact that the laws of the different countries in relation to electrical units are not in complete agreement, the conference holds it desirable that an official conference should be summoned in the course of a year with the object of bringing about this agreement."

The conference further expresses the opinion : (1) That the information before it is not sufficient to enable it to propose any alteration in the formerly accepted value for the ampere. (2) That the information before it is not sufficient to enable it to lay down exact directions in respect to the silver voltameter and the standard cell. (3) That if a proposal for a change in the accepted value of the ampere is to be brought from any source before a formal congress to be held later, an agreement in writing on the point should be come to previously between the parties interested. If differences of opinion in the matter cannot be removed, a new preliminary conference should be held.

The same procedure should be observed in regard to the specification for the silver voltameter and the standard cell, in the event of such specifications being submitted to a formal conference from any quarter.

## ARRANGEMENTS FOR THE WEEK.

**(To-day) FRIDAY, March 9th.**

Faraday House Old Students' Association.

*7 for 7:30 p.m.* Second Annual Dinner at the Florence Restaurant, Rupert-street, London, W. Mr. C. D. Taite, the President, will be in the chair.

Physical Society.

*8 p.m.* Meeting at the Royal College of Science, Exhibition-road, South Kensington. Agenda : (1) "The Velocities of the Ions of Alkali Salt Vapours at High Temperatures," by Prof. H. A. Wilson. (2) "Some Experiments on Earth Currents at Kew Observatory," by Dr. Harker.

Institution of Electrical Engineers : Manchester Students' Section.

*7:30 p.m.* Meeting at the Royal Technical Institute, Salford. Paper to be read : "Modern Primary Batteries," by E. Müller and J. Davies.

**SATURDAY, March 10th.**

Institution of Electrical Engineers : Students' Section.

*10 a.m.* Visit to Messrs. Elliott Bros.' Works at Lewisham.

Royal Institution.

*3 p.m.* Afternoon Lecture II. on "The Corpuscular Theory of Matter," by Prof. J. J. Thomson, F.R.S.

Junior Institution of Engineers.

*7 p.m.* Conversazione at the Westminster Palace Hotel. Reception by the President and Mrs. Dugald Clerk and the Chairman and Mrs. Adam Hunter.

Birmingham and District Electric Club.

*7:30 p.m.* Meeting at the Colonnade Hotel, New-street, Birmingham. Paper to be read : "Electricity in Mines," by R. G. Mercer.

**MONDAY, March 12th.**

Institution of Mechanical Engineers ; Graduates' Association.

*8 p.m.* Meeting at Storey's Gate, St. James's Park, London. Paper to be read : "Notes on the Design and Construction of Large Gas Engines," by J. H. Hurst.

**TUESDAY, March 13th.**

Institution of Electrical Engineers : Manchester Local Section.

*7:30 p.m.* Meeting in the University. Paper to be read : "Economic Considerations in the Employment of Storage Batteries," by J. R. Salter.

Institution of Electrical Engineers : Glasgow Local Section.

*8 p.m.* Meeting at 207, Bath-street, Glasgow. Paper to be read : "The Internal Energy of Elements," by Prof. F. Soddy.

Institution of Civil Engineers.

*8 p.m.* Ordinary meeting. Paper to be considered : "The Widnes and Runcorn Transporter Bridge," by J. J. Webster.

**WEDNESDAY, March 14th.**

Institution of Electrical Engineers : Birmingham Local Section.

*7:30 p.m.* Meeting at the Municipal Technical School, Suffolk-street, Birmingham, when Dr. W. E. Sumpner's original communication to the Institution Journal on "New Iron Cored Instruments for Alternate Current Working" will be discussed. [An abstract of this was published in *The Electrician* for February 2, 1906, p. 641.] An experimental demonstration of the instruments and other apparatus will be given both before and after the meeting.

Institution of Electrical Engineers : Students' Section.

*7:30 p.m.* Meeting at 92, Victoria-street, Westminster, London. Paper to be read : "The Efficiency of Lamp Globes," by F. C. Prentice and J. S. Westerdale.

**THURSDAY, March 15th.**

Institution of Electrical Engineers : Leeds Local Section.

*8 p.m.* Meeting at the University. Paper to be read : "The Cost of Electricity per Unit from Private Plants," by Wilson Hartnell.

**FRIDAY, March 16th.**

Institution of Electrical Engineers : Students' Section.

Afternoon visit to the Board of Trade Electrical Laboratory, 8, Richmond-terrace, Whitehall.

Royal Institution.

*9. p.m.* Evening Discourse on "How to Improve Telephony," by W. Duddell.

**SATURDAY, March 17th.**

Royal Institution.

*3 p.m.* Afternoon Lecture III., by Prof. J. J. Thomson, F.R.S., on "The Corpuscular Theory of Matter."

# THE GREENWICH POWER HOUSE OF THE L.C.C. TRAMWAYS.

(*Continued from page 792.*)

The four alternators are all of similar design, and have been made by the Electric Construction Co. for an output of 3,200 kilovolt-amperes at 6,600 volts and 94 revs. per min. on a load with a power factor of 0·94. Their overload capacity is 25 per cent. overload for two hours. Fig. 10 is a general arrangement of the machine, and it will be seen that the armature, which is of course stationary, is built up in four sections, and that the two lower sections have feet cast on to them. These feet rest upon a sliding nut on each side, which enable the whole armature to be traversed in a direction parallel to the shaft of the machine. The overall diameter of the armature frame is 29 ft. 3 in., and the weight of the complete stator is about 105 tons. The core stampings are made with dovetails which fit into grooves milled in the cast-iron frame.

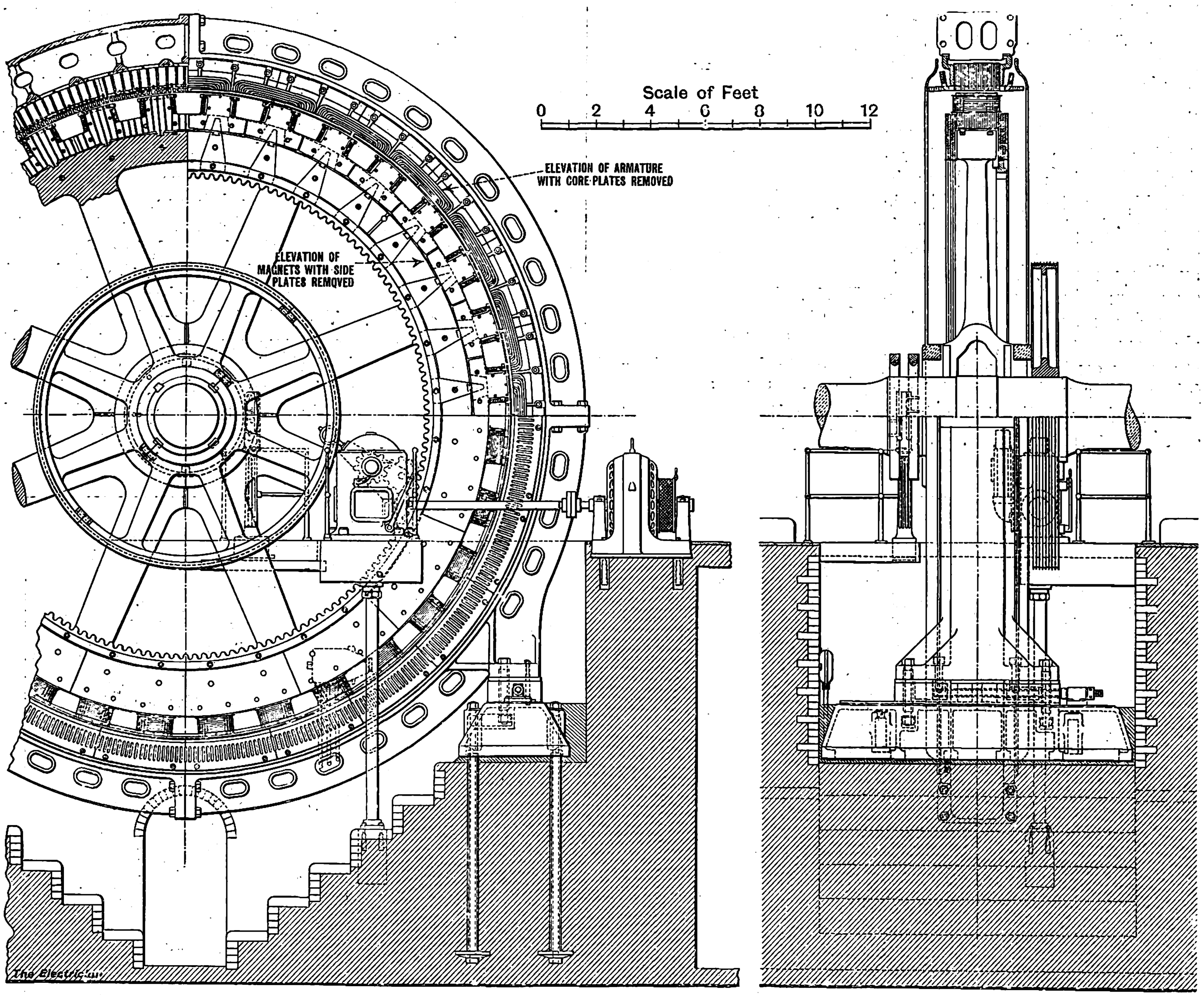
Scale of Feet
0 2 4 6 8 10 12
ELEVATION OF ARMATURE WITH CORE PLATES REMOVED
ELEVATION OF MAGNETS WITH SIDE PLATES REMOVED
The Electrician

Fig. 10.—Sectional Elevations showing General Arrangement of Alternator.

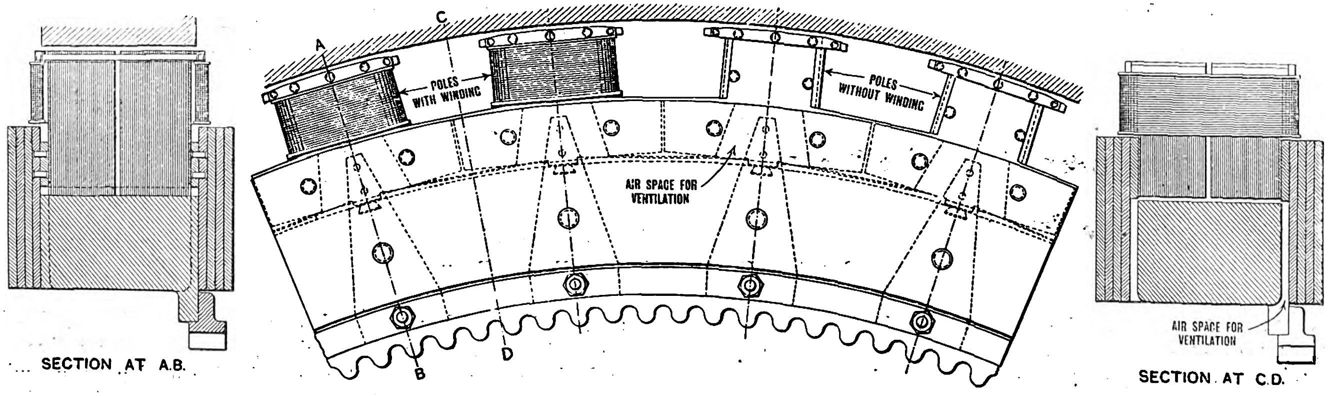
A
C
POLES WITH WINDING
POLES WITHOUT WINDING
AIR SPACE FOR VENTILATION
B
D
SECTION AT A.B.
AIR SPACE FOR VENTILATION
SECTION AT C.D.

Fig. 11.—Detail of Flywheel Rim showing Field Magnets. Scale: ½ in. = 1 ft.

They are assembled under very great pressure, and the clamping rings that are held by a bolt passing behind the core plates are pulled down evenly and under considerable hydraulic pressure. There are 15 slots per pole, each slot containing one highly-insulated coil of flexible conductor impregnated "solid" with insulating compound, and afterwards tested to a pressure of 20,000 volts from winding to core. Efficient ventilation is secured by the spacing of the coils at the ends and also by means of seven vents in the body of the laminated core. The windings of the stators are star-connected, and the centre of the star is earthed on the condensing water-pipe system.

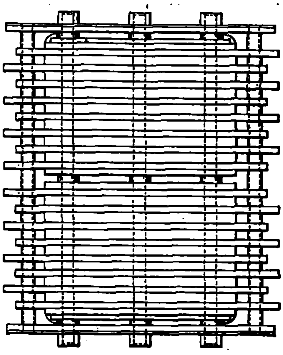
Fig. 12.—Plan of Pole showing Method of fixing Pole-faces.
Scale: 1 in.=1 ft.

The rotating field magnets are fixed to the periphery of the flywheel in the manner shown in Fig. 11, and the required kinetic energy of 11,000 foot-tons is obtained without the use of any auxiliary flywheel. It will be seen from Fig. 11 that the magnet poles and yoke are formed in the same stamping, and each stamping contains two poles. They are built up with lapped joints all round the periphery, and are held in place by means of dovetails fitting into corresponding grooves of the cast-iron supporting rim. The steel side plates are cut out of the solid and turned to the exact circumference of the wheel. The joints of these plates overlap each other all round the periphery, and the plates are securely bolted through the magnet stampings and also through the cast-iron rim. These plates are of 1 in. thickness, and provide additional weight at the rim of the wheel. Ventilating spaces are left between the steel side plates and the cast-iron rim, allowing air to pass underneath the magnet windings and also through a central duct left in each pole.

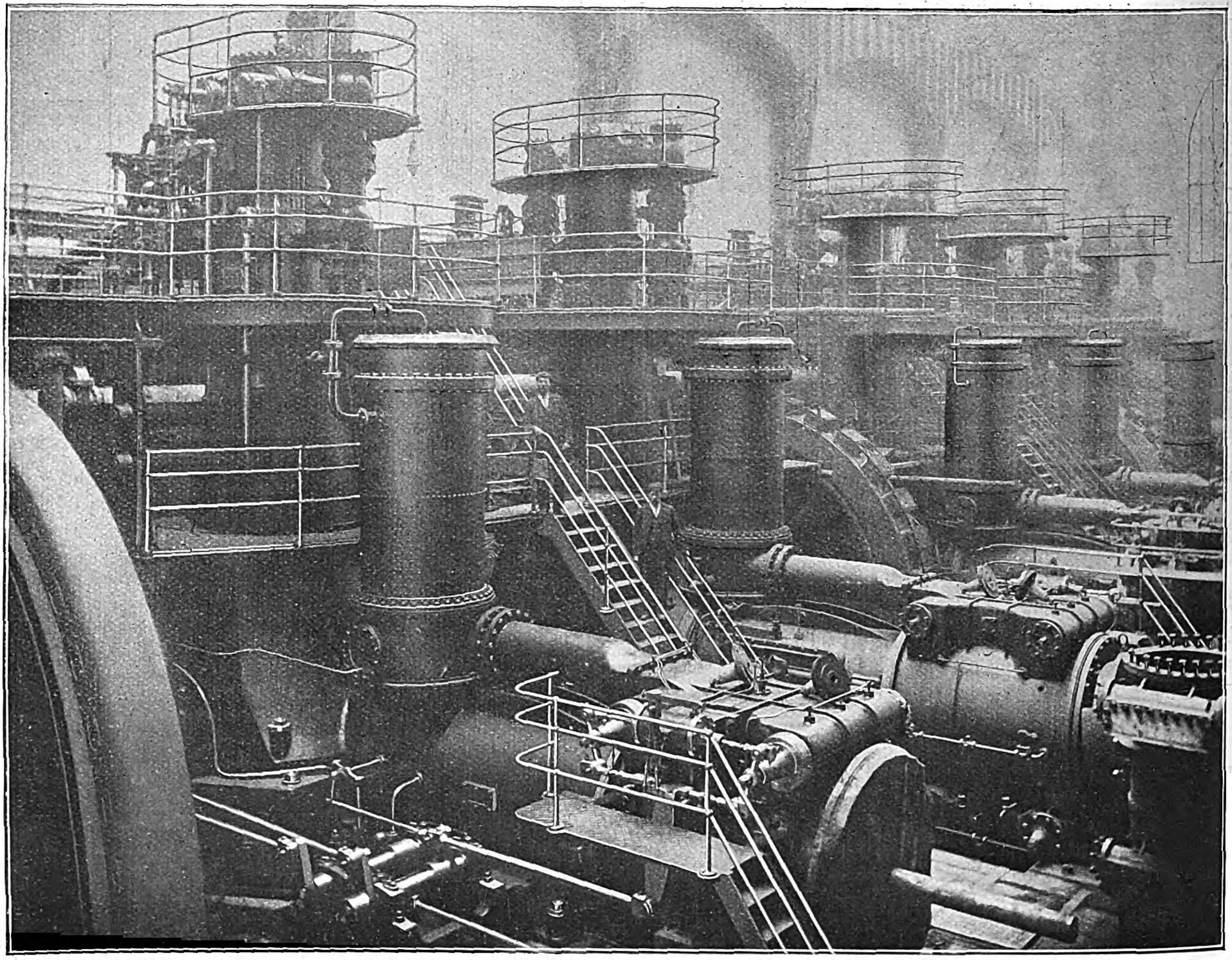
Fig. 13.—General View of Engine Room.

The field windings consist of a heavy section bare copper strip bent to the exact shape of the coil—that is, rectangular with slightly rounded corners. The coils are exposed to ample ventilation, both internally and externally, but, at the same time, they are thoroughly insulated from the magnet stampings. They are held securely in place by means of the projecting pole faces, which are fixed after the windings are in place; the method of holding these is seen in Fig. 12. The special construction of the pole faces is shown in this figure and the previous one; the laminations are assembled in three groups so as to give overlapping edges. This arrangement is designed to give a very gradually tapering field strength, and the shape is adjusted to give a sine curve of E.M.F.; these considerations, and the numerous slots per pole in the armature, should reduce the harmonics to a minimum.

The flywheel is cast in four sections, each section consisting of two arms with a quarter of the rim, and, in order to ensure that these will be freed from casting strains, the rim is divided between the two arms, the latter being, therefore, free to contract during cooling. The wheel is keyed to the shaft by means of a steel key in each quadrant, and massive steel rings are shrunk on each end of the boss to ensure that the latter will have a satisfactory grip upon the shaft. The diameter of the shaft at the boss is 34 in., and the complete wheel weighs 80 tons. The phosphor bronze collector rings have a diameter of 4 ft. 6 in., and are carried on a cast-iron spider which is supported from the boss of the wheel. They are of massive section, and the rubbing contact is ample for cool running with the maximum exciting current of 400 amperes. The cables connecting the collector rings to the field windings are carried in a groove moulded in one arm of the wheel, and, while completely hidden, are quite accessible and well protected from injury.

The specification called for an efficiency of 95 per cent. at full load, 94 per cent. at three quarter load and 92 per cent. at half load, while the rise in volts from full load to no load with 0·94 power factor should not exceed 8 per cent., and, from the designer's calculations, these figures should all be improved upon on actual test.

Fig. 13 is a general view of the engine-room in its present condition, and Fig. 14 is from a photograph of the alternator. The first set is practically completed, and the magnet wheel of the second is in course of erection.

The exciters are rope-driven by means of a rope pulley fixed on the engine shaft alongside the alternator flywheel, and there is a direct-current barring motor driving through worm gear. Rope-driven exciters were adopted because of the difficulty of applying a direct-driven exciter without making it of unduly large size on account of the slow speed of the machines. The exciters are shunt machines running at 450 revs. per min., and supply current to the field circuits at 125 volts. The field rheostat of the exciter is mounted on the machine and is set once for all, and all regulation is carried out by a rheostat in the main field circuit, which is placed on the lower switchboard gallery, and is controlled mechanically from the desk switchboard there. There is no switch in the field circuit at all. If an exciter breaks down, two loose leads are run straight from the field terminals of the alternator to a pair of terminals on one of the auxiliary machines.

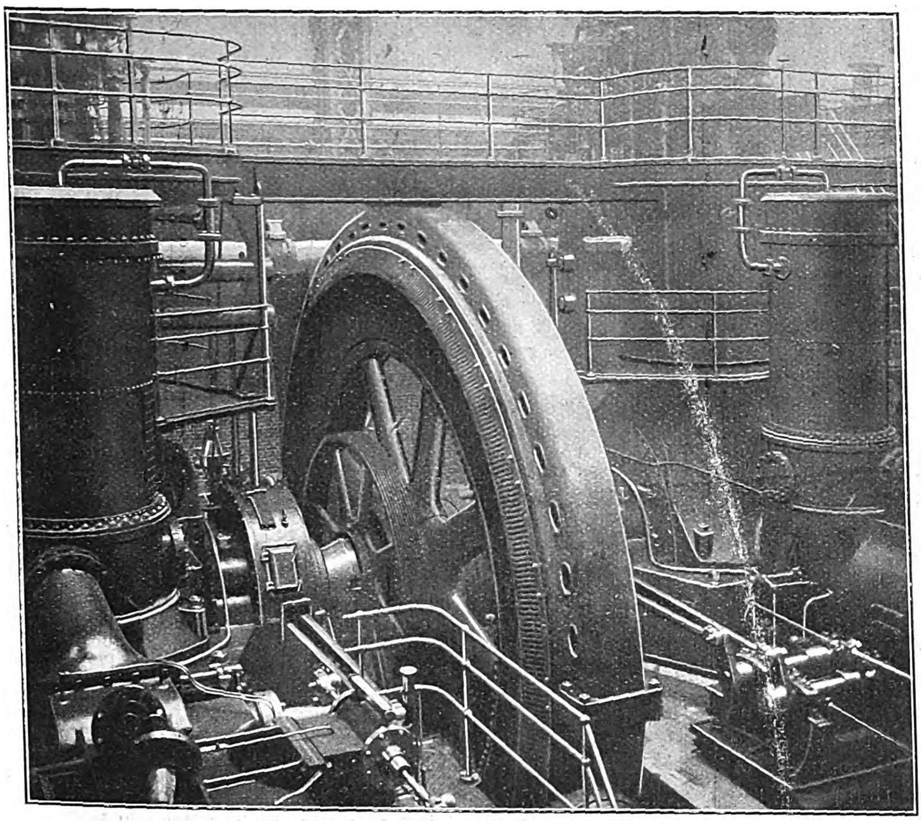

Fig. 14.—General View of Alternator.

These auxiliary machines supply current at 125 volts, and consist of two Belliss-Dick Kerr 150 kw. shunt machines. As an alternative current can be taken from a "buffer-battery", connected across the 550 volt D.C. traction 'bus bars of the local sub-station, which is contained in the same building as the power house, and supplies the Greenwich section of the tramways. The pump motors, the electric knock-off on the engines, the exciter fields, the incandescent lighting of the station, and, more important than all, the operating circuit of the switch gear, are supplied from this 125 volt circuit. One of the two machines is sufficient for all the power, and the other serves as a stand-by and can be used as a special exciter if necessary. The battery is a large one, and consists of 280 Tudor cells with a capacity of 645 ampere-hours at the three-hour rate of discharge, or 450 ampere-hours at the one-hour rate, and it can furnish, if necessary, without damage to the plates, 900 amperes for 15 seconds. It is charged from the 550 volt mains by means of a booster, and the 125 volt point of the battery is permanently on to the 125 volt 'bus bars, as is also the auxiliary dynamo. The battery is in a room under the workshop, and it is in one tier, standing on a sloping asphalt floor with channels to carry away any spilt acid. Each cell stands on corrugated glass insulators, and the feet of the rack rest on creosoted blocks set in concrete.

*(To be concluded.)*

# A STUDY IN THE DESIGN OF A 500 KW. CONTINUOUS-CURRENT GENERATOR.

BY DR. MAX BRESLAUER.

Although much discussion is now prevalent in the technical Press about compensating devices to suppress armature reaction and reactance voltage in direct-current machines, there are still a great many experienced designers who are keeping aloof from a free use of auxiliary poles and the like, being of opinion that sparkless commutation can be obtained, in ordinary cases at least, by simpler means. The theory of dynamo design, specially with respect to commutation, is now, thanks to the work of many distinguished engineers, so far advanced that the conditions conducive to sparkless commutation are quite clear and well known. Still, there are some constants used in the different formulæ the proper values of which are not quite certain. No apology is, therefore, needed for bringing forward reliable data, with a view to fixing the extreme limits of the constants used, corroborating and extending experience already acquired.

It is well known that for any given output there exists a certain limit of speed beyond which a satisfactory generator cannot be built without special devices, such as auxiliary poles. The 500 kw. generator which is referred to in the present article runs at a speed of 300 revs. per min. and is hard upon these limits. As, however, it proved to be very successful in operation, a full discussion of its design appears to be justified. Before, however, discussing the figures and dimensions of this special machine, it is necessary to find a common basis for the comparison of the different formulæ generally used as a criterion for the sparking conditions.

## Formulæ for Reactance Voltage.

It is universally agreed that the so-called reactance voltage—that is, the mean voltage generated in a short-circuited armature coil by the reversal of the current during the time of commutation—has the greatest influence on the sparking conditions. A certain limit must not be overstepped if the brush position is to be fixed, and a further extension of this limit can only be admitted if it is allowed to shift the brushes according to the load. But even then a limit exists for the reactance voltage ($e_r$) beyond which a sparkless position cannot be found.

According to the writer's experience there are very few generators at present in use in central stations which allow overloads up to 20 per cent., or even full load, to be suddenly switched off and on without moving the brushes and without showing any signs of sparking, although this is generally required of and can be fulfilled by the most recent machines, and was a condition specified in the present case.

On looking through the literature dealing with the calculation of reactance voltage, one finds a bewildering number of formulæ for calculating its value, and whilst one author fixes the limit at about 5 volts, others take 3 volts or even 1 volt as a maximum. It would, therefore, be of no avail to give here simply the value of this quantity without showing how to compare it with the results obtained by the different methods of calculation.

It is to Hobart that the credit is due of finding a practical method of calculating. He arrived at the now generally accepted assumption that every centimetre "embedded length" of a conductor carrying 1 ampere creates 4 lines, and every centimetre "free length" 0·8 line of force. This holds good for modern machines with comparatively shallow and broad slots. If we take in account that all along the embedded length of the conductors the bars are always adding their flux, which is not the case outside the slots, this means that the "embedded" flux per centimetre is always in the ratio of 8 : 0·8, or 10 : 1, compared with the "non-embedded flux." This leads at once to a method of calculating the flux produced by the number $m_s$ of conductors under commutation.

Calling the embedded length of each conductor—that is, the length of the armature without ventilating ducts—$l$, and its free length $l_f$, then each conductor will produce per ampere in the neutral zone a flux $8l + 0{\cdot}8l_f = 8(l + 0{\cdot}1l_f) = 8l'$, where $l'$ stands for the corrected armature length which is about 20 to 40 per cent. greater than the actual length of the core; and if $m_s$ conductors are short-circuited per segment, and $i$ is the total armature current, the total flux in the neutral zone linked with the conductors under commutation will become $N_z = 8l'\frac{i}{2a}$, where $2a$ is the number of paralleled circuits in the armature.

Now the mean E.M.F. induced in the $m_s$ conductors by this flux will be $e_r = \frac{2N_z}{T}m_s \times 10^{-8}$, where T is the time of commutation, the flux being doubled owing to the current changing from a positive maximum to a negative minimum. To work out the time of commutation, a certain width of the brush compared with the segment has to be assumed. Hobart actually takes this into account and calculates the reactance voltage in all cases with respect to the width of the brush as employed in the case under consideration. Now, experience shows that the width of the brushes never has, within certain limits, a perceptible influence upon the commutating conditions. Obviously the good effect of a prolonged time of commutation is counterbalanced by the increased ampere-turns under short circuit.

Hence, for the sake of comparison, we are justified in taking an arbitrary value for the width of the brush and, since carbon brushes are seldom narrower than two segments, we may conveniently select the width of two segments as the standard width of our brushes. Calling, therefore, the commutator diameter $d_c$, the number of segments S and the peripheral speed of the commutator $v = \frac{d_c\pi n}{60}$, the time T of commutation will be equal to the time during which the space of two segments, viz., $2\frac{d_c\pi}{S}$, is covered at the speed $v$, or

$$T = \frac{2\frac{d\pi}{S}}{v} = \frac{2\frac{d_c\pi}{S}}{\frac{d_c\pi n}{60}} = \frac{120}{nS}.$$

Now, calling the total number of conductors $2am$, where $m$ is the number of efficient wires or conductors in series between two adjacent brushes of opposite polarity (for instance, in a simple series-wound armature, half the total number of conductors), we get $m_sS = 2am$ or $S = \frac{2am}{m_s}$.

This value of S, substituted in the equation for T, gives the time of commutation $T = \frac{120m_s}{n2am}$.

Hence the reactance voltage

$$e_r = \frac{2N_z}{T}m_s = \frac{16l'm_si/2a}{120m_s/n2am}m_s \times 10^{-8},$$

$$e_r = 0{\cdot}133m_sl'imn \times 10^{-8}.$$

This is the simplest method of calculation for this all-important quantity I have been able to find, and it can be shown that all other formulæ used can be reduced to this same formula, with the exception of the constant 0·133 and the correction to be applied to the armature length $l$, which is modified above to $l'$.

Whilst dealing with this formula it may be of interest to drawn attention to the fact that its components are very similar to the ordinary formula for calculating an E.M.F. Taking $im$ as proportional to the ampere-turns, the expression $l'$ standing for magnetic conductivity, we find immediately that the product $lmi$ is proportional to the flux generated by the ampere-turns of the armature in the neutral zone: this flux is cut by $m_s$ conductors moving with a velocity proportional to $n$ just the same as any other law governing the generation of an E.M.F.

Thus the factors of paramount importance in dealing with the commutation problem are clearly shown to be the number of conductors per segment $m_s$, the magnetic conductivity represented by $l'$, the ampere-turns of the armature $im$ and the speed $n$. One finds by experience that the reactance voltage $e_r$ thus calculated must not, under ordinary conditions, exceed 2 volts if no brush movement is permitted from no load to 20 per cent. overload. This, of course, is not the only condition, since the ratio of armature A.T. to the A.T. required for the gap, teeth and core is of no less influence, but must be treated separately. It must be understood that with a reactance voltage of 2 volts, the brushes cannot be kept in the geometrically neutral point, but already require a fixed constant lead. For brushes in the neutral position—as, for example, with reversible motors—a reactance voltage greater than 1·1 volts is not admissible, but in cases where shifting of the brushes according to the load is allowed, the limit for $e_r$ can be extended up to 3·2 volts.

Having thus developed the formula as used to determine $e_r$ it remains to be seen how it compares with data given by other authors. It is, of course, in close dependence on Hobart's method, and leads to exactly the same results if the brush width is uniformly assumed to be equal to twice the pitch of the commutator segments, a correction which can easily be applied in any special case, but cannot, of course, be expressed by a simple and constant ratio.

Prof. Arnold, in his latest book (Vol. II., p. 288) on continuous-current machines, introduces a so-called armature constant which for good commutation must not exceed a certain limit. This formula reads: $m_sACl v \times 10^{-8} < 0{\cdot}3 - 0{\cdot}35$. Now, the expression AC, or ampere conductors, per centimetre circumference of armature can be written $AC = mi/d\pi$, where $m$ is the total number of efficient conductors, $i$ the total armature current, and $d$ the armature diameter. Substituting further $v = d\pi n/60$ we get Arnold's armature constant

$$m_s\frac{mi}{d\pi}l\frac{d\pi n}{60} < 0{\cdot}3 - 0{\cdot}35,$$

or

$$0{\cdot}0166m_slmin < 0{\cdot}3 - 0{\cdot}35.$$

Comparing this with above formula for $e_r$ one finds it actually identical but for the figure 0·0166 instead of 0·133. Therefore, to make both values comparable, Arnold's constant has to be multiplied by eight on both sides, and allows a limit of 2·4–2·8 volts. Taking into account, however, the correction of $l$ into $l'$ with respect to the "free length" of each conductor, and assuming, as an average, $l'$ to be 30 per cent. greater than $l$, Arnold's limit will be reduced to the values 1·85–2·15 volts, which is near enough to our former figure, 2 volts.

Fischer-Hinnen, in the latest edition of his well-known book on D.C. machines, gives the following simple formula for the comparison of the reactance voltage:—

$$e_r = \frac{\text{conductors per segm.} \times \text{watts}}{dBa} \times \frac{\text{pitch of segm.}}{\text{width of brushes}} < 0{\cdot}3.$$

Now, having assumed uniformly that the brushes have to cover two segments, the latter fraction becomes $\frac{1}{2}$. Considering further that watts $= ei = m\frac{2pn}{60}Ni$, where N = flux per pole, and that the induction B in the air-gap ($\alpha$ being the ratio of pole arc to pole pitch) can be written $B\alpha = N2p/d\pi l$, the formula of Fischer-Hinnen, by the above substitutions, will read

$$e_r = \frac{m_sm\frac{2pn}{60}Ni}{d\frac{N2p}{d\pi l}}\frac{1}{2} < 0{\cdot}3,$$

or

$$0{\cdot}026m_slmin < 0{\cdot}3.$$

Again, we see that but for the constant 0·026 instead of our 0·133, and for having introduced the non-corrected armature length $l$, instead of our $l'$, Fischer-Hinnen's formula is in complete accordance with the formula deduced from Hobart's data. To make Fischer-Hinnen's expression comparable with ours both sides have to be multiplied by 5·1, and accordingly the reactance voltage $e_r = 0·133 m_s l m i n < 1·53$ volts.

Introducing again the correction owing to the free length from $l$ into $l'$, Fischer-Hinnen's limit would be reduced to $e_r < 1·2$ volts, which is a far stricter condition than our former assumption of $e_r < 2$ volts.

A very similar result, however, is also obtained with the formula deduced by Prof. Pichelmayer,* which reads $e_r = \zeta m_s v \mathrm{AC} l \times 10^{-8} < 1·5$. The symbol $\zeta$ here stands for the number of lines generated per centimetre armature length by one ampere turn. As this constant, according to Pichelmayer, is said to vary between 6 and 9, an average of 7·5 may be assumed, and substituting again $\mathrm{AC} = mi/d\pi$ and $v = d\pi n/60$, Pichelmayer's conditions finally give $e_r = 0·125 m_s l m i n \times 10^{-8} < 1·5$ volts.

Again we find the result identical with our formula, but for the constant 0·125 instead of 0·133, therefore multiplying both sides with 1·06 the limit is given as $e_r < 1·6$ volts, or taking in account the correction of $l$ into $l' e_r < 1·23$ volts, which is practically identical with Fischer-Hinnen's limit. In a recent Paper read before the Manchester Section of the Institution of Electrical Engineers dealing with labour-saving formulæ in dynamo design, Mr. Frith gives the following formula:—

$$e_r = \mathrm{AT\ per\ inch\ diameter}\ nldk \times 0·105 \times 10^{-8} < 5 \text{ volts.}$$

All quantities given in inches. He assumes $\mathrm{K} = 20$ to be the number of lines generated per inch of armature length and per ampere-turn. Transforming everything from inches into centimetres where it may be observed that the term AT per inch diameter exactly corresponds to four times ampere conductors per centimetre periphery or 4 AC, one gets finally

$$e_r = 0·207 m_s l m i n \times 10^{-8} < 5 \text{ volts.}$$

which condition, if reduced to our constant 0·133 instead of 0·207 and to the corrected $l'$ instead of $l$, would give $e_r < 2·45$ volts.

Mr. Punga (*Electrical Review*, 1904, p. 653), gives a formula reading

$$e_r = 12·5 m_s l \frac{ei}{\mathrm{N} 2p} < 3·5.$$

Substituting again $$e = m \frac{2pn}{60} \mathrm{N} \times 10^{-8},$$

one obtains $$e_r = 0·208 m_s l m i n \times 10^{-8} < 3·5.$$

This condition would amount, according to our formula, to $e_r < 1·72$.

Mr. Hunt, in *The Electrician*, Vol. LIII., p. 53, recommends the formula

$$e_r = \mathrm{AT\ per\ pole} \times ln \frac{m_s}{2} \times \frac{2p}{4} \times 10^{-8} < 0·6.$$

Substituting here AT per pole $= \frac{1}{2} \frac{mi}{2p}$, we get $e_r = 0·0625 m_s l m i n < 0·6$, or, making the reduction on our figure 0·133 instead of 0·0625 and on $l'$ instead of $l$, one arrives at $e_r < 0·99$ volts.

Finally, the rather elegant formula of Mr. Rothert† reading

$$e_r = \frac{m_s l' \mathrm{K} w}{2p\mathrm{N}} 7·5 \times 10^3$$

deserves attention. This can be developed by substituting $e = m \frac{2pn}{60} \mathrm{N}\, 10^{-8}$ into $e_r = \frac{1}{8} m_s l' m i n \times 10^{-3} < 1·9$ which leads, if reduced to our constants, to the limit $e_r < 2·0$ volts, being in complete accordance with the limit given by the writer for constant brush position.

Looking over the above results of the different designers we find that they vary in the ratio of 1 : 2—viz., from 1·2 volts as stated by Fischer-Hinnen and Pichelmayer to 2·4 volts as in the case of Arnold and Frith. Taking in account the wide differences in opinion as to what can be called good performance of a generator these discrepancies are in reality smaller than one might have expected. Also it was not always stated whether any brush shifting was allowed or whether the brushes were supposed to be kept in the geometrical neutral position. It is sufficient, however, to know that none of those designers allows a reactance voltage greater than 2·4 volts. Most of them are considerably below this figure, whereas in my experience $e_r > 2$ volts appears to be unsafe if, under ordinary circumstances, fixed position of brushes up to 20 per cent. overload is required.

Let us now apply the method to the new 500 kw. generator constructed for the Perth Corporation, the main dimensions of which are represented by Figs. 1 and 2. This machine has 10 poles, the normal current is 910 amperes; there are 144 slots with 8 conductors per slot, and 575 segments. Hence the total number of conductors is $8 \times 144 = 1,150$, and as the armature is lap-wound with 10 parallel circuits the efficient number of conductors would be $m = 115$. The total armature iron length ($l$) with insulation but without ventilating ducts is 27·5 cm., and the mean length of one conductor is 95 cm., leaving a free length of 67·5 cm., therefore $l' = l + 0·1 l_f = 27·5 + 6·8 = 34·3$ cm.

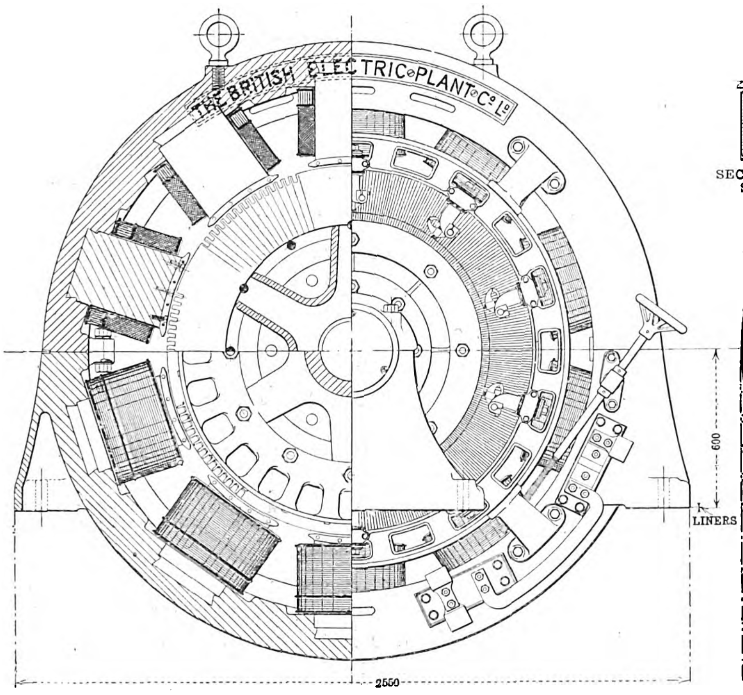

Fig. 1.—500 kw. Generator. Sectional Elevation.

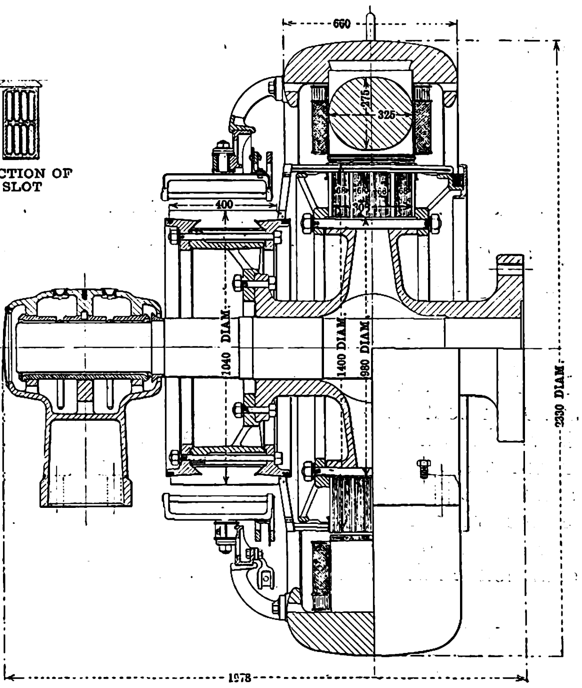

Fig 2.—500 kw. Generator. Section through Shaft.

Further, as there are 1,150 conductors and 575 segments, the number of conductors per segment ($m_s$) is 2. The speed being 300 revs. per min., our formula yields

$$\begin{aligned} e_r &= 0·133 m_s l' m i n \times 10^{-8} \\ &= 0·133 \times 2 \times 34·3 \times 115 \times 920 \times 300 \times 10^{-8} \\ e_r &= 2·9 \text{ volts.} \end{aligned}$$

We now see that in this generator the value of $e_r$ is almost $2\frac{1}{2}$ times Fischer-Hinnen's limit, and is more than 40 per cent. above the writer's condition, or 20 per cent. greater than the highest value considered as permissible by any of the other authors quoted. If we consider, further, that the output coefficient which is the ratio of the product $d^2 l$ to watts per revolution,

$$\mathrm{G} = \frac{ld^2}{\text{watts per rev.}} = 32·4,$$

is rather small, and that the number of ampere conductors per centimetre periphery is not higher than $\mathrm{AC} = 240$ per centimetre, or $= 960$ AT per inch diameter, nothing abnormal can be found in these two values to explain the good results obtained with this machine.

### Armature Reaction.

We know, however, that next to reactance voltage the ratio of armature ampere-turns per pair of poles, $\mathrm{AT}_2$, to the ampere-turns for air gap, teeth and core is of prime importance

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* *Elektrotechnische Zeitschrift*, 1902, p. 623.

† *Elektrotechnische Zeitschrift*, 1902, p. 311.

To determine this ratio we must calculate the various sections of the machine, dimensions of which are given in Figs. 1, 2 and 3. From the figures given in these drawings, and taking a mean air-gap of 6·5 mm., we find that, to obtain a terminal voltage of 550 on full load with 11 volts drop in the armature and brush resistance, a flux of 9·75 megalines is required, and with a maximum apparent induction in the teeth of 23,500 lines per centimetre the total AT for gap, core and teeth per pair of poles work out to $AT_f = 12{,}100$. This appears to be a very reasonable figure, as the saturation curve obtained from the test (Fig. 4) gives a total of 16,500 ampere-turns for the whole magnetic circuit, leaving 4,400 for yoke, pole, limbs and joints. On the other hand, with 115 efficient conductors, the armature ampere-turns per pair of poles are

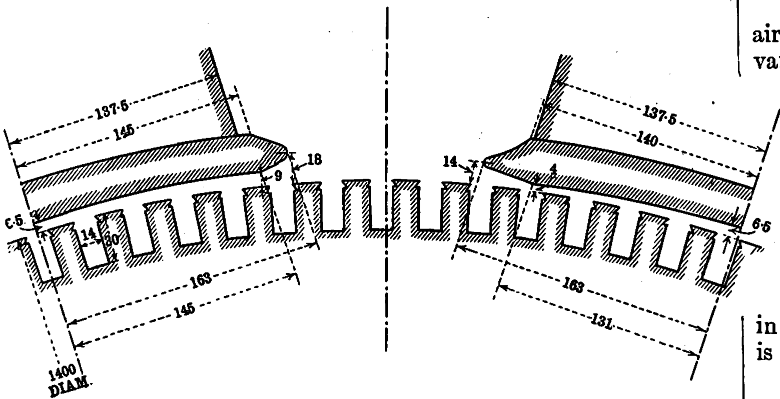

Fig. 3.—Section showing Shape of Pole Faces.

$$AT_2 = \frac{115{,}920}{10} = 10{,}600.$$

We therefore get a ratio of $AT_2 : AT_f = 10{,}600 : 12{,}100 = 0·88$, and at 20 per cent. overload $AT_2 : AT_f = 1·05$.

It is well known that in general, with the ratio of armature ampere-turns to ampere turns for gap, teeth and core above 0·7, a machine is not considered safe, and 1·0 is assumed to be the very limit. Hence, in this respect also the machine seems to be dangerous and to considerably exceed the orthodox limit of design. It will be interesting to compare with the above ratio a formula given in Fischer-Hinnen's book on D.C. machines (p. 242). It is rather complex in appearance, but we, for our purposes, will try to simplify it. This formula gives a second limit for good commutation, and reads in our notation

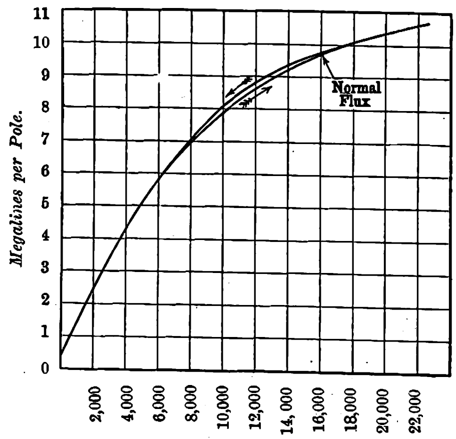

Fig. 4.—Saturation Curve.

$$\delta B_a \frac{pa}{(1-a)i2am} \cdot \frac{\gamma n_c}{d_c} > 3·5 - 4,$$

where $B_a = 10{,}000$ is the air saturation, $a = 0·7$ the ratio of pole arc to pole pitch, $\gamma = 15$ mm. the thickness of the brushes, $n_c$ the number of segments, and $d_i$ the diameter of commutator. Now, since the pitch of segments can be written $\gamma_i = \frac{d_c \pi}{n_o}$, the term at the end of the formula $\frac{\gamma n_c}{d_c} = \pi . \frac{\gamma}{\gamma_c}$ means nothing but the ratio of brush width to pitch of segments.

In the middle fraction

$$\frac{pa}{(1-a)i2am} = \frac{1}{1-a} \frac{1}{4} \cdot \frac{2p}{i.m} = \frac{1}{4} \frac{1}{AT_2} \frac{1}{1-a},$$

we recognise our well-known armature AT, but multiplied by $(1-a)$, which means that only that part of $AT_2$ is taken into consideration which is situated between the pole tips, or in our case only $0·3AT_2$; it is that part which is directly opposed to the field AT, or the proper "reacting" AT.

Finally, in the first part, $\delta B_a = \frac{1}{1·6} 2\delta B_a 0\ 8$, we recognise the air AT which in our case amount to 10,400, and, combining the various numbers, one obtains as Fischer-Hinnen's second criterion $0·45 \frac{\text{air AT}}{\text{reacting AT}} \cdot \frac{\text{brush width}}{\text{pitch of segm.}} > 3·5 - 4.$

By writing the formula in this way it is clearly shown that it contains as its principal part the inverse value of the well-known ratio between field and armature AT, which, in the interest of a stable field, ought to be as large as possible. Although the writer is not of opinion that much can be gained by altering the thickness of the brushes, we may as well work out the above formula and find its value in our case where the ratio of brush width to pitch of segments is $15 : 5·68 = 2·65$.

The figure therefore becomes $0·49 \times \frac{10{,}400}{3{,}200} \times 2·65 = 4·25$, which is very near to the limit of 3·5 – 4.

Summing up, therefore, we find that whilst the reactance voltage or armature constant is not only already in excess of what is generally considered safe, that this is by no means compensated for by a small armature reaction: on the contrary, the armature strength is also greater than generally admitted.

(*To be concluded.*)

## THE KINGSTON SUB-STATION OF THE LONDON UNITED TRAMWAYS CO.

The group of new lines in Surrey to which we referred briefly in a note in our last issue are fed entirely from the company's new sub-station in London-road, Kingston, to which power is supplied from the generating station of the Underground Railways Co. of London at Lot's-road, Chelsea. A full description of this station, which already supplies the Metropolitan District Railway and the Baker Street & Waterloo Railway, was given in *The Electrician*, Vol. LIV., p. 4. Current is supplied to the sub-station by special underground cables at 11,000 volts, 33⅓ cycles. This transmission line is 10 miles 650 yds. in length and passes over Wandsworth Bridge, following a route through Wimbledon and New Malden to Kingston. The first portion of the line as far as Wimbledon is laid "solid" in earthenware ducts and consists of three separate three-core cables, one of which, however, is not yet used, as it was laid to supply the sub-station which is about to be established at Wimbledon when the Wimbledon-Tooting group of lines are completed. The section between Wimbledon and Raynes Park is laid on the drawn-in system in "Sykes" conduits, but the solid system is used on the last portion through New Malden to Kingston.

This cable was supplied and laid by Henley's Telegraph Works Co., who also supplied and laid some 45 miles of L.T. feeder and distributor cables in connection with this group of lines. A section of the E.H.T. cable was given in *The Electrician* of October 20th, p. 27. It is of the three-core type, each core consisting of 19 strands and having an aggregate section of 0·05 sq. in. The cable is insulated with impregnated paper and lead covered, the armouring being directly on the lead, without an intermediate serving of jute or covering of tape, in order that the conductance of the lead may be reinforced by that of the armouring. The thickness of the insulation is $\frac{7}{16}$ in. and of the lead covering $\frac{3}{16}$ in. The armouring consists of 66 galvanised steel wires, each No. 12 gauge. The conductor resistance is 0·492 ohms, the dielectric resistance 350 megohms, and the capacity 0·144 mfd. per 1,000 yds. At places where the E.H.T. cables follow the same route as the trams, the L.T. feeders are laid in separate ducts in the same conduits. No special feeder charging arrangements have been installed at Lot's-road, but protective spark-gaps are provided at the Kingston end, immediately over the trifurcating boxes where the two cables enter the sub-station. These are of the standard Westinghouse multi-gap type, consisting of a number of rows of cylinders of non-arcing metal mounted on marble panels, all six sets being in separate chambers. Difficulties of resonance are not, however, anticipated. Each cable was tested last week with a pressure of 22,000 volts applied to each core for 20 minutes, after they had been subjected to a pressure of 11,000 volts for two hours, the other two cores being earthed. Both the cables withstood the test thoroughly satisfactorily without the slightest trouble being experienced with any of the numerous joints (about 300) throughout the line.

The switching arrangements in the sub-station are simple and straightforward, following very closely the lines of the other sub-stations supplied from Lot's-road, a typical example of which may be found in the Charing Cross sub-station of the District and new Tube railways, described in *The Electrician*, Vol. LIV., p. 615, the chief difference being the greater amount of floor space available, rendering the arrangement of the plant much less cramped. The whole equipment of the sub-station is by the Westinghouse Company, and represents their latest standard practice.

The E.H.T. feeders enter the sub-station behind the board, and the main feeder oil switches are situated on a floor above, each phase, as usual, in a separate fireproof compartment. The transformer switches are exactly similar to the feeder switches and are placed in chambers at the other end of the board. The single set of 'bus bars runs horizontally at the back above the switches. Isolating links are provided for cutting out the switches for inspection, and the series transformers for operating the instrument are contained in chambers above the oil switches. The oil switches are all hand-operated by levers on the main board below. The incoming feeder switches are fitted with reverse current releases tripped by relays on the front of the board, the feeder overload cut-outs being at Lot's-road. The transformer switches, however, are provided with time limit overload relays. The voltmeter transformers are also situated in chambers near the machine switch. Insulated leads are run on insulators from the switches to the transformers below.

Seven separate single-phase transformers are used, each of 200 kw. capacity. One of these serves as a spare and can be temporarily connected to either phase. They are all of the oil-cooled type without forced air blast. The operating board consists of vertical marble panels, the feeder panels being at the extreme left, the H.T. transformer panels in the centre and the rotary panels on the right. The rotary panels contain the starting switches for the small motors, which run the converters up to speed as well as the main three-pole switches. Spare panels for extensions are also provided.

Two rotary converters for 500 kw. each have been put down, small three-phase motors being coupled to their shafts for starting up. Space is provided for future extensions. We are informed that the efficiencies of the rotaries on full load and half load are 94 and 91 per cent. respectively, and that they can give their full-rated outputs for 12 hours with a temperature rise not exceeding 40° C. The transformer efficiencies are given as 97 per cent. on full load, 97 per cent. on half load, and 96 per cent. on quarter-load.

The continuous-current switchboard is entirely distinct from the alternating board, and is situated on the opposite side of the building. The following panels are provided: Two machine panels, one spare panel, one Board of Trade panel, one meter panel, five feeder panels, two booster panels and one depot panel. The recording instruments are of Messrs. Elliott Bros.' pattern. Two negative boosters are provided, each rated at 15 kw. The efficiency of the combined motor and booster set at full load is stated to be 76 per cent.

The resident engineer to this part of the tramways is Mr. C. R. Holmes, and the sub-station is under the charge of Mr. W. Nairne, electrical engineer, to whom our thanks are due for kindly showing our representative over the sub-station.

The opening of these lines took place on March 1st, when the Mayor of Kingston drove the first car over Kingston Bridge. The addition of these routes to the London United Tramways Co.'s system brings up their total route-miles from 37 to 44, and this figure will be further increased to 55 when the Wimbledon and Tooting extensions are completed. The new cars, which are running on these lines, are of the double-deck type with top canopies, and are the first of this pattern which the company has put into service. We regret to learn that Sir J. Clifton Robinson met with a slight accident on the day of the opening, having been knocked off the step of one of the cars on the occasion of a collision of a brewer's dray with the car caused by a frightened horse which got across the track. Fortunately, however, he escaped without serious injury.

## A NEW SINGLE-PHASE COMMUTATOR MOTOR.*

BY V. A. FYNN.

During the last few years quite a number of engineers have been engaged in an attempt to produce a single-phase motor which could compare with its continuous-current rival. As the railway problem has been principally in mind, these efforts have been restricted to types possessing a series characteristic, and consequently to motors unsuitable for most of the stationary work. There exists, however, a great demand for a "constant-speed" machine, with great starting torque and high power factor. The motor to be described in this Paper can be built with either shunt or series characteristic; the former class has now been fully developed.

No description of a modern single-phase commuatator motor can be complete without a reference to the pioneer work of Mr. Ll. B. Atkinson, who, in a masterly Paper read in 1898 before the Institution of Civil Engineers, described those forms from which all the modern single-phase commutator motors are directly derived, and who already then dwelt at length on their several advantages and peculiarities. The Atkinson motor is shown diagrammatically in Fig. 1. The primary member is magnetised along an axis, F, by means of the winding S. The secondary member, which consists of an armature provided with a continuous-current winding connected to a commutator, is short-circuited by means of the brushes CC and DD along two perpendicular axes, one of which coincides with the field axis of the primary member or stator. This diagram and all the following ones represent two-pole machines, while throughout the armature winding is supposed to be of the Gramme-ring type with the brushes bearing directly on the armature winding; and hence the axis of a field which could be set up in the rotor by a current passing a set of brushes will coincide with the axis of that particular brush set.

Such a commutator motor has all the characteristics of the asynchronous single-phase squirrel-cage motor; in fact, the latter is only a special case of the former. The motor in Fig. 1 will not start; if brought up to speed artificially it will do useful work running somewhat below synchronism, but its power factor is bad, it is very liable to spark at the commutator and its output for a given weight is small.

Early recognising the possibilities of this type of motor, the author subsequently set himself the problem of evolving from it a new motor, in which the above defects would be, as far as possible, eliminated. The presence of the commutator at once suggests the possibility of starting such a machine as a shunt, a series, or a "repulsion motor," and of phase compensation, but the shunt arrangement for starting must be at once discarded, since it is only at very low speeds that the motor will develop a good torque under those conditions, while plain-series connection also gives comparatively poor results. On the other hand, the machine starts very well as a "repulsion motor." It is feared that the term "repulsion motor," which has already been used repeatedly in this Paper, may lead to some misunderstanding. As far as could be ascertained this term is now generally applied to a machine mainly consisting of two members which are disposed in such a way that the one can rotate with respect to the other, and where the secondary member is short-circuited along a fixed axis not coinciding with the axis of the field produced by the primary member. It is further generally stated that the speed and torque of such a motor is, for equal conditions, entirely dependant on the angle enclosed between the axis along which the secondary member is short-circuited, and the field axis of the primary member.

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* Paper read before the Institution of Electrical Engineers last night.

In Fig. 8 is shown one form of such a "repulsion motor." The secondary member is here the rotor, which is short-circuited along a fixed axis by means of the brushes CC. The primary member is here the stator, and carries the winding S, which produces the field with the axis F. The axis along which the secondary member is short-circuited is displaced by $a$ degrees with respect to F. It is, we believe, fairly well understood how the magnitude of $a$ affects the general performance of the motor, but we are afraid that the operation of the motor is often attributed to some peculiar repulsive effect between the short-circuited rotor and the stator field such as was discovered by Elihu Thomson in 1887, and made use of by him in the construction of his motor.

Now the term "repulsion motor," although thoroughly justified when applied to Elihu Thomson's original motor (American Patent No. 363,165), is an entirely unsuitable designation for that type of motor to which it is applied nowadays. This confusion probably arose out of a misapprehension as to the true principles underlying the operation of machines such as are diagrammatically represented in Figs. 5 and 8. These machines do not depend for their operation on Thomson's repulsion effect between a short-circuited coil on the rotor and the primary field. In fact, the Thomson effect in these machines is, particularly at starting, directly responsible for a negative torque which can reach extremely high values in a bad design, and which is due to the current in those coils which are short-circuited under the brushes.

We think it is much more correct to consider such motors as being "series induction machines"; it is a more ponderous denomination than the well-established term "repulsion motor," but it is at least correct and will avoid confusion, more particularly as true repulsion motors as originated by Elihu Thomson are, we believe, still made use of. That the motors shown in Figs. 5 and 8 are true series induction machines can be easily established, and the author will take this opportunity of briefly stating what he believes to be the true theory of these machines. First turning our attention to the arrangement shown in Fig. 5, we have a stator winding divided into two groups, $S_1$ and $S_2$, connected in series and displaced by $\pi/n$ degrees with regard to each other ($n$ stands throughout for the number of poles of the machine). The axis of the group $S_1$ coincides with the axis along which the rotor is short-circuited. In this axis CC we have all the conditions of a transformer, the rotor representing the secondary and the stator group $S_1$ representing the primary. It follows that under all conditions the rotor current will be (omitting sign) very nearly in phase with the current in both stator groups, since they are in series. The field in the axis of $S_1$, and to which we will refer as the transformer field, is due to the magnetising component of the transformer no-load current; the latter is represented in phase and magnitude by the resultant of the primary and secondary currents. The field in the axis of $S_2$ is due to the total current flowing through the stator, and is in phase with it, consequently very nearly in phase with the rotor current. This second field induces no current in the rotor, but with the rotor current induced along the transformer axis, which is perpendicular to the axis of this second field, it produces the motor torque, and hence we will refer to this second field as the motor field. We, therefore, have here precisely the same conditions as exist in the series-conduction motor, except that in the present case the current is not conveyed into the rotor by conduction, but by induction. The direction of rotation is in both types of motor determined by the same rules, and the torque is due to the same causes.

Turning now to Fig. 8, it is easy to see that the conditions there are the same. The field with the axis F produced by the winding S really resolves itself into two components, one of which, $f_1$, coincides with the axis along which the rotor is short-circuited, and represents the transformer field; whereas the other, $f_2$, is displaced by $\pi/n$ degrees with regard to the former, and represents the motor field. It can be said that in Fig. 8 the stator winding directly produces the resultant F of the transformer field $f_1$, and the motor field $f_2$, whereas in Fig. 5 the stator windings each produce one of the components (transformer field in the axis CC, and motor field in the axis DD) of the resultant field F. In Fig. 8 the phase, magnitude and direction of the resultant F are fixed by the stator winding; the phase, magnitude and direction of the transformer and motor field are, roughly speaking, determined by the position occupied by the axis along which the rotor is short-circuited with respect to F. In Fig. 5 the phase magnitude and direction of the two compotent fields are determined by $S_1$ and $S_2$ respectively, and they determine the phase, magnitude and direction of the resultant F. Considering more closely the conditions prevailing in Fig. 5, we see that the phase relation between the transformer and the motor field is a variable one. When at rest, the conditions in the axis CC are those of a short-circuited transformer, and in consequence the resultant current in the primary $S_1$ will lag very considerably behind the E.M.F. impressed on the stator and will, therefore, tend to approach the phase of the transformer field, which lags by practically 90 deg. behind that E.M.F. The current in $S_1$, when taken through $S_2$, sets up the motor field in the axis DD, the phase of which practically coincides with the phase of the current producing it. Now the phase of that current will vary with respect to the phase of the transformer field very much as the power factor of the motor varies, with the result that the phase of the motor field will also vary with respect to the phase of the transformer field.

When the motor begins to move, an E.M.F. due to rotation of the rotor conductors in the motor field is set up in the rotor along the transformer axis; in phase, this E.M.F. coincides with the phase of the motor field, and tends to oppose the E.M.F. impressed on the rotor (by induction) in the transformer axis. This last E.M.F., which we will call ET, is, omitting sign, in phase with the E.M.F. impressed on the stator, and corresponds to the working E.M.F. impressed by conduction on the armature of an ordinary continuous-current motor; the E.M.F. due to rotation and tending to oppose ET corresponds to the back E.M.F. in a continuous-current motor, and we will refer to it as EB. As the motor gathers speed the conditions in the CC axis, to which we can also refer as the armature axis, approach more nearly those prevailing in a transformer working on a circuit possessed of a small amount of self-induction, and the phase of the current in $S_1$ will approach more closely to the phase of the E.M.F. impressed on the stator. The current in the armature axis is determined by EW, an E.M.F. which goes to cover the $C^2R$ loss in the rotor, and which is the resulant of ET, EB and ES, the latter being the E.M.F. of self-induction, and principally due to the leakage between secondary and primary in the transformer axis. It will be observed that we have here conditions quite similar to those obtaining in single-phase induction motors, or single-phase shunt induction motors, as the author prefers to designate them.

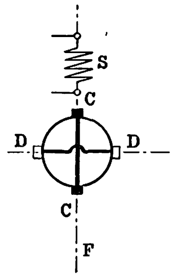

Fig. 1.

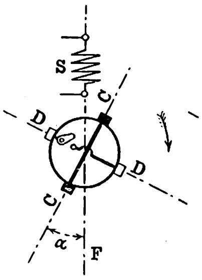

Fig. 2.

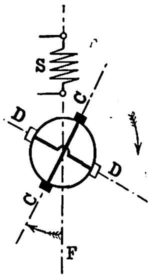

Fig. 3

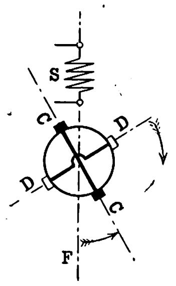

Fig. 4.

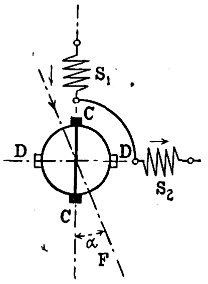

Fig. 5.

The speed of the series induction motor for a given torque will fall until the resultant of ET, EB and ES can produce in the armature axis a current of sufficient magnitude to yield the torque required in conjunction with the motor field then available. That current for a given field strength will be the greater, the greater the phase difference between itself and the motor field. The phase of the armature or rotor current will depend on the phase and magnitude of EB and on the magnitude of ES, which is proportional to the rotor current. The phase of EB depends indirectly on the phase of the stator current; its magnitude depends on the motor field strength and the speed of rotation. The strength of the motor field depends, as has already been pointed out, on the stator current, and this last condition imparts to the motor its series characteristic. Taking an ideal motor of this type, where the transformer field is quite in quadrature with the motor field, where ES is zero and where there are no losses, then, for a given torque, the speed will fall until the difference ET—EB is reduced to just that value which will suffice to drive through the rotor a current of such magnitude as will produce with the motor field then available the required torque. The field available depends, as is well understood, on the number of turns in the field winding and the magnitude of the current flowing through them, as long as the densities are not too high.

It is seen that these conditions are identical with those of an ideal continuous-current motor, and only very little different from those of a commercial motor of this class. An ordinary commercial single-phase series induction motor will, however, run very much slower than a corresponding continuous-current motor operated under exactly similar conditions, and that on account of the phase difference existing between the armature current and the motor field, which makes a larger armature current necessary to produce the torque required with a given field, and consequently calls for a smaller EB and a correspondingly lower speed. The angle $\alpha$ is, to a certain extent, a guide to the performance of the machine; thus the greater $\alpha$ in Fig. 8, the smaller $f_1$ (the transformer field), and the smaller ET, but at the same time the greater $f_2$ (the motor field), consequently the lower the speed at which EB will nearly equal ET. Since with increasing $\alpha$ the E.M.F. impressed on the armature axis decreases, whilst the number of turns and the resistance of the rotor remain constant, the output of the machine must also decrease. When $\alpha$ equals 90 deg. the motor field becomes a maximum, but there is no E.M.F. impressed on the armature, and the motor cannot exert any torque. If, on the other hand, $\alpha$ is continually decreased, the power of the motor, after reaching a maximum, finally again becomes nil when $\alpha$ is zero, because then there is only a transformer field and no motor field. If $\alpha$ is now increased in the opposite direction the motor will also start in the opposite direction, because, whilst the direction of the transformer field, and with it the direction of the armature current, has remained unchanged, that of the motor field in respect to it has been reversed. In the case of Fig. 5, and as a rough approximation, one could say that the ampere-turns in $S_2$, divided by the magnetising ampere-turns in $S_1$, were equal to $\alpha$, or, as a very rough approximation, one could take the proportion of the ampere-turns in $S_2$ to the ampere-turns in $S_1$.

We can now proceed with the description of the motor under consideration. The machine shown in Fig. 1 can be started as a series induction motor by opening one of the rotor short circuits, say DD, and displacing the whole brush system in such a way that the brushes CC will short-circuit the rotor along an axis forming an angle $\alpha$ with the axis of the stator field as in Fig. 2. After a sufficient speed has been attained the brushes DD may be short-circuited, and under these conditions the motor will operate as a shunt induction motor, but that component of the field produced by the stator which falls in the direction DD of the motor field will have a disturbing effect on the operation of the motor, because the phase of that component will not be the same as the phase of the motor field produced by the current flowing in the DD circuit.

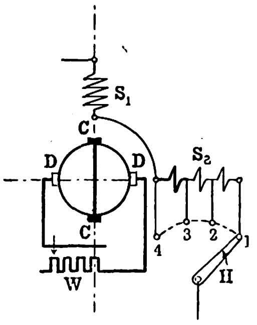

FIG. 6.

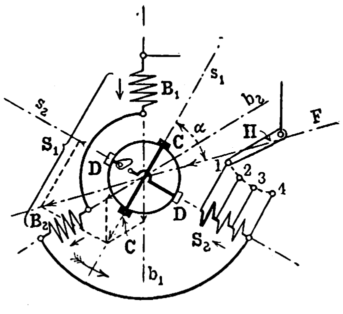

FIG 7.

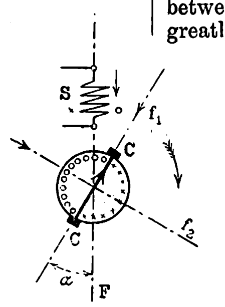

FIG. 8.

A shunt induction motor, having its rotor short-circuited along two perpendicular axes, operates best when the axis of one of the short circuits coincides with the stator field axis. If, for instance, a motor of this kind is running in a clockwise direction, and the brush system is displaced *in* the direction of rotation as shown in Fig. 3, then the current in the D circuit will fall off while that in the C circuit will rise, the line pressure and the load on the motor remaining constant; on the other hand, if the brush system is displaced in a direction *opposed* to that of rotation, as in Fig. 4, then the current in the D circuit will rise while that in the C circuit will fall. In the first case the component of the stator field coinciding with the motor field axis tends to strengthen the motor field, which accounts for the decrease in the current in the DD circuit, but at the same time it increases the phase difference between the motor field and the armature current in the axis CC, hence the increase of current in that axis for the same torque. In the second case this component is of the opposite direction, and tends to weaken the motor field, hence the increased current in the DD circuit; at the same time, it brings the phase of the motor field into closer coincidence with the phase of the armature current, hence the decrease of the CC current. Either condition is detrimental to the working of the motor, and of the two the former gives the worst results. The direction in which such a motor will start depends on the direction in which the short-circuited brushes CC are displaced from their original position of coincidence with the stator field axis; and, with a constant voltage at the terminals, the torque obtained and the current taken depend on the amount of that displacement; but it is obvious that the brush system could not be displaced at all in any commercial machine.

The disposition shown in Fig. 5 allows of the direction of rotation being reversed by reversing the current either through $S_1$ or $S_2$, but there is no provision for regulating the starting current or the torque, and when the motor has been brought up to speed it shows the same disadvantages as have already been pointed out in connection with Fig. 3. The author, by suitably modifying the disposition shown in Fig. 5, gets over all these difficulties by the arrangement shown in Fig. 6; it makes it possible to reduce the current taken by the motor, when switched on to the mains, to any desired amount, and it allows of this motor being gradually started and brought up to its normal speed without the use of the usual resistances, transformers or the like; all that is necessary is a switch such as shown at H connected to the various tappings provided in the group $S_2$. With the help of this same switch, the group $S_2$ can be finally switched out altogether, thus enabling the motor, after it has been converted into a shunt induction machine, to work under the most advantageous conditions, current being supplied to the group $S_1$ only.

With this end in view the number of turns in the group $S_1$ is so chosen as to secure the required flux densities under normal terminal pressure, and the cross-section of the conductors in this group is determined by full-load conditions. The total number of turns in the group $S_2$ is determined by the permissible current on the first notch of the starting switch, and the smaller this current is to be the greater must be the number of turns in $S_2$. A comparatively small number of turns in the $S_2$ group will be sufficient in most cases, since an increase in the number of these turns not only reduces ET, the E.M.F. impressed on the armature, and consequently the short-circuit current, but also increases the total number of turns in series across the mains, and consequently the total impedance of the motor; this rises the quicker because the turns of that group are increased which possesses the greater self-induction. With the same number of turns in both groups, a motor of this type will start light with somewhat less than its no-load current.

The group $S_1$ provides the transformer field, whereas the motor field is excited by the group $S_2$, the motor starts as a series induction motor and the greatest torque is secured with the (D or) field brushes on open circuit; were they short-circuited from the very first, this short circuit in the motor field axis would necessarily alter the phase of the motor field and bring it into nearer coincidence with the transformer field, thus increasing the phase discrepancy between the armature current axis (CC) and the motor field, and greatly reducing the torque. As the speed increases, this D circuit can be closed over resistances, and these can be gradually cut out, the motor acquiring by degrees the characteristics of what is known as the asynchronous induction motor. If care is taken to close the D circuit at about synchronous speed, the resistances can be dispensed with, and they are not provided with the small motors. Although the motor is now running at practically normal speed, it will only be able to give little power if part of the group $S_2$ is still in circuit, owing to the weakening effect of this $S_2$ winding under these circumstances, and also because the densities in motor will be below the normal.

In order to gradually bring about the more advantageous conditions of Fig. 1, and to raise the densities to their normal value, the lever H is gradually moved further and further until the whole of the $S_2$ winding is cut out. A certain amount of speed regulation, however, can be secured by including more or less of the $S_2$ winding in the motor circuit and still leaving the D brushes short-circuited. The conductors of the $S_2$ group, when the latter is used only for starting, can have a comparatively small cross-section. But when this winding is also to be used for speed regulation, the conductors will require to be larger.

The stator winding can also be arranged in three divisions on the lines of the ordinary three-phase winding, if this is a manufacturing convenience, as shown in Fig. 7. The three divisions $B_1$, $B_2$ and $S_2$ are displaced by $4\pi/3\pi$ deg. The divisions $B_1$, $B_2$ (forming together the group $S_1$) each set up a field, the respective axes of which are $b_1$ and $b_2$, while the division $S_2$ produces a field along the axis $s_2$. The two former combine according to the parallelogram of forces to form the resultant field $s_1$, which is necessarily perpendicular to $s_2$; the actual fields are shown by dotted lines in Fig. 7. If we now place the brushes CC coaxially with $s_1$, we arrive at a disposition that is equivalent to that in Fig. 6, and it is only necessary to provide the third division $S_2$ with the required tappings 1, 2, 3 and 4 in order to be able to regulate the starting torque or the speed of the motor. The motor as it now stands still has a bad power factor and a small output for a given weight, and is still liable to spark.

Before describing the means adopted to improve the power factor and the weight efficiency of the motor, it will be best to set forth shortly the working theory of such machines when running at their normal speed: Considering a motor of the class indicated in Fig. 1, we find that the stator or transformer field, as we will call it, will induce in the rotor an E.M.F. along the axis CC. This E.M.F., to which we will refer as the working E.M.F. and designate by ET, being due to static induction (transformer action), will lag by 90 deg. behind the inducing field, and will consequently be nearly in phase with the E.M.F. impressed on the stator. Its periodicity and magnitude are independent of the speed at which the rotor revolves, and only vary with the magnitude and periodicity of the transformer field. When the rotor is at rest, this E.M.F. sets up a heavy short-circuit current in the rotor along the axis CC. With increasing speed a counter E.M.F. is set up which prevents a short circuit, so that under these conditions, and in the direction of the CC axis, the motor may be looked upon as a transformer with a considerable amount of leakage, whose secondary works on a circuit having only a small amount of self-induction. The rotor current in the axis CC, to which we will refer as the armature current, lags behind the secondary E.M.F., and the stator or primary current will lag behind the impressed E.M.F.; the phase difference, however, will not be greater than that existing in a badly-designed transformer, and owing to the same reasons in both cases it will decrease with increasing load.

The rotor winding is, however, the seat of a further E.M.F. induced therein by the rotation of the rotor conductors in the primary field of the motor. This E.M.F., which we will designate by ER, is set up along the axis DD, and its magnitude depends on the magnitude of the transformer field and the speed of rotation; its periodicity is equal to that of the transformer field. Since the rotor is short-circuited along DD, ER will set up a current in the rotor windings. Owing to the great self-induction of the motor along the DD axis, this current will lag by nearly 90 deg. behind its E.M.F. As this E.M.F. must be in phase with the transformer field, the magnetising component of the current along DD, and the field it produces in that direction, will be nearly in quadrature with the transformer field. We have already seen that the armature current is nearly in quadrature with the transformer field; it must accordingly be nearly in phase with the secondary field produced by rotation, and which, in space, is at right angles to CC. It is to this last field, which we will call the motor field, and to the armature current that the torque of the motor is due.

As the position of the axes along which the armature current and the motor field act is the most advantageous it is possible to secure, there is no room for improvement in this direction, but the torque can be increased by bringing the armature current and the motor field more nearly into phase. Also the phase difference between the stator E.M.F. and current can be varied to any extent and in any direction by varying the phase relation between the armature current and the E.M.F. due to static induction along CC, or, in other words, between the armature current and the transformer field. If the armature current lags behind ET, then the stator current will lag behind the E.M.F. impressed on the stator; if, however, the armature current leads ET, then the stator current will lead the E.M.F. impressed on the stator, the conditions being equivalent to a capacity load on a transformer.

Before we proceed to indicate how, for the motor shown in Fig. 1, the phase of the armature current can be adjusted with regard to the phase of the transformer field, it will be well to examine more exactly the conditions prevailing in the axis CC of the rotor. There is, first of all, ET, induced by a transformer field; then a back E.M.F., to which we will refer as EB, and which is set up in the axis CC by rotation of the rotor conductors in the motor field; it is of the same period as the latter, consequently also of the same period as the transformer field and ET; it depends for its magnitude on the magnitude of the motor field and the speed of rotation, and at a speed slightly above the synchronous it equals ET in magnitude; it is further in phase with the motor field, and consequently not quite in phase with ET. A third E.M.F. acting in this circuit is ES, the E.M.F. of self-induction, principally due to the very appreciable amount of leakage between secondary and primary in the transformer axis; this E.M.F. is proportional to the rotor current, and lags 90 deg. behind the same. The resultant of the three E.M.F.s in phase magnitude and direction is a small E.M.F., which goes to cover the ohmic losses in the rotor, and which we will call EW; it is co-phasal with the armature current. The phase of ET is practically fixed by the phase of the E.M.F. impressed on the stator. The phase of ES is fixed by the phase of the armature current; its magnitude is determined by the quality of the design. The counter E.M.F. is dependent on the phase of the motor field and it is by influencing the phase of the motor field that the author influences the phase of EB, and with its help adjusts the phase of the resultant EW and the phase of the armature current.

It is well to remember that even when the armature current has been brought into phase coincidence with ET the stator current will still lag to some extent behind its E.M.F. on account of the phase difference introduced into the primary circuit by the self-induction of the same. By forcing the armature current to lead ET even that phase difference may be eliminated, but one runs the risk of again bringing the armature current and the motor field appreciably out of phase, and thus increasing the armature current beyond that amount which would suffice in the case of complete phase coincidence. Thus, although the power factor can always be brought up to unity, and although the stator current can even be made to lead its E.M.F., it is not in all cases possible to achieve these results without impairing the efficiency of the machine. It is, nevertheless, always possible to obtain extremely high power factors without lowering the efficiency.

The method by which the author varies the phase of the motor field in these motors consists in introducing into the circuit DD an auxiliary E.M.F. differing in phase from ER. The resultant of the two is then responsible for the motor field, and the author has found that an auxiliary E.M.F. differing by about 90 deg. from ER, or materially in phase with the motor field, gives the best results. Under these conditions the greatest phase displacement of the resultant E.M.F. can be obtained with the smallest auxiliary E.M.F., and without materially influencing the motor field strength.

It would seem at first sight that it would be simpler to introduce into the CC circuit an auxiliary E.M.F. which would influence the phase of the secondary current directly. The author has made quite a number of tests in this direction, and has found no difficulty in obtaining coincidence of phase between stator current and E.M.F. for light loads and for constant values of secondary current. Now this secondary current cannot be constant, but varies with the load; consequently such a method has no great practical value. If it be adopted the E.M.F. should be derived from a non-inductive resistance, or a capacity on which an E.M.F. of suitable phase is impressed. By this means one can avoid the inclusion of additional self-induction in the rotor circuit in the CC axis, when very much better results will be secured.

*(To be continued.)*

## PHYSICAL SOCIETY.

At a meeting of the Physical Society on February 23, 1906, Prof. J. Perry, F.R.S., president, in the chair. A Paper on

### "Secondary Röntgen Radiation"

was read by Dr. C. G. Barkla. In previous Papers the author has shown that the secondary X-rays from certain gases and light solids subject to Röntgen radiation may be fully explained by considering the corpuscles or electrons constituting the atoms to be accelerated in the direction of electric displacement in each primary Röntgen pulse as it passes through such substances, and that the interaction between the electrons affects only to a slight extent the character of the secondary radiation. The methods of investigating the more complex secondary radiation from metals was suggested by the results of the experiments on lighter substances. The character of secondary radiation (measured by absorbability) was found to depend on the atomic weight of the radiator. The radiation from compounds was in all cases such as would be given by a mixture of the radiations from the separate constituent elements. By heating an iron wire to white heat and studying the radiation proceeding from it when exposed to X-rays, it was seen that there was no direct connection between the intensity or character of the radiation and temperature, electric conductivity or magnetic permeability. Experiments on absorption showed that the radiation from heavier atoms did not consist of an easily absorbed radiation superposed on a scattered radiation, such as proceeded from light atoms, but that the latter was not present to any appreciable extent.

No special absorption by a metal of the radiation proceeding from the same metal was observed. Thus there was no evidence of a definite periodic vibration. Changes in the character of the primary produced changes in the secondary. Variation in intensity of the primary beam was found not to affect the character of the radiation from calcium—the only substance experimented upon. When substances were exposed to polarised Röntgen radiation, the secondary radiations, which differed little in absorbability from the primary producing them, showed approximately equal variations in intensity in different directions. The very different radiations exhibited no such variation; while the radiation from a substance of atomic weight between those of the two classes showed the variation to an intermediate extent. In this polarisation effect compounds behaved as mixtures of the constituent elements. Experiments on the absorption of rays proceeding from thick plates of a large number of elements showed that beyond the region of atomic weights in which the character of the secondary radiation is almost independent of the nature of the radiation, the absorbability is a periodic function of the atomic weight of the radiator, and that as far as these experiments have gone different periods are represented by curves of similar form. The theory which has been found to explain all the phenomena of secondary radiation from light atoms may be extended to explain these results if we conceive the independence of motion of the electrons to disappear with an increase in the number of electrons in the atom. Inter-electronic forces called into play make the pulses emitted by each electron thicker than if the electron were accelerated only during the period of passage of the primary pulse over it. Hence the radiation becomes less penetrating. Only agencies altering the construction of the atom would be expected to change the character of the radiation produced by a given primary; hence temperature, electrical resistance, magnetic permeability, may all vary without producing appreciable effect. The theory also explains the disappearance of the more purely scattered radiation, the absence of selective absorption, the connection and difference between the primary and secondary rays, and the absence of influence of variation in intensity of primary radiation on absorbability of the secondary. When applied to the atom as conceived by Prof. J. J. Thomson, the periodicity shown by the curve connecting absorption and atomic weight is explained.

A Paper entitled

**"Records of the Difference of Potential between Railway Lines when a Train passes and at other Times, and a Suggested Method for the Observation of Earth Currents and Magnetic Variations,"**

by Messrs. C. W. S. Crawley and F. B. O. Hawes, was read. The experiments described in the Paper were made on the London & South-Western main line, between Walton and Weybridge stations. To each rail of the up line a wire was permanently attached, and the other ends of the wires were connected to the terminals of a reflecting galvanometer. The deflections of the galvanometer were recorded on a moving sheet of paper, and curves obtained showing the variation in the current through the galvanometer. The curves showed a concordance in the results from successive trains. The normal current through the galvanometer began to be disturbed about one minute before the passage of a train, and the disturbance lasted about two minutes. The curves, although very complex, showed some regularity. In addition to the disturbances caused by passing trains, very distinct smaller disturbances were noticeable at the times when a receding train was passing over the points at Walton and Esher stations. Effects were also shown corresponding with the passage of a train over the Hampton Court Junction points The observations on different occasions varied in many respects, the state of the weather probably being an important factor. The E.M.F. between the rails was on one occasion as much as 28 millivolts, and differences of 8 and 15 millivolts were frequent. It appears probable to the authors that the effects are due to earth currents, and they suggest that by making the galvanometer very sensitive its deflections might furnish a means of studying their variation.

Dr. C. Chree expressed his interest in the Paper, and remarked that it was often more desirable to avoid earth currents than to record them. He questioned whether the effects described by the authors were due to earth currents, and asked if the authors had satisfied themselves that the variations in the galvanometer deflections were not due to magnetic storms.

Dr. J. A. Harker described some experiments similar to those made by the authors. In his case, wires from a galvanometer were connected to two large plates about 200 yds. apart and about 5 ft. underground. He found that the effects varied with the weather.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

*Recombination of Salt Ions.*—G. Moreau has determined the coefficient $a$ in the equation

$$dn/dt = -an^2,$$

which expresses the manner in which the recombination of ionised salt vapours depends upon the number $n$ of ions present in the unit of volume. The method employed was the same as that employed by Townsend for gases ionised by Röntgen rays. Determinations were made at two different temperatures, 80 and 15 deg. The comparative recombination coefficients were 415 and 78 for potassium iodide, 410 and 10·6 for chloride and 421 and 0·84 for bromide. The ratio of recombinations to collisions was found to range 56 per cent. for potassium chloride at 80 deg. to 99 per cent. for potassium bromide at 15 deg. The mobility of these vapour ions is smaller than that of ordinary gaseous ions. The average proportion of recombinations at 80 deg. is two-thirds, whereas at lower temperatures it often happens that every collision results in a recombination. This is due to the great mass of the ions, which are positive atoms surrounded by several layers of neutral atoms, thus approaching the constitution of the heavy ions produced by phosphorus, which might perhaps be called charged droplets rather than ions.

[G. Moreau, *Comptes Rendus*, February 12, 1906.]

*Origin of Terrestrial Magnetism.*—A. Pflüger discusses the interpretation of terrestrial magnetism as derived from the rotation of a charged ellipsoid. He points out that the magnetic field must be discoverable at the surface even when the magnetic instrument rotates with the ellipsoid. Bucherer has rigidly proved that the ponderomotor force on a magnet at rest is the same as that on a magnet rotating with the earth. Hence the equations determining the magnetic moment of a revolving electron also apply to the magnetic moment of the earth. The charge of the earth is unknown, but a rough idea of it may be obtained from the potential gradient above the ground. According to Exner, it would appear to be about $2{\cdot}4 \times 10^{17}$ electrostatic units of negative electricity (giving a potential of nearly a billion volts), or about the same charge as that of the sun, only of opposite sign. The rotation of this charge in the direction of the actual rotation of the earth would produce a magnetic field approximately the same in direction as the observed field, but about 10,000 times weaker than the actual field. If a positive charge is supposed to be located in the upper regions of the atmosphere, and is allowed for in the calculations, the agreement is not much better. It must, therefore, be concluded that the rotation of the earth's charge is not the only cause producing its magnetic properties.

[A. Pflüger, *Physikalische Zeitschrift*, March 1, 1906.]

*Field of a Revolving Electron.*—J. Geest has generalised the problem, first solved by Bucherer, of the magnetic field due to the rotation of a spherical electron. He calculates the field due to a spherical shell by the method devised by Lorentz and Wiechert. He supposes that the charge of the electron is uniformly distributed over the volume comprised between the radii $a$ and $b$, the latter being the larger radius, and that the electron rotates with a uniform angular velocity $\omega$. The electrostatic field, as Wind has shown, is not influenced by this rotation. The author finds for the vector-potential in the case of $a = 0$ the formula

$$\frac{e\omega R^2}{20\pi c} \cdot \frac{\sin\gamma}{r^2},$$

where R is the radius of the electron, $c$ the velocity of light, and $r$ the distance of the point from the centre. When this distance is less than R, the vector-potential becomes

$$\frac{e\omega}{4\pi c}\left(\frac{1}{2R} - \frac{3}{10}\,\frac{r^2}{R^3}\right) r \sin\gamma.$$

The magnetic moment of the solid sphere uniformly charged is $e\omega R^2/20\pi c$, of an infinitely thin spherical shell $e\omega R^2/12\pi c$, and for a thick shell $\frac{e\omega}{20\pi c}\,\frac{b^5 - a^5}{b^3 - a^3}$. The total inner and outer magnetic energy of a surface charge is $e^2\omega^2 R/36\pi c^2$, two-thirds of which are internal.

[J. Geest, *Physikalische Zeitschrift*, March 1, 1906.]

*Polonium Rays.*—Thomson and Rutherford suspected that polonium rays, although they produce a positive charge by their impact, do not consist of purely positive particles, and Rutherford estimated that for every four $\alpha$-particles emitted one electron was also emitted by polonium, thus reducing their apparent positive charge. Soddy also supposed that both positive and negative corpuscles are generated by the impact upon the gas of neutral particles, which alone, he maintained, are emitted by the polonium. In order to test these questions P. Ewers has adopted a new apparatus, consisting of a copper disc coated with polonium and surmounted by a nest of small copper boxes serving as diaphragms, and enabling the observer to control the path of the particles shot out from the polonium. The boxes had such dimensions that no particle could reach the upper plate unless it were projected at an angle of at least 55 degrees to the lower plate. By employing magnetic and electric fields of different strengths he was enabled to prove that the negative particles are the slowly-moving electrons discovered by J. J. Thomson. He does not agree with Soddy and Bragg that the positive charges are acquired by collision, since higher potential gradients fail to increase the ionisation of the residual gas.

[P. Ewers, *Physikalische Zeitschrift*, March 1, 1906.]

**Municipal Opposition to Electric Power Bills.**—As the result of a conference between 40 Lancashire municipal boroughs and urban district councils, a combination of these and the London municipal authorities with the object of conducting a vigorous opposition to all the electric power bills deposited in Parliament this session is being arranged. All the members of Parliament for the districts concerned are being urged to oppose the bills on second reading.

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## THE POSITION OF THE ELECTRICAL INDUSTRY.

A connection between the present position of the British electrical engineering industry and the discoveries of aniline purple, synthetic alizarin red, and of coumarin will not be immediately apparent to the majority of our readers, but nevertheless they will doubtless evince some interest in these products of the chemist when we inform them that their musical names have formed the prelude to an interesting correspondence in *The Times*, which contains some "straight talk" about the recent unsatisfactory position of British manufacturing industries generally and the electrical industry in particular. Mauve was the first of this series of aniline dyes, but to the older members of the chemical industry the subject acts as a red rag; for the discoveries to which we have alluded, forming the foundation of the coal tar colour industry, were due to a British chemist, Dr. W. H. PERKIN, and yet the industry has found its home in Germany, and Great Britain has been left far behind in what has been one of the most profitable branches of applied chemistry. The chemists give two reasons for this. One is that "although in this country there have never been wanting capable chemists able to carry on and extend the manufacture of colouring matters, there has been complete lack of understanding on the commercial side of the complex requirements of the industry and complete lack of sympathy between the capitalist and the scientific worker." This "lack of understanding and sympathy" was not noticeable in Germany. Not only was the great industrial importance of the discovery fully realised there, and a great industry created, but our chemists here relate that the wise Germans proceeded to work out the corollaries of the original discovery and gradually patented whole series of "processes" —succeeding in obtaining broader master patents in this country than in Germany—which have secured the foremost place for the German manufacturer. Thus, when it was announced that a meeting would be held at the Mansion House to commemorate the fiftieth anniversary of Dr. PERKIN's discovery, there was an immediate outcry that the occasion was rather one for sackcloth and ashes than for jubilation. Prof. SILVANUS P. THOMPSON, who opens the correspondence in question in Saturday's *Times*, attaches himself to the first of these reasons, and states that the lack of understanding on the commercial side and the absence of sympathy between the capitalist and the scientific worker have not been confined to the chemical industry, but have acted equally as a drag to our electrical engineering progress. Not only, he complains, have our manufacturers shown deplorable want of foresight in omitting to provide a sufficiency of properly-organised research and experimental departments in their works, but they are at the present moment, with a few "honourable exceptions," actually abandoning their experimental departments and cutting down the number of technical men they employ. It is true, Prof. THOMPSON says, that "for the last six years British electrical firms have been so busy undercutting one another in prices that they have no means available for maintaining expensive research departments," but this dazzling truth should not blind them to the importance of the larger ultimate question. Mr. IVAN LEVINSTEIN, who follows, attributes the disaster in the coal tar industry entirely to the second reason which we have stated, and contends, as he has often done before, that as a condition of holding a British patent, the patentee should be compelled to work his process in this country on an industrial scale. Finally, Sir JOSEPH LAWRENCE, in Tuesday's *Times*, reviews both Prof. THOMPSON'S and Mr. LEVINSTEIN'S letters. In reply to the former he points out that the real cutting of prices is the result of German and American competition rather than competition among ourselves, and he supports Mr. LEVINSTEIN'S views as to our patent laws.

Prof. THOMPSON, and the anonymous article in *The Times* which provoked his almost violent diatribe, are undoubtedly right in their main article of belief—namely, that the present unsatisfactory condition of affairs has been brought about by the insufficient importance attached to the scientific and engineering industries by the capitalists of the country. Industrial supremacy can only be maintained nowadays by building up large manufacturing businesses on a broad commercial and sound technical basis, and by removing from them those obstacles which stand in the way of their proper development. On the one hand, the capitalist is not encouraged to invest his money in industrial enterprises, while, on the other hand, the engineers find that the most remunerative of their talents are not those of the highest order. We can cite several cases in which English engineers who have held high positions in English electrical engineering works have found it to their interest to throw up their engagements in order to take up agencies in this country for foreign manufactures. Under the peculiar trade conditions of this country more money can be made by buying and selling on commission than by manufacturing. In the meantime, many of the British firms rely largely on engineers and designers from abroad, and, owing to the "price cutting" which has been alluded to, their perspective is narrowed down to the immediate execution of the work in hand at the lowest possible cost, and they are no longer in a position to encourage the broader outlook and freedom of research and investigation that should be available to those engaged in an advancing engineering industry. And unfortunately these effects are cumulative, and the more engineers cry out that the times are bad, the less ready will the capitalist be to invest his money in their undertakings.

The malady from which our electrical industry is suffering is certainly a serious one. It is not a disease amenable to treatment by quack remedies, and the genius and broad mind of a great statesman is required to diagnose it properly and to prescribe an effective course of treatment which shall restore it to a healthy condition, for the electrical industry is not the only one in this country that suffers in this manner. As a preliminary measure, however, a full Government inquiry into the state of our industries might with advantage be made in the first instance. The appointment of a Royal Commission for this purpose would be welcomed by the whole industrial community, for then the subject could be properly investigated in a smooth atmosphere undisturbed by party politics, and the ground would be prepared for definite action either by the present Ministry or its successors in office.

## "IDLE CURRENTS."*

BY M. B. FIELD.

At the commencement of the Paper the somewhat unusual sense in which the term "Idle Current" is employed throughout is explained as "including all currents which do not perform any useful work, and consume energy to the extent of their $C^2R$ losses." Thus the term "Idle Currents" is used to include eddy current. The author then continues:—

In the following Paper we shall restrict ourselves to a short general discussion of the idle currents met with in the main conducting circuits, and then examine, with somewhat greater detail, one particular effect, which probably deserves more consideration on the part of designers than has been accorded it heretofore. The characteristic of every form of idle current here dealt with is that, while constituting a part of the *total* current flowing in the circuit, it may be considered, conventionally, as an altogether separate entity superposed upon the real useful current, and be treated as such.

To illustrate this, let us take the case of an alternate-current system where the power factor is less than unity.

Let $C_1$ be the amplitude of the useful or power component, $C_2$, that of the idle component of the current. The main ammeter indicates, as we know, $\sqrt{(C_1^2+C_2^2)/2}$. If this current flow in a conductor of resistance $r$ ohms, the time average value of the ohmic loss will be $(C_1^2+C_2^2)\frac{r}{2}$. Considering the power and idle components as separate entities, we obtain for the ohmic losses due to each $C_1^2r/2$ and $C_2^2r/2$ respectively, so that the sum of these losses is identical with the time-average loss due to the actual total current flowing.

It will be scarcely necessary to point out that this is not generally true of any arbitrary sub division of a current into component parts—*e.g.*, a current of 10 amperes flowing through a conductor of 1 ohm resistance would represent an ohmic loss of 100 watts. Magnetically, this current would be equivalent to one of 15 amperes flowing in the positive direction superposed upon one of 5 amperes flowing in the negative direction. The sum total of the ohmic losses of these components would, however, be 225 + 25 = 250 watts. While, therefore, it is self-evident that a current may not be resolved into any arbitrary components, and these be treated from all points of view as separate entities, yet we may always treat the power and idle current components as if they existed independently of each other.

This very simple conception is of material assistance in the consideration of some problems; for example, a certain distribution of current in a system of conductors may be a very complex matter to deal with as a whole. If, however, we can show that the complex distribution is equivalent to a "natural" distribution superposed upon an idle current, and we can isolate the cause of the idle current, we may be able to estimate its value, and hence arrive at the characteristics of the actual complex distribution.

The Paper then deals shortly with the idle currents which may be ascribed to defective power factor, wave-shape, and to cross currents between generators working in parallel, and the remainder of the Paper is devoted to what the author terms "internal idle currents."

These may be classified broadly under two heads: (*a*) Those whose magnitude is determined by the degree of excitation, and which depend very slightly, if at all, upon the load; (*b*) those whose magnitude is determined by the load and which depend very slightly, if at all, upon the excitation of the machine. Both produce a disturbance of the natural current density in the conductors of the machine, and increase the losses in consequence. The first class may be said to add a definite constant loss (for a given excitation) to whatever loss would be occasioned by the natural distribution of current density, while the second produce an additional loss proportional to the square of the working current, hence the actual loss may, in this case, be determined by simply assuming a *virtual increase of the resistance* of the circuit. The exact meaning of this will be better appreciated later, but as an example we may mention that the so-called skin-effect in a solid conductor traversed by an alternating current is really due to an idle current proportional to the working current flowing, while the total loss due to idle and working currents may be determined by simply assuming the resistance of the conductor has been, by some means, increased. Again, the additional loss in the sheathing and cores of a cable are proportional to the working current, and the total loss may be estimated by assuming an increase of the resistance of the conductors. The co-efficient by which the actual resistance must be multiplied to allow for the additional losses depends upon the frequency, specific resistance, and dimensions of the conductor.

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* Abstract of a Paper read before the Manchester Local Section of the Institution of Electrical Engineers, February 13th.

Large generators usually have two or more paths through the armature, and an uneven distribution of current between the various paths is equivalent to a uniform (or natural) distribution superposed upon a system of idle currents. Again, each path may be composed of two or more conductors, laminæ or strands in parallel, and an uneven distribution between them is equivalent to a natural distribution plus an idle current. Lastly, the distribution of current density in each individual strand may be far from uniform, so that here again we have an idle current superposed upon a natural distribution.

It sometimes occurs that one particular class of idle current may predominate to a totally unexpected extent, and in fact a cooler, cheaper and more efficient machine may be obtained by a decrease of the amount of copper therein. As an illustration, the following may be cited, though the reference is to a type of machine which is now practically obsolete—viz., the ironless flat disc alternator.

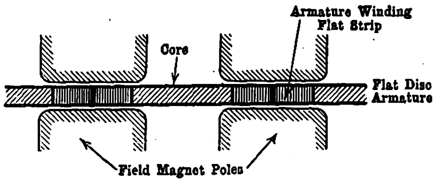

FIG. 1.—ALTERNATOR WITH FLAT DISC ARMATURE.

In Fig. 1 two poles of such a machine are represented with a portion of the armature consisting of copper strip wound into flat coils. Each strip, as it passes edgewise through the magnetic field, has an idle current induced in it. To calculate the loss we may apply the eddy current formula used for iron armature plates and the like,* viz. :—

Loss in watts per cubic centimetre $=f^2B^2t^2/6\times10^{15}\rho$ ; where $t$ = thickness in centimetres ; $f$ = frequency, cycles per second ; B = induction density in air gap, lines per square centimetre ; $\rho$ = specific resistance in ohm-centimetres.

Let us take the nominal maximum current density at 310 amperes per square centimetre (=2,000 amperes per square inch), then the nominal $C^2R$ loss will be 0·18 watts per cubic centimetre at about 45°C.

Applying the formula above, for the loss due to idle currents, we have for $f=50$, $B=5{,}000$, $\rho=1\cdot9\times10^{-6}$.

$t=0\cdot1$ cm. loss per cubic centimetre $=0\cdot0548$
$t=0\cdot2$ „ „ „ $=0\cdot22$
$t=0\cdot3$ „ „ „ $=0\cdot493$

and so on, hence, with an armature wound with strip 2 mm. thick the additional loss due to disturbance of current density in the active part of the armature conductors is greater than the nominal $C^2R$ loss. It is to be feared that this state of affairs exists in a considerable number of machines in use at the present time. The result of using thinner strip, might be to reduce the heating, and might increase the efficiency and provide a lighter and cheaper machine. For the same reason it is clear an increase of the specific resistance would cause a decrease of the total losses, hence we have the somewhat paradoxical condition that the efficiency improves as the temperature increases.

Our attention has been called to an interesting investigation published in Germany in 1903 by Dr. Simon Ottenstein, giving the results of tests made to determine, among other things, the "eddy current loss" in solid copper conductors laid in slots, due to the radial and tangential components of the flux within the slot, *which emanates from the field magnets*; this flux being quite independent of the load current in the armature conductors. The title of the investigation is "Das Nutenfeld in Zahnarmaturen und die Wirbelstromverluste in Massiven Armatur-Kupferleitern." The armatures experimented upon had a diameter of 225 mm., and the slots were dimensioned in the different armatures as follows:—7 × 22·5, 7 × 35, 9 × 35·5, 7 × 23, 8·5 × 23, 14 × 11·75, the first dimension giving slot width and the second the depth in millimetres.

In the different experiments the theoretical tooth induction varied from 18,000 to 31,000, and the eddy current losses in the various solid conductors employed were found to be equivalent to the loss that would have been occasioned by a current density of from 400 amperes to 4,700 amperes per square inch in the active portion, depending upon size and position of conductor, dimensions of slot, air gap, and nature of polar surface. The frequency in all these experiments was 33·3.

The two previous examples cited are cases where the magnitude of the losses are dependent upon the degree of excitation and not upon the load on the machine, the following, however, represent the other case, where the losses are dependent upon the load current and not upon the degree of excitation.

In Fig. 2 we have represented a solid copper conductor of depth $b$ centimetres and thickness $d$ centimetres lying in a slot of a laminated armature. An alternating current flows in the conductor in a direction at right angles to the plane of the paper, the plane of lamination of the armature plates corresponding with that of the paper. We shall show that the current flows in layers, being densest in the outside layers at the mouth of the slot, and least dense at the root. For this reason we have thought that the term "lamellar effect" is not out of place in describing this phenomenon. It is, of course, closely allied to the skin effect in a circular conductor, where the idle currents flow in one direction along the peripheral portions, and in the opposite direction along central portions.

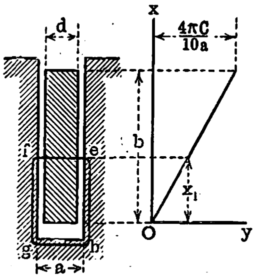

FIG. 2.—SECTION OF CONDUCTOR IN SLOT.

The effect of any current flowing down the solid conductor in Fig. 2 will be to produce a magnetising flux across the slot from side to side. If the width of the slot be small compared with the depth, the lines will be very nearly straight from wall to wall, except near the mouth of the slot, where they will bow outwards.

If $efgh$ be a line of force, we know that the total magnetic force (or line integral) taken round the closed path will be $4\pi/10$ times the total current in amperes in that portion of the conductor enclosed within it. Now, the magnetic resistance of the iron portion of the path—*i.e.*, from $e$ to $h$ to $g$ to $f$ is negligible in comparison with the air portion from $f$ to $e$, hence we may say with great accuracy that the line integral of magnetic force from $f$ to $e$ equals $4\pi/10$ times the current in amperes flowing in the conductor, between the limits $x=0$ and $x=x_1$. The induction density at the mouth of the slot is, therefore, $\frac{4\pi}{10}\frac{C}{a}$, where C is the total current flowing in the conductor ; and the induction at the slot root is zero. If, now, we suppose that the density of the cross induction increases uniformly from zero value at the root of the conductor to $\frac{4\pi}{10}\frac{C}{a}$ at the top edge, the total flux traversing the conductor will be $\frac{4\pi}{10}\frac{C}{a}\cdot\frac{b}{2}$ per centimetre length.

Consider a very thin lamina along the top edge of the conductor forming, in conjuction with a similar lamina along the lower edge, a loop through which this total flux threads. The E.M.F. induced in this loop per centimetre length of conductor will be $\frac{4\pi^2}{10}\frac{bfC}{a}10^{-8}$ volts, where $f$ is the frequency of alternation. This expression gives the R.M.S. value of volts, if C represents the R.M.S. value of the current. If the conductor be long in comparison with its cross-section, such an E.M.F. would produce an idle current density flowing in the loop of value $\frac{2\pi^2}{10}\cdot\frac{bfC}{a\rho}10^{-8}$ where $\rho$ is the specific resistance in ohm-centimetres.

As an example, we will write $f=50$, $b=5$ cm., $\frac{d}{a}=0\cdot7$, $\rho=1\cdot9\times10^{-6}$ (at about 45°C.) when the value of the idle current density works out at about $2\cdot6C/a$ ; but the nominal current density is $C/5d$ ; hence the idle current density in the outer layers is over nine times the nominal current density when worked out on this basis, and the loss density (or loss per cubic centimetre) at the extreme edge due to the idle current is over 80 times that due to the nominal current density.

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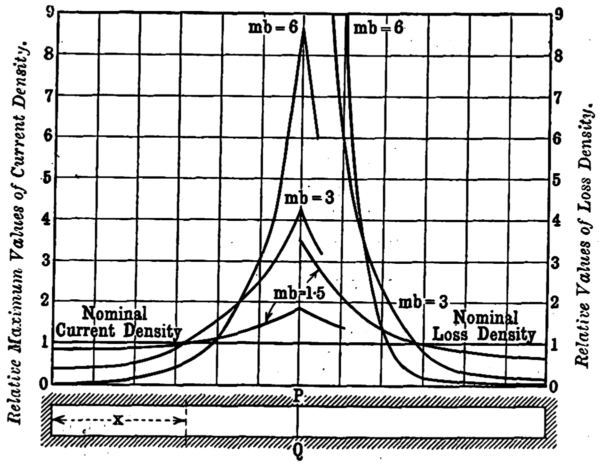
* This formula is applicable so long as the lines of force pass straight across the gap from pole to pole, the variation of induction being assumed to follow a sine law, and provided the thickness of the strip does not permit of idle currents of such magnitude as to sensibly disturb the distribution of magnetic lines, a contingency not likely to arise in the case under consideration.

This example has been cited to show in a rough and ready way that some phenomenon occurs in such conductors which is well worth while studying. The assumption made that the distribution of cross flux is that which would be given by a uniform current density is obviously disproved by the result of the calculation, and the actual redistribution of the cross flux is such as to materially reduce the estimated idle current effect. While, therefore, the above result is greatly exaggerated on account of the assumption made, it may be mentioned that machines are at work to-day where the loss density in the outer edge of the conductor is as much as 30 times that due to the nominal current density.

Fig. 3 represents the case of two conductors lying in a closed slot, current flowing up one and down the other. The effect in each conductor will be the same as if we had but one conductor lying in an open slot, of which the mouth was at P, Q, except for the fact that the tendency of the lines to bow outwards at the mouth will here be largely neutralised. Curves in Fig. 3 show the distribution of current and loss* density in the conductors, it being assumed that $f=50$; $\frac{d}{a}=0{\cdot}61$, and $b$ has the values 1·875 cm., 3·75 cm. and 7·5 cm. We will now proceed to show, as briefly as possible, how such calculations are made. Let $\Delta_0 \sin pt$ be the nominal current density in each conductor, so that $bd\Delta_0 \sin pt$ represents the total current flowing in the conductor. Let us confine our attention to the left-hand conductor in Fig. 3, and consider $x$ as distance measured from the root of the conductor towards the centre of the slot. Within the length of the slot the current density will be disturbed, hence let $\Delta$ be the actual instantaneous value at $x$. Let $\rho$ = specific resistance in ohm-centimetres.



Taking $\frac{d}{a}=0{\cdot}61$ and $f=50$, the value of $m$ is 0·8, hence
$mb=6$ corresponds to $b=7{\cdot}5$ cm
$mb=3$ ,, $b=3{\cdot}75$ ,,
$mb=1{\cdot}5$ ,, $b=1{\cdot}875$ ,,

FIG. 3.—CURVES OF CURRENT AND LOSS DENSITY.

Where the conductor emerges from the slot the current will redistribute itself and become uniform, and the potential at all points of the conductor in any plane parallel with the plane of lamination (of iron) will be the same.

Consider two such planes, one at each end of the iron armature, but just far enough outside for the current to have become uniform, and let the distance between them be $l$ centimetres; and the P.D. be $v$. Remembering that the flow of current in the conductor within the slot is lamellar, Ohm's law for the current at $x$ will be $v+Vl_1=\Delta\rho l$, $l_1$ being the length of the slot plus an allowance for fringes at the ends.

V and $\Delta$ are functions of $x$, but $v$ is independent thereof, hence differentiating we have—

$$\frac{dV}{dx}=\frac{l}{l_1}\rho\frac{d\Delta}{dx}. \quad \ldots \ldots \quad (1)$$

If C be the total current in the conductor between the limits $x=0$, $x=x$, the induction density at $x$ will be $\frac{4\pi}{10}\frac{C}{a}$. The total current in the conductor between the limits $x=0$ and $x=x+\delta x$ is $C+d\,.\,\Delta\delta x$, and the induction density at $x+\delta x$ will be

$$\frac{4\pi}{10}\left(\frac{C+d\,.\,\Delta\delta x}{a}\right),$$

$d$ being the thickness of the conductor; hence

$$\frac{dB}{dx}=\frac{4\pi}{10}\cdot\frac{d}{a}\Delta, \quad \ldots \ldots \quad (2)$$

V being the E.M.F. induced at $x$ per centimetre length by the cross flux, is equal to $-\frac{dN}{dt}10^{-8}$, where N is the total number of lines which may be considered as surrounding the imaginary lamina at $x$, as above defined; but $-\frac{dN}{dx}=B$.

Hence
$$\frac{dV}{dx}=10^{-8}\frac{dB}{dt}. \quad \ldots \ldots \quad (3)$$

Equations (1), (2) and (3) are the fundamental equations of the problem; we can now eliminate V and B and obtain

$$\frac{d^2\Delta}{dx^2}=\frac{4\pi}{10}\,\frac{d}{a}\cdot\frac{l_1}{l}\cdot\frac{1}{\rho}\cdot 10^{-8}\frac{d\Delta}{dt}. \quad \ldots \ldots \quad (4)$$

It is then proved that

$$\Delta=\delta_1\epsilon^{mx}\sin\left(pt+mx+\beta_1-\frac{\pi}{4}\right)+\delta_2\epsilon^{-mx}\sin\left(pt-mx+\beta_2-\frac{\pi}{4}\right) \quad (5)$$

where
$$m^2=\frac{2\pi p}{\rho}\cdot\frac{d}{a}\cdot 10^{-9}.$$

It is easy to see that, where we have only one conductor in the slot, or the equivalent, as in Fig. 3, $\delta_1=\delta_2$ and $\beta_1=\beta_2$; but where there is more than one conductor in the slot, carrying current in the same direction, $\delta_1$ and $\beta_1$ will differ from $\delta_2$ and $\beta_2$ respectively, for all but the lowest conductor. The values of $\delta_1\ \delta_2\ \beta_1\ \beta_2$ for any conductor are determined by the two conditions:—

1. That the total current flowing or integral of current density over the cross-section of the conductor $=d.b\Delta_0 \sin pt$.

2. That the cross-induction at the root of the conductor, or where $x=0$, equals
$$\frac{4\pi}{10}\cdot(n-1)\frac{d.b}{a}\Delta_0 \sin pt,$$
where $(n-1)$ is the number of conductors below the one in question.

In the single-conductor case we have

$$\left.\begin{aligned}\delta_1&=\frac{mb\Delta_0}{\sqrt{\cosh 2mb-\cos 2mb}},\\ \text{and}\qquad \tan\beta_1&=\frac{\tanh mb}{\tan mb}\end{aligned}\right\} \quad \ldots \ldots \quad (6)$$

for which the curves in Fig. 3 are plotted.

The important fact to determine is how much greater is the actual ohmic loss due to the ununiform distribution than the nominal loss, or that calculated on the assumption of uniform distribution.

For this purpose we have only to consider the maximum values of the current at varying depths, and do not need to trouble about the relative phase relations. The maximum value of the current density at $x$, as derived from (5) and (6), is

$$\sqrt{2}mb\Delta_0\sqrt{\frac{\cosh 2mx+\cos 2mx}{\cosh 2mb-\cos 2mb}}. \quad \ldots \ldots \quad (7)$$

The values of the current density at different points of the solid conductor shown in Fig. 3 are plotted corresponding to the three cases $mb=6$, $mb=3$, and $mb=1{\cdot}5$. If we take $\frac{d}{a}=0{\cdot}61$, $f=50$, then $m=0{\cdot}8$, and the above values will correspond to depths of conductor 7·5 cm., 3·75 cm. and 1·875 cm. respectively. Where there are more conductors than one in a slot, current flowing in each in the same direction, these effects are greatly magnified in the upper conductors.

It must be borne in mind that the phase of the current is not the same at all points of the conductor, but a continuous change of phase occurs from one edge to the other. For example, in the case where $mb=3$ the current at the outer edge (P.Q) is 45 deg. in front of the load current; while the current at the root of the slot lags 127 deg., making a total phase difference of 172 deg. between the current at mouth and root. In Fig. 3 the values of the square of the current density have also been plotted, showing how enormously the loss density increases towards the outer edge of the conductor. The mean height of these loss-density curves, or what is the same thing, the ratio of the area of the actual to the nominal loss-density curve, represents the coefficient of virtual increase of resistance of the conductor, or the ratio of the actual to the nominal ohmic loss.

This ratio will be the mean square value of expression (7) taken over the cross-section, divided by $\Delta_0^2$. Calling this value K, we have

$$K=mb\frac{\sinh 2mb+\sin 2mb}{\cosh 2mb-\cos 2mb}. \quad \ldots \ldots \quad (8)$$

This value, derived from the equations of the single-conductor case, will apply only to the bottom conductor, where there are more than one in a slot, carrying current in the same direction.

In the case of several conductors one above the other, each carrying the same total current, counting the lowest 1, the second 2, and so on, it can be shown that :—

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* The loss density at a point is the loss per cubic centimetre at that point.

$$K_n = mb\left[\frac{4(n^2-n)(\cosh mb-\cos mb)(\sinh mb-\sin mb)+(\sinh 2mb+\sin 2mb)}{\cosh 2mb-\cos 2mb}\right] \quad . \quad . \quad . \quad (9)$$

It will thus be seen that the constant by which the nominal ohmic loss per centimetre must be multiplied, in order to determine the actual loss in a given conductor, or the coefficient of increase of resistance, depends entirely upon the depth of the conductor, the frequency, specific resistance and the ratio $d/a$.

The formulæ (8) and (9) have been utilised for the calculation of curves in Fig. 4, corresponding to $n=1$, $n=2$, $n=3$, $n=4$—*i.e.*, for cases where slots contain 1, 2, 3, and 4 conductors connected in series, current flowing in the same direction in each. The curves apply merely to that part of the conductors lying within the slot, and show how many times the actual loss is greater than that calculated from Ohm's law. As examples illustrative of the use of these curves we will take the case of a four-layer winding, the depth of each conductor being 1 cm., frequency 50. Let $d/a$ be 0·61 ; we have then $m=0·8$. Referring to the values of K corresponding to $mb=0·8$ for the 1st, 2nd, 3rd, and 4th conductors respectively, we obtain the values 1·04, 1·3, 1·85, and 2·6, that is to say that while the nominal loss is increased by the idle current effect to the extent of 4 per cent. in the lowest conductor, it is increased 2·6 times in the topmost conductor.

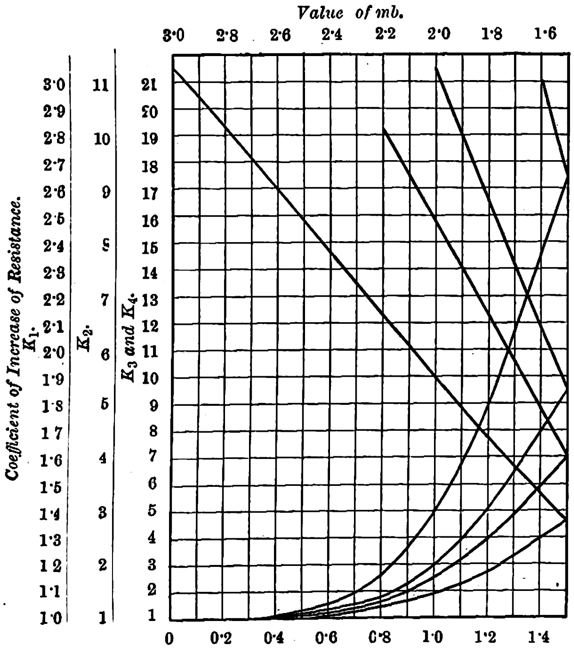

FIG. 4.

(*To be concluded.*)

## NOTE ON THE USE OF THE BOLOMETER AS A DETECTOR OF ELECTRIC WAVES.*

BY C. TISSOT.

It is several years ago since I carried out a number of experiments in all respects analogous to those of Mr. Duddell, by taking observations with a sensitive thermo-detector placed in circuit with the receiving aerial. The apparatus which I used in my experiments is a kind of bolometer which enables one to record the variations of resistance of a very fine metal wire produced by very small changes in temperature in a similar way to the arrangement of Langley.† The principal object of these experiments was the investigation of the conditions of resonance in the aerial systems, but occasionally they resulted in my observing phenomena identical with those which have been pointed out by Messrs. Duddell and Taylor. It may, therefore, be of interest to describe my unpretentious experiments, and in so doing I propose to allude only to those particular points which appear to be common to both series of investigations, and not to deal either with questions of resonance, frequency, or damping.

The principle of Langley's bolometer is well known. Two fine metal wires are inserted respectively in the two arms of a Wheatstone bridge. A variation in temperature of one of the wires produces a variation in its resistance which is indicated by the bridge galvanometer, the bridge having been previously balanced.

In applying the bolometer to the detection of electric waves it is necessary to ensure the complete heat isolation of the bolometric arms, and, on the other hand, to localise the action of the waves in one arm only.

To effect this the arms, which are straight and very short—1·5 cm. of 10$\mu$ diameter platinum wire, in the most sensitive models—are brought very near to one another within the same enclosure.

In one of the types employed these arms are in vacuo. The case in which they are contained is made as small as possible, and is enclosed in two successive coverings of silver-plated brass, between which is a very thin air space. The whole is immersed in a small vessel filled with water. In another model the heat isolation is obtained in a more simple manner by means of a Dewar vacuum vessel.

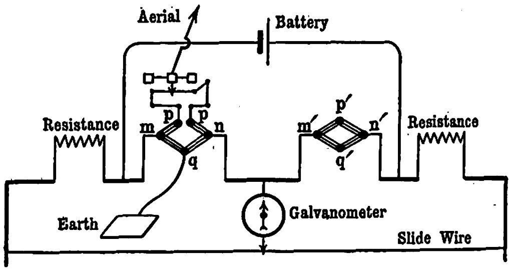

FIG. 1.

According to the kind of measurements for which the apparatus is intended, two different methods are employed for localising the effect of the wave. In one of these methods, similar to that employed by Rubens, each arm of the bolometer is formed by four exactly equal pieces of wire arranged in the form of a bridge (Figs. 1 and 2).

The balancing resistances of the bridge are either of German silver or platinoid, and are immersed in petroleum. The balancing of the main bridge is performed by means of a slide wire of large diameter. The aerial and the earth connection are attached at $pp$ and $q$ to that diagonal which is not in the circuit of the main bridge.

The apparatus can be calibrated direct by a continuous current and can be used as a wattmeter (the resistance being known and the self-induction negligible). The method employed for taking the measurements consists in the observation of the permanent deflection of the galvanometer of the main bridge under the action of the waves received during a suitable time. The aerial and the earth are removed, and there is connected in their place a source of direct current capable of supplying the required current to the bolometric bridge $m\ n\ p\ q$, so as to produce the same deflection of the galvanometer of the main bridge.

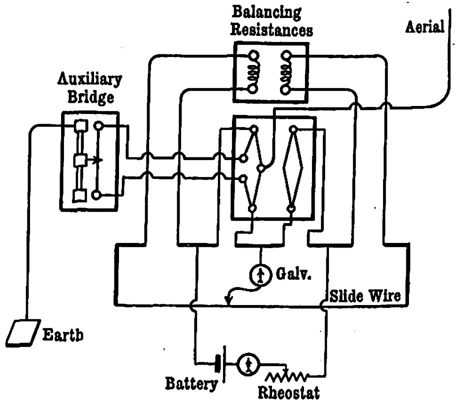

FIG. 2.

Since it is necessary that the unbalancing of the main bridge shall be solely due to the heat developed in the auxiliary bridge $m\ n\ p\ q$, an external means of adjustment (a kind of slide wire) was added to the bolometric bridge in order to be able to realise exactly the desired conditions. These are obtained when the galvanometer deflects in the same direction and exactly to the same amount on reversing the direct current in the auxiliary bridge.

The other method of localising the effect of the waves consists in inserting between the bolometric arms, each of which are formed of a single piece of wire, suitable ironless choking coils, of dimensions

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[*] Original communication which has been accepted for publication in the *Journal* of the Institution of Electrical Engineers.

[†] *Comptes Rendus*, February, 1903; November, 1903. *Journal de Physique*, July, 1904.

previously determined by experiment. The aerial and earth are then connected as shown in Fig. 3. The sensibility of these arrangements depends, of course, upon that of the galvanometer employed. For moderate degrees of sensibility a d'Arsonval dead-beat galvanometer was used. The apparatus is then suitable for use on board ship. Where extreme sensitiveness was required I employed a moving-needle galvanometer (Thomson's type) with two parallel vertical needles, the resistance of the galvanometer being chosen equal to that of each of the bridge arms. I was thus able to obtain deflections of about 10 mm. with an effective current of 100 micro-amperes (scale at 1 metre distance).

The arrangement of the transmitter and receiver is shown in Fig. 4.

If the length of the transmitting aerial A is left constant and that of the receiving aerial B be varied progressively, it will be noted that the deflections of the bolometer reach a maximum for a certain length of B. The aerial system A B are then in resonance and have the same natural period. When the aerials A and B have the same shape, for instance both being either simple wires or both consisting of four parallel wires, it will be found that the resonance always occurs when the lengths are equal whatever may be the general curvature or inclination of the aerials. The measurements given refer to systems in resonance.

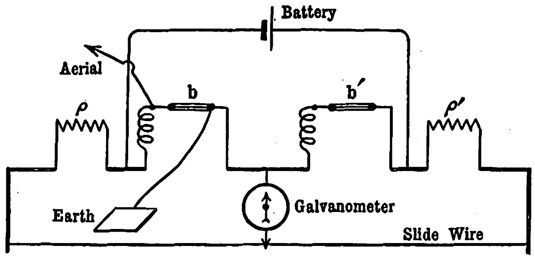

FIG. 3.

*Influence of the Resistance of the Measuring Instrument.*—By varying the value of a non-inductive resistance arranged in series with the instrument in the receiving aerial, I found that there was a best value for the resistance from the point of view of the energy absorbed. In my experiments this value appeared to lie between 50 and 60 ohms. In fact, of three similar instruments the respective resistances of which were 15, 42 and 82 ohms, it was the 42 ohm instrument which absorbed most energy and therefore gave the best results.

I am of opinion that the value of the "best" resistance depends upon the aerial employed, and that the most favourable conditions are approximately reached when the resistance of the instrument is equal to the resistance of emission. By "resistance of emission" I mean that amount of resistance which, assuming no loss of energy by radiation, the aerial should have, in order that the damping of the oscillations by the frictional resistance may be equal to that due to radiation only.

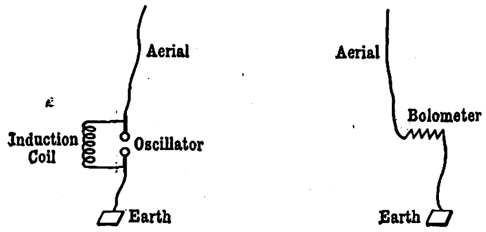

FIG. 4.

*Variation of the Received Energy with Distance.*—At first I only carried out tests at distances between 1 km. to 9 km.* But within these restricted limits, and when working with aerials tuned in such a manner as to reduce the influence of the harmonics, I found that the effective value of the current in the receiving aerial is inversely proportional to the distance. The energy received, which is represented by the product $ri^2$, varies, therefore, inversely as the square of the distance. At a later date I was able to extend these measurements to a distance of 40 km., and I obtained absolute confirmation of the law which Mr. Duddell has so well demonstrated over longer distances.

*Influence of the Earth.*—I also carried out a great number of measurements with various methods of earthing, both at the transmitting and receiving stations. Without entering into the details of these experiments I may say that with regard to the influence of the surface of the earth capacity I arrived at the same general conclusions as Mr. Duddell. I observed particularly that the "earth" obtainable on board ship by connecting to the hull is very much better than that which one gets on land by means of plates buried in the ground. I believe, however, that I have established the fact, contrary to the opinion expressed by Mr. Duddell, that the ground when damp makes a better earth than when dry. These conclusions are rendered apparent not only by direct measurements of the energy by means of the bolometer, but by the data resulting from the study of the damping.

*Number of Interruptions.*—My experimental observations also showed that if the number of interruptions is made to vary from $n$ to $n'$ per second, the effective value of the current received by the aerial varies in the ratio of $\sqrt{n}$ to $\sqrt{n'}$. This result, which appears in accord with the observations of Duddell and Taylor, is readily capable of interpretation by reasoning as follows: Let I denote the reading on a hot wire ammeter put in series at the bottom of the transmitting wire, A = the amplitude of the current in the aerial. T = the period. $\gamma$ = the decrement of the oscillation. $n$ = the number of interruptions—that is, of wave trains per second.

By a simple integration we then obtain for the fundamental wave:

$$I^2 = n\frac{A^2}{4\gamma} \cdot \frac{4\pi^2}{4\pi^2+\gamma^2} \cdot T.$$

Since the factor $\frac{4\pi^2}{4\pi^2+\gamma^2}$ is almost equal to unity, it is clear that the energy transmitted by a single wave train, which is proportional to $A^2$, is given by a relation of the form $W_c = KA^2 = K'\frac{I^2}{n}$ (K and K′ being constants). In the same manner the energy received for a single wave train is easy to compute, if one assumes that the detector completely absorbs this enery. If an effective current $i$ is obtained with $n$ interruptions, that is with $n$ trains per second, then the equation $W = \frac{\rho i^2}{n}$ expresses the energy received for single wave train, $\rho$ being the resistance of the measuring instrument (.n this case the bolometer), when the number of interruptions varies from $n$ to $n'$, $i$ varies from $i$ to $i'$, and $\frac{i'^2}{i^2} = \frac{n'}{n}$, whence $\frac{i'}{i} = \frac{\sqrt{n'}}{\sqrt{n}}$

*Numerical Value of the Energy brought into Play.*—These considerations enable us to compare the values we have obtained with those obtained by Mr. Duddell. The direct system of excitation was used, the transmitting aerial being connected to one spark ball of the oscillator, the other ball being connected to earth. The transmitting and receiving aerials were identical, and were consequently in resonance without any added self-induction. Each of the aerials consisted of four parallel wires at a distance apart of 1 metre and having a total length of 55 metres from the extreme summit to the ground.

With 26 interruptions per second the hot wire ammeter in the transmitting aerial shows 2·8 effective amperes. With a bolometer inserted between the receiving aerial and the earth the following values were obtained:—

| Distance D in kilometres. | Current $i$ in the receiver in micro-amperes. | Product $i \times$ D. |
|---|---|---|
| 1·150 | 8,290 | 9,550 |
| 8·000 | 1,180 | 9,450 |
| 40·000 | 235 | 9,400 |

Although a slight regular decrease is apparent in the product $i \times$ D, it may be, nevertheless, regarded as constant. Consequently, under the same conditions at the transmitter the value of the current at 48 km.—that is, at 30 miles—would be 195 micro-amperes.

The values obtained appear, therefore, to be somewhat higher than those of Duddell and Taylor, since they refer in this case to 26 wave trains. But the conditions of the experiments are not altogether the same, seeing that my observations refer to a system which was excited by direct coupling. I believe, moreover, that the resonance was somewhat sharper in my experiments, because the proper frequency of the aerials as arranged was strictly the same.

# SOME RECENT ELECTRICAL MEASURING INSTRUMENTS.*

BY KENELM EDGCUMBE.

*Ampere Gauges.*—Owing to the fluctuating nature of the load, it is essential that these instruments should be moderate dead-beat; and another point, which has hardly been sufficiently considered, is that they should be fitted in exceptionally strong and durable cases, the ordinary brass spun cases with exposed glass fronts being quite unsuitable for the rough usage to which these meters are often subjected. When it is mentioned that these instruments have to be sold at anything from 20s. to 25s. each, and, moreover, have usually to stand 500 volts between windings and case (often in an excessively damp and dirty situation), it will be admitted that the problem is not an altogether simple one.

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* *Comptes Rendus*, March, 1904.

* Abstract of a Paper read before the Junior Institution of Engineers on February 2nd.

There has been for some time, particularly in this country, a prejudice against the use of cast-iron cases for moving-iron instruments, on account of the errors which were often found, owing to the magnetisation of the case itself. A moment's consideration will show that so long as the ordinary solenoid movement is screwed down to an iron base without any "magnetic insulation," so to speak, in between, the case will become strongly magnetised, and large errors will almost certainly be introduced. There are, however, two ways of overcoming this difficulty. One consists in employing a coil whose axis lies parallel to the base instead of at right angles to it. This is the method adopted in instruments of the so-called "Universal" pattern, and has several incidental advantages. The other alternative is to leave a considerable gap between the coil and the base. The latter method is the one employed in the Everett-Edgcumbe gauge, as will be seen from the section of the instrument given in Fig. 1. The path of the lines of force passing out at the bottom of the coil is through the insulating base to the soft-iron shield and back again through the base to the cast iron side walls of the bottom plate of the case.

With this arrangement it is found that, on the one hand the meter can be placed close beside a fully-excited motor without perceptibly affecting the readings, and on the other hand, a dead short circuit through the instrument is practically without effect on its subsequent accuracy, showing that the case has not become appreciably magnetised.

*Wattmeters.*—It is really only within the last few years that the scientific design of wattmeters has been fully understood and seriously taken in hand. It would lead the author too far were he to enter further upon this question. Suffice it to say that, whereas for laboratory and standard instruments all metal must be excluded as far as is reasonably possible, at the same time for ordinary purposes, such as for motor work, by careful design ample metal can be employed in the working parts to ensure mechanical strength, and the instrument can even be shielded by being fitted in a cast-iron case of special construction.

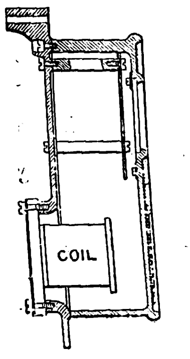

FIG. 1.—IMPROVED AMPERE GAUGE.

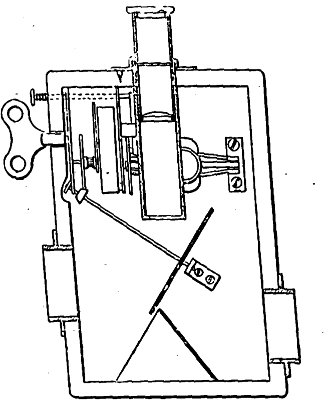

FIG. 2.—PHOTOMETER ON THE FLICKER PRINCIPLE.

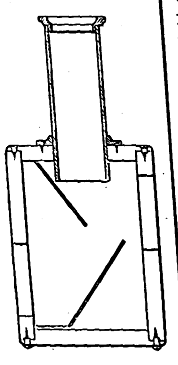

FIG. 3.—TROTTER PHOTOMETER.

As far as he is aware, only two serious attempts have been made to produce a cheap instrument of fair accuracy and strong mechanical construction in a cast-iron case. One of these is due to Dr. Drysdale, and consists of a laminated electromagnet having two narrow air-gaps, in which a flat volt coil is suspended. This coil is so placed that its top and bottom halves—which of course carry currents in opposite directions—find themselves in opposite magnetic fields, and are thus both urged in the same direction, say downwards. The coil is supported from an arm fixed to a spindle carrying the pointer, which is thus moved over its scale in opposition to a spring. A stationary volt winding similar to the moving coil is fixed close to it, and so connected as to almost completely eliminate self-induction. It will also be seen that the instrument is perfectly astatic. The electromagnet carries a winding through which flows the current to be measured, while the pressure coils are connected through a non-inductive resistance across the mains. The accuracy of the instrument depends, as will be seen, on the flux due to the series winding being in phase with the current producing it (unless the current in the pressure coil is made to lag behind the voltage, and this, the writer understands, is not the case). That owing to hysteresis and eddy currents they cannot be absolutely in phase is obvious, and it is difficult to see how the lag can be negligible, even for rough work. He understands, however, that this is so, although he has not, so far, seen any actual figures bearing on this point.

The other instrument alluded to is the watt gauge of Messrs. Everett Edgcumbe. It is constructed on the dynamometer principle, and is chiefly distinguished by its strong mechanical construction and by the fact that it is fitted in a cast-iron case. The magnetic field employed is particularly strong, so that the effects of stray fields are negligible. The instrument is air-damped and substantially made.

*Photometers.*—So long as lights of the same or nearly the same colour are to be compared, the difficulties are not great, and either a Lummer-Brodhun or a Trotter photometer will give perfectly consistent and accurate results. If, however, the lights differ in colour the problem becomes extremely involved. Some authorities have even gone so far as to say that it is incorrect to speak, for instance, of the "candle-power of an arc lamp" on account of the physiological effect of so white a light being different from the more yellow light of a candle. Be that as it may, it becomes absolutely essential to find some basis on which the illuminating power of various sources of light may be compared, even when as different in colour as the mercury vapour lamp and the flame arc.

With any ordinary photometer it is found, as may well be imagined, that to obtain a balance of illumination when the lights are of different colours is a matter of extreme difficulty. Mr. A. P. Trotter has suggested a method of getting over this difficulty, which consists in employing two differently tinted screens to receive the two lights. For example, if an arc lamp is to be compared with a glow lamp standard, an orange-yellow screen might be employed for the arc and a bluish screen for the glow lamp. By choosing suitable tints the screens can be made to appear almost identical in colour when illuminated by their respective lights, and an accurate balance is easily obtained. The objection to this method is that a constant has to be found for each pair of screens, and this constant will depend upon the relative colours of the lights under test. Moreover, it can only be determined by comparing two known lights of the same colour by means of the screens, so that the difficulty of obtaining the constant, and the inaccuracy thereby introduced, is considerable.

Of late years the "Flicker" photometer has been coming more and more into favour, an ingenious form being introduced some years ago by Messrs. Simmance & Abady.* The principle of the Everett-Edgcumbe form, which makes use of the rotating card arrangement, due originally to Whitman, is shown diagrammatically in Fig. 2. Whichever form is employed, it will be found that there is a particular speed of rotation which gives the maximum sensitiveness, and as a rule it may be said that the greater the difference of colour between the two sources of light the more rapid should be the alternations. After taking all the available evidence into consideration, based both on tests made by the author and by others, he can confidently say that he has never yet come across any case in which there was not complete agreement between the "Flicker" method and the "equality of illumination method" to well within the errors of observation. In the hands of an experienced worker, and so long as the two lights to be compared are of the same or nearly the same colour, the "Flicker" photometer is more sensitive than the ordinary Bunsen grease spot, but not so sensitive as either the Trotter or the Lummer-Brodhun.

It has been frequently mentioned, and with reason, that as the chief use of artificial light is to enable one to see, the ideal photometric test would be to determine at what distance from the source of light one could, for example, look out a train in Bradshaw's Railway Guide, with a reasonable hope of arriving at one's destination. Photometers based on a principle analogous to this have been several times proposed, and, more recently, Carter has applied this principle to the Joly Paraffine Block photometer and Prof. Fleming to the Wedge photometer. The arrangement can also be applied with success to the ordinary Trotter form of photometer (see Fig. 3). The method pursued in this case is to rule on each of the two cards a diagram, usually somewhat similar to a spider's web, and the eye of the observer is placed in such a position that he is readily able to judge whether one of the two patterns is more distinctly visible than the other. As far as the writer is aware, this device has not been very largely used, but it would certainly appear to merit careful consideration as it forms another possible solution of the colour difficulty, though he must confess that personally he has not been able to obtain anything like such satisfactory results with the "distinctness" photometers, as they are often called, as with the "Flicker."

*Street Photometers.*—Nearly all modern street photometers are constructed on the "Flicker" principle, and the various types are distinguished chiefly by differences in the standard of light employed and in practical details of construction, upon which latter, it may be said, the success or failure of a street photometer really depends. The chief points to be aimed at are: (1) portability; (2) rapidity of measurement; (3) ease of manipulation in a badly-lit position; (4) accuracy of measurement by an untrained observer under adverse conditions. All things considered, there is no doubt that the best standard is a small 8 or 10-volt glow-lamp worked off a portable accumulator having a capacity of 15 or 20 ampere hours. It is inadvisable to work at a lower voltage than this owing to the resistance of the lamp circuit then becoming so low that a faulty connection is liable to cause a large variation in the candle-power.

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* For a description see *The Electrician*, Vol. LII., p. 380.

*Watt Photometer.*—What appears to be wanted is an apparatus which can be taken to the consumer's premises on request, and into which a lamp can be placed and its candle-power and current consumption read off with little or no manipulation. In the so-called "Watt photometer" of Messrs. R. P. Wilson and G. M. Hardingham a very successful attempt has been made to provide such an instrument.* After having obtained a photometric balance in the ordinary way, the candle-power is read off the photometer scale, and the watts per candle off one of the wattmeter scales. The watts per candle scale can, of course, be graduated in any other way, such as in pence per candle-power hour and so forth.

*Recording Instruments.*—The pioneers in recorder design were undoubtedly Messrs. Elliott Bros. in 1896. Since then there is not much to record in the way of progress until the last few years. The chief troubles met with in recorders are inaccuracies in the clocks, spilling or drying up of the ink, and clogging of the pens, as well as frictional and other errors. An ingenious form of self-inking pen has lately been introduced by Messrs. Elliott Bros.† The device consists of a small trough containing ink, which is fixed in front of the chart and into which dips a capilliary tube carried by the pen arm. As the arm swings from side to side the tube is carried with it, one end still dipping into the trough, while the other traces a line on the chart. It is claimed that the friction between the pen and paper is reduced by this arrangement, though it is somewhat difficult to see in what way, and the total friction would necessarily be increased owing to the viscosity of the ink through which the pen has to be drawn. One great advantage secured by this device is that the pen will hold an almost unlimited supply of ink which will not spill. Should the small capilliary pen become clogged—and with so fine a tube there is always a danger of this—it can easily be replaced by a new one.

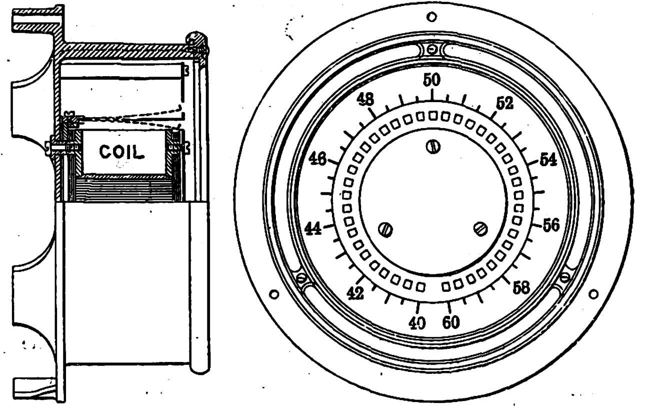

Fig. 4.–Everett-Edgcumbe Frequency Indicator.

Besides Messrs. Siemens & Halske's mechanical intermittent registering instrument, brought out in 1906, this firm have introduced an ingenious recorder, in which the pen arm carries a sharp point which swings just clear of the chart. This pen arm is connected to one pole of a small induction coil and the chart drum to the other. A prepared paper is employed for the charts, which records the position of the pointer at each instant by a dark trace cause by the passage of the spark through it. This instrument also does not appear to have been so extensively taken up as its accuracy might lead one to expect. One of the latest additions to the ranks of recording instruments is the Everett-Edgcumbe "Inkless" synchronised recorder.‡ This instrument, like that of Messrs. Siemens & Halske, is of the intermittent registering type, but is distinguished from it by the fact that an entire installation, consisting of any number of recorders, can be worked off a single master clock with the certainty, moreover, that all the instruments are absolutely alike as regards timing. For ordinary purposes, a record every five seconds forms the standard, but for traction work a record every second is often found advisable. The controlling clock is constructed on the well-known Hope-Jones "synchronome" principle, the chief feature of which is the self-cleaning contact. From what has been said, it will be seen that the chief points of interest about these recorders are: (1) absence of ink; (2) absence of friction; (3) absence of clockwork; (4) accuracy of timing.

Being able to eliminate friction at once opens up new fields of usefulness for recording instruments, such, for example, as recording power-factor indicators, recording pyrometers, &c., since in the past it has been found impossible to obtain sufficient power in such instruments to overcome the friction inseparable from an ordinary recording pen §

*Frequency Indicators.*—In Mr. Campbell's frequency indicator, an electromagnet energised by the alternating-current, whose frequency is to be determined, acts upon a steel reed, the length of which can be varied until resonance is attained. The length of the reed is then simply read off on a scale, a given length corresponding to a definite frequency. The position of resonance is easily recognised by the hum increasing in loudness as the point is approached, and then decreasing again as it is passed. In another modification, due originally to Messrs. Kempf & Hartmann, a number of reeds, each having a definite period of vibration, are acted upon by the electromagnet. Each reed carries at its end a small white flag, and as the swing amounts to nearly ½ in. the particular reed which happens to be vibrating can be at once seen. Opposite each tongue is marked the frequency to which it corresponds, so that this can be at once read off. In another modification (Fig. 4), the electromagnet is circular in form, and the reeds are arranged round it, and, being of steel, are attracted at their upper ends, and thus kept in vibration. It will be clear that the tongues are attracted once in each half-period—that is, twice per cycle. A very simple method of doubling the range thus suggests itself, which consists in providing the electromagnet with a second winding, through which a direct current can be sent. If the ampere-turns of the two windings are the same it will be seen that one-half of each wave is wiped out, while the other half is doubled in magnitude, and thus the reeds are attracted only once per cycle instead of twice—that is, they respond to double the previous frequency. The sharpness with which a particular reed is picked out is quite extraordinary. Fig. 5 shows this very clearly. Numbers of reeds which have been tested after being in continual use for years have been found to possess identically the same time of swing as when first installed. Another successful form of frequency indicator, working on an analogous though slightly different principle, has been introuced by Frahms. This instrument, like that just described, is provided with a number of tuned tongues, but in this case, instead of each being set separately in vibration by an electromagnet, they are all fixed to a common support, which is vibrated by the electromagnet. Thus the impulses in this case are mechanical rather than magnetic. In other respects the arrangement is similar to the one just described.

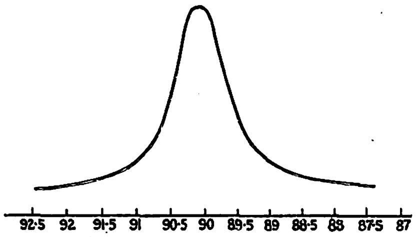

Fig. 5.—Amplitude of Vibration of Reed of Frequency Indicator.

## THE UNWATERING OF THE ACHDDU COLLIERY.

A Paper on this subject was read by Mr. John Morris before the North of England Institute of Mining and Mechanical Engineers some time ago. After describing the colliery in question, which is situated in Caermarthenshire, the author proceeded to give an account of the portable electrically-driven Riedler Express pump (which was used to unwater the mine), and of the electrical power plant which was erected for the supply of energy. This power plant comprised a 150 kw. 500 volt Crompton compound-wound continuous-current dynamo rope-driven from a tandem compound non-condensing engine. Current was conveyed to the mine by two 39/16 cables, bitumen-insulated and double-armoured with steel wire. A slant or day-drift had been driven, years ago, a distance of about 1,335 ft. from the surface, and the unwatering was carried out by making use of this slant. The upper 300 ft. of the slant was unwatered by means of a steam pump, and thence downward the colliery was pumped out by following down the old slant and pumping the water to the surface by means of a Riedler Express pump designed for 375 gallons a minute against a head of 500 ft. This pump was driven through single-reduction gearing by a Crompton open-type compound-wound 75 H.P., 450 volt motor. The pump, motor and starter were mounted together on a steel girder carriage having wheels of 2½ ft. gauge—*i.e.*, the same gauge as the colliery tramroad The tram-rails weighed 36 lb. to the yard. The pump worked on a road-laid on one side of the slant, while the tramroad was laid on the other side, so that the trams could pass the pump on their way to and from the face. This arrangement necessitated the widening out of the old slant to a width of 14 ft., the original width being 6 ft. The arrangement of mounting the motor starter on the pump-carriage, soon proved unsatisfactory, as, owing to the vibration of the pump, the starter continuously cut out the current. The starter was then taken to the power house (the shunt-lead then extended from the motor to the starter in the power house) and the engineman in the power house had to stop and start the pump, as signalled by the pumpman. An ordinary switch was put on the pump-carriage, so that, in case of an emergency, the pump could be stopped by the pumpman. This pump was introduced in May, 1903. When the author took charge of the colliery in November of the same year, the slant had been reopened for a distance of 450 ft., that is, 750 ft. from the surface, with this pump. The average rate of opening out was about 22½ ft. per week, but six weeks previous to this the pump had failed to cope with the water (the make being about 175 gallons per minute) and it was being gradually drowned out.

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* For an illustrated description see *The Electrician*, Vol. LV., p. 993.

† An illustrated description of this device appeared in *The Electrician* for October 20, 1905, p. 28.

‡ A description of this instrument will be found in *The Electrician*, Vol. LV., p. 993.

§ The recording pyrometers of Prof. Callender are, of course, well known, but they are somewhat too complicated for ordinary use.

A Scott-Mountain pump arrived a few days after the author took charge of the colliery. It was a three-throw pump, having rams 7½ in. in diameter by 12 in. stroke, running at 40 crank-revs. per min. driven through double-reduction gearing by a shunt-wound open-type 65 H.P. motor at 500 volts: its capacity at this speed being 200 gallons per minute. The motor was fitted with a raw-hide pinion. The carriage for this pump, built at the colliery, consisted of four pitch pine baulks, suitably braced and bolted together, and fitted with wheels for a road of 2½ ft. gauge, the axles being 3 in. in diameter, with four pedestals fitted to each axle. This pump weighed, when ready to work, mounted on its carriage, about 16 tons, and it was 17 ft. 6 in. long, 6 ft. 6 in. high and 6 ft. 8 in. wide. It was got ready to work in about 14 days, and worked splendidly. (The Express pump had been drowned out a week previously, the motor only being removed, and the water had risen about 180 ft. in the slant.) In working it rested against two stout props, which were put up in front of it, and it was also fastened to another prop put up behind it. After being lowered (before being started to work) it was always chocked up by wooden wedges, so as to relieve the wheels of part of the weight.

The electric cables were carried along the side of the slant, on horizontal pieces of wood fixed for the purpose. A length of about 450 ft. of both cables was coiled on the side of the slant. The time taken to disconnect the cables, suction pipes and delivery pipes, lower the pump, connect together again and start was generally about three hours.

The two pumps referred to did not work together at the same time; while one would be working the other would be standing idle and the flow of water from the bore-hole would have to be regulated according to which of the two pumps was in use. The reasons for keeping one of the pumps idle were that the cable was of insufficient capacity, and there was only one line of delivery pipes 6½ in. in diameter. Further, the motors of the two pumps were not built for the same voltage. Tests made by the author on the Riedler-Crompton set went to show that the combined efficiency of the set was 85 per cent.

# PARLIAMENTARY INTELLIGENCE.

## POST OFFICE TELEPHONE FACILITIES.

We mentioned in our last issue that Mr. Nield (Ealing) had given notice of two questions relating to the London telephone service. In a printed answer to the first question, to the effect that £15 per annum, plus the message rate, was being charged for the use of a telephone in the northern postal district,

The POSTMASTER-GENERAL states that the ordinary message-rate subscription for a line to any exchange in the London telephone area outside the county of London is £4 a year, with a fee of 1d. for each call on the same exchange and 2d. for a call to another exchange. The unlimited-service subscription, covering communication with all exchanges throughout the London area is £17 a year. He was not aware of the circumstances of the particular case referred to, but if particulars were given he would be happy to make inquiry.

Mr. Nield's second question related to the "considerable dissatisfaction" existing among Post Office telephone subscribers in connection with the working of the central exchange, and in reply to this

The POSTMASTER-GENERAL said that the lines of the subscribers to the central exchange, some 12,000 in number, were transferred to a new switchboard on Saturday, Feb. 17, in order to allow some necessary alterations in the central exchange switchboard. The transfer temporarily affected the working of some of the subscribers' lines; but the faults were remedied in the course of last week, and the exchange was now working under normal conditions. The change was of great magnitude, and he considered that great credit was due to the engineers and to the exchange staff for carrying out a very difficult operation with so little disturbance to the service. He was unaware of any dissatisfaction among the subscribers of the exchange, so far as its ordinary working was concerned.

## THE LONDON POWER, &c., BILLS.

The following electric power bills relating to London came up for second reading on Monday last in the House of Commons, but were postponed for a week: Charing Cross & Strand Electricity Supply, City of London Electric Lighting, London Electric Supply Corpn., West London Electric Undertakers' Association, Additional Electric Supply, London County Council (Electric Power), Administrative County of London & District Electric Power, Hackney Electricity, and Shoreditch and Stepney Electricity. Several rumours have been circulated as to the possible action of the Government in respect to these bills, but no official announcement has been made.

Further motions have been placed on the paper by members to move the rejection of various London and provincial electric power bills.

At a meeting of London Liberal members on Wednesday it was decided to oppose all the electric power bills promoted by companies on the motion for second reading, but to support the London County Council bill.

## GAS COMPANY SEEKING ELECTRIC LIGHTING POWERS.

On Tuesday the Court of Referees had before it a petition by the Ascot & District Gas Co. challenging the locus standi claimed by Messrs. Foote & Milne to oppose the Ascot & District Gas (Electric Lighting) Bill.

Mr. HUTCHINSON, who appeared for Messrs. Foote & Milne (Ltd.), stated the facts of the case. By this bill the Ascot & District Gas Co. were seeking powers to extend their present area and to supply both gas and electricity. His clients, Messrs. Foote & Milne, were at present applying to the Board of Trade for a provisional electric lighting order for practically the same district, and whereas, on the one hand, the Gas Co. had a locus against, and were opposing, the provisional order, it was sought, on the other hand, now to prevent Messrs. Foote & Milne from appearing against the Ascot Gas Co.'s bill before Parliament. There were one or two peculiar circumstances. Messrs. Foote & Milne, under the Electric Lighting Acts, had to give notice of their intention to apply for a provisional electric lighting order in July. Having seen this notice the Gas Co. determined to promote a bill with the same object in view, instead of proceeding by provisional order, when both applications would have been considered on their merits.

Mr. VESEY KNOX, for the Gas Co., said that as a statutory company he could not go to the Board of Trade, as the latter had no power to authorise the use of the funds of the company for the purpose of electric lighting.

Mr. HUTCHINSON replied that the company could have promoted a bill to enable them to apply their funds for electricity supply (as had been done by many gas companies), and then have gone to the Board of Trade for a provisional order. Continuing, he pointed out that the bill also asked for relief from certain sections of the Electric Lighting Acts, which would not be allowed under provisional order procedure, and particularly did the Gas Co. exempt themselves from purchase by the local authority. Again, whereas his clients in seeking a provisional order had to obtain the consent of the local authority, by proceeding under a bill the Gas Co. did not. The Gas Co. were seeking, through there being two methods of procedure for the same powers, to stifle competition by preventing opposition to their bill.

Mr. VESEY KNOX, for the promoters of the bill, after having argued as to the inconvenience which the two methods of procedure involved, said that if Messrs. Foote & Milne would withdraw their opposition, he would undertake not to oppose any bill confirming their provisional order, should the Board of Trade grant it. He opposed the granting of a general locus on the ground that his company already existed, and Messrs. Foote & Milne at present had no powers.

Lord ROBERT CECIL: Will you withdraw from opposing the provisional order at the Board of Trade?

Mr. VESEY KNOX: No; that is our existing right.

The Court allowed the locus.

## FOLKESTONE, SANDGATE AND HYTHE TRAMWAYS.

Mr. CAMPION, examiner of Standing Orders, had before him on Tuesday for proof of compliance with Standing Orders, the two rival bills for tramways from Folkestone to Hythe. No. 1 bill is promoted by a number of gentlemen for whom Mr. Stephen Sellon is acting as consulting engineer, whilst No. 2, for which Mr. J. E. Waller is consulting engineer, is promoted by the National Electric Construction Co. No. 1 bill was taken first and Mr. Lees (Messrs. Lees & Butterworth) appeared for all the memorialists, including the promoters of No. 2 bill, against this bill. His first point on behalf of the Sandgate Urban District Council related to the question of purchase of the existing tramways, which are in the hands of the South Eastern Railway Co. The notices specified that the promoters of No. 1 bill sought the compulsory purchase of the existing lines from the Railway Co. The Sandgate Council, however, has given notice to the Railway Co., as provided for by an Act of Parliament, to purchase the lines in Sandgate, and since the appearance of this notice the promoters have inserted the name of the Sandgate Council in bill, as the authority to compulsorily sell the lines. He therefore contended that the notice was not sufficient. The Examiner did not consider that the Sandgate Council had been placed at any disadvantage, and the matter could well be dealt with by the Select Committee which considered the bill. The next memorial was in respect of the compulsory running powers, asked for in the bill, in respect of any of the tramways purchased by the local authorities. He contended that there was no mention of such a power in the notice, and asked for a non-compliance. The Examiner came to the same decision as on the last point. There are about 60 cases under the bill by which property is to be acquired compulsorily, and it was next pointed out that in a large number those cases in which portions only of the property were to be taken, notices had not been given in the proper manner. Some 20 witnesses were in the room on this point, but the promoters admitted their error and a non-compliance was reported. The question of the consent of the Sandgate Council was then raised. Mr. Wakeford (of the firm of J. Kennedy, Parliamentary agents), contended that the Sandgate Council had entered into an agreement with the promoters of No. 1 bill in 1900 for the construction of tramways, and there was a clause in it, upon which he relied, which made the consent apply to any subsequent bill. The Examiner said he must have a definite consent for this bill, and he must report a non-compliance as regards the consents of the Sandgate Urban District

Council, the Folkestone Corporation and the Hythe Corporation, the latter two being admitted by the promoters.

The memorials against the National Electric Construction Co.'s bill were then taken. The first concerned the width of certain roads in Folkestone, which, it was contended, were less than the statutory width. Mr. Lees called evidence from the Folkestone Corporation to show that the roads in question were actually being widened, and were almost completed. The Examiner refused to report a non-compliance.

An endeavour was then made to show that the consent of the Hythe Corporation to the bill was not valid, owing to the Corporation having omitted to rescind a resolution laying down certain routes which had since been altered; but the Examiner said that since the promoters of No. 2 bill had produced the consent he could not report a non-compliance. A large number of objections were next raised, such as the failure of the promoters to describe the lines properly in the notices, and so on, but they were all over ruled.

The result is that whereas No. 1 bill has been reported for non-compliance on several points, none of the allegations against No. 2 bill were sustained by the Examiner, but he will report to the Standing Orders Committee that the consent of the Folkestone Corporation to No. 2 bill was not received until after the expiry of the statutory period.

## WIRELESS TELEGRAPHY BILL, 1906.

This bill was considered in Committee by the House of Commons on Thursday last week, and was reported, with amendments. The next stage is the third reading, which has been postponed until Monday next.

## ABANDONMENT OF THE KENT COLLIERIES POWER BILL.

The promoters of the Kent Collieries Electric Power Bill have notified the authorities of the House of Lords that it is not intended to proceed with this measure this session.

## MISCELLANEOUS.

**Minister of Commerce.**—Mr. Field asked the First Lord of the Treasury on Monday whether the Government would consider the expediency of appointing a Minister of Commerce, in conjunction with a Consultative Committee. Sir Henry Campbell-Bannerman in a printed reply acknowledged the importance of this subject, but feared that there was no prospect of its being dealt with this session.

**Post Office Telephone Employes.**—In a printed answer to a question in the House of Commons on Monday, Mr. Sydney Buxton said that certain classes of telephone employés were included in the reference to the Committee dealing with Post Office employés, but not the supervising or clerical classes.

**National Telephone Employes.**—In the House of Commons last evening, Mr. Keir Hardie asked the Postmaster-General whether he accepted the findings of the Telephone Transfer Committee of last year relative to the position of the employees of the National Telephone Co., and whether he intended to embody these in a Bill this session. The Postmaster-General replied that he accepted the arrangement agreed to by Lord Stanley last August.

**The Metric System.**—Mr. H. Norman will ask the First Lord of the Treasury if he will afford time for the passage of a bill, which would probably be non-contentious, to carry into effect the second of the three recommendations of the Select Committee of 1895, the first and third having been already carried out—viz., that after a lapse of two years, the metric system of weights and measures be rendered compulsory by Act of Parliament.

The West Cumberland Electric Tramways Bill was read a first time in the House of Lords on Monday, and the Cumberland Electricity and Power Gas Bill a second time.

The St. Pancras Electricity Bill was read a second time in the House of Commons on Monday.

The London Southern Tramways Bill and the North Metropolitan Tramways Bill were read a second time in the House of Commons on Tuesday.

The Standing Orders Committee on Tuesday gave their decision regarding the London Outer Circle Railway Bill, the London United Tramways Bill and the Romford and District Tramways Bill. In all cases the bills are allowed to proceed, but the proposals for new lines in the London United Tramways Bill have been struck out, as the consents of the local and road authorities were not obtained.

The Police and Sanitary Committee meets for the first time on Wednesday, March 14, but the early bills on the list are not of electrical interest.

The Baker Street & Waterloo Railway Bill was read a second time in the House of Commons on Wednesday.

The General Committee on Railway and Canal Bills, of which Sir John Kennaway is chairman, has formed the following groups, among others:—Group 1. Hammersmith, City & North East London Railway, North West London Railway, North East London Railway, Romford & District Tramways. Group 2. London Southern Tramways, London United Tramways, London County Council (Tramways and Improvements), Middlesex County Council (Tramways), Corporation of London (Blackfriars and other bridges), Macclesfield & District Tramways. Group 4. Baker Street & Waterloo Railway, Metropolitan District Railway, London Outer Circle Railway, Metropolitan Railway. The consideration of groups Nos. 1 and 4 will not take place until after Easter, but No. 2 will commence on March 22.

## LEGAL INTELLIGENCE.

### J. Defries & Sons (Ltd.) and the Helios Mfg. Co. v. Electric & Ordnance Accessories Co. (Ltd.)

As stated in *The Electrician* of March 2 (p. 812), this case came before Mr. Justice Joyce in the Chancery Division on March 1.

Mr. Younger, K.C., and Mr. J. D. Israel appeared for plaintiffs, and Mr. A. J. Walter and Mr. J. C. Gray for defendants.

Mr. YOUNGER, K.C., in opening the case, said it was an action brought by plaintiffs for an injunction to restrain defendants from selling and passing off arc lamps under the name of "Stewart arc lamps" without properly distinguishing, and the case was somewhat peculiar in its facts and raised one or two interesting questions of law. The second plaintiffs (the Helios Mfg. Co.) were an American concern, whose predecessors in interest for a considerable number of years past manufactured a certain form of electric arc lamp and other electrical appliances which had been introduced into the English market, and under the name of the Stewart Lamp had acquired a considerable reputation. The way in which these lamps were introduced into the English market and received the name "Stewart" was that in 1896 a gentleman named Stewart was in America, and entered into an agency agreement to push the sale in Great Britain of, amongst other commodities, these arc lamps. Stewart came over to England, and shortly after he arrived formed the Stewart Electrical Synd. (Ltd.). This was largely the creation of Mr. Stewart, and he, by agreement, assigned the benefit of this agency, and himself entered into an agreement as the manager of the syndicate. The syndicate proceeded to place this American lamp on the English market. A very considerable number of the "Stewart" lamps were sold in the English market, and acquired a reputation for excellence. He thought it would be established that no lamps sold by the syndicate under that name were not of the American company's manufacture. What happened to the Stewart syndicate was that apparently other branches of its business were not very successful, and in 1903 a receiver was, at the instance of debenture holders, appointed, and it either went into liquidation or was wound up. Thereupon the agency for the sale of these lamps was determined, and the agency and the right to sell these lamps in England had passed by contract to the first plaintiffs. The receiver was minded to dispose of the assets of the syndicate to the best advantage, and he sold to the first plaintiffs certain of these lamps which were in the possession of the syndicate, and he offered for sale by public auction the goodwill of the syndicate, with the right, so far as he was able to sell it, to attach the word "Stewart" to electrical appliances. At that sale by auction defendant company, acting through its manager, Mr. Richard Bate, who had been for a considerable number of years the electrical manager of the Stewart syndicate, paid £95 for the goodwill, and accordingly the goodwill of the syndicate was assigned and transferred to defendant company.

His LORDSHIP: With the express right to use its name?

Mr. YOUNGER: Yes, so far as it could be conferred.

His LORDSHIP: The case raises a very interesting point.

Mr. YOUNGER: Yes, and they are selling other lamps altogether under the same name. The first question his Lordship would have to determine was whether the defendant company were entitled to apply the description "Stewart" to arc lamps manufactured in England and which had nothing to do with the American company's lamps at all, thereby representing that they were, in fact, the same lamps, both in point of quality and construction as supplied by the syndicate. The other question raised by defendants' counterclaim was whether defendants were entitled to stop them from applying the word "Stewart" to the real old original lamps which were the lamps manufactured for and sold through the syndicate to which he had referred.

Mr. W. N. NELSON said he was about six months with the Stewart syndicate and during that time the Helios lamps were supplied to them through Messrs. Peck. A few sample lamps called the "Pioneer" were sold by the syndicate for a time, but they were not satisfactory. These lamps were sent by another manufacturing company in New York and were never sold under any other name but "Pioneer." The Helios Co.'s lamps were always sold under the name of the "Stewart." During the time he was with the syndicate the main portion of their business was the sale of these lamps. The other part of the business was the sale of rheostats and electrical appliances. The name of Stewart was not attached to the articles. There was a German lamp in the market called the Helios lamp. He had, however, never known that lamp to be sold in England.

His LORDSHIP said he should have thought that if a small alteration were made in the form of the advertisement that would have put an end to the whole case.

Mr. YOUNGER said plaintiffs' case was that the name "Stewart Arc Lamp" had never been used in this country except on lamps manufactured by the Helios Co.

His LORDSHIP said there was no question of trade mark or monopoly, nor did he think there was any question of real actual fraud. Each party insisted upon doing what that party was doing, and the only question to his mind was whether defendants were doing that which was a fraud at common law. The case had nothing whatever to do with the Trades Marks Act or anything else, except whether defendants were representing the goods they sold to be manufactured by plaintiffs.

In answer to his Lordship, Mr. WALTER said defendants were the only persons entitled to use the name of "Stewart."

His LORDSHIP: It is not a question of the name of Stewart. It is not a trade mark. The only question is whether you are committing a fraud, and I do not think you are.

Mr. NELSON (continuing): The lamps when they arrived in England occasionally required adjustment. The lamps were made for different voltages. With that exception the lamps were sold as they came from America. The Stewart syndicate had no laboratory at first, but later on they had. The Helios Co. was a fully equipped manufacturing company. Open alternating lamps were sold in his time. The Stewart syndicate paid all the cost of their own advertisements. The syndicate were building up a business, and as part of their business they sold Stewart arc lamps by their advertisements. The Helios Co. was an unknown firm so far as this country was concerned.

After further evidence his LORDSHIP intimated that he thought plaintiffs' had made out no case on the claim.

Mr. WALTER then opened defendants' counterclaim, and said that defendants were dealers in electrical appliances, lamps, motors, &c. The lamp as introduced from the States was quite unsuitable for the English market, and about a dozen changes were made in it by defendants' servants and from defendants' instructions, and then there was a lamp produced suitable for the English market. The syndicate had built up a connection with the name Stewart, which was meant to mean the name of the Stewart syndicate. The man who did everything in connection with the syndicate was now the manager of the defendant company. He was the man who made every one of these improvements, and the defendant company had bought the goodwill of the Stewart syndicate. Plaintiffs had flooded the country with advertisements and threatening letters and circulars stating that they were the sellers of the Stewart arc lamp, and that nobody else was entitled to sell them. The learned counsel submitted defendants were entitled to restrain plaintiffs from doing this.

Mr. D. C. BATE, sales manager to defendant company, said that in April, 1897, he became manager of the syndicate after Mr. Stewart left. The condition in which the Stewart lamp was sent over was not suitable for the British market. He made various alterations in the structure of the lamp. He bought the lamps from Pecks and they were paid at first 10 per cent. commission and afterwards 5 per cent. He took a large part in building up the business of the Stewart syndicate himself. Plaintiffs had issued an advertisement and circularised the trade saying they were the sellers of the Stewart lamp, and that nobody else was entitled to sell them. That had done great damage to the defendants' trade. They claimed the right to use the word Stewart by reason of the purchasing of the goodwill of the syndicate and by reason of the assignment.

Mr. W. DEFRIES gave evidence on behalf of plaintiffs to the effect that he had never applied the name of Stewart to any lamps except those of the Helios Co.

In the result his LORDSHIP said he could not assent to the proposition that the word Stewart belonged in any sense to the American company. In his opinion the word Stewart was the sole property of the Stewart syndicate. He thought the right to use the title "Stewart Lamp" belonged to defendants. He held that if the American company and their agents were going to sell Stewart lamps in this country they must do it in such a way as to distinguish their goods absolutely from the goods sold by defendants. In his opinion defendants were entitled to judgment on the claim and also to an injunction on the counterclaim, the plaintiffs to pay the costs.

Judgment accordingly.

### Cooper Patent Anchor Rail Joint Co. (Ltd.) v. London County Council.

Yesterday (Thursday) Mr. Justice SWINFEN EADY, delivered his considered judgment in this action brought by plaintiffs for an injunction to restrain defendants and their agents from infringing plaintiffs' letters patent (25,578 of 1898 and 14,941 of 1899). Damages were also claimed. Defendants in 1904 used plaintiffs' patent rail joints in the construction of the Brixton electric tramways. The validity of the patent was disputed, defendants alleging it had been anticipated by the publication of a number of British and foreign patent specifications and other publications. Defendants further said that, having regard to the published knowledge at the date of plaintiffs' patent with respect to methods of jointing rails of railways, electric tramways, &c., no invention was required to produce the joints described in plaintiffs' claim, and that the letters patent were invalid for want of subject matter.

In giving judgment, his LORDSHIP said that if the patent was valid defendants did not deny infringement. Previous to 1898 it was well known to engineers that the best method for laying tramway rails was different from that for railways. In the case of railways the rails were laid above the surface of the ground, and provision had to be made for the expansion of the metal. The road had to be made elastic, and some slight space had to be left between the joint of the two rails and the joint made by means of fish plates, and sometimes by sole plates between the sleepers. In the case of tramways the rails were not laid above the surface, but the top of the rail was level with the surface of the ground, and the rails were protected by the surrounding soil from the extremes of temperature, and accordingly the joints made by riveting and bolting together were made as rigid as possible. It was claimed that the result of plaintiff's specification is to make an improved joint for tramway purposes. The joint was made rigid, the rails being laid in a bed of concrete, and therefore all play was avoided. Plaintiffs claimed that according to the patented invention the two ends of the rail were brought together, the effect being that after the concrete was set the rails were kept rigid at the joints, there being no play at the points, and pumping action and wear and tear were obviated and conductivity of the rail was preserved. The advantages to be derived in laying the rails in this manner were not denied by defendants, but they said it was not the invention which Cooper specified and claimed, and that even if it had been it was not valid subject matter for a patent. In his lordship's opinion the method of jointing rails specified by plaintiff was described by Leslie in 1872. There was no practical difficulty in applying Leslie's joint to tramways, and there was no ingenuity in Cooper's method of using it. In his opinion there was no subject matter here for a valid patent, and for these reasons he thought the action failed, and must be dismissed with costs.

### Tozelands v. West Ham Guardians.

The Defendants have decided to appeal against the recent decision of a Divisional Court (the Lord Chief Justice of England, Ridley and Darling, J.J.), reversing a judgment of the Bow County Court Judge (Judge Smyly), and ordering judgment to be entered for plaintiff for the damages (£100) provisionally assessed by Judge Smyly.

The original action was for damages for personal injuries. Plaintiff, who had become an inmate of West Ham workhouse, was afterwards transferred to Whipp's Cross infirmary, where he was placed under an officer, who was carrying out extensions of the electrical installation at the infirmary. To get some cables through the wall a scaffold had been erected. The scaffold, for the proper erection of which the head of the electrical department took responsibility, gave way while plaintiff was upon it and he sustained severe injuries. Questions were raised at the trial with regard to what rights a pauper had, but the learned Judge, in a considered judgment, decided the case in favour of defendants, on the ground that the plaintiff was in "common employment" with the man whose negligence caused the accident, the electrical engineer being a permanent official of the union.

For plaintiff it was contended that the doctrine of "common employment" did not apply to the case. The basis of that doctrine was voluntary contract, and in this case the pauper was doing work that he was compelled to do. The relation between him and the guardians was not contractual, but in fulfilment of statutory obligations. He could not refuse to do the work, under penalty of one month's imprisonment, by 34 & 35 Vict., c. 108, sec. 7.

For the guardians it was argued that if plaintiff was not in the position of a servant, his position was still worse, for his rights could only be those of a volunteer, and the defendants would not be liable for injuries he received while helping their servants. There was no suggestion of personal negligence against the guardians to make them liable. Poor Law guardians acted ministerially, and were not (it was contended) liable in such an action as that.

The LORD CHIEF JUSTICE, in delivering judgment, said that upon the main question upon which the County Court Judge decided the case—the question of common employment—he had not felt any doubt. The pauper was working subject to penalty if he did not do the work. The man went to the workhouse under compulsion of hunger, and did not contract for any particular work. He held that the doctrine of common employment did not apply. On the liability of the guardians for the negligence of a subordinate he felt more difficulty. There was no doubt, from the decided cases, that guardians were liable in some cases and not in others. The work being done was not their ordinary ministerial work as guardians; it was an extension of the electric lighting installation, and, with some hesitation, he held that this case fell within the class of cases like "Levingston v. the Lurgan Guardians," in which the guardians were held liable on the same principles as would be applied to the case of ordinary individuals. The judgment of the County Court Judge must be reversed and judgment entered for plaintiff.

Mr. Justice Ridley and Mr. Justice Darling concurred.

### Bournemouth Corporation v. Poole and District Electric Traction Co.

On Monday Mr. JUSTICE JOYCE delivered his reserved judgment in this case. He said that the three items upon which he reserved his judgment were Parliamentary deposits (£1,875), sundry debtors (£544), and cash in hand (£14. 10s.) The question he had to decide was whether upon the sale of the Poole undertaking as a going concern the three items mentioned did or did not pass to the Corporation. Looking at the agreement he doubted whether the intention of either party was directed to these particular items, but he had to take the agreement as he found it. He came to the conclusion that all three items did belong to the company in connection with the railways and works or management thereof, and therefore passed to the Corporation. All questions of costs would be reserved.

### Swansea Corporation v. National Telephone Co.

In the Court of Appeal on Wednesday, before Lords Justices Vaughan Williams, Stirling and Fletcher Moulton, this case was mentioned.

Lord Justice VAUGHAN WILLIAMS intimated that the report of Major P. Cardew had now been received and would be filed. He desired to know whether counsel in the case wished to advance further arguments. If so the court would have to be constituted as formerly.

It was arranged that counsel should see the report, after which they might apply to the court if they desired to advance further arguments.

### Williams v. New St. Helens Tramways Co.

At Liverpool Assizes last week, before Mr. Justice Bray and a special jury, plaintiff (a Mrs. Williams) sought to recover damages for the death of her husband, killed on defendants' tramways by the fall of a trolley and standard, alleged to be due to a defective trolley head belonging to the company, or defective overhead equipment belonging to St. Helens Corporation.

Mr. T. DAVIES, engineer, said that from experiments he had made his conclusion was that when the tramcar on which the accident occurred came round a certain curve it caused a surging of the wire and a part of the attachment of the ear, which was soldered only at two points, to go, with the result that the wire became arched and the trolley head caught in the ear and broke it. It was a hundred chances to one against the trolley wheel catching in the span wire. Owing to expansion and contraction there was a constant difficulty in maintaining the right adjustment. Sometimes the head came off, at other times it would not come off. As an expert he was in a quandary about this matter, and could not advise in regard to it.

Mr. W. HUTCHINGS, general manager of defendant company, gave corroborative evidence. The Board of Trade had approved the trolley head, and witness was not entitled to alter it in any way. The Board only suggested a detachable trolley head, and did not recommend any particular pattern.

Mr. E. M. HOLLINGSWORTH, borough electrical engineer of St. Helens, said that during the 12 months prior to the accident that particular point on the overhead equipment was inspected 29 times, and the latest inspections were a few days prior to the accident on April 29. His opinion was that the trolley left the wire on leaving the curve, and the head, being previously damaged, caught the span wire at the kink which he found in the wire 2 ft. 9 in. on the left side of the trolley ear.

Mr. H. ENGLAND, manager of Wakefield & District Light Railways Co., thought the car was carelessly or furiously driven round the curve, with the result that the trolley left the wire, and, proceeding in a straight line, the boom struck the span wire, and the wire became engaged between the trolley head and the wheel. Judging from the result, he thought the speed could not have been less than 10 miles an hour. There was no indication of the bad attachment of the live wire to the ear.

Mr. J. M. M‘ELROY, manager of Manchester Corporation tramways, supported Mr. England's view.

The jury found that the accident was caused by the negligence of the Corporation alone. They assessed the damages at £1,100, being £2,500, less £1,400 insurances.

Judgment was at first reserved, and in the result his LORDSHIP gave judgment in favour of the company, and against the Corporation for £1,100, with costs.

### Tramway Bye-Laws.

At Paisley Sheriff Court on Thursday last a passenger was charged at the instance of Paisley District Tramways Co. with having left, or attempted to leave, one of their electric cars while in motion, the penalty for which was 40s. or one month's imprisonment.

For the defence, it was urged that the complaint was made as to contravening the company's bye-laws made under certain sections of the Railway Clauses Consolidation Act, 1845, whereas the Tramways Act, 1870, should have been specified.

Mr. SWANSON (for the company) pointed out that the bye-laws had been approved by the Board of Trade, but the Sheriff upheld the objection, with costs.

**Edison & Swan United Electric Light Co., Ltd. and Reduced.**—Mr. Justice Warrington has sanctioned the petition to reduce the capital of this company from £941,090 to £888,071.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT AND FILLED.

London County Council invite applications for the following positions in their tramways department: One resident electrical superintendent (commencing salary £300, rising by two annual increments of £25 to £350); three charge engineers (salary £250 per annum). Further particulars are given in an advertisement. Applications, on forms to be obtained from the clerk of the Council (Mr. G. L. Gomme), County Hall, Spring-gardens, S.W., by 10 a.m. March 20.

London County Council also require an electrical and mechanical engineer and an assistant electrical engineer to be responsible, under the chief officer of the Fire Brigade, for matters connected with electric lighting and heating at places of entertainment. The salaries are £400 and £200 a year respectively. Applications by 10 a.m. March 12.

London County Council also want for their tramway department an assistant permanent-way engineer, between 30 and 45 years of age. Salary £250. Forms of application from the Clerk, Spring-gardens, S.W.

London County Council also require a district traffic superintendent for their tramways. Age between 30 and 45 years. Salary £300, rising by two annual increments to £350.

The Cambridge Scientific Instrument Co., Carlyle-road, Cambridge, require a junior test-room assistant to assist in the manufacture and adjustment of electrical instruments. See an advertisement.

Hammersmith (London) Council require an assistant engineer, whose chief duty will be to act as canvasser for the electricity department. Salary £3 per week. Applications, on forms from the borough electrical engineer (Mr. G. G. Bell), 85, Fulham Palace-road, Hammersmith, W., by noon March 15. See an advertisement on another page.

Croydon Education committee invite applications for the chief lectureship in electrical engineering at Croydon Polytechnic for three evenings per week for a session of about 30 weeks. Duties to commence in September. Payment £1 per evening. Forms of application, &c., up to March 31. See also an advertisement.

A draughtsman is required in the electrical engineer's department of H.M. Dockyard, Devonport, with experience in central station work and electrical distribution (3-wire c.c. system). Applications to the Electrical Engineer, H.M. Dockyard (North), Devonport. See an advertisement.

An electrician is required immediately for service on the Gold Coast Government railway. Salary £250 per annum, rising to £270 by annual increments of £10, with free single furnished quarters, first-class passages out and home, &c. Further particulars are given in an advertisement. Applications to Messrs. Baker & Shelford, consulting engineers, 35A, Great George-street, London, S.W.

Walthamstow District Council require an electrical and mechanical engineer for their electricity supply and tramways undertakings. Salary £350 per annum, rising to £450. Applications by 5 p.m. 13th inst.; also a tramways traffic manager. Salary £200, rising to £300.

A science master (physics and chemistry) is wanted for Auckland (N.Z.) Grammar School. Salary £300 rising to £350. Applicacation forms from High Commissioner for New Zealand, 13, Victoria-street, London, S.W.

The Bombay, Baroda & Central India Railway Co require a signal engineer, with knowledge of electrical engineering. Salary R500, rising to R800 per month. Applications by 27th inst. to Mr. T. W. Wood, Gloucester House, Bishopsgate-street Without, London, E.C.

Hampstead (London) Council require an electricity rental clerk. Salary £75. Applications by 17th inst. to Mr. C. E. Moon, 7, Belsize Park-gardens, Hampstead, N.W.

Johannesburg Tramway and Lighting committee recommend the Town Council to appoint Mr. A. E. Gibbs as distribution engineer to the Council at a salary of £840 per annum, subject to his entering into a three years' contract. Mr. Gibbs has since 1904 been superintending engineer in South Africa for W. T. Glover & Co, contractors for the Johannesburg underground cables

Mr. Harold T. Hincks has been appointed station superintendent at the North Wales Power & Traction Co.'s power station at Cwmdyli.

Bradford Education committee have appointed Dr. Pohl to the post of lecturer in electrical engineering at the City of Bradford Technical College, in place of Mr. Bohle, who was recently appointed professor of electro-technics in the University of Cape Town. Dr. Pohl, who holds the degree of Dr. Ing. of the Technical High School at Hanover, has been engaged for some time past in working out improvements for the Phœnix Dynamo Co., under the "Phœnix-Pohl" patents. Dr. Pohl will retain his practice as consulting engineer, and will take up his new duties in the course of the next week.

Mr. A. Kaye Butterworth (hitherto solicitor to the company) has been appointed general manager of the North-Eastern Railway in succession to Sir George Gibb; and Mr. Philip Burtt (deputy general manager) has been appointed also chief traffic manager.

Mr. C. H. Lydall having resigned his position as works superintendent at Dover electricity works, Mr. E. W. Smith has been appointed to the position at £160, rising to £200, per annum.

**Arc Lamp Litigation**.—In connection with the action brought by J. Defries & Sons against the Electric and Ordnance Accessories Co. (a full report of which appears on another page) we are asked by Messrs. Defries & Sons to publish the following:—

HELIOS LAMPS.

We shall be obliged if you will allow us to state that, in consequence of the decision of Mr. Justice Joyce, whereby the original manufacturers of the "Stewart" enclosed arc lamp have been restrained from selling their lamp by that name for the future, the original enclosed arc lamps manufactured for and during the existence of the Stewart Electrical Synd. (Ltd.) by the Helios Mfg. Co., and then sold in England as the "Stewart" enclosed arc lamp, will henceforth be known as the "Helios" enclosed arc lamps, by which name they have for many years been widely known and used in the United States. The change will be solely one of name, and no alteration will be made in the construction of the lamps or of any of their repair or spare parts.

**Argentina.**—The Minister of Public Works has approved plans for an electric tramway at the port of Buenos Ayres from Calle Cuyo to Calle Garay.

The Mayor of Buenos Ayres has refused consent to La Capital Tramways Co. to extend their lines to Villa Devoto on the ground that two concessions for the same route have already been granted.

Mr. Valentin A. Brown resigned the management of the Buenos Ayres Electric Tramways Co. on Jan. 31 to take up the position of technical director of the Rural Tramway Co., Buenos Ayres. The latter company owns electric tramways in the city and a steam line from Buenos Ayres to Zarate, about 10 km. of which (from Chacarita to San Martin) are shortly to be converted to electric traction.

**Aston.**—At a meeting of the Council on Wednesday the Tramways committee reported that the period of maintenance of certain tramway routes by the contractor having expired, and Mr. Robt. Green, consulting engineer, having issued his final certificate, these lines had been taken over by the committee.

**Australasian Notes.**—Our correspondent writes: On behalf of an influential company with English backing, Sir A. J. Peacock has just paid a visit to Adelaide, where he has interviewed the Government and various tramway companies in furtherance of the scheme of electrification recently submitted to the Government, of which particulars were given in our issue of Feb. 16. The company, which has already two tramways in operation in Western Australia and a third nearly complete at Essendon, Victoria, would be prepared to start operations within a month of receiving authority. Nothing can be done at present, however, as the Government are bound by the 1904 Act, but new tramway legislation is to be enacted in the forthcoming session.

A conference of delegates from the Municipal Councils of Hawthorn, Kew, Camberwell, Caulfield and St. Kilda was held on Jan. 24, when it was unanimously decided that a scheme should be prepared for through communication, by electric traction or otherwise, from Kew to St. Kilda. The route tentatively suggested is 8¼ miles long, and it is considered that an adequate service of electric trams could be inaugurated at a cost of £66,000.

Prahran Council have been informed that their application for powers to construct electric tramways will be opposed by the Government, on the ground that the Council have remained idle too long, especially as the State Railway Commissioners have gone to the expense of running motor 'buses to test the traffic.

Capt. Walker, of the Marconi Wireless Telegraph Co., has returned from New Zealand, where he found Sir Joseph Ward, Postmaster-General, keenly interested in the proposals for communication between Australia and New Zealand. The erection of the experimental stations at Queenscliff, Victoria, and Devonport, Tasmania, is to be rapidly pushed on.

The first annual meeting of the N.S.W. Tramway Officers' Association was recently held at Sydney, when the following were elected: President, Mr. John Kneeshaw; vice-presidents, Messrs. G. R. Cowdery and H. F. Brown; secretary, Mr. C. N. Neale; treasurer, Mr. W. Andrew; committee, Messrs. H. A. De Courcy Browne, C. Peters, J. Herrmann, E. Silcocks, W. J. Napier, G. Holt, and W. Johnson; librarian, Mr. N. J. Munro; auditors, Messrs. A. E. Davies and J. J. Young.

The "Australian Mining Standard" says Wellington (N.Z.) electric tramways have shown a net profit of £7,262 on nine months' working.

**Belfast.**—At the City Council on Thursday last the Lord Mayor said that the manager of the tramways (Mr. Nance) expected the tramway undertaking to show a balance of £27,000 on the right side at the end of the year. The matter of the men's wages would come before the committee again.

**Bermondsey (London).**—Application is to be made to the L.C.C. for sanction to borrow £15,507 for electric lighting purposes—viz., £13,500 for mains, £1,307 for machinery, and £700 for meters.

**Brighton.**—At the meeting of the Corporation on Thursday last week, the Lighting committee reported having considered reports by the resident electrical engineer (Mr. John Christie) and the consulting engineer (Mr. Arthur Wright) on the method of charging for electric current.

Writing to the committee on Feb. 6 Mr. Wright stated that in view of the very generally expressed wish that a simpler method of charging for supply of electricity should be adopted in Brighton, and of the very patent fact that no reduction in revenue could be contemplated at present, he thought the following modification of the tariff now in use would meet the views of the committee and Mr. Christie without interfering in any way with the commercial soundness of the electricity undertaking: (1) That present consumers be supplied at a flat rate during each year equal to the average price they would have paid during the preceding year on the present tariff. (2) That all new consumers be charged for the first 12 months at a flat rate, equal to the average price paid during the preceding year by the particular class to which they belong. (3) The flat rate, at the beginning of each year, to be fixed on the average quarterly readings of the completed year preceding.

The committee recommended that as an alternative to the existing supply within the borough upon the maximum demand system, a lighting and general supply be given to consumers requesting it at a flat rate of 4d. per unit consumed without the use of a demand indicator. That any consumer desiring to change from the maximum demand system to the flat rate system or vice versa, be entitled to do so upon giving seven days' notice in writing to the engineer, in which case the change shall come into effect as from the beginning of the next succeeding half-year (*i.e.*, Jan. 1 or July 1 next) after the expiration of the seven days' notice. That the arrangements upon which certain churches, schools and other premises are supplied at 1d. per unit for lighting during restricted hours on the time switch system be determined as from June 30. That the town clerk and the engineer be authorised to revise the general conditions of supply so far as necessary to give effect to the foregoing alterations in the tariff and regulations, and that as so revised the same be adopted and issued as the conditions of supply relating to the undertaking.

In moving the adoption of this report the chairman of the committee (Mr. Butt Thompson) said with regard to the estimated loss of £2,800 entailed by the alterations recommended, the committee hoped that it would be made up by those who were at present paying less than 4d. per unit coming on to the 4d. flat rate.

The report was adopted.

The Council also approved the Tramways committee's recommendation that the engineer and manager (Mr. W. Marsh) be authorised to use Jarrah wood for renewing the tramway track when necessary.

**Colne.**—The Council have applied for a loan of £5,300 for wiring consumers' premises, hiring out motors, and mains extensions.

**Coventry.**—The Electric Lighting committee recommend the Council to apply for sanction to a further loan of £35,000 for extensions of the electricity works.

**Customs Decisions.**—It is announced by a Customs notice that, in accordance with the provisions of the Australian Commonwealth customs regulation, No. 131, a drawback of duty will be allowed (subject to certain conditions) on the importation of telephone parts used in the manufacture of telephones within the Commonwealth.

A recent decision of the New Zealand customs authorities fixes the duty on magnetic-electric ignition parts of gas engines, if unattached to the engine, at 10 per cent.; if attached to the engine, free.

**Dublin.**—On the presentation of the minutes of the Lighting committee at the Corporation meeting on Monday,

Ald. Kelly said the churches of the city were as much entitled to preferential treatment in the matter of electric lighting as the music halls.

Mr. Vance took exception to some items of expenditure in connection with the electric lighting.

The chairman of the committee (Ald. Irwin) said Councillor Vance had deliberately intended to create the impression on the minds of ratepayers that the Lighting committee entered into an unbusinesslike bargain with the clergy, but what had been done was in the public interest. He (Ald. Irwin) was pleased to say that the estimate made by himself and Mr. Ruddle 12 months ago had actually been attained, notwithstanding the reduction of £1,200 a year in the charges. After providing for interest and sinking fund, in addition to extra capital now being expended, the committee were in a position to show a profit on the year's working.

**Eastbourne.**—The borough electrical engineer (Mr. J. K. Brydges) has reported that the underfeed stoker, which has been in use at the electricity works since Oct. 9 last, has been tested with 20 kinds of coal, and has given the results guaranteed, showing a saving of £63. 16s. 6d. per annum. The Council have, therefore, now purchased the stoker.

**Electric Driving in Wool-combing Mills.**—Messrs. Witting, Eborall & Co. have recently equipped a wool-combing mill in Italy, supplying all the necessary transformers and electrical machinery, including switch gear. The supply pressure is three-phase 8,100 volts, and is transformed down to 525 volts for operating the running machinery.

**Electricity in Mining.**—Noyes Bros., Melbourne, are supplying electric power plant to the Mount Bischoff Tin Mining Co., Waratah, Tasmania. It is intended to light the whole of the works electrically and to use electric power for pumping, drilling, crushing, &c.

**Excess Passengers on Tramcars.**—At their meeting last week Wood Green Council considered a proposed bye-law as to the local tramways which would allow 12 persons in excess of the seating accommodation inside the electric tramcars between Muswell Hill and Finsbury Park, and it was decided by five votes to four to oppose the bye-law.

A Hanley solicitor, who recently refused to pay his fare in one of the Potteries Electric Traction Co.'s cars because the car was overcrowded, was fined 5s. and costs by the local bench on Thursday last. One of the magistrates was good enough to suggest that anyone in an overcrowded car had a remedy at hand—he could get out.

**Exeter.**—The Council decided on Wednesday to apply for sanction to a further loan of £15,500 for extensions of the electric lighting undertaking, including mains to Heavitree.

**Exhibition.**—The prospectus is ready of the National Engineering and General Trades Exhibition, to be held at Bingley Hall, Birmingham, from March 29 to June 9.

**Fareham.**—The charge for electric current is to be reduced from 7d. to 6d. per unit.

**Glasgow.**—Negotiations are proceeding between a syndicate of London financiers and electric engineers and the directors of the Glasgow Subway Co. for the sale of the undertaking to the syndicate with a view to its electrification.

**Hammersmith (London.)**—As the experiment in Askew-road of dispensing with arc lamp columns, and suspending the arc lamps from alternate tramway posts has proved satisfactory, the same method is to be adopted in Goldhawk-road, at an estimated net cost of £546. The arc lighting of Hammersmith-road is also to be improved at a cost of £219. The Council on Wednesday took up an L.C.C. loan of £15,578 for the electricity undertaking.

**Huddersfield.**—The Tramways committee have dismissed the driver of the Corporation tramcar which ran off the line at Colne-road on Saturday, in accordance with a resolution of the Council passed in June last, which provides "that all drivers who have runaway cars or who lose control be dismissed if it be afterwards found that the brakes were in good working order." The tramway employés union are asking the Tramways committee to reinstate the driver.

The Corporation tramways manager is about to report upon the possibility of complying with a request from Whitley Upper and Lepton Councils to extend the tramways to those districts, for the purpose of developing the coal traffic from the pits, as well as passenger traffic to and from Huddersfield.

**Islington (London).**—The Council on Friday adopted the recommendation of the Lighting committee to extend the public electric lighting by the addition of 245 flame arc lamps.

**Leeds.**—The chairman of the Electric Lighting committee (Ald. Matheson) has prepared a lengthy report upon the present position of the electricity undertaking.

Ald. Matheson states that a considerable portion of the installation which was laid down by the old House-to-House Co. at the commencement (in 1892-3) was out of date almost as soon as put down, though it was selected in accordance with the best practice of the time. He thinks that "it will probably be deemed advisable within a few years to reconstruct the older portions of the present works, with a view to utilising the space to best advantage, and so deferring the time when it will be necessary to erect a new works to supplement or supplant the present one, an event which will involve great expenditure and some initial diminution of economy." The chief causes of difference between the present real value and the present book value of the assets are due to assets destroyed or discarded in consequence of wear and tear or obsolescence; wear and tear of plant still in use; out-of-date plant still in good working order and still in use, but not of most improved design or of most economical size; reduction of market prices of plant since date of purchase; premium on purchase of undertaking, costs of issuing stock, &c. The position of Leeds, with its capital expenditure of £85. 14s. 5d. per kw. is more favourable than that of electric supply companies on the average, notwithstanding the onerous terms of purchase, but, as compared with municipal electrical undertakings, the burden upon Leeds is excessive to the extent of £9. 16s. 5d. per kw., or £113,332 in the aggregate, this apparent over-capitalisation being more than accounted for by the estimated premium on stock issued in payment for the undertaking. Goodwill, in the case of a municipal undertaking like that of Leeds, must not be overestimated. While the Corporation possesses a monopoly for the present, it is obvious that if prices are charged beyond those paid outside the protected districts, other forms of lighting will be preferred, and public opinion will demand that a reasonable price shall alone be charged, even if special means be taken to reduce the burden of capital. If the capital charges per kilowatt were reduced to the average figure of other municipal undertakings, it would mean a reduction of ¼d. per unit in the average price at which electricity could be supplied; but this could not be effected while every surplus is directed to the relief of rates. In a successful manufacturing business (continues Ald. Matheson) it is not unreasonable that the capital shall be turned over at least once a year. But in Leeds so great is the outlay for plant in proportion to its working hours, and so onerous is the provision for duplicate and stand-by machinery, that the capital is only turned over once in 10 years. While the capital in Leeds in 1905 (including estimated premium on stock) was £989,236, the gross income during the year ended March, 1905, was only £84,416. Mr. Dickinson, the manager of the electric lighting department, roughly estimated the cost of the scheme of reconstruction at £230,000, towards which he anticipated that £30,000 would be obtained by the sale of discarded plant, leaving £200,600. Ald. Matheson thinks that (apart from goodwill) the capital liabilities are in excess of the value of the assets, and that such liabilities are excessive in proportion to the capacity of the plant compared with the average of other electricity undertakings; that such capital liabilities necessitate a scale of charges for current higher than would be necessary; that in addition to redemption fund a substantial reserve is necessary to provide for replacements of plant required before the loans for such plant are paid off; that the amount accumulated in reserve (£10,441) is not an adequate provision for such renewals; and that the sums taken from the undertaking for the relief of rates (£16,600) are shown by subsequent events to have been not properly so applicable, but that if this amount with interest is refunded, and no further sums be so withdrawn, the undertaking will probably be able to meet all claims upon it. Assuming the scheme for reconstruction of works to be approved, application should be made for sanction to the borrowing of £120,000, or such other sum as shall bear the same proportion to the total estimated cost as the increase of capacity in the reconstructed works bears to the total capacity. The remainder of the cost should be carried to an "extraordinary renewals account," and the amount in reserve fund, together with any surplus that would otherwise, according to the old method, be called "profits," should be transferred to this "extraordinary renewals account." That until such a provision is found to be unnecessary or excessive, any surplus, up to 3 per cent. on the entire capital, be placed to reserve for renewals. No further sums should be applied to relief of rates, until the renewals now contemplated are fully provided for and the net liabilities on capital account are reduced to the average of other municipal undertakings.

At the meeting of the Corporation on Wednesday, Ald. Matheson, in moving the adoption of the report of the Electricity committee, said:—

The Council had not been much troubled with the electricity department, but as there was about a million sterling concerned it demanded attention. He gave a full account of the extensions, &c., made since the undertaking was purchased in 1898. At the present time there was still some plant to discard, not because it was old or out of repair, but because it was obsolete. Very large renovations had been necessary in the past, and further renovations would be necessary in the next few years. They had already got specifications in the hands of manufacturers for tenders for the new plant, so that in a month or two they should be able to put before the Council details of what they intended to do. They stood well among the big cities for the steadiness and reliability of their supply. In regard to price also, they compared well with other cities, their price of 4d. per unit being less than the average. They charged no meter rent, and they allowed 5 per cent. for prompt payment. The new tariff offered the best terms to those customers, large and small alike, who took the current in what would be idle hours, so that a small tradesman, if his work called for it, could get the same rebate as the largest manufacturers or shopkeepers, namely, a reduction from 4d. to 1d. when the lamps were used beyond a certain number of hours.

Out of the total 50 miles of tramway route they were now lighting about 16 miles by means of 650 lamps, and they were doing it for £5,000 per annum. Mr. Dickinson, their able superintendent, told him that they were up to the very highest standard of street lighting in the country. The committee were offering great inducements to power users, and especially to small manufacturers. Those who wanted anything from 1 H.P. to work a few sewing machines, up to 50 or 100 H.P. to work a factory, get it cheaply—about 1¼d. per H.P. per hour. The sinking fund charges were twice as great as the cost of generating and distributing electric current, and as long as they had those burdens they could not reduce the price; but they looked forward to the time when, the sinking fund period being ended, they would be in a position to reduce the price.

The report and the committee's recommendations were adopted.

**Leek.**—Application has been made for sanction to a further loan of £730 for extensions of the electric lighting mains.

**Lees.**—The Board of Trade have granted an extension of 12 months for carrying out the Council's 1902 order.

**Light Railways.**—The Board of Trade have granted an extension of two years for the completion of Barking District Council's light railways authorised by their 1903 order. The Council proposes to abandon one section.

Middlesbrough Corporation resolved on Tuesday to continue the opposition to the scheme for the construction of a tramway between Middlesbrough and Hartlepool, with a transporter bridge across the River Tees, as far as the transporter bridge is concerned.

The Board of Trade have confirmed the Blyton and Frodingham Light Railway Order, 1906.

**London County Council.**—At Tuesday's meeting the Highways committee brought up the recommendations for the future disposition of the staff of the North Metropolitan Tramways Co., particulars of which were given in our last issue.

Mr. Mitchell moved that the recommendation to raise the salary of Mr. Rider, the electrical engineer, from £1,000 to £1,200 be referred back, and suggested that the Council ought to wait to see how the Greenwich generating station turned out.

Mr. E. Collins seconded the amendment.

Mr. Allen Baker (chairman of the committee) said that Mr. Rider was one of the Council's most efficient and capable officers, and his services had resulted in great economy to the Council in connection with the Greenwich generating station. In addition his work would be greatly increased by the electrification of the lines north of the Thames.

Mr. Saunders intimated that the labour members looked for greater benefits being given to the lower grade of the service.

Mr. McKinnon Wood reminded the Council that a great deal had been done for the lower grades, and if anything more was required that was no reason for doing an injustice to Mr. Rider.

The amendment was defeated by 54 votes to 30, and the recommendation was agreed to. The other recommendations were also carried.

*Tramways.*—The Highways committee recommended that an additional 170 cars should be fitted with electric magnetic brakes, at estimated cost of £10,200.—Postponed.

The same committee reported having considered what arrangements should be made for obtaining the 150 cars required for the electric working of the first section (about 22½ miles of single track) of the Council's northern tramways. The total contract prices for the 150 cars contracted for in October last amounted to £124,825, or about £832. 3s. 4d. a car, and they had considered the question of extending the contracts so as to include the supply of the 150 cars now required for the northern tramways, the contractors in each case being prepared to undertake the further work required, the British Westinghouse Co. being prepared to supply the electro-magnetic brakes at £56. 10s. a car instead of £57 as under the existing contract. The contractors were willing to undertake to deliver all the cars by the time they were required for the electric working of the northern tramways. Having regard to all the circumstances and to the fact that time would thereby be saved, they were of opinion that the present contracts should be extended. The expenditure involved would be £63,525 for car bodies, £18,000 for trucks, and £43,225 for equipments, &c., making £124,750, an average of £831. 13s. 4d. a car. —Postponed.

**Municipal Telephony.**—At the last meeting of Hull Telephone committee a resolution was passed instructing a sub-committee to consider and report upon the commercial management of the undertaking.

Last week Glasgow Corporation decided to charge to the Common Good the expenses incurred by the Telephone Department in collecting and giving evidence, &c., before the Parliamentary Committee which considered the purchase of the National Telphone Co.'s undertaking in the 1905 session.

Glasgow Corporation have also issued a memorandum explaining the present position of the negotiations with the Postmaster-General on the telephone absorption question.

The memorandum states that the Corporation's application for a telephone licence was made in the belief that so long as they proivded an efficient service, the licence would not be disturbed. They therefore consider it a hardship to deprive the telephone owning municipalities of their licences. They allege that telephone users in Glasgow are saved about £150,000 per annum by the reduced rates now offered as a result of competition; and the opinion is expressed that the National Telephone Co. would take over the system at full capital value. Glasgow Corporation have expended £360,000 on the service, and, on the basis of the offers made by the Government to other Corporations, the loss to the city would amount to £90,000. It is also asserted that the competition of the National Telephone Co. is being carried on at a considerable loss.

At Manchester Corporation meeting on Wednesday Mr. Plummer said that, although he had been chairman of the Telephone committee, he had to move an amendment to the proposals of the committee.

The committee had decided not to comply with a claim for compensation made by the Mutual Telephone Co. It was, he said, decided some time ago by the Corporation that they would attempt to establish a telephone system in Manchester, but they were unable to proceed with the provision of a municipal telephone system. A number of citizens took up the matter and took steps to establish a system, with the proviso that it should be handed over to the Corporation at any time. The idea of the citizens who started the project was the purely disinterested one of serving the city. On April 14, 1897, the Council passed a resolution which expressed approval of the objects of the proposed company. Without that sanction the promoters could not have taken any further steps. The scheme, however, was not carried out, and Mr. Plummer urged that an obligation rested upon the Council to refund some of the cost to which the promoters were put. He moved as an amendment that the Council was of opinion that the claim of the Mutual Telephones Synd. was entitled to consideration.

A long discussion followed, but the amendment was rejected by 46 votes to 41.

**New York.**—It has been decided to amalgamate the Metropolitan Traction line with the Interborough Rapid Transit Co. By this arrangement all the surface, elevated and subway lines in Manhattan and Bronx are to be consolidated under the name of the Interborough Metropolitan Co.

**Newcastle-on-Tyne.**—On Wednesday the Corporation again considered the proposal of the Watch committee to erect 180 arc lamps to be attached to the tramway poles in a number of the leading thoroughfares of the town.

The matter was before the Council in September, but it was allowed to stand over, to enable the gas company to amend their tender. It was estimated that the 180 arc lamps would give a total illuminating power of 126,000 standard candles, and would cost £1,980 per annum, including the sum required for interest and redemption of £4,500, the estimated capital expenditure on lamps, fittings, &c. The reduction in the cost of the existing 200 lamps would amount to £900 per annum. To properly light the streets with gas they would require 206 self-intensified lamps, giving an illuminating power of 61,800 standard candles, and the cost would be £841 a year.

After discussion the recommendation was adopted.

**Nottingham.**—The Corporation have decided to commence the construction of the London-road tramway route.

**Obituary.**—We regret to record the death of Mr. Reginald Frederick Yorke, M.I.E.E., consulting electrical engineer and managing director of the Fort William Electric Light Co., which took place on Tuesday.

**Police Regulations for dealing with Broken Trolley Wires.**—The Birmingham Chief Constable (Mr. C. H. Rafter) drew up some time ago a code of rules for dealing with broken trolley wires, &c., and each member of the local police force has received instruction in them.

**Presentations.**—The staff of Bridlington electricity works have presented Mr. D. H. Simpson, the retiring assistant engineer, with a gold-mounted cigar-holder in a silver case.

Mr. A. C. J. Reynolds, senior shift engineer at Gillingham (Kent) has been presented by the staff with a silver cigarette-case on his departure for the Tyne.

**Private Bills.**—It is announced that the Westminster Electric Supply Corpn. have withdrawn their opposition to the City of London Electric Lighting Bill; the Charing Cross, West End & City Electricity Supply Co. their petition against the Hackney Electricity Bill; and Brighton Corporation their petition against the London, Brighton & South Coast Railway Bill.

**Provisional Orders Revocation.**—The Board of Trade have revoked the Rishton, Great Harwood and Clayton-le-Moors Electric Lighting Order, 1901, and the Crediton Electric Lighting Order, 1904

**Royal Warrant.**—We are informed that the honour of a Royal Warrant has been granted to Messrs. A. P. Lundberg & Sons as suppliers of electrical accessories to His Majesty King Edward VII. We learn that this firm will in future be known as "A. P. Lundberg & Sons" instead of "A. P. Lundberg," as for so many years. This change will not, however, affect the management or proprietorship in any way, Mr. Gus. C. Lundberg and Mr. C. A. Lundberg having been associated with the business for the past 23 years.

**Rugby.**—From 1st prox. the Council's charges for electric current for private lighting will be 5d. per unit up to 500 units, and 4½d. beyond, and the rate for power, heating and cooking will be 3d.

**St. Pancras (London).**—A loan of £1,965 is to be taken up for street lighting. With the view of ascertaining the suitability of electric radiators for the Central Public Library, the electrical engineer (Mr. S. Baynes) has been instructed to fix a number of electric radiators in the council chambers.

**South Africa.**—Statistics compiled by the Acting Commissioner of Mines for the Transvaal (Mr. H. Weldon) show that at June 30 last electric motors and hoisting appliances in the Transvaal mines were valued at £26,073, an increase of £6,015 over the corresponding time in 1904, while other electrical plant in the mines amounted to £942,597 (increase £135,248).

The "British and South African Export Gazette" states that the total number of dynamos at work in the Transvaal at June 30 last was 493 of 33,525 H.P., compared with 445 and 25,264 H.P. in 1904. These included 91 polyphase machines (compared with 81 in 1904), 398 direct current (against 349) and four single-phase (against 15). Electric motors numbered 1,378 of 30,064 H.P. (against 1,014 of 22,346 H.P.)

Volksrust Municipality is about to bosrow £20,000, of which £6,000 is required for carrying out an electricity supply scheme prepared by Messrs. Hubert Davies & Spain. The same firm are concessionaires for a new tramway undertaking at Bloemfontein, upon which they will commence work next month.

The electricity supply scheme for Hillary's (Natal) is suspended owing to the illness of the engineer (Mr. W. W. Cato).

New electricity works are also projected for Middelburg, Queenstown and Ladybrand.

The question of the use of hydraulic or electric cranes is again before Durban Port Advisory Board. Four cranes are required for the new wharves, and the Board's engineer (Mr. C. J. Crofts) reports that the extra cost of four electric cranes would amount to about £3,120, some recently imported hydraulic cranes of identical lift and reach having cost in England £925 each, against £1,705 quoted for the electric type. The quotations for electric cranes range from £1,320 to £2,350, and Mr. Crofts favours the adoption of an electric crane made by J. Abbot & Co. He thinks a design submitted by Sir W. G. Armstrong, Whitworth & Co. was "undoubtedly the best," but that the price was prohibitive. It is probable, however, that the Board's past adhesion to the hydraulic type is not likely to be broken at present.

The new three-phase motor recently supplied by the A.E.G. Electrical Co. of South Africa to the Village Main Reef mine is of 440 B.H.P. The hoist which this motor is to operate is stated to be the largest ever worked electrically in South Africa, and will raise 8,000 lb. of rock 1,500 ft. per minute on an incline of from 38 deg. to 32 deg. The same company are supplying two direct-coupled steam generating sets to the Village Main Reef mine for which the steam engines were made by W. H. Allen, Son & Co.

The Esperanza Estates (Natal) sugar farm has been equipped with Yaryan evaporators and electrically-driven centrifugals of a capacity of 220 tons.

**Sunderland.**—An inquiry was held here on Wednesday into the application of the Corporation for permission to borrow £180,000 for electric lighting extensions.

After the town clerk (Mr. F. M. Bowey) had given particulars of the outstanding loans, ratable value, &c., the borough electrical engineer (Mr. John F. C. Snell) gave technical details of the proposed extensions, and said about one-third of the loan was for buildings. The extension was necessary owing to the increasing demand for energy. The output last year amounted to 4,772,913 units. The estimated output this year was over 6,000,000 units and for next year over 8,000,000. There was no opposition.

The electricity and Lighting committee recommend the Council to reduce the tariff for current for lighting so that no consumer shall pay more than 3½d. per unit, and for the tramways from 1¾d. to $1\frac{1}{16}$d.

**Wallasey.**—The Council have decided to reduce the charge for current for private lighting from 5d. to 4d. per unit.

**Wimbledon.**—Application is to be made for sanction to a loan of £500 for arc lamps for street lighting.

**Dinners, &c.**—Mr. P. T. J. Estler, 25, Laurence Pountney-lane, London, hon. sec. of Past Engineering Students, University College, London, informs us that the annual dinner will be held jointly with that of the Present Students at the Hotel Cecil, London, W.C., on March 16, at 7:30 p.m. Sir Alexander Kennedy, F.R.S., will preside. It is hoped that old students who may not have had notice of the dinner owing to their addresses not being available will communicate with the hon. sec. at once.

Mr. John Steven, signal superintendent of the Caledonian Railway Co. for the last 32 years, was entertained to a complimentary dinner on Friday, and was presented with a silver tea and coffee service, a gold albert and other articles on his retirement.

The members of the Chelsea Electricity Supply Co.'s club held their annual dinner and concert on 24th ult., Major Fountain Woods presiding. Among those present were Messrs. Percy Still (the chief engineer), Hastings Squire, W. R. Rawlings, &c.

The Dundee tramways men on Thursday last participated in a dance and supper. Mr. Peter Fisher, manager of the Corporation tramways, and Mr. J. H. Shepherd, manager of the Broughty Ferry tramways, were present, and ex-Bailie Speed, convener of the Tramways committee, presided.

## TRADE NOTES AND NOTICES.

**NOW READY.**

**"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1906 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.**

**All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is even more complete and accurate than in previous issues, and has been revised up to Feb. 12, 1906. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Traders' purposes. The valuable large sheet Tables, &c., have been very carefully revised and extended, making the 1906 Edition of this indispensable work the most complete book of the kind ever published.**

**A full Digest of Contents will be sent post free on request.**

### TENDERS INVITED.

*Sunderland* Corporation invite tenders for supply of one 750 kw. triple-expansion engine, direct-coupled to three-phase generator (5,000 volts), with exciter; one 300 kw. static transformer, and two portable air compressors. Specifications, &c., from the borough electrical engineer (Mr. J. F. C. Snell). Tenders, addressed to the chairman of the Electricity and Lighting committee, Town Hall, Sunderland, to the town clerk (Mr. Fras. M. Bowey), by noon March 30. See an advertisement.

*Bolton* Electricity committee invite tenders for one continuous current electric generator, and also for one steam engine complete. Specifications, &c., of the borough electrical engineer (Mr. Arthur A. Day), Spa-road, Bolton. Tenders (addressed to the chairman of the Electricity committee, Town Hall, Bolton) to the town clerk (Mr. Samuel Parker) by noon March 29. See also advertisements.

*West Bromwich* Corporation invite tenders for supply, delivery and erection of (*a*) one 400 kw. turbo generator, (*b*) alterations and additions to exhaust pipes. Specifications from the borough electrical engineer (Mr. W. A. Jackson), electricity works, Black Lake, West Bromwich. Tenders to chairman of Electric Light and Power committee, Town Hall, West Bromwich, by noon March 19. See an advertisement.

*London* County Council invite tenders for supply and erection of high and low tension switch gear for certain of the council's substations. Drawings may be inspected and specifications obtained from the County Hall, Spring-gardens, S.W. Tenders, upon official forms, to the clerk, Mr. G. L. Gomme, Spring-gardens, S.W., by 10 a.m. March 27. See also an advertisement.

The Asylums committee of *London County Council* invite tenders for the installation of electric lighting and power (including generating plant) at Long Grove Asylum, Epsom. Tenders to 6, Waterloo-place, London, S.W., by March 26.

*London* County Council also want tenders by 10 a.m. 20th inst. for seven electrically-operated car traversers.

*Willesden* Urban District Council invite tenders for supply and delivery of 66 "flame" arc lamps for street lighting. Specifications from the resident electrical engineer (Mr. J. G. Bruce), Electricity Office, Salusbury-road, Kilburn, N.W., to whom tenders by 5 p.m., March 22. See also an advertisement.

*Norwich* Corporation invite tenders for rubber-covered wires and accessories, underground cables and incandescent lamps. Specifications, &c, from the city electrical engineer, Mr. F. M. Long. Tenders (addressed to Chairman of Electricity committee) to the electricity works, Duke-street, Norwich, by 10 a.m. March 19. See an advertisement.

*Belfast* Tramways and Electricity committee invite tenders for one 400 kw. steam dynamo. Specification from the city electrical engineer, Mr. Victor A. H. McCowen. Tenders to the town clerk (Sir Samuel Black), Town Hall, Belfast, by 11 a.m. March 19. See an advertisement.

*Leeds* Electricity committee invite tenders for one or two sets of electric generating and condensing plant, each comprising a steam turbine, two-phase alternator and exciter of 3,000 kw. capacity, electrically-driven surface-condensing plant, and the necessary pipes and valves. Preference will be given to tenders for plant of British manufacture. Tenders to town clerk (Mr. Robert E. Fox) by 10 a.m. April 9.

*Leeds* Tramways committee want tenders by March 12 for 12 months' supply of electrical sundries, ironmongery, iron and steel, castings, oils, engineers' furnishings, coals, &c.

*Shoreditch* (London) Borough Council invite tenders for stores for one year ending March 31, 1907, including electric cables and sundries, gas pipe and fittings, and engineers' stores. Tenders to the town clerk (Dr. H. Mansfield Robinson), Town Hall, Old street, E.C., by 3 p.m. March 13.

*Fulham* (London) Council invite tenders for supply of general stores (including engineering goods, packings, jointings, &c., tools, castings, cables, incandescent and other lamps, carbons, street lighting goods, &c., oils, paints, &c.) for year ending March 31, 1907. Tenders to the Town Hall, Fulham, S.W., by 4 p.m. March 14.

*St. Marylebone* (London) Borough Council invite tenders for supply and delivery of stores for 12 months, including engine room stores, cables and cable-jointing material. Tenders to the town clerk (Mr. Jas. Wilson), Town Hall, Marylebone lane, W., before 4 p.m. March 14.

*Briton Ferry* Urban District Council invite tenders for supply, delivery, erection and laying of sub-station switchboard, non-rubber feeder and distributor cables, feeder pillars, joint boxes, arc standards, arc lamps, &c. Tenders to the clerk (Mr. Trevor H. Hunter), Council Offices, Briton Ferry, Glam., by noon March 26.

*Barnes* Urban District Council invite tenders for supply, delivery and erection of one straight-tube type water-tube boiler, surface condenser, feed pump and pipe work. Tenders to the Clerk, Council House, High street, Mortlake, by March 12.

*Edinburgh* Corporation invite tenders for stores for 12 months from May 16, 1906, including arc lamp carbons, cast-iron pavement boxes and pipes, electricity meters house service fuse boxes and bitumen. Tenders to the town clerk (Mr. T. Hunter, W.S.) by March 12.

*Greenock* Corporation invite tenders for supply and delivery of two d.c. steam generators of 750 kw. each and one 500 kw. d.c. motor generator. Tenders to the town clerk (Mr. C. MacCulloch), by midday March 15.

*Bristol* Corporation want tenders from manufacturers for direct and alternating-current motors for letting out on hire. Particulars from Mr. H. Faraday Proctor, Temple Back, Bristol.

*Torquay* Electric Lighting committee invite tenders for supply of 1,500 to 2,500 tons of smokeless steam coal. Tenders to the town clerk (Mr. Frederick S. Hex) by noon March 19.

*Leyton* District Council want tenders by 7:30 p.m. 15th inst. for steam and exhaust pipes, &c. Forms of tender from the electrical engineer, Electricity Works, Cathall-road, Leytonstone.

*Croydon* Guardians want tenders by 6 p.m. 19th inst., for supply of electrical fittings and appliances. Forms of tender from the Clerk, Mayday-road, Thornton Heath, Surrey.

*Wrexham* Corporation want tenders by 23rd inst. for supply of stores and materials for the electrical engineer's department, including cables, joint boxes, cut-outs, meters, lamps, carbons, coal, oils, &c.

*Islington* (London) Guardians want tenders by 20th inst. for electrical stores, &c., for 12 months.

H.M. Consul-General at *Antwerp* has forwarded to the Commercial Intelligence Branch of the Board of Trade particulars of a notice, issued by the municipal authorities of that city, inviting tenders for an electric light installation in the new Flemish theatre. Tenders to the Collège des Bourgmestre et Echevins de la ville d'Anvers, Hôtel de Ville, Antwerp, by 19th inst. A deposit of 7,000fr. (£280) is required to qualify any tender. Copy of the specification at the offices, 73, Basinghall-street, London, E.C.

## TENDERS RECEIVED AND ACCEPTED.

London County Council have accepted the tender of J. G. White & Co. of £141,399. 6s. 9d. for the reconstruction of the tramways from Shoreditch to Stamford Hill for electric traction, and that of Dick, Kerr & Co. at £238,045. 12s. 8d. for the reconstruction of the lines from Bloomsbury to Poplar. Additional particulars of these contracts were given in our last issue (p. 816).

Leyton Council have received the following tenders for underground electrical feeders on the solid system for their tramways:—

| | £ | s. | d. |
|---|---|---|---|
| Callender's Co. (*acc.*) | **£17,241** | **12** | **3** |
| St. Helens Cable Co. | 18,324 | 15 | 11 |
| Western Electric Co.. | 18,122 | 10 | 0 |
| W. T. Henley's Co... | 18,067 | 6 | 8 |
| Johnson & Phillips ... | 17,885 | 14 | 4 |
| Siemens Bros. & Co. | £17,709 | 16 | 2 |
| W. T. Glover & Co. .. | 17,613 | 9 | 8 |
| British Insulated & Helsby Cables .... | 17,587 | 1 | 0 |

Owing to the highly satisfactory showing made during the test (particulars of which were published in our last issue) of the first 1,500 kw. Curtis steam turbine installed at their Wandsworth and City-road stations, the County of London Electric Supply Co. have placed orders with the British Thomson-Houston Co. for three additional turbine generators, each of the same capacity.

Camberwell (London) Council have accepted the tender of the General Electric Co. for annual supply of Robertson incandescent lamps (100 or 200 volts) 8 or 16 c.p. at 8s. 6d. per doz., 32 c.p. 11s., frosted 9s. 6d. and 12s.; and that of the Electrical Engineering & Maintenance Co. for maintenance of private telephones and electric bells at the Town Hall and Grove Vale depot.

Hackney (London) Council have accepted the tender of H. Tuchman for supply of 10 ampere arc lamp carbons at £3. 2s. per 1,000 pairs, and 7 ampere carbons at £2. 8s. per 1,000. There were 13 tenders.

Wimbledon Council have accepted the tender of the General Electric Co. for supply and erection of air compressing plant at the pumping station at £701; and that of the Stanton Ironworks Co., for cast-iron pipes at £483.

Southwark (London) Council have accepted the tender of the British Insulated & Helsby Cables for 220 yds. of 0·05 cable at £32. Johnson & Phillips tendered at £33. 18s., W. T. Glover & Co. at £36. 2s. 4d, and Siemens Bros. & Co. at £38. 10s.

Leyton Council have accepted the tender of the British Electrical Equipment Co. for the overhead electrical equipment of the Council's tramways at £11,404. 7s. The full list of tenders was given in our issue of Feb. 2.

St. Pancras (London) Council have accepted the tender of Veritys Limited for electrical advertising signs for the baths at £13. 10s.

The contract for rolling stock, overhead equipment and cables for the Wemyss (N.B.) tramways (9 miles in length) has been placed with Bruce Peebles & Co., Edinburgh and London.

The Metropolitan Asylums Board have entered into an agreement with Pritchetts & Gold for the maintenance of the storage battery at the Grove Hospital for five years at £75 per year.

Colchester Corporation have accepted the tender of Davey, Paxman & Co. for supply and delivery of triple expansion double-acting engine, direct-coupled to a Siemens dynamo, at £4,055.

Dover Corporation have accepted the tender of the British Westinghouse Co. at £1,753 for a 350 kw. steam dynamo (Allen engine). There were 49 tenders from 20 firms and the amounts varied from £1,458 (Johnson & Phillips) to £1,972 (British Westinghouse Co.).

Exeter Corporation have placed an order with Dick, Kerr & Co. for six additional tramcars.

Derby Corporation have accepted the tender of Milnes, Voss & Co. for four single-deck tramcars at £2,232.

Lancaster Council have placed a contract with R. Wilson for wiring the Greave schools at £169. 10s.

## BUSINESS NOTICES.

Messrs. Eckstein, Heap & Co., 5, Chapel-walks, Cross-street, Manchester, have been appointed by Messrs. Elliott Bros., Century Works, Lewisham, sole selling agents for their manufactures in the Lancashire, Yorkshire, Cheshire, and North Wales district. Mr. Heap, having worked with Messrs. Elliott Bros. a good many years as chief engineer in the design and construction of electrical instruments, is on this account very familiar with all the technical points, and will be pleased to answer any inquiries for apparatus of Messrs. Elliott Bros.' manufacture.

The headquarters of the publicity department of Messrs. Bruce Peebles & Co. (Ltd.), hitherto located in Edinburgh, have now been transferred to the London office of the company, 1, London Wall-buildings, E.C, where all communications intended for the department should in future be addressed. The department will remain under the control of Mr. N. D. Cameron.

We are informed that Messrs. Richard Hornsby & Sons (Ltd.), of Grantham, have acquired the business of J. E. H. Andrew & Co. (Ltd.), of Stockport, and that the chairman and managing director of Messrs. Andrew & Co. have joined the board of Messrs. Hornsby. Mr. Bellamy retains the management of the Stockport branch works, Grantham remaining the firm's headquarters.

The Wilson-Wolf Engineering Co., Ltd., Laycock's Mill, Thornton-rd, Bradford, have purchased the whole of the stock, plant and patterns of the Webster Electrical Engineering Co., Ltd., and are continuing the business.

Samuel Barnes Griffith and Frank Biliotti, electrical and mechanical engineers, 8, John-street, Adelphi, London, W.C., have dissolved partnership.

The Bigelow Co., of New Haven, Conn., U.S.A., have acquired the American rights of the Hornsby upright water-tube boilers, and will manufacture these boilers in the United States.

## BANKRUPTCIES, LIQUIDATIONS, &c.

A receiving order has been made against Geo. Aaron Benton, electrical engineer, formerly of 8, The Exchange, Muswell Hill, London, N.

At London Bankruptcy Court on Wednesday, Mr. Registrar Giffard suspended for two years the discharge of James Stephen Bakewell, electrical engineer, lately trading in partnership with W. A. Charles as electrical engineers, at Leicester and London, under the style of the Central Electrical & Engineering Co.

Claims against Harry Jones and Gwilt Lloyd Cathrall, electrical engineers, &c., 19, Chester-street, Wrexham, by 21st inst. to Mr. L. H. Jones, Crypt-chambers, Eastgate row, Chester.

A first and final dividend of 4s. is payable at District-chambers, Darwen, in the bankruptcy of Alex. Holmes and Alex. McCallum, electrical engineers, 29, Victoria-street, and Crown Works, Darwen.

Claims against the Crystal Palace District Electric Supply Co. (Ltd.)—whose undertaking has been acquired by the South Metropolitan Electric Light & Power Co. (Ltd.)—to be sent to Mr. Jas. Gray, Dashwood House, New Broad-street, London, E.C, by April 13.

Electroid Limited is being wound up voluntarily. Mr. F. L. Jenkins, 17, Ironmonger-lane, London, E.C., is liquidator.

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**Sale by Auction.**—Messrs. Horne & Co., 8, Delahay-street, Storey's-gate, Westminster, S.W., will sell by auction by order of the Secretary of State at the Royal Arsenal, Woolwich, on Thursday, March 22, at 11 a.m., some unserviceable and obsolete stores, including a quantity of metals (copper, lead, phosphor bronze, brass, steel, &c.), lathes, electric lamps and cable, telegraphic instruments, indiarubber, &c. Further particulars are given in an advertisement. Catalogues from the War Office, Pall Mall; Ordnance Office, Tower; and the Ordnance Office, Royal Arsenal, Woolwich.

**Plant, &c., for Sale.**—Newport (Mon.) Electricity and Tramways department invite tenders for the purchase of quantities of old iron, steel and old and short ends of electric cables consisting of lead and copper, old transformers, &c. Particulars from the borough electrical engineer, Mr. H. Collings Bishop, Town Hall, Newport, Mon. See also an advertisement.

Messrs. White Bros. & Co., engineers, Stratford, London, E, have for sale some electrical plant, particulars of which are set out on another page.

Some electric lighting plant (consisting of a Cochran boiler, pair of Browett-Lindley engines and Elwell Parker shunt-wound dynamo) is advertised for sale by the Colosseum Theatre, Oldham.

Messrs. J. T. & J. Taylor (Ltd.), Batley, advertise for sale a 36 H.P. Phœnix shunt motor.

Some X-ray apparatus (Ruhmkorff coil, accumulator and a quantity of scientific experimental apparatus) is advertised for sale by Mr. H. Shewen, Oatlands Park, Weybridge.

Messrs. Lee & Hunt, Nottingham, advertise for sale a powerful vertical turning, surfacing and boring mill.

**Business for Sale.**—Messrs. Firth & Co., 7, Cookridge street, Leeds, advertise for sale an electrical engineer's business.

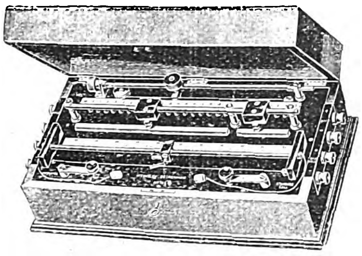
"**Garcke's Manual of Electrical Undertakings, 1906.**"—This is the 10th annual issue of this excellent "Manual," and we gather from the preface that statistical and general information relating to 2,700 electrical undertakings owned by companies and municipalities in the United Kingdom is given in the new edition, as well as similar particulars relating to a number of electrical undertakings in British colonies and Possessions. This compares with 200 undertakings only in the first edition of the "Manual" in 1896. The particulars relating to electric tramways, light railways and tramways under construction or conversion, and authorised, show a total of 3,831 track miles. There are a large number of maps (54 in all) of the principal inter-urban and urban tramway systems, of the first railways in the provinces to be electrified, and of power undertakings. The vast mass of information concerning electricity supply which is always to be found in the "Manual" has been brought up to date so far as this is possible, and has been amplified in many directions. The published price is 15s. net.

**D.P. Batteries.**—Late in the day, but none the less welcome, is a well executed calendar issued by the D.P. Battery Co., which, besides showing some good views of these cells, gives a coloured view of the great water wheels at the company's Lumford works, with the supplemental steam plant aggregating 600 H.P. This is a very neat calendar and worth waiting for. Only a limited number of copies are available, and early application should therefore be made by those desirous of obtaining a copy.

**Catalogues, &c.**—The Simplex Steel Conduit Co. have recently placed upon the market a new electric shade tilter, and a leaflet is now ready illustrating this device. This is an extremely simple and very compact arrangement for canting the lamp and shade at any angle, and although the Simplex Co. have only just placed it on the market there has already sprung up a great demand. The Simplex shade tilter is provided with universal rolling motion, complete automatic lock in any desired position, can be used with any shade, and has perfect action with any number of lights. No extra flexible is required in using it, and there is no strain on the flexible wire. The shade tilter pendant can be used in connection with a variety of Simplex boxes, and these are also illustrated on the leaflet, copies of which will be supplied to the trade on application.

The General Electric Co. have christened their new burglar alarm the "Chubb," a happy appellation. This alarm is so constructed and arranged that it is claimed that (no matter how the attempt is made to open the safe furnished with this contrivance) an alarm is immediately given whether this be an attempt to open the door with a skeleton or duplicate key, to burst open the door, to drill or perforate the back, front, top or sides, to cut the electric wires, or to short-circuit the terminals, and it is urged that no self-respecting burglar, however crafty and experienced, will be prepared to face such working conditions.

The British Thomson-Houston Co. announce that the prices for Thomson recording wattmeters (switchboard type) given in their price list No. 94 have been cancelled.



"TINSLEY" POTENTIOMETER.

Mr. Henry Tinsley, Elmers End-road, Beckenham, Kent, has two price lists ready for issue, one dealing with standard cells and the second with potentiometers. We illustrate the latter instrument, which Mr. Tinsley states is designed to meet the demand for a moderate price potentiometer, constructed on simple but sound lines. Particular attention is given to winding and adjusting, the coils being wound in circular form of large diameter and mounted on mica plates. The instrument is designed to work on any accumulator between 1·8 to 2·2 volts, and between these voltages adjustment can be made on the instrument itself without any supplementary rheostats, two of these, a coarse and a fine one, forming a portion of the potentiometer itself. The fine adjustment rheostat is fitted with a micrometer screw, which enables an adjustment to $\frac{1}{10000}$ to be easily obtained.

Lists Nos. 92 and 95 just issued by Ferranti Limited, Hollinwood, Lancs., deal respectively with oil-brake enclosed two-pole and three-pole mining switches for alternating current up to 1,000 volts and 450 amps., and brackets for supporting instruments (fixed and swinging patterns). A number of these brackets are illustrated

A valuable and very complete list of high-class antique and ornamental electric light fittings has been sent us by C. J. Thursfield & Co., Clement-street, Parade, Birmingham. This new list, which covers nearly 240 large quarto pages, includes illustrations of some hundreds of brackets, standards, electroliers, ceiling fittings, pendants, lanterns, billiard fittings and, in fact, the whole range of this class of goods in best-class metal work, and Messrs. Thursfield point out that only a small proportion of the fittings manufactured by them can be found space for, even in so complete a publication. It is very properly pointed out that the whole of the illustrations are produced from photographs of the actual fittings, and consequently suffer from no exaggeration of design. The examples of fittings in hand-wrought, scroll and leaf work are very fine, as are also many of the cast scroll-work examples shown. It is not possible to particularise where so large a number of good examples of the metal-worker's craft are shown, and it must suffice to say that the list is one of the best we have seen. It is particularly strong in some new and elegant patterns of glass, and it is stated that in many instances these portions of the fittings have been specially designed to be in keeping with the patterns and ornamentation of the complete fitting.

A new pamphlet (A.C. 63) of portable instruments is issued by Elliott Bros., Century Works, Lewisham, London, S.E., which briefly describes a set of ammeters, voltmeters and wattmeters, spring controlled, with balanced coils, and having external zero adjustment, and which can be used horizontally or vertically. The ammeters are self-contained up to 30 amperes, the voltmeters up to 300 volts, and the wattmeters up to 100 amperes 300 volts. The instruments of this class are arranged for alternating current circuits and are dead-beat, but can be made for both alternating and direct current.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Feb. 28 to March 6, with the ports of destination :—

*Aden*, £26 (telegraph material). *Africa*—Alexandria, £49; Beira, £600 (including £588 telegraph material); Cape Town, £1,424 (including £174 telegraph material); Delagoa Bay, £113; Durban, £1,088 (including £640 telegraph material); East London, £109; Mombasa, £29 (telegraph material); Port Said, £34; Sekondi, £242. *Argentina*—Buenos Ayres, £362; Rosario, £78 (telegraph material); Santos, £63. *Australasia*—Adelaide, £150; Fremantle, £21; Hobart, £69; Lyttelton, £33; Melbourne, £191; Perth, £13; Sydney, £385 (including £87 telegraph material); Wellington, £5,689 (including £367 telegraph material). *Belgium*—Ostend, £20. *Brazil*—Pernambuco, £22 (telegraph material); Rio Janeiro, £134 (including £72 telegraph material). *Burma*—Rangoon, £1,107. *Ceylon*—Colombo, £36. *China*—Shanghai, £77. *Denmark*—Copenhagen, £15. *Dutch East Indies*—Cebu, £9 (telegraph material). *France*—Boulogne, £150 (telegraph material); Marseilles, £11; Paris, £531. *Germany*—Hamburg, £52. *Gibraltar*, £311. *Holland*—Amsterdam, £282 (including £100 telegraph cable). *India*—Bombay, £323; Calcutta, £1,764 (including £172 telegraph material); Madras, £749. *Japan*—Nagasaki, £35; Yokohama, £4,774 (including £367 telegraph material). *Madeira*, £19. *Malta*, £105. *Mauritius*, £31 (telegraph material). *Philippines*—Manila, £22 (telegraph material). *Straits Settlements*—Penang, £9; Singapore, £119. *Sweden*—Stockholm, £75. *Turkey*—Constantinople, £74 (telegraph material). *U.S.A.*—New York, £329. *Zanzibar*, £18 (telegraph material). Total, £21,971, against £34,586 in the corresponding week last year (March 1 to 7).

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Practical Electro-Chemistry." By Bertram Blount. Second edition. (London : Archibald Constable & Co.) 15s. net.

"Modern Milling Machines: Their Design, Construction, and Working." By Joseph G. Horner. (London : Crosby Lockwood & Co) 12s. 6d. net.

"Practical Physics." By William R. Bower, in collaboration with J. Satterly. (London : University Tutorial Press.) 4s. 6d.

"Proceedings of the Royal Society." Series A. Vol. LXXVII., No. A516. Mathematical and Physical Sciences. (London : Harrison & Sons.) 2s. 6d.

"Science Abstracts." February. Section A : Physics. Section B : Electrical Engineering. (London : E. & F. N. Spon.) 1s. 6d. each.

"Patents to Inventors." With a Chapter on Patent Agents. By Arthur Hugh Stanley. (London : Percival Marshall & Co.) 3d. net.

"Proceedings of the Royal Society." Series B, Vol. LVII. No. B517. Biological Sciences. (London : Harrison & Sons.) 2s. 6d.

"Prüfungen in Elektrischen Zentralen." Part II. "Prüfungen von Anlagen mit Wasserrad, Wasser-und Dampf-Turbinen-Betrieb." By Dr. E. W. Lehmann-Richter. (Brunswick : Friedrich Vieweg und Sohn.) 7m.

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are no open to public inspection until after acceptance of Complete Specification. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

January 29, 1906.

2,244 JUSTICE. (Phönix Electrotechnische G.m.b.H., Germany.) Arc lighting and apparatus therefor.*
2,249 MARPLES. Controlling devices for electric motors.
2,259 B.T.-H. Co. (G.E. Co., U.S.) Arc lamps.

January 30, 1906.

2,264 GOLDSTRAW. Spark preventer.
2,285 POLLOCK. Electromagnetic coils.
2,286 MEIKLEJOHN. Branch switches.
2,317 KÜPPERS. Electric welding.*
2,322 JUSTICE. (Bullock Electric Mfg. Co., U.S.) Shaft bearings for dynamo electric machines.*
2,328 CERVENKA. Arc lamps.

2,329 **Pfatischer.** Electrically propelled vehicles.
2,337 **Warming.** A potential regulator for electric currents. (Date applied for, June 14, 1905.)*†
2,338 **Hancock.** Protecting buildings from lightning.
2,342 **Kotyra.** Means for perforating paper slips for telegraphy.
2,345 **Kelly.** Heat-insulating materials.*
2,364 **Mackie.** Dynamos and motors maintaining constant E.M.F. under variations of speed.
2,367 **Fynn.** Single-phase alternate-current motors and generators.

January 31, 1906.

2,383 **Ingram.** Improvements connected with the safety guards of tramway cars and motor vehicles.
2,407 **Clarke.** Coverings for 'bus, tramcar and motor seats.
2,409 **Smith.** Portable screw box and feed for electric drilling machine.
2,437 **Zerning.** Manufacturing filaments for incandescent lamps.*
2,441 **Graetz.** Arc lamps.*
3,452 **Hall.** Telephone system. (Date applied for, Feb. 8, 1905.)*†
2,456 **Cowper-Coles.** Electrolytic production of copper wire strip.
2,458 **B.T.-H. Co.** (G.E. Co., U.S.) Dynamo-electric machines for electric vehicles.
2,463 **Duke & Hirst.** Incandescent lamps.
2,465 **Hermite.** Electrolytic apparatus.

February 1, 1906.

2,479 **Siebert.** Electric motor starters with overload and no-voltage release.
2,485 **Turner, Peers & Ridley.** Wireless telegraphy.
2,510 **British Westinghouse Electric & Mfg. Co.** (Roberts, Natal) Electrical measuring instruments.
2,514 **Watkins.** Grinding the contact surface of carbon brushes.
2,545 **Wyld & Chadwick.** Slipper brakes.
2,547 **Frost.** Electric ignition for gas and petrol engines.
2,548 **Letroieur.** Safety apparatus for overhead conductors. (Date applied for, Feb. 10, 1905.)*†
2,552 **Betts.** Electric furnaces.*
2,553 **Tate & Weekes.** Economic production of mechanical energy for distribution by electricity, or other agent.
2,554 **Zerning.** Filaments for incandescent lamps.*

## SPECIFICATIONS PUBLISHED.

1904 Specification.

28,416 **Arnold & la Cour.** Commutation of current in armatures.

1905 Specifications.

2,172 **Boult.** Electric traction systems.
2,747 **Beaver & Claremont.** Cables.
4,287 **Marino.** Secondary batteries.
4,741 **Dawson & Buckham.** Electrical apparatus for signalling.
4,878 **B.T.-H. Co. & Wedmore.** Electric distribution systems.
5,398 **Hateley.** Pendants, brackets and other fittings for electric light.
6,383 **Garside.** Electric switches having resistances.
6,595 **B.T.-H. Co.** (G.E. Co., U.S.) Dynamo-electric machines.
6,790 **Potthoff.** Apparatus for electro-plating hollow articles.
6,834 **Reader.** Insulation-cutting contact clip for cables.
7,019 **Bowron.** Contact breakers for induction coils.
7,444 **Greenwood.** Electric lamps, particularly tail lamps of motor vehicles.

# COMPANIES' MEETINGS AND REPORTS.

## Hart Accumulator Co. (Ltd.)

The seventh annual general meeting of this company was held on Feb. 28, Mr. G. W. Kidd in the chair. We have received the following note of the proceedings at the meeting :—

The Secretary (Mr. Poulton) having read the notice convening the meeting, the Chairman said the presence of so many shareholders was very satisfactory to the directors, who always desired to see a good attendance. The balance-sheet showed a profit for the year to Dec. 31 last of £6,936. 17s. 11d., making, with the balance forward (after deducting preference dividend, £327. 18s. 4d.), £13,021. 12s. 11d. The directors recommended a dividend of 12½ per cent. on the ordinary shares, asborbing £5,000, placing £1,000 to reserve and leaving £7,021. 12s. 11d. to be carried forward. Buildings, plant, tools, &c., have been augmented by £9,163. 10s. 3d., which had been charged to capital and duly depreciated. Maintenance of works, plant, &c., had cost £652. 19s. 7d., which had come out of revenue. Competition had been as keen as ever. The price of raw material had gone up about 40 per cent., but they had only been able to increase their prices by 5 per cent. Careful attention to details and improvements introduced in almost every branch of the company's business by their energetic manager (Mr. Clark) had enabled them to reduce the cost of manufacture, and their sales had largely increased. The results of the company's exhibiting at Olympia at the recent electrical exhibition had been extremely gratifying. The new buildings in which the meeting that day was being held had been put up at a cost of nearly £14,000. They had invited tenders for this work, but considering these too high they had decided to build the premises themselves, and had saved a considerable sum of money in so doing. The buildings throughout were lighted by electricity, and the whole of the plant was driven by electricity, current being supplied by the local authority in bulk at a satisfactorily low price. He moved the adoption of the report and the declaration of the dividend recommended therein.

This was carried unanimously.

Mr. E. G. Clark was re-elected as director, and, the retiring auditors having been re-appointed, the Chairman moved a vote of thanks to Mr. Clark, Mr. Poulton and the staff generally, saying that the directors were very grateful for all the services that had been rendered to the company by their officials, who had worked with a great zeal. The resolution was carried unanimously and Mr. Clark and Mr. Poulton returned thanks. A cordial vote to the chairman brought the proceedings to a close.

## Buenos Ayres Grand National Tramways Co. (Ltd.)

An extraordinary general meeting was held on Tuesday under the presidency of Mr. J. Irving Courtenay, to confirm a series of resolutions passed at the meetings of shareholders held on Monday, Feb. 19. (A report of the proceedings at these meetings was given in *The Electrician* for Feb, 23, p. 777.) At Tuesday's meeting, after the notice convening the meeting had been read by the Secretary (Mr. Fortesque Thursby), the Chairman said the subject matter of the resolutions had been thoroughly thrashed out, and the enormous majorities of votes given by the shareholders of all classes in favour of the directors' proposals showed that, with the exception of one or two individuals, the shareholders were practically unanimous in supporting the directors' policy of reorganisation of the company's capital. The special resolution was then put to the meeting and carried with two dissentients. At subsequent meetings of the different denominations of shareholders the same resolution was submitted and carried with about equal unanimity. At the conclusion of the meetings a poll was taken, when the following results were announced: At the extraordinary general meeting 76,312 votes were given in favour of the resolution, 3,324 against, majority for the resolution 72,988. At the meeting of ordinary shareholders 31,629 for the resolution, against 166, majority 31,463. At the meeting of A preference shareholders, for the resolution 21,426, against 3,588, majority 17,838. At B preference shareholders' meeting, for the resolution 13,722, against 100, majority 13,622. At the meeting of second preference shareholders, for the resolution 9,695, against 100, majority in favour of the resolution 9,595.

**BRITISH ENGINE, BOILER & ELECTRICAL INSURANCE CO. (LTD.)**—At the annual meeting on Friday last the chairman (Mr. M. Longridge) said that during 1905 no boiler under the company's inspection had exploded; in fact, no boiler had ever yet exploded for which the company's certificate had been issued. The greater part of the amount received as premium for boiler insurance was expended on the inspection of the boilers, with the result that the ratio of claims to premium income was reduced to an insignificant figure. Unfortunately the same could not be said with regard to insurance of engines (steam, oil and gas) and electrical plant. A dividend of 3s. and a bonus of 1s. per share were declared.

**BROMPTON & KENSINGTON ELECTRICITY SUPPLY CO. (LTD.)**—At the meeting yesterday (Thursday) the chairman (Mr. W. P. Page) moved the adoption of the report given in our last issue. The number of lamps connected had increased by 18,717 8 c.p., which was much the largest increase in any year of the existence of the company. They now had 3,861 customers, of whom 286 were connected during the year. The total costs had been further reduced.

**CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)**—The report of the directors for the year ended Dec. 31 states that the expenditure on capital account during the year amounted to £32,064. 15s. 6d. This expenditure has been made without trenching upon the balance of authorised loan and share capital remaining unissued, which amounts to £194,050. £89,058. 9s. 10d. has been deducted from capital expenditure in respect of buildings, plant and other works dismantled. Capital expenditure consequently stood at Dec. 31 at the reduced amount of £2,036,071. 6s. 5d. The amount at credit of the redemption account at Dec. 31 was £53,330. 13s. 11d. The sums of £45,000 and £500 from net revenue have been transferred to reserve. A careful investigation has been made as to the original cost of buildings, plant, cables and other works dismantled, and this cost, as certified by the engineer, amounts to £89,058. 9s. 10d. The general stores have also been re-valued, especially as regards old items taken out of service and returned to stores, and these have been written down by £10,040. 0s. 8d., to provide for any loss on schedule prices arising on the eventual sale or otherwise. These sums of £89,058. 9s. 10d. and £10,040. 0s. 8d. have been debited to reserve, for which purpose this account was partly created. The balance at credit of reserve at Dec. 31 consequently stood at £196,320. 13s. 1d., making, with other reserve items (first debenture stock premium redemption fund £53,330. 13s. 11d., reserve for doubtful debts £1,400 and amount brought forward £22,235. 1s. 6d.), £273,286. 8s. 6d. The total revenue for the year (including interest) was £263,739. 0s. 4d. Operating and management expenses were £116,317. 14s. 2d., interest £1,249. 18s. 9d., staff superannuation £304. 0s. 5d., leaving £145,867. 7s., added to £21,876. 17s. 6d. brought forward, or £167,744. 4s. 6d. Of this sum interest has absorbed £34,470, transfer items £48,000, leaving for dividends £85,274. 4s. 6d.

The directors recommend the following dividends for the year (less tax): Preference shares, balance of 6s. per share; ordinary shares, balance of 7s. per share (making 6 per cent. for the year), leaving to be carried forward to 1906 £22,235. 1s. 6d.

**CORK ELECTRIC TRAMWAYS AND LIGHTING CO. (LTD.)**—The receipts for 1905 were £47,359. 16s. 4d., and the expenses £29,381. 0s. 4d. After adding £885. 4s. 11d. from 1904 and deducting interest (£4,420), the balance is £14,444. 0s. 11d., out of which £5,750 was paid in interim preference dividends, £1,500 added to reserve, £448. 0s. 4d. written off, and the directors now recommend payment of a 5 per cent. dividend on ordinary shares (requiring £5,750) and carrying forward £996. 0s. 7d. 187 additional consumers were connected up during the year. A contract has been entered into for the supply of current for lighting Cork military barracks. Traffic receipts show an increase of £694. 5s. 10d. over 1904. Capital expenditure during the year was £3,647. 15s. 5d., mainly on house services and cables.

**COUNTY OF DURHAM ELECTRICAL POWER DISTRIBUTION CO. (LTD.)**—The total units sold during 1905 were 6,190,709, an increase of 1,753,110 over the previous year. Of the units sold in the past year 5,786,610 were for power and 404,099 for lighting. The profit (including £1,056. 12s. 1d on sale of land, plant, &c.) was £15,723. 17s. 3d. The directors recommend a balance preference dividend of 2½ per cent., and a dividend of 4 per cent. on the ordinary shares. £1,072. 2s. is carried forward. Capital expenditure during the year has been £50,224. 7s. 10d. The extension of the system of general distribution is in active progress throughout the districts where the company holds provisional orders, and it is anticipated that an additional supply of energy will be available early in the summer. To further develop the demand for electricity for lighting, the price of current was reduced to 3¾d. per unit, less 5 per cent., as from July 1 last. The Whickham electric lighting order has been transferred to the company and a supply of energy for lighting and power is now being given. Blaydon Council have agreed to transfer their electric lighting order to the company, and a supplemental order confirming the transfer is now before the Board of Trade. The Board of Trade are also considering applications from the company for the granting of provisional orders for Ryton Urban District and for Mid-Durham District. The Bishop Auckland electric lighting orders have been transferred by the company to the Cleveland & Durham County Electric Power Co.

**COUNTY OF LONDON ELECTRIC SUPPLY CO. (LTD.)**—The directors' report for the year ended Dec. 31 last states that the capital expended during the year in respect of the company's London districts amounted to £82,380. 3s. 9d., bringing the total expenditure on account of those districts up to £1,465,972. 19s. 10d. The total available revenue for the year was £96,648. 12s. 4d. Deducting interest (£36,367. 2s. 11d.), interim dividends (£16,150), amount carried to reserve for depreciation, repairs, renewals, &c. (£20,000), there is available for further distribution £24,131. 9s. 5d. The directors now recommend payment of the balance preference dividend, and a further dividend on the ordinary shares at the rate of 6 per cent. per annum (less tax). This will absorb £19,950, and leave £4,181. 9s. 5d. to be carried forward. A contract has been entered into with London County Council for supply of current for working the electric tramways between Aldwych and Islington pending completion of arrangements for supply from the County Council's own supply station.

*London Stations.*—The profits from the London stations for 1905 amounted to £102,391. 18s. 7d., against £92,730. 19s. 6d. for 1904, an increase of over 10 per cent., while the percentage of working expenses to revenue from sale of current fell from 45 3 per cent. to 44 per cent. The total applications received at Dec. 31 last were equivalent to 770,640 8 c.p. lamps, an increase of 122,929 lamps for the year, against 118,855 lamps for 1904. Included in these figures are 1,050 users of motors aggregating 9,932 H.P., an increase of 2,121 H.P. for 1905, of which 1,000 H.P. is in respect of the Wandsworth station. The total units sold were 8,614,187, against 7,181,309 for the previous year. Turbine plant was erected at both the City-road and Wandsworth stations during the autumn of 1905, and is now in satisfactory operation. The company has adopted the "Curtis" type of turbine, which effects a great economy of floor space as compared with reciprocating engines. Further extensions with the same type of machinery are now under consideration.

In regard to the company's investments in provincial electricity supply companies, it is reported that both the Bournemouth & Poole Electricity Supply Co. and the Scottish House-to-House Electricity Co. have made satisfactory progress during the year.

**HOVE ELECTRIC LIGHTING CO. (LTD.)**—The net profits increased from £11,807 in 1904 to £12,490. 5s. 5d. in 1905. At Dec. 31 there were 1,374 houses, representing the equivalent of 92,194 8 c.p. lamps connected, against 1,236 houses and 82,968 8 c.p. in 1904. The units sold were 901,384, against 820,781. The balance from 1904 (£325. 9s. 11d.) added to the net profit for 1905 makes an available balance of £12,815. 15s. 4d. After deducting interest, interim dividend and income tax the surplus is £7,851. 12s. 5d. The directors propose to place £3,250 to reserve, to add £250 to maintenance and renewals fund and to declare a final dividend (payable April 12) at the rate of 10 per cent. per annum (making 9 per cent. for the year) and to carry £965 forward. Capital expenditure during 1905 was £3,360, chiefly in mains.

**LONDON UNITED TRAMWAYS (1901) (LTD.)**—The chairman (Mr. C. J. Cater Scott), in moving the adoption of the directors' report and accounts (abstracted in our last issue), said the condition of their line was excellent, except about 2 miles of line running from the south side of Kew Bridge to Richmond. It had always been their intention to rebuild and reconstruct that line and to convert it from horse to electric power. Delay had occurred owing to negotiations with local authorities, but they intended to take in hand the reconstruction of the line at once and convert it to electric traction. Generally, they found that as soon as they proposed to give an efficient tramway service all the local authorities were up in arms, and trying to squeeze them in some way. They had a tramway in Richmond which the company wish to make a thoroughly up-to-date concern by altering it from horse-power to electricity, and yet the council were trying to insist that if the company extended across Kew Bridge they should put down the conduit system, which was more expensive. When they had completed the works which they had in contemplation, they would have about 55 miles of tramways in operation. About 30 per cent. could be acquired by various local authorities on the Tramways Act terms, the remaining 70 per cent. being acquirable on "going-concern" terms. If they took the average life of those 55 miles, it amounted to about 20 years. Last year they had 37 miles in operation and 9 miles in construction. On Thursday week, of those 9 miles they opened 7 to traffic through Kingston, Surbiton and neighbourhood, making 44 miles in operation. Now they were taking in hand something like 8 miles more, which would link up the eastern end of their Surrey group of Kingston and Surbiton, passing on from Wimbledon to the L.C.C. tramways at Tooting. When they had done that they would have 55 miles in operation.

**METROPOLITAN ELECTRIC SUPPLY CO. (LTD.)**—The report of directors for the year ended Dec. 31 shows that capital expenditure, which at the end of 1904 amounted to £1,539,582. 1s. 11d., has reached £1,696,007. 7s. 8d., an increase during the year of £156,425. 5s. 9d. The greater part of this sum was expended in the erection of Fisher-street sub-station and on other works consequent upon the sale of Sardinia-street generating station, and also on further extensions of the system of low-pressure distribution. Towards meeting this expenditure some of the securities in which the portion of the Marylebone purchase-money representing repaid capital was temporarily invested have been sold. The sales resulted in a profit of £4,119. 14s. 7d., which has been carried to a special reserve fund against depreciation of investments generally. £10,000, part of the amount awarded to the company for the sale of the Marylebone portion of its undertaking, which was paid into court pending the settlement of questions of title, has since been received. After deducting therefrom the cost of certain severance works, and giving effect to the final adjustment of arbitration and other expenses, there remains a balance of £2,649. 8s. 3d., which has been carried forward. A considerable portion of the Marylebone business was taken over by the Borough Council on Aug. 6, and since that date further portions have from time to time been transferred. At the end of the year about one-third of the business remained in the hands of the company. The gross revenue for the year, including that received in respect of the Marylebone business remaining in the hands of the company, amounted to £269,007. 9d. 3d., compared with £306,540. 15s. 3d. in 1904, when the whole of that business was included. There is, therefore, a decrease of £37,533. 6s. Working expenses, which in 1904 were £129,703. 9s. 9d., amounted in 1905 to £108,724. 19s., a decrease of £20,978. 10s. 9d. The balance at credit of revenue, before providing for depreciation, is £160,282. 10s. 3d. The directors have set aside £20,000, as an addition to depreciation and reserve fund, which now amounts to £236,355. 5s. 5d., carrying to credit of net revenue £140,282. 10s. 3d. This sum, with the balance brought forward from last account and other receipts, makes £171,496. 6s. 3d., of which, after deducting interest, preference dividend, and other charges (including interest paid to St. Marylebone Council under agreement), there remains £102,219. 8s. 8d. The interim ordinary dividend at the rate of 10 per cent. absorbed £50,000, and the directors now recommend a further dividend of 5s. per share (making 10 per cent. for the year). This will absorb a further £50,000 and leave £2,219. 8s. 8d. to be carried forward. During the year new connections representing the equivalent of 80,834 8 c.p. lamps were added to the company's system, excluding Marylebone, and connections representing 260,524 lamps were transferred to Marylebone Council, leaving a total connection at the end of the year (exclusive of Marylebone) of 607,762 lamps.

**NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY CO. (LTD.)**—The total units sold during 1905 amounted to 30,378,852, an increase of 13,246,699 over 1904. The units sold for power amounted to 21,479,493, and bulk supply to the County of Durham Electrical Power Distribution Co. and the County of Durham Electric Power Supply Co. to 6,190,709. The profits, including £872. 8s. 11d. from 1904, were £74,653. 1s. 9d., out of which there have been paid interest £12,354. 19s. 7d., interim dividends £18,514. 15s. 5d., leaving £43,783. 6s. 9d., and the directors recommend payment of a further preference dividend of 2½ per cent. on the amount called up, and 5½ per cent. on the ordinary shares for the half-year (making 5 per cent. and 8 per cent. respectively for the year). £12,500 has been transferred to depreciation account, leaving £1,354. 6s. 9d. to be carried forward. The depreciation account now stands at £156,000, capital expenditure during the year, necessitated by the further extension of the Carville power station and of the system generally, was £45,037. 2s. In order to meet expenditure on current and future extensions it is proposed to take powers for the increase of preference and ordinary share capital by £250,000, and to create second mortgage debentures to the extent of £250,000. £175,000 of these debentures are to be issued in the autumn.

**OXFORD ELECTRIC CO. (LTD.)**—At the meeting last week the chairman (Sir Henry Mance) said the lamps added during 1905 were equal to 7,928 8 c.p., bringing the total to 73,000 8 c.p. There were 140 new customers, or exactly the same number as in 1904, but the number of lamps added was less than in the preceding year. A new unit of plant (E.C.C.-Belliss set) had been installed at the works, also a Babcock & Wilcox boiler. They were gradually spreading their mains north and east. The hire-purchase system of wiring continued to be popular. They had added 51 new customers on that system during the year, and those additions had brought on 1,500 8 c.p. lamps. The cost of production at the generating station in respect of the units delivered had fallen from 1·65d. to 1·47d. per unit, and the total costs had been reduced by about $\frac{1}{10}$d. In regard to the rates, the directors considered their new assessment excessive, and their expert advised them to appeal, unless the Assessment committee assured them that more reasonable figures would be accepted.

**SOUTH LONDON ELECTRIC SUPPLY CORPN. (LTD.)**—The total receipts for 1905 amounted to £76,473. 0s. 9d., and the outgoings to £43,990. 4s. 10d., leaving £32,482. 15s. 11d. as gross profit. After making adequate allowance for depreciation and preliminary expenses and provision for interest, the balance is £22,042. 1s. 10d., out of which the board recommend payment of a dividend at the rate of 4 per cent. per annum on the ordinary shares, carrying forward £9,042. 1s. 10d. At the end of 1905 there was connected to the company's mains the equivalent of 120,412 8 c.p. lamps, an increase during the year of 13,412 lamps, while signed applications were then in hand for a further 5,000 lamps. The total number of units sold in 1905 was 10,144,995, an increase of 939,653 units. The increase in revenue has not been correspondingly larger from the fact that in order to meet the severe competition with the gas company the Board decided on making a substantial reduction in the price for lighting as from July 1 last, which means a rebate to the consumers of about £4,000 per annum. Lambeth Borough Council's action against the company, which was decided in favour of the company, is to be appealed against.

**VICKERS, SONS & MAXIM (LTD.)**—The report for 1905 states that the year's working has been satisfactory. All the large branches of the company's business have contributed to that result, but the directors are especially pleased to note that the improvement is largely due to increase in business done with foreign countries, both in goods manufactured at home and in those made to the company's systems abroad. The prospects for 1906 are satisfactory, and an interim dividend of 5 per cent. on the ordinary shares will be paid on Aug. 1 next. The directors now recommend a final dividend of 2s. each on the ordinary shares (making 3s., or 15 per cent. for 1905), leaving a balance to carry forward of £215,146.

## NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES, LIENS, &c.

### NEW COMPANIES.

**ACCESSIBLE BATTERY & ENGINEERING CO. (LTD.)** (87,644.)—Reg. Feb. 19, capital £1,500 in £1 shares, to acquire business carried on as the Accessible Electric Battery Co., to adopt an agreement with A. J. Fippard and C. L. Cartwright, and to carry on the business of electrical, mechanical, and chemical engineers, electricians, suppliers of electricity, manufacturers of and dealers in electric batteries, cells, and other apparatus, &c. Subscribers, C. B. Marshall, T. Hucklebridge, A. J. Fippard, electrical engineer, C. L. Cartwright, C.E., D. W. Ratliff, electrical engineer, E. Ward, electrical engineer, and H. Childs. First managing directors, A. J. Fippard and C. L. Cartwright (both permanent). Reg. office, Victoria-street, Westminster, London.

**A. T. BOULTON & CO. (LTD.)** (87,799.)—Reg. March 2, capital £1,000 in £1 shares, to acquire the business carried on by H. Maskell as A. T. Boulton & Co., and to carry on the business of electrical and mechanical engineers, art metal dealers, ironmongers, manufacturers of and dealers in electrical appliances and machinery, &c. Reg. office, 19, Craven-terrace, Paddington, London, W.

**CALEDONIAN ELECTRIC WIRE CO. (LTD.)** (6,109.)—Reg. in Edinburgh on Feb. 19, capital £2,000 in £1 shares, to cover and insulate wires, cables ane other metal conductors used for electrical or other purposes, and to carry on the business of electricians, electrical and mechanical engineers, &c. First directors, Henry W. Warde, Percy J. Sims and W. J. Walker. Reg. office, 65, Renfield-street, Glasgow.

**W. G. CANNON & SONS (LTD.)** (87,796.)—Reg. March 1, capital £3,000 in £1 shares, to acquire and carry on the business of electrical, gas and steam engineers, &c., carried on as W. G. Cannon & Sons. First directors, J. A. Cannon, A. C. Cannon and W. V. Cannon. Reg. office, 107, London-road, Southwark, S.E.

**COMMERCIAL INDIA RUBBER MFG. & SUPPLY CO. (LTD.)** (87,760.) Reg. Feb. 28, capital £5,000 in £1 shares, to acquire business carried on as the Commercial India Rubber Mfg. & Supply Co. and to manufacture and deal in indiarubber and rubber goods, including electrical appliances and requisites. First directors, F. W. Ingram and S. Baster.

**IMPROVED ELECTRIC TRACTION (LTD.)** (87,822.)—Reg. March 3, capital £15,000 in £1 shares, to acquire certain contracts and properties and to carry on the business of proprietors and manufacturers of motors, motor cars, engineers, electricians, &c. Reg. office, 60, Coleman-street, London, E.C.

**KRYPTOL SYND. (LTD.)** (87,682.)—Reg. Feb. 21, capital £15,000 in £1 shares, to acquire the British patents, trade marks and rights in respect of "Kryptol," and to carry on the business of electrical, mechanical and general engineers, founders, metal workers, &c. Subscribers, A. Voelker, electro-chemist, H. Hälssen, G. H. Daniell, C. Tucker, C. H. Barham, A. Gallenkamp, and A. E. Glover. First directors, A. Voelker and H. Hälssen. Reg. office, 6-8, Scrutton-street, Finsbury, London, E.C.

**LLEWELLINS & JAMES (LTD.)** (87,662.)—Reg. Feb. 20, capital £100,000, to acquire the business of Llewellins & James, electricians, mechanical and general engineers, makers of electrical plant, &c. First directors, J. H. Howell (permanent governing director), H. L. Wethered, and C. A. Palmer.

**NAIROBI ELECTRIC POWER & LIGHTING CO. (LTD.)** (87,728.)—Reg. Feb. 23, capital £30,000 in £1 shares (12,000 preference), to adopt an agreement with Z. Hirtzel and to carry on in the said Protectorate and elsewhere the business of producers, suppliers and sellers of electricity, &c. Subscribers, Gen. Sir S. de Burgh Edwardes (100 shares), E. M. Preston, engineer (2,000 shares), Major L. H. Vidal (100 shares), A. G. Preston, engineer (1,000 shares), and W. H. Hooker, T. A. Glenny, and J. H. Parker (10 shares each). First directors, Gen. Sir S. de Burgh Edwardes, K.C.B., E. M. Preston, and Major L. H. Vidal. Reg. offices, 28, Martin's-lane, Cannon-street, London, E.C.

**RHONDDA TRAMWAYS CONSTRUCTION SYND. (LTD.)** (87,772).—Reg. Feb. 28, capital £250,000 in 2,500 shares of £100 each, to construct and equip tramways authorised by the Rhondda Urban District Council (Tramways, &c.) Act, 1902, and to electrify the existing horse tramways belonging to Rhondda District Council. The Council has undertaken to grant a 42 years' lease of the tramways (when constructed) to the Rhondda Tramways Co. at an annual rent of £2,250. This syndicate will receive from the Rhondda Tramways Co. for the construction and equipment, debentures and shares not exceeding £450,000. The syndicate has entered into a contract with the National Electric Construction Co. for the construction and equipment of the tramways, and the National Electric Construction Co. has contracted with the Rhondda Tramways Co. to manage the tramways for six months after they are opened for public traffic, or longer if required. It is not intended to erect a generating station, but negotiations are in progress for obtaining supply in bulk. The subscribers are L. B. Schlesinger, J. C. Saunders, B. Bernheim, J. T. Jervis, M.Inst.C.E., W. B. Cownie, M. M. Keyser, and E. Morley. First directors, L. B. Schlesinger, J. C. Saunders and B. Bernheim. Secretary and reg. office, W. B. Cownie, Qneen Anne's Chambers, Westminster, S.W.

**ST. HELENS CABLE & RUBBER CO. (LTD.)** (87,774.)—Reg. Feb. 28, capital £10,000 in £1 shares, to acquire the business of the St. Helens Cable Co. (Ltd.), to adopt an agreement with Callender's Cable & Construction Co., the British Insulated & Helsby Cables and Siemens Bros. & Co., and to carry on the business of cable makers, manufacturers of indiarubber goods, wire rope makers, suppliers of electricity, electricians, electrical and mechanical engineers, &c. The number of directors is to be three, one of whom is to be appointed by holders of shares numbered 10 to 4,206 (known as Callender Co. shares), one by holders of shares numbered 4,207 to 8,703 (known as the B.I. Co. shares) and the third by holders of the remaining shares, numbered 8,704 to 10,000 (known as the Siemens Co. shares). First directors, T. O. Callender, J. Taylor and G. von Chauvin. Reg. office, Warrington, Lancs.

### STATUTORY RETURNS.

**CENTRAL ELECTRIC SUPPLY CO. (LTD.)**—According to return to Feb. 13 capital is £100,000 in £5 shares, all of which have been taken up and paid for in full. Mortgages and charges, £336,876 4 per cent. guaranteed debenture stock.

**DIRECT UNITED STATES CABLE CO. (LTD.)**—In return to Feb. 13 capital is £1,300,000 in 65,000 shares of £20 each, of which 60,710 have been taken up. £1,214,200 is considered as paid. Mortgages and charges, nil.

**EASTERN TELEGRAPH CO. (LTD.)**—The return to Feb. 7 gives capital as £6,000,000 in £4,000,000 ordinary and £2,000,000 preference stock, of which £3,999,890 ordinary and £2,000,000 preference have been taken up. £5,999,890 has been received. Mortgages and charges, £1,907,704.

**ELECTRIC CANAL HAULAGE CO. (LTD.)**—Return to Feb. 19 gives capital as £3,000 in £1 shares, of which seven have been taken up. £7 has been received. Mortgages and charges, nil.

**EUROPE & AZORES TELEGRAPH CO. (LTD.)**—In return to Feb. 8 the capital is £200,000 in 20,000 shares of £10 each, of which 18,146 have been taken up. £10 per share has been called up on 12,578 and £125,780 has been received. £55,680 is considered as paid on 5,568 shares. Mortgages and charges, nil.

**GENERAL ELECTRICAL INSPECTION CO. (LTD.)**—According to return to Feb. 12 the capital is £10,000 in £1 shares, of which 1,907 have been taken up. £7 has been received and £1,900 is considered as paid. Mortgages and charges, nil.

**LANCASHIRE ELECTRICAL ENGINEERING CO. (LTD.)**—In return to May 6, 1905 (filed Dec. 31) capital is £5,000 in £1 shares, 1,883 of which have been taken up. £50 has been received and £1,833 is considered as paid. Mortgages and charges nil.

**MORLEY ELECTRICAL ENGINEERING CO. (LTD.)**—Return to Feb. 13 gives capital as £5,000 in £1 shares, of which 1,524 have been taken up. £504 has been received and £1,020 is considered as paid. Mortgages and charges £1,000.

### MORTGAGES AND CHARGES.

**BRITISH PROMETHEUS CO. (LTD.)**—A memorandum of satisfaction in full of debentures, dated Nov. 7, 1903, securing £2,250, has been filed.

**LLANGOLLEN & DISTRICT ELECTRIC LIGHT & POWER (LTD.)**—An agreement for further charge, dated Feb. 23, 1906 (endorsed on debenture dated Feb. 4, 1905), to secure £600, charged on company's undertaking and property, present and future, including uncalled capital, has been registered. Holder, S. L. Jones.

**W. R. SYKES INTERLOCKING SIGNAL CO. (LTD.)**—A trust deed dated Feb. 27, 1906, to secure £15,000 debenture stock, has been registered. Property charged, leasehold premises at Clapham and company's general assets, except uncalled capital. Trustees, J. E. Nichols and A. H. Johnson.

**TYPEWRITING TELEGRAPH CORPN. (LTD.)**—Issue on Feb. 16 of £410 debentures, part of series created Nov. 14, 1904, to secure £3,000, charged on company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series, £740.

## CITY NOTES.

**MEMORANDA** (March 8).—Bank rate 4 per cent. (since Sept. 28, 1905). Price of silver $29\frac{11}{16}$d. per oz. Consols $90\frac{7}{16}$—$90\frac{9}{16}$ for money, $90\frac{11}{16}$—$90\frac{13}{16}$ for account; $2\frac{1}{2}$ per cent. annuities $89\frac{1}{2}$—$89\frac{3}{4}$. Consols Pay Day, April 4. Stocks and Shares Continuation Day, March 26; Ticket Day, March 27. Pay Days, March 9 and 28; Mining Share Carry-over Day, March 23.

**BOURNEMOUTH & POOLE ELECTRICITY SUPPLY CO. (LTD.)**—The transfer books and register of members will be closed from 10th to 21st inst. inclusive, preparatory to payment of dividend on the ordinary shares for the year ended Dec. 31.

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. No. of weeks | Aggregate. Amount. | Aggregate. Inc. or Dec. (a) |
|---|---|---|---|---|---|---|
| | | £ | £ | | £ | £ |
| Aberdeen Corporation | March 3 | 1,109 | − 5 | 40 | 54,405 | − 845 |
| Airdrie | Feb. 23 | 211 | + 28 | 8 | 1,606 | + 178 |
| Anglo-Argentine | March 4 | 15,747 | + 2,018 | 9 | 132,717 | + 13,940 |
| Ayr Corporation | ,, 3 | 180 | − 2 | 41 | 12,170 | − 79 |
| Barnsley | Feb. 23 | 160 | + 8 | 8 | 1,159 | + 14 |
| Barrow | ,, 23 | 200 | + 23 | 8 | 1,528 | + 151 |
| Bath Electric Trams, Ltd | ,, 28 | 620 | + 114 | 9 | 5,612 | + 842 |
| Birkenhead Corporation | ,, 4 | 1,028 | + 78 | 9 | 9,131 | + 79 |
| Birmingham Corporation | March 3 | 408 | + 21 | 48 | 17,998 | + 2,254 |
| *Birmingham & Mid. | Feb. 23 | 1,370 | − 338 | 8 | 10,339 | − 2,680 |
| Blackpool Corporation | March 1 | 809 | + 10 | 9 | 48,203 | + 2,035 |
| Blackpool and Fleetwood | ,, 3 | 212 | − 5 | 9 | 1,623 | − 88 |
| Bolton Corporation | ,, 4 | 1,951 | + 277 | 49 | 93,443 | + 4,941 |
| Bournemouth Corporation. | ,, 1 | 1,265 | + 389 | †48 | 67,221 | + 15,833 |
| Bradford Corporation | ,, 3 | 3,927 | + 255 | 48 | 207,918 | + 2,324 |
| Brighton Corporation | ,, 4 | 750 | − 3 | 49 | 47,409 | + 475 |
| Bristol Trams & Carriage | ,, 2 | 4,793 | + 308 | 8 | 14,007 | + 825 |
| Buenos Ayres & Belgrano | ,, 4 | 3,784 | + 589 | 9 | 81,618 | + 3,080 |
| Buenos Ayres Elec. Trms | Feb 3 | 1,384 | + 256 | 5 | 6,951 | + 1,584 |
| Burnley Corporation | March 3 | 1,047 | + 105 | 48 | 62,649 | + 8,455 |
| Burton Corporation | ,, 4 | 274 | − 24 | §48 | 1,464 | − 1,655 |
| Bury Corporation | Feb 25 | 756 | ... | §47 | 35,745 | ... |
| Calcutta Tramways Co. | March 3 | R42,722 | − R852 | 9 | R403,548 | + R44,657 |
| Camborne-Redruth | ,, 3 | 108 | + 10 | 18 | 1,911 | + 43 |
| Cardiff | ... | ... | ... | ... | ... | ... |
| Carlisle Tramways Co. | ... | ... | ... | ... | ... | ... |
| Cavehill | Feb. 23 | 78 | + 41 | 8 | 298 | + 21 |
| Central London Railway | March 3 | 7,060 | − 164 | 9 | 62,825 | − 2,088 |
| Chatham & Dist. Lt. Rys. | ,, 1 | 545 | − 8 | †9 | 4,916 | − 58 |
| *City of Birm'gh'm Tram Co. | Feb. 23 | 5,152 | − 104 | 8 | 39,699 | − 686 |
| City & South London Rly. | March 4 | 2,908 | − 56 | 9 | 27,091 | + 133 |
| Colchester Corporation | ,, 1 | 155 | + 10 | §9 | 5,680 | − 1,484 |
| Cork Electric Trams Co. | ... | ... | ... | ... | ... | ... |
| Devonport & Dist. Trams | Feb. 23 | 878 | − 16 | 8 | 3,129 | − 194 |
| Dover Corporation | ,, 3 | 176 | + 13 | ‡48 | 10,615 | + 88 |
| Dublin & Lucan Railway | March 2 | 91 | + 2 | §9 | 760 | − 68 |
| Dublin United | ,, 2 | 4,469 | + 178 | ‡9 | 89,652 | + 1,441 |
| Dudley—Stourbridge | Feb. 23 | 753 | + 40 | 8 | 5,704 | + 300 |
| Dundee Corporation | ,, 28 | 936 | + 157 | §41 | 88,692 | + 3,482 |
| East Ham Council | March 3 | 823 | + 192 | 48 | 89,610 | + 5,609 |
| Gateshead & Dist. Trams | Feb. 23 | 911 | + 33 | 8 | 7,056 | + 395 |
| Glasgow Corporation | March 3 | 15,027 | + 942 | 40 | 607,521 | + 89,849 |
| Glossop | ,, 3 | 180 | + 22 | 9 | 1,106 | + 171 |
| Gloucester Corporation | Feb. 28 | 212 | + 5 | 48 | 13,639 | + 1,154 |
| Gravesend—Northfleet | ,, 23 | 128 | + 3 | 8 | 1,492 | + 77 |
| Gt. Northern & City Rly. | March 3 | 1,877 | + 119 | 9 | 16,349 | + 485 |
| Greenock & Port Glasgow | Feb. 23 | 529 | + 67 | 8 | 4,317 | + 898 |
| Halifax Corporation | ,, 28 | 1,229 | + 91 | 48 | 74,042 | + 5,401 |
| Hartlepool Tramways | ,, 23 | 246 | ... | 8 | 1,938 | + 101 |
| Hastings Elec. Trams Co. | March 1 | 830 | ... | 9 | 3,146 | ... |
| Huddersfield | ,, 3 | 1,332 | + 126 | 48 | 65,360 | + 3,810 |
| Hull Corporation | ,, 3 | 2,136 | + 45 | 48 | 106,932 | + 2,184 |
| Ilford Dist. Coun. | ,, 3 | 406 | + 61 | 48 | 22,233 | + 1,043 |
| Ipswich Corporation | ,, 3 | 810 | + 12 | 48 | 20,064 | − 1,881 |
| Isle of Thanet Co. | ,, 3 | 289 | ... | 21 | 5,638 | − 456 |
| Kidderminster & District | Feb. 23 | 89 | + 2 | 8 | 689 | + 1 |
| Kilmarnock Corporation | March 3 | 137 | − 4 | 42 | 6,525 | ... |
| Kirkcaldy Corporation | Feb. 28 | 168 | − 3 | 26 | 5,082 | − 96 |
| Lanarkshire Trams Co. | March 1 | 771 | + 151 | †9 | 7,328 | + 1,714 |
| Leamington | Feb. 28 | 128 | + 54 | 8 | 903 | + 268 |
| Leeds Corporation | March 3 | 5,625 | + 817 | 49 | 286,777 | + 9,187 |
| Leicester Corporation | ,, 3 | 2,160 | + 168 | 9 | 17,661 | + 2,400 |
| Leith Corporation | Feb. 24 | 405 | + 212 | 40 | 14,571 | + 10,919 |
| Liverpool Overhead Rly. | March 4 | 1,421 | + 1 | 9 | 12,519 | − 650 |
| Liverpool Corporation | Feb. 24 | 9,976 | + 589 | 8 | 80,248 | + 8,071 |
| *London-County Council | ,, 24 | 18,620 | + 530 | 47 | 668,727 | + 90,024 |
| Lowestoft | March 3 | 104 | − 12 | 22 | 8,031 | − 55 |
| Maidstone Corporation | ,, 1 | 78 | − 12 | 48 | 5,674 | ... |
| Manchester Corporation | ,, 3 | 12,880 | + 1,024 | 48 | 615,781 | + 81,942 |
| Merthyr | Feb. 23 | 176 | + 2 | 8 | 1,821 | − 10 |
| Metropolitan Dist. Railway | March 4 | 8,148 | + 878 | 9 | 73,821 | + 4,034 |
| *Metropolitan Elec. Trams | Feb. 23 | 2,515 | + 675 | 8 | 20,736 | + 6,213 |
| Middleton | ,, 23 | 294 | + 42 | 8 | 2,184 | + 166 |
| Nelson Corporation | March 3 | 127 | + 24 | 49 | 6,890 | + 732 |
| Newcastle-on-Tyne Corp. | ,, 3 | 3,566 | + 5 | 48 | 182,271 | + 4,411 |
| Newport (Mon.) | ,, 3 | 542 | + 42 | 22 | 12,605 | + 946 |
| Northampton Corporation | ,, 2 | 859 | + 20 | 48 | 20,242 | + 5,279 |
| Oldham, Ashton & Hyde | Feb 23 | 513 | + 39 | 8 | 8,878 | + 182 |
| Oldham Corporation | March 4 | 1,618 | + 267 | 49 | 79,611 | + 17,984 |
| Perth (N.B.) Corporation | Feb. 21<br>,, 28 | 127<br>119 | ...<br>... | 17 | 2,464 | ... |
| Perth (W. A.) Elec Trams | March 2 | 1,556 | + 55 | ‡9 | 13,926 | + 643 |
| Peterborough | Feb 23 | 94 | − 4 | 8 | 787 | − 81 |
| Portsmouth Corporation | March 3 | 1,428 | + 41 | 48 | 91,567 | + 1,736 |
| Potteries | Feb. 23 | 1,784 | + 106 | 8 | 13,296 | + 824 |
| Preston Corporation | ,, 23 | 551 | + 8 | 8 | 4,633 | ... |
| Reading Corporation | March 3 | 528 | + 10 | ... | ... | ... |
| Rotherham Corporation | ,, 1 | 422 | + 47 | 48 | 21,769 | − 63 |
| Rothesay | Feb. 18 | 42 | + 3 | 8 | 286 | + 46 |
| Salford Corporation | March 5 | 4,220 | + 411 | 49 | 207,764 | + 12,362 |
| Sheerness | Feb. 21 | 45 | − 13 | 8 | 258 | − 42 |
| Sheffield Corporation | March 4 | 4,988 | + 496 | 49 | 241,819 | + 14,697 |
| Southampton Corporation. | Feb. 23 | 835 | + 78 | 21 | 18,556 | + 91 |
| Southend Corporation | ,, 28 | 231 | + 25 | 48 | 17,419 | + 1,066 |
| Southport Tramways | ,, 23 | 222 | + 7 | 8 | 1,770 | + 49 |
| S. Staffordshire Trams. | ,, 23 | 759 | + 127 | 8 | 5,854 | + 982 |
| Stockport Corporation | March 2 | 786 | + 324 | 48 | 36,446 | + 10,551 |
| Sunderland Corpn. | ,, 4 | 1,192 | + 87 | 48 | 68,038 | + 2,924 |
| Swansea Trams | Feb. 23 | 625 | + 200 | 8 | 5,678 | + 2,019 |
| Swindon Corporation | ,, 21<br>,, 28 | 160<br>151 | − 1<br>+ 4 | 48 | 9,243 | ... |
| Taunton | ,, 23 | 42 | + 6 | 8 | 322 | + 22 |
| Tynemouth and District | ,, 28 | 159 | − 2 | 8 | 1,227 | − 58 |
| Tyneside Trams Co. | ,, 21 | 364 | + 27 | 8 | 2,548 | + 72 |
| Wallasey District Council | March 3 | 686 | + 28 | 48 | 86,927 | + 1,516 |
| Warrington Corporation | ... | ... | ... | ... | ... | ... |
| West Ham Corporation | ,, 1 | 1,925 | + 862 | 47 | 88,276 | + 38,024 |
| Weston-super-Mare | Feb. 21 | 26 | − 2 | 8 | 192 | − 10 |
| Wolverhampton Corpn. | ,, 28 | 716 | ... | ... | ... | ... |
| *Wolverhampton District | ,, 23 | 391 | + 36 | 8 | 2,828 | + 227 |
| *Worcester | ,, 28 | 224 | − 15 | 8 | 1,812 | − 94 |
| Wrexham | ,, 28 | 87 | − 6 | 8 | 690 | − 16 |
| Yorkshire W.R. Trams | March 4 | 782 | + 217 | 9 | 5,985 | + 1,872 |
| Yorkshire Woollen District | Feb. 28 | 824 | + 280 | 8 | 6,286 | + 2,176 |

(a) These comparisons are with the corresponding period last year. † Minus 8 days. ‡ Minus 2 days. § Plus 2 days. ¶ Plus 8 days. * Partly electrical.

**DAVIS & TIMMINS (LTD.)**—The directors recommend payment of the six months' preference dividend and 12 months' dividend on the ordinary shares at the rate of 8 per cent. per annum.

**DIRECT SPANISH TELEGRAPH CO. (LTD.)**—In addition to the dividend at the rate of 10 per cent. per annum on the preference shares, the directors have decided to pay a dividend at the rate of 4 per cent. (tax free) on the ordinary shares for the half-year ended Dec. 31, payable April 2.

**GENERAL ELECTRIC CO. (LTD.)**—The transfer books of the 4 per cent. debenture stock will be closed from 19th to 31st inst. inclusive.

**MACKAY COMPANIES.**—The regular quarterly dividend of 1 per cent. on the preferred shares will be paid on April 2. The transfer books will be closed from March 19 to 31 inclusive.

**RAND CENTRAL ELECTRIC WORKS (LTD.)**—During February 824,000 kw-hours were generated, yielding a gross revenue of £7,700, compared with 739,000 units and £6,950 in the corresponding month of 1905.

**STOCK EXCHANGE NOTICES.**—The Stock Exchange Committee have been asked to grant quotations to a further issue of 3,000 £10 fully paid ordinary shares of the *Bournemouth & Poole Electricity Supply Co. (Ltd.)* and $53,000,000 $1,000 4 per cent. collateral trust bonds of the *American Telephone & Telegraph Co.*

**WESTERN TELEGRAPH CO. (LTD.)**—The directors have declared an interim dividend (payable 24th inst.) of 3s. per share (or at rate of 6 per cent. per annum), tax free, for the quarter ended Dec. 31. The transfer books will be closed from 17th to 23rd inst. inclusive.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Mar. 7. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Mar. 7. Highest. | Business, Week to Mar. 7. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | £ s. d. | | | |
| 5 | 8/0 | Anglo-Argentine Ord. Shares | $8\frac{13}{16}$—$9\frac{1}{16}$ | 4 8 0 | Ap, Oct | $8\frac{13}{16}$ | $8\frac{7}{8}$ |
| 5 | 2/9 | Do. 5½% Cum. Pref. | $5\frac{7}{8}$—$6\frac{1}{8}$ | 4 10 0 | — | $6\frac{3}{32}$ | 6 |
| St. | 6% | Do. Permanent 6% Deb. Stock | 141 —144 | 4 3 3 | — | .. | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 104 —106 | 4 14 3 | — | $105\frac{1}{8}$ | $104\frac{1}{2}$ |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1 —$1\frac{1}{2}$ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | $3\frac{7}{8}$—$4\frac{1}{8}$ | 6 1 4 | — | $4\frac{1}{16}$ | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 113 —116 | 4 13 9 | — | .. | — |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 120 —123 | 4 17 6 | — | .. | .. |
| St. | 5% | Do. Pref. Ord. Stk | 110 —113 | 4 8 4 | — | $110\frac{1}{2}$ | .. |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock. | 108 —111 | 4 10 0 | — | .. | — |
| 40 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%—105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 102 —105 | 4 5 0 | — | $104\frac{3}{4}$ | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | $3\frac{1}{2}$—$3\frac{3}{4}$ | 5 6 6 | — | $3\frac{5}{8}$ | $3\frac{11}{16}$ |
| 5 | 8/0 | Do. 6 per Cent. "A" Cm. Pref. | $5\frac{7}{8}$—$6\frac{1}{8}$ | 4 13 0 | — | .. | .. |
| 5 | 8/0 | Do. "B" | $6\frac{1}{4}$—$6\frac{3}{4}$ | 5 4 0 | — | $5\frac{5}{8}$ | .. |
| St. | 5% | Do. 5 per Cent. Debs. | 106 —108 | 4 12 6 | — | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102 —105 | 4 15 0 | — | .. | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 99 —101 | 4 19 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 102 —106 | 5 4 3 | .. | 104 | — |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 102 —106 | 5 13 0 | .. | .. | .. |
| 5 | 5/6 | Calcutta Tramways (Nos. 1 to 105) | $9\frac{5}{8}$—$10\frac{1}{8}$ | 4 4 0 | — | 10 | $9\frac{13}{16}$ |
| 5 | 2/6 | Do. Nos. 105,001 to 137,610 | 9 —$9\frac{1}{2}$ | .. | .. | .. | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 106 —108 | 4 3 8 | — | .. | .. |
| 1 | 0/6 | Cape Electric Tram Shares | $\frac{5}{8}$—$\frac{7}{8}$ | 5 11 0 | — | .. | — |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 102 —104 | 4 16 0 | — | .. | — |
| .. | 5% | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 96 —98% | 5 2 0 | .. | 97 | $96\frac{5}{8}$ |
| St. | .. | Kalgoorlie Elec. Trams 5% "A" Deb. Stock | 91 —93 | .. | .. | .. | .. |
| St. | .. | Do. 6% "B" Ditto | 83 —88 | .. | .. | $84\frac{1}{2}$ | $82\frac{1}{2}$ |
| 1 | .. | Lisbon Elec. Trams Ord. | $1\frac{7}{16}$—$1\frac{9}{16}$ | .. | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | $1\frac{1}{8}$—$1\frac{3}{8}$ | 4 7 4 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 100 —103 | 4 17 0 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 101 —103 | 4 17 0 | Ja, Jul | .. | .. |
| 100 | 5% | †Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101 —103 | 4 17 0 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102 —104 | 4 6 6 | — | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 105 —108 | 4 12 6 | .. | . | .. |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 147 —149 | 5 7 3 | .. | .. | .. |
| .. | 5% | Do. 5% 1st Mt. $500 Dbs. | 99%—101% | 4 19 0 | .. | 100 | $99\frac{1}{2}$ |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | — | Adelaide Elec. S'ply Co. 6% Cu. Pr. | $4\frac{3}{4}$—$5\frac{1}{4}$ | — | .. | .. | .. |
| 5 | 3/8 | Calcutta Elec. (1-60,000) | 9 — $9\frac{1}{2}$ | 4 6 6 | — | .. | — |
| 10 | 5% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbr. | 50 —52 | 4 16 0 | .. | .. | .. |
| .. | 5% | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 94 —96 | 5 4 0 | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | $2\frac{1}{2}$— 3 | .. | .. | .. | — |
| St. | 5% | Do. 5% Debs. | 88 —92 | 5 9 4 | — | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | $7\frac{3}{4}$— $8\frac{3}{4}$ | — | — | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92 —94 | 5 6 8 | .. | .. | .. |
| St. | 26/2 | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. | 110 —113 | 5 6 0 | .. | $111\frac{1}{2}$ | 111 |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | $\frac{7}{8}$—1 | 6 0 0 | — | $\frac{31}{32}$ | $\frac{15}{16}$ |
| 1 | 1/0 | Rand Electric | $1\frac{5}{16}$—$1\frac{7}{16}$ | .. | — | .. | — |
| 1 | .. | River Plate Electricity Co. Ord. | $\frac{9}{16}$—$\frac{11}{16}$ | .. | .. | $\frac{5}{8}$ | .. |
| 1 | 1/2⅞ | Do. 6% Non. Cum. Pref. | $\frac{15}{16}$—$1\frac{1}{16}$ | .. | .. | 1 | $\frac{31}{32}$ |
| St. | 5% | Do. 5% Deb. Stock | 101 —103 | 4 17 0 | .. | .. | .. |
| 5 | 8/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | $5\frac{1}{4}$—$5\frac{3}{4}$ | 5 4 4 | .. | .. | — |
| 5 | 9·13d | Do. (12,001-20,000) | 5 —$5\frac{1}{2}$ | 3 8 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100 —103 | 4 7 5 | Ap, Oct | — | ... |
| .. | 5% | Shawinigan Water and Power 5% Bds., Scrip | 102 —104 | 4 16 0 | .. | — | .. |

* In calculating the yield, allowance has been made for accrued interest but not for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

### ELECTRICITY SUPPLY.

| Shre. | Last Dividend | Name. | Price Wed., Mar. 7. | Rate % Yielded £ s. d | Dividend Due | Business, Week to Mar. 7. Highest | Lowest |
|---|---|---|---|---|---|---|---|
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12⅛—12⅝ | 6 6 0 | .. | .. | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref. | 10—10½ | 4 5 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11—12 | 5 0 0 | .. | 11⅛ | — |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 106—108 | 4 3 3 | .. | [illegible] | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 103—106 | 4 5 0 | — | .. | .. |
| 5 | 4/6 | Brompton & Kensington Elec. Sup. Ord. | 8½—9½ | 5 8 6 | — | 8 11/16 | 8¾ |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 8½—9½ | 3 14 5 | Mar, Sept | .. | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 102—105 | 3 16 3 | — | 104 | .. |
| 5 | 2/6 | †Charing Cross (W. End & City) El. Sup. Co. | 4¾—5¼ | 4 15 0 | Feb, Aug | 5 1/16 | 4⅞ |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 4⅞—5⅛ | 4 8 6 | Feb, Aug | 4 15/16 | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 101—103 | 3 17 6 | — | .. | .. |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4½—4¾ | 4 14 9 | — | 4½ | .. |
| 5 | 2/3 | Do. Do. (1903) | 4½—4¾ | 4 14 9 | .. | .. | .. |
| 5 | 2/3 | Chelsea Electric Supply Ord. | 5¼—5¾ | 5 4 6 | March .. | — | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 108—110 | 4 1 6 | Jn, Dec .. | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 10¾—11¾ | 5 2 0 | Feb, Aug | 11 3/16 | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13¾—14¼ | 4 4 2 | Jan, July | 13 7/16 | 13¾ |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 123—126 | 3 19 4 | Jn, Dec .. | — | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 100—102 | 4 8 8 | .. | .. | .. |
| 5 | 4% | County of Durham Elec. P.D. Ord. £2 pd. | 2 1/16—2 3/32 | 3 17 8 | April, Oct | 2 1/16 | .. |
| 5 | 5% | Do. Do. 5% non cum. pref. | 5¼—5⅜ | 4 13 0 | April, Oct | .. | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 8½—9½ | 4 6 6 | — | 8 15/16 | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅜—12⅞ | 4 13 0 | Mar, Sept | 12 9/16 | 12½ |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 109—112 | 4 0 4 | .. | 110½ | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 101—103 | 4 7 6 | .. | 102¼ | 102 |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5—5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101—104 | 4 6 6 | — | .. | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8½—9 | 4 14 0 | .. | 8½ | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100—103 | 4 7 5 | — | .. | — |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 10½—11½ | 6 4 0 | .. | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½—7 | 4 5 9 | Jan, July | — | — |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98—101 | 3 19 2 | .. | .. | — |
| St. | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 103—105 | 3 16 0 | .. | .. | .. |
| 3 | 1/9⅜ | London Electric Supply Ord. | 2⅝—2⅞ | 3 2 6 | .. | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5⅝—5⅞ | 5 9 6 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 98—101 | 3 19 2 | Mr, Jn, S, D | 99½ | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 8½—9½ | 5 10 6 | April, Oct | 9¼ | 9 |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5⅜—5⅝ | 4 0 0 | Jan. July | 5 7/16 | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 110—114 | 3 19 0 | Jn, Dec .. | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 95—97 | 3 12 8 | — | 96 | 95½ |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 101—103% | 4 7 4 | — | .. | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 11¾—12 | 5 13 8 | Feb, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 101½—102½ | 4 6 6 | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 8 1/16—8 3/16 | 4 18 5 | Feb, Aug | 8⅛ | 8 |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6—6¼ | 4 1 4 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99—101 | 3 19 7 | Jan, July | .. | .. |
| 1 | 3% | Northern Counties Elec. Sup. | 15/16—31/32 | 3 2 6 | Mar, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 101—102 | 4 7 6 | Jan, July | — | — |
| 10 | 6/0 | Notting Hill Electric Ord. | 13½—14½ | 4 16 8 | March | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98—100 | 4 0 0 | .. | .. | .. |
| 5 | 2/6 | Oxford Electric Ord. | 6½—7 | 5 0 0 | March .. | .. | .. |
| St. | 4% | Do. 4% Deb. Stock | 99—101 | 3 19 0 | — | .. | .. |
| 5 | 7/6 | †St. James' & Pall Mall Elec. Ord. | 9—10 | 6 5 0 | Feb, Aug | 11 | 9¾ |
| 5 | 3/6 | † Do. 7 per Cent. Pref. | 7—8 | 4 7 0 | Feb, Aug | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 97—99 | 3 10 9 | — | .. | .. |
| 5 | 4/0 | †Smithfield Markets Electric Sup. Ord. | 2¼—2¾ | 8 4 0 | .. | 2 15/32 | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76—80 | 5 0 0 | — | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 3¼—3¾ | 5 6 8 | .. | .. | .. |
| 1 | .. | South Metrop'n Elec. Lt. & Power Ord. | ¾—⅞ | .. | .. | .. | — |
| 1 | 0/8⅜ | Do. 7% Cum. Pref. | 1¼—1⅜ | 5 2 0 | .. | 1 11/32 | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105—108 | 4 3 8 | — | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4½—4¾ | 5 5 0 | — | 4½ | 4⅝ |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5—5¼ | 4 16 8 | — | 5 3/16 | 5 3/32 |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 104—106 | 4 5 0 | .. | .. | .. |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 10—11 | 5 18 0 | Mar, Sept | 10¾ | 10 5/16 |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5 5/16—5 9/16 | 4 10 0 | .. | 5 5/16 | 5 5/16 |
| 5 | .. | Do. £1 and 7/6 premium paid | 1⅛—1½ | .. | .. | .. | .. |

### ELECTRIC RAILWAYS, TRAMWAYS, &c.

| Shre. | Last Dividend | Name. | Price Wed., Mar. 7. | Rate % Yielded £ s. d | Dividend Due | Business, Week to Mar. 7. Highest | Lowest |
|---|---|---|---|---|---|---|---|
| 1 | — | Bath Elec. Trams Pref. Ord. | 15/16—1 1/16 | .. | .. | 1 | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16—1 1/16 | 4 14 9 | .. | 1 1/32 | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 102—104 | 4 6 6 | .. | 103½ | .. |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 101—103 | 4 7 9 | .. | 102¼ | .. |
| 10 | 9% | †Bristol Tramways and Carriage Ord. | 15½—16½ | 5 9 0 | Feb, Aug | .. | — |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10—10¼ | 3 18 0 | .. | .. | — |
| St. | 4% | Do. 4 per Cent. Debs. | 104—106 | 3 15 6 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 6—7 | 4 6 6 | — | 7½ | 6½ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 9½—10½ | 5 17 0 | Feb, Aug | 10 7/16 | 9 11/16 |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 117—120 | 4 3 4 | .. | 120¼ | 119 |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 98—100 | 4 10 0 | .. | 99½ | .. |
| St. | 4% | Central London Ordinary Stock | 91—93 | 4 6 0 | June, Dec | 92 | 91 |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 103—105 | 3 16 0 | .. | 104½ | .. |
| St. | 4% | Do. Deferred Stock | 81—83 | 4 15 0 | .. | 82¾ | 81¼ |
| 100 | 4% | Do. 4 per Cent. Debs. | 110—112 | 3 11 3 | .. | .. | .. |
| St. | 4% | Charing X, Euston & Hmpstd. Pr. Dl. Stk. | 96—98 | 4 1 6 | .. | 97⅛ | .. |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 5⅛—5⅜ | 4 13 0 | .. | 5⅜ | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 101—104 | 3 17 0 | .. | .. | .. |
| St. | 1¾% | City and South London Rly. Con. Ord. | 41—43 | 4 7 0 | Feb, Aug | 42½ | 42 |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 120—123 | 4 1 4 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 115—118 | 4 4 8 | .. | .. | .. |
| St. | 5% | Do. (1901) | 113—116 | 4 6 0 | — | .. | — |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 106—109 | 3 13 4 | May, Nov | 107 | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13¾—14¾ | 4 1 6 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½—15½ | 3 17 3 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 4½—5 | 8 0 0 | .. | 4 11/16 | .. |
| 10 | 4/0 | †Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8—9 | 4 8 11 | — | 8½ | .. |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 103—105 | 4 5 8 | .. | 104 | .. |
| 10 | 9% | †‡Imperial Tramways Ord | 15½—16½ | 5 9 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 12½—13 | 4 12 0 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 101—103 | 4 8 0 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2½—2¾ | 9 8 6 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 80—85 | 4 14 0 | — | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8 1/16—8 3/16 | 3 18 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾—10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99—102 | 3 19 8 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9—9½ | 5 5 0 | — | 9 5/16 | 9¼ |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 92—95 | 4 4 0 | — | 93¼ | 93¼ |
| St. | .. | Mersey Con. Ord. Stock | 6—8 | — | — | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8—11 | — | — | .. | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | [illegible]—9/32 | .. | — | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1—1 1/16 | 4 14 1 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104—106 | 4 5 0 | — | 104½ | 104¼ |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | [illegible]—1½ | .. | May — | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8½—9 | 5 15 0 | .. | 8 13/16 | 8 11/16 |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9¼—9¾ | 5 2 6 | Feb, Aug | 9½ | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103—106 | 4 5 0 | — | — | .. |
| 100 | 5% | Sunderland Dst. Elc. Trms. 5% 1st Mt. Db. | 92—95 | 5 6 0 | .. | .. | .. |
| .. | 5% | Underground Elec. Rys. Co. of London | 98—100 | 5 0 0 | .. | 98¾ | 98⅝ |
| St. | 3½% | †Waterloo and City Ord. | 101—104 | 3 7 8 | June, Dec | 101½ | 101 |
| St. | 4½% | Yorkshire W.R. El. Trs. Co. 4½% 1st Debs. | 95—97 | 4 13 0 | .. | 96½ | .. |

### ELECTRIC MANUFACTURING, &c.

| Shre. | Last Dividend | Name. | Price Wed., Mar. 7. | Rate % Yielded £ s. d. | Dividend Due | Business, Week to Mar. 7. Highest | Lowest |
|---|---|---|---|---|---|---|---|
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝—⅞ | 6 6 6 | — | — | .. |
| 1 | 10⅘d. | Aron El. Met. 6% Cm. Pf. | 1 7/16—1 9/16 | .. | .. | 1½ | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3⅞—4⅛ | 4 14 5 | .. | [illegible] | [illegible] |
| 1 | 7⅕d. | Do. Pref | 1 7/16—1 9/16 | 3 16 10 | .. | .. | .. |
| 5 | 4/0 | British Insulated & Helsby Cables Ord | 6—7¼ | 5 10 0 | July, Feb | 7 | [illegible] |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾—6¼ | 4 16 0 | Jan, July | [illegible] | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103—106 | 4 4 11 | .. | — | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db | 98—100 | 4 10 0 | .. | .. | .. |
| 5 | .. | British Westinghouse 6% Pref. | 1⅞—2⅛ | .. | .. | 2 1/16 | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 80—85 | 4 14 0 | .. | 82½ | .. |
| 2 | — | Brush Electrical Engineering | ⅝—⅞ | .. | March .. | [illegible] | .. |
| 2 | 2/4⅘ | Do. 6 per Cent. Pref. Non-Cum. | 1½—2 | 6 0 0 | Mar, Sept | .. | .. |
| St. | 4½% | † Do. 4½ per Cent. Perp. 1st Deb. Stock | 97—99 | 4 11 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 82—84 | 5 7 4 | Jan, July | .. | .. |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11—12 | 5 0 0 | Jan, July | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5¾—6 | 4 3 4 | Jan, July | [illegible] | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 108½—110½ | .. | Nov, May | .. | .. |
| 1 | 4⅘d. | Castner-Kellner Alkali Co. | 1 1/16—1 3/16 | 5 1 0 | .. | [illegible] | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 95—100 | 4 10 0 | — | .. | .. |
| 1 | 9⅗d. | Chadburn's (Ship) Telegraph Ord. | 1 3/16—1 5/16 | 7 10 0 | .. | [illegible] | [illegible] |
| 1 | 7⅕d. | Do. 6% Cum. Pref. | 1 1/16—1 3/16 | 5 8 0 | .. | .. | .. |
| 3 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 2—2¼ | 3 9 0 | Jan, July | .. | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 81%—83% | 6 2 0 | Jan, July | .. | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8¾—9¼ | 5 8 0 | Sept — | [illegible] | .. |
| 5 | 3/0 | Do. 6% Cum. Pref. | 6—6½ | 4 14 0 | Sept — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104—106 | 4 5 0 | .. | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅝—1⅞ | — | Feb, Aug | [illegible] | .. |
| 5 | 2/6 | Do. (£5 paid) | 2½—3 | — | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 86—88 | 4 11 0 | June, Dec | — | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92—97 | 5 3 1 | .. | .. | .. |
| 5 | 2/6 | Edmundson's Elec. Corp. Ord. | 4½—4¾ | 7 7 0 | H'lf-yearly | 4½ | .. |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5¼—5¾ | 5 4 6 | .. | 5½ | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 104—106 | 4 5 0 | .. | 104½ | [illegible] |
| 2 | 1/7½ | Electric Construction Co. | ½—¾ | 9 6 0 | July — | [illegible] | .. |
| 2 | 2/9⅗ | Do. 7 per Cent. Cum. Pref | 2—2½ | 5 12 0 | July .... | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 89—92 | 4 7 0 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9¼—9¾ | 5 4 6 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 96—99 | 4 1 0 | — | .. | .. |
| 5 | 5/0 | Henley's Telegraph Works Ord. | 13—14 | 5 7 0 | Feb, Aug | 13½ | [illegible] |
| 5 | 2/3 | † Do. 4½ per Cent. Pref. | 5¼—5½ | 4 2 0 | Feb, Aug | [illegible] | .. |
| 10 | 15/0 | India Rubber, Gutta Percha, &c., Wrks. | 18—19 | 2 12 6 | Feb, Aug | [illegible] | [illegible] |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99—102 | 3 18 5 | Mar, Sept | — | — |
| 10 | 5/0 | †Mather & Platt 5 per Cent. Cum. Pref. | 11¾—12¼ | 4 1 8 | Mar, Sept | .. | .. |
| 1 | 1/2⅖ | Richardsons, Westgarth & Co., Ltd. Ord. | 15/16—1 | 6 0 0 | .. | .. | .. |
| 1 | 7⅕d. | Do. 6% Cum. Pref. | 1—1⅛ | 5 7 6 | .. | .. | .. |
| St. | 4½% | Do. 4½% Perp. Deb. Stock | 100—102 | 4 8 8 | .. | 100¼ | .. |
| 12 | 17/6 | Telegraph Construction & Mainten'ce. | 34—36 | 5 0 0 | Mar, July | [illegible] | [illegible] |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 100—102 | 3 13 6 | Jan, July | .. | .. |
| 1 | 1/0 | Vickers, Sons & Maxim, Ltd., Ord. | 2⅝—2¾ | 4 8 6 | .. | [illegible] | [illegible] |
| 1 | 6d. | Do. 5% Non-Cum. Preference | 1 3/16—1 5/16 | 3 16 0 | .. | .. | .. |
| St. | 5% | Do. 5% Non-Cum. Preferred | 122—126 | 4 0 0 | .. | [illegible] | .. |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock Red. | 105—107 | 3 14 8 | .. | 106½ | .. |
| 100 | 4½% | Do. 4½% 2nd Mort. Debs., Red | 106—108 | 4 3 8 | .. | 108 | 107 |
| 5 | — | Willans and Robinson Ord. | 2¼—2¾ | — | Apr, Oct | [illegible] | [illegible] |
| 5 | — | Do. 6 per Cent. Cum. Pref. | 4—4½ | — | Apr. Oct | [illegible] | [illegible] |
| .. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 82—87 | 4 12 0 | May Nov | 85 | [illegible] |

### TELEGRAPHS.

| Shre. | Last Dividend | Name. | Price Wed., Mar. 7. | Rate % Yielded £ s. d. | Dividend Due | Business, Week to Mar. 7. Highest | Lowest |
|---|---|---|---|---|---|---|---|
| 100 | 4% | *African Direct Tel. 4% Mrt. Deb. (red.) | 99½—101½ | 3 18 6 | Jan, July | .. | .. |
| 10 | — | Amazon Telegraph | 3¾—4¼ | .. | Jn, Dec .. | .. | .. |
| 100 | 5% | Do. 5% Debs. (red.) | 83—88 | 5 18 6 | .. | .. | .. |
| St. | 21/0 | Anglo-American | 66—67 | 4 17 0 | F, My, Ag, N | [illegible] | [illegible] |
| St. | 32/0 | Do. Preferred | 113—114 | 5 5 4 | F, My, Ag, N | 19 | [illegible] |
| St. | 10/0 | Do. Deferred | 18¾—19 | .. | F, My Ag, N | [illegible] | [illegible] |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 97½—98½ | 4 0 6 | Jn Ap, Jy, O | [illegible] | [illegible] |
| 10 | 5/0 | Cuba Submarine Ord. | 8½—9 | 5 11 0 | Feb, Aug | .. | .. |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17—18 | 5 11 2 | Feb, Aug | .. | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜—3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 8½—9 | 5 11 0 | April, Oct | .. | .. |
| 100 | 4½% | Do. 4½ per Cent. Deb. | 100%—103% | 4 7 8 | Jan, July | [illegible] | [illegible] |
| 20 | 3/6 | Direct United States Cable | 15¼—15¾ | 4 6 0 | Ja, Ap, Jy, O | .. | .. |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 99½—101½ | 4 8 6 | Jn, Dec .. | [illegible] | [illegible] |
| St. | 25/0 | Eastern Ordinary | 147—150 | 4 13 3 | Ja, Ap, Jy, O | [illegible] | 91 |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 91—93 | 3 15 8 | Ja, Ap, Jy, O | [illegible] | [illegible] |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 107½—109½ | 3 13 0 | May, Nov | [illegible] | [illegible] |
| 10 | 2/6 | Eastern Extension | 14¾—15¼ | 4 11 6 | Ja, Ap, Jy, O | [illegible] | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 105—107 | 3 14 8 | Feb, Aug | [illegible] | .. |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb. 1909 | 99—101 | 3 19 3 | Feb, Aug | .. | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101%—103% | 3 18 8 | May, Nov | .. | .. |
| 10 | 5/0 | G. N. (of Copenhagen) with coupon 66 | 17½—18½ | 6 2 0 | Jan, July | .. | .. |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 99½—101½ | 4 8 9 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57—59 | 5 10 0 | May, Nov | .. | .. |
| 100 | $1 | Mackay Companies Common | 61 1/16 | 3 5 0 | Jan, July | — | .. |
| 100 | 1% | Do. Preference | 75½ | 5 5 6 | Ja, Ap, Jy, O | [illegible] | .. |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1⅛—1⅜ | .. | .. | .. | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 99—102 | 3 18 6 | June, Dec | .. | .. |
| 10 | 4/0 | West African Telegraph Shares | 9½—10 | 5 0 0 | .. | .. | .. |
| 2½ | — | West Coast of America | ⅝—¾ | .. | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100—102 | 3 18 3 | Jan, July | [illegible] | .. |
| 10 | — | West India and Panama | ⅜—⅝ | .. | May, Nov | [illegible] | [illegible] |
| 10 | 6/0 | Do. 6% 1st Pref. | 8¼—8¾ | 6 6 8 | May, Nov | .. | .. |
| 10 | — | Do. 6 per Cent. 2nd Pref. | 6½—7½ | .. | May, Nov | .. | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 100—103 | 4 17 0 | Jan, July | [illegible] | [illegible] |
| 10 | 3/0 | Western Telegraph | 14½—15 | 4 13 0 | Mr, Jn, O, D | .. | .. |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 100—102 | 4 18 0 | June, Dec | 101¼ | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 102—104 | 3 16 10 | .. | .. | .. |

### TELEPHONES.

| Shre. | Last Dividend | Name. | Price Wed., Mar. 7. | Rate % Yielded £ s. d. | Dividend Due | Business, Week to Mar. 7. Highest | Lowest |
|---|---|---|---|---|---|---|---|
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 103—105 | .. | .. | [illegible] | .. |
| 5 | 8/0 | Chili Telephone (fully paid) | 8—8¼ | 4 17 0 | August — | [illegible] | .. |
| 1 | 0/9⅗ | Monte Video Telephone Ord. | ⅞—1 | 4 0 0 | — | .. | .. |
| 1 | 1/0 | Do. 5% Pref. | ⅞—1 | 5 0 0 | .. | [illegible] | [illegible] |
| St. | 6% | National Co. Pref. Stock | 114—115 | 5 4 6 | — | [illegible] | [illegible] |
| St. | 5% | Do. Def. Stock | 110—112 | 4 8 8 | — | [illegible] | [illegible] |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 13½—14½ | 4 2 9 | Feb, Aug | [illegible] | [illegible] |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 11—13 | 4 12 4 | Feb, Aug | [illegible] | [illegible] |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5½—5¾ | 4 7 0 | Feb, Aug | .. | .. |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 99—101 | 3 9 3 | June, Dec | [illegible] | [illegible] |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 103—105 | 3 16 8 | — | [illegible] | .. |
| 1 | 0/7⅕ | Oriental | 1½—1⅝ | 4 12 0 | April, Oct | .. | .. |
| 1 | 0/7⅕ | Do. 6 per Cent. Cum. Pref. | 1¼—1⅜ | 4 7 0 | — | [illegible] | [illegible] |
| St. | 24/7⅔ | Do. 4% Red. Deb. Stock | 97—99 | 4 1 0 | .. | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 103—106 | 4 4 9 | .. | .. | .. |
| 5 | 3/0 | United River Plate | 7¼—7½ | 5 6 8 | July — | — | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5½—5¾ | 4 7 0 | June, Dec | — | — |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 110—112 | 4 9 8 | June, Dec | .. | — |

### FINANCIAL, INVESTMENT, &c.

| Shre. | Last Dividend | Name. | Price Wed., Mar. 7. | Rate % Yielded £ s. d. | Dividend Due | Business, Week to Mar. 7. Highest | Lowest |
|---|---|---|---|---|---|---|---|
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 5—5½ | 5 9 0 | .. | [illegible] | [illegible] |
| 10 | 2/0 | Globe Telegraph and Trust | 11⅝—11⅞ | 4 16 6 | Ja, Ap, Jy, O | [illegible] | [illegible] |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14¾—15 | 4 0 0 | Ja, Ap, Jy, O | .. | — |
| 10 | 6% | Submarine Cables Trust (Cert.) | 127—130 | 4 12 0 | April, Oct | .. | — |

* In calculating the yields, allowance has been made for accrued interest but not for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

**WHEATLEY KIRK, PRICE & CO.**

*(Established 1850.)*

ELECTRICAL AND MECHANICAL VALUERS, ARBITRATORS AND AUCTIONEERS.

**TRAMWAY & ELECTRICITY SUPPLY VALUATIONS.**

Periodical Valuations, Stock-takings and Reports for DEPRECIATION, RENEWALS, &c., in conformity with the Acts.

Valuations and Arbitrations for transfer under local or other powers. Sales or Purchases of Entire Undertakings by Private Treaty negotiated.

**46, Watling Street, Queen Victoria Street, LONDON, E.C.**
**And Albert Chambers, Albert Square, MANCHESTER.**

Telephones { 5077 Bank London. 3218 Central Manchester.
Telegraph Addresses { Indices London. Indicator Manchester.

## PLANT FOR SALE.

ELECTRIC PLANT.—LEWIS'S, Market-street, Manchester, have the following **ELECTRIC PLANT FOR IMMEDIATE SALE:—**

One 20ft. × 6ft. 6in. Galloway Boiler.
One Pearn Feed Pump.
One Royle Feed Water Heater.
One 100 B.H.P. Horizontal Steam Engine (Marshall, Class C).
One 60 B.H.P. Horizontal Steam Engine (Marshall, Class G)
One 40 B.H.P. Crossley Gas Engine.
Five 300 amp. 100 volt Compound-wound 2-pole Royce Dynamos with Slide Rails

SWITCHBOARD.—Large Polished Slate Switchboard, with the following Instruments mounted:—

Five Ammeters reading to 400 amps.
One " " 300 amps.
Five Voltmeters reading to 120 volts.
Five Ward-Leonard Shunt-Regulating Switches
Five 300 volt Dorman & Smith Reverse-Current Switches.
Five 300 volt Dorman & Smith Maximum Switches.
Five 300 volt Single-Pole Switches.
Five Field-Breaking Switches.

With 'Bus bars and all Connections necessary for running.

Five 300 amp. 100 volt GENERATORS in parallel. Also Belting, Pulleys and Shafting.

The whole of the machinery may be seen working any day between 10 a.m. and 7 p.m., and will be sold either as a whole or in part, owing to space being required for business extensions.

Order to view may be had from Mr. ELLOR, at Lewis's.

Tenders for above must be received not later than the end of this month, March 31st.

## MISCELLANEOUS PLANT, &c., WANTED.

WANTED, LAMP TOPS, with Platinum, Scrap Platinum, &c.—EDEY & Co., 29, Ludgate-hill, London, E.C.

## MISCELLANEOUS PLANT, &c., FOR SALE.

FOR SALE.—SIEMENS ALTERNATOR, 100 volts, 100 periods, 50 amperes, 1,000 r.p.m. EXCITER for ditto, 24 volts 12 amperes. Good working order. Price £38.—Apply SNOWDON, SONS & CO., LTD., Millwall, London, E.

HORNSBY ELECTRIC LIGHTING OIL ENGINE for SALE, type BE., 20 brake horse power, speed 220 revolutions per minute; flywheels, two, heavy, 66in. by 7in., one pulley 55in. by 14in., with necessary cooling tanks, exhaust piping, silencer, spanners, and starting lamp; all practically new and guaranteed in first-rate working order. Price £150, not including delivery.—Apply F. R. WEBB, Randalstown, Antrim, and Fethard, Tipperary.

ELECTRIC LIGHT PLANT, two sets of 100 k.w., for power or traction, consisting of two sets of Belliss and Morcom triple expansion engines, coupled direct to Mather and Platt dynamos, 200 amps., 400 to 570 volts, at 550 revs. per minute. Each set complete, with surface condensers, air pumps, and circulating pumps, coupled to crank shaft. Sell cheap to save second removal.—WHITE BROS., and Co., Engineers, Stratford, London. Telephone 365 Stratford.

WANTED TO SELL, ELECTRIC PLANT in first-class condition, consisting of dynamo, 17½ kilowatts, 110 volts, speed 780: Crossley's gas engine (three tanks) 28 B.H.P., exhaust box and silencer, self-starter, and switchboard complete; 8 new Jandus arc lamps and 20 old type. Only reason changing to higher voltage.—NEW SPA AND GARDENS, LTD., Bridlington.

ELECTRIC PLANT, consisting of Vertical Cochran Boiler, 11 ft. by 5 ft.; Pair of Inverted Engines, 12 in. cylinders, by Browett, Lindley & Co.; Shunt Dynamo, 110 volts, at 450 revs., by Elwell Parker, Limited: all complete as recently worked.—Apply Colosseum Theatre, Oldham.

ELECTRIC MOTORS FOR SALE.—One British Thomson-Houston enclosed ventilated 2 H.P. 110 volts 960 revs., spare armature, starting and regulating switch; price £25. One McClure & Whitfield open type 3 H.P. 1,300 revs., armour-clad, starting and D.P. switches and cutouts; price £20.—Apply ENGINEER, Clement's Printing Works, Portugal-street, London, W.C.

WANTED, offer for 36 H.P. SHUNT-MOTOR, 440 volts, 700 revolutions, 3 bearings, slide rails, and belt pulley; made by Phœnix Dynamo Company, Bradford. Perfectly new; can be seen by appointment.—J. T. & J. TAYLOR, LIMITED, Batley.

X-RAYS APPARATUS complete, Ruhmkorff Coil, giving good 7 in. spark, splendid Accumulator, and a large quantity of SCIENTIFIC EXPERIMENTAL APPARATUS, to be SOLD CHEAP. Can be seen by appointment.—H. SHEWEN, Oatlands Park, Weybridge.

**GAMBRELL BROS.** MANUFACTURERS of ELECTRICAL TESTING INSTRUMENTS.

Durham House, North Side,
Clapham Common, London, S.W.

CATALOGUE ON APPLICATION.

Telegrams: Turnstile London. **STANLEY** GOLD MEDAL, St. Louis, 1904.

**SURVEYING & DRAWING INSTRUMENTS.**

*NOTICE OF REMOVAL OF THE RETAIL DEPARTMENT*
from GREAT TURNSTILE to
**286, HIGH HOLBORN, LONDON, W.C.** Price List post free.

## TENDERS INVITED, &c.

### COUNTY OF LONDON.

**TO ELECTRICAL ENGINEERS.**

The London County Council invites TENDERS for the Manufacture and Erection of THREE LOW-TENSION FEEDER SWITCHBOARDS for certain of the Tramway substations.

Persons desiring to submit Tenders may inspect the Drawings and obtain the Specifications, Bills of Quantities, Form of Tender, and other particulars at the County Hall, Spring Gardens, S.W., upon payment to the Cashier of the Council of the sum of £2. This amount will, after the Council or its Committee shall have come to a decision upon the Tenders received, but not before, be returned to the tenderer, provided he shall have sent in a bona fide Tender and not have withdrawn the same, but in no case will the fee be returned unless a bona fide Tender is submitted. Full particulars of the work may be obtained at the County Hall, previously to the payment of the fee for the Specification, &c.

Tenders must be upon the official forms, and the printed instructions contained therein must be strictly complied with. The contractors will be bound by the contract to pay to all workmen (except a reasonable number of legally bound apprentices) employed by them, wages at rates not less, and to observe hours of labour not greater, than the rates and hours set out in the Council's list, and such rates of wages and hours of labour will be inserted in and form part of the contract by way of schedule. Each Tender is to be delivered at the County Hall, in a sealed cover addressed to the Clerk of the London County Council, Spring Gardens, S.W., and marked "Tender for Low-Tension Switchgear, L.C.C. Tramways." No Tender will be received after 10 o'clock a.m. on TUESDAY, the 27th day of March, 1906. Any Tender which does not comply with the printed instructions for Tender may be rejected.

The Council does not bind itself to accept the lowest or any Tender, and it will not accept the Tender of any person or firm who shall on any previous occasion have withdrawn a Tender after the same had been opened, unless the reasons for the withdrawal were satisfactory to the Council.

G. L. GOMME,
Clerk of the London County Council.

County Hall, Spring Gardens, S.W., March 12th, 1906.

### COUNTY BOROUGH OF BOLTON.

ELECTRICITY DEPARTMENT.

The Electricity Committee of the County Borough of Bolton are prepared to receive TENDERS for

**ONE STEAM ENGINE COMPLETE.**

Specifications and Forms of Tender may be obtained on and after March 12th, 1906, on application to Mr. Arthur A. Day, A.M.I.C.E., M.I.E.E., Borough Electrical Engineer, Spa-road, Bolton, on payment of £1. 1s., which will be returned on receipt of a bona fide Tender.

Tenders, addressed to the Chairman of the Electricity Committee, Town Hall, Bolton, must be sealed and endorsed "Tender for Steam Engine" and delivered to the undersigned not later than 12 o'clock noon on THURSDAY, March 29th, 1906.

The Committee do not bind themselves to accept the lowest or any Tender.

SAMUEL PARKER, Town Clerk.

Town Hall, Bolton, March 7th, 1906.

### COUNTY BOROUGH OF BOLTON.

ELECTRICITY DEPARTMENT.

The Electricity Committee of the County Borough of Bolton are prepared to receive Tenders for

**ONE CONTINUOUS-CURRENT ELECTRIC GENERATOR.**

Specifications and Forms of Tender may be obtained on and after March 12th, 1906, on application to Mr. Arthur A. Day, A.M.I.C.E., M.I.E.E., Borough Electrical Engineer, Spa-road, Bolton, on payment of £1. 1s., which will be returned on receipt of a bona fide Tender.

Tenders, addressed to the Chairman of the Electricity Committee, Town Hall, Bolton, must be sealed and endorsed "Tender for Electric Generator" and delivered to the undersigned not later than 12 o'clock noon on THURSDAY, March 29th, 1906.

The Committee do not bind themselves to accept the lowest or any Tender.

SAMUEL PARKER, Town Clerk.

Town Hall, Bolton, March 7th, 1906.

**TENDERS INVITED continued on next page.**

**Royal Doulton Potteries.**

**INSULATORS**

AND ALL KINDS OF

**POTTERY FOR ELECTRICAL PURPOSES.**

**DOULTON & CO.,**

*LIMITED.*

**Lambeth, LONDON, S.E.**

**EVERSHED & VIGNOLES, LIMITED.**

Our New List of AMMETERS and VOLTMETERS will be forwarded post free on application.

*Makers of all kinds of ELECTRICAL INSTRUMENTS,*
**Acton Lane Works, CHISWICK, LONDON, W.**

## TENDERS INVITED—*continued.*

### BOROUGH OF WALSALL.

**ELECTRICITY DEPARTMENT.**

TENDERS are requested by the Electricity Department for the following PLANT :—

I. 500 H.P. HIGH-SPEED STEAM ENGINE.
II. 350 K.W. HIGH-PRESSURE CONTINUOUS-CURRENT DYNAMO.
III. HIGH-PRESSURE FEEDER CABLES, LOW-TENSION DISTRIBUTORS, and PILOT WIRES.

Copies of the Specifications may be obtained from Mr. Alex. Wyllie, Borough Electrical Engineer, Wolverhampton-street, Walsall, on payment of One Guinea for each Specification, which will be returned on receipt of a bona fide Tender.

Sealed Tenders, endorsed "Tender for Steam Engine," "Tender for Dynamo," or "Tender for Cables," as the case may be, must be addressed to the Town Clerk, Walsall, and must reach his office not later than MARCH 30th.

The Corporation do not bind themselves to accept the lowest or any Tender, and they will not accept the Tender of any firm or person paying less than the standard rate of wages to their own workmen.

March 13th, 1906. JOHN R. COOPER, Town Clerk.

---

## FOR DISPOSAL.

£2,200 (ABOUT).—Populous London Suburb, S.E.—Well-established WORKING BUSINESS, ELECTRICAL CONTRACTORS, Gas Appliances, etc. Turnover upwards of £3,000 per annum, net profit £600 per annum. Capital business premises with good residence; several workmen employed; fullest investigation solicited.—Address W. D., at Horncastle's, 61, Cheapside, London, E.C.

ELECTRICAL BUSINESS, Yorks., manufacturing town, net profits £180; certified accounts; full investigation allowed; every assistance given to purchaser. £500 or offer.—FIRTH'S, 7, Cookridge-street, Leeds.

---

## FACTORIES & WAREHOUSES TO LET & WANTED.

FACTORY to be LET, 32 miles from London, on a main line, close to station, having direct communication with all the manufacturing centres in the North of England, in a locality where labour is cheap, having steam power, and suitable for any kind of manufacture. Rent low. Immediate possession.—GLADDING & Co., 8 to 11, Pavilion-buildings, Brighton.

FACTORY, in E.C. district, most excellent light, private and workpeople's entrances, L.C.C. stone staircase, lift, area over 16,000 ft., to be LET at extremely low rent of £650 per annum. Immediate possession.—Apply, Mr. S. CLIFFORD TEE, 50, Moorgate-street, London, E.C.

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## CHEAP PREPAID ADVERTISEMENTS.

**MISCELLANEOUS PLANT, &c., WANTED, FOR SALE OR FOR EXCHANGE.**

| | |
|---|---|
| *Three Lines and under (Minimum)* ... ... ... | 1s. 6d. |
| *Per Line after* ... ... ... ... ... ... | 6d. |

Ten Words to the Line.

Where answers to any of the above Advertisements are to be sent to the Publishing Offices to be forwarded, the sum of 3d. must be sent with the order to pay for postage of these replies. Six Words must be allowed for the address of the Publishing Offices.

---

## THE LONDON TELEGRAPH TRAINING COLLEGE.

**NOTICE OF REMOVAL.**

THIS COLLEGE, established at Brixton for the past 14 years, is now being removed to Earl's Court, London, S.W., where LARGER AND MORE COMMODIOUS PREMISES, within easy access of all parts of London, have been secured.

The College will be re-opened on the 26th inst., and is the ONLY TELEGRAPH TRAINING INSTITUTION LICENSED BY H.M GOVERNMENT FOR WIRELESS TELEGRAPHY. It is equipped with the latest appliances for training young men for the Inland, Cable and Wireless Services, and ALL QUALIFIED STUDENTS HAVE APPOINTMENTS SECURED FOR THEM.

New Prospectus, containing full information and List of Appointments recently obtained, free on application to—

**The Secretary, Morse House, Earl's Court, London, S.W.**

**MOSELEY'S FAMOUS**

NOTE THE FINISH.

**RUBBER GLOVES.**

**OUR OWN MAKE.**

Perfectly Soft Finish. Never Harden.
Stand any Climate. Guaranteed absolutely
**PURE FINE PARA RUBBER.**

**DAVID MOSELEY & SONS, LD.**
INDIA RUBBER MANUFACTURERS.
**ARDWICK, MANCHESTER.**

**"ANTI-SULPHURIC" ENAMEL**
Should be used in all **ACCUMULATOR ROOMS** for Protection from Acid Fumes.
Sole Makers: **GRIFFITHS BROS. & CO.,** Mack's-rd. Bermondsey, LONDON, S.E.

**PAUL**
Manufacturer of **ELECTRICAL AND PHYSICAL INSTRUMENTS.**
Newton Avenue Works, New Southgate,
LONDON, N.
CATALOGUES FREE.

**GEO—J HODGES & Co**
SWITCHBOARD & INSTRUMENT MAKERS,
BALFOUR HOUSE, FINSBURY PAVEMENT, LONDON, E.C.
**"SPARKLESS" ENCLOSED FUSES**

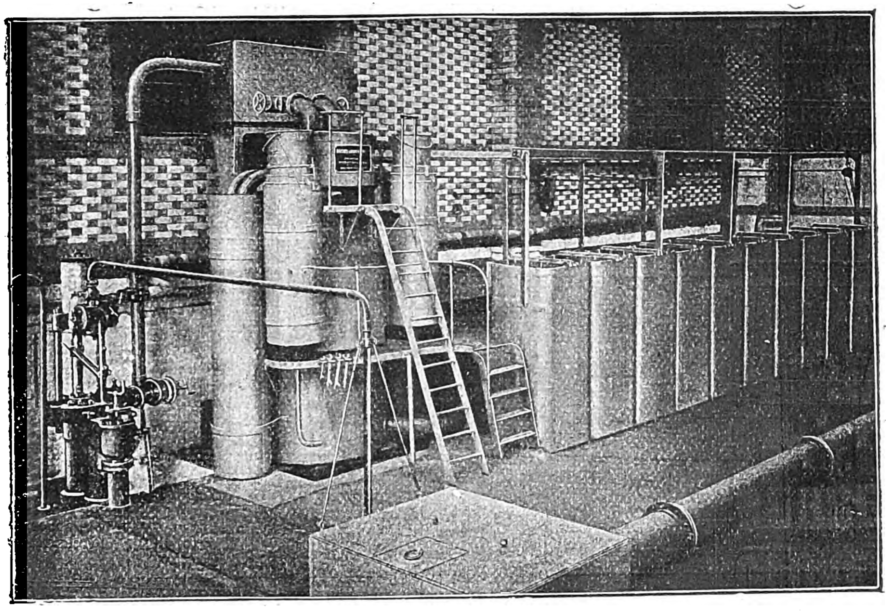
**C. PASS & SON, LTD.,**
**Bedminster Smelting Works, BRISTOL.**
SELLERS OF
***ANTIMONIAL LEAD OF ALL GRADES.***
BUYERS OF
**LEAD ASHES AND LEAD RESIDUES FROM ACCUMULATORS.**
Telegrams: PASS BRISTOL. Telephone, 475.

**NO MORE COLLAPSED FURNACES OR BUCKLED TUBES**

**THROUGH GREASE**

**IF YOU PURIFY THE CONDENSED WATER**

**WITH THE "HARRIS-ANDERSON" PURIFIER.**



"Harris-Anderson" Purifier, Pinkston Power Station, Glasgow Corporation Tramways.
Capacity, 22,000 gallons per hour.

Grease Absolutely Removed.
No Objectionable Matter introduced.
Automatic and Simple Action.
Minimum Waste of Water.
Numerous Plants now at work in Electric Light and Power Stations, &c.

*WRITE for FULL PARTICULARS to the—*

**HARRIS PATENT FEED WATER FILTER, LTD.,**

82, Victoria St., Westminster, LONDON, S.W.
Telegrams: WINDTIGHT LONDON.
Nat. Tel.: 876 WESTMINSTER.
26, St. Thomas Street, SUNDERLAND.
Telegrams: WINDTIGHT SUNDERLAND. Telephone 569
2, Hamilton Street, GREENOCK.
Telegrams: WINDTIGHT GREENOCK. Telephone 127.

◆ ◆ ◆

**VICKERS, SONS & MAXIM, Ltd.**

TELEGRAMS:
VICKERS SHEFFIELD.

**SHEFFIELD.**

ON ADMIRALTY LIST.
ON WAR OFFICE LIST.

MAKERS OF
GENERATORS and MOTORS
FOR
CONTINUOUS and ALTERNATING CURRENTS.

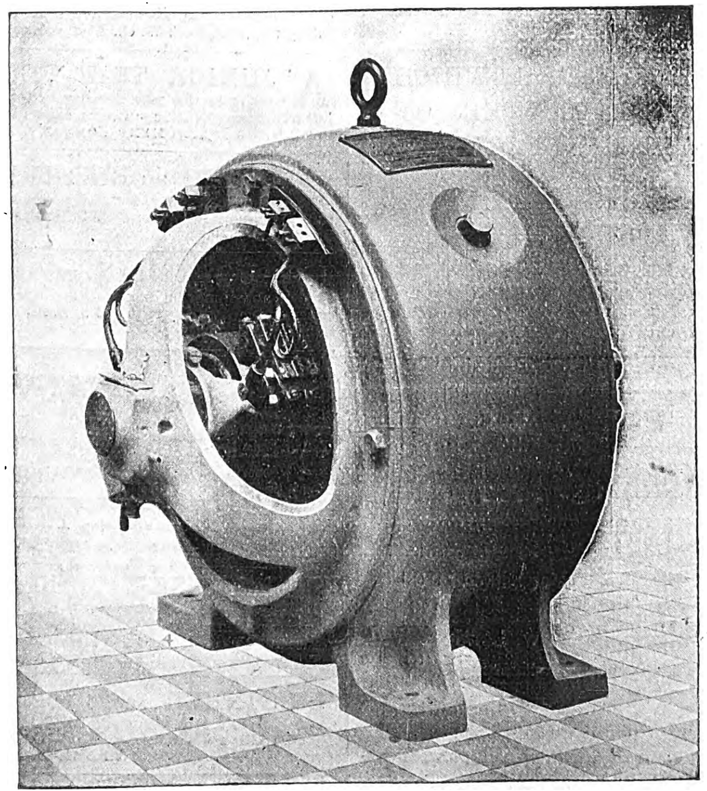
COMPLETE EQUIPMENTS
FOR
ELECTRIC DRIVING
OF
FACTORIES.

VICKERS' VARIABLE SPEED MOTORS.

SPEED RANGE, UP TO 6 : 1.

BY SHUNT REGULATION ONLY

FULL POWER at ALL SPEEDS.



STANDARD SEMI-ENCLOSED MOTOR.

**FESSENDEN** Wireless Telegraph System

**NATIONAL ELECTRIC SIGNALLING COMPANY.**

NEW YORK (U.S.A.)
**HANOVER BANK BUILDING.**

PITTSBURG, PA.
**FARMERS BANK BUILDING.**

WASHINGTON, D.C.
**EIGHTH and WATER STREETS.**

CIVIL SERVICE COMMISSION.—FORTHCOMING EXAMINATION.

ASSISTANT EXAMINERS in the PATENT OFFICE (20-25) 5th APRIL.

The date specified is the latest at which applications can be received. They must be made on forms to be obtained, with particulars, from the SECRETARY, Civil Service Commission, Burlington Gardens, London, W.

**John E. Raworth,**

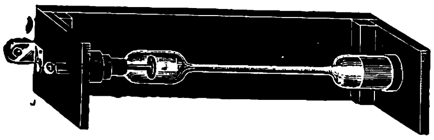
*Queen Anne's Chambers,*
*The Broadway, Westminster, London, S.W.*
**Patent Agent.**

**THE STIRLING BOILER Co., LTD.**
**MOTHERWELL, N.B.**
*See Illustrated Advertisement last week.*

**VACUUM TUBE DETECTOR for HIGH-TENSION MAINS**

Works on any Voltage above 2,000. **Price 48/- doz.,** unmounted.

**A. C. COSSOR,**
**54, Farringdon Rd.,**
**LONDON, E.C.**
Telephone: 10547 CENTRAL.
*GOLD MEDAL,*
*St. Louis Exhibition, 1904.*



**PROTECTION OF ENGLISH TRADE IN ELECTRICAL FITTINGS.**

ENGLAND CFA

All goods made by Members of this Association are marked with this Trade Mark, WHICH IS A GUARANTEE OF ENGLISH MANUFACTURE.

**CHINA FURNITURE AND ELECTRICAL FITTINGS MANUFACTURERS' ASSOCIATION.**

BULLERS, LTD., 3, Laurence Pountney Hill, Cannon Street, London, E.C.
GASKELL & GROCOTT, Whiteball Works, Longport, Stoke-on-Trent.
WM. KENT, Novelty Works, Wellington Street, Burslem.
J. MACINTYRE & CO., LTD., Washington Works, Burslem
J. WHITEHOUSE & SON, Birchall Street, Birmingham.
WILLIAM WOOD & CO., Albert Street Works, Burslem.

**INSTRUMENTS AND PLANT TESTED.**

**THE ELECTRICAL STANDARDIZING, TESTING AND TRAINING INSTITUTION.**

(Proprietors: The Syndicate of Electrical Engineers, Ltd.)
**(Established 1889.)**

**FARADAY HOUSE, 66-70, Southampton Row, London, W.C.**
Telephone No. 9999 Central. Telegraphic Address: "Standardising London."

Standardizes and Tests Electrical Instruments.
Inspects and Certifies every kind of Electrical Plant and Materials.
Investigates and reports upon Electrical Inventions.
Inspects installations of Electric Wires and Plant on behalf of Architects, Householders, Manufacturers, Supply Companies, Fire Offices, &c.
Lets Private Experimenting Rooms, and offers every facility, with skilled assistance when desired, to Experimenters in Electrical Science.

A Scale of Fees will be sent on application to the SECRETARY.

~~FERBECK CHIMNEY CONSTRUCTION CO.—CHIMNEY SHAFTS in any part of the World (Economical Patent System), CHIMNEY TANKS, LIGHT TOWERS, WATER TOWERS (Intze System), ELECTRIC and all other FURNACES, SOOT KILNS, ARC and DYNAMO CARBON PLANTS, &c.—FINSBURY PAVEMENT HOUSE, LONDON, E.C.~~

## CHEAP PREPAID ADVERTISEMENTS.

**SITUATIONS VACANT**

| | |
|---|---|
| *Three Lines and under (Minimum)* ... — — | 1s. 6d. |
| *Per Line after* — — — — — — | 6d. |

Ten Words to the Line.

**SITUATIONS WANTED.**

*Sixpence per Line of Ten Words, minimum One Shilling.*

Where answers to any of the above Advertisements are to be sent to the Publishing Offices to be forwarded, the sum of 3d. must be sent with the order to pay for postage of these replies. Six Words must be allowed for the address of the Publishing Offices.

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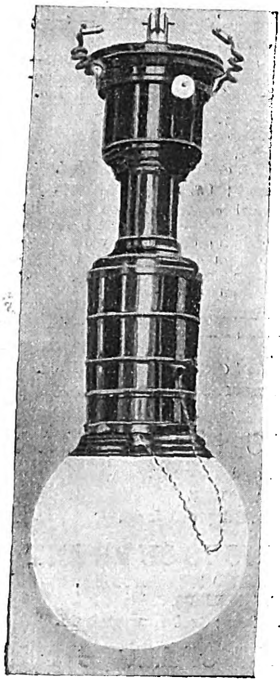

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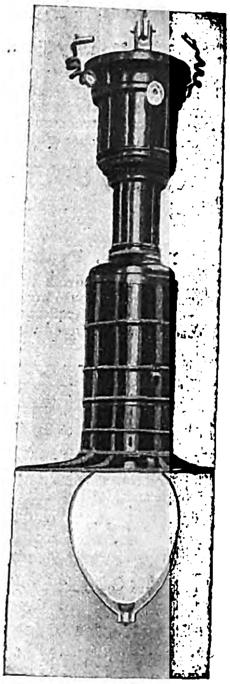

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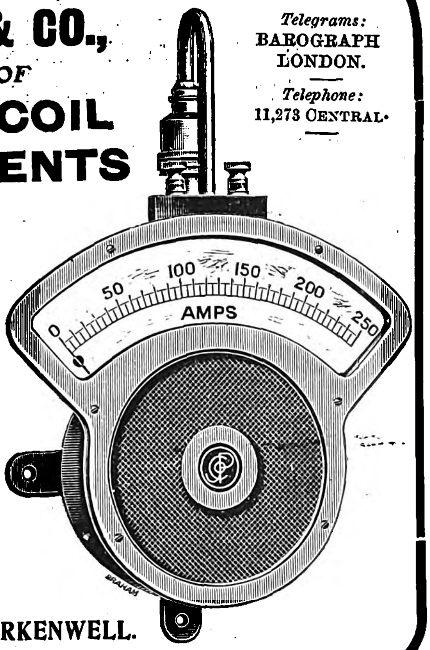

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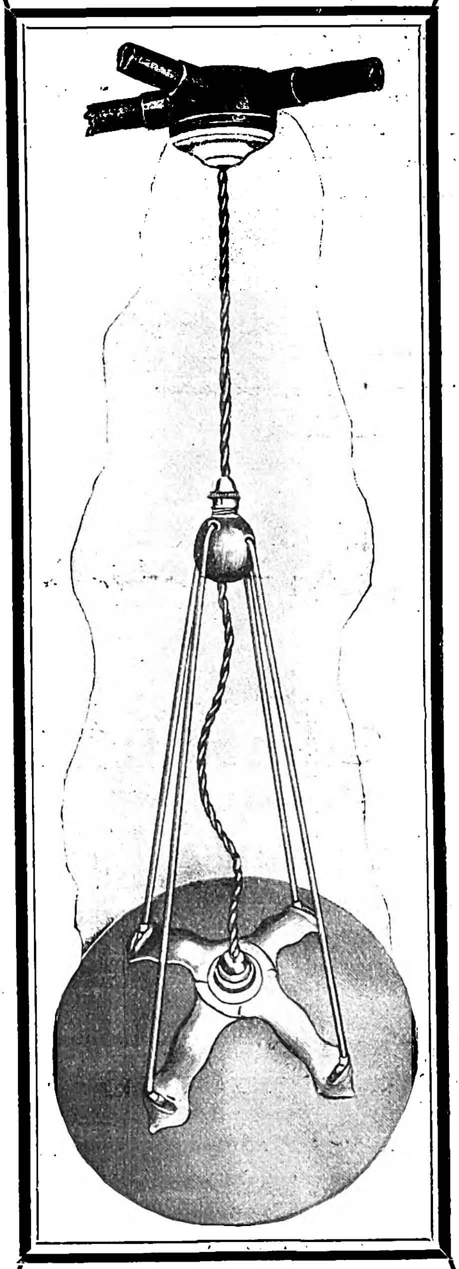

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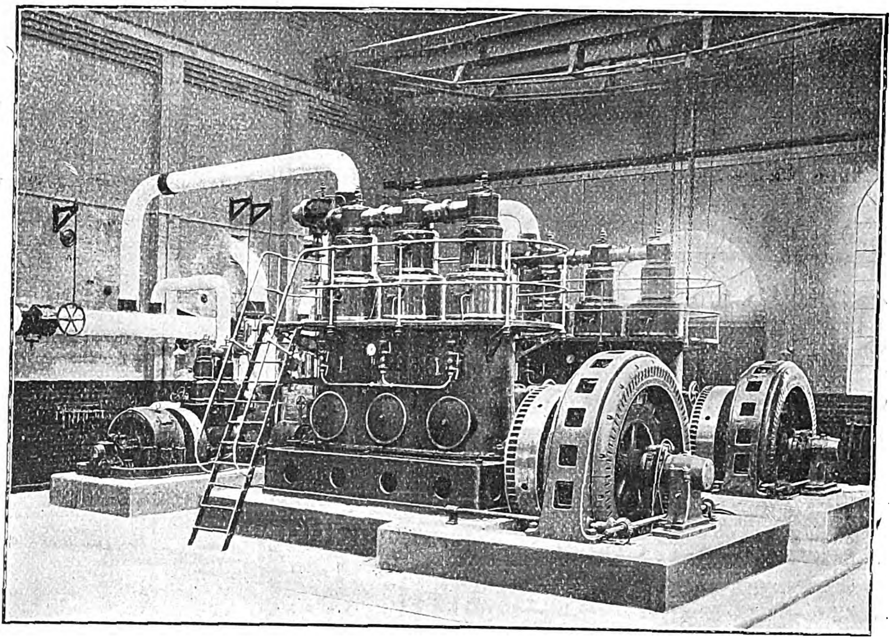

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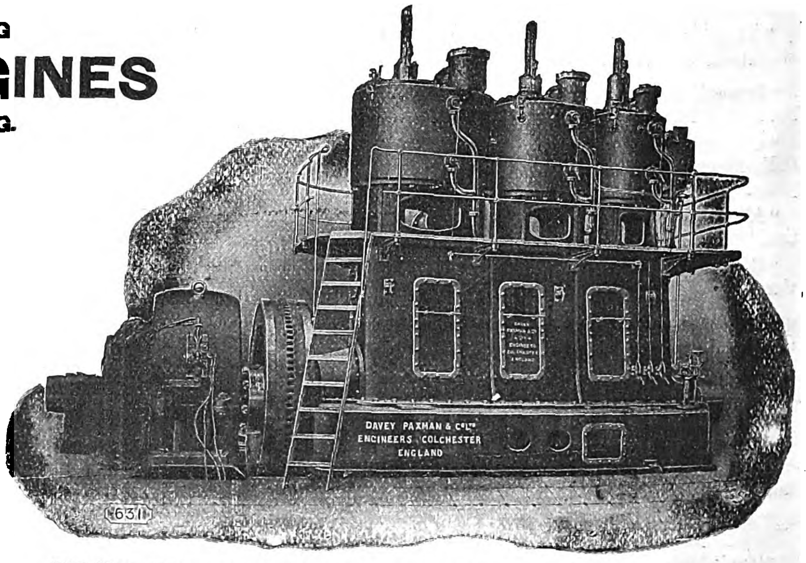
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No. 1,452. [No. 22. Vol. LVI.] FRIDAY, MARCH 16, 1906. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c.; or 80pf.

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## NOTES.

WE report this week at considerable length the discussion on Mr. GEORGE WILKINSON'S proposals for checking the wasteful use of old and inefficient lamps by consumers, and we do not doubt that these expressions of opinion from different quarters will be found valuable by the supply station engineers. The lamp makers' point of view was ably expressed by Mr. WILSON, but he made too much of the disadvantages under which he says lamp makers in this country suffer on account of the absence of "grading" in supply station voltages. Perhaps the lamp makers have not been consulted as to this grading, but we venture to suggest that the variety in declared pressures in this country should be quite sufficient to afford a market for the "outfalls" in 220-volt lamp manufacture.

◆

WHY is it that some manufacturers insist, in season and out of season, on the better conditions for manufacture that obtain in the United States and the Continent than in Great Britain? Ten or twenty years ago, before this was the fashion, the British manufacturer, when he spoke in public, took the line that his goods were the best, although some foreigner might possibly be able to sell goods of inferior quality to his at a cheaper rate. Now he loses no opportunity to insist on the conditions which, he says, enable the foreigner to make the same class of goods as his own at a lower price. He is, in fact, too apt to forget that he is a business man, and to become a politician.

To return to the question of the grading of lamp pressure: A buyer of lamps, after reading Mr. WILSON'S remarks, will naturally say, if the American lamp maker can make his lamps cheaper, owing to this process of grading, we shall get better value for our money in America—either better lamps at the same price, or the same quality lamps as in England but at a lower price. He will therefore buy in America. Fortunately there is little foundation for Mr. WILSON'S complaint on this score, although his figures and data on other points have a practical value. We append a list of the various pressures and the number of supply stations using them. This list is derived from our tables of electricity supply works of the United Kingdom, published last January:—

| Declared pressure. | Number of stations. | Declared pressure. | Number of stations. |
|---|---|---|---|
| 100 | 48 | 204 | 1 |
| 102 | 3 | 205 | 4 |
| 104 | 1 | 210 | 28 |
| 105 | 7 | 214 | 1 |
| 107 | 1 | 215 | 1 |
| 110 | 8 | 220 | 81 |
| 115 | 3 | 225 | 8 |
| 120 | 1 | 230 | 125 |
| 150 | 2 | 240 | 60 |
| 200 | 77 | 250 | 10 |

◆

MR. M. B. FIELD'S Paper on "Idle Currents," an abstract of which is concluded in this issue, is of much interest and importance in connection with the subject of heat losses occurring in the heavy conductors used with large alternating-current plant. It has long been known that these heat losses are greater than correspond to the $C^2R$ losses calculated on the assumption of uniform current density in the conductors, but we doubt whether anyone has suspected the existence of such a striking increase as Mr. FIELD finds in certain circumstances by no means unusual with large machines. The Paper is purely theoretical, but the formulæ have been numerically worked out, and the results have been made clear in the form of curves. It is also seen from the discussion that some of the results are quite in accordance with experimental tests made by the Westinghouse Company.

◆

THE mathematical working is somewhat complicated, but the ideas involved are very simple. The current flowing through the conductors in a slot causes a leakage of magnetic field across the slot, the density of which is greatest near the top and least towards the bottom of the slot. The eddy currents are, therefore, most serious in those conductors nearest the gap surface, and in some cases they cause an extra current density as much as 30 times that of the normal current density due to the load current in the main circuit. The copper losses may thus go up enormously. So much is this the case that where there are several conductors in a slot, the one nearest the armature surface may give rise to less heat loss if made thinner and of higher specific resistance than the other conductors. Of course, by so doing the heating due to the normal load current is increased, but the extra heating due to the eddy currents is so much more important that its reduction by these means results in a decided lessening of the heat losses. Similar considerations explain another apparent paradox pointed out by Mr. FIELD: that it is possible to use too much copper in large machines, and that in some cases the dynamo efficiency can be increased by using conductors of smaller section with slots of lesser depth.

◆

IN an appendix to the Paper, which we do not reprint in our abstract, the author establishes a theorem showing that the heat loss involved in passing a current, C, through a conductor, or conducting network, is least when the current is distributed in the natural manner which results from Ohm's law assuming no disturbing E.M.F.s in the network. This is an old theorem connected with Ohm's law, and as the effect of the eddy current E.M.F. is merely to disturb this natural distribution, it is no new fact to prove that such disturbance must result in increased heat losses in the conductors. Mr. FIELD goes a little further, however, for he proves that the total heat loss is the sum of that calculated assuming the normal distribution, and that calculated due to the eddy currents considered separately.

◆

THE "Juno" flame arc lamp, of which a description appears elsewhere in this issue, represents a new type of lamp of extreme simplicity. In the pattern described and illustrated, a hot wire is made use of for striking the arc, but when this has once been struck, the feeding of the carbons is done without the intervention of any clockwork or clutch mechanism. One of the two converging carbons of the "Juno" lamp rests with its edge on a copper stop, and drops down by gravity as it burns away. Since the two carbons are mechanically connected at their upper ends, however, the second carbon feeds with the first, so that the arc remains stationary and of the same length. The arc is blown out to a "flame" by a magnet in the usual manner, with the result that the fringe only of the arc just touches the copper stop, and this stop, the makers state, will last for three months when the lamp is in ordinary use. Another obvious question is, what happens if one carbon burns away slightly faster than the other, due to inequalities in the material, as both must feed at exactly the same rate. One would expect the arc to lengthen in this case until it extinguished itself. As the makers state that the lamp has been found to burn with steadiness, however, the explanation may be that the "striker," which is controlled by the hot wire in series with the arc and increases the deflection of the second carbon, affords sufficient regulation for this purpose.

THE communicated contributions to the discussion on Messrs. TWEEDY and DUDGEON'S Paper on Overhead Equipment are of considerable value as records of experience. The South Staffordshire case is remarkable in several ways, especially as to the successful use of very light poles, and the small wear of the wire; but the service has to be considered as well as the lapse of time. Mr. TWEEDY'S statements as to undulating wear of wire at and near the points of suspension are confirmed in several quarters, but no satisfactory explanation is forthcoming. The point is so important that it ought to be investigated; it is conceivable that a record, similar to Mr. TWEEDY'S, from all the tramways which have been at work over three or four years would give strong indications of the true causes and how to avoid them. The discussion throws no light on the statement made in the Paper that brass insulated bolts fail more frequently than those of iron. It certainly is not a universal rule, and probably the nature and amount of the local atmospheric impurities would explain the facts. There is a plain way to get rid of insulated bolt failures, and that is to put the insulator at a safe distance from the bolt, and to make it of durable porcelain and not of organic substances.

◆

In another column Dr. LEWIS JONES calls attention to RUHMER'S ingenious oscilloscope, which makes a graph of the discharge in high potential circuits by mapping the length of cathode rendered luminous by the discharge. The visualising of the quickly-varying glow of the cathode is effected by a rotating mirror, and the method has, therefore, evident limitations in the direction of frequency. But since the lag of the glow is probably extremely small, there is no doubt that the oscilloscope method could be pushed to fairly high frequencies. The instrument will be of service in the examination of the performance of induction coils; to mention only one point, it should throw great light on the real function of the condenser usually used in shunt with the primary current interrupter. It appears also that it could be of considerable utility in high pressure alternating current supply stations for the direct observations of wave forms.

◆

Dr. LEWIS JONES gives some interesting curves of the induction coil discharge. One shows very clearly the gradual rise of the make E M.F. and the sudden rise of net break E.M.F. The concave dying curve of the break current suggests vividly the discharge of a charged body through a high resistance. Other curves make evident the action of the Villard valve in suppressing one of the phases of the induction-coil secondary current. We suggest that the double peak in the make curve is a consequence of the slow rise of E.M.F. at make, and of the Villard tube's property of yielding with suddenness. The double peak indicates that a sudden heavy and complete discharge occurs before the generation of E.M.F. has finished, and that a second follows as soon as the potential has risen again to that required to break down the Villard tube's resistance. The inclusion in the circuit of an inductionless resistance would probably prevent the doubling. This example serves to point to the great value of the oscilloscope as an instrument for testing and for research.

**Rugby Engineering Society.**—A lecture was given last evening before the Rugby Engineering Society by Mr. J. M. Gledhill on the subject of "High-Speed Tool Steel."

**Electrical Engineers Volunteers.**—The following notices appeared in the London Gazette for Tuesday:—

> Supernumerary Captain (Hon. Captain in the Army) J. J. F. O'Shaughnessy is absorbed into the establishment. Dated September 5, 1903. Captain (Hon. Captain in the Army) J. J. F. O'Shaughnessy is seconded under the conditions of paragragh 90 of the Volunteer regulations for service under the Colonial Office. Dated October 14, 1905. Supernumerary Captain (Hon. Captain in the Army) J. E. Pearce is absorbed into the establishment. Dated September 5, 1903.

**The Conroy Photometer.**—Mr. A. P. Trotter informs us that the photometer illustrated on p. 850 of our last issue, in Fig. 3 of Mr. K. Edgcumbe's Paper, is not his photometer but is the invention of Sir John Conroy. It is described in *Proc.* Roy. Soc., XXXV., 1883, p. 28, and in Palaz's "Photometrie Industrielle"; Mr. Trotter's forms of photometer were described in *The Electrician*, September 20, 1895, and in *Journal* Inst. Elec. Eng., Vol. XXXII., p. 188.

**"Free" Wireless Telegraph Experiments.** — One of our Australian correspondents informs us that the electrical staff of Hobart (Tasmania) postal department have received the sanction of the Postmaster-General to make experiments upon communication with Tasman Island, a distance of 45 miles in a direct line, where a lighthouse has lately been established. The apparatus to be used will be largely of the experimenters' own construction, as it is stated that no expense will be entailed by the postal department in the matter.

**The Selenium Cell.**—Some of our readers will remember an account of an "invention" for seeing at a distance through wires, which certain sections of the Press treated as of considerable importance a few years ago. In our issue of October 20, 1899, we pointed out that the patent in question suggested no new practical development in the problem of using the selenium cell in this manner. According to the Vienna correspondent of the *Standard*, this patent, together with others taken out by Mr. Jan Szczepanik, were put up for sale by auction last week, but there was no bid for them.

**Cable Interruptions and Repairs.**

| | Date of Interruption. | Date of Repair |
|---|---|---|
| Tarifa—Tangier | Jan. 18, 1904 | — |
| Jamaica—Colon | Jan. 10, 1905 | — |
| Cadiz—Teneriffe | July 20, 1905 | — |
| Puerto Plata—Martinique | Dec. 15, 1905 | — |
| Tangier—Cadiz | Feb. 17, 1906 | — |
| Santa Lucia—St. Vincent | Feb. 19, 1906 | — |
| St. Vincent—Grenada | Feb. 19, 1906 | — |
| Grenada—Trinidad | Feb. 24, 1906 | Mar. 12, 1906 |
| Porto Rico—St. Croix | Feb. 26, 1906 | — |
| Alexandria—Larnaca | Feb. 28, 1906 | — |
| Guadaloupe—Dominica | Mar. 8, 1906 | Mar. 8, 1906 |

**Faraday House Old Students' Association.**—An enjoyable evening was spent by the Faraday House Old Students and their guests at the second annual dinner at the Florence Restaurant last Friday. Mr. C. D. Taite (*President*) was in the chair, and among those present were Mr. H. E. Harrison (*Principal of Faraday House*), Mr. C. P. Sparks (*Past President*), Mr. Robert Hammond (*Patron*), Messrs. G. W. Partridge and S. F. Beevor (*Vice-Presidents*), Mr. H. Foulds (*Hon. Sec.*), and Messrs. A. B. Anderson, Beales, J. E. Edgcome, J. S. Highfield, Hugo Hirst, P. V. McMahon, E. T. Ruthven-Murray and A. H. Walton. The speeches were of an informal character, and an excellent musical entertainment was provided.

**Tramways and Light Railways Association.**—The next meeting of the Tramways and Light Railways Association will be held on Tuesday, March 27th, at the Society of Arts, when a Paper will be read by Mr. Norman D. Macdonald on "Motor Services in Relation to Tramways." An excursion has been arranged for Saturday, March 24th, when the members will take a trip over the loop, from Marylebone to Neasden, and will also visit the electric generating station of the Metropolitan Railway at Neasden. A special train will leave Marylebone at 1 p.m. Owing to the illness of Mr. S. Sudworth, the reading of his Paper "On the Upkeep of Tramway Electric Motors," which was to have taken place this month, is unavoidably postponed. On Thursday, April 26th, a Paper on "All-Steel Cars," by Mr. G. H. Sheffield, will be read. A visit to the Great Northern, Piccadilly & Brompton tube railway works will also be made during April. Owing to the vacancy on the Council caused by the death of Mr. C. R. Bellamy, the Council have elected Mr. J. B. Hamilton (Member of Council) as Vice-President, and Mr. L. A. Atherley-Jones, K.C., M.P. (Past President), as Member of Council.

**Electric Hoists in the Rand Mines.**—The largest electrically driven hoist in the Rand mines has just been set to work at the Village Main Reef mine. The hoist raises a net load of 8,000 lb. of rock at a speed of 150 ft. per minute on an incline from 38 to 32 deg. and 1,750 ft. in length. The drums have a diameter of 8 ft. by 30 ft. width, and are driven through by gearing a three-phase motor developing normally 440 B.H.P., and running on a 2,000 volt circuit. The starting and regulating of the motor is performed by a specially designed liquid resistance. Current is taken down through the shaft by means of a three-core armoured cable from the central station, in which a generator, with an output of 700 K.V.A., direct-coupled to an Allen engine, has been erected, and another similar set is under erection. Current will be supplied not only to the hoist, but also for the crusher station, tube mills, cyanide plant, and underground pumps. The electrical equipment was supplied by the A.E.G. Company of South Africa. We understand from *Commercial Intelligence* that the only other electric hoist actually in the Transvaal is at the City and Suburban mine, but it is on a much smaller scale.

**Fatal Shock from a 110-volt Wire.**—Mr. J. Denham, the Government electrician to Cape Colony, has sent us particulars of an accident from contact with a 110-volt alternating-current wire at East London, South Africa. The wire in question was in connection with a 110 volt 50 ∿ alternating-current arc lamp system. It was a bare wire, and had fallen to the ground owing to its having been burnt through by contact with a 500 volt wire on the same poles. At the time of the accident, however, it was not in contact with the latter wire, but it was subsequently found that there was an earth on the other main of the 110 volt circuit. The man killed was a seaman, who was taking a short cut across some vacant ground, and as the night was very wet and stormy he was wet through. He got hold of the wire to pull it to one side, and receiving a shock fell into a gutter of running water, but the fall did not release his hold upon the wire. The people who ran to his assistance, on hearing his shouts, also received shocks in their endeavours to release him, and by the time he was got clear of the wire and a doctor had been summoned he was quite dead. The post-mortem examination showed that death was caused by the passage of the current transversely across the body and through the heart and lungs.

**Obituary.**—We were only able last week to publish the bare announcement of the death of Mr. R. F. Yorke, which came in as we were going to press. Reginald Frederick Yorke, second son of the late Admiral Reginald Yorke, was born in Herefordshire, in 1862, educated at Marlborough College, and his first practical experience of electrical work was in the service of the Eastern Telegraph Company at Porthcurnow. It was his lot to be the first man in England to learn of the disaster at Majuba Hill. Subsequently he was employed at Derby in the Midland Railway Co.'s telegraphic department under the late Mr. William Langdon. Here he first turned his attention to accumulators, in which he devised various improvements. During the greater part of his professional career he had been occupied with the application of water power to electric lighting, and many private houses in England and Scotland, as well as in the town of Fort William, bear witness to his ability and skill.

The death took place at Gainsborough last week of Mr. Henry D. Marshall, director of Marshall, Sons & Co. (Ltd.), the famous engine builders. Mr. Marshall was 66 years of age, was a J.P. for Lindsey, a member of the county council since its formation, a member of Council of the Institution of Mechanical Engineers, a member of Council and past president of the Agricultural Engineers' Association, and a member of the executive board of the Engineering Employers' Federation.

**Hull Municipal Telephone System.**—Reports are current to the effect that negotiations are proceeding between the National Telephone Co. and the Hull Corporation with regard to a transfer of the municipal telephone system in that city to the company. It is stated that offers have been made, both by the Post Office and the National Telephone Co., and that after a further conference in London a few days hence, an official announcement will be made. A hint has been made that there will be strong opposition to the removal of the competition which at present exists, and which, it is claimed, has been to the advantage of the telephone user in Hull. The Hull and District Chamber of Trades has already held a meeting of protest. On the other hand it is stated that the offer of the National Telephone Co. in question provides for the complete recoupment of all the expenditure incurred by the Corporation, and that the rates now charged to the subscribers to the municipal service will not be disturbed for a period of three years. The Hull Corporation was granted a licence by the Postmaster-General on August 8, 1902, and in the ordinary course of events it would expire on December 31, 1911, coincident with the acquisition of the whole of the National Company's undertaking by the Post Office. The capital expenditure on the undertaking to December 31, 1905, was £26,900, but the borrowing powers of the Corporation under this head to December 31, 1904, were £64,075. The total number of instruments on the system at December 31, 1905, were 1,790, in addition to 149 junction lines. The system was put into operation on November 1, 1904.

**Bristol Corporation and the Somerset Electric Power Co.**—At the meeting of the Bristol Corporation on Tuesday, a report from the Electrical committee with regard to the Somerset Electric Power Co. was considered. It will be remembered that Bristol and Bath were the first two Corporations owning electricity undertakings to be included in the area of an electric power company, the Somerset Bill of 1903 creating a precedent in this respect. Under the terms of the act the company must secure the consent of the Bristol Corporation to supply within the city, but the company could appeal to the Board of Trade if such consent were refused on the ground that it was unreasonable. As a matter of fact, very little has been done by the Power Company to put its act into force, and the report of the Bristol Corporation Electrical committee, referred to above, stated that "they had considered the desirability of approaching the Board of Trade with the view of obtaining an order providing that the powers of the Somerset & District Electric Power Co. under the Somerset and District Electric Power Act, 1903, shall cease to be operative within the area of the city and county of Bristol, and, being of opinion that it is desirable, they recommend that they be authorised to apply to the Board of Trade for an order accordingly." The Corporation adopted the report. We may point out that the Bristol Corporation is enabled to make this effort to rid itself of the Power Company by the following clause in the Act of 1903:—

> *Clause 69.*—If within two years of the date of the passing of this Act the company have not substantially commenced their works for the purpose of carrying out their powers under this Act, and if within four years from the date of the passing of this Act the company have not provided a generating station or stations sufficient in the opinion of the Board of Trade, and are not in a position to supply therefrom, the Board of Trade may, on the application to them of any authorised undertaker, and after hearing the parties, order that the powers of the company under this Act shall cease as to the whole or any part of the area of supply, and on any such order being made its powers shall cease accordingly.

**The Paris Automobile Salon.**—*La Revue Technique* has issued a compendious account of the recent Paris Automobile Exhibition, which consists of the contents of three thick numbers of that journal bound together. The work contains fully illustrated descriptions of all the principal cars and accessories exhibited. and forms a valuable record of the present state of the automobile industry in France. The electric cars are comparatively few. The Védrine carriages, not often seen in this country, but famous for the run recently made from Paris to Trouville without recharging, are described, and attention is drawn to the simplicity of the controlling apparatus. Amongst other electric cars mentioned are those of Mildé, ranging from landaulettes to heavy lorries, Garcin Renault, and those of La Société "L'Electromotion," in which the motor forms a part of the back wheel. All the principal makes of petrol cars are described, and it is interesting to note the large proportion which are fitted with magneto ignition, the high-tension variety being especially prominent. One of the Panhard models for this year, however, is fitted with a small shunt-wound dynamo driven by the engine which charges the accumulators, an automatic switch disconnecting it when the speed falls below a certain value. In the section devoted to accessories, numerous forms of accumulators are mentioned, and the ignition devices of J. Lacoste & Co., including their latest form of self-contained high-tension magneto, are fully described. The "Nilmelior" magneto for use with a separate induction coil is also noticed, and a description is given of a rectifier of the vibrating tongue type exhibited by J. F. Henrique for charging ignition accumulators from an alternating circuit. Ammeters and voltmeters of various type, both indicating and recording, are illustrated, together with electrical speed indicators, some of these also being of the recording type. One of the most interesting parts of the volume is the account of the collection of up-to-date machine tools, especially those for high-speed gear cutting, which formed such a remarkable feature of the exhibition.

**The Corpuscular Theory of Matter.**—In the second lecture of his Saturday series at the Royal Institution, Prof. J. J. Thomson, continuing his survey of the sources of negative corpuscles, described their production from zinc and other metals under the action of ultra-violet light. Using the liquid alloy of sodium and potassium he demonstrated on the lecture table the existence of a stream of corpuscles from the metal when light fell on its surface, and showed that the stream was deflectable by a magnetic field. The corpuscles, again, are given off from the surface of red-hot metals or oxides of metals and from other bodies, and they are no doubt emitted copiously from the sun. Finally, the corpuscles are given off abundantly and at high speeds by radium and other radio-active substances. All these corpuscles can be measured by the methods previously described, and are thus found to be all alike. The size, that is the linear magnitude of the corpuscles, has been estimated by the deeper consideration of their mass. In the first place, it has been calculated that the effective mass of a charged conducting sphere, as measured by its inertia when set into motion, is, on account of the charge, greater than the ordinary mechanical mass by $\frac{2}{3}$ (charge)$^2$/radius, approximately. This is because a moving charge sets up a magnetic field whose establishment requires that work shall be done over and above that of the ordinary accelerating force. For spheres of ordinary size this electrical mass is insignificant, but for bodies so small as corpuscles it is important. Further, the electrical mass is greater at greater speeds; for at higher speeds the lines of force radiating from a conducting sphere crowd more closely to the zone of the sphere farthest from the line of motion, so that the strongest parts of the magnetic field become strengthened. This variation of the electrical mass with speed provides means for its detection; and Kaufmann, taking advantage of the variety of speeds among the corpuscles that constitute the $\beta$-rays of radium, has thus measured the electrical mass of corpuscles. His results show that the electrical mass of a corpuscle is the whole mass; there is no mechanical mass. Thus the total mass $m$ of a slowly moving corpuscle is $\frac{2}{3}\,e^2$/(radius); and this, taken with the known ratio $e/m$ yields for the radius of the corpuscle the value $10^{-13}$ cm. Now, the conventional atom has a radius about $10^{-8}$ cm.; therefore the corpuscle is to the atom, in bulk, as a very fine pellet is to a very large room. The electric field, however, of the corpuscle, though in fact mostly concentrated very centrally, extends theoretically to infinity, raising the question, Where is, or, rather, where is not the corpuscle? and giving, if matter is made up of corpuscles, a rude blow to the old dogma of the impenetrability of matter. Apart from the experiments already described on the properties and dimensions of corpuscles, many of the conclusions so reached have been confirmed by Zeeman's discovery that a magnetic field alters the period of vibration, as shown by the spectrum lines, of the constituent parts of an atom. In particular, the ratio $e/m$ of the corpuscles of which material atoms are built was shown by Zeeman to be the same as that already given by electrical measurements. The lecturer next entered upon the question of the existence of small carriers of positive electricity. Positive carriers are found in the vacuum tube discharge, but have properties very different from those of the cathode rays. For example, the cathode rays—that is, negative corpuscles—if made to bombard a lithium salt, cause a blue phosphorescence; positive particles ("canal rays") cause a red phosphorescence. Moreover, their mass, measured in the same way as is the mass of the negative particles, varies with the nature of the gas and of the electrode, and are usually a very mixed company. Some are as small as the hydrogen atom, and some are much heavier. The $\alpha$ particles of radium give $e/m = 500$; which shows (if $e$ is the same for positive and negative carriers) that they are as big as two hydrogen atoms, or half as big as the helium atom. Further, the $\alpha$ particles cannot be considered to be a mere mixture of hydrogen and helium atoms, or there would be more dispersion than is the fact in a magnetic field; and yet on the whole we cannot consider that the $\alpha$ particles are the indivisible units of positive electricity in the same sense that corpuscles are units of negative electricity.

**Electric Winding.**—A Paper on "The Use of Electricity in Collieries" was read by Mr. B. Barrett Coulston before the Manchester Geological and Mining Society on February 13th, Mr. Henry Bramall in the chair. According to the *Colliery Guardian*, Mr. Coulston referred in his Paper to Mr. Mountain's recent Paper on "Electric Winding" (see *The Electrician*, February 9th, p. 658), and is reported to have said that the costs of the electrical plant given by Mr. Mountain were distinctly high, and, even using the same system, he (the author) felt satisfied that an electrical plant could be installed at a considerably smaller first cost. It should, however, be noted that Mr. Mountain's comparisons were simply taken on a plant for one shaft only, and where (as at so many collieries) there were several shafts, the electrical drive would, at once, begin to compare favourably as regards first cost with the mechanical system, owing to the possibility of having a central generating station and boilers, instead of having a number of isolated plants. It should also be noted that when the fact was taken into consideration that the electric current might be supplied to the winding plant and also to machines underground, instead of erecting a separate plant, this discrepancy in the costs of the mechanical and the electrical systems was again greatly reduced. Some interesting figures recently published seemed to demonstrate, if the electrical system were adopted for the whole of the operations on the surface and underground, that the cost of the machinery would be only slightly higher than that required for the mechanical system, and that the actual working costs were reduced from 10 to 30 per cent. There was also another side of the use of electricity, but, in his opinion, it had been almost worked to death by the advocates of the mechanical system, and that was the question of the extra labour entailed in superintending the running of electrical machinery. This, however, actual experience had proved, even with the systems of winding now in use, to cost no more for the electrical than for the mechanical; and in the future, when, as the writer firmly believed, the turbine would be used almost universally for providing the motive power of the generating plant, both the wages and upkeep would be considerably less than at present. It should, moreover, be noted that, with an electrical installation, the question of the site for the engine house could be decided without considering for one moment the question of the position of the mine shaft; and this was often a question demanding a considerable amount of attention, having especially in view the question of water supply. There was also another point relating to the question of first cost of an electrical winding plant, and that was the possibility of taking a supply from the large power companies now starting operations in this country. Some of the prices for electric current which had been quoted by these companies were extremely low, and as, for the purpose of making dividends, it was necessary that the machinery should be kept running constantly, with as near a maximum load factor as possible, it was more than probable than any large colliery, guaranteeing to take power from one of these companies, would be offered extremely low terms. This was being done at the present moment in staple pits, and the costs of running were found to be extremely low, and to compare very favourably with the mechanical system. The electrical system was undoubtedly the most economical and efficient for haulage; and, where main-and-tail haulage was employed, the load on the motor, in actual practice, had been shown to be so regular that it was a common thing to see the ammeter connected to the motor running steady within 5 per cent. of the normal load. The author also referred to the use of coal-cutters driven by electricity. For pumping, Mr. Coulston continued, electrical driving had proved, owing to its flexibility, to be considerably in advance of any other system. In many cases pumps were mounted on a truck and moved down the roadways as the water is pumped out of the mines; and, further, an electrically-driven pump might often be found in an out-of-the-way corner, left without attention, except for being overhauled occasionally. The alternating-current system was most suitable, and most likely to be adopted for future installations. Due to the fact that squirrel-cage motors could be used for any operation throughout the mine, sparking troubles were at once eliminated.

## ARRANGEMENTS FOR THE WEEK.

(To-day) **FRIDAY, March 16th.**

INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.

Afternoon visit to the Board of Trade Electrical Laboratory, 8, Richmond-terrace, Whitehall.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse on "How to Improve Telephony," by W. Duddell.

**SATURDAY, March 17th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture III., by Prof. J. J. Thomson, F.R.S., on "The Corpuscular Theory of Matter."

**MONDAY, March 19th.**

INSTITUTION OF ELECTRICAL ENGINEERS: NEWCASTLE LOCAL SECTION.

*8 p.m.* Meeting at the Armstrong College, Newcastle-on-Tyne. Paper to be read: "Electric Winding Considered Practically and Commercially," by H. G. Hooghwinkel.

**TUESDAY, March 20th.**

ELECTRICAL CONTRACTORS' ASSOCIATION: LONDON SECTION.

*8 p.m.* Meeting at Frascati's Restaurant, Oxford-street. Paper to be read: "Gas Suction Plant," by Mr. Rigby of Messrs. Crossley Bros., Ltd.

**THURSDAY, March 22nd.**

ROYAL INSTITUTION.

*5 p.m.* Afternoon Lecture I: "Internal Combustion Engines," by Professor B. Hopkinson.

JUNIOR INSTITUTION OF ENGINEERS.

*6.15 p.m.* Visit to the Works of Messrs. Fraser & Chalmers, Erith.

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Ordinary General Meeting. Paper to be read: "The Electrical Equipment of the Aberdare Colliery of the Powell Duffryn Colliery Co.," by C. P. Sparks. This Paper will be discussed in conjunction with Mr. W. C. Mountain's Paper, read before the Manchester Local Section on January 16, on "Electric Winding as Applied to Main Shafts, considered Practically and Commercially" (*The Electrician*, February 9th, p. 658).

**FRIDAY, March 23rd.**

PHYSICAL SOCIETY OF LONDON.

*5 p.m.* Meeting in the Pender Electrical Laboratory, University College, Gower-street, London. Agenda: (1) "On Unilateral Electric Conductivity over Damp Surfaces," by Prof. F. T. Trouton, F.R.S. (2) "The Construction and Use of Oscillation Valves for Rectifying High-frequency Electric Currents," by Prof. J. A. Fleming, F.R.S. (3) "On the Use of the Cymometer for the Determination of Resonance Curves," by G. B. Dyke.

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER STUDENTS' SECTION.

*7.30 p.m.* Meeting at the Municipal School of Technology, Sackville-street, Manchester. Paper to be read: "Lubrication and Lubricants," by R. C. C. Yates.

**SATURDAY, March 24th.**

TRAMWAYS AND LIGHT RAILWAYS ASSOCIATION.

*1 p.m.* Trip over the Aylesbury & Chesham lines and a visit to the Neasden power house. Special train leaves Marylebone Station at 1 p.m.

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture IV., by Prof. J. J. Thomson, F.R.S., on "The Corpuscular Theory of Matter."

# LARGE ALTERNATORS AT SIEMENS BROS.' DYNAMO WORKS.

Messrs. Siemens Bros. & Co. have just completed a pair of large alternators, forming, together with some smaller machines, part of a large order for the Municipality of Johannesburg. These generators were designed and constructed entirely in this country, and form good examples of slow-speed alternating current practice. Through the courtesy of Mr. C. F. von Siemens we were given an opportunity, on Monday last, of seeing these machines running on Hopkinson test, and of inspecting the works at Stafford.

A point of interest lies in the fact that these alternators will be driven directly by Oechelhäuser gas engines. They are designed for an output of 1,800 k.v.a. at 3,300 volts, two-phase, 50~, at a speed of 100 revs. per min., and are intended to work on a circuit having a power factor of 0·75, this giving 1,350 kw. with 275 amperes per phase. The guarantees called for by the specification of Messrs. Mordey & Dawbarn were that the temperature rise should not exceed 50°F. on any part after running for 12 hours on the full non-inductive load of 1,350 k.w. The rise of voltage on throwing off full load at unity power factor at 3,300 volts was specified not to exceed 5 per cent., and the drop on throwing on full non-inductive load with excitation for 3,100 volts open circuit was not to be more than 6 per cent. The excitation losses at full load at 0·75 power factor was required not to exceed 20 kw., the excitation voltage being 230 volts. These strict guarantees necessitated somewhat larger machines for the output, and the makers inform us that if the generators had been rated in accordance with their standard practice, allowing a temperature rise of 70°F., the same size of machine could have been supplied for 2,400 k.v.a.

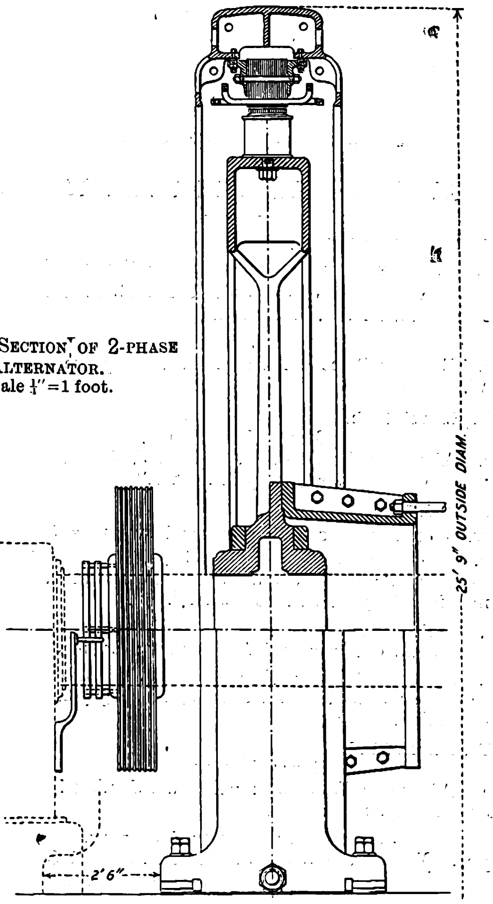

Fig. 1.—Section of 2-phase Alternator.
Scale ¼" = 1 foot.

A part section of one generator is given in Fig. 1, and the principal dimensions are as follows: Diameter of stator core, 260 in. (= 660·4 cm.); length of core, 10 in. (= 25·4 cm.); ventilation ducts, none; 480 slots—*i.e.*, four per pole per phase. The air-gap for which the machine is designed is 6·6 mm., but, as will be seen later, the air-gap when the machines are warm is slightly greater.

The cast-iron stator frame is made in four parts, held together by concealed bolts. The stator core plates are firmly clamped by means of insulated bolts between two cast-steel angle plates, which are fixed to the stator frame by means of bolts and adjustable sleeve nuts, making it unnecessary to machine the inside of the stator frame. The core plates are insulated with paper and, the slots being open, the coils are held in place in the usual way by wood keys. All the coils are former wound and insulated with micanite moulded on to the straight portions. These micanite tubes project some distance beyond the stator cores to ensure a sufficient leakage distance. The ends are taped with a special oiled tape and kept well away from all parts of the frame or core. The rotor consists of a cast-steel wheel made in four sections. The poles are round and solid and carry laminated pole-shoes. Each pole is attached to the periphery of the wheel by a single screw prevented from working loose by a locking washer, and is kept from turning on its seat by a steady-pin. No special arrangements have been employed for increasing the flywheel effect of the rotors, as large independent flywheels are to be used. In view of the high excitation voltage specified, "strip or edge" has not been employed for the field winding, although it is the firm's usual practice. The slip-rings are of brass, and are supported on insulated pins screwed into the boss of the rope pulley which drives the exciter. Two carbon brushes are provided to each ring.

The two identical machines have been coupled together on a temporary shaft and mounted on the ordinary test-bed in the main erecting shop, as shown in Fig. 2. It will be seen that there is ample room both in the pit and overhead under the traveller for machines of this large diameter to be tested without any special arrangements having to be made. The method of testing adopted has not often been applied to such large machines, and enables both machines to be run at their full rated capacity with an expenditure of power only slightly in excess of the losses in the two machines. The proper value of current at normal full load is obtained by the two frames being angularly shifted from their normal position so as to give a phase displacement of about 25 degrees. The leading machine runs as a generator under actual working conditions with an output of 1,350 kw. (205 amperes) at unity power factor. The lagging machine runs as a motor with slightly reduced flux. The necessary power to overcome the losses of the machines was supplied by a continuous-current motor directly coupled to the shaft and shown in Fig. 2. The instruments on which the readings were taken were collected together on the table shown at the right of the figure, and we noticed how very steady was the current circulating between the two machines, showing no signs of hunting or surging.

According to one of the preliminary tests, the losses for one alternator at an output of 1,377 kw. (non-inductive) worked out at 93 kw. (not including bearing friction) made up as follows: Windage, 19 kw. Iron losses, 38 kw. Copper loss: Stator, 10 kw., field, 16 kw. This gives a full load efficiency of 94·3 per cent., including excitation. The official tests had not been made at the time of our visit, but we hope to be able to give the results of these, together with some further notes of the method of testing and the way in which the angle through which the stators are displaced relatively to each other was calculated, in our next issue. Some further tests are also to be taken at various power factors up to 0·75 by giving the two machines different excitations.

A number of other interesting machines, representing some of the very latest developments in design, are under construction in the works. Amongst the turbo-machines is a 650 kw. three-phase alternator for a South African mine, in which the whole machine is enclosed, and fan blades on the rotor drive the air through axial ventilating channels in both rotor and stator, the usual radial ventilating ducts being entirely absent. The rotors have a smooth surface, the winding being carried in closed slots instead of on separate poles. Another interesting set just completed is a flywheel motor-generator for a mine winding plant on the Ilgner system. This particular set was of small size, being driven by a three-phase 550 volt motor of 33 B.H.P. We were informed that this motor, which runs on a 40 cycle circuit at a full load speed of 1,160 revs. per min., has a power factor of 0·93 and a temperature rise of 30°C. after continuous running at full load. The motor is in no way "special," but is one of the firm's new standard "V" type induction motors, of which we saw a large number in course of construction, a new form of squirrel cage being employed in the smaller sizes.

Some new developments in design are in progress in the continuous-current turbo-generators with the object mainly of obtaining better ventilation. In some of the latest machines even the commutators have axial ventilating channels in each segment, through which the air is forced by fan blades.

Experiments are being carried out with very promising results with the new electro-pneumatic multiple unit control equipment for single-phase traction motors which Messrs. Siemens Brothers have recently designed, and we understand that a line of single-phase commutator motors for crane work will very shortly be introduced. We also witnessed an experimental demonstration of a new train lighting system, in which a specially constructed generator is used which will give a practically constant voltage between limits of speed of 1,600 and 400 revs. per min.

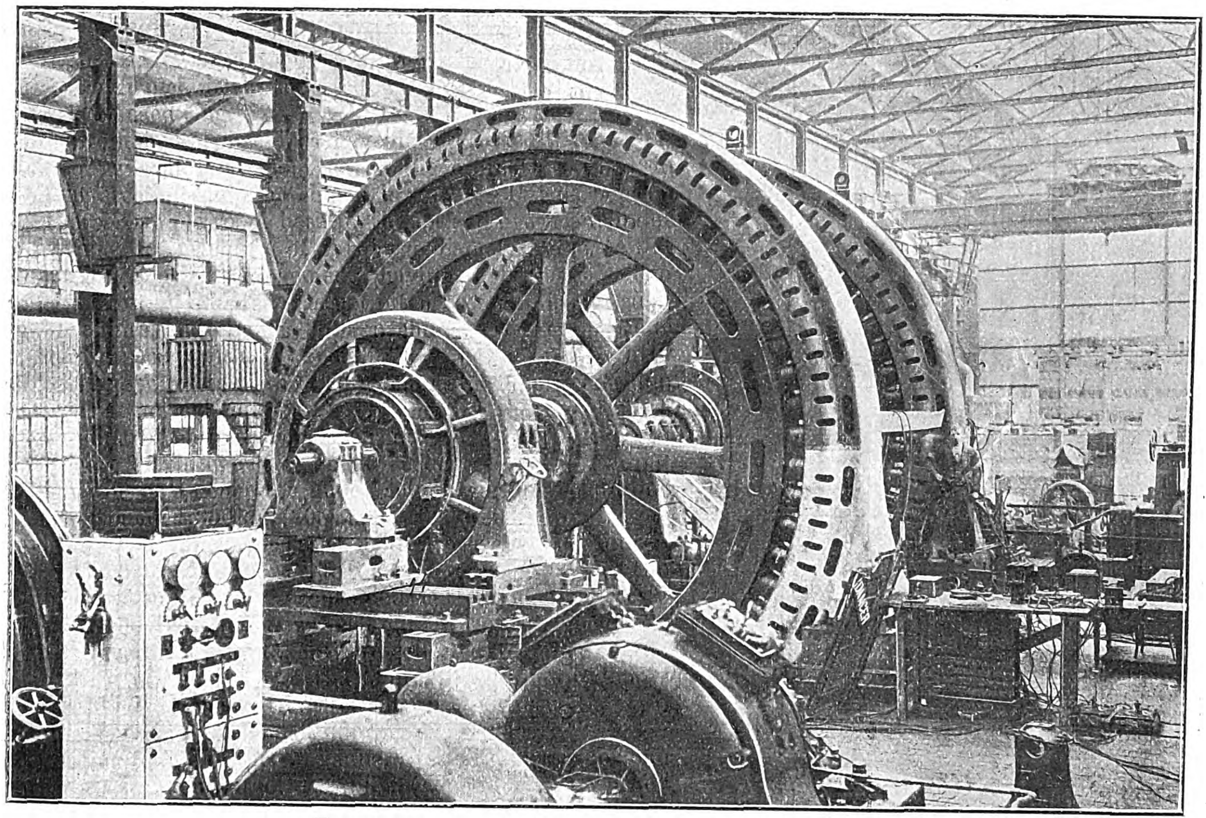

FIG. 2.—ALTERNATORS COUPLED TOGETHER FOR TESTING.

The main erecting shop, in which machines of all sizes are put together, contains at one end the test-beds to which we have referred, including a 800 H.P. Belliss engine for testing purposes, and the main generating plant is situated in the same building, the boilers being contained in an annexe. A continuous-current machine is directly coupled to the Belliss engine permanently at one end of the shaft. If a larger power than 800 H.P. is needed, the machine can be run as a motor to assist the engine, and the machine to be tested is then connected to the other end of the shaft. The whole shop is 478 ft. long by 115 ft. wide, and is constructed in three bays. The machine shop building is separate and is 284 ft. long by 275 ft. wide, consisting of eight bays, four of which are provided with galleries. The stores for materials run across the whole width of the building at one end, being arranged in sections so that each bay is provided with its own store. A railway siding runs across the extreme end behind the stores. The first bay is devoted to the machining of various parts and contains a number of turret lathes and automatic machines. Part of the second bay is used as a switchboard shop. Only a portion of the switchboard work is, however, carried out at Stafford, as the greater part of the high tension switchboards are at present constructed at the older works at Woolwich. The manufacture of the latest types of oil-break switch has, however, been commenced at Stafford. The remainder of the second bay is principally devoted to lathes and grinding machines for spindles and shafts, and the special band saws for cutting off the round wrought-iron pole pieces which are used in all the standard direct-current machines cast into the yokes. These are set to cut automatically the required curve corresponding to the diameter of the frame of the machine they are being made for. Half of the third bay forms the tool room, the rest being occupied by lathes, &c., for machining various small parts. The fourth bay is fitted up with the smaller size boring mills, drilling machines and planers for dealing with frames, bearing brackets, and contains some special double-ended boring mills for carrying out a number of operations at one setting. The heavy tools are all together in the fifth bay, where they are all driven by separate motors. Amongst these is the large boring mill which was a familiar sight at the old Woolwich works, capable of taking work up to 30 ft. in diameter. Part of this bay is occupied by the portable tool beds, where portable self-contained electrically-driven slotting machine and other tools can be moved about to suit large work fixed to the bed. The sixth bay is used for commutator manufacture and armature winding, but the largest commutators and armatures are dealt with in the seventh bay. The eighth bay contains the presses of all sizes for stamping armature core plates, &c.

The first of the four galleries about the machine shop is devoted to turning and milling of small parts such as brush-holders. The second gallery is used for the manufacture of motor starters, crane controllers, field rheostats and some of the larger switches. We particularly noticed the arrangement of some of the larger starters, in which the moving contact is formed of a renewable block of graphite which minimises wear by keeping the contacts well lubricated. The other two galleries are devoted to former wound armature coils and bobbin winding respectively. The papering of the core plates is done before stamping by a special machine in a separate building, and a quality of core plate is used which does not require annealing. The saw-mills and pattern shop are in an independent building, and a small foundry is provided where small parts are cast, but all the larger castings are made elsewhere.

(*To be concluded.*)

# THE BIRMINGHAM CARBON FACTORY.

A party of Press representatives were given an opportunity on Friday last of inspecting the carbon factory established by the General Electric Co. at Witton, near Birmingham. Mr. Max Railing, one of the directors of the company, who presided at the lunch before the inspection of the works, briefly outlined the history of the undertaking in a short speech.

Mr. Railing said that it was five or six years ago that the directors of the General Electric Co., realising the increasing use of electric light carbons in this country, determined to establish a carbon works in England. At that time some 20 to 25 million metres of carbons were imported yearly, and an equipment was laid down as a start to manufacture about 6 million metres per year, about 250 men being employed. The output of the works had, however, not been able to increase since then with the speed he might have wished, as the prices charged by foreign carbon manufacturers had in the meantime been reduced by something like 100 per cent., rendering competition more difficult. He was satisfied, however, that their actual cost of production at Witton was as low as that of the firms abroad, and expressed the hope that a better time was in store for them when public bodies and large industrial concerns would be willing to place a larger proportion of their orders for carbons with the only firm who made them in this country. He also referred briefly to their engineering works, and mentioned several large orders which they had in hand, including material for the electrical equipment of Portsmouth Dockyard and a very large order for motors to be used on the lifts of the new London Underground Railways.

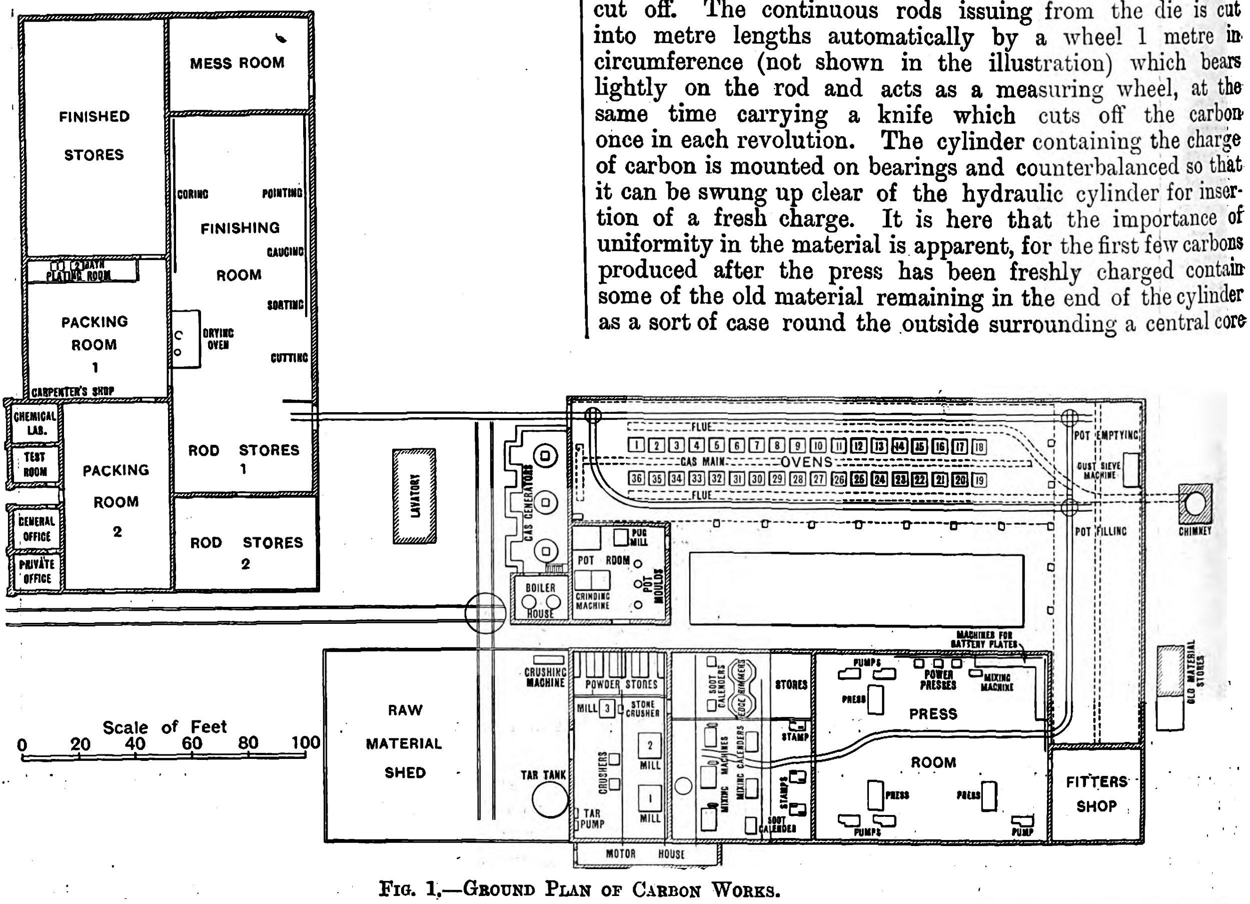
MESS ROOM
FINISHED STORES
CORING
POINTING
FINISHING ROOM
GAUGING
SORTING
DRYING OVEN
CUTTING
PLATING ROOM
PACKING ROOM 1
CARPENTER'S SHOP
CHEMICAL LAB.
TEST ROOM
GENERAL OFFICE
PRIVATE OFFICE
PACKING ROOM 2
ROD STORES 1
ROD STORES 2
LAVATORY
GAS GENERATORS
BOILER HOUSE
POT ROOM
PUG MILL
GRINDING MACHINE
POT MOULDS
FLUE
GAS MAIN
OVENS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
36 35 34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19
POT EMPTYING
DUST SIEVE MACHINE
POT FILLING
CHIMNEY
OLD MATERIAL STORES
MACHINES FOR BATTERY PLATES
Scale of Feet
0 20 40 60 80 100
RAW MATERIAL SHED
CRUSHING MACHINE
TAR TANK
POWDER STORES
MILL 3
STONE CRUSHER
CRUSHERS
2 MILL
1 MILL
TAR PUMP
SOOT CALENDERS
EDGE RUNNERS
MIXING MACHINES
MIXING CALENDERS
SOOT CALENDER
STORES
STAMP
STAMPS
PUMPS
POWER PRESSES
MIXING MACHINE
PRESS
PRESS ROOM
PUMP
FITTERS SHOP
MOTOR HOUSE

Fig. 1.—Ground Plan of Carbon Works.

The process of carbon manufacture is very straightforward in principle, and a stroll round the works gives the impression that no great difficulties require to be overcome. The raw materials pass through a series of comparatively simple operations, but it is only by the most careful attention to detail that success can be assured and a good and a uniform quality of carbon produced. The purity of the materials is as important as in a chemical factory, and the greatest care has to be observed in the handling of the rods to prevent them becoming even slightly bent, and therefore useless. The raw materials used are gas-retort carbon, soot and tar. The retort carbon is obtained as a by-product in the manufacture of gas, but the soot and tar have to be specially prepared for the purpose, as they require to be of certain definite physical and chemical constitution.

A short description of the works was given in *The Electrician*, Vol. L., p. 678, but we are now able to give some fuller particulars of the manufacture.* A general ground plan of the works is shown in Fig. 1. The first process is the selecting and cleaning of the raw retort carbon, all of which is carefully examined and hand-picked to remove impurities, an operation needing some skill and experience. The selected carbon passes to the crushers, one of which is shown in the foreground in Fig. 2, where it is broken up to pieces about the size of small pebbles and further reduced to fine powder in the grinding mills. An air separator is used to separate out the coarser particles, which are passed back to the mills to be reground. The soot is put through calendar rolls and mixed with the pulverised carbon and tar in a steam-heated mixing machine working on the same principle as the machines used in bread making. The mixed material is afterwards passed through steam-heated calenders, in which the ingredients are still further incorporated. The semi-solid mixture is then fed by hand into the stamps in which it is stamped up into cylindrical blocks under a drop hammer, those blocks being of the exact size of the cylinders of the presses used for making the rods.

One of the presses is shown in Fig. 3, where the carbon rod is seen issuing from the die and passing on to a series of rollers from which it is lifted by the attendant after being cut off. The continuous rods issuing from the die is cut into metre lengths automatically by a wheel 1 metre in circumference (not shown in the illustration) which bears lightly on the rod and acts as a measuring wheel, at the same time carrying a knife which cuts off the carbon once in each revolution. The cylinder containing the charge of carbon is mounted on bearings and counterbalanced so that it can be swung up clear of the hydraulic cylinder for insertion of a fresh charge. It is here that the importance of uniformity in the material is apparent, for the first few carbons produced after the press has been freshly charged contain some of the old material remaining in the end of the cylinder as a sort of case round the outside surrounding a central core of the new material. The pressure in the hydraulic cylinder is obtained from four-throw electrically-driven pumps, of which one is seen behind the press in the figure. The pressure required varies according to the size of carbon being made, ranging from about 200 up to 800 atmospheres. In making cored carbons, the die has a needle fixed in its centre, so that a hole is produced down the centre of the rod which is afterwards filled with a softer preparation. The rods when they leave the presses are quite flexible, being somewhat of the consistency or indiarubber, but become appreciably stiffer after being kept for a few days. After this seasoning, the rods are packed into bundles of a size to closely fit into the long cylindrical fireclay pots in which they are baked. The bundling is done

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* Those who desire to obtain more information as to carbon manufacture should consult Mr. F. Jehl's exhaustive work on "The Manufacture of Carbons for Electric Lighting and Other Purposes," published by "The Electrician" Printing & Publishing Co.

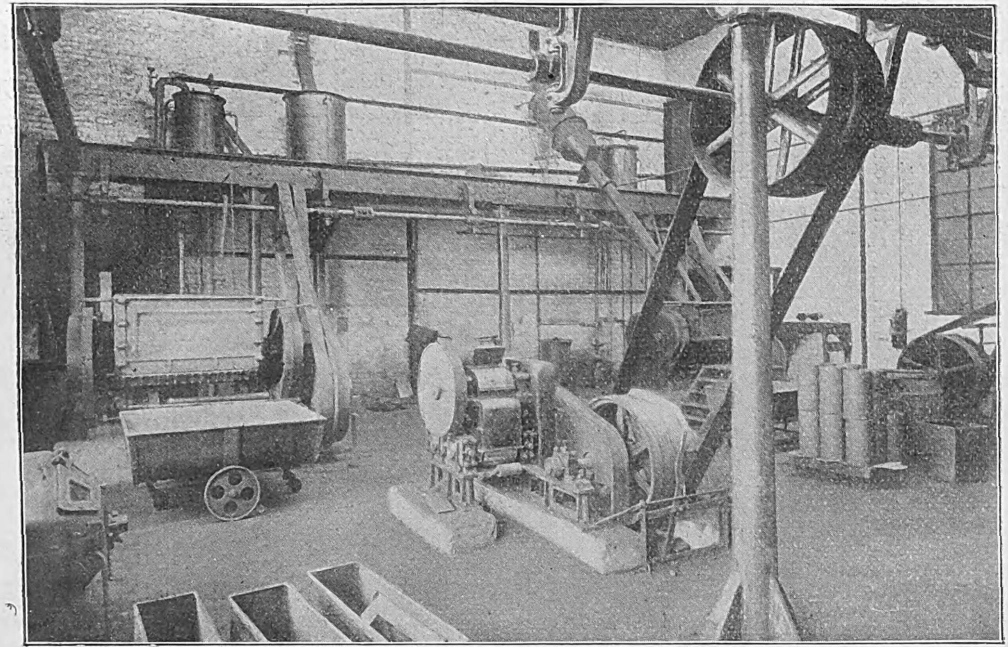

FIG. 2.—CRUSHING AND MIXING MACHINES.

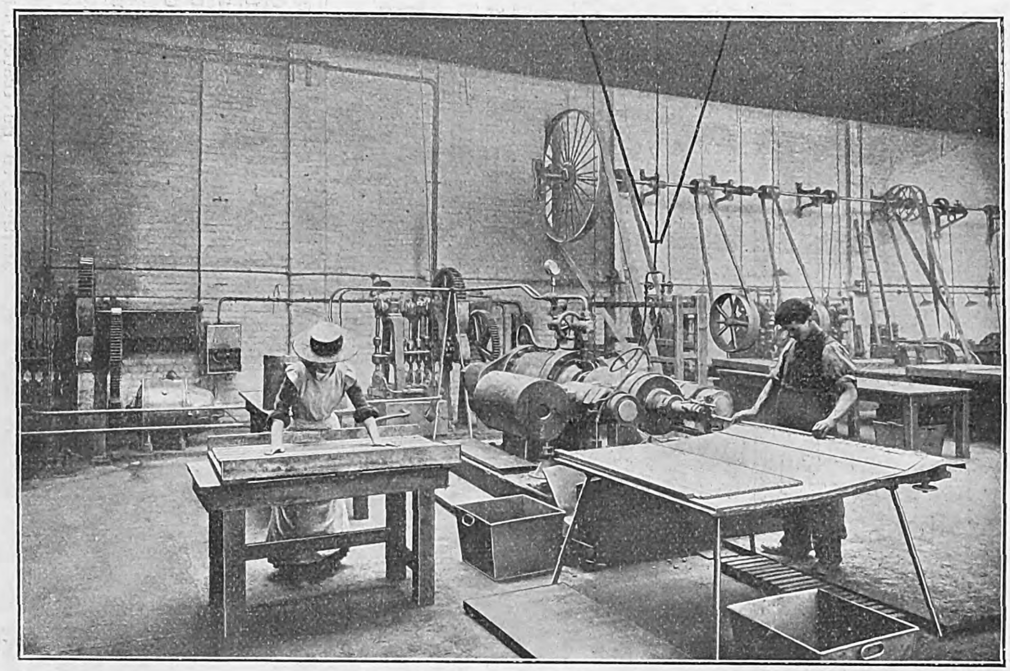

FIG. 3.—HYDRAULIC PRESS.

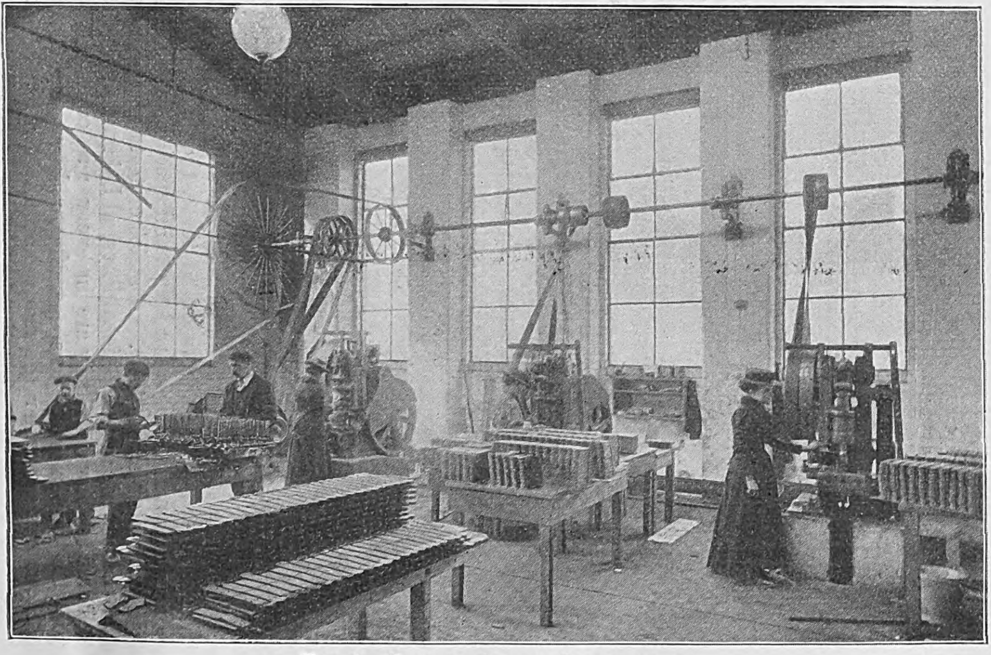

FIG. 4.—BATTERY CARBON DEPARTMENT.

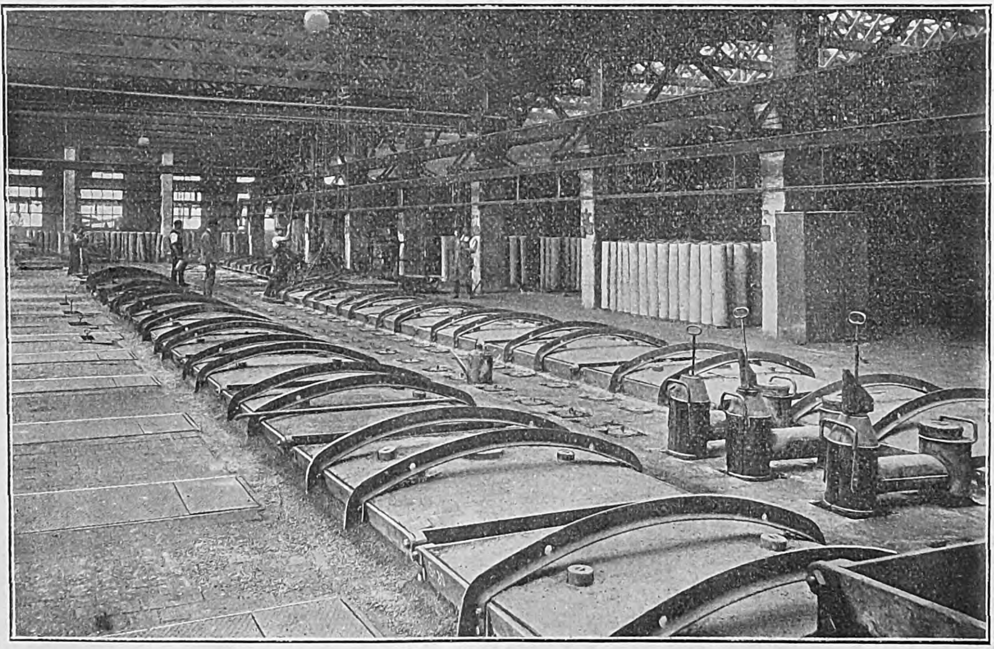

FIG. 5.—FURNACES.

in special hexagonal troughs, so the rods shall fit together and support each other to avoid becoming bent during firing.

Battery carbons are also made in the same part of the factory and a similar process is employed for the manufacture of agglomerate block for Leclanché cells. Special presses, shown in Fig. 4, are provided for forming the heads on the battery carbons into which the terminals are screwed. The head is composed of an enlargement of the carbon itself, instead of the older method of casting on a metal head being used.

The long fireclay pots into which the bundles of rods are packed for firing are made in a special department of the works of carefully selected clay, and fired in a special furnace near the carbon ovens. After the bundles have been placed in the pots they are entirely filled up with fine carbon dust, which prevents the access of air to the rods while they are being fired.

The gas-fired ovens in which the carbons are baked are let into the ground in two rows, each cell having a separate lid. The arrangement is shown in Fig. 5. The gas is generated in producers adjoining the oven room, and the gas main passes down between the two lines of ovens, to any of which it may be connected, the flues leading to the chimney shaft being along the sides as indicated in Fig. 1. Only a small group of cells are actually alight at one time, but the working is continuous, all the cells being fired in rotation. Following the course of operations, we will start with an oven which is cool, and from which the baked carbons have been removed. The oven is filled with the pots containing the unbaked carbons and the cover fixed down, connection is then made with the flue and the passage opened between the next oven of the series, which is then disconnected from the flue. By this means the exhaust gases which have passed from the furnaces under gas through all the intermediate cells pass into the oven containing the new carbons and the gradual heating up commences. As the successive ovens are filled and those the other side progressively fired, the oven we are considering has hotter and hotter gases passed through it at each step, until in its turn it is connected to the gas supply and fired. By this method a gradual heating up is assured. A somewhat similar arrangement is adopted in the cooling process, as it is of equal importance for this to be effected gradually. The air feeding the furnace in action passes through a series of ovens which are cooling, being heated up step by step and causing the carbons to cool progressively. The fire thus travels round the whole ring in order, and is only allowed to go out once or twice a year for cleaning of the ovens. The total time during which the carbons are in the ovens is about 64 hours.

After being fired the carbons are quite hard and stiff and pass on to the finishing shops. They are then cut to the required lengths and passed through the sorting machine, in which any that are not perfectly straight are rejected. This is done by allowing them to roll between two parallel plates set at an exact distance apart so that only the straight ones can pass through. The next machine automatically grinds the ends flat and to the exact length, a further machine pointing one end. This completes the process so far as solid carbons are concerned, but the cored carbons have yet to be filled with the soft-core mixture. An automatic machine first blows compressed air through the canal to clean out dust and afterwards pumps in the core mixture under considerable pressure. After this the cored carbons are dried in an oven, but do not require again baking at high temperature. A few carbons for special purposes are copper-plated in a small shop devoted to this work, being kept in motion all the time they are in the plating tanks.

Several different qualities of carbons are manufactured, amongst which are the following: The "Apostle" brand, for open-type lamps, burning with a long life and comparatively small percentage of ash; the "Nubia" quality, which is a higher grade for open lamps; and the "Witton" brand for enclosed lamps. In addition to these, the factory also produces carbons for flame arc lamps and special carbons for projectors for other purposes. A series of tests of these carbons has been made at the National Physical Laboratory, the results of which show that they are in every way equal in quality to the best-known types manufactured on the Continent. The works are under the management of Mr. M. Solomon, to whom our thanks are due for much of the information contained in this article.

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While at Witton the opportunity was taken to make a short tour of inspection of the engineering works, under the guidance of Mr. R. Dumas. This works has already been described in *The Electrician*, Vol. L., p. 675. The main shop, which is divided into two bays, measures about 330 ft. by 140 ft., and contains the machines and erecting bays and the armature winding and commutator-making departments, such operations as coil winding and insulating being carried on in the cross galleries at the end. The firm make great use of a special impregnated paper, which, although only 5 mils in thickness, will, we are told, easily stand a P.D. of 6,000 volts without puncturing, and is particularly proof against damage through cracking when folded. We noticed several large machines in the works nearly or quite completed, including a single-phase alternator for the South London Electricity Supply Corpn. and a two-phase alternator for Fulham. Amongst the smaller machines under construction, the large number of lift motors for the London Underground Railways were particularly noticeable. The machine equipment includes a fine boring mill capable of taking work up to 24 ft. in diameter. We noticed a few generators under construction with auxiliary commutating poles, of which a much freer use is now being made by designers, even for quite moderate speeds, than formerly. A separate mica and micanite shop is provided in a small building by itself, where we particularly noticed the arrangements for moulding a micanite covering the exact shape of the slot on to armature coils for high-tension generators. This method has a great advantage over drawing into separate micanite tubes owing to complete exclusion of air inside the insulation, but, of course, is only applicable to cases where open slots are used.

The large machines are tested in the main shop, but the testing of small motors is carried on in an adjoining building, which contains, also, the power station and some of the packing shops and stores. A row of seven special testing beds are provided, so that the machines to be tested are raised some 2 ft. or 3 ft. above the floor level; being thus much more accessible for connecting up and examination by the attendant. The leads are carried under the floor from the raised test beds to a separate switchboard for each bed, entirely dispensing with the usual maze of temporary leads lying about the test-room floor. The paint shop adjoining is entirely enclosed and partitioned off from the packing shop, to avoid the entry of dust. The firm carry out the whole of their casting up to the largest sizes in their own foundry, which, together with the pattern stores, are contained in a separate building a short distance away from the main shops. The separate buildings are kept well apart, so that ample space is left for extensions of any particular department.

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**Electrolytic Preparation of Lithium.**—It has always been a difficult matter to obtain pure lithium by the electrolysis of fused lithium chloride, which has been the method up to now usually employed. In the *Zeitschrift für Elektrochemie* of March 9th O. Ruff and O. Johannsen describe a method which they have satisfactorily worked out for its preparation by the electrolysis of lithium bromide. They prepare the lithium bromide by the action of hydrobromic acid on the carbonate. As electrolysing apparatus a copper vessel is employed, which is water jacketed, so that the walls can be kept cool. The anode is of retort carbon, and the cathodes, which are two in number, of iron wire 4 mm. in diameter. The electrolyte consists of a mixture of lithium bromide, containing 15 per cent. of the chloride. A current of 100 amperes at 10 volts is employed, and the yield of metallic lithium is about 80 per cent. of the theory. From time to time the metal, as it collects on the iron, is removed by a flat iron spoon and immediately placed on a cold stone surface, where it rapidly solidifies. The metal so obtained does not contain more than 0·17 per cent. of sodium. Determinations of the melting point of lithium show it to be 180 deg., which agrees with that found by Bunsen more than half a century ago.

# THE GREENWICH POWER HOUSE OF THE L.C.C. TRAMWAYS.

*(Continued from page 835.)*

The high-tension switch gear is undoubtedly one of the most interesting features of the power-house equipment, for it has been carried out by the British Westinghouse Co. to a specification of Mr. Rider's, in which particular attention has been directed to attaining absolute certainty of working and perfect safety. We published an article about two years ago giving the main points of the specification, and although the arrangements indicated have not been departed from, it is necessary to repeat ourselves to some extent in order that the details of the gear as actually constructed may be properly appreciated. Provision has been made for eight generators and 32 feeders, representing the full equipment of the station, and not merely the half-station of four generators which is now approaching completion. There are eight section 'bus bars, each for four feeders and one generator, which can be connected together to main 'bus bars, and these again are divided into two distinct sets. The connections of these sectional 'bus bars and the positions of the switches and isolating plugs are shown in Fig. 15, two sections sufficing to illustrate the arrangement, and, to avoid overcrowding the diagram, the instrument transformers have been omitted. The feeders come in in the basement through a tunnel, and are enclosed in wrought-iron casing, as shown in Fig. 16. All the high-tension switches are "remote control." In the tunnel this casing is covered in with concrete, as seen in the illustration. Attention may also be drawn to the angle-iron construction on the ceiling of the basement, which has been provided specially to carry the cables from the generators and the auxiliary circuits. Heavy wooden cleats are used to fix the cables to this framework. From the basement upwards, the cables run in open chases which were designed with the buildings, so that no cutting away has been necessary in bringing up the cables to the galleries on which the switches, &c., are placed. Cast iron bricks were also laid at about 4 ft. intervals to take the cleats which hold the cables. The walls and chases are in brown glazed brick and present a neat appearance. Some of them are seen in Fig. 17, which shows some of the cables on the first gallery on their way to the switches and 'bus bars on the second gallery; this illustration may be read in conjunction with Fig. 18, which shows the galleries in section. On arriving at the first gallery the lead-covered three-wire cables are divided by trifurcating boxes, from which rubber cables rise to heavy isolating plugs placed in chambers protected with wire fronts permanently screwed on, and thence they pass to the current transformers in the large tanks seen above them, and are then again connected to lead-covered three-core cable in tail boxes. On the second gallery similar cable boxes are employed, and single rubber

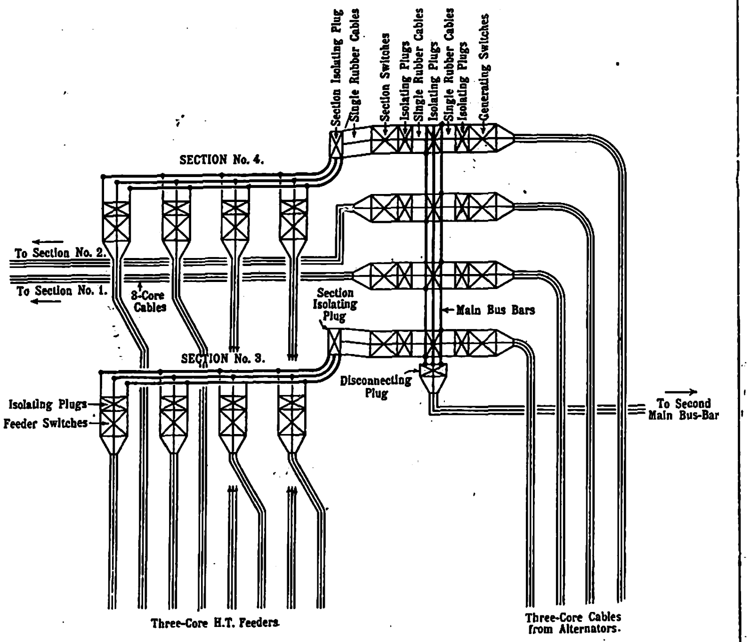
Section Isolating Plug
Single Rubber Cables
Section Switches
Isolating Plugs
Single Rubber Cables
Isolating Plugs
Single Rubber Cables
Isolating Plugs
Generating Switches
SECTION No. 4.
To Section No. 2.
To Section No. 1.
3-Core Cables
Section Isolating Plug
Main Bus Bars
SECTION No. 3.
Disconnecting Plug
Isolating Plugs
Feeder Switches
To Second Main Bus-Bar
Three-Core H.T. Feeders
Three-Core Cables from Alternators.

Fig. 15.—Diagram of Connections of H.T. Switch Gear.

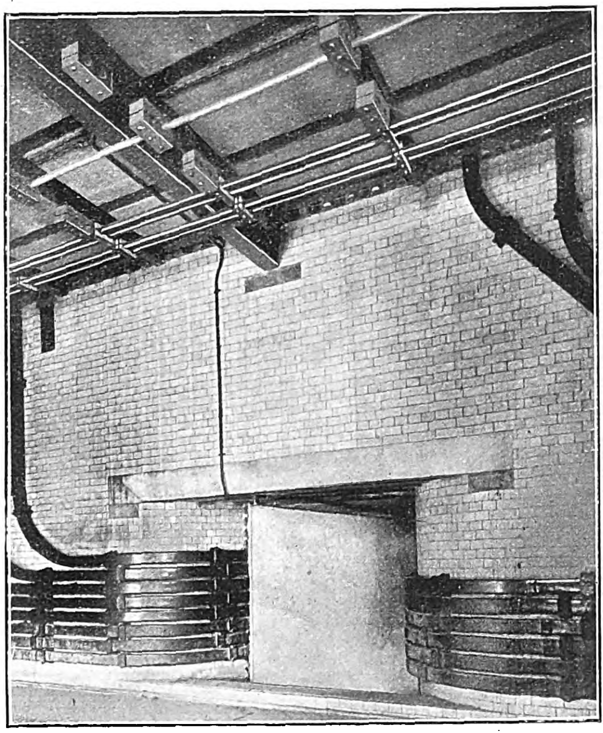

Fig. 16.—Point of Entry of Feeders in Basement.

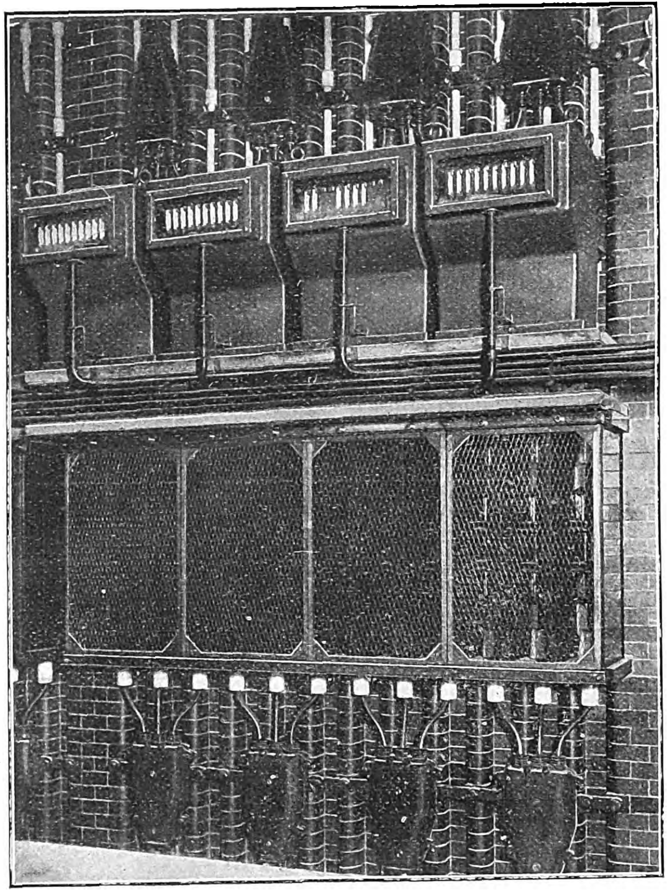

Fig. 17.—Cables, Tail Boxes, Isolating Plugs and Instrument Transformers.

cables are led to the feeder switches and isolating plugs which connect on to the section 'bus bars.

The arrangement of the instrument transformers differs from previous practice. Instead of the various current and pressure transformers being separate, the cast-iron tank seen in Figs. 17 and 19 contains all the transformers necessary for working the ammeters, wattmeters, and relays, &c. Each tank contains three series transformers and two shunt transformers, together with three fuses for the latter. This grouping of all the instrument transformers into one large tank, filled with oil, is a convenient and compact arrangement. The secondary terminals are connected to wires which run to the control desk, and are there connected to the various instruments on a board in front of the control desk. As the main H.T. cables are sweated to terminals which are in line with each other, no deviation is made in the direct alignment of the H.T. cables. The transformers themselves are fixed to a cast-iron frame which can be readily withdrawn from the tank. In front of the transformers are the L.T. fuses in a box with glazed cover resembling an ordinary house-circuit fuse-board.

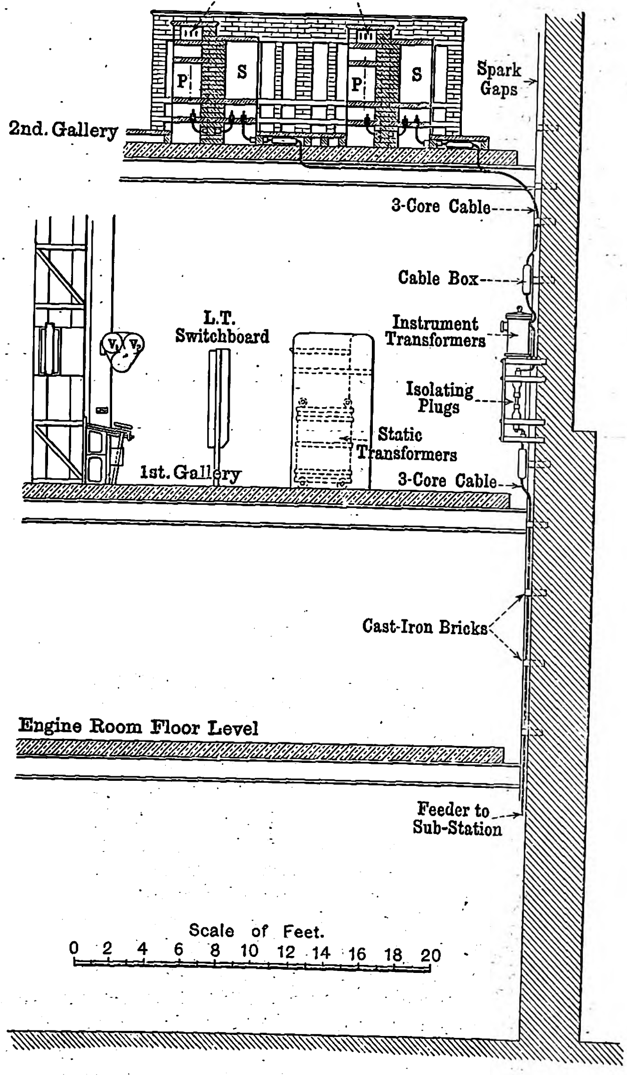
Sectional Bus Bars
P
S
P
S
Spark Gaps
2nd. Gallery
3-Core Cable
Cable Box
L.T. Switchboard
Instrument Transformers
Isolating Plugs
Static Transformers
1st. Gallery
3-Core Cable
Cast-Iron Bricks
Engine Room Floor Level
Feeder to Sub-Station
Scale of Feet.
0 2 4 6 8 10 12 14 16 18 20

FIG. 18.—CROSS-SECTION OF SWITCHBOARD GALLERIES.
P—Chambers for isolating plugs. S—Chambers for oil switches.

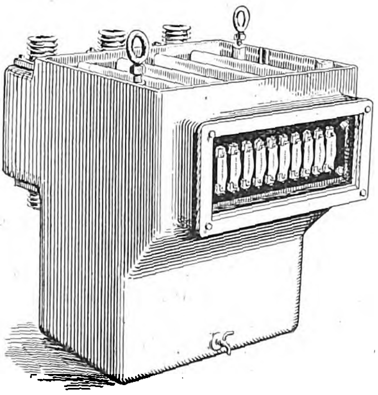

FIG. 19.—INSTRUMENT TRANSFORMER.

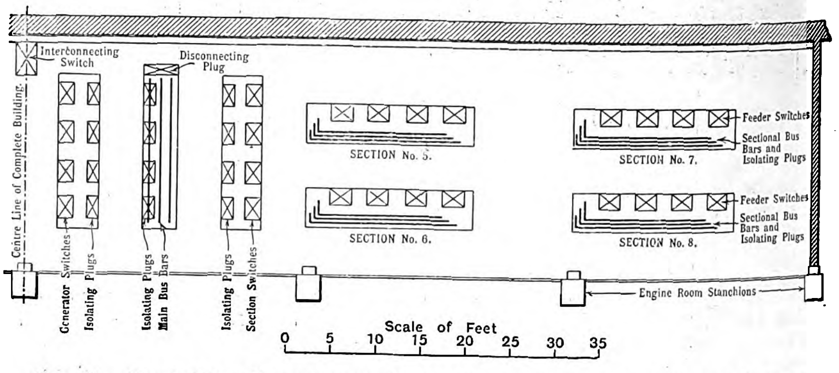
Interconnecting Switch
Disconnecting Plug
Centre Line of Complete Building.
Generator Switches
Isolating Plugs
Isolating Plugs
Main Bus Bars
Isolating Plugs
Section Switches
SECTION No. 5.
SECTION No. 6.
SECTION No. 7.
SECTION No. 8.
Feeder Switches
Sectional Bus Bars and Isolating Plugs
Feeder Switches
Sectional Bus Bars and Isolating Plugs
Engine Room Stanchions
Scale of Feet
0 5 10 15 20 25 30 35

FIG. 21.—DIMENSIONAL DIAGRAMMATIC PLAN OF RIGHT-HAND HALF OF SECOND GALLERY.

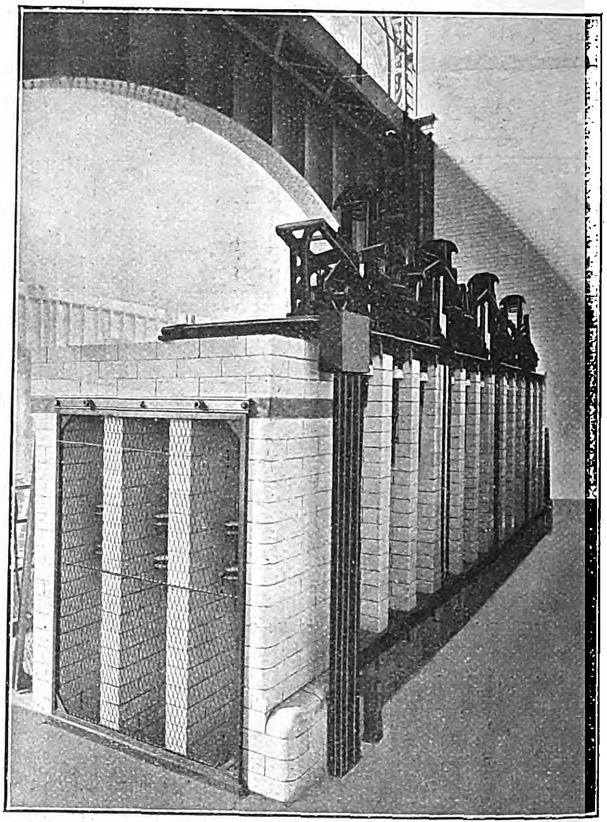

FIG. 20.—ONE OF THE SECTIONS CONTAINING H.T. SWITCHES, ISOLATING PLUGS AND 'BUS BARS.

The arrangement of the various sections on the second gallery is seen in the key plan, Fig. 21. Fig. 20 shows one of the blocks of switches and isolating plugs. The 'bus bars are in brick cells at the top of the block, disposed as indicated in Fig. 18. All the cells are faced with glazed brick. Figs. 22 and 23 show the switches themselves in greater detail. They are of the British Westinghouse Co.'s latest pattern. with solenoid operation, and a feature is the relatively small quantity of oil requisite for the entire immersion of the live parts. Each pole and its respective oil tank are in a separate compartment. There are two stationary contacts per pole, one connected to the incoming lead and the other to the outgoing lead of the same phase, and each contact is mounted within a large porcelain insulator fixed to the cast-iron frame, which forms the top of and supports the oil tank. These frames are fastened by means of strain insulators to the underside of a slate slab, which is placed on the top of the cell structure, and the cast-iron base of the operating mechanism is mounted on the top of this slab. The movable contact for each pole consists of a U-shaped copper cross-piece fastened to the end of a stout wooden rod. In the closed position of the switch, one such cross-piece electrically connects the two stationary contacts of one pole. The wooden rods are fastened at their upper ends to a common cross-bar, which, through a system of levers giving a straight-line motion, is raised by means of the closing magnets, assisted at the beginning of the motion by a pair of balancing springs. A toggle joint automatically locks this system of levers when the circuit breaker is in the closed position, and the toggle is released by a blow from a tripping magnet, which with gravity, assisted by a powerful spring, causes the cross-bars—with the movable rods and contacts—to drop to the open position. There are thus two breaks in series for each pole of the circuit breaker. The stationary contacts are each fitted with a removable plug which enters a hole in the movable contact, Contact between this plug and the movable contact is broken after the main contacts have separated, hence all spark-wear occurs on this plug, which can be removed and replaced when worn out.

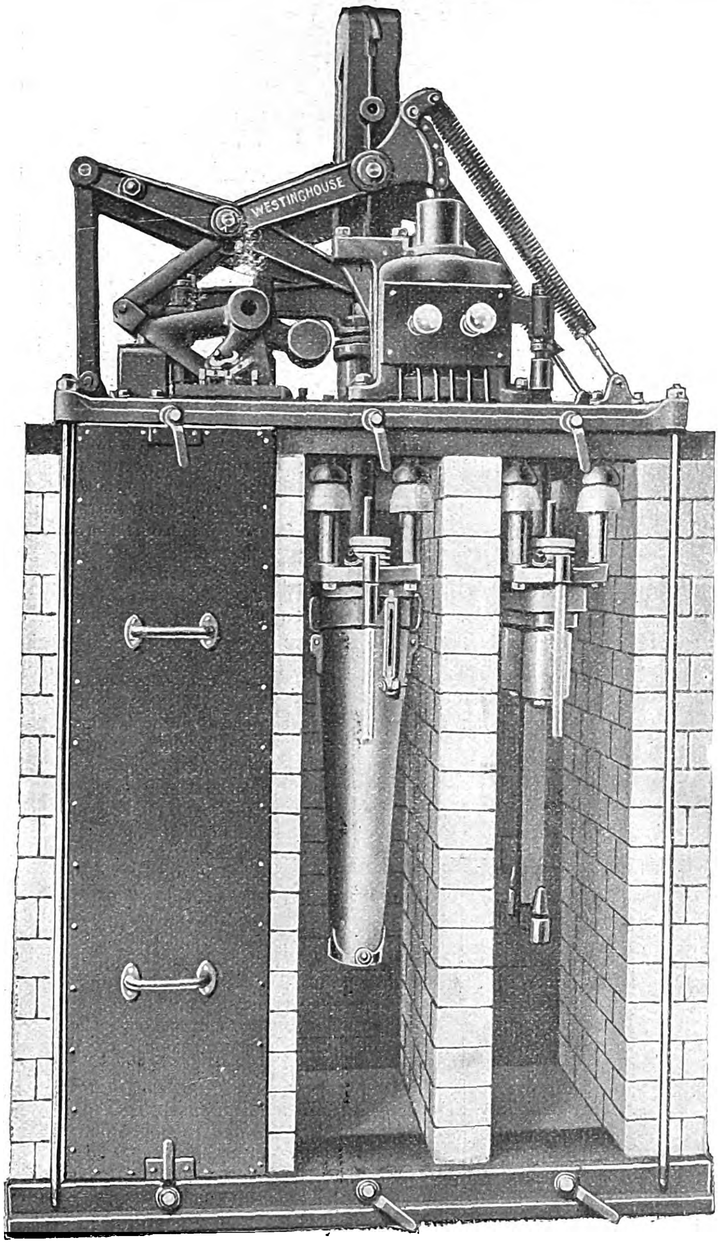

Fig. 22.—Westinghouse H.T. Switch in Brick Compartment; Two Front Covers Removed and One Oil Tank Removed.

The oil tanks are constructed of heavy sheet metal, and are held in place by means of clamps, to the underside of the frame carrying the terminals. The interior is lined with insulating cement, which is moulded to such a form as to fit closely about the terminals and moving contact piece, leaving just room enough for the free movement of the parts in the oil. By this means the amount of oil is reduced to a minimum as already stated. Suitable levers are provided for handling the tanks, so that they can be readily lowered away from the contacts and removed, without dismantling the switch. The oil level is indicated by means of a small sight gauge. When necessary a tank may be drained or refilled without removing it from its position. The tanks themselves are insulated from the circuit.

Mounted on each switch is a small double-pole double-throw knife switch, which is used in connection with the indicating and tripping circuits, and is operated by the motion of the levers of the switch. The controlling and indicating devices consist of a controlling switch and red and green lamps mounted on the switch and also on the controlling desk at the operating platform. A polyphase overload relay, connected to series transformers in the main circuit, is provided for automatic opening of the feeder switch, and a reverse-current relay is provided for the automatic opening of the generator switch.

Connections are taken from the first tail box of each feeder to the spark-gaps which are situated on the second gallery. These are for the purpose of discharging any excessive high pressure in the feeders due to surging effects; no feeder-charging gear is employed. The wire from each core of each feeder comes up through the pipe at the bottom of each of the narrow panels (Fig. 24), and is connected through a fuse to four series of spark-gaps between short cylinders of non-arcing metal. The porcelain tops of these are seen in the figure. The gaps are shunted by a resistance, which is intended to divert from the spark-gaps the current following the discharge, and there is also a series non-inductive resistance between the spark-gaps and the earth bar at the top of the panels. These resistances are contained in the three frames above the spark-gaps in Fig. 24; the lower ones are the shunt resistances and the upper ones the main resistances. There are dividing partitions of slate between each panel, the first seven of which have been removed for the purposes of the photograph.

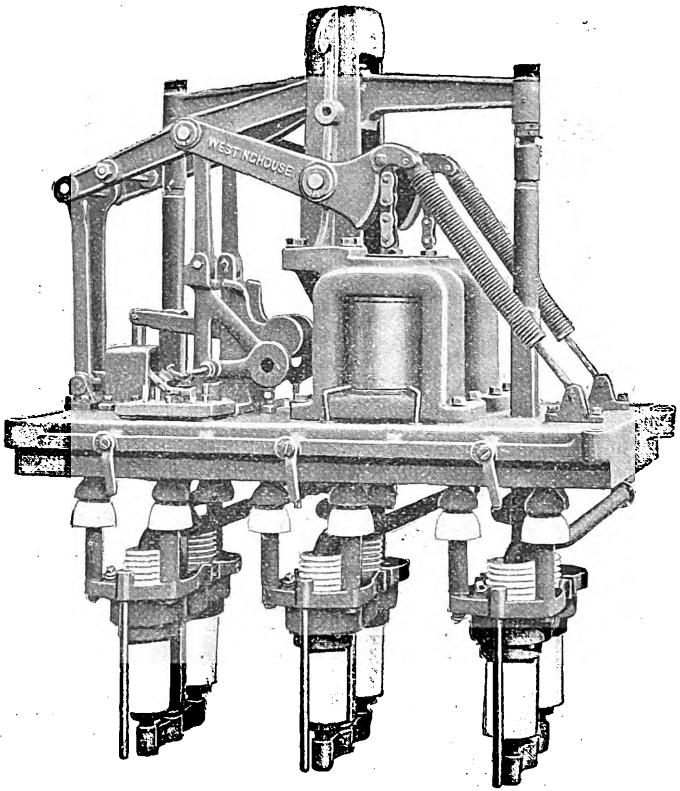

Fig. 23.—H.T. Switch (closed), without Oil Tanks and Removed from Brick Cell.

The controlling, measuring and indicating gear needed in conjunction with the E.H.T. generator and feeder apparatus is grouped on a control desk and instrument board, both of which are arranged in such a manner that the operator faces the engine room, as seen in Figs. 18 and 25. The instrument board is fixed in front of and at a higher level than the desk, so that the attendant can read his instruments, operate his switches, and see what is going on in the engine room without turning round. The desk is 60 ft. long over-all, and is built up of white marble panels, fixed to a frame made with wrought-iron base, vertical castings and top wrought-iron tie straps. Every generator panel has one, and every feeder panel and section panel two controlling switches; and each switch has two indicating lamps, one red which lights when the switch is closed, and the other green which lights when the switch is open. The controlling switches are of the drum type and are arranged so that a simple motion of the handle to left or right closes or opens the main switch, and when the controller handle is released it springs back to a central zero position. Figs. 25 and 26 show the generator and feeder control boards for the present half of the station; the instrument board is not yet in position. The circular rings are the covers of the lamps.

In addition to the controlling switch each generator panel has the following equipment: (*a*) A switch which operates the engine governor, by causing a small motor to wind or unwind a weight along a spindle, as already described in our description of the engines; (*b*) a push actuating a signal bell; (*c*) a second push, which is designed to operate the electromagnetic knock-off on the engine, which has also been mentioned (this push cannot be used until a small glass cover above it has been broken); (*d*) three synchronising plug sockets, which are spaced unequally, and only two plugs provided—*i.e.*, one for each spacing—so that the danger of two machines being plugged on to the synchronising 'bus bars at the same time is prevented;* (*e*) a hand wheel operating the field resistance, and which is fitted with an indicator and pointer (the indicator is divided into 60 sections, to correspond with the 60 contacts of the resistance, and the pointer is geared to follow the travel of the brush of the resistance switch over the contacts); (*f*) six tumbler switches for signalling purposes, by means of which various signals—"slow," "run up," "on load," "reduce," "stop," "No. 1," "No. 2," "No. 3," "No. 4," "A," "B," &c.—are illuminated on a board placed at a convenient height at the end of the station in such a position as to be visible from all required parts.

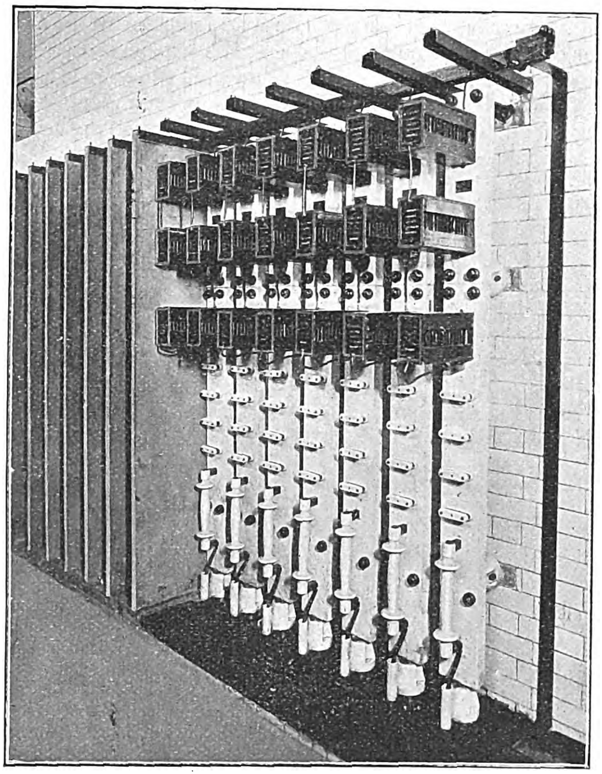

Fig. 24.—Spark-gap Panels.

For the sake of neatness of appearance, the signal lamps, control switch and bell pushes are all arranged with a bezel which can be removed from the front of the desk for cleaning purposes. Each panel is distinctly engraved with the name of the apparatus which it controls. All the wiring of the control desk is brought to terminal boards, which are plainly marked for connecting-up purposes.

One of the main roof stanchions passes through the centre of the control desk, and around this a frame has been built, carrying panels, on which are mounted the switches and fuses for the 125 volt. D.C. supply to the control desk, and main H.T. switches. These panels are also fitted with fuses for the signalling circuits, and a control switch to operate the H.T. switch interconnecting the main 'bus bars. This latter is provided with a glass-fronted guard to prevent improper use.

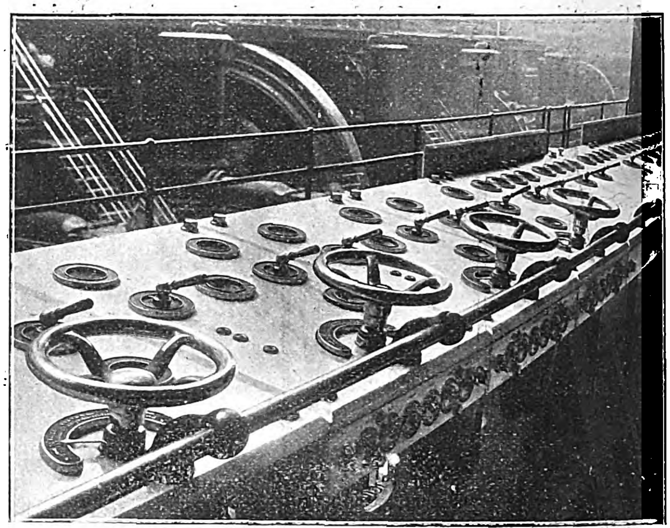

Fig. 25.—Generator Panels of Control Board.

The instruments provided for each feeder circuit are, power-factor meter, indicating wattmeter, and A.C. ammeter on the instrument board, and an integrating wattmeter with overload inverse time element relay, for tripping the main switch on the control desk. For each generator circuit the instrument board panels contain power-factor meter, indicating wattmeter, A.C. ammeter and D.C. ammeter; and on the control desk, integrating wattmeter with adjustable time limit reverse current relay for tripping the main switch.

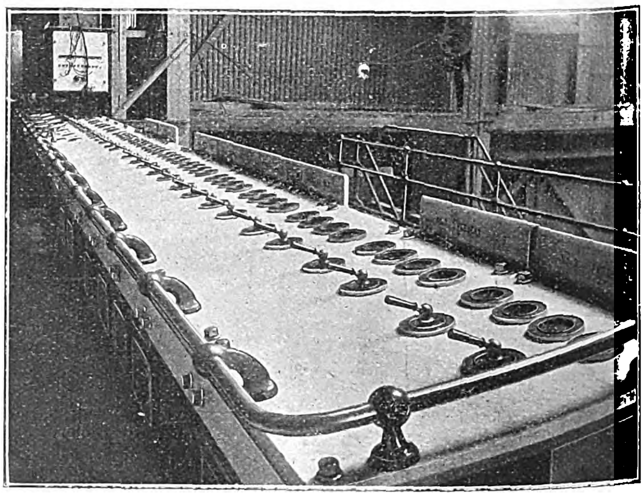

Fig. 26.—Feeder-panels of Control Board.

The main low-tension switchboard, for the works motor circuits and for distributing the low-tension D.C. circuits working the switches is placed on the first gallery in the position indicated in Fig. 18. It contains 46 panels and its total length is 90 ft. It is enclosed by a glazed brick wall 8 ft. 6 in. high which has two openings fitted with Bostwick gates and spring locks. The panels of the board are of enamelled Welsh slate, 1½ in. thick, and its design follows the usual practice for switchboards of this nature. The first 15 panels are connected to a set of 220 volts three-phase 'bus bars, for supplying the induction motors which drive the auxiliaries in the station. Each of these panels is fitted with a three-pole overload loose-handle circuit breaker, two ammeters and one three-pole switch. At the extreme left of the board, a swinging arm carries an illuminated dial voltmeter. The next two panels control the two 120 volt auxiliary generators, and are each fitted with double-pole loose-handle reverse-current circuit breakers, two S.P. knife switches, the hand-wheel for regulation of the shunt circuit and the usual instruments. Then follow four panels for the 105 volt D.C. lighting and motor circuits, and three panels for the 125 and 550 volt battery supply and battery booster mentioned in our issue of last week. A control switch operates a motor-driven battery switch fixed near the battery, and an indicating lamp shows when the contact brush of the battery switch is full on a contact. Nine panels are provided for the 550 volt D.C. lighting and motor circuits, and next come 12 track-feeder panels for the local tramway service, and at right angles to these is placed the testing panel. These 22 panels form the switchboard equipment of the local sub-station, and contain similar arrangements for indicating faults and testing as in the other sub-stations described in detail in *The Electrician*, Vol. LI., p. 159.

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* For further particulars of the synchronising connections the reader is referred to our previous article, *The Electrician*, Vol. LIII., p. 134.

(*To be concluded.*)

## THE OSCILLOSCOPE.

BY DR. LEWIS JONES.

Under the name of the glow-light oscillograph, Ruhmer* has suggested the use of a special form of vacuum tube as a means of observing the wave contours of high potential discharges. It is based upon an adaptation of the fact observed by H. A. Wilson† that in a vacuum tube the area covered by the glow upon the negative wire is proportional to the magnitude of the current through the tube. When a suitably exhausted tube is traversed by a high potential discharge the negative wire is partly covered by a violet glow, which seems to form a luminous sheath to the free extremity of the wire along which it also extends for a certain distance. With increase of current the area covered by the glow lengthens out, and with decrease of current it becomes shorter. If the current is alternating in direction, then both wires show the negative glow, but to an unequal degree. To the eye the glow appears steady, but when viewed in a revolving mirror it is found to form upon each wire alternately, and to rise and fall in time with the variations of the current, and so it traces out the contours of the wave impulses of which the discharge consists.

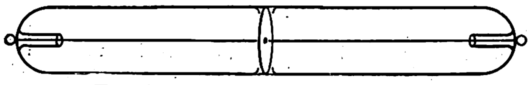

FIG. 1.—OSCILLOSCOPE OF RUHMER.

Ruhmer's tube (Fig. 1) is 35 cm. long and 4 cm. in diameter, with two slender rigid nickel wires arranged axially. The distance between their ends is about 2 mm., and a disc of thin porcelain or of mica is fixed at this point. It is pierced by a small hole, which corresponds with the ends of the electrodes. The degree of exhaustion corresponds to 6 mm. of mercury. This simple apparatus may be used to obtain valuable information as to the behaviour of high potential tranformers or of induction coils. By its means the character of the discharge under different conditions can be examined. For instance, it can be used to examine the working of the interrupter of an induction coil in order to see whether the impulses are regular or irregular; it throws light upon the nature of the current through an X-ray tube, and it can be used to test the degree of efficiency of rectifying devices or valve tubes. The images seen in the revolving mirror are of great beauty, and photographs can be taken by the device of driving the mirror synchronously, as has been shown by Ruhmer. In judging the appearances observed in the mirror, it is necessary to remember that the glow upon the wire is not a mathematical line, but has a certain thickness, and, in addition, it has a peculiar "test-tube" shape, and for these reasons the curves seen in the mirror present a certain degree of distortion, which, however, is not sufficient to interfere with the value of the apparatus for qualitative purposes.

An interesting point to be observed with this apparatus when it is arranged in an induction coil circuit in series with an X-ray tube and viewed in the revolving mirror is that the discharges under these conditions are almost instantaneous. The long waves which occur when there is no X-ray tube in circuit are no longer seen, but are replaced by the simple image of the negative glow, and practically no elongation of this image is produced even with moderately fast rotation of the mirror.

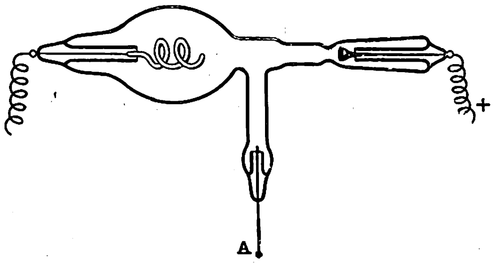

FIG. 2.—VILLARD'S VALVE TUBE.
A is a platinum tube used as a vacuum regulator.

A curious effect can also be observed if a Villard valve tube be connected in series with the oscilloscope, without an X-ray tube. The Villard tube (Fig. 2) is a rectifying device in the form of a vacuum tube having the internal electrodes of different kinds. One is an open helix of aluminium wire situated in a wide portion of the tube, and the other is a straight wire narrowly enclosed in a constricted part. Such a tube has a very strong rectifying effect. Current passes easily when the helix is cathode, but not in the other direction. This apparatus is widely used in X-ray work as a means of protecting the X-ray tube from the currents of the coil. It has the effect of improving the action of the tubes and of permitting measurements of current to be taken with a direct-current milliamperemeter. When its action is examined by means of the oscilloscope tube one observes, in the first place, that the current of the coil is completely suppressed in one direction. If the current which passes is the current of rupture, a succession of single impulses of bold outline is seen (B, Fig. 3); but, when the commutator in the primary circuit is reversed, the valve tube opposes the current of rupture of the coil and allows the current of closure to pass through the circuit, and then the wave often presents a double contour, as of two impulses grouped in pairs (C, Fig. 3). I am not able to give an explanation of this effect, although I have observed it on many occasions; but these examples serve to show that the oscilloscope tube lends itself very well to the study of the phenomena of the X-ray circuit, and it is probable that further useful indications may be obtained from its study.

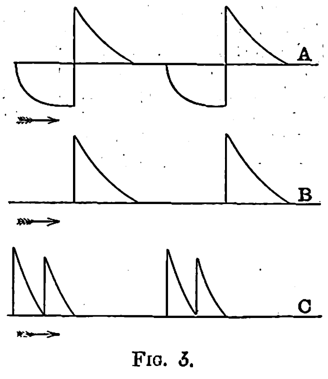

FIG. 3.

A. Induction coil currents at make (below) and at break (above).
B Same with Villard valve in circuit, stopping the make currents.
C. Current reversed, Villard valve stopping the break currents.

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* *Elektrotechnische Zeitschrift*, February 9, 1905.
† *Phil. Mag.*, November, 1902.

# WASTE IN INCANDESCENT ELECTRIC LIGHTING AND SOME SUGGESTED REMEDIES.

The following is an abstract of the discussion which took place at the Leeds Local Section of the Institution of Electrical Engineers on February 15th in connection with Mr. Geo. Wilkinson's Paper on the above subject. The Paper itself was published in our issue of February 16th, p. 722.

Mr. R. L. ACLAND, who communicated his remarks in writing, said he had issued to all his consumers a card of hints as to how they should use their incandescent lamps, at the same time telling them that all their lamps would be tested at the electricity works free of charge, and only those returned to the consumer as were fit for further use. During the two months this had been in operation, some 2,000 lamps had been dealt with, among which had been found many samples quite as bad as those quoted by Mr. Wilkinson. They also sold lamps at a reasonable margin of profit. He regretted that contractors should look upon the lamp sales as the mainstay of their business and should sell them at too great a profit, for the result was that consumers continued to burn lamps when they had long passed their useful life. "Free lamps," he thought, was the best solution of the difficulty, and was largely adopted in the United States.

Mr. S. E. FEDDEN (communicated) maintained that electric supply departments should sell lamps. The presence of a "live" wiring and fittings department, he said, went far to prevent the occurrence of cases such as had been mentioned in the Paper. He was not convinced that lamp selling was the mainstay of an electrical contractor's business ; it certainly was not in the case of the Sheffield Corporation where the lamp sales amount to less than 7 per cent. of the business. He had been in the habit for some time of fixing notices to consumers' accounts recommending them to use only the best lamps, but had not yet established a system of certification. Of course, all lamps purchased and sold by the Corporation were supplied to a specification, and tests were carried out on a certain number of lamps from each consignment. He agreed with the author that closer regulation than 2 per cent. is not obtained on supply mains. Automatic apparatus prevented fluctuation, but could not level the pressure all over the network. It was not financially possible to use separate circuits for power and light. His experience with Nernst lamps had not been satisfactory up to the present. The only burner which had lasted any length of time had been one fitted with the author's diffuser, and it had occurred to him that the freer access obtained by the air to the filament had, perhaps, contributed to its longer life.

Mr. BOOT (communicated) had found that printing notices on the accounts and sending out quarterly letters to the consumers, calling the attention to the serious waste taking place due to the continual use of lamps that were worn out, had very little effect, and he had for years advocated the necessity for the supply authority inspecting, changing, renewing and advising on consumers' lamps. Unfortunately, there was no power in the ordinary electric lighting acts to enable this work to be undertaken. The wiring contractor was not satisfied with a small profit on lamp renewals—he expected to see many times as much as 100 per cent.—and he did the supply grievous injury ; whereas, if the supply authority made a point of renewing consumers' lamps and maintaining them—the same as the gas companies did with their mantles—the cost to the consumer of electric lighting as a whole would be greatly reduced. It would ultimately be to the benefit of the contractors. It had not been found that the gas companies undertaking the maintenance of gas mantles, &c., had done very serious damage to gas fitters and the local ironmongers. He had, however, never come across lamps in his experience taking the enormous figures in watts per candle-power which were given in the Paper. It was becoming more difficult every day to keep the regulation of pressure within 2 per cent., owing to the demand for power at intermittent times, and he had had to draw up strict regulations with regard to the connection of motors to the mains, and the fluctuation to the pressure caused thereby. He was quite in accord with Mr. Wilkinson that the practise of trusting to hand regulation was unsatisfactory, and should be abandoned when it was possible to come across a practical commercial automatic regulator. He had tried "Nernst," "Tantalum" and "Osmi" lamps on public lighting circuits, and so far the most successful had been the "Osmi" when burning four in series on 220 volts. The street lighting which he believed was likely to prove a great boon in the future was the vacuum tube lighting mentioned by Mr. Wilkinson.

Mr. TAITE (communicated) said that in America every consumer was supplied with new lamps free of charge whenever he required them, and the standard consumption for new 110 volt lamps was 3·2 watts per candle. In this country it was now too late—even were it desirable—for the undertakers to enter into the lamp business, but if all station engineers were to adopt the certification of lamps for watt consumption and for initial candle-power—a method which Mr. Wilkinson had found so successful—he thought it would be a long step in the right direction. However, he would not go so far as contending that the supply authority should have the power to compel consumers to use certified lamps. His view was that if the consumer had been consistently advised by circular and other ways to use certified lamps, and yet failed to do so, he had only himself to blame if his bills were higher than his neighbours'. The system should be permissive and not compulsory, as it would be most arbitrary and contrary to the interests of the industry for a consumer to be forbidden to make experiments with lamps on his own account. Irregular pressure had great influence on the matter of lamp efficiency. The automatic regulators—to which the author had referred—were of great assistance, but a cheap and reliable regulator applicable to self-excited direct-current generators was wanted. The regulator, however, could not be expected to deal with a purely local disturbance on a large network.

Mr. CAMPION had no idea there were such bad lamps as 6·6 watts per candle. At any rate, he had not had any. In some cases he knew contractors were charging as much as 50 per cent. more than cost for the lamps, and the consumers could not stand it. and he thought that if some system, such as they had at Bradford, of giving lamps as discount was adopted it would improve matters considerably. He complained of the prices charged for repairs by contractors, and intimated that if it were going to be so excessive they would very seriously have to take up the idea of installation work. With reference to the raising of the pressure for quicker candle-power drop tests, the increase would blacken the lamps and then a decreased candle-power would be obtained. Too narrow a view had been taken of the regulating pressure, and the idea of refusing power consumers, who could be made to provide starting switches that did not appreciably affect the regulation, was original. He did not think any town could afford to lay down separate mains for power consumers. In conclusion, he asked Mr. Wilkinson to give them some idea as to when the Standards Committee would issue the result of their proceedings.

Mr. WOODHOUSE said that they must make the consumer their study. Improvements in the station were not so necessary as in consumers' installations ; they must remember, in fact, that they were selling light, not current. He agreed with Mr. Wilkinson that the wiring contractor was a valuable canvasser and should be encouraged. Mr. Wilkinson's system of ensuring good lamps to the consumers was excellent. There were other ways of doing this ; one system which worked successfully was to change all the consumers' lamps every six months and supply new ones. Those taken out were tested for wattage and candle-power ; those that did not come within certain limits were destroyed, and the others were returned to stock ready to be sent out again. The cost of doing this could be included in the price per unit charged for current. On the subject of lamp testing he would like to ask the lamp-makers whether conclusions drawn from ageing and wattage tests, at pressures above the normal, could be depended on. Mr. Wilkinson suggested ageing lamps at 50 per cent. above their rated pressure, and if the tests made after such accelerated ageing could be relied on much time would be saved.

Mr. A. S. BLACKMAN, whilst agreeing with the author to a certain extent, certainly thought that he was advocating a most cumbersome method of getting over the difficulties. As would be generally known, his predecessor (Mr. A. H. Gibbings) initiated a system of supplying free lamps in Bradford, and after two years' experience in working the system he (the speaker) certainly thought it was one of the very best things that had been done in the way of looking after the consumers' end of the problem. They had been distributing something like 14,000 lamps per annum, and the cost of supplying them amounted to less than 3 per cent. of the consumer's bill. This could be looked upon as a discount of 3 per cent., and it is rather interesting to note that previous to the free lamp scheme, the consumer had a discount of 2½ per cent. allowed for prompt payment, but the free lamp system was found to ensure this very much better than the giving of discount, from which it could be inferred that the consumer appreciated this very much more than a corresponding reduction in his account. They had found from experience that a man felt it a good deal more when he lost his lamps than his discount. If a wiring contractor had to shut up his shop, or rather keep it open upon the profits he was going to make from supplying lamps, contracting must be a pretty bad job. He thought Mr. Gibbings' free lamp scheme was much preferable to the registration at the cost of ½d. per lamp as suggested in the Paper. At Bradford they had no automatic means of regulation. He thought it was Edison who said that the best automatic regulator was "a nigger at the wheel," and he (Mr. Blackman) preferred a good switchboard attendant to any automatic device. A clerk went over each voltage record with a rubber stamp and marked the name of the charge engineer for each eight-hour shift during the 24 hours ; the records were then put up in the engine room and everything was done to encourage very keen competition between the men having the supervision of the switchboard attendants.

Mr. WILKINSON : Do the Bradford Corporation take any measurements of the candle-power and the voltage of the lamps?

Mr. BLACKMAN : Yes, we do, and I can, perhaps, amplify that point when I say that we have recently got into trouble by supplying our consumers with certain foreign-made lamps which proved most unsatisfactory. The wiring contractors in the town got hold of this and worked it for all it was worth, and we now divide our lamp contracts among the principal English makers ; consequently, a consumer can have any well-known lamp which he may desire on application.

Mr. HOWELL said it seemed to be the impression that the condition of affairs shown by Mr. Wilkinson was entirely the fault of the lamp makers. In the United Kingdom at the present time there were something like 1,000,000 kw. of plant laid down, of which about 600,000 kw. were used for private lighting only, and the way in which lamps were used and the average indifference of the user, he considered, made a most unsatisfactory condition of affairs. If the supply station engineers would co-operate with the lamp makers towards improving the methods of using lamps he felt sure the quality of the lamp would improve, and such co-operation could not fail to be beneficial to all concerned. In the use of high-efficiency lamps as steady an operating voltage as possible was of primary importance. If lamps were operated on a voltage that was constantly 4 per cent. high (the limit of the Board of Trade regulation) the life of the lamp would be reduced to 44 per cent. of what it was at normal voltage. He considered there appeared to be a certain amount of haze about lamps in general, and the sooner the users knew more about lamps and their use the better it would be for the manufacturer and the user. A life test could be shortened by burning it at some higher efficiency than that for which the lamp was made, as there was a definite relation between the watts per candle-power and the life of lamps. This relation had been determined as far back as 1883, and in 1888 figures were obtained and published on the old types of carbon lamps then in use, and these figures were approximately correct, within certain limits, for all types of ordinary carbon filament lamps manufactured at the present day. He considered that if one lamp was 10 per cent. better than another at an efficiency of 2·5 watts candle-power it would be 10 per cent. better at 4 watts per candle or any other efficiency.

Mr. DICKINSON thought they did not sufficiently appreciate the value of the lighting load. It was the lighting load that made the profit and the other the load that lost it. They ought to try to keep the power prices up as much as possible. The bad instances of inefficient lamps mentioned by the author must be isolated cases. Since reading the Paper he (the speaker) had sent a man round to pick out some lamps, about a dozen, from different installations, and had had them tested. The worst ones showed 4·99 watts per candle, whilst some of them were down to 3·5 and 3·6. Some of them certainly looked black, but he thought the author had overdrawn the case a little. The tests given of 8 c.p. and 16 c.p. lamps taken from stock showed a variation of from 2·98 to 5·67 watts per candle, which was very peculiar and surely only a special case. With regard to the suggested remedies, it might be advisable to have clause 18 of the 1882 Electric Lighting Acts altered, but he did not think it would come about. He did not think there was any precedent to allow the undertaker to specify the type of lamp the consumer should use. In the case of the gas department, however, they cannot specify what kind of burner they were to use, or even select the form of taps for the water consumers in the water department. In the electricity department they could only do as the author had done, and test the lamps. It was entirely out of the question to think of laying separate mains for lighting and power. He would have been very glad if the author had told them something more definite with regard to the Nernst lamp. The consumers liked them on account of the saving on their bills, but there was a lot of trouble with them, and he did not think the fault was due so much to pressure regulation as to some faults of the lamp which the makers had not got over. It would be very useful if the author could give them some more definite information.

Mr. WILSON, speaking from the manufacturers' point of view, was not quite sure that the question of grading lamps could be settled in the way which the Sub-standards committee anticipated. It was an unfortunate fact that up to the present no lamp maker had been found who could make lamps for a given voltage, and guarantee that all the lamps would turn out to this particular voltage when finished. This necessarily meant that every lamp maker must have a number of outfalls which did not come into the voltages for which they were intended. If specifications were issued with narrower limits than those existing at the present time, it must be borne in mind that this necessarily meant that the price of lamps would go up instead of down, and a very great advantage would be put into the hands of the gas companies. The consumer did not look so much at the total on his bill at the end of the quarter as on the amount he was repeatedly called upon to pay for his lamps, and a rise in the price of lamps would have a very bad effect upon the trade. The speaker next referred to the American system of grading voltages which, he said, was superior in every way to the one existing at the present time in England. At his factory they had a very large proportion of orders for, say, 200 and 220 volt lamps; they executed these orders and they had left on their hands out of both classes a number of lamps which would come into, say, the 210 volt class. For these lamps they had no demand. They must either break them up, in which case the consumer must pay the cost of manufacture, or the lamps remained in stock as useless. The Standards committee proposed to standardize the voltages at 220 volts, allowing a 10 per cent. margin on either side. Mr. Wilkinson stated in his Paper that it was possible to keep his voltage within 2 per cent. What difficulty would there be in the way of arranging to have a different voltage in each town, the greater number to have, say, 220 or 110 volts, and varying on each side in steps of, say, 5 volts. By proportioning the number of stations with each voltage to suit the lamp makers they would not interfere with the standardizing of their motors and other apparatus which they required, but they would certainly help the lamp makers in grading their lamps, and in helping the lamp manufacturers to do this they would do themselves a service. The lamp manufacturers would then undertake to supply them with a more efficient lamp, graded nearer than even Mr. Wilkinson or the Standards committee were asking for, and at the same time the manufacturers would be able to keep down their stock of outfalls, and thus the lamps would be cheaper to the consumers. He had twice had the opportunity of visiting the United States, principally with regard to the lamp business, and it could not be denied that the lamps supplied in America were far more closely graded than the lamps supplied in this country owing to the advantageous conditions under which they worked. The central stations in America were closely allied to, and worked hand in hand with, the lamp manufacturer, and if it was found in their lamp works that they had a percentage of outfalls for which there was no demand, in the next central station which was put down the voltage was graded to suit that particular line. There should, he thought, be no difficulty in arranging that a standard voltage should be set up, and that, say, 60 per cent. of the stations be run at this standard voltage and the other 40 per cent. be graded below and above in steps of, say, 4 or 5 volts. Mr. Wilkinson had mentioned the question of bad results of varying pressure. A nominal 200 volt circuit run at, say, 206, which was not uncommon, would increase the consumer's bill from 4 to 5 per cent. The poor contractor, who was asked to state the exact amount the prospective consumer would have to pay, based his figures on those supplied by the lamp makers as to the watt consumption of their lamps, but when the bill came in and the consumer had to pay the extra percentage he naturally grumbled. That was quite apart from the question of shortening of life and the rapid blackening of the lamp. A nominal 3¾ watt lamp if over-run 2 per cent. became a 3·5 watt lamp, over-run 4 per cent. it became a 3·3 watt lamp, and over-run 6 per cent. a 3 watt lamp. The figures given by Mr. Wilkinson as to the 50 per cent. deterioration of candle-power by blackening were quite correct provided the lamp was absolutely black. He had recently made some tests on that particular point. A number of lamps were obtained from consumers, and according to the density of the blackening the results showed from 15 to 40 per cent. loss in candle-power. One can hardly believe that any British maker would knowingly send out lamps such as were mentioned by Mr. Wilkinson in the early part of his Paper. Evidently the 32 c.p. lamp which Mr. Wilkinson tested had been originally 50 c.p. and supplied in error. The total wattage of a 32 c.p. lamp should not exceed from 110 to 120 watts. With regard to the other variations in watts mentioned by Mr. Wilkinson, he did not mind admitting that his own lamp factory and others had at various times supplied for circuits which they had known to be continuously over-run, some less efficient lamp than they would have supplied for a circuit run at normal voltage. If these lamps supplied had been tested at the normal voltage then there was no doubt that the candle-power would have appeared too low. A further great question which remained practically in the hands of the central station engineer was to educate the consumer to the fact that the lamp which burns the longest hours is not necessarily the cheapest lamp. It was a fault which must be laid entirely on the station engineer that the general public believe even to-day that the lamp must be made to last 1,000 hours. Lamp makers had tried for some considerable time to induce people to believe that the higher efficiency lamp at the prevailing price of current would be the cheapest lamp to burn, but the recommendation, coming from a lamp maker, made the consumer suspect him of pushing his own interests. On the question of high-voltage lamps, one of the greatest difficulties to the lamp maker had been the fact that in change-over operations, when the low voltage was used, lamps were supplied in very small bulbs, frequently, say, 40 mm. to 45 mm. diameter, and crinkled lamps were also supplied in small bulbs. It had been some years before they could induce contractors and others to persuade their customers that these small bulbs would not be satisfactory. Even so recently as the Marylebone change-over there had been a demand for 240 volt lamps in these small bulbs, and there had been a great deal of trouble in connection with them. Consumers should be educated to the fact that they could not get high-voltage lamps in the same small bulb as previously supplied for low voltage.

Mr. EMMOTT said that exhibitions, permanent showrooms and advice on gas-consuming appliances were at the service of the customer of a gas undertaking; and he strongly advocated something of this nature in electricity undertakings. He had had a large number of tests made somewhat on the lines indicated by Mr. Wilkinson for some time and generally agreed with his results, although he had few so bad as the worst recorded in the Paper; they were, in his experience, the exception and not the rule. Consumers required educating; for instance, many good lamps lost 15 per cent. of their illuminating power simply through an accumulation of dust.

Mr. HARTNELL said that if Mr. Wilkinson had tested them on the voltage that best suited each individual lamp he would probably have found very little difference in the watts per candle. With reference to the point mentioned by Mr. Dickinson, he held that the consumer had a perfect right to do as he pleased. In Leeds some manufacturers were buying lamps in hundreds and paying 8d. or 9d. each. In one large factory where they had at least 2,000 lamps, the engineer in charge tested the lamps in his own way. In three-light pendants he would put the lamps of three different makers. On a 110 volt circuit he used 105 volt lamps, and directly they began to show signs of dullness he threw them away and bought new ones, so that this consumer did what the station engineer would advise. He saw no objection to the Corporation supplying lamps, providing it were done at a profit on such business lines as a private concern would supply them. Regarding the suggested graduated differences of standard voltages in different towns, he thought that might be most convenient for makers of lamps, but it would be awkward for the makers of motors.

Mr. ROSLING said that, taking current at 4d. per unit and lamps at 1s. each, and allowing for the increased candle-power and decreased life, over-running the lamps 1 per cent. would decrease the yearly cost 3 per cent. for the same candle-power as compared with normal running, and by over-running them 5 per cent. the cost per candle-power hour would be decreased 12 per cent. He did not think there would be any objection, from the motor point of view, to Mr. Wilson's suggestion of varying voltage at different stations, as for continuous-current work they already had to face a larger variation than proposed—viz., 200 to 250 volts with almost every multiple of 5 in between—and it would usually be found that for well-designed alternating-current motors, on ordinary supply circuits, 5 per cent. above or below the standard voltage would not affect their satisfactory operation, providing they were fairly liberally rated. Motors designed for 210 volts should be quite satisfactory on 200 or 220 volt circuits, and this variation, coupled with direct-current stations and private supply variation, should give lamp makers sufficient margin. As to voltage regulation, he had known the pressure to vary from 10 per cent. below to 10 per cent. above the normal in the space of half an hour a good way from the centre of the network.

Mr. ROGERSON approved of Mr. Wilson's plan as to the grading of the lamps. He was quite with Mr. Rosling that 5 or 10 per cent. difference in the pressure had no serious effect on the motor. In Halifax motors were running for various purposes fed from the tramway feeders, and occasionally the variation exceeded 15 volts with no serious effect to the consumer.

Mr. CHURTON objected that if there were 40 or 50 different voltages to work at, everybody would order a motor made for their particular voltage, and as motors were liable to be tested they certainly would not get the same from the motor at such varying voltages.

Mr. CORRINGHAM said: With regard to the "legislation" part of the Paper, he would like to say that clause 18 of the 1882 Electric Lighting Act did not lay down any new law, but was merely declaratory of the common law, or rights of persons. There was no chance of it being done away with. With reference to the comparison of the small arc lamp with the Nernst lamp, he would like Mr. Wilkinson to say how the arc was enclosed and in what kind of globe. With regard to the average cost per unit for local authorities and companies, if that average cost had been obtained, as he surmised it had, by the addition of all the average costs in the table divided by the number of average costs, it was not correct unless the author had taken into consideration the various outputs attached to the average costs. He would have liked the author to have said a few words about the tantalum lamps, because he believed his experience had been better than that of most engineers. Most of the gentlemen would no doubt remember the correspondence in the technical Press some time ago with reference to the changing of polarity in Nernst lamps, in which an engineer in the north of England stated he had changed the polarity of the Nernst lamps in his station a dozen times during an evening, and if it had done anything to them he thought it had made them last longer.

Mr. WILKINSON replied first to the suggestions that the examples of wasteful lamps given in the Paper were exceptional cases. He had thought so himself at one time, but he did not think so now because he had come across numbers of equally bad cases of more recent date which could have been quoted, and fresh discoveries of a like character were constantly being made. When he cited the examples of wasteful lighting given in his Paper to his friends upon the Council of the Municipal Electrical Association, they expressed the same view that had been expressed that evening; but after they had looked into the matter in their own towns, they were fully in accord with what he had stated, and some of them produced even worse examples than he had quoted. One example has been particularly referred to—viz., the public building in which he found 80 32 c.p. 100 volt lamps taking an average of 170 watts each. Unfortunately, other installations in the town were found with similar lamps. They were British lamps made by one of the best known firms, and they were returned. He took the trouble to get the figures with regard to the saving in this instance, and he found it had amounted to £108 during the last 12 months. As far as he knew, the hours of working and the conditions of usage were identically the same as obtained the previous year. He had a very interesting chart which came from one of his former assistants, who was now in South Africa. His station carried a load of about 400 kw. He found some trouble with the motors on the mains, one in particular, about 1½ miles away, driving a large circular saw, and on certain occasions it was taking 50 amperes on each phase and absolutely dislocating his lighting load (three-phase network). He had followed his (Mr. Wilkinsons's) advice, and had put in an automatic regulator, with the result that the motor coming on or going off now causes only a momentary kick on the chart. In reply to Mr. Campion, it was quite within reasonable practice to get within 2 per cent. of standard voltage, under which condition lamps had a satisfactory life. He could not give any information furnished by the lamp makers to the Physical Standards sub-committee, as it was of a private character, but it would doubtless be published in due time. He might say, however, that the pressure regulation asked for in their proposed specification was such that a supply station engineer could not obtain under existing working conditions. As long as they had lamps with carbon filaments they must keep their regulation within 2 per cent. The Municipal Electrical Association had prepared a specification for carbon filament lamps, but at the request of the Standards committee it had been withheld. If they did not look out they would get the specification after they had got a better lamp. He was glad to hear one or two speakers, including Mr. Wilson, inviting engineers to co-operate and seek information from the lamp makers. So far as his experience went, they had always been willing and ready to give information and any advice that had been asked. There were many points that ought to and could be very easily altered in the Nernst lamp, but the Germans had such a demand for these lamps that they would not listen to the English requirements. In six out of seven failures in street lamps, he found extinction was due to nothing else but the contacts on the lamp getting out of line with the contacts in the lamp-holder. If they were to make wide contacts on the Nernst lamps like an ordinary incandescent lamp had, they would get much better results. He made a test of 90 Nernst lamps and took careful note of each one, and obtained an average life of 520 hours; they were fixed in street lamps and subject to vibration. He believed the long average life was attributable to the good pressure of regulation they had. With reference to the alteration of clause 18 of the Electric Lighting Act, he did not think they could have satisfaction without this alteration, so as to give a measure of control to the supply authority. Water companies had a statutory right to examine and put a stamp on every tap and every valve that was put on the supply system. The tests recommended in his Paper did not tell whether the lamp was in for a long life, but they advised the merchants to get a gaurantee from the lamp makers that the lamps should last a certain number of hours.

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**Royal Society.**—The Papers down for reading yesterday were "A Discussion of Atmospheric Electric Potential Results at Kew from Selected Days during the Seven Years 1898 to 1904," by Dr. C. Chree, F.R.S.; "On the Specific Heat of, Heat Flow from and other Phenomena of the Working Fluid in the Cylinder of the Internal-Combustion Engine," by Dugald Clerk. Communicated by the Hon. C. A. Parsons, F.R.S.

## "IDLE CURRENTS."*

BY M. B. FIELD.

(*Concluded from page 848*).

When we find in any machine that the idle current loss largely exceeds the nominal loss, and bear in mind that the one increases while the other decreases with the copper section, we are naturally led to inquire whether an actual diminution of the amount of copper may not improve the efficiency. Suppose $q$ is the ratio of the active length of the conductor to the length of a half-turn. Let us now keep $a$, $d$, C and all other dimensions the same, varying only $b$, and for the present let us call $m=1$. The nominal loss per centimetre length is $P/b$ where $P=\frac{\rho C^2}{d}$ and the actual average loss per centimetre is $\frac{P}{b}(qK+(1-q))$ where K is the coefficient corresponding to the value $mb$. If we plot $P/b$ vertically and $b$ (or $mb$ where $m=1$) horizontally, we obtain, of course, a rectangular hyperbola. If, now, we multiply each value of $P/b$ by the corresponding value of $\{qK+(1-q)\}$ we obtain the actual loss for each value of $b$, $m$ being unity. This curve shows a minimum value—*i.e.*, there is a certain critical value of $b$ giving minimum loss, and this critical value is evidently independent of the value of C. If we double $b$, the nominal loss is halved, but if at the same time we halve $m$, the K coefficient remains unchanged, hence the curve last referred to applies equally well for $m=0{\cdot}5$, if for any given point of the curve we multiply the reading of the abscissa by two, and the reading of the ordinate by a half. Or, if we consider that the abscissa represent values of $mb$ instead of $b$, we do not need to change their scale

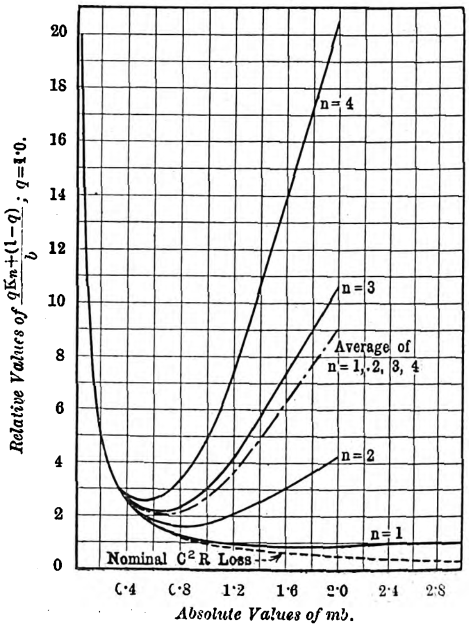

FIG. 5.

Hence, we observe that for all values of $m$ the point of minimum of the curve occurs at the same value of $mb$. Figs. 5 and 6† show these curves plotted for $n=1$, $n=2$, $n=3$, $n=4$, $q=1$, and $q=0{\cdot}5$.

These curves show the relative losses when $m$ is kept constant at any value and $b$ is varied, but it must be remembered that when $m$ is changed, the vertical scale is changed proportionately. They show, moreover, the value of $mb$ at which minimum loss always occurs.

In Figs. 5 and 6 we have also shown the relative values of the nominal loss, as also the average value of the four curves for $n=1$, 2, 3 and 4.

Referring to Fig. 5, where $q=1$—*i.e.*, for the case where the whole length of conductor is active, it will be seen that no matter what current we require to take out of the conductor, the minimum loss for the lowest is obtained when $mb=1{\cdot}4$, for the second when $mb=0{\cdot}8$, and so on.

If, now, we put

$$f=50,\ \frac{d}{a}=0{\cdot}61$$

so that $m=0{\cdot}8$, the critical depths of conductor are 1·75 cm., 1 cm., 0·8 cm. and 0·7 cm. for the 1st, 2nd, 3rd and 4th respectively. Any additional depth means an increase of loss and a waste of copper, no matter how large a current the machine may have to supply.

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* Abstract of a Paper read before the Manchester Local Section of the Institution of Electrical Engineers, February 13th.

† As $mb$ increases $K_n$ approaches the value $mb[2(n^2-n)+1]$; it follows therefore, that the curves, if extended, will turn over horizontally and approximate to the straight line of which the ordinate is constant.

It also follows that if this critical depth be exceeded, an increase of specific resistance may decrease the loss, hence that the efficiency of the machine may actually improve as the temperature increases.

In Fig. 6 the curves correspond to $q=0{\cdot}5$—*i.e.*, where half the total length per turn is active. The average-loss curve connects $mb$ and

$$\sum_{n=1}^{n=4}\frac{q\mathrm{K}_n+(1-q)}{4b}.$$

This curve obviously shows the critical value of $b$ for a coil of four layers of solid conductor. For the same value of $m$ as above, this critical value works out $b=1$ cm.

Although we have determined the critical depth for a four-layer coil, provided the same section of conductor is used throughout, a little consideration will show that by grading the section of the conductor in the different layers a still better arrangement may be arrived at. Remembering that when $mb=0{\cdot}8$ a depth of 1 cm. has already passed the critical value of the outer layer, and has not yet reached that for the lowest layer, it follows that a more efficient arrangement will be obtained by transferring some of the copper from the outer to the inner layer.

In determining slot and conductor dimensions there are, of course, other important factors which need due consideration. For example, the heat generated in the active part of the conductor is, to a large extent, conducted to the end connections at which it is dissipated by ventilation and radiation. A large cross-section of conductor forms a better conductor thermally, and may tend to reduce the maximum temperature within the active portion. Again, it has been urged that a deep conductor is sometimes advisable for mechanical considerations owing to the very great mechanical forces which may be exerted on the end connections, and yet, again, the suggestion has been made that a certain amount of idle current in the conductors is useful, in that it reduces the reactance of the whole winding.

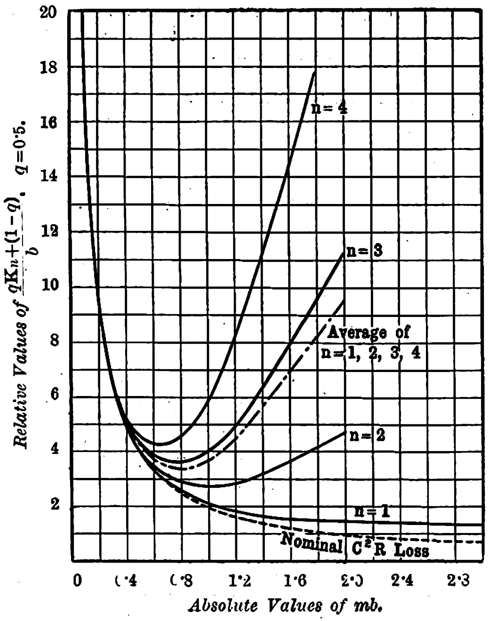

FIG. 6.

The enormous forces which are sometimes called into play between conductor and conductor are scarcely credible until one has seen the destructive effects of heavy short-circuits. When an arc is suddenly formed and a terrific amount of power is poured into the flame, one can almost imagine the explosive action that must take place; yet it is difficult to realise the mechanical force excited between conductor and conductor when no arc takes place. We can best illustrate the point by a description of actual phenomena.

A serious trouble which has been experienced with the turbo generators in the Chelsea generating station of the London Underground Railway is the bursting of the end connections when a "short" occurs. The machines are four-polar, and the end connections of the armature, which is stationary, therefore bridge across 90 deg. The end connections lie one up against the other in the usual manner, and those of each phase are all strongly bound together to form a compact whole. They are otherwise unsupported. On the occurrence of a "short" the bindings burst and the end connections fly out with all the appearance of an enormous internal force wrenching them apart, usually necessitating the complete rewinding of the armature.

We have so far only dealt with the lamellar effect in connection with alternating-current machines. When we consider, however, that the current flowing in the armature conductors of direct-current machines is, in reality, an alternating current, we see that the above results, with certain modifications, are also applicable to direct-current machinery. We do not propose to enlarge the scope of this Paper unduly by entering upon a lengthy discussion of the critical depth, temperature gradient, &c., of direct-current armature conductors, but merely to indicate the lines upon which these considerations may be investigated. Confining our attention to a particular armature conductor of a direct-current machine, we remember that the current is flowing in one direction when the bar is passing under a N-pole, and in the opposite direction when passing under the S-pole. The change of direction is effected during the commutation period. The current value at any instant during this period is somewhat indefinite, but the period is of relatively short duration. Fig. 7 may be taken as representing the current in any armature conductor where the dotted portion is substituted for the unknown which occurs during commutation.

If, as an approximation, we take the current in each bar as being equivalent to that shown in Fig. 8, the case is capable of fairly exact computation. Let C be unity, then the current at any instant is given by $\frac{4}{\pi}\left(\sin pt+\frac{1}{3}\sin 3pt+\frac{1}{5}\sin 5pt+\text{\&c.}\right)$, where $p=2\pi f$. We thus have a number of sine wave alternating currents of differing frequencies flowing in each bar, and, as already pointed out, we can calculate the loss due to each as if it existed separately. There is, therefore, no difficulty in applying our previous curves and formulæ. Take the case of a 6-pole 500 revs. per min. direct-current generator, $f$ will be 25 cycles per second. We must, therefore, calculate the value of $mb$ for $f=25$, 75, 125, &c., and calling the corresponding $\mathrm{K}_n$ values respectively ${}_1\mathrm{K}_n$, ${}_3\mathrm{K}_n$, ${}_5\mathrm{K}_n$, &c., where the suffix determines the position of conductor in slot (*i.e.*, 1st, 2nd, or $n$th), and the prefix determines the frequency term of the Fouriers series.

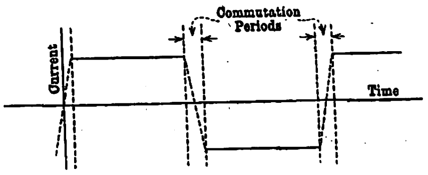

FIG. 7.

The coefficient of increase of resistance for the $n$th conductor carrying the current shown in Fig. 8 will then be given by the expression

$$\frac{8}{\pi^2}\left[{}_1\mathrm{K}_n+\frac{1}{9}\left({}_3\mathrm{K}_n\right)+\frac{1}{25}\left({}_5\mathrm{K}_n\right)+\text{\&c.}\right]$$

In general the K values for solid conductors of direct-current machines will be greater than those for conductors of the same depth in alternate-current machines running at the same speed and having the same number of poles, because in the direct-current machines the current is largely composed of higher-frequency terms, and secondly, since direct-current machines are generally constructed for lower voltages, less space will be occupied in the slot with insulation. Fig. 9 represents a two-layer winding in a direct-current armature. The K value of the active portion of the upper conductor calculated from the first 17 terms of the above series is 2·5, $f$ being taken at 25 cycles per second. The K value for the lower conductor is 1·26, and for the whole winding 1·44, assuming as before $q=0{\cdot}5$.

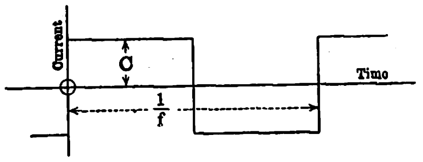

FIG. 8.

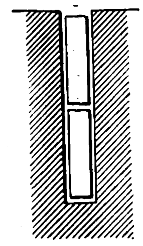

FIG. 9.

Unfortunately this series is not very rapidly convergent.

The K values for the higher frequency terms may be calculated from the expression

$$mb[2(n^2-n)+1].$$

In the armature of a rotary converter, the effect is still more pronounced, since the higher frequency terms are more predominant.

## DISCUSSION.

Mr. S. L. PEARCE, from the chair, expressed the indebtedness of the section to Mr. Field for his exceedingly able Paper, which must have involved a tremendous amount of work. Although chiefly a Paper for designers, there were many points of practical importance, from which an engineer in charge of large alternating systems could learn much. The latter part of the Paper, in which Mr. Field touched on the problems involved in the enormous forces exerted on the end windings of alternators when subjected to shorts or bad phasing was exceedingly interesting. He thought he was right in saying that manufacturers had not until quite recently taken into account these forces which produced distortion effects, in the design of alternating machines. Up to a recent date machines were built with their end windings totally unsupported from the stator frames.

Mr. J. FRITH complimented the author on his valuable Paper, but remarked that he had always hitherto understood the term "Idle Current" to mean current at right angles to volts.

Mr. MILES WALKER wished to express his high appreciation of the Paper. All engineers concerned with the design of electrical machines have for long been wanting to know exactly how much eddy current to expect in straps of different depths. It had been possible by a rough graphic construction to arrive at an approximate value for the loss due to the eddy current. But by means of these beautifully simple curves we can in the course of a few minutes figure out the eddy-current loss exactly for any given case, and can find at once the most economical depth of strap to use under any circumstances. The question naturally arises, Are these curves correct? Do they really give the additional losses found in practice? In 1903 the Westinghouse Company, realising the importance of eddy-current losses, made a number of experiments to find out their values in different cases. The trials were made by winding coils with different kinds of straps in the same armature core and measuring the watts supplied when an A.C. current was passed through the coils. The iron loss was separately measured and taken into account. The report of Mr. F. D. Newbury upon the results of the tests gives a number of curves for the losses with different straps and at different frequencies. Taking two good cases for comparison—one at 25 cycles and one at 60 cycles—the results agree very closely with Mr. Field's calculations. Taking the formula given by Mr. A. B. Field in the July number of last year's *Proceedings* of the American Institute of Electrical Engineers, we arrive at almost the same result. It had been said that the Chelsea 5,500 kw. turbo-generators had their windings bent by being short-circuited. The facts are that these machines were thrown out of phase when running in parallel with other generators. These conditions are very much worse than a short-circuit. The forces might be almost four times as great as a simple short-circuit. The windings were braced, but the bracing was not sufficient for the difficult conditions. They are now being braced in a much more solid way.

Dr. C. C. GARRARD ventured to criticise the author's definition of "Idle Current." To his mind the term had already got a certain fixed meaning and represented the "wattless component of an alternating current at right angles to the voltage." The author's definition is, however, an extremely wide one and included all currents which waste energy to the extent of their $C^2R$ loss, including even the actual working current, and a paper on "Idle Currents" under this definition would cover the whole field of electrical design. He suggested, therefore, that the proposed new definition of idle current should not be adopted, as if it were, it would tend to cause confusion as to a term which at present has got a definite significance. He thought one of the most valuable parts of the Paper was the proof that any system of currents would be regarded as an "idle current" distribution superimposed upon the distribution which would obtain with continuous current. While for mathematical investigation, of course, this is of the utmost importance, it does not always represent what actually takes place in the circuit. Consider the case of two equally-rated transformers working in parallel which have different impedance and phase values so that they do not bank properly. The current does not divide up equally between the two transformers, but divides so that the drops due to the different impedances is such that the terminal voltages of the two transformers become equal. The sum of the virtual values of the currents in the two transformers is equal to the virtual current in the outside circuit. There is no idle current circulation at all. I think this consideration can be applied to other problems, such as a number of circuits connected in parallel. The distribution of current in the various circuits is always a natural one. In the direct-current problem simply the ohms have to be taken into account, in the alternating-current problem the impedance and mutual induction between the conductors determine the volt drops in the conductors and the condition of equilibrium is that the volt drops of the various conductors connected in parallel are all equal. A massive solid conductor can be considered from the same standpoint as a bundle of very fine parallel wires. The question of eddy-current losses in transformers is of great practical importance, and in their design, some care has to be taken to eliminate all such causes of loss, or, where they are unavoidable, to allow for them in the design, so that the required efficiency and temperature rise may be obtained. Several cases had come under Dr. Garrard's notice. One consisted of a 1,000 ampere transformer, wound with copper strip of a total cross section of 1½ sq. in. The copper loss in this transformer was 44 per cent. larger than that which would be calculated from the ohmic resistance of the windings, this being the eddy-current loss in the heavy current winding. Another case was a core type transformer made for a special purpose. It had four coils per leg, two primary and two secondary, all having the same mean turn. It will be seen that the impedance of the middle coils was less than that of the end coils. This results in an eddy-current effect in that when the coils are connected in parallel the middle coils take more current than the end ones. This results in the efficiency of the transformer being not so good when the coils are connected in parallel as when connected in series. In order to avoid eddy-current losses in the coils of transformers, it was sometimes recommended to wind them with stranded conductor for the larger currents. As stranded conductor is very much more costly than strip it is more economical to use the latter, providing no losses are introduced thereby. He had found, however, in core type transformers, that for currents up to at least 500 amperes, if the winding be made of strips, about 0·5 in. by 1 in. section, connected in parallel, and proper precautions be taken, no appreciable eddy-current loss takes place in the windings—*i e.*, the copper loss is the same under working conditions as calculated from the ohmic resistance. It may be asked what was the good of using strips in parallel, as, if the strips were soldered together at the ends, as is the case generally, they were equivalent to a solid conductor. He did not think this was correct, however, and that in a solid conductor local eddy-current losses would occur owing to the fact that the leakage field was not by any means a uniform one. The lines leak out between turns and between layers in a very irregular fashion, and the lamination of the conductor prevents such losses as would otherwise occur. Regarding alternator windings, he was under the impression that nowadays stranded conductor was generally used for the winding owing to it being easier to wind than solid conductor. With stranded conductor, of course, the conclusions arrived at in the Paper would be very considerably modified.

Mr. J. S. PECK remarked that Mr. Field had dealt in his Paper with the question of idle currents in armature conductors. Difficulties of the same nature, however, have been encountered in the design and operation of transformers. In 1892 the Westinghouse Company designed a small transformer which was intended to have an extremely high efficiency. In order to keep down the copper losses, the low-tension winding was composed of large rectangular copper strap. When the transformer was put on test, the designers were greatly surprised to find that the low-tension winding reached an excessively high temperature. After some consideration it was decided that the excess heating was due to eddy-current or idle-current loss in the rectangular strap, the currents being set up by the leakage magnetic field through the windings. It was realised that this was a matter little understood, but which would have great weight in the design of large transformers. A series of investigations were therefore carried out, using wires and straps of various dimensions placed in different ways in magnetic fields of different densities and frequencies. From these tests, supplemented by theoretical considerations, curves were plotted showing what idle-current losses might be expected in copper conductors under different conditions. These curves enabled the transformer designer to choose such conductors as to avoid excessive losses due to local currents set up within the conductor. It was found, however, that parallel conductors—even though insulated throughout their entire length—were subject to much the same idle-current losses as solid conductors unless properly transposed. Another difficulty which has been frequently encountered is due to the attempt to operate in parallel coils which are not located in symmetrical magnetic positions, so that on account of the difference in the leakage magnetic field cutting the two coils, unequal voltages are induced. Once the reason for this inequality is understood, no trouble should be encountered in designing a transformer to avoid this difficulty, but until it was understood some very puzzling results were obtained. I believe that no trouble occurred due to the displacement in end windings of generators and transformers until units of very large size were installed. A certain amount of trouble was encountered with the Niagara generators winding, due to displacement of the coils in the event of one machine being thrown in parallel with other machines when out of phase. Methods were devised for bracing this winding, and great care is given to this bracing in all machines of large capacity. In the Chelsea generators referred to by the author, the coils were braced in a manner which it was thought was amply sufficient. It was found, however, that when one machine was thrown in parallel out of phase with other machines, the forces were so enormous that the supporting blocks were crushed and torn loose from their supports. Shortly after the first Niagara machines were installed, a short circuit occurred on the secondary circuit of a 200 kw. transformer. An examination of the transformer showed that when the short occurred the outside end coils which project beyond the iron core had been bent over at right angles and flattened against the end frames which held the laminations together. These coils were wound with large rectangular wire, several wires in parallel, so that an enormous force must have been required to bend the coils into the position in which they were found. After this accident steps were taken to brace the coils of large transformers in order to prevent their being thrown out in case of sudden short circuits, In very large transformers having extremely close regulation it is necessary to take the greatest care in bracing the coils in every direction, as the currents which may flow through the coils of such a transformer in the event of a short circuit may be 20 to 40 times the normal, thus producing forces between the coils 400 to 1,600 times the normal force.

## BOOKS RECEIVED.

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"Derniers Progrès du Telphérage Électrique." By Emile Guarini (Paris: Mme. Vve. Dunod.) 2fr.

"Fortschritte der Elektrotechnik." Edited by Dr. Karl Strecker. Part II., 1905. (Berlin: Julius Springer.) 7m.

"Die Akkumulatoren und galvanischen Elemente: Theorie, Konstruktion und Anwendung." By Dr. L. Lucas. Vol. VI. of "Repetitorien der Elektrotechnik," edited by A. Königswerther. (Hanover: Dr. Max Jänecke.) 3.80m.

"Lexikon der Elektrizität u. Elektrotechnik." Edited by Fritz Hoppe. Nos. 2 to 5, "Aperiodisches Galvanometer" to "Einschnur system." (Liepzig: A. Hartleben's Verlag.) 50pf each.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. FOURNIER D'ALBE.]

*Calibration of Gold-Leaf Electrometers.*—The gold-leaf electroscope is being widely employed in measurements of ionisation. It is calibrated by applying known potentials to it. But H. W. Schmidt points out that it is not as a rule used for measuring differences of potential, but for measuring currents by noting the variation of the potential. To obtain the best results, therefore, another principle of calibration should be employed. The relative difference of potential between two scale divisions may be obtained by exposure to the $\beta$ and $\gamma$ rays of a radium preparation fused into the glass wall, and noting the times taken by the leaf to traverse successive divisions. If there is a saturation current, these times are proportional to the differences of potential. If the shape of the electroscope leaves a doubt as to whether there is a saturation current, it is only necessary to connect the electroscope with an air condenser which is not too small, and to expose this alone to the radium rays. The author believes that with a well-calibrated leaf electrometer as good results may be obtained as with a quadrant electrometer. It has besides the great advantages of simplicity, small capacity, and independence of external electric disturbances.

[H. W. SCHMIDT, *Physikalische Zeitschrift*, March 1, 1906.]

*Canal Rays.*—By an ingenious experimental contrivance C. Füchtbauer has been enabled to prove that canal rays impinging upon metals cause them to emit electrons, and that some metals reflect the canal rays to a very perceptible extent. Behind the perforated cathode he mounted a circular diaphragm consisting of six sectors, five of them covered with various metals and the sixth open. The diaphragm could be turned by means of a magnetic contrivance, and was so arranged that each sector could in turn be brought to face the canal-ray tube. But for a small aperture, the diaphragm was completely enclosed in a metallic cylinder, which could be earthed. When the open sector was presented to the canal rays they penetrated into the cylinder and gave up their charges to it. But on interposing one of the metallic sectors the canal rays were reflected, and they and the electrons issued from the cylinder. By deflecting the electrons the two constituents could be estimated separately. The author found that at high voltages (30,000) all metals give off electrons, in the same order as Volta's series. Platinum gives off least, and aluminium gives off four electrons for each canal-ray particle it receives. Platinum, silver, and copper reflect 10 per cent. of the incident canal rays, even at the highest voltages.

[C. FÜCHTBAUER, *Physikalische Zeitschrift*, March 1, 1906.]

*Polarisation by Alternating Currents.*—P. G. Gundry has made some researches calculated to throw light on the action of an electrolytic coherer, whose resistance is increased by the impact of electric waves, or diminished when the electrolyte, like phosphoric acid, diminishes in resistance with increase of temperature. The experiments consisted essentially in sending an alternating current of frequency varying between 80 and 5,000$\sim$per second through an electrolyte between two mercury electrodes, one of which was very small, while the other was more than 1,000 times as large, so that the latter was unpolarisable in comparison with the former. The results show that a perfectly symmetrical alternating current acting at a polarisable electrode leads, according to the osmotic theory of polarisation, to an asymmetry of the polarisation—in other words to a direct current. The case of a mercury electrode being worked out gives as a result that the direct current I satisfies the relation $\frac{\mathrm{NI}}{i_0^2} = \text{const.}$, where N is the frequency and $i_0 \sin 2\pi \mathrm{N}t$ is the alternating current. The direction of the current corresponds with an effective diminution of the concentration in the neighbourhood of the electrode. The same relation should hold when the electrode is a solution of a complex salt, provided that diffusion from and to the layer of electrolyte surrounding the electrode plays the important part in the polarisation. In the electrolytic coherer it may be supposed that some reaction such as $\mathrm{H}_2 = 2\mathrm{H}$ is reached with finite velocity, whereupon the relation $\mathrm{I}/i_0^2$ holds good, and is independent of the frequency.

[P. G. GUNDRY, *Philosophical Magazine*, March, 1906.]

*Molecular Conductivities.*—The formation of a salt MX from the acid HX and the base MOH may be represented by the equation

$$\mathrm{H}^{\cdot} + \mathrm{X}' + \mathrm{M}^{\cdot} + \mathrm{OH}' = \mathrm{M}^{\cdot} + \mathrm{X}' + \mathrm{HOH},$$

where the dots represent cations, the dashes anions, and the unmarked compound is neutral water. The initial and final electrical states differ by the expression $\mathrm{H}^{\cdot} + \mathrm{OH}' = \mathrm{HOH}$; hence we should expect in the formation of the salt the disappearance of electrical conductivity equivalent to that required by the above equation. P. Blackman calculates from the data in Landolt and Börnstein's *Tabellen* the loss of molecular conductivity occurring in the formation of various salts from the same acid at the same temperature and molecular concentration. At unit molecular concentration, the loss of molecular conductivity represented by $\mu v\mathrm{HC}l + \mu v\mathrm{KOH} - \mu v\mathrm{KC}l$ is 358, while that represented by $\mu v\mathrm{HC}l + \mu v\mathrm{N}a\mathrm{OH} - \mu v\mathrm{N}a\mathrm{C}l$ is the same. For lithium chloride it is 344. Generally, the equation holds

$$\mu v\mathrm{HX} + \mu v\mathrm{M_1OH} - \mu v\mathrm{M_1X} = \mu v\mathrm{HX} + \mu v\mathrm{M_2OH} + \mu v\mathrm{M_2X}.$$

The derived equation

$$\mu v\mathrm{M_1OH} - \mu v\mathrm{M_2OH} = \mu v\mathrm{M_1X} - \mu v\mathrm{M_2X}$$

furnishes a means of calculating the molecular conductivities of insoluble or unstable bases or salts. Finally,

$$\mu v\mathrm{M_1X} - \mu v\mathrm{M_2X} = \mu v\mathrm{M_1X_1} - \mu v\mathrm{M_2X_1} = \text{constant},$$

which explains a fact observed by Kohlrausch.

[P. BLACKMAN, *Philosophical Magazine*, March, 1906.]

*Colouration of Jewels by Radium Rays.*—A. Miethe has found that an unexpectedly large number of jewels change their colour under the influence of radium rays from strong preparations. It has been known for some time that glass is coloured brown or violet, and the chlorides of potassium and sodium brown or yellow. Speaking generally, the colour is changed most easily in the more transparent stones. The author used a preparation of 60 milligrammes of radium bromide. A colourless diamond from Borneo was coloured a light yellow after eight days, and a decided lemon yellow after another eight days. On heating the diamond to 250°C. the yellow colour was diminished, but it could not be entirely got rid of even at a red heat. A colourless Brazil diamond showed no colouration. A peculiar behaviour was shown by a light blue sapphire from Ceylon. After only two hours' exposure to radium bromide it showed a colouration, green at first, then light yellow, and after a few more hours, reddish yellow. After a fortnight it was dark yellow, or nearly chestnut. The colour could be eliminated by heating, but the light yellow colour always returned on cooling. Rubies show no change. Tinted tourmalines show little change, but a tourmaline having a pink colour at one end acquired a red colour at any section by exposure to radium rays, and a tourmaline having a green end acquired a dark green colour at any section. Amethyst, blue topaz and chrysoberyl show no change.

[A. MIETHE, *Annalen der Physik*, No. 3, 1906.]

*Capacity of Mica Condensers.*—The differences in the value of the capacity of the same condenser observed in determinations made at different times (with different galvanometers) have given the impression that mica condensers are not available for measurements of high precision. The manufacturers of the best condensers guarantee an accuracy of only one-fourth of one per cent. and even this is not usually trusted by the purchaser. The reason for these differences is that with the method of measurement commonly employed the capacity value is dependent upon the period of the galvanometer. The condenser is charged or discharged through the galvanometer and remains in circuit with it during the whole period of the first throw. The gradual liberation of the absorbed charge produces a current which flows through the coil of the galvanometer the whole period of the throw. The longer this period the greater is the amount of the absorbed charge that affects the throw, and the greater is the value obtained for the capacity of the condenser. A. Zeleny has devised a special triple key which, with one tap, closes the condenser circuit through the galvanometer and opens it immediately afterwards. He thus measures the "free-charge capacity" of the condenser, and finds it to be a very constant quantity, measurable within a maximum error of 0·01 per cent. He suggests defining all capacities as free-charge capacities.

[A. ZELENY, *Physical Review* February, 1906.]

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## ELECTRICITY IN MINES.

At next Thursday's meeting of the Institution of Electrical Engineers, Mr. W. C. MOUNTAIN'S Paper on Electric Winding, which was originally read and discussed at the Manchester Local Section on January 16th, is to receive the honour of further discussion on the occasion of the reading of Mr. C. P. SPARK'S Paper on the electrical equipment of a large South Wales colliery. We welcome this decision of the parent Institution, for it will provide electric mining engineers and others interested in the development of this important branch of the electric industry with an opportunity of correcting his conclusions and the wrong impressions to which the acceptance of the Paper by the Committee of the Manchester Section may have given rise. Mr. MOUNTAIN, as may be remembered from our report on his Paper in *The Electrician* for February 9th, p. 658, compared the initial and working costs of heavy steam-operated and electrically-driven winding plants, and came to the conclusion that—with the possible exception of the case where current can be purchased at a small fraction of a penny—direct steam winding is the more economical of the two. In the Paper, the costs of winding at a single shaft were estimated and compared, account being taken of capital costs as well as working expenses. It was assumed, apparently, that a special generating plant is put down for supplying power for winding at this shaft, and in such circumstances the conclusion is obvious. Such a comparison is manifestly inapplicable in the majority of actual cases. Not only do a large number of collieries possess more than one shaft, but electric driving when, it is used, is not confined to this one application. How many collieries are there which would instal an electric plant for the sole operation of winding and not make use of the electric energy at their disposal for driving all kinds of electric machinery above and below earth and for lighting? We venture to think, none. The electric power for the whole works is generated then at one large central station, and great economies are realised on this account alone. As an example of the peculiar nature of Mr. MOUNTAIN'S figures, we may mention the costs at a Belgian mine which he quotes for comparison with the estimates for direct steam driving taken as a basis for his arguments. If we leave out capital charges in the two cases, the figures of actual running cost per 100 tons wound from a depth of about 2,000 ft. are about 3s. 6d. in the case of steam winding and 10s. in the case of electric winding. To assume that the figures are on the same basis implies an efficiency of only 35 per cent. for the electrical system, apart from engine losses—an obvious absurdity. It is difficult to conceive what has been Mr. MOUNTAIN'S object in writing this Paper. An important branch of his business is, we believe, the electrical equipment of collieries; if he does not appreciate the advantages of electric winding and prefers to confine himself to the other applications of electricity in mines, this is no reason for his discrediting the work which other electrical engineers may be striving to do in this direction.

As we have said, we look forward to a complete discussion of the broader questions at the next Institution meeting, when Mr. SPARKS will doubtless not be as pessimistic as Mr. MOUNTAIN. At the same time we may refer to a number of Papers on the subject recently read (and another Paper is down for reading at next Monday's meeting of the Newcastle Local Section). Two of these Papers, one by Mr. B. BARRETT COULSTON, the other by Mr. R. G. MERCER, are reported elsewhere in this issue. Both combined give an excellent idea of the great practical advantages to be derived from electric motors and—as is more to the point in the present discussion—they also prove that it is considerably cheaper to work collieries and mines electrically than by any other means. Mr. MERCER'S figures, which are based on actual cases and not on mere estimates, are especially interesting. He shows, for instance, that the electric plant which was installed at the South Durham collieries at an expenditure of £10,000 conduced to an annual saving of £1,500 in fuel alone. Even if the other savings effected by electrical working be left out of consideration, it will be gathered, that the electric plant pays for itself in less than seven years. The figures quoted for the Northumberland collieries are even more striking. Here the electric installation cost £3,000 and led to an annual saving of from £1,500 to £1,800. More figures could be marshalled to show the economic superiority of an intelligently designed electric colliery equipment, but the results quoted above will suffice to prove our point.

One of the points urged against electric operation by advocates of steam or compressed air relates to the more skilful attendance which electric machinery requires, or is supposed to require. It is interesting to note that Mr. MERCER, for one, holds the opposite view. He argues that the concentration of the electric generating plant combined with the robustness of squirrel-cage motors often leads to an actual reduction in the necessary staff of skilled operators.

In conclusion, we should like to express the hope that the forthcoming discussion at the Institution will be taken part in by men who have had practical experience in the electrical equipment and working of collieries and mines, and who are in a position to further the development of this branch of electrical industry, which is not as advanced in this country as on the Continent and in America.

## A NEW SINGLE-PHASE COMMUTATOR MOTOR.[*]

BY V. A. FYNN.

*(Continued from page 842).*

It is absolutely necessary for the working of this motor that there should be as much self-induction as possible along the motor field axis; but it is equally important that there should be as little self-induction as possible in the motor along the transformer axis. The phase of the auxiliary E.M.F. inserted in the C circuit should coincide with the phase of the field along that axis. Of course this auxiliary E.M.F. can be obtained from any convenient source, provided the periodicity is the same as that of the E.M.F. impressed on the stator and its phase a suitable one. The proper phase of the auxiliary E.M.F. to be applied to the D or C circuit bears a simple relation to the phase of the E.M.F. (E) impressed on the stator. In the general case indicated in Fig. 9, let the brush system be so placed that one of the brush sets, CC for instance, forms an angle, $a$, with the stator field axis F; then the phase of the auxiliary E.M.F. ($E_1$) to be included in the D circuit must differ by $a$ degrees from the phase of E, and the phase of $E_2$ must differ from it by $90+a$ degrees. For $a=0$ the phase of $E_1$ becomes equal to the phase of E, and the phase of $E_2$ is in quadrature with it.

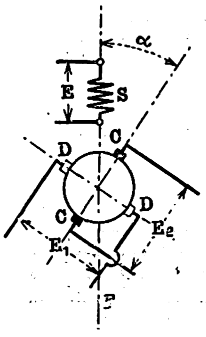

FIG. 9.

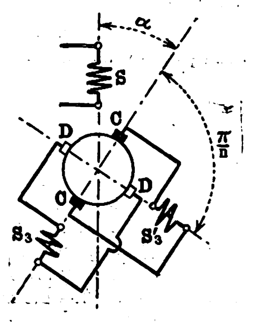

FIG. 10.

It was always recognised that in order to make a commercial success of such a compensated motor, it would be necessary to avoid accessory apparatus as far as possible, and for that reason the author arranges to procure the auxiliary E.M.F. from the motor itself. We have seen that the motor field is practically in quadrature with the transformer field. The motor field will, therefore, induce statically an E.M.F. in phase with the transformer field, and vice versa. If the auxiliary E.M.F. is then to be obtained from the motor itself, it can be got from a winding whose axis forms an angle of $\pi/n$ degrees with the axis of the brushes to which it is to be connected; it will then be acted upon by a field of the required phase. Fig 10 indicates the position of these windings for the general case illustrated in Fig. 9, and, as will be seen from the performance curves of actual motors annexed to this Paper, this method of obtaining the compensating E.M.F. gives excellent results in practice

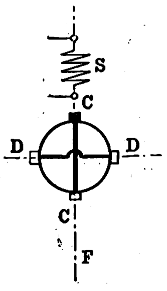

FIG. 1

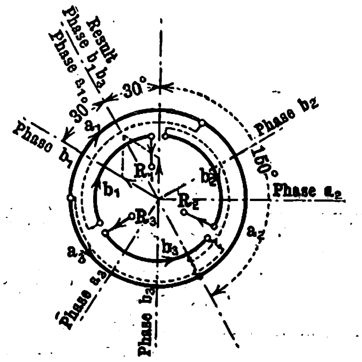

FIG. 11.

It remains for us finally to consider the question of sparking, and although for the purpose of this Paper it was found convenient to deal with this last, it is in reality a question of first importance.

It has been shown that the motor in Fig. 1 is electrically the equivalent of a motor with a squirrel cage; it must, therefore, also behave like a motor having a rotor provided with a polyphase winding short-circuited by means of slip-rings or otherwise; nothing in the nature of the motor would, therefore, be changed if, in addition to the two sets of brushes on the commutator, say, three equidistant points of the rotor were short-circuited when up to speed. This scheme was resorted to with the object of relieving the commutator of the greater part of the current it was carrying, and thus diminishing sparking. The sparking was, indeed, entirely suppressed. The same arrangement was used at starting, when resistances between the three equidistant points were inserted by means of slip-rings, and gradually cut out as the speed was increased. It was, however, found that the ordinary rotor windings in use did *not* answer the purpose at all well, particularly when phase compensation was attempted. It is easy to see that, with a number of points of the rotor winding directly short-circuited, for instance over slip-rings, any E.M.F. impressed on the rotor by means of the one or the other brush set would send a heavy and useless current through these slip-rings; phase compensation is practically impossible under such circumstances. Then, again, it is advantageous to have a very low voltage on the commutator, whilst a high voltage on the slip-rings is important.

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[*] Paper read before the Institution of Electrical Engineers, March 8th.

An obvious way out of the difficulty is to use two distinct windings on the rotor, the one connected to the commutator and the other to the slip-rings. This arrangement lowers the output of the motor very appreciably, because it makes it impossible for that part of the winding which is connected with the commutator to be made use of in normal running (when the machine operates as a shunt-induction motor), as almost the whole of the current induced in the rotor will flow through the slip-rings. To get over the difficulty completely, the author makes use of a continuous-current and polyphase winding in his rotors, combined in such a way that, as far as the commutator is concerned, only the continuous-current winding is operative; whilst both continuous and polyphase windings are operative as far as the slip-rings are concerned. The best possible use is thus made of the rotor winding space and copper. The commutator voltage depends on the continuous-current winding only. The polyphase winding is so disposed with regard to the continuous-current winding as to obtain at the slip-rings the highest possible voltage resulting from the combination of the two windings.

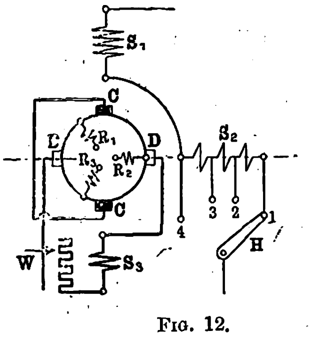

Fig. 12.

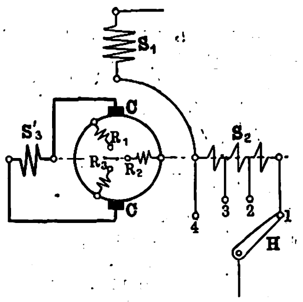

Fig. 13.

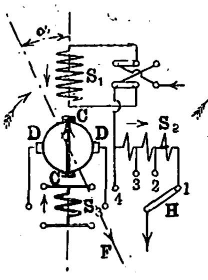

Fig. 14.

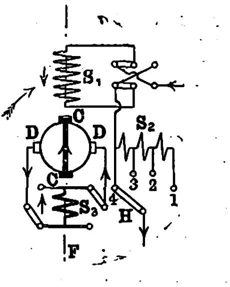

Fig. 15.

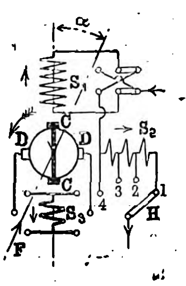

Fig. 16.

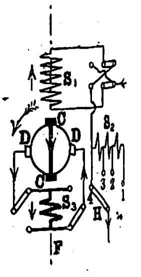

Fig. 17.

For the case of a three-phase winding (and this will mostly be used) the relative positions and the mode of connection of the two windings is shown in Fig. 11. Since any continuous-current winding can be considered as a mesh-connected three-phase winding, this arrangement can be looked upon as the combination of a three-phase mesh and star winding. The three legs of the mesh are designated by $a_1$, $a_2$, $a_3$, whereas $b_1$, $b_2$, $b_3$ stand for the three star legs, and $R_1$, $R_2$, $R_3$ for the three slip-rings. The dotted lines show how the two must be interconnected, the arrows indicate the momentary direction of the induced E.M.F.s, assuming a clockwise direction of rotation and a direction of the magnetic field from top to bottom of the sheet of paper. If $a$ is the voltage per phase of the mesh, and $b$ that of the star winding, then the maximum obtainable voltage between any two slip-rings will be $=a+b\sqrt{3}$. This winding makes it impossible for the brush sets disposed on the commutator to be at any time short-circuited, or even nearly so, over the slip rings; a great number of turns will always be interposed. Tests have shown that a motor provided with such a rotor can be fully compensated without raising by more than 2 or 3 per cent. the current taking its way over the slip-rings. The complete motor is shown diagrammatically in Figs. 12 and 13 in its two early forms, as arranged for "constant speed work." For the sake of clearness, the slip-rings have been omitted from the figures; they are connected to the points $R_1$, $R_2$, $R_3$ of the rotor winding.

The arrangement shown in Fig. 12 allows of the conversion of the motor from a series-induction to a shunt induction machine by the gradual closing of the D circuit in combination with a gradual reduction of the number of turns in the group $S_2$, and, when desired, also in combination with a gradual decrease of the resistances inserted between the slip-rings. A reduction of the resistances inserted in the D circuit and a reduction of the resistances between the slip-rings increases the shunt excitation; a reduction of the number of turns in the group $S_2$ after the motor has started reduces the series excitation. At first both methods were used simultaneously on account of sparking difficulties, and one was naturally led to simplify this disposition by leaving out the D circuit altogether. The motor shown in Fig. 13 was thus evolved, and quite a number of such machines were executed.

The author thinks that although this last form of motor is simpler than that shown in Fig. 12, electrically it is somewhat inferior. It may, perhaps, not be at once clear how and why the motors shown in Figs. 12 and 13 can be compensated with the help of the same auxiliary E.M.F.s as were used for that purpose in conjunction with the motor as shown in Fig. 1. Considering Fig. 12, and remembering that the smaller the rotor resistance the faster will a shunt-induction motor run, it must be evident that the speed in this particular case will be determined by the slip-ring circuit, if short-circuited, for the latter will undoubtedly have a smaller relative resistance than the circuit of the continuous-current winding closed over the armature and field brushes (CC and DD). There will be two alternative paths for the armature current, the one over the slip-rings, the other over the brushes CC; the former will carry all the current, not only directly on account of its smaller relative resistance, but also because this smaller resistance determines a higher motor speed, thus increasing EB in the latter circuit, whilst ET remains constant. There will also be two alternative paths for the field current, the one over the slip-rings, the other over the brushes DD. The greater part of the motor field will be supplied by the current through the former, and the smaller part by the current through the latter; the auxiliary E M.F. ($E_1$) will only act on the latter circuit, but in exactly the same manner as before when the rotor was only short-circuited by means of brushes disposed on the commutator.

When including the auxiliary E.M.F. ($E_2$) in the armature-circuit of the continuous-current winding by means of the brushes CC, whilst the slip-rings are short-circuited, as shown in Fig. 13, a current is caused to flow in that circuit mainly through the agency of $E_2$ and ES. As before, EW will determine the phase and magnitude of this current; this E.M.F. is again the resultant of ET, EB (which is greater than it would be if the slip-rings were not short-circuited, and nearly equals ET) and ES. Under these circumstances the current flowing in this circuit will be practically constant for all loads (until the speed begins to drop materially), independently of the current flowing over the slip-rings, and will cause a decrease of the latter. In phase the current flowing by way of the commutator will lead ET, whereas the current flowing by way of the slip-rings will lag behind ET. The *resultant* rotor ampere-turns in the armature axis can, therefore, be made to coincide with or to lead EE. The resultant stator ampere-turns must balance the resultant rotor ampere-turns, and the stator current can, therefore, be made to coincide with or even lead the E.M.F. impressed on the stator. It is seen that in this case external self-induction is only included in part of the rotor winding in the armature axis and in that part through which the current remains practically constant, so that its detrimental effects are greatly minimised. The beneficial effect of this arrangement as far as the power factor is concerned is greatest at no load, and diminishes as that component of the rotor ampere-turns in the armature axis which is due to the current flowing by way of the slip-rings increases; the result is a very constant and high power factor.

The conversion from series-induction to shunt-induction working cannot be effected as smoothly with the help of the slip-rings only (Fig. 13) as it can with the help of the D circuit (Fig. 12); and in the former case it is quite impossible in practice to avoid a very marked falling off in the starting-torque curve, which makes this form of motor unsuitable when heavy and sustained starting torques are required. For light work, however, it is very useful, and its power factor under normal working conditions approaches unity. On the other hand, the starting-torque curve of the motor in Fig. 12 (with or without the help of slip-rings) is an almost straight line, and the motor in this form can be used in all those cases in which heavy and sustained starting torques are required—for instance, for lift and similar work. The slip-rings are a very unwelcome complication, at any rate for smaller machines, but a way was found of doing without them by simply suitably dimensioning the rotor winding.

In the continuous-current machine we obtain sparkless commutation whenever it is possible, to balance the reactance voltage by a voltage induced in the short-circuited coil by some external means, or simply by the voltage resulting from the unequal distribution of the current under the brush. The last process is automatic, but limited in its effect; it fails when the balancing voltage can only be obtained by raising the current density in some part of the brush beyond the permissible limit. For the continuous-current machine the problem is therefore a comparatively simple one; whereas it is far more complicated for the machines under consideration. In the continuous-current machine there is only the reactance voltage to provide for: this may vary in magnitude, but its phase is constant; in the motor under consideration we have to deal with three distinct E.M.F.s of different phase and varying magnitude. As in the continuous-current machine, there is a reactance E.M.F. to consider, which varies in magnitude with the speed and the rotor current, and is nearly in phase with the latter: in addition there is an E.M.F. due to the static induction of the motor field (axis D) on the coil undergoing commutation, whose magnitude, of course, depends on the strength of the motor field, while in phase it lags about 90 deg. behind the reactance E.M.F. The third E.M.F. is that due to the rotation of the short-circuited coil in the transformer field (axis C), whose magnitude depends on that field strength and on the speed, while in phase it is opposite to the E.M.F. due to static induction. The resultant of these three is the one to be balanced, and this varies in phase as well as in magnitude. This fact makes it particularly difficult to balance it by inducing in the commutated coil a suitable E.M.F. by some external means, since that E.M.F., in order to be effective, would have to follow the variations of the resultant not only in magnitude, but also in phase. At any rate, for small machines one must fall back on commutation by means of unequal distribution of current under the brush, which at once presents limits to the designer. At starting only the first two E.M.F.s above mentioned need be considered, and, as a rule, the second will be the greatest. As the motor speeds up the third comes into play; being of opposite phase to the second its effect is to diminish the latter. When synchronism is reached these two practically cancel out, and there only remains the first, or the reactance E.M.F., to balance.

Taking advantage of these conditions, and with careful design of the rotor, it has been possible so far to dispense with the slip-rings altogether up to sizes corresponding to about 50 H.P. at some 400 revolutions; such smaller machines are made on the lines of Fig. 12, but with only one winding on the rotor and without slip-rings. In motors of greater power intended for continuous running at full load, provision is made for short-circuiting a number of points on the rotor winding, so as relieve the commutator and to be able to make a smaller one do. The complete diagram of connections of a motor for intermittent load and designed to run in both directions (for instance, for elevator service), is given in Figs. 14, 15, 16 and 17; in this case it will be noticed that the resistances in the field circuit are suppressed. In order to reverse the direction of rotation, it is preferable to reverse the current through the winding $S_1$. Rotation would also be reversed if the current through $S_2$ were reversed; but as the tappings must be unequally spaced in the latter, such a course would lead to complications in order to restore the proper stepping.

The average results which can be obtained with such motors vary somewhat with the periodicity of the supply and the number of poles of the motor. Taking as a basis 50 periods, and what can be considered as a normal number of poles, and further assuming that the voltage at the terminals is not raised at starting above the value for which the motor is designed, a maximum torque, two to two and a-half times the normal, can be secured with about one and a-half times the normal current. The motors will start light with about no-load current, or not more than one-fourth of the normal current. The power factor can always be brought up to unity; this, however, may entail a heavier current in the rotor and slightly higher losses. On that account the smaller motors are not, as a rule, fully compensated, as it does not appear advisable to lower the efficiency for the sake of improving the power factor by some 5 per cent. Thus for small machines up to 6 H.P. or 7 H.P. the power factor is only raised to 0·7 or 0·8 at no load, reaching 0·9 to 0·94 under load. The power-factor curve rises very rapidly at first, and as the load increases it remains nearly constant. The larger machines are designed for a power factor seldom falling below 0·9 and reaching 1; these can be made to take a leading current when desired.

The efficiency of these compensated motors closely approximates to that of good asynchronous machines with squirrel-cage rotors. In the smaller sizes it falls some 2 to 3 per cent. below the latter, as is to be expected; since for small outputs only a small increase in the losses is sufficient to reduce the efficiency by several per cent. In this case the increased losses are mainly due to the friction of the brushes on the commutator and to the $C^2R$ losses in commutator and brush-gear. In the larger sizes the efficiency quite equals, and sometimes, for a large number of poles and high frequencies, materially exceeds that of the corresponding asynchronous motor. Altering an ordinary asynchronous single-phase motor to the construction which we have described will increase its output from 30 to 40 per cent., besides vastly improving its power factor; but the increased output and the better power factor of these machines do not entirely compensate for the increased losses.

The number of poles which are here considered as normal run somewhat as follows; Four up to about 3 H.P.; four and six up to about 10 H.P.; four, six and eight up to about 40 H.P., and so on. An increase in the number of poles for the same frame decreases the maximum starting torque obtainable, roughly, in the same proportion as the increase in leakage, while the current for a given torque increases. The power factor can be maintained at its high values for any number of poles likely to be adopted. But the efficiency naturally falls off with an increasing number of poles, since the speed and output are reduced, whilst the losses remain much the same. The maximum starting torque varies inversely as the square root of the periodicities, the current taken increasing nearly in the same proportion. The power factor can be maintained at its high values for any periodicity; the efficiency, however, falls off a little with an increase in the number of cycles.

The maximum output varies with the square of the terminal voltage, and the starting torque also increases in the same proportion as long as saturation is not reached. By boosting up the terminal voltage at starting, a torque equal to four times the normal can be obtained with about three times the normal current. The behaviour of these compensated machines under normal running conditions is interesting, and differs in many respects from that of the ordinary asynchronous induction motor.

Thus, for instance, at no load the speed is, as a rule, a little above the synchronous—some 2 to 4 per cent., the actual amount depending on the auxiliary voltage impressed on the field brushes. At full load the drop in speed reaches about 10 per cent. in the smaller sizes, and where no means of short-circuiting a number of points of the rotor winding, independently of the commutator, are provided. In the larger sizes, and where independent short-circuiting devices are employed, the slip approximates more nearly to that of the ordinary asynchronous motor. When heavily overloaded, the speed may drop to about two-thirds of the synchronous before the motor will pull up. The great drop acts as a safety valve to some extent, and prevents the motor from falling out of step under momentary heavy overloads.

The starting gear for the smaller machines simply consists of a three-pole two-throw switch. As a rule $S_2$, the stator series field winding, is provided with two tappings besides the beginning and end; these are taken to four terminals; the end is joined directly to the beginning or end of the $S_1$ winding, according to the direction of rotation required. In the starting position the switch is connected to one of the three free terminals of the series field winding $S_2$, the choice depending on the torque required. In the working position the $S_2$ winding is entirely cut out, and the shunt circuit closed on the $S_3$ winding. It is, of course, best to throw the switch over into the working position at the time when the motor has reached its normal speed, but no damage or undue rush of current will result if the exact moment has not been correctly estimated. If the motor starts light, the switch can thrown over as soon as the motor has made a few revolutions; if left in this starting position the speed will rise to perhaps 20 or 30 per cent. above the synchronous, but will at once fall to the normal on the switch being brought into the working position—there will be a momentary rise in the current not exceeding 25 per cent. If the motor starts under load the switch can be thrown over at any time after the motor has reached, say, a third of its normal speed. If the motor does not start at all in the first position, it is useless to throw the switch over, as this will only cause a short-circuit.

Larger motors are provided with controllers connected according to Figs. 14 to 17. The current is switched on gradually, and the motor starts according to the torque required on the first, second or third point. With such a controller it is possible to regulate the speed of the motor to a great extent. If the $S_3$ winding is only in circuit on the last point, then on all the others the motor will have a series characteristic. If this winding is kept in circuit, then the speed, even at no load, can be greatly reduced by moving the controller back; that reduced speed will, however, not be maintained nearly constant under load, but will fall off much in the same way as the speed of the shunt motor with weakened field. This drop will be the greater the more of the $S_2$ winding is switched into circuit. Under these conditions the power factor and efficiency fall off to about two-thirds of their normal value. Better results with regard to efficiency and power factor during starting can be obtained in special cases by regulating the E.M.F. impressed on the D circuit, increasing it as the speed decreases, but this necessitates a little more complication in the connections and windings.

*(To be concluded.)*

# NOTES ON THE CONSTRUCTION AND MAINTENANCE OF OVERHEAD EQUIPMENT.

The following is an abstract of some further communicated contributions to the discussion on Messrs. R. N. Tweedy and H. Dudgeon's Paper on the above subject, which was read before the Birmingham Local Section of the Institution of Electrical Engineers on February 14th. The Paper itself and the discussion which followed it were reported in *The Electrician* for February 16th, p. 711, and February 23rd, p. 764.

Mr. R. F. BROWNE, in a written amplification of his remarks made during the discussion on the Paper (see *The Electrician* for February 23rd, p. 766) said the suggestion that a 2 in. rake was enough for a pole before any strain was put on depended entirely upon the strength of the pole. He agreed with the authors' remarks about concrete, and suggested that there were many poles in this country standing up to their work which had been erected with practically no cement in the concrete. He could see no reason why poles, except possibly anchor and pull-off poles, could not be erected with lime concrete in maiden ground. He believed in pot reel insulators, and had had some tested, of the same type as those mentioned, which broke with a strain of 2,200 lb. He now used a larger size, which he had no doubt would not fail under 2 tons. A great point in favour of these insulators was that if they failed electrically they had already failed mechanically, and this failure could be seen from the road without difficulty. They were also more easily replaced than other types, and required no re-nozzling. He favoured "figure 8" section wire. An advantage not mentioned in the Paper was that anchoring and splicing could be done without bending the wire. A small portion of the top lobe of the wire was cut out, and one side of the ear or switch had a projection or boss which fitted into this recess. This gave a level surface for trolley wheels to pass under.

Mr. H. R. PROSSER said the South Staffordshire poles, which had been referred to in the Paper, were strong enough to meet all necessary strains, but were far too resilient when the cars were passing, and this caused that hammering and sparking which gave so much trouble. Bases protected the most important part of a pole. A very simple method could be arranged to get over the difficulty of painting underneath the bases and collars. He did not believe in the arrangement of soldering a piece of "figure 8" section wire to the top of the trolley wire and to the underside of a clip, when a proper mechanical clip would do away with all the difficulties spoken of. Owing to oscillation, trolley wheels did not wear to the radius of the wire, but to a larger radius, and so were able to accommodate their travel along the clips. He could not understand the authors' statement that the lower surface of the wire at the clip was not touched by the trolley wheel, especially as they showed worn clips having an undulated surface on the bottom or running side of the clip. How would the soldered wire method stand the extra strains caused by curves or changes of grade?

Mr. H. HARTLEY said the South Staffordshire poles had been instanced as light poles. The larger size. 7 in. by $3\frac{3}{4}$ in. by $\frac{1}{4}$ in. had in some cases bracket arms 10 ft. to 11 ft. long, carrying two wires. They had been in service 13 years, and were still in excellent condition except for a little corrosion on the ground line. They would not be suitable for span-wire work, but would surely be strong enough as centre poles with arms, say, 6 ft. to 8 ft. long. Bases did protect the pole, and it would be a mistake to dispense with them. He had found no rust inside, in cases where the poles had been in service three to four years. By raising the concrete a little above the ground line, moisture would drain off, and there should be no sweating. The old Staffordshire poles had no bases, but simply a small collar at the ground line. They showed undoubted signs of corrosion, but on the footpath side only. His experience bore out that of the authors as to the local action which took place between gunmetal and the galvanised span wire. Malleable fittings were generally machined after being galvanised, and it was at the junction of the machined portion and the galvanising that it commenced to peel off. The best insulator he knew of was the bell-shaped, with the bolt moulded into the insulating material. He knew some in service now that had been in use since 1892. Electrolytic action took place as in other types, but they were much easier cleaned. Porcelain was the best material for secondary insulation, and he saw no reason why it should not be used for primary insulation. Such insulators were cheap, and, if designed to suit a malleable iron hanger, galvanised but not machined, local action would not occur as it did with gunmetal. He had had experience with practically every type of ear, and considered the mechanical type the best. Hammering action, resulting in a certain amount of sparking or arcing, occurred with either mechanical or soldered ears. It was most marked on solid construction or short bow strings, even when the trolley tension was cut down to a minimum. He had had a short experience with "figure 8" wire, and it had given every satisfaction. They obtained smooth running and no wear on the ears. The trolley wire on the old South Staffordshire system was originally 0·34 in. diameter, and the maximum reduction due to wear, that he was able to trace, was 0·015 in. This figure did not, of course, refer to the wear at the ear, which was much greater. He did not think that the new soldered type of ear, which the authors had shown to the meeting, would suspend the wire efficiently.

Mr. C. W. FOURNISS thought the rake of a pole depended to a large degree on the nature of the ground. The small rake of 2 in. mentioned in the Paper was not visible from the ground. For all practical purposes bases were unnecessary. On the line with which he was connected they used two kinds of pillars, one filled with bitumen and the other finished off with concrete. The former gave no trouble, and when inspected the whole pillar was found perfectly dry. The latter type was a continual source of trouble, water collecting in nearly every box on the route. He found that a very small percentage of insulated bolts failed, and that such failures were due to a very strong side strain. As regarded secondary insulation, they had decided to discontinue the use of Brooklyn and Globe strains, as they found porcelain insulators quite suitable. Was the authors' suggestion that reel insulators be placed horizontally with the downward strain on the flange the result of actual experience? He agreed that 2/0 wire was sufficient for a line with a five-minute service, but with a more frequent service a larger wire was absolutely necessary, and in such cases the extra capital cost did not assume any great importance. There were two reasons for wear of trolley wire in addition to those mentioned by the authors—the speed of the cars and the nature of the trolley wheels and wire. Poor or hard metal in the wheels soon caused appreciable wear. His experience had been that rolling friction had a great deal to do with depreciation, and also that the method of suspension did affect the wear to a very great degree. He had personally measured several sections of trolley wire which had been erected $2\frac{1}{2}$ years, and which had been in actual service 14 months. Forty-eight measurements were taken on hills of varying gradients, in 20 cases the "up" and in 28 cases the "down" wire having worn more than the other. The most interesting discovery was that the wire wore taper from ear to ear, getting smaller in the direction of running, the wear at the centre of the span being approximately a mean between the wear at either end. He found that wear on central under-running work was much less than on side-bracket work. He would like to ask the authors if they had noticed the peculiar "U"-shaped corrugations which appeared in close proximity to the ear, these corrugations getting smaller and smaller as they approached the ear, finally tapering down to nothing.

Mr. MERCER said he had never yet planted a span pole with only 2 in. rake except in rock, and in other cases never less than 4 in. to 6 in. according to the soil, the result being that the span wire was pulled up taut, and gave about 12 in. sag with the weight of the trolley wire on it. With 24 in. sag in a 40 ft. span, and such light poles as the authors recommended, he thought there would be considerable whipping after a car had passed at speed. He would not dispense with bases, but thought that they should be shorter and lighter than those generally used, and certainly should be ventilated. All guard wires should be thoroughly connected to the rails every 200 yds. He understood that in Coventry, where circular wire was in use, mechanical grooved ears were now being employed, a groove being pressed into the wire by a clamp and die. This seemed satisfactory, and tests had shown that the pressed wire was every bit as strong as the remainder.

Mr. R. N. TWEEDY, in reply to the further communications, said Mr. Prosser's statements did not altogether agree with the facts. The flexibility of the South Staffordshire poles tended to decrease the hammering and sparking, and these evils were due solely to the particularly bad type of ear which was used on those lines. The authors would prefer something less expensive than a 5 ft. base weighing 500 lb. and over to protect poles on the "wind and weather" line. Mr. Prosser's remarks on the subject of ears showed that he has not grasped its elements, for he spoke of the figure 8 portion being soldered to the "clip," whereas it is soldered to nothing but the wire. In reply to Mr. Hartley's objection to malleable iron fittings, he said it was possible to buy fittings which are properly galvanised and able to stand the atmosphere of the Black Country. To obtain satisfactory results, the surfaces to be painted had first to be properly cleaned. Mr. Hartley's opinion that the signs of corrosion on the footpath side were due to the attentions of dogs was borne out from other quarters, and that trouble might be overcome by simpler means than those adopted now. What the "figure 8 ear" did beyond question was to endow circular wire with all the advantages of figure 8 wire, while the efficiency of its suspension had been proved in practice. The corrugations of which Mr. Fourniss wrote were commonly seen on the trailing end of an ear and the adjacent wire, and without much doubt they were caused by vibrations of the trolley pole, and of the wire itself. The recommendation to fix reel insulation horizontally, instead of vertically, as usual, was based on experience, but referred more to flexible suspensions than to spans. The reel in that position was able to withstand the shock of a de-wired pole, hitting the suspension wire much better than if it were vertical and the strain had to be taken by the flanges. The expedient of grooving the trolley wire at Coventry for the reception of mechanical ears was brilliant, but he would like to point out again that grooved wire ears always fouled the trolley wheels when the latter are partly worn.

# THE USE OF ELECTRICITY IN MINES.*

BY R. G. MERCER.

No industry calls for the transmission of power to greater distances and under more disadvantageous conditions, and no class of work exposes the machinery to rougher or more onerous usage than the mining industry. For these reasons steam, compressed air and mechanical transmission are being rapidly superseded by electrical methods, which, besides giving increased reliability and freedom from breakdown, have been proved to be considerably more efficient and convenient and to reduce working expenses correspondingly.

*Electric Winding.*—Much has been written on this subject, but little has been done in this country with regard to the application of electricity to winding. This is probably due to the difficulty of coupling motors satisfactorily to existing drums. Steam winding engines, as at present used in this country, are among the most inefficient appliances about a colliery, owing to the large amount of power for starting and accelerating the load; the steam consumption of these engines per horse-power-hour of actual work done, in raising coal, varies from 50 lb. to 120 lb. or more in many cases. The most modern steam plant, even when fitted with automatic expansion gear and exhausting into a condenser, cannot compare with an electric winding plant from an economical point of view. The certainty and simplicity of control, and the handiness of electric winding gear, the uniform torque of the motors, which allows the flywheel effect of the winding engine to be reduced to the smallest possible amount, while a steam engine must in many cases have a greater flywheel effect, due to its reciprocating action, are strong recommendations.

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* Abstract of a Paper read before the Birmingham and District Electric Club on Saturday.

There are several systems of electric winding. Those in most general use are: (1) Electric winding by means of direct-currect or alternate-current motors direct coupled or geared to the winding drums and taking current direct from the mains; (2) electric winding by means of direct-current motors direct coupled or geared to the winding drums, the supply of current, which may be three-phase or continuous, being regulated by a balancer with heavy flywheel.

*Electric Haulage.*—In the United States electric locomotives are largely used, the coal seams being more free from faults than in this country, and the roads consequently more level. In many of their collieries the locomotives bring the trains out of the hill side, no winding shaft being used. The conditions limiting their use are, firstly, the gradients, which should not as a rule exceed 1 to 50 for long stretches, and secondly, the fact that the collection of current from the bare overhead trolley wire entails a certain amount of sparking, which would, of course, give rise to danger in fiery mines. On the other hand, for surface work and in those roads where the atmosphere is not of a fiery nature, considerable economies may be effected. The greatest saving as compared with either animal or mechanical haulage is in the cost of attendance, while the cost of maintenance is less than with any other form of haulage. Again, the compactness of the electric locomotive makes it perfectly suitable to low and narrow entries. It may be used on temporary tracks and in crooked passage ways where a rope haulage system would be impracticable. It is very handy and well adapted for shunting and distributing trucks, work which would otherwise require extra men and horses. A good example of the great saving effected by the use of electric locomotives in mines is the Norton Coal Co., of Norton, Virginia. The seam of coal is nearly level and of fairly uniform thickness; there are two mines now in operation under the town, with an output of about 550 tons a day. The trolley wire extends 4,000 ft. into mine No. 1, to the surface of the workings and from the drift mouth 800 ft. to the tipple. A feeder line extends 2,000 ft. into the mine. These wires are carried overhead, the trolley line being divided into four sections, each of which can be connected at will and independently of the other. 30 lb. rails are laid in a single track line of 3 ft. gauge. The locomotive, weighing 10 tons, hauls 18 cars with a total load of 36 tons of coal up a maximum 3 per cent. grade. Formerly a steam locomotive hauled the cars out from a point 1,700 ft. within the mines, mules being used to collect the loaded cars and to bring them over a distance of 2,300 ft. to the locomotive. Each train of cars had to be broken up into two or three sections and hauled separately over certain portions of the up grade on a sharp curve. The electric locomotive was introduced in this mine for the sake of economy and operation, as well as to increase the output. It now takes a train of 18 loaded cars all the way up from the face of the workings to the tipple without a break. Electric haulage has enabled the company to double the output of the mines, and the cost of traction has been reduced from about 4d. per ton to ½d. per ton, though to this, of course, must be added the interest upon the electrical investment. The company also uses electric current for operating coal cutters and other mining machinery. The Eureka mines owned by the Berwind-White Co., and situated in Somerset county, Pennsylvania, are equipped with an extensive system. The company's property extends over 70 sq. miles, and is being rapidly developed, seven mines being already in operation. At the mines 32 electric locomotives, each weighing 13 tons, are in regular service. They can haul 45 loaded cars up a 2½ per cent. grade, each car weighing over 1½ tons gross. Each locomotive hauls over 500 tons of coal per day, making 11 trips and running on a regular schedule. Each train has one driver and one trainman. At these mines the cost of haulage has decreased from 5d. per ton with mule haulage to less than ½d. per ton with electric locomotives. The average haul at all the mines is approximately 5,000 ft., and the average number of cars handled per locomotive is 400 per day of nine hours. The capacity of these locomotives would be considerably more than 400 cars per day but for the fact that in these mines no mules whatever are used, the additional duty being imposed on the locomotives of distributing the empty cars to room partings for men to push to the face, and of collecting the loads from these rooms.

Electric locomotives both for mine and surface haulage as at present constructed are thoroughly sound and efficient machines. In general the motors are of the steel clad enclosed railway type, the controllers have magnetic blow-outs which prevent arcing between contacts and are, together with the resistance and motor, specially designed and constructed for mining service. Standard sizes of these locomotives range from 16 H.P. to 100 H.P. or over, weighing respectively 2 and 13 tons. The track gauge may be anything from 18 in. upwards and the minimum height exclusive of trolleys, respectively, 32 in. and 36 in., so it will be noted what a very small amount of head room these locomotives require. Where rope haulage plants are already in use and where the conditions are not suitable for locomotives, the electric motor can with advantage replace the steam engine for driving the drum. When the endless rope system is employed a constant speed motor drives the drum continually in one direction. With the main and tail system two drums may be connected to a reversing motor or to two separate motors. Where polyphase current is used it is advisable, unless a friction clutch be used, to operate the haulage gear by means of a slip-ring motor, the controllers and switches being immersed in oil of a high flash point. When a friction clutch is used, the squirrel cage motor can be used. The absence of sensitive parts is an immense advantage where motors are entrusted to the care of unskilled men and exposed to much dirt, dust or damp. This motor is as simple as a grindstone and will run continuously with no further attention than that required to fill the oil wells. It may be pulled up dead by extreme overload without injury, a thing impossible with any other type of motor; it is capable of developing a torque several times its normal full load torque and is therefore not liable to be stopped by momentary overload.

*Electric Pumping*—It is not necessary to refer at length to the application of electric motors to all classes of pump, including sinking pump, since this is already recognised as one of their most successful uses. In all the earliest installations a double reduction between the motor and pump was necessary, the pumps being of the slow speed reciprocating type, with plunger speeds ranging from about 70 ft. to 100 ft. per minute, the outfit having a combined efficiency of 60 to 68 per cent. according to the capacity. Now, however, it is possible to obtain high speed reciprocating pumps having higher efficiencies, and running at speeds that enable the motor to be coupled to the pump with a single reduction gear, the speed of the pumps varying from 160 to 300 revs. per min. according to size. It would of course be quite possible to couple the motor direct to a pump running at either of these speeds, but it is not advisable on account of the extra cost of installing a slow speed motor, to say nothing of the efficiency.

High lift turbine pumps are now being used extensively, the cost of making foundations and excavating rooms for them is less than for a reciprocating pump of similar capacity, because the turbine pumps operate at a very much higher speed (such a speed indeed that the motors have to be specially designed for running them), and consequently the pump and motor are very much more compact. There are no air vessels, there is no water-hammering in the pipes, and the flow is continuous.

The most important factor limiting the speed is the quality of the water passing through the pump; if the water is dirty and gritty the speed should be as moderate as possible, owing to the excessive wear of the internal parts of the pump if it is running at as high a speed as it can with clean water. It is impossible to fix any hard-and-fast rule about the relation of capacity to head, but generally speaking at ordinary speeds, to obtain the best results with a pump of moderate price, the number of gallons per minute should be about equal to the number of feet in total head. As an example, a pump designed to deliver 500 gallons per minute against a head of 500 ft. would give an efficiency of not less than 72 per cent., while the best efficiency possible with a pump designed to deliver 50 gallons against the same head would only be about 60 per cent. Where the conditions are such as demand variation in head, this can be easily obtained within certain limits by adopting a multi stage turbine, arranged so that one or more of the impellers can be cut out, either by removing the impellers from the pump or by the use of a special bye-pass; should the quantity only require to be varied the result can generally be obtained with a little loss of efficiency by throttling the discharge. The very best type of motor for coupling up for turbine pumps is undoubtedly the squirrel cage motor, whose starting current is not excessive and will probably not exceed full load current.

Two motors of this type are just now being installed at the Newdigate Colliery at Bedworth for pumping purposes. One is a 180 H.P. Westinghouse squirrel cage motor, three-phase 50 periods coupled direct to a Worthington multi-stage turbine pump operating at 1,450 revs. per min. having a capacity of 500 gallons per minute against a total head of 600 ft. The other is a 50 H.P. squirrel cage moter direct-coupled to a similar pump having a capacity of 250 gallons per minute against 380 ft. head. These motors are controlled by oil-immersed auto-starters.

At the Lewis Merthyr Consolidated Collieries in South Wales a 60 H.P. Westinghouse squirrel cage motor three-phase 440 volts is coupled direct to a four-stage Worthington turbine pump. The suction of the pump is fed from an overhead tank, which in turn is supplied by a Westinghouse-Worthington centrifugal pump drawing the water from the various sumps. These pumps possess a combined efficiency of nearly 70 per cent. when delivering 350 gallons per minute against a head of 342 ft.

*Electric Coal Cutting.*—There is not much choice between the powers at our disposal for coal-cutting machinery, the only powers being compressed air and electricity. The former is favoured by many, especially in fiery mines, and there is no doubt that it is a safe and simple power, but on the other hand it is very costly and the efficiency is very low as compared with electricity when one considers the long lengths of pipes and the cost of keeping them in repair, also the cost of removing them from cross gate to cross gate, as the face advances. Where direct current is in use a compound-wound motor is most suitable, and will, of course, have to be completely enclosed and rated so that the temperature rise will not become excessive. Where three-phase current is employed a slip-ring motor has generally been preferred to the squirrel cage type, owing to the large amount of starting current required by the latter to overcome the starting torque. But it will be found in the majority of cases that the cables feeding the cutters are nothing like large enough, their size being based on the normal full load output of the motor. In practice, however, a coal-cutter motor is usually working at the top of its power all the time it is in operation, and as it is most important to get the heaviest torque out of the motor when starting, the cables feeding the motor should have a current density not exceeding 500 amperes per square inch, so as to enable the full voltage to be on the primary winding when starting, and so obtain the benefit of the highest possible torque when switching on. If this is borne in mind, the squirrel cage motor is undoubtedly the more suitable on account of its ability to withstand rough usage and the small attention required. The liability of these motors to get jammed by reason of overfeeding or because of the settlement of the coal makes little or no difference to this type of motor.

*Distribution.*—Distribution systems may be divided into two main heads. (1) Polyphase alternating-current system, (2) direct-current system. These may be combined in some cases, the latter being used for locomotives and the former for all other purposes. Polyphase, preferably three-phase, current should be used where the installation is a very large one and where distances are considerable. Direct current may be employed satisfactorily in small installations and where the mines are not fiery.

By generating electrical energy on a large scale under the most favourable and economical conditions, and transmitting it over long distances by means of high-tension alternating-current, power companies, of which several are already in existence, will be enabled to supply power to consumers at terms which will render it unnecessary for any but the very largest power users to instal their own generating plant.

With regard to the best methods of cable laying, each case has to be considered separately. In general, however, for alternating current, the feeders on the surface from the generating station to the top of the shaft may be laid underground, in which case they should be laid on the solid system, or they may be carried overhead. The writer prefers the former system for the reason that though it may be more expensive to lay the feeders in this way, it should not be necessary to touch them again. At the top of the shaft there should be a disconnecting box, and at the bottom a disconnecting distributing box or distributing board, so as to allow of each section of cable to be tested separately, and, in the case of distribution cables, allowing a faulty section to be cut out without interfering with the rest of the network.

One of the most important points in connection with cables is the best method to be adapted for fixing these in the shaft. Unarmoured cables laid in impregnated wooden casing, the grooves being made tight enough to grip the cable and the casing being packed off from the sides of the shaft to prevent water running down it, is absolutely the best method, though it is somewhat costly on account of the labour and material involved. A cheaper method is to run double-armoured cable down the shaft, supported at intervals of 15 ft. to 20 ft. with strong wooden cleats; the cables should be three-core, not triple concentric, and armoured with galvanised iron or steel wires. On no account should steel tape be used because of its inability to resist tension. For the same reason the use of lead-sheathed cable has been found inadvisable. In the main roads armoured cables can be suspended either from the roof timbers or the props with raw hide suspenders, but in cases where the ground has a tendency to move a margin of slack should be allowed. They can also be laid in troughs behind the props or under the floor, the troughs being filled in solid with bitumen. All armoured cables should be well earthed to water pipes, and failing these to an old steel rope, and the armouring should be made continuous.

*Economy of Electric Working.*—From what has been written on the foregoing subjects it will be clearly seen that the application of electricity in collieries means not only a large reduction in the cost per ton of coal mined, but an increased output and all round better working conditions. With regard to electric haulage the figures given above show that it has doubled the output of the mines in one company and at the same time has reduced the cost of traction from 4d. to ½d. per ton, and effected a total yearly saving equivalent to 30 per cent. on the outlay of the electrical plant, so that in about three years the latter paid for itself. In the second case where mule haulage was used, the substitution of electric locomotives reduced the cost of traction from 5d. to ½d. per ton, and effected an annual saving equal to 90 per cent. of the cost of the electrical installation. The advantages of electric coal-cutting machines are manifold: (1) there is a considerable reduction in the cost per ton of coal mined, due to the increased output per man; (2) the selling value of the coal is increased on account of the larger percentage of round coal obtained and the corresponding decrease of slack; (3) a better roof due to the increase in the rate at which the work advances. The following is a table showing some financial results of electrical working in collieries :—

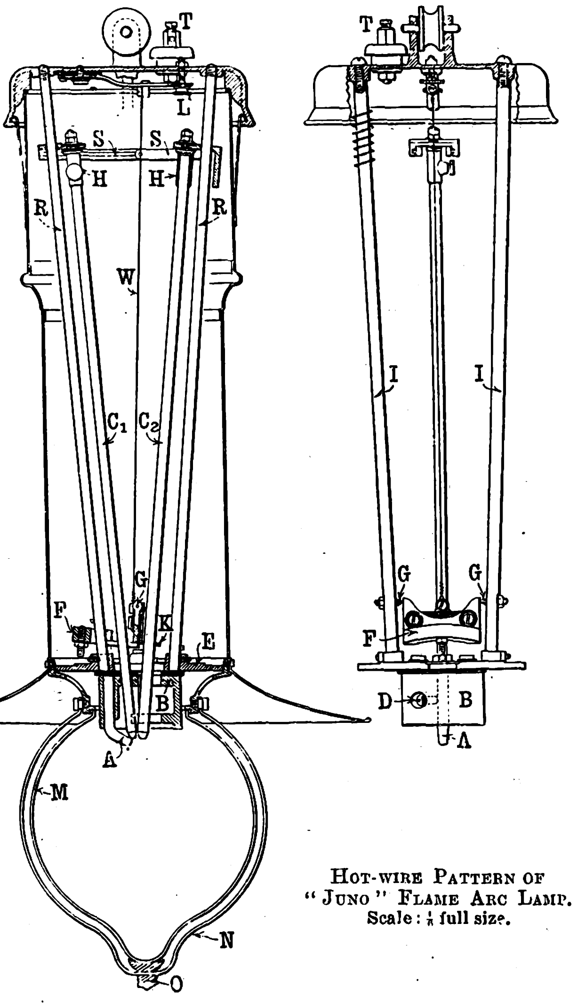
| Situation. | Old plant. | New plant. | Total cost incurred | Annual saving. |
|---|---|---|---|---|
| South Durham | Spear rod pumps delivering 1,000 gallons per min. agst. 400 ft. head. Pumps worked from bank. | 400 H.P. steam engine, dynamo & motors to drive existing pumps, one additional pump, and electric coal cutters. | Under £10,000 (exclusive of coal cutters). | Over £1,500 in fuel alone. Besides, the shaft formerly occupied by pump rods is utilised for winding, and the output facilities thus largely increased. |
| Northumberland. | Seven single-barrel pumps (each delivering about 100 gallons per min.) driven by endless wire rope from two hauling engines & boilers underground. | Horiz'nt'l steam engine & dynamo, eight electric motors driving existing pumps and one additional pump. | £3,000. | £1,500 to £1,800. |
| Scotland | (*a*) Spear rod pump to shaft bottom.<br>(*b*) Two duplex pumps undergr'nd with steam pipes, one 800 yds in-bye. Attendance, seven men. Fuel consumption, 14 tons per day. | 250 H.P. engine driving 130 kw. dynamo. 150 H.P. motor driving three-thr'w p'mp giving 500 gals. per min. against 600 ft. head. Attendance, three men. Fuel consumption, 2¼ tons per day. | £6,000. | Over £3,000. |

From a study of these figures it will be noticed that the annual saving in consequence of using electric plant is large, so large indeed as to enable the plant to pay for itself in a few years. There are other economies which are less easily reduced to definite figures than the fuel and labour items, among these may be mentioned the possibility of centralising the power generating plant and most of the skilled attendants within the walls of a single building. This is of special advantage where several shafts are worked under the same management. A large reduction is effected in the cost of maintenance and repairs as compared with more antiquated machinery and, again, a safe, efficient and economical means of lighting the mine is provided, this being a contingent advantage of the greatest value.

## THE "JUNO" FLAME ARC LAMP.

The "Juno" flame arc lamp, which has recently been designed and placed on the market by Messrs. Johnson & Phillips, of Old Charlton, is remarkably simple in construction and operation, as will be gathered from the sectional drawing, Fig. 1. At present it is made in one standard size, which is stated to emit about 2,300 c.p. (mean spherical) at a consumption of 450 watts. Four lamps of the type described below will burn in series across a 240 volt supply.

Referring to Fig. 1, $C_1$ and $C_2$ represent the carbons, which are o a special quality, and not of the metal core variety. When the lamp is to be fed by continuous current, the carbons are of different thickness, and in the lamp we were shown at the works, the carbons were of a diameter of 8 mm. and 9 mm. respectively. If fitted with these carbons, the lamp, which consumes from 8 to 10 amperes, will burn from 10 to 12 hours before needing re-trimming, but with carbons of 11 mm. and 13 mm. the hours of burning are increased to about 20. When used on an alternating-current circuit, carbons of the same thickness are used, of course. The carbons are 18 in. long, and are clamped at the top by the carbon holders HH, which are fixed to, but insulated from, the cross slides SS. By this arrangement, if the carbon $C_1$ is allowed to drop, $C_2$ will travel down at the same rate. RR are of brass rod, and serve to guide the cross slide The carbons converge towards their lower ends as shown, and pass through two holes in the brass cup B. The carbons slide down together by gravity until the carbon $C_1$ rests against the abutment A, which is simply a bent copper bar secured by the screw D to the metal cup B. This cup, which is split to allow for expansion, is fastened to, but insulated from, the brass plate E. Its chief function is to protect the flame arc from draughts, but it also helps to reflect the light downwards. The copper piece A is provided for the carbon $C_1$ only, and the cross slides, the guiding rods and the holes in the cup B ensure that the second carbon $C_2$ moves in exact step with $C_1$. The magnetic flux to elongate the arc is created in the iron rods I I, which are wound with bare copper wire. This wire is insulated from the iron rod by a layer of mica and other insulators. W is a stout wire of a nickel-iron alloy, which also contains a little copper. When the lamp is not burning, the tension of the wire W keeps the striker F (whose fulcrum is at G) in the position shown, and the carbon $C_2$ is pressed against the carbon $C_1$ by the collar K, which is rigidly fixed to the striker. L is a thumb-screw, by means of which the tension of the hot wire W can be adjusted. In order to assist cooling, the middle portion of the hot wire is flattened out.



Hot-wire Pattern of "Juno" Flame Arc Lamp.
Scale: $\frac{1}{8}$ full size.

If the lamp now be switched into circuit, current will enter by one of the terminals TT, and, after flowing through the hot wire, the carbons and the blow magnets in series, will leave by the other terminal. The flexible connections (not shown in the drawing) between the various parts are protected in the customary manner by insulating beads. The hot wire heats up very quickly and elongates, and the striker is free to rotate in a counter-clockwise direction about G by gravity. At the same time the collar K moves towards the right, and in doing so draws the carbon $C_2$ away from $C_1$. In this way the arc is struck. When the current is switched off, the hot wire cools down and contracts; the striker is rotated in a clockwise direction against gravity and the carbons are again brought into contact with one another, ready for starting the arc. Although the whole length of the iron rods II, which constitute the cores of the blow magnets, is wound with copper wire, only a portion of the available turns is utilised. With alternating currents a larger number of turns is used than with continuous currents. The number of turns is easily regulated by connecting the flexible conductors to the copper helix (by means of clamps) at any point along the rod I. The glass globe M is held in place by the springy wire N and the cap O. The voltage across the arc is from 40 to 45 volts, and from 6 to 7 volts are lost in the carbons, hot wire and the copper helix which produces the magnetic flux.

When visiting the arc lamp department of Messrs. Johnson & Phillips (Ltd.), the other day, we examined an arc lamp which had been running on test for 4½ hours and found very little ashes deposited in the globe. Scarcely any visible fumes or obnoxious gases are given off, and we were told—as a proof of the suitableness of the "Juno" flame arc lamp for interiors—that a lamp of this description is employed to illuminate the staircase of the Hotel Cecil.

The carbon $C_1$ does not burn away quite equally, but tapers down to a fine point where it comes into contact with the copper abutment A. After a while, however, this fine point breaks off and both carbons drop a small fraction of an inch until the solid part of $C_1$ again rests on the abutment. A faint click is heard when this takes place, but the light remains steady. The only slight disadvantage of this hot-wire type of lamp, we were informed, is that it takes some time (about 10 seconds) for the lamp to light up again when suddenly switched off and on. In many cases this is of no consequence, but to meet all requirements the firm are also making a lamp—otherwise identical with the one just described—in which an electromagnet takes the place of the hot wire. It has been found from experience that the copper abutment lasts two or three months. The light emitted is of a bright yellow colour. Since the mechanism has been reduced to a minimum, and what there is of it takes up little room, the lamp is compact for its power, its overall height being 29½ in. The hood is of sheet copper and is brightly polished in places, and the reflector is enamelled in white.

# CORRESPONDENCE.

## DESIGN OF A 500 KW. GENERATOR.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In his article on the above subject in the current number of *The Electrician*, Dr. Breslauer refers to the commutation formula which was printed in *The Electrician* (Vol. LIII., p. 53) in 1904. He has in transposing it, I think, confused the units. Examining the commutating qualities of the 500 kw. generator under discussion it will be found that

$$\delta = 5{,}240 \times 1 \times 300 \times 12{\cdot}1 \times 2{\cdot}5 = 47{\cdot}6 \times 10^6.$$

This figure is well within the limiting value of $60 \times 10^6$, and should ensure perfectly satisfactory commutation with fixed brush lead.—Yours, &c., L. J. Hunt.

Chester, March 12.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: On p. 837 of your issue of the 9th inst. Dr. Breslauer defines the output coefficient of a dynamo as the ratio of the product $d^2l$ to the watts per revolution, and gives the formula $G = d^2l/\text{watts per rev.} = 32{\cdot}4$ for the machine under consideration. The expression "watts per rev." is, however, without meaning. The watt is a unit of power or rate of doing work, and an output of 500 kw. means an expenditure of energy at the rate of 500,000 joules per second. If this output of energy per second be divided by the revolutions per second, the output per revolution is obtained in joules. Joules per revolution may also be written watts/revs. per second, or watts per rev. per second. Watts/revs. per minute or watts per rev. per minute is a smaller quantity—viz., a sixtieth of the joules per revolution. The expression "watts per rev." has, however, no definite meaning.

The relation between the output per revolution and $d^2l$ may be expressed in several ways, but I consider "output coefficient" a very misleading name to apply to the expression $d^2l$/Joules per rev. or any analogous expression, which is evidently *inversely* proportional to the output for a given $d^2l$. "Size coefficient" would be a more suitable name for the above ratio, and the term "output coefficient" should be confined to its reciprocal, which is a measure of the output for a given size of machine.

I have always found that $\dfrac{\text{kilowatts} \times 10^6}{d^2l \,.\, \text{revs. per minute}}$ gives a convenient output coefficient, lying between 2 and 3 for the size of machine under consideration, when $d$ and $l$ are expressed in centimetres.—Yours, &c. G. W. O. Howe.

Central Technical College, London, March 14.

## PHASE MEASUREMENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of February 23rd Dr. Sumpner establishes some expressions used in his explanation of the action of phasemeters which are similar to those we have employed for some time past at the Royal Naval College for the analogous purpose of determining the power factors of two or three-phase circuits by means of a wattmeter.

Suppose it is required to find the phase difference ($\phi$) between the current and E.M.F. in a synchronous or induction motor or transformer in a two-phase system. The current coil of the wattmeter is inserted in one line wire of the circuit to be tested, one terminal of the pressure (or volt) coil is connected as usual to the same wire and the other terminal in turn to the remaining line wire of the same phase and then to one wire of the second phase. If $W_1$, $W_2$ are the readings of the instruments in the two cases,

$$W_1 = E_1C_1 \cos\phi, \quad W_2 = E_2C_1 \cos(90+\phi) = -E_2C_1 \sin\phi$$
$$\text{or } E_2C_1 \cos(90-\phi) = E_2C_1 \sin\phi,$$

depending upon whether the current lags behind or leads the E.M.F., and also to which line of the second phase the coil is connected. Whence $\tan\phi = \pm\frac{W_2}{W_1}\frac{E_1}{E_2}$.

The ordinary method of determining $\cos\phi$ by dividing $W_1$ by $E_1C_1$ depends upon the accuracy of three instruments, and without constant and accurate calibration of all three can scarcely be expected to give very reliable results. The above plan involves no knowledge of the constant of any instrument if, at any rate, $E_1$ and $E_2$ are measured by the same voltmeter, and, as may be presumed, do not differ widely, if at all. In the case of the Siemens wattmeter the accuracy would depend only on the graduation of the divided circle or on the truth of the assumption that the two phases are in quadrature. The observation shows also, which $W_1/E_1C_1$ does not, whether the current leads or lags behind the E.M.F. In the one case, say a lagging current, the volt coil connections must be reversed during one reading; in the other case, say a leading current, they must not. If this is noted once for all for a case in which there is no doubt, the rule can be applied in all later observations. Obviously the volt coil can be joined to the throw-over switch generally used to connect the voltmeter to either phase. In the three-phase circuits, by a similar argument, if the current coil of the wattmeter be inserted in one line, and one end of the volt coil be inserted in that line and the other end alternately connected to the remaining line wires, then $\tan\phi = \frac{W_2 - W_1}{W_2 + W_1}\sqrt{3}$, assuming the voltage (RMS) in each line to be the same.

The results given by these methods are far more accurate, in my experience, than those obtained by the comparison of the real and apparent power as shown by the ammeters, voltmeters and wattmeters. There is also the advantage that the efficiency and power factor of a synchronous or induction motor can be obtained by the use of a single electrical instrument, the wattmeter. If these simple arrangements are well known I must apologise for troubling you, but I have not happened myself to see them described, except as they are more or less included in Dr. Sumpner's article.—Yours, &c.,

Royal Naval College, March 12. J. W. WAGHORN.

## PARLIAMENTARY INTELLIGENCE.

### LONDON COUNTY COUNCIL ELECTRIC WIRING POWERS.

Before the Court of Referees on Monday, an application was made on behalf of the Charing Cross, West End & City Electricity Supply Co,, the City of London Electric Lighting Co., the County of London Electric Supply Co., the London Electric Supply Corpn. and the South Metropolitan Electric Light & Power Co., for a locus to be heard against Part VI, of the London County Council (General Powers) Bill, which seeks to authorise London borough councils to supply electric fittings, &c. The ground of the petition was that a new competition would be set up, and that in all such cases it was the practice of the court to grant a locus. For the London County Council it was argued that the alleged new competition was only an extension of existing competition so far as the two borough councils already supplying electricity in the areas of some of the petitioners were concerned, and that the proper course for the supply companies in the remaining cases, where at present there was no competition, was to oppose any application made by the borough councils for electric lighting powers. Further, all the electric supply companies could supply fittings, &c., and the borough councils, who were electric supply undertakers, wished to be placed on equal terms.

The court granted the locus.

### THE LONDON POWER BILLS.

In a printed reply on Monday to Mr. Brodie,

Sir HENRY CAMPBELL-BANNERMAN stated that there was no intention on the part of the Government to appoint a Royal Commission to inquire into the whole question of electric supply in London.

The second reading of all the bills relating to electric power supply in London was further postponed for a week in the House of Commons last Monday.

### ROYAL COMMISSION ON LONDON TRAFFIC.

Sir HENRY CAMPBELL-BANNERMAN, in a printed reply to Mr. Remnant on Monday, stated that the Government did not propose to ignore the recommendations of the Royal Commission on London Traffic, but they were not yet in a position to express an opinion on the findings of the Commission, and, as he had already said, he could not hold out any hope of legislation on the question this session.

### MISCELLANEOUS.

**'Bus Companies and Tramway Reconstruction.**—Before the Court of Referees yesterday an application was made for a locus to be heard against the London County Council (Tramways and Improvements) Bill on behalf of the Association of Omnibus Companies of London. Mr. Lewis Coward, K.C., for the petitioners, asked for a locus on the ground of competition, and also on the ground of obstruction to the streets. The latter point arose on clause 37 of the bill, which gave the London County Council power to lay temporary rails, above the surface of the streets, during the reconstruction of existing tramways. This might cause to be necessary a temporary deviation of existing routes to the detriment of the omnibus traffic. Mr. Pollock, K.C., for the London County Council, said that if the Court granted a locus in respect of competition he would ask that it be confined to the few short lines of tramway which affected the omnibus traffic. As to the obstruction of the streets, he submitted that the local authorities were the only authorities who could object in this matter, and that the omnibus companies had no more right to oppose the bill in this way than any ordinary user of the road. This was the first time such a question had been raised, and a precedent would be created if the Court allowed the locus. The Court eventually allowed the locus on both points.

**North Metropolitan Tramways Bill.**—This bill was passed by the Unopposed Committee of the House of Commons on Monday. Its object is to dissolve and wind up the North Metropolitan Tramways Co., consequent upon the surrender of its lease to the London County Council. The transfer of the undertaking to the London County Council will take effect on April 1.

**Breakdowns on the District Railway.**—Viscount Castlereagh will ask the President of the Board of Trade on Tuesday whether his attention has been directed to the public inconvenience caused by repeated breakdowns and stoppages on the District Railway; whether he can say what these stoppages arise from, and whether he will use his influence with the company to secure the provision of plant and rolling stock which will ensure the proper running of the trains.

**Standing Orders.**—The Standing Orders Committee of the House of Commons met on Tuesday to consider several private bills which had been referred to them. In the case of the London County Council Tramways Bill it was decided to allow the bill to proceed, but that the 16 short lengths of line for which the necessary consents had not been obtained should be deleted. The Middlesex County Council Tramways Bill was also allowed to proceed. The application of the Electrical Contractors' Association for leave to bring in a late petition against Part VI. of the London County Council (General Powers) Bill was disallowed.

The National Telephone Co. was granted by the Court of Referees on Monday a locus to appear against the Hull Corporation Bill in regard to clauses relating to street widenings, on the ground that they were, technically, landowners, inasmuch as the bill in question sought to acquire lands upon which the company had both overhead and underground telephone wires.

The following bills were read a second time in the House of Lords on Thursday last week: Nottinghamshire and Derbyshire Tramways, South Lancashire Tramways, and the Preston, Chorley and Horwich Tramways.

In the House of Commons on Thursday last week the Derbyshire and Nottinghamshire Electric Power Bill and the South Wales Electrical Power Distribution Bill were read a second time. The London United Tramways Bill and the Romford and District Tramways Bill was read a first time.

The following Bills were read a second time in the House of Lords on Monday: County of Durham Electric Power Supply, Newcastle-upon-Tyne Electric Supply, Crediton Lighting and Power, and Southport and Lytham Tramroad (extension of time).

The Brixham Gas (Electric Lighting) Bill was read a second time in the House of Commons on Monday.

The Wallasey Tramways Bill was read a second time in the House of Lords on Tuesday.

The Ascot & District Gas (Electric Lighting) Bill was read a second time in the House of Commons on Wednesday.

The second reading of the Hammersmith, City & North-East London Railway Bill has been postponed until Tuesday. Mr. A. C. Morton will move the rejection of the bill.

The Nottinghamshire and Derbyshire Electric Tramways Bill is now proceeding unopposed, all opposition having been withdrawn.

# LEGAL INTELLIGENCE.

## Electrical Power Storage Co. v. Patents Exploitation (Ltd.)

On Wednesday Mr. Justice Joyce had before him this action. Plaintiffs were exclusive licensees from defendants of a patent for the manufacture of dry electric batteries, and the question was whether the licensees were entitled to share in the damages recovered from an infringer by the owner of the patent.

Mr. HUGHES, K.C., said the patent was granted on Jan. 21, 1890, and on Feb. 20, 1892, an agreement was come to between defendants (the owners of the patent) and plaintiffs, who were to have exclusive licence to manufacture under the patent on payment of certain royalties. There was a clause in the agreement with regard to protection against infringement as follows: "That the licensors hereby declare that they firmly believe the English patent to be valid, and agree to maintain the same, and the licensees hereby accept the same as valid. It is hereby agreed that if at any time in the opinion of both the parties to this agreement any third party be infringing the same, and that it is advisable to proceed against such third party, then the licensors shall allow the licensees to use the name of the licensors and of the original inventors as parties in the action, and the parties shall defray the costs of the action and share the damages, if any, in the proportion of one-third to the licensors and two-thirds to the licensees." In 1900 it was found that certain persons were infringing the patent, and defendants issued a writ against Siemens Bros. & Co. for such infringement. The action was tried before Mr. Justice Buckley, who, on Jan. 31, 1902, decided that the patent was bad on the ground of invalidity. The Court of Appeal on Dec. 20, 1902, allowed an appeal, and ordered an inquiry as to damages. Siemens Bros. & Co. went to the House of Lords, and on June 21, 1904, their appeal was dismissed. Messrs. Siemens paid £3,000 into Court in respect of the inquiry as to damages, and the question was whether plaintiffs were entitled to share in the damages and to recover a contribution made by them to the costs of the action. In correspondence between the parties plaintiffs agreed to pay £250 towards the costs, but were not to be called upon to pay a further sum, and in the event of obtaining a favourable decision, out of the amount of the costs and damages received they were to be reimbursed. Defendants accepted this, but pointed out that the agreement did not in any way refer to the Court of Appeal and House of Lords. Defendants took the view that as the case failed in the Court of first instance plaintiffs had lost the £250 and their interest in damages and costs had gone. Plaintiffs, however, contended that the proviso in defendants' letter merely prevented either party being under the obligation to go on with the case after the decision of the Chancery Court, but if the case went on, costs and damages would be divided.

After hearing Mr. Astbury, K.C., and Mr. Shaw for defendants, His LORDSHIP held that the construction put by plaintiffs on the agreement was the correct one, and that all costs must be dealt with and the ultimate residue of the damages divided in the way prescribed by the agreement.

## London Hydraulic Power Co. v. St. James' and Pall Mall Electric Light Co.

Mr. Justice FARWELL commenced on Wednesday the hearing of this action, which raised the question as to who was responsible for the mischief caused in the West End by the bursting of a water main in Piccadilly-circus on July 10 last. Plaintiffs are owners of the main and defendants were alleged to have caused the accident by constructing an inspection chamber or manhole so that it rested on the pipe and transmitted to it the vibration caused by traffic above.

Sir E. CLARKE, K.C., M.P., said that although the amount actually claimed by plaintiffs was under £200, a declaration was asked for which would affect other liabilities of a very considerable sum. Plaintiff company had about 150 miles of hydraulic mains in London, and supplied about 6,000 customers with power for lifts and other purposes. In 1888 they had a main through Piccadilly-circus, and in 1889 defendants, without informing plaintiffs, constructed a manhole or inspection chamber over the main in such a way that two of the walls, 2 ft. 6 in. in dia., rested on the pipe. It was a strong 6 in. pipe, the metal being $1\frac{1}{8}$ in. thick. The pressure at which the water entered the main was 75 lbs. per square inch, whereas it had been tested to bear a strain of 2,250 lbs. The accident happened at about 8:15 p.m. on July 10, and it was not until midnight that the escape could be located, by which time the wood paving almost as far as Pall Mall had been ripped up and other serious mischief done. Plaintiffs would prove that the breakage of the pipe was not caused by pressure of water. Defendants counterclaimed in respect of damage done to them in the matter on the ground that there was something faulty in the construction of the pipe. Defendants also alleged that a great deal of damage was due to delay in remedying the mischief after it was discovered, but he would prove that everything possible was done at the earliest moment. The damages claimed, apart from the declaration, were in in respect of relaying the main and the cost of 300,000 gallons of water that escaped.

A number of witnesses gave evidence to the effect that there was no defect in the pipe; that the bursting was not caused by excessive water pressure; and that immediately the pipe burst prompt measures were taken to stop the outflow of water and prevent further damage. Various witnesses gave it as their opinion that the two walls of the inspection chamber which rested on the defendants' main transmitted the vibration of the traffic overhead and led to the fracture of the pipe.

The plaintiffs' case had not concluded at the rising of the Court.

## Attorney-General (ex. rel. Birkenhead Corporation) v. Mersey Railway Co.

This action came before Mr. Justice Warrington last week, and raised the question whether the Railway Co., possessing the usual statutory and special powers of a railway company, was entitled to carry on, as ancillary to the general purposes of its railway undertaking, the business of omnibus proprietors, involving not only the carrying of passengers in connection with, and for the purposes of, its railway system, but also the carriage of "pick-up" passengers. The relators (Birkenhead Corporation) claimed a declaration that it was ultra vires for the company to run omnibuses between Claughton and Central station in Birkenhead and to carry passengers between those or intermediate points, &c.

After hearing legal arguments, the Judge decided in favour of plaintiffs' contention, and granted an injunction, the operation of which was suspended for a fortnight to give defendants an opportunity of appealing.

## Telephone Assessment.

In the Outer House, Edinburgh, on Thursday last, Lord Dundas gave his decision in an action of suspension and inderdict by Glasgow Corporation, as owners of the municipal telephone undertaking (situated in several parishes), against certain assessments. The Corporation alleged that the assessments were illegal, because the Parish Council had failed to make proper deductions in terms of sec. 37 of the Poor Law (Scotland) Act, 1845.

Lord DUNDAS found that the Corporation were entitled to the following deductions: (1) Repairs on underground cables, on overhead wires, &c., on subscribers' instruments, on switchboards, on tools, on poles, standards, or fixtures upon roofs of buildings, and also repairs on these roofs rendered necessary by the renewing or repairing of such poles standards or fixtures; (2) insurance against loss by fire; and (3) owners' rates. With these findings he appointed the cause to be enrolled for further procedure, and reserved all questions of expenses. His lordship said that, as to complainers' demand for deductions in respect of repairs on subscribers' instruments and on switchboards, if posts and wires were, as he was bound to assume, and did assume, lands and heritages, it would not seem to be a great stretch to include as such the wires to their ultimate extent and their terminals. It was sufficient to say that he was not at all satisfied, upon the somewhat imperfect information before him, that repairs of these instruments and switchboards were not repairs necessary to maintain the lands and heritages of which that undertaking consisted in their actual state. He therefore thought that the complainers were entitled to deductions in respect of repairs on subscribers' instruments and on switchboards. The next deduction claimed was in respect of repairs on roofs. Complainers conceded that they could not ask deduction in respect of rent or wayleave paid by them to the owner of a roof. But he pressed his claim in respect of expenditure on necessary repairs of poles and roofs. His lordship thought that a deduction ought to be allowed so far as regarded the repairs of poles, standards, or fixtures upon roofs of buildings, and also repairs on those roofs rendered necessary by renewing or repairing such poles, standards or fixtures. Parties were agreed that if his opinion in regard to the instruments and switchboards were in favour of complainers, a further deduction must be allowed in respect of their insurance against loss by fire. Complainers' counsel abandoned the claim for deductions in regard to employers' liability insurance, third party insurance and revenue insurances. His lordship pronounced findings in accordance with these views, and said that the parties had informed him that when the legal questions were decided they would be able without difficulty to adjust the necessary figures.

## Valuation Appeals.

In the Lands Valuation Appeal Court, Edinburgh, on Saturday, Lords Low and Dundas delivered judgment in the appeal of the Parish Council of Edinburgh against the valuation of the burgh assessor, which was upheld by the Burgh Valuation Appeal Court, of the electric lighting undertaking of the Corporation. Appellants contended that under sec. 13 of the Lands Valuation (Scotland) Act, 1854, the electric lighting undertaking was entered in the valuation roll at other than the just and true amount. The gross value of £45,269 should (they maintained) be increased to £79,000. Dewar-place station was valued at £12,000, appellants contending that it should be increased to £20,941; M'Donald-road station, £14,023, appellants' figure being £24,472; and the mains throughout the burgh, £19,246, appellants' contention being for £33,587.

The Court sustained the appeal to the extent of increasing the valuation to £61,923.

Lord LOW said two methods of ascertaining the amount of the valuation had been proposed. The first, which had been adopted by the assessor and approved by the magistrates, was what had been called the contractors' method, which consisted of taking as the yearly value a percentage of the cost of the various lands and heritages constituting the undertaking. The other method, for which appellants contended, consisted of taking the annual amount of the receipts of the undertaking and deducting therefrom all necessary expenditure, including interest on movable plant, floating capital and cost of collection and management. The difference between those two amounts represented, according to circumstances, either the hypothetical rent or the free surplus which was available for rent on the one hand, and tenants' profits on the other. For the purpose of ascertaining the yearly value of public undertakings such as that, there was a strong body of judicial opinion in favour of the second method, but his Lordship by no means regarded the contractor's method as having been entirely negatived. The assessor contended that his method should be accepted on the grounds that the electric light undertaking had not been in operation for a sufficiently long period to furnish a reliable basis for the revenue method, and, second, that appellants could not complain of the valuation because it was larger in amount than that which would be arrived at by a proper application of the revenue method. The former of these points appeared to his Lordship to be untenable, considering that the undertaking had been carried on for ten years, and in regard to the second point, it was sufficient to say that, in his opinion, the operation properly worked out on the revenue method gave a much larger sum than that arrived at by the assessor. Applying the revenue principle to this case, his Lordship, after allowing certain deductions for depreciation and tenants' profits, came to the conclusion that the undertaking should be entered in the roll as of the value of £61,923.

Lord DUNDAS concurred.

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Hawick Parish Council also appealed against the decision of the magistrates of the burgh adhering to the valuation by the assessor of the electricity supply works and mains of the Urban Electric Supply Co. at £800. Appellants asked that the valuation should be increased to £675 for the works and £675 for the mains, or in all £1,350. They contended that, in assessing the yearly rent or value, regard must be had to capital expenditure as well as to profits of the preceding year. The magistrates held it proved (1) that in an electrical undertaking there was a large amount of plant and machinery, both heritable and movable, which was perishable in the using; (2) that the expenditure required for keeping up and repairing such plant and machinery must vary considerably from year to year; (3) that the capital required by a tenant might be fairly estimated at the sum stated by the company (£14,378); and (4) that having regard to the gross revenue hitherto earned by the company and making reasonable allowance for such expenditure as would have to be borne by the tenant working the undertaking, the rent at which one year with another the premises in their actual state might reasonably be expected to let from year to year was at Whit Sunday, 1905, £800. The grounds of their determination were that in estimating what rent could be obtained for such an undertaking it was proper and necessary to take into account that a tenant would have to bear at least a large proportion of such expenditure on plant and machinery, both heritable and movable, and that the actual expense of repair appearing in the balance-sheets for the past two years should not, in the circumstances, be regarded as determining the expenditure required one year with another, and that in place there should be included a sum representing the estimated annual allowance for repairs and depreciations. Appellants' submission was that the company had only been working two complete years, and the profits principle did not form a reliable criterion by itself.

The Court upheld the decision of the magistrates.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT AND FILLED.

An assistant is wanted in the department of mechanics and mathematics, Central Technical College, Exhibition-road, London, S.W. Applications to Prof. Henrici. See an advertisement.

London County Council invite applications for the following Positions in their tramways department: One resident electrical superintendent (commencing salary £300, rising by two annual increments of £25 to £350); three charge engineers (salary £250 per annum). Applications, on forms to be obtained from the clerk of the Council (Mr. G. L. Gomme), County Hall, Spring-gardens, S.W., by 10 a.m. March 20.

Croydon Education committee invite applications for the chief lecturership in electrical engineering at Croydon Polytechnic for three evenings per week for a session of about 30 weeks. Payment £1 per evening. Forms of application up to March 31.

An assistant is wanted in the mathematics department of the Northern Polytechnic Institute, Holloway, London, N. Applications by 29th inst.

Oldham Corporation require an experienced canvasser for their electricity department. Applications by 17th inst.

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Mr. W. A. Kemm has resigned his position of borough electrical engineer at Battersea, and the Council have appointed Mr. Alex. P. MacAlister (formerly mains superintendent) as acting borough electrical engineer pro. tem.

Mr. T. S. Midgley, of Keighley, has been appointed junior assistant engineer at Oldham.

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**Alleged Electro-Medical Frauds.**—At Wolverhampton a man named Albert E. Richard (sometimes styled "Prof." Richard, and claiming to be a "medical electrician"), was again charged with obtaining moneys by false pretences. The prosecuting solicitor, Mr. T. P. Haslam, asked that the prisoner's bail might be increased or revoked, as numerous complaints were coming in from all parts of the country from persons who alleged that they had been defrauded by Richard. Prisoner was remanded in bail of £1,000, and two sureties of £500 each.

**Australasian Notes.**—The town clerk (Mr. T. H. Nesbitt), who was requested to report to the Sydney Electric Lighting committee on the methods of companies competing with the Council in the supply of electricity, and to make suggestions as to effective means of combating the opposition, has reported that

"The prices charged by companies are more than 40 per cent. less than those charged prior to the inauguration of the municipal supply, and that when the companies know that one of their consumers is negotiating for supply by the Council they immediately reduce their charges below those of the Council." The report goes on to say that the canvasser of the Council considers that all the business of the competing companies could be obtained if the Council would wire free of charge those places which are already wired and have a three years' agreement, would wire new buildings at the expense of the owner, would charge so much per month without meter rent and would abolish deposits. Judging from the experience of the past 12 or 15 months (the report continues), the system of quarterly accounts tends somewhat to give consumers the impression that electricity is expensive, and with small consumers it allows them to get too much in the Council's debt.

The report recommends (1) that the regulations now in force be amended so as to allow customers the option of having monthly accounts rendered; (2) that the contract system for lighting, trimming and cleaning arc lamps be approved and authorised as regards veranda arc lighting; (3) that the general principle of wiring by the Council be approved, the repayments of the outlay incurred to be made by instalments as may be agreed upon; and (4) that £2,000 be allocated for the purchase of motors, to be let on hire at rentals sufficient to recoup the Council in respect of maintenance and capital charges on the outlay, with the option of purchase on terms to be arranged.

The committee recommend the Council to adopt the report.

Mr. J. Y. Neilson, engineer of N.S.W. Postal Telegraph Department, reports that the telephone exchanges in the State increased from 22 in 1896 to 64 at the close of last year, and subscribers' lines from 3,974 to 14,260. The calls last year were 68,640,900, an increase of about 6,000,000.

The construction of the Essendon and Flemington (Victoria) tramway, for which J. G. White & Co. are supplying generating plant, is making rapid progress and will, it is expected, be working by June.

The Postmaster-General of the Commonwealth has decided to introduce a toll system of charging for new telephone subscribers.

Our Australian correspondent writes:—

Applications are being invited in the Australian Press for the position of chief electrical engineer to the Postmaster-General's department at a salary of £750 per annum, the successful applicant to be attached to the Central Office in Melbourne. It is considered probable that the position will be conferred upon Mr. Hesketh, who is at present attached to the Brisbane staff, having been head of the Queensland technical staff prior to the federation of the Australian colonies. Mr. Hesketh, who recently visited America and Europe in order to acquaint himself with the latest developments in telephony, has, since his return, been acting as general adviser to the federal postal department on all questions of telephonic improvements.

The outcome of Mr. Hesketh's recent visit to Adelaide is that it has been definitely settled to place the telephone wires of that city and its principal suburbs underground. The cost of the work, which is officially estimated at £30,000, will be spread over five years. Tenders have already been called for the supply of 2,800 six-way and 300 three-way lengths of conduit, and it is hoped that the work of laying these will be started by the end of the present month.

Hobart (Tasmania) anticipates being the first Australian town to possess a complete telephone installation of the common battery type with automatic glow-lamp signalling and clearing, as tenders have been invited for a board of this type to be erected in the new Post Office buildings. Mr. Hesketh has gone to Hobart to be present at the opening of the tenders.

Mr. J. Milward, chief electrician and inspecting officer to the Pacific Cable Board arrived in Brisbane from Vancouver on Jan. 29 on his annual visit of inspection. He expects to remain in Australia for some months, and will meet in Melbourne at the end of February Mr. C. K. Reynolds, the general manager, when alterations in the working of the Pacific cable will be discussed.

The Metropolitan Gas Co. (Melbourne) recently obtained an injunction against the Corporation to restrain them from selling electricity at differential rates. The Electrical committee advise that this decision be appealed against, and the Council having confirmed the recommendation, the case came before the Court of Appeal on Feb. 27.

Messrs. Babcock & Wilcox have offered to present a 100 H.P. water-tube boiler to the Working Men's College, of which the company's Australian manager, Mr. A. J. Arnot, was formerly a teacher and director. The offer has been gladly accepted.

An action will come before the Victorian Supreme Court in March between Ballarat Municipal Council and the local Tramway Co. upon the question of rating. The company claim that, under the terms of its constitution and legal rights, it is exempt from the payment of municipal rates upon the bulk of its undertaking.

The disastrous bush fires that have raged of late in Victorian back country have seriously interfered with the Commonwealth telegraphic service. In the south-east, especially, a great many towns have been isolated.

Mr. Austin Chapman, Postmaster-General to the Australian Commonwealth, sailed for Europe in the "Moldavia" on Feb. 21 to attend the International Postal Conference at Rome, accompanied by Mr. Justinian Oxenham, chief clerk to the Central Postal Administration. It is said that nothing definite will be done by his department in the way of calling for tenders for a Commonwealth wireless telegraph service until his return.

**Battersea (London).**—The Lighting committee reported on Monday that the chief electrical engineer (Mr. W. A. Kemm) had resigned his appointment as from March 3, and that the resignation had been accepted.

**Bexhill.**—After 31st inst. the charge for electric current will be 5½d. per unit with a sliding scale of discounts.

**Birkenhead.**—On Wednesday the Council adopted the proposals of the Electricity committee for an extension of plant at the electricity station, &c., at a cost of £11,896. Besides a new steam dynamo and condensing plant, two new water-tube boilers are to be added.

**Blackrock (Co. Dublin).**—Messrs. Tomlinson and Mills, Dublin, who are promoting a scheme for supplying electricity in Blackrock, Kingston and Dalkey, and also for constructing an electric tramway from Blackrock to Enniskerry, have asked for the Council support and offer to pay £150 for the Council's order. Consideration of the matter has been deferred.

**Boston.**—The Council last week received an intimation that the Board of Trade intend to authorise the National Provincial Electricity Corpn. to supply electricity in Boston. The Council approved the terms of an agreement with the company, which provides for the right of the Council to purchase the undertaking after 21 years.

**Bournemouth.**—The salary of the assistant borough electrical engineer (Mr. H. G. Andrews) has been increased to £175 per annum, with a further increase of £25 in 12 months.

**Bury St. Edmunds.**—On Tuesday the Council instructed the Electric Supply committee to report as to what improvements can be made in the public lighting.

**Cannock.**—The Council have transferred their electric lighting order to the Shropshire, Staffs. & Worcestershire Electric Supply Co., who will pay the Council £575.

**Cheltenham.**—It has been decided to adopt a revised system of charging for electric current—viz., 5½d. per unit for the first 125 hours' maximum demand per quarter, 4d. per unit for the next 125 hours and 2d. per unit for all additional current, with 5 per cent. discount. For power a flat rate of 2d. will be charged.

The chairman of the Electric Lighting committee (Mr. Ley Wood) said the present system of rebates was involved; nobody understood it, and some customers imagined that they were being swindled. The electrical engineer (Mr. W. J. Bache) had devised the new system of charging, and it was intended to issue circulars showing how customers could read their meters, so that they would know at the end of every quarter what they had to pay.

The minutes were approved.

**Chiswick.**—At an inquiry recently held into the application of the Council to borrow £557 for extending the electric lighting mains, it was stated that on the first year's working, after paying interest and sinking fund, the profit was £18. 3s. 11d. At Dec., 1904, the equivalent of 6,071 8 c.p. lamps were connected, but by Dec., 1905, the figure was 14,272. At the end of Feb., 1906, this number had increased to 15,378.

**Coventry.**—At the Corporation meeting on Tuesday the Electric Lighting committee recommended that application be made for sanction to a further loan of £35,000 for extensions of the electricity generating plant, mains, &c.

The chairman (Ald. West) said the estimated revenue this year was £18,634, against £13,100 in 1904-5. With such a satisfactory increase extensions were absolutely necessary. The committee asked for the smallest amount possible, and were unanimous in their recommendation. The present year's working would show a net profit, after paying interest and sinking fund, of £2,000.

An amendment, postponing the matter until full information as to the financial position of the undertaking is available, was carried by 25 votes to 12.

**Crewe.**—The salary of the borough electrical engineer (Mr. H. H. Denton) has been increased to £275 per annum.

**Devonport.**—The salary of the borough electrical engineer (Mr. J. W. Spark) has been increased from £275 to £300, and that of the assistant engineer (Mr. W. J. Stamp) from £140 to £150 per annum.

**Doncaster.**—The L.G. Board have approved a scheme of main sewerage and sewage disposal for Bentley-with-Arksey, Doncaster, and the contract for the work has been let to G. Mackay & Son, Edinburg.h It is proposed to pump the sewage from a small storage tank by means of centrifugal pumps actuated by electric motors. A central generating station is to be erected at the disposal works near Bentley, from which cables will be laid to the three pumping stations. To deal with the night flow power will be obtained from a storage battery. The motors at each pumping station will be started and stopped by floats automatically operating the switches, so that the whole pumping plant will be worked from the central station. The sewage will be delivered at the disposal works and treated in bacterial tanks and filters with final treatment over land. The works have been designed by D. Balfour & Son, consulting engineers, London and Newcastle-on-Tyne, and the contract was let at a sum below the engineers' estimate.

**Durham.**—An extension until Oct. 4, 1906, for completing the works under the Durham and District Light Railways Order has been applied for by the British Electric Traction Co.

**East Ham.**—An inquiry was held on Tuesday into the application of the Council for sanction to borrow £18,750 for electric lighting extensions.

The deputy town clerk (Mr. E. Wilson) and the borough treasurer (Mr. G. H. Fry) having given figures as to population, assessable value, &c., the borough electrical engineer (Mr. W. C. Ullmann) detailed the progress of the electricity undertaking, which was started in 1901. By March, 1902, a loss had been incurred of £1,293. 12s. 8d. In the following 12 months' working there was a loss of £809. 2s. 10d., but for the next two years the net profit was £908. 12s. 10d. and £2,830. 17s. 8d. respectively.

The inspector (Mr. H. Ross Hooper) commented on the fact that the average cost of connections to private houses was the highest he had known, namely, £9. There were towns, he said, where such connections cost less than £3, and the highest he had before met with was £6. 7s. 6d. average cost.

**Edinburgh**—The Electric Lighting committee offer to lay mains and to supply electric current for lighting the common stairs with 5 c.p. lamps on the same terms as gas lighting is at present supplied, 20s. per lamp per annum.

**Electrolytic Refining of Lead.**—The process adopted by Locke, Blackett & Co., Newcastle-on-Tyne, for the refining of lead is not the Heroult process, as stated in our issue of 2nd inst., but the Betts system, which has been patented by Mr. A. G. Betts, of Troy, N.Y.

**Exhibitions.**—There will be nearly 300 individual firms exhibiting at Cordingley's Motor Car Exhibition at the Agricultural Hall, London, which opens on 24th inst. Many new vehicles will be on view.

The Electro-Technical Exhibition which was to have been held from March 25 to April 7, 1906, at Kieff, Russia, has been postponed until April, 1907, the congress of electro-technical engineers, which it was intended to hold during the run of the exhibition, being likewise postponed.

Mr. Kerr, borough electrical engineer and manager of the electricity department at Hereford, is organising a small exhibition of electric light fittings, cooking and heating appliances, &c.

**Felixstowe.**—The Council last week considered a report by the Finance Committee recommending the payment of £3,000 (balance of purchase money) to the Suffolk Electricity Supply Co. in settle- of their claim for the balance of purchase money of their electricity undertaking. The committee were advised by Mr. Vesey Knox and by Messrs. Deloitte, Plender, Griffiths & Co. that they could not resist the claim, and it was decided to apply for sanction to borrow the money.

**Folkestone.**—On Wednesday the Council decided to approve the electric tramway scheme of the National Electric Construction Co., provided the company pay the Council £15,000 on Royal assent being given to the company's bill now before Parliament.

**Fulham (London).**—The Council on Wednesday voted a gratuity of £50 to Mr. A. J. Fuller, the borough electrical and consulting engineer, by way of recognition of special services rendered in connection with the management and extension of the Council's electricity undertaking.

Three thoroughfares are to be lighted by incandescent electric lamps at an estimated cost of £113. 17s.

**Henley.**—The Corporation have assented to the application of the Mutual Electricity Supply Co. for a provisional electric lighting order.

**Hoddesdon (Herts.)**—The Board of Trade have deferred until December the question of revoking the Council's Electric Lighting Order, 1901.

**Hucknall Torkard.**—The Council decided on Monday to apply to the Board of Trade for an extension of time for complying with their provisional order, 1902, and to approach the Derbyshire & Nottinghamshire Electric Power Co. as to their giving a supply in the district.

**Kearsley (Lancs.)**—The proposal to transfer the Council's provisional order to Messrs. Foote & Milne has fallen through, as the Board of Trade regard the transfer as ultra vires.

**Leicester.**—At Tuesday's Council meeting, Councillor Edwards (chairman of the Gas and Electric Lighting committee) said the outstanding capital of the department was £218,934.

The half-year's expenses were £6,826. Sales of current produced £17,194, an increase of £1,198; meter rents, £720, and the profit from the fitting department was £101, total £1,806, leaving a balance of £11,337. Interest charges came to £3,734, and sinking fund to £3,343, leaving a profit for the half-year of £4,259, which added to profit in hand (£14,515) made £18,774. The committee had spent out of profits £16,300 in new machinery, leaving a balance of £1,801, which would be absorbed in the purchase of three new boilers. The past half-year was the best the department had had,

The accounts were approved, and the committee's recommendation to abolish the meter rents was adopted.

Councillor Edwards said that this step would cost the department something like £1,400 per annum. The reason for asking for the abolition of those rents was that they had at last found a more reliable, a cheaper, and better meter than they had hitherto been able to use—a meter that would be more satisfactory to the department, and also to consumers. The committee recognised that it was an illogical position to retain meter rents for electricity supply after abolishing the rents for gas meters.

**Leyton.**—An inquiry has been held into the application of the Council for permission to borrow £21,000 for extensions of the generating plant at the electricity works to provide electrical energy for the tramways. There was no opposition.

**Light Railways.**—The Bath & Lansdown Light Railways Order has been submitted to the Board of Trade for confirmation. Objections by 28th inst.

**Lisbon.**—The Anglo-Portuguese Telephone Co. has received advices from Lisbon that its new telephone cable has been laid across the Tagus and is a complete success.

**Liverpool.**—The report of the Board of Trade inspector (Col. von Donop) on the recent tramway accident was referred to at the Council meeting on Wednesday.

The report stated that the brakes when tested, both before and after the accident, were found to be in working order. The driver appeared to have entirely lost his head, as neither the hand brake nor the electric brake was being applied to the car as it ran down the hill, so it was not surprising that it attained a high rate of speed. The derailment of the car was doubtless facilitated by the want of super-elevation of the outer rail of the curve and the fact that there was a rush of passengers to the rear end of the car, their weight tending to lift the front wheels off the rails. The hill on which the accident occurred had a maximum gradient of 1 in 17·5. The hand and electric brakes with which the car was provided should have amply sufficed to keep the car well under control when negotiating such a gradient. If the braking power provided on these cars were in good order, as appeared to have been the case on that occasion, only ordinary care would be required to prevent such an occurrence. The report concluded by recommending the Corporation to consider whether the roadway at the junction of Leece-street and Renshaw-street, where the accident hpppened, could not be rearranged so as to provide suitable super-elevation of the outer rail on the curve at that point.

The Tramways and Electric Power committee reported to the Council against the running of motor omnibuses.

**London County Council.**—At Tuesday's meeting it was agreed to loan Stepney £10,000 for electric lighting.

*Highways Committee.*—The Highways Committee for the next twelve months was chosen as follows: Sir R. M. Beachcroft, Sir H. W. Bliss, Capt. Hemphill, Messrs. J. Allan Baker, J. Williams Benn, E. Browne, J. W. Cleland, N. W. Hubbard, W. C. Johnson, I. H. Mitchell, R. C. Phillimore, W. W. Thompson, D. S. Waterlow, T. Wiles and T. McKinnon Wood.

*Electromagnetic Brakes.*—The Highways committee brought up their adjourned report recommending that £10,200 be expended in equipping some additional 170 tramcars with electromagnetic brakes.—Agreed.

*New Sub-station.*—Consideration of a recommendation of the same committee that £10,000 be authorised for a sub-station for the north of the Thames tramways, to be erected on a site in Gray's Inn-road belonging to the Council, was postponed.

*Supply of Power.*—It was reported that the arrangement with the South London Electric Supply Corpn. for a supply of power for the Council's tramways would expire on May 15, and it was recommended that the arrangement be continued, on a sliding scale of charges based upon the output, the minimum price being 0·75d. per unit and the maximum 1·25d. a unit, the agreement to be terminable upon one month's notice on either side.

**Macclesfield** —The Corporation have decided not to proceed with the municipal electricity scheme.

**Maidstone.**—The Council have decided to open showrooms for the display of electric light fittings, cooking and heating appliances, &c.

Mr. O. Jones has been appointed part time canvasser to Maidstone Electricity department at 25s. per week and 6d. per lamp obtained, or 5d. per lamp in "free" wiring cases.

**Maldens and Coombe.**—After consideration of a report by the Parliamentary committee on electric lighting, the Council have decided to engage an electrical engineer at a fee not to exceed 30 guineas to report upon the comparative advantages of taking current in bulk from a neighbouring local authority or a company and of establishing municipal electricity works.

**Manchester.**—The Tramways committee have passed a resolution expressing regret at the resignation of the chairman (Mr. D. Boyle) and appreciation of the many valuable services rendered by him. A special meeting of the committee is to be called for the election of a successor.

The committee have drawn a cheque for £46,000 as a contribution from the Tramways department in aid of the city rates for the financial year ending March. In addition the Tramways department also provides £4,000 towards interest and sinking fund of the infirmary purchase account.

**Marseilles.**—Mr. Consul-General Gurney, in a report on the trade of Marseilles for 1905, states that the coal trade of Marseilles is likely to be seriously affected by the lighting of the city by electricity. There are two companies competing for this business, whose operations began in January of this year and will by the end of the year be in complete working. As soon as the work of construction and supply is complete it is anticipated that factories, of which there are a large number in the Marseilles district, will be worked by electric power.

**Marylebone (London).**—To enable the coal for the generating station to be economically and conveniently conveyed and handled, and for the ash to be removed, a lay-by is to be constructed on the bank of the Regent's Canal, and the canal is to be widened at the site.

The Council are to be permitted to use the canal water for condensing purposes for plant up to 3,000 H.P., paying an annual rent of £250 for same, also to guarantee the Regent's Canal Co. an annual traffic of not less than 6,000 tons. If the traffic exceeds 6,000 tons the permissible horse-power is to be increased pro rata without any increased payment. The agreement is to be for a minimum of seven years, with option to continue same for similar period. In connection with the foregoing, coal-handling plant is to be obtained at a cost, in addition to £2,114 already sanctioned, of £1,703. The work is to carried out by Babcock & Wilcox.

The Finance committee report that it will be necessary to take up the balance (£44,850) of the loan of £433,800 for the electricity undertaking from London County Council.

**Municipal Telephony.**—We have received from Glasgow Corporation telephone department a copy of the Municipal Telephone Directory for 1906. The new edition is much bulkier than the last issue, and we calculate that there are nearly 12,000 subscribers' names in the 1906 issue.

**Overhead Telephone Wires and Commons Preservation.**—In connection with the erection of a new Post Office telephone trunk line from London to Portsmouth, part of the route was originally intended to be over the summit of Hindhead and round the edge of the Devil's Punch Bowl, a spot of considerable natural beauty, which was acquired at the sale of the late Mr. Whitaker Wright's property for preservation as a public open space. Upon being requested to refrain from using this site for telephone poles the Postmaster-General has arranged with the L. & S. W. Railway Co. to carry the line along the railway, the company agreeing to waive, in this case, their right to maintain telephone lines erected on their property.

**Oxford.**—The Council have appointed a committee of 15 to consider and report upon the best method of utilising the City of Oxford & District Tramway Co.'s undertaking. The National Electric Construction Co. are prepared to enter into negotiations for the conversion of the lines to electric traction on the Dolter surface contact system.

**Pembroke (Dublin).**—The Council decided on Monday to apply for a further loan of £3,000 for electric lighting extensions.

**Portslade (Sussex).**—The Council decided on Tuesday to allow the joint committee on electricity supply to expend 20 guineas in getting expert opinion on the adoption of a flat rate of charging for electrical energy by Brighton Corporation.

**Presentation.**—Mr. W. Jensen, manager and engineer of the Chetham & District Light Railway Co, has, on the occasion of his silver wedding been presented by the staff and employés with a silver tea and coffee service and a flower and fruit stand in cut glass and silver.

**Railway Electrification.**—The Lancashire & Yorkshire Railway Co. propose to undertake the electrification of the line from Marsh-lane to Aintree, and to erect two additional stations to tap the traffic between these points. A further development will be the coupling of the Liverpool Overhead line with the Lancashire & Yorkshire Railway at Marsh-lane by a junction corresponding to the one recently formed at Seaforth.

**Rand Power Schemes.**—At the meeting of the Vereeniging Estates (Ltd.) on Monday the chairman (Mr. J. N. de Jongh) referred to the projected power schemes for supplying the mines and other consumers of power on the Witwatersrand and elsewhere with electricity for use in the mines and otherwise. Various localities had been indicated, but not one of them was so favourably situated as their estate, or where there were so many advantages of coal, water, &c., so well placed close together. The Government had been approached in regard to the required way-leave, and a powerful syndicate, which would be prepared to find the required capital, had been formed. Two of their expert advisers left Europe on the 27th of last month, and were now on their way to the estate. They would make the necessary investigations, and the completion of this scheme would enable very considerable economies to be effected in capital outlay and in working costs of the mines of the

Transvaal. In their case it would find a suitable outlet for large quantities of coal produced in their mines, and would add largely to the value of their property.

**Salford.**—Last week the Corporation were recommended by the Electricity committee to increase the salary of the borough electrical engineer (Mr. C. D. Taite) from £700 to £800 per annum.

In support of the recommendation the chairman of the Electricity committee (Councillor Hodgson) said that when the committee undertook to provide electrical energy for the tramways they had some difficulty in securing an engineer. Ultimately they appointed Mr. Taite. He had now been with them five years, and was receiving the same salary as when he commenced his duties. During those five years the work had increased, and it had now come to be a profitable trading department. The staff under Mr. Taite's charge had largely increased. They had got a thoroughly capable man, not only technically but commercially, and they felt that in the electricity undertaking they must have at the head of affairs a thorough expert.

A discussion followed, and, although several members (including Councillor McDougall and Ald. Snape) testified to the great ability of, and the eminent services rendered by, Mr. Taite as well as the advance made by the electricity undertaking while under his control, the recommendation was referred back by 23 votes to 19.

The salary of the chief clerk of the electricity department (Mr. H. M. Crossfield) was increased from £175 to £187. 10s.

On Wednesday the Corporation decided, on the recommendation of the Electricity committee, to apply for sanction to borrow £7,720 for a new turbo-generator and condensing plant at the Frederick-road generating station. It was also decided to spend £1,488 on automatic tramway point controllers to replace the point boys now engaged.

**Sheffield.**—The special committee recently appointed to consider the cost of generating electrical energy at the electric lighting and tramway stations, &c., recommend that Sir Wm. Preece be retained (at a fee not exceeding 100 guineas) to prepare a report upon the desirability of combining the Corporation stations for the generation of electric energy for all purposes, and also as to the utilisation of the waste heat from the refuse destructors in raising steam for generating electricity.

**Stockport.**—The borough electrical engineer (Mr. A. J. Carter) has been granted six months' leave, owing to ill-health. The council have decided not to take over from Cheadle Council the Cheadle and Gatley Electric Lighting Order, 1900.

**Swindon.**—The salary of the electrical engineer (Mr. J. G. Griffin) has been increased to £325, and that of the tramway traffic manager (Mr. T. Medcalf) to £160 per annum.

At the Council meeting last week the chairman of the Electricity and Tramways committee (Mr. Thomas) referred to a statement by the chairman of the Swindon United Gas Co. that a number of consumers who had adopted electric lighting were reverting to gas, but that statement was denied by their electrical engineer. Three people had reverted to gas, not because they were dissatisfied with the light, but entirely in consequence of the heat provided by gas for their shops. During 12 months the electricity consumers had increased by 47 per cent., and power consumers by 80 per cent.

**Tiverton.**—The L.G. Board have refused to sanction a loan of £13,000 for municipal electricity supply.

The Tiverton provisional order was granted to the Council in 1890, and after many debates a provisional agreement was entered into with Frank Suter & Co. for equipping electricity works and maintaining them for a period.

**Turbine Patent Litigation in America.**—The Westinghouse Machine Co., Pittsburg, has commenced proceedings against the Allis-Chalmers Co., Milwaukee, Wis., for alleged infringement of patents. The Westinghouse Co. alleges that the turbine made by the Allis-Chalmers Co. incorporates patented improvements of the Westinghouse machine. The Allis-Chalmers Co. answer that they have acquired all the American patents of the Parsons steam turbine except those granted prior to Sept. 11, 1900, which, they urge, constitute the only Parsons rights purchased by the Westinghouse Co., none of which the Allis Chalmers Co. has included in its turbines.

**Warrington.**—An unopposed inquiry was held here on Wednesday into the application of the Corporation for permission to borrow £10,000 for electric lighting extensions. The assistant town clerk (Mr. T. H. Spinks) said the Electricity committee decided on Tuesday to reduce the application to £7,000. The borough electrical engineer (Mr. F. V. L. Mathias) said that £1,400 was required for services and meters and £5,600 for mains.

**West Ham.**—The Corporation on Tuesday had before them a report by the borough electrical engineer (Mr. A. Hugh Seabrook) on the question of increasing the output of electric energy.

In this report Mr. Seabrook says that a large and profitable revenue could be derived by enabling consumers to obtain arc lamps and other apparatus on the hire-purchase system, but great care is necessary in selecting consumers who might be dealt with under that system. The arrangement he proposed was different to the old "free" wiring system in vogue in the borough in the early days of electricity supply. Briefly, the scheme was as follows: 15 per cent. was added to cost (including charge for fixing the lamps, apparatus, wiring, &c.); the consumer would pay 25 per cent. of the total cost down and the balance in two years, in monthly instalments. For consumers wishing to extend payments over three years 20 per cent. would be added to the first cost instead of 15 per cent. Consumers wishing to purchase outright could do so at any time, and of course that feature would be encouraged. Before supplying any consumer under this arrangement the Corporation could, if considered necessary, require a security or a deposit in cash. The fact that the consumer had paid a deposit of 25 per cent. would get over many of the drawbacks of the old system. The Corporation have powers to hire out electrical fittings and apparatus, and Mr. Seabrook urges that those powers should be turned to good account. He felt that an arrangement on those lines would have good results, and no time should be lost in putting it into effect. Provided the Corporation retained full control as to the selection of consumers, and as to the wiring contractors to be employed to do the work, no abuses could creep in.

The report was generally approved.

**Whitby.**—At last week's Council meeting Mr. H. Walker proposed that application be made for permission to consolidate and reborrow the electric lighting loans for 40 years. He said there was a tendency on the part of many to shift the burden of debt as largely as possible on to posterity, and he thought that in his resolution he was acting with fairness to the present generation. The resolution was passed.

Mr. Walker also proposed that the salary of the electrical engineer (Mr. L. H. King) be increased to £175, but an amendment to defer the question "until such time as the undertaking justified an increase" was carried.

The Council decided to apply for sanction to an excess loan of £456 in respect of additional plant.

**Will.**—The value of the estate of Sir Robert George Wyndham Herbert, late chairman of the Telegraph Construction & Maintenance Co., who died on May 6, 1905, has been entered at £39,897.

**Wolverhampton.**—At the meeting of the Council on Monday the Finance committee's estimates for the year were presented. The chairman of the committee (Ald. Johnson) said that the Electricity department had contributed a sum equivalent to 1d. rate to the relief of the rates. That was the first time they had been able to do this.

**York.**—The Electricity committee have received the report of the consulting engineer (Mr. Hutchinson) on the recent accident to the plant at the electricity works, and the committee announce that they consider it necessary to appoint a works superintendent at £150 per annum, and also an additional engine driver.

**Dinners, &c.**—The P. & O. Batti-Wallahs Society, which has recently been formed with the object of promoting social intercourse between past and present electricians of the P. & O. Co., held their first annual dinner on Saturday last. The chair was occupied by Mr. Lawrence M. Waterhouse, who was unanimously elected first president of society, with Mr. E. Lawley Pinching as vice-president.

After the usual loyal toasts, the success of the P. & O. S. N. Co. was proposed by the Vice-President and responded to by Mr. R. J. Elmhirst, who, in the course of some interesting remarks, traced the rapid advance which the use of electricity has made on board ship, stating that on the newest boats as much as 1,000 amperes are used for power and almost as much again for lighting.

"Success to the Society" was proposed by Mr. Chambers, who said that old P. & O. Batti-Wallahs were to be found in almost every large central station throughout the country; and their hon. secretary (Mr. E. Sheppard), in his reply, thanked the electrical journals for the cordial help it had extended to the society in bringing the doings of the committee before members who had been lost sight of since leaving the service.

Mr. W. Riggs proposed the visitors, and Mr. N. E. Bevis replied.

Mr. T. B. Joseph proposed the health of the chairman and committee, and thanked them for the work they had done in bringing the members of the society together.

Mr. Waterhouse, in reply, said it was proposed to arrange a trip up the river in the summer, in addition to the annual dinner. The proposal was agreed to by all the members present.

The musical programme, contributed by those present, was carried through with success.

The annual supper and dance of Greenock Corporation electricity department staff took place on Thursday evening last. The borough electrical engineer (Mr. J. A. Robertson) was in the chair, supported by Messrs. W. A. Toppin and D. M‘Lellan. Amongst those present were Provost Denholm, Treasurer Neil M. Brown, Mr. Colin MacCulloch, town clerk; Provost Campbell, Port Glasgow; Bailie J. W. Bailey, Mr. D. M‘Murrich, &c.

Mr. M‘Murrich submitted the toast of "The Electricity Committee," and Treasurer Brown, in replying, made a statement regarding the extraordinary progress in the use of electricity in Greenock since the opening of the works in Nov., 1899. The output of electricity during the first 13 months was 157,000 units, the original capital expended being under £40,000. Two years ago the output for private use had reached over 500,000 units, and they were also selling about 750,000 units to the Tramway Co. The progress during the past two years had, however, beaten all previous records, and it was estimated that during the current year the total output from the works would reach 2,500,000 units—1,500,000 units for power and lighting by private consumers. The capital expenditure had increased from £40,000 to over £100,000. The space available on the original site was limited, and, after considering the question of purchasing the adjoining property, it had been decided to erect a second station principally for the production of current for power, and also a refuse destructor.

Bailie J. W. Bailey proposed the "The Works Staff," and the Chairman, replying, said that during the six years the department had been in existence there had been nothing in the nature of a hitch, and there had been complete immunity from accident to machinery or plant. Mr. Robertson claimed that, to some extent, the department had raised the standard of material and workmanship and discouraged the employment of those who traded on the ignorance of the public in matters electrical.

The annual smoking concert of Leeds City electric lighting department athletic club was held on Saturday evening and proved a great success. The city electrical engineer (Mr. H. Dickinson) presided over a large company of members and friends.

# TRADE NOTES AND NOTICES.

## NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1906 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is even more complete and accurate than in previous issues, and has been revised up to Feb. 12, 1906. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Traders' purposes. The valuable large sheet Tables, &c., have been very carefully revised and extended, making the 1906 Edition of this indispensable work the most complete book of the kind ever published.

A full Digest of Contents will be sent post free on request.

## TENDERS INVITED.

*Bolton* Electricity committee invite tenders for one continuous current electric generator, and also for one steam engine, complete. Specifications, &c., of the borough electrical engineer (Mr. Arthur A. Day), Spa-road, Bolton. Tenders (addressed to the chairman of the Electricity committee, Town Hall, Bolton) to the town clerk (Mr. Samuel Parker) by noon March 29. See also advertisements.

*Walsall* Corporation invite tenders for a 500 H.P. high-speed steam engine, a 350 kw. high-pressure continuous-current dynamo, and high-pressure feeder cables, low-tension distributors and pilot wires. Specifications from borough electrical engineer (Mr. Alex. Wyllie), Wolverhampton-street, Walsall. Tenders to the town clerk (Mr. John R. Cooper) by March 30. See also an advertisement.

*London* County Council invite tenders for the manufacture and erection of three low-tension feeder switchboards for tramway substations. Drawings may be inspected and forms of tender, &c., obtained at County Hall, Spring-gardens, S.W., where tenders must be delivered, addressed to the Clerk of the Council, by 10 a.m. of 27th inst. See also advertisement.

*London* County Council require tenders by 10 a.m. 27th inst. for supply of eleven 500 kw. and three 50 kw. induction motor-generators for tramway sub-stations. Forms of tender from County Hall, Spring Gardens, S.W.

*London* County Council also require tenders by 10 a.m. 27th inst. for about 65,000 tons of coal for the tramways generating station, East Greenwich.

*London* County Council also want tenders by 10 a.m. 20th inst. for seven electrically-operated car traversers.

The Asylums committee of *London County Council* invite tenders for the installation of electric lighting and power (including generating plant) at Long Grove Asylum, Epsom. Tenders to 6, Waterloo-place, London, S.W., by March 26.

*Leeds* Electricity committee invite tenders for one or two sets of electric generating and condensing plant, each comprising a steam turbine, two-phase alternator and exciter of 3,000 kw. capacity, electrically-driven surface-condensing plant, and the necessary pipes and valves. Preference will be given to tenders for plant of British manufacture. Tenders to town clerk (Mr. Robert E. Fox) by 10 a.m. April 9.

*Sunderland* Corporation invite tenders for supply of one 750 kw. triple-expansion engine, direct-coupled to three-phase generator (5,000 volts), with exciter; one 300 kw. static transformer, and two portable air compressors. Tenders (addressed to the chairman of the Electricity and Lighting committee) to the town clerk (Mr. Fras. M. Bowey), by noon March 30.

*Briton Ferry* Urban District Council invite tenders for supply, delivery, erection and laying of sub-station switchboard, non-rubber feeder and distributor cables, feeder pillars, joint boxes, arc standards, arc lamps, &c. Tenders to the clerk (Mr. Trevor H. Hunter), Council Offices, Briton Ferry, Glam., by noon March 26.

*West Bromwich* Corporation invite tenders for supply, delivery and erection of (*a*) one 400 kw. turbo generator, (*b*) alterations and additions to exhaust pipes. Tenders to chairman of Electric Light and Power committee by noon March 19.

*Willesden* Urban District Council invite tenders for supply and delivery of 66 "flame" arc lamps for street lighting. Tenders to Mr. J. G. Bruce, Electricity Office, Salusbury-road, Kilburn, N.W., by 5 p.m. March 22.

*Norwich* Corporation invite tenders for rubber-covered wires and accessories, underground cables and incandescent lamps. Tenders to Chairman of Electricity committee by 10 a.m. March 19.

*Belfast* Tramways and Electricity committee invite tenders for one 400 kw. steam dynamo. Tenders to Sir Samuel Black, Town Hall, Belfast, by 11 a.m. March 19.

*Aston Manor* Corporation want tenders by noon 20th inst. for brickwork, boiler setting, stanchions and girders, &c., in connection with the extension of electricity works.

*Plymouth* Corporation want tenders by 5 p.m. 22nd inst. for alterations of and additions to Armada-street electricity sub-station. Forms of tender from borough engineer and surveyor.

*Glasgow* Tramways committee require tenders by 10 a.m. April 4 for 12 months' supply of stores, &c., including carbons and carbon brushes, cables, ironmongery, paints, oils, &c.

*Chester* Corporation want tenders by 31st inst. for permanent way construction, bonding and overhead equipment of tramways.

*Perth* (*N.B.*) Corporation want tenders by noon 26th inst. for supply of about 3,000 tons of small coal to the electricity works.

Tenders are invited for the supply of material for the electric lighting of the town of *Couvin*, Belgium. Particulars from the Secrétariat Communal, Couvin, Namur, Belgium, to which address tenders by April 19.

## TENDERS RECEIVED AND ACCEPTED.

Battersea (London) Council have accepted the following tenders for annual supplies for the electricity undertaking:—

A. Duckham & Co., lubricating oils; Middleton Bros., engine room stores, except oils; Charrington, Sells, Dale & Co., coals; Geipel & Lange, arc lamp carbons; Electrical Co., electricity meters; Callender's Co., service joint boxes, cables, &c., provided the company undertakes to maintain the whole of the cables supplied by them for a further year; T. Rowatt & Sons, arc lamp globes.

Marylebone (London) Council have accepted the tender of Babcock & Wilcox for ash conveyor and motor equipment at £1,118. The Electrical Power Storage Co., is to enter into an agreement for maintenance of the two storage batteries at Rathbone-place and Manchester-square sub-stations for 10 years, in consideration for which they are to receive £600 and an annual payment of £784, being 6¼ per cent. of the cost of the batteries.

The following tenders have been accepted by Grimsby Corporation:—Brush Co., engine and dynamo, £2,410, and condensing plant, £907; Stirling Boiler Co., boiler and stokers, £1,428; Johnson & Phillips, extension of switchboard, £265, and supply of cables, £1,265; John Wilson & Co., pipework, &c., £748. 11s.; Chain Belt Engineering Co., coal conveyor, £243; — Gilbert, extension of building, £1,570.

The Electric Lighting & Traction Co. of Australia have placed an order with Witting, Eborall & Co. for two 115 kw. motor-generator sets, converting from low-pressure continuous current to single-phase high-pressure alternating current, these to be used in connection with extensions being carried out by the Adelaide Electric Supply Co.

Sunderland Electricity Committee have accepted the following tenders:—Bruce Peebles & Co., a fourth motor-generator for the Pallion sub-station; the Electrical Co., for switchboard extension at the same station; and J. W. White for extension of the Hylton-road station.

The Stirling Boiler Co., Motherwell, N.B., have received a repeat order from the Newcastle & District Electric Lighting Co. for two Stirling boilers, each of 5,770 sq. ft. heating surface, and fitted with chain grate stokers and superheaters of the Stirling Co.'s manufacture.

Poole Council have accepted the tender of the Brush Co. for the construction of tramways at £26,167. 18s 3d. The following also tendered: W. T. Glover & Co., George Holloway, J. Moran & Sons, British Electric Equipment Co, William Griffiths & Co., J. G. White & Co., Smith & Co., Dick, Kerr & Co. and George Law.

Fulham (London) Council have accepted the tender of Aiton & Co. for water and exhaust piping at £1,379. 14s. in place of that of Clapham Bros. at £1,284. 6s. originally accepted. The latter firm made a mistake of £216. 6s. in their tender.

Battersea (London) Council have accepted the tender of Reavell & Co. for an air compressor at £89. 2s., and the contract with the Electrical Co. for the supply of Nernst lamps and globes, burners, &c., has been renewed for one year.

The Postmaster-General's Department (Brisbane) have placed orders with the British Insulated & Helsby Cables for McIntyre sleeves, copper binders, wire and copper tapes; Webster & Co., for Acme insulators; and Geo. Wills & Co., for phospor bronze wire.

The tender of the Triumph Stoker (Ltd.), of London and Leeds, has been accepted by Sunderland Corporation for mechanical stokers for the four new Galloway boilers for the Hylton-road electricity works.

Marylebone (London) Council have placed a contract with Babcock & Wilcox for coal-handling plant, &c, for the electricity department.

Liverpool Corporation have accepted the tender of Johnson & Phillips for 12 months' supply of electric cables and wires.

The London & South-Western Railway have placed with Johnson & Phillips a contract for six months' supply of cables and wires.

Bristol Electrical committee have accepted the tender of Siemens Bros. & Co. for extra high-tension cables at £7,887.

Cardiff Asylums committee have let the contract for wiring the new asylum at Whitchurch to A. G. Arnold & Co. at £6,334.

Faversham Council have accepted the tender of Jabez Smith for the supply of electric lamps for the market.

Cheltenham Council have accepted the tender of Danks Limited, for a superheater at £85.

Canterbury Corporation have placed an order with Siemens Bros. & Co. for a 7 H.P. motor at £41. 10s. 9d.

Manchester Corporation have accepted the tender of the Gamewell Fire Alarm Co. for the installation of fire alarms at £13,870.

Colchester Corporation have placed an order with Dick, Kerr & Co. for two additional tramcars at £550. 14s. each.

Gillingham Council have placed an order with W. H Willcox & Co. for oil for the ensuing year.

Chascomus (Argentina) Municipality have accepted the tender of the Cia Obras Publicas del Rio de la Plata (the only tender received) for the electric lighting of the town at $27.50 m./n. per 8 ampere lamp (all night) per month and $20.30 per 4 ampere lamp.

**Electric Power in Cotton Mills.**—Witting, Eborall & Co. have supplied to Greaves Cotton & Co., of Bombay, the equipment for five cotton spinning mills, including generating plant and switchboards, together with all lighting fittings and accessories. The company are, further, shipping a considerable quantity of material to the above firm in connection with the same class of work.

## BUSINESS NOTICES.

The London offices of the Rhodes Electrical Mfg. Co. (whose head offices are at Sunbridge-road, Bradford) have been removed to 102, Charing Cross-road, and are under the management of Mr. H. Holt.

Messrs. A. Reyrolle & Co., of Hebburn-on-Tyne, have opened a Glasgow depot at 61, Pollok-street, Pollokshaws.

Arthur Dean & H. W. Tyler, electrical engineers and contractors, 45, High street, Beckenham, Kent, have dissolved partnership. Debts by Mr. Tyler, who continues.

The London Telegraph Training College, which has been established at Brixton for the past 14 years, is being removed to Earl's Court, where larger and more commodious premises have been acquired. Prospectuses, &c., can be obtained from the secretary, Morse House, Earl's Court, London, S.W. See an advertisement.

## BANKRUPTCIES, LIQUIDATIONS, &c.

Thos. King, electrical engineer, Maidstone, was examined on March 7. Gross liabilities £573. 3s. 2d., assets (including £980 book debts) £984. 7s.

Debtor commenced business at Maidstone 10 years ago, having previously failed in London, but paying his debts in full. He also failed at Maidstone in 1898. Adjourned to Mar. 28.

Claims against Electroid Limited (in liquidation) are to be sent by March 30 to Mr. F. L. Jenkins, 17, Ironmonger-lane, London, E.C.

The trustee in bankruptcy of John Morley, electrician, &c., 7, North street, Hull, has been released.

**Testamentary Notice.**—Claims against the estate of the late George Hill (trading as George Hill & Co.), electrical engineer, 347 and 349, Chester-road, Cornbrook, Manchester, and of Sale and Ashton-on-Mersey, by April 12 to Mr. N. Heywood, 3, Mount-street, Manchester.

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**Plant, &c., for Sale.**—Messrs. J. T. & J. Taylor (Ltd.), Batley, advertise for sale a 36 H.P. Phœnix shunt motor.

Some particulars of a complete electric lighting plant, which is for disposal owing to the proprietors having decided to take their supply from the municipal mains, are given in an advertisement. Applications to Mr. Ellor, Market-street, Manchester.

Mr. F. R. Webb, Randalstown, co. Antrim, and Fethard, co. Tipperary, advertises for sale a 20 B.H.P. Hornsby oil engine, with pulley, &c.

The New Spa & Gardens (Ltd.), Bridlington, have some electric lighting plant (a dynamo, gas engine, switchboard, &c.) for sale. See an advertisement.

Clement's House Printing Works, Portugal Street, London, W.C., have for sale two electric motors (one 2 H.P. B.T.H. and one 3 H.P. McClure and Whitfield) with starting switches, &c.

Snowdon, Sons & Co. (Ltd.), Millwall, London, E., advertise for sale a Siemens alternator and an exciter.

**Businesses for Sale.**—Messrs. Firth & Co., 7, Cookridge street, Leeds, advertise for sale an electrical engineer's business.

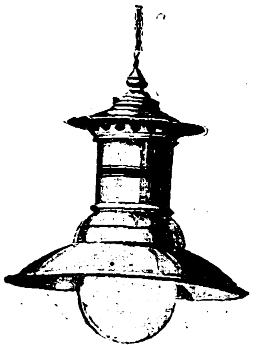
An established business (electrical contractor's, gas appliances, &c.) is advertised for sale in another column.

**Nernst Lamps.**—The A.E.G. English Mfg. Co. forward us a copy of a flattering testimonial received by them in regard to the merits of the Nernst lamps in use by the Compañia Alemana Transatlantica de Electricidad, which company have over 20,000 Nernst lamps in use for street and private lighting in Buenos Ayres.

**Country House Lighting.**—J. H. Holmes & Co. forward us a well-illustrated pamphlet giving a long list of electric lighting installations carried out by them in mansions and country houses. The introductory portion of the pamphlet contains some useful information concerning electric lighting generally, the advantages of electricity as an illuminant, &c. Brief technical particulars of some typical installations, with good illustrations of the country houses where these have been supplied, are also given.

**Catalogues.**—A good list of electric heating and cooking apparatus is issued by the Electrical Co., 121-125, Charing Cross-road, London, W.C. All the usual utensils employed in cooking operations are listed, and illustrations are provided of a large selection. Besides cooking utensils a number of radiators are shown.

"Geeco" ignition accumulators are listed in a sheet sent out by the General Electric Co., and notification is made that a considerable reduction in prices of these accumulators has now been effected. Another list sent out by the company (No. 63) includes a description of a cover for the Nernst lamp, made in enamelled iron with green exterior and white interior. This cover is shown fixed on a Nernst lamp in the accompanying illustration.



NERNST LAMP COVER.

We have received from the A.E.G. Foreign Department, 125, Charing Cross-road, London, W.C., a batch of the company's latest publications, covering a large range of subjects, including arc lamps, incandescent lamps, motors, ventilators, flexible wires, electrical accessories, and petrol-electric sets. The first mentioned list includes continuous current, alternating current, flame, enclosed and indirect light arc lamps and projectors. In the indirect light arc lamp section several neat designs of lamps are shown. This list is a very complete one. The incandescent lamp list comprises lamps for all kinds of ordinary and special uses. The motor list includes single, two-phase and three phase machines for outputs up to 5 H.P. and complete particulars are given of the construction and method of erecting. In the ventilator list a good assortment of all kinds of small ventilators are priced and described.

Messrs. Geipel and Lange have ready a new list of "Henrion" carbon brushes for tramway motors.

Ferranti Limited continue the issue of their catalogue lists. Nos. 101 and 104 are now ready, dealing respectively with oil-break fuses and blocks and Ferranti A.C.D.C. rectifiers. Some good rectifier sets are illustrated.

A revised price list of Waltham's switches is now ready, and can be obtained on application to the makers of these goods, 46, York-street, Buckingham-gate, London, S.W.

Portable Accumulators (Ltd.), 210, Shaftesbury-avenue, London, W.C., have prepared an attractive showcard relating to their manufactures.

**"Export Merchant Shippers' Directory of Great Britain and Ireland."**—This is a work that shows a healthy expansion year by year, and the 41st edition, now ready, indicates no diminution in this respect. The publishers (the Carter Publishing Co., 8, New Bridge-street, London, E.C.) assure us that every page of the work has been carefully revised and brought as far as possible up-to-date. It is 40 pages larger than its predecessor, and will be found to give a compact and complete guide to the exporters and merchant shippers of the United Kingdom, giving the places of shipment and class of goods shipped, as well as a representative list of manufacturers. We are promised some re-arrangement of the 1907 volume. The price of the 1906 issue is 15s. 6d.

**Imports.**—The following are official values of imports of electrical machinery, material and apparatus imported into this country during February, 1906:—

Electrical machinery, £64,913 (an increase of £33,517); telegraph and telephone cables, £11,856; telegraph and telephone apparatus, £30,328; other electric wires and cables (rubber insulated) £8,467, (with other insulations), £10,957; other electrical goods and apparatus, £42,314. Total of electrical goods and apparatus (other than machinery and telegraph and telephone wire), £103,922 (increase, £12,590).

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from March 7 to 13, with the ports of destination:—

*Africa*—Alexandria, £294 (including £217 telegraph material); Cape Town, £402; Delagoa Bay, £184 (including £165 telegraph cable); Durban, £2,146 (including £873 telegraph material); East London, £175; Port Elizabeth, £832. *Argentina*—Buenos Ayres, £3,795 (including £534 telegraph material); Rosario, £336. *Australasia*—Auckland, £61; Fremantle, £141; Hobart, £35; Lyttelton, £15; Melbourne, £561; Otago, £1,205; Perth, £65; Sydney, £1,421 (including £252 telegraph material); Wellington, £2,762 (telegraph material) *Belgium*—Antwerp, £166; Ghent, £82; Ostend, £14. *Brazil*—Pernambuco, £22,500 (telegraph cable). *Burma*—Rangoon, £8. *Canada*—Montreal, £80. *Canary Islands*, £25. *Ceylon*—Colombo, £146. *China*—Shanghai, £1,477 (and 101 tons tramway poles). *Cuba*, £60. *Denmark*—Copenhagen, £40. *France*—Boulogne, £22; Paris, £30. *Germany*—Hamburg, £520. *Holland*—Amsterdam, £245 (including £165 telegraph material). *Hong Kong*, £459. *India*—Bombay, £1,118 (including £30 telegraph material); Calcutta, £7,605 (including £232 telegraph material); Chittagong, £21. *Madras*, £795. *Italy*—Palermo, £15. *Malta*, £2,505 (including £58 telegraph material). *Portugal*—Lisbon, £1,095. *Russia*—Kureh, £6,140. *Spain*—Bilbao, £305; Malaga, £24. *Straits Settlements*—Singapore, £113 (including £67 telegraph material). *Sweden*—Stockholm, £75 (telegraph material). *Uruguay*—Monte Video, £55. *U.S.A.*—New York, £153. Total, £60,323, against £18,734 in the corresponding week last year (Feb. 8 to 14).

# PATENT RECORD.

## APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are no open to public inspection until after acceptance of Complete Specification. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

February 2, 1906.

2,574 Phillips. Recording and indicating current used in electrical appliances.
2,603 Kilburn. (Phönix Elektro Technische G.m.b.H., Germany.) Metallic vapour arc lamps.*
2,604 Lamme. Speed regulation of single-phase commutator motors. (Date applied for, Feb. 6, 1905.)*†
2,605 Lamme & Renshaw. Phase regulation of single-phase commutator motors operated from polyphase circuits. (Date applied for, Feb. 6, 1905.)*†
2,624 Gaiffe. Automatic mercury interrupters. (Date applied for, April 8, 1905.)*†
2,629 B.T.-H. Co. (G.E. Co., U.S.) Controlling devices for electric motors.
2,630 Warwick Machinery Co. (G.E. Co., U.S.) Turbines.
2,631 B.T.-H. Co. (G.E. Co., U.S.) Resistances.
2,641 Beck & Physikalischtechnisches Laboratorium. (G.M.B.H.) Iron wire-resistances. (Date applied for, Feb. 2, 1905.)*†

February 3, 1906.

2,656 Ayton. Contact makers for internal combustion engines.
2,691 Moseley. Electric heating, cooking and smelting.
2,705 Siemens Bros. & Co., Wilson & Griffith. Commutation windings for direct-current dynamos.*
2,706 Siemens Bros. & Co. & Dieselhorst. An improvement in the manufacture of submarine cables or the like.
2,707 Siemens Bros. & Co. (Siemens Schuckertwerke G.m.b.H., Germany.) Introduction of electrical apparatus with magnetic cores into alternating current circuits.*
2,709 Apostoloff. Public electric lighting systems.
2,716 Boult. (O'Brien, U.S.) Automatic starting devices for electric motors.*

February 5, 1906.

2,735 and 2737 Acland & Greiff. (Bleichert & Co., Germany.) Circuit closing arrangements for electrically driven suspended railway cars with hoisting gear.*
2,739 Aldworth, Crosta & Boot. Trolley wheel with renewable centre.
2,741 Richards. Means for opening and closing ventilator or ventilators in railway and tramway vehicles.
2,757 Purton. Arc Lamps.
2,761 Simmons. Distributing contacts for electrical ignition.
2,763 Lee. Mercury vapour electric lamps and manufacturing same.
2,770 Rooker. Setting out curves for railways, trams, &c.
2,777 Anness & Denny. Fuse boxes.
2,792 B.T.-H. Co. (G.E. Co., U.S.) Electric heating devices.
2,794 Siemens Bros. & Co. (Siemens-Schuckertwerke G.m.b.H., Germany.) Protection of circuits from excessive voltages.*
2,802 Küsel & Deutsche Solvay-Werke A.G. Electrolytic manufacture of salts of oxy-acids of the halogens.
2,823 Teichner & Askenasy. Electrolytically producing persulphates.*
2,833 Leech. Direct-current generators and motors.

February 6, 1906.

2,850 Fabry & Mitchell. Electric generators and motors.
2,853 White. Inspection sight for electric ignition spark.
2,857 Pollard. Preventing breakage of flexibles at switch or lamp holders.
2,887 Lacy. Construction of electromagnets.
2,911 Heyber-Gymnich & Thomas. Spark arresters.*

# COMPANIES' MEETINGS AND REPORTS.

## Metropolitan Electric Supply Co. (Ltd.)

The nineteenth ordinary general meeting was held on Tuesday, under the presidency of Mr. W. Harrison Cripps.

The SECRETARY (Mr. E. Cunliffe Owen, C.M.G.) read the notice calling the meeting and the certificate of the auditors,

The CHAIRMAN then said: Capital expenditure, which in 1904 amounted to £1,539,582, now totals £1,696,007, an increase of £156,425. This seems a large outlay to have expended during the year, but in explanation I would remind you that London County Council took over the whole of our Sardinia-street station and generating plant, the compensation for which was settled at £183,000. A large part of the capital spent last year was in altering the mains and building sub-stations to provide for the removal. In addition to this we had a large expenditure in Paddington in changing over from high to low-pressure distribution. This change has already saved a considerable amount in works costs and rendered our supply thoroughly safe and efficient. It has not been found necessary to call upon the shareholders to find any further capital for these works, which have been paid for out of the award moneys put by for the purpose. The sale of the necessary investments was satisfactory, leaving a margin of £4,000 over cost price, which sum has been carried to a special reserve fund to meet any depreciation in investments generally. The sum of £10,000, part of the Marylebone award money, was kept back by the Borough Council pending the question of certain titles. This question has been satisfactorily settled and the money paid, and after paying certain costs of severance there remains a credit of £2,649 which has been carried forward for future disposal. From the revenue account you will see that from the sale of current, &c., we have received £269,007 for the supply of about 14,000,000 units. This sum compares with a revenue of £306,540 in 1904, when we had the whole of the Marylebone supply, the loss of revenue being £37,533. The works costs amounted to £108,724, compared with £129,703 for the previous year. Thus we have lost £37,533 in revenue, but have saved £20,978 in cost of production. In other words, the revenue was 12 per cent. down, but the working costs have fallen by 16 per cent. To explain the loss of £37,533 in revenue, I would tell you that last summer the Marylebone Borough Council took over a large part of the supply which up to that date we had been giving them, and now it is practically all taken over. The loss of Marylebone, of course, we knew would occur about this period, and that a considerable portion of our Willesden plant would be set free for other work which I will refer to later. I will here call attention to our reserve fund. You will see that we have again put by £20,000 under this heading, making the amount of the fund £236,000. We consider that £20,000 is an ample provision for the year. Not only does out engineer certify that all our plant is in good order, but I would remind you that out of the whole of the plant nearly all of it is practically new, of the most recent design, and thoroughly up to date. I may state that no less than three-fourths of it is less than eight years old. Our reserve fund is a real one, being invested in first-class securities altogether outside our business. I may add that in addition to our cash reserve we have a most valuable asset in the splendid freehold site bordering on Kingsway ready to be let or disposed of at a favourable opportunity. This property only stands in our books at the value of the old site in Sardinia-street. The balance of revenue account, before providing for depreciation, is £160,282, and after setting aside £20,000 for this purpose there remains £140,282 for the credit of net revenue. This amount, with the balance brought forward and other sums, makes a total of £171,496. From this has to be deducted debenture interest, dividend on preference shares, and interest paid by way of rent to Marylebone under the working agreement, or in all £69,277, leaving a balance of £102,219 for dividend on the ordinary shares. An interim dividend was paid last August at the rate of 10 per cent., leaving £52,219 now to be dealt with. The Directors recommend, subject to your approval, that a further dividend at the same rate—10 per cent.—should be now paid, leaving a balance of £2,219 to be carried forward. With regard to our at present superfluous plant at Willesden, set free by the loss of Marylebone, it has been a matter of anxious concern to us to find employment for it and not to allow it to remain idle. It was with this view that we asked for powers from Parliament last year to become suppliers in bulk. This resulted, after a long and keenly fought battle, in our being granted the powers we sought to supply into West and South Middlesex, an area of upwards of 120 square miles, and, owing to its being so much opened up by electric tramways and new railways, it is quickly developing. Over this area we have already made agreements with Acton and Uxbridge to supply in bulk, and are engaged with other bodies at the present time with the same view. It was during these negotiations that we found that it would be desirable to go a little further westward so as to make our boundaries coincident with the bodies who wished to take our supply in bulk. These additional powers are sought for in our bill of this year. It is partly from this new district in the possession of which I hardly think even the present Government will disturb us and partly by a steadily growing demand in our London areas that the Company hopes to gain sufficient business to once again give full employment to our Willesden works. Last year we obtained in the London areas that remained to us an equivalent of new lamps amounting to 80,000. A gratifying feature during the year has been the steady growth of demand for current for power and heating purposes. This class of consumer takes a large amount of current during hours of daylight, and this enables us to quote a low price for energy, and as we can produce power at Willesden as cheaply, or cheaper, than any other Corporation we may safely look forward to a large and increasing business in this direction. We are now recommending you to pay a dividend at the same rate as last year. No doubt during the present year, when the full effect of the loss of Marylebone will be felt, and while the new business cannot have sufficiently increased to compensate for the deficiency, it would not be possible in the ordinary course to have maintained a 10 per cent. dividend, but I would remind you that a certain amount of the Marylebone award money was given for the express purpose of compensating us for this temporary loss. This sum might have been paid away at once as a bonus to the shareholders in a lump sum, but the Directors considered it more prudent to retain the money in reserve, and to use it if necessary for the equalisation of dividends until such period as the natural growth of business brings us back to the same position as we were in before we disposed of the Marylebone undertaking. During the year the work of our large business has been most satisfactory. This we attribute entirely to the ability and energy of our staff, who have always worked together with the greatest loyalty to the Company. Where all have done so well it may seem somewhat invidious to mention names, but I cannot help singling out Mr. Conacher, our general manager, Mr. Cunliffe Owen, our secretary, and Mr. Highfield, our chief engineer, to each of whom we feel more than ever indebted for their invaluable services during the year. I now move the adoption of the report and accounts and the declaration of the dividends therein set out.

Sir JAMES PENDER, Bart, seconded the motion.

Col. PERRY enquired as to how the unexpended balance of the award moneys had been dealt with in the accounts.

Mr. FISHER stated that at a small meeting which was held at the Company's offices some time ago the Chairman, in reply to a question of his, stated that the Company had a virtual, if not an actual, monopoly of supply over the area painted red on the map accompanying the report—the new area. He wished to know if that were the case.

The CHAIRMAN: Yes, for bulk supply.

Mr. FISHER, continuing, said that the Chairman had remarked that he did not think that "even this Government" would be likely to disturb the Company very much in the new area. He himself, however, had very little faith in any Government if it came to be a question of putting public interests before private interests: but he wished to know—and he was sure that the shareholders generally would be glad to know—if it was in the power of the Government to disturb them at all. If the Government could upset the arrangements which the Company had entered into with the local authorities, and if it was in the interests of the Government, or of its present majority, to upset them to that extent, he felt positive they would do so.

Mr. J. NEWTON said it was understood that an arrangement with which the Directors were satisfied was made on the part of the Company last year with the promoters of the Administrative County of London Bill, which, however, did not obtain the Royal Assent by a few hours in the last session. If that company or body were applying to Parliament in the present session, would the Directors make arrangements with them similar to those made last year?

The CHAIRMAN: I will answer the last speaker first. I may say at once that we refused to make an agreement with anyone. We fought the thing out. We know our own minds and what we want, and if we are right we stick to it. If we can carry out what we want we do so, and so far we have always been successful in that policy. Mr. Fisher asked us whether the Government could turn us out of our new area. I do not know. I believe that they could, if they wished to do so, sell up the whole of these islands (laughter). I do not know that they will do so, but I have no information that they will not. We are applying for no bill of any kind this year which really affects us in our London area. Col. Perry wants to know what has become of the rest of the money of the award. The answer is that during the last three years we have been developing our district everywhere. Instead of calling upon the shareholders for the new capital required to meet this outlay, we have been using the balance of the Marylebone award. The motion was then carried unanimously.

The retiring directors and the auditors having been re-elected, a vote of thanks to the Chairman, Directors and staff was carried unanimously, and the proceedings terminated.

## City of London Electric Lighting Co. (Ltd.)

The sixteenth ordinary general meeting was held on Wednesday, Mr. J. B. Braithwaite presiding.

The MANAGER and SECRETARY (Mr. J. Cecil Bull) read the notice convening the meeting and the auditors' report.

The CHAIRMAN then said: The report is very much the same as last year. Our capital expenditure has been small—only £32,000—and the whole of it has been provided without further issue of capital, so that we have again gone through the year without any addition to our capital account. In spite of the competition we have had to meet during the past year—a competition probably more severe than any we have ever had to contend with—our revenue shows an increase and our net profit has improved. Revenue account exhibits an increase of about £7,000—£261,994 against £255,087—and this notwithstanding that the price we received for the commodity we supply has again fallen by nearly ½d. per unit. The average price received was a fraction over 2¾d. per unit for our whole output. In face of the fact that our price has been reduced by nearly ½d. per unit, you will understand how much credit attaches to the engineering and technical staff for the result that our net profit is somewhat greater. The economy which has been effected in the engineers' department in the costs of generating and distribution represents almost exacty £15,000. I think that is a very great achievement, following, as it does, on sensible reductions in previous years. The revenue is £7,000 larger, the net earnings have increased, and we are able to recommend the same dividend as a year ago—6 per cent. on the ordinary shares—after putting the same sum to reserve. In addition to that, we have provided £2,500 out of revenue towards the liquidation of the costs of our opposition to the various power bills before Parliament last year and the costs of the attempts that we made to obtain bills on our own account, With regard to progress in other respects, the increase in equivalent 8 c.p. lamps was nearly 91,000, comparing with 87,276 in the previous year. Of this increase, the equivalent of close upon 57,000 lamps represents power and heating supply. This heating supply is a matter of some interest to you in a double sense. In the first place, the extension of the use of electricity for heating adds to our summer load at a time when we are anxious to have the load increased. At the present time we have 2,000 radiators connected to our mains, and we hope that number will be increased to 10,000 at no distant date. The cleanliness and convenience of these radiators for heating purposes is so great that I think they are bound to be increasingly used.

With regard to our progress during the current year. So far as it has gone the progress has been extremely satisfactory. We have had an increase of the equivalent of 15,415 8 c.p. lamps, against 9,436 in the corresponding period of 1905. We have now been able to ascertain the exact figure for the various demolitions of plant which have taken place. The exact amount has been written off reserve and deducted from capital account, so that now the whole thing is presented in a perfectly clear form. We still have a substantial depreciation fund, to which we are adding at the rate of £45,000 per annum. Respecting our experience in Parliament last session, as our opponents did not get their bills through, so far our opposition was successful. We went also for a bill of our own, which, however, we did not obtain. We are reintroducing a short bill this session for powers to supply railways and other large consumers in bulk. We do not know what will happen, but we hope to get those powers, which would be of distinct advantage in certain contingencies, Perhaps a further illustration of the economies which have been effected in our generating department may be interesting to you. We sold in the past year 3,336,000 units in excess of those sold in the previous 12 months. It cost us to produce those extra units £1,170, which was at the rate of 0·084d. per unit, so I think we come very near to producing them for nothing per unit. That sounds rather paradoxical, but of course as the load factor improves and the output increases the tendency is to reduce the cost of every unit we generate, and in the past year the result was that we sold between 3,000,000 and 4,000,000 extra units at a cost of £1,170. With regard to the feature that appears in all electric lighting accounts, and which the Board of Trade has been accustomed to put in as "units unaccounted for," you will have noticed that we have not adopted that phrase, but have called them "units expended in distribution," because these units are not unaccounted for. We know what has been done with them. A certain expenditure of energy is necessary in getting your electricity from your generating station to your consumers' lamps. The only question is, what is the most economical way of transmitting it, and how little energy can be expended for that purpose? Our area is very compact, but, in spite of that advantage, I think our loss in distribution is almost a record. It is only 6·3 per cent.—that is, we get paid for 93·7 units out of every 100 we generate. I do not know of any other company that can show such a low record of distribution loss. I now move the adoption of the report and accounts.

Mr. F. W. REYNOLDS seconded the resolution, which was carried unanimously.

Resolutions approving the dividends and re-electing the retiring directors and auditors having been passed, a vote of thanks to the chairman and his colleagues terminated the proceedings.

## County of London Electric Supply Co. (Ltd.)

The twelfth ordinary general meeting was held on Monday, Mr. J. B. Braithwaite presiding.

The SECRETARY (Mr. H. B. Renwick) read the notice convening the meeting, and the auditor's report having been read,

The CHAIRMAN, in moving the adoption of the report and accounts, said: The balance-sheet of some of the London electric supply companies have not turned out so satisfactory as shareholders could wish.

It is very satisfactory for us to be able to show a considerable increased revenue, and to slightly increase our dividend, as I foreshadowed last year might be the case. On the debit side there is practically no change this year. Capital expenditure during the year is £82,380, after making the deduction which you will find in the reserve for depreciation account, £7,559, which is the ascertained figure for writing off the small units which we had at the inception of the company and which have since been scrapped. There are otherwise few changes in the balance-sheet. Turning to the revenue account, this shows an increase of £10,224 over the previous year, the figures being £146,014, against £135,790. This increase is in the face of reductions which we have been making in the price at which we supply current. The full effect of this reduction will be felt this year, but I believe the increase in our business will more than compensate us for the reduction we have made. We do not think it will be necessary for us to make any further substantial reduction in the immediate future, as we have now got our price down to a figure at which I think we can cry a halt. The increased gross revenue to which I have referred was earned on an increased expenditure so far as the generating expenses were concerned of only £654, so that £9,570 out of the £10,224 is net. This bears excellent testimony to the skill and efficiency of our technical staff, for, as a matter of fact, the extra revenue was earned with the reduction in the coal bill of £23. Every year we have been able to make a pound of coal go further than in the previous year. This year we have have sold 1,432,000 extra units of electricity with the smaller coal bill, as I have mentioned. We are paying £978 more in rent, rates and taxes, general charges are £306 more, and we have written off suspense accounts £1,765 more than last year. These items reduce the increased revenue to £6,521. We have also increased interest charges, absorbing £4,070, and the extra dividend we are proposing to pay requires £1,900, a more substantial addition being made to depreciation fund this year than last. The total amount we are distributing in dividends to the ordinary shareholders is £20,000. We are placing £24,450 out of revenue to depreciation, reserve and suspense accounts, and I hope in the future we may be able to put a still larger sum to depreciation annually. There is one item to which I should like to make reference. I mean units unaccounted for, 2,731,000. Some of our shareholders appear to think that this quantity of current trickles out of our mains at different points, like a leakage in a gas or water pipe. This, however, is not the case. It is the amount of energy expended in sending electricity from our generating stations to the point where the consumer uses it. One of our distributing lines is 13 miles long. You cannot deliver either water or electricity over 13 miles without some loss of power. With regard to our capital expenditure, which has been almost exactly the same as in the previous year. last year I congratulated you when this was £50,000 less than in the year before, and I then said that this seemed to show we were at last overtaking the heavy capital expenditure which had been going on for some years in order to reach our distant customers. Last year 68 per cent. of the total was expended on mains, and this year it has been the same figure. Although this capital expenditure is unproductive at the moment to a large extent, I believe we should act unwisely if we did not avail ourselves of the opportunity of putting down these mains and encouraging the builders of new property to wire their houses for electricity supply, I told you last year that we were going to adopt turbine plant in our stations, and the first of two 1,500 kw. "Curtis" turbines have been delivered, and are now both at work. The results so far achieved are satisfactory, and we have ordered additional turbines. When this order is completed, it will probably equip us with generating plant for a considerable time to come. The total costs compared with revenue during the past year have fallen slightly. The percentage of revenue was 45·3 last year, and this year it is 44. With regard to the capital expenditure being remunerative, we have spent in all during the past year £82,380, and the net increase in revenue has been £9,570, or 11½ per cent. on the expenditure. This percentage would have been higher but for the reduction in price of current which we have made. You will see from the figures I have given you, that the progress of the company, measured by the units sold, is almost exactly the same as last year; 1,426,000 extra units in 1904, and 1,432,000 units last year. Actual lamp connections were last year a record, but this year we have even exceeded that, the equivalent of 122,000 8 c.p. lamps having been connected, compared with 118,000 in 1904. This is the largest increase of any London company. During the present year we are thus far 40 per cent. ahead of the 1905 figures, so that we have begun the year well in that respect. With regard to the supply of current for motive power, we have 10,000 H.P., approximately, on our mains at the present time, an increase of 2,121 H.P. on the year, and we have some large customers in prospect. We are supplying the whole of the power required by the London County Council for the new shallow tramway from Aldwych to the Angel, at a price at which the County Council could not generate it for themselves. If this proves to be the case, I hope we shall have the supply on our mains for a considerable time, although our contract is only for 12 months.

The Chairman then dealt exhaustively with the proceedings taken by the company in Parliament in safeguarding the interests of the shareholders. Proceeding, the chairman said: With regard to the associated companies, the Bournemouth & Poole Co. continues to do extremely well, and their Coatbridge investment is improving rapidly. We have now reached the point of giving you a 5 per cent. dividend, and I hope we shall be able to maintain this, and yet steadily add to our reserve. We are proposing, in order to deal with our capital, to make an almost immediate issue of the remaining 10,000 6 per cent. cumulative preference shares. We shall offer these to the public at £12 a share, at which they will pay a clear 5 per cent. to the investor, and we hope the shares will be readily subscribed. On previous occasions we have allotted new issues to our own shareholders, but in view of the growing magnitude of our undertaking, we think it important to widen our clientele. But I need hardly say that if any shareholder wishes to apply for shares and intimates that he is a shareholder, we shall endeavour to see that he gets the shares he requires. I now move the adoption of the report and accounts.

Mr. F. W. REYNOLDS seconded the motion.

Mr. MAKINS asked if the company were in an equally favourable position with regard to the County of London Bill as was the case with regard to the Administrative County of London Bill introduced last year.

The CHAIRMAN said he was afraid not. London County Council did not propose to bind themselves to supply anyone in bulk, and therefore their company would not be in a position to demand a bulk supply. Consequently, owing to the fact that municipal bodies did not seem to be able to carry on technical concerns like electricity undertakings so economically as private companies, he did not anticipate that the Council would be able to supply it at a better price than they could themselves generate current.

Other questions having been answered, the resolution was carried unanimously, as were also resolutions approving the dividends set out in the report, the re election of the two retiring directors, and the re-appointment of the retiring auditor. A vote of thanks to the chairman and his colleagues, and to the staff, particularly to the secretary and engineer, was then proposed and carried unanimously, and the proceedings terminated.

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## South London Electric Supply Corpn. (Ltd.)

The ordinary general meeting was held on Wednesday under the presidency of Mr. J. ATHERTON.

The SECRETARY (Mr. Herbert H. Boyer) read the notice calling the meeting and the auditors' certificate.

The CHAIRMAN: I am able to announce that steady progress in our business continues to be made. The actual number of lamps added to the circuits is the equivalent of 13,412 8 c.p. This number has already been added to considerably since the commencement of this year, and there still remains on our books awaiting connection the equivalent of nearly 5,000 lamps. Negotiations are in progress with several manufacturers for supply of power to their premises. We are always endeavouring to increase our day load, and for the past three years we have let out motors on hire, and are now arranging a hire-purchase scheme, so that manufacturers can spread their capital outlay for motors over a period of years on favourable terms. In July last year the price for current used for lighting purposes was reduced from 5¼d. per unit to 4¼d. per unit, with an additional rebate if consumers settled their accounts monthly. This reduction became absolutely necessary in face of the severe competition with the gas company, and it has been the means of bringing us a considerable increase in our business, and further has prevented the loss of consumers who would otherwise have reverted to the older illuminant. You may not, perhaps, be aware that our Company is the only electric supply authority in London that has to compete with gas at 2s. per 1,000 cubic ft. in every part of its area, and it needs the most systematic canvassing in order to increase the Company's load in face of this competition. A reference to the net revenue account will show an item which does not appear in our previous accounts. I allude, of course, to the costs incurred in opposing bills in Parliament last session, £1,959. 6s. 9d. These costs were incurred in successfully opposing new schemes in connection with undertakings proposed to give both a bulk and in some cases direct supply to premises within our area of supply, and, in fact, throughout the metropolis. Such schemes, if they had been passed in the form in which they were introduced, would have most injuriously affected the interests of the shareholders. We need not look this year for anything like the costs we had to bear last year under this heading. Like most of the other electric lighting companies in the metropolis, we shall from April next have to bear an increased burden of rates. The rateable value during the last quinquennial period—namely, £3,000, will be increased to £4,000, with an additional sum proportionate to the income derived from our contract for steam supply to the London County Council. Whilst mentioning the London County Council, the three years' contract entered into in 1901 for steam supply will expire on May 15 next, but I am pleased to say that we have just concluded negotiations for a supplemental contract from that date which we hope will benefit the revenue account for some time to come. The capital expenditure during 1905 has been on a moderate scale, the principal item being for an additional 900 kw. steam alternator, which has been installed in the existing generating station, and is now running on the load satisfactorily. The only other amount of any importance is the cost of additional mains, which of course only reflects the increase in the Company's operations and the connection of additional consumers. We do not think it will be necessary to raise any further capital during this year, but it may be well to remind you that the provisional debenture bonds issued by the Company in 1904 will become due for repayment on April 1 next year, and we shall give careful consideration to the question of an issue of debentures for this purpose at a more moderate rate of interest. The cost per unit sold has again been reduced, and now stands at 1·04d., and is the second best of any of the metropolitan companies. The only other company to beat us is the London Electric, who have sea-borne coal; but they beat us by only a very small fraction. The cost of coal per unit sold is lower than in the previous year, and it would have been further reduced had it been possible to conclude the agreement with the railway company for the provision of a siding into our works. The two actions brought by the Lambeth Council against us for repayment to the Council of the expense incurred by the Vestry and Council for the removal of dustbin refuse from 1900 to 1904 on the contract which the Council themselves prevented us from carrying out were heard by Mr. Justice Bigham on Nov. 15 and 16 last, both actions, I am glad to say, being dismissed with costs against the Council. The Council have since served a notice of their intention to appeal against these decisions, and so, apparently, to continue their unsuccessful litigation against the Company which they began more than five years ago. With regard to the profit available for distribution, after providing the handsome sum of £7,287. 10s. for depreciation, writing off £4,300 from the cost of the acquisition of the provisional order, £793 for depreciation of plant on hire on consumers' premises, and £1,959 for Parliamentary costs, &c., there is an available balance of £22,042. 1s. 10d., out of which the Board have pleasure in recommending a dividend of £4 per cent. for the year, leaving a balance of £9,042. 1s. 10d. to carry forward. I now move the adoption of the report and accounts.

Mr. F. J. LESLIE seconded the motion, and said: There is one subject I should like to touch upon a little more fully than has been done by the Chairman—I refer to the proceedings during the last five years of the Lambeth Borough Council, which have really been of a vexatious character. I think that the shareholders—some of whom, probably, are ratepayers and electors—ought fully to understand the persecution, really, which this Company has had to undergo at the hands of that body. It seems to me both extraordinary and unprecedented, and I speak not only as a lawyer as to their legal proceedings, but also as having had considerable experience of municipal administration, because I was a member for a great many years of the City Council of Liverpool. What are the facts of the proceedings which the Borough Council has adopted against us? First of all, when the Company was originally formed they tried to get, as one of the terms of allowing the Company to take over the order, a provision that the Company should run a dust destructor. The Board of Trade promptly struck that out, and said that it was no part of the transfer of the provisional order, and that they would not have anything to do with it. Then the Council (or the Vestry as it then was, but it is practically the same body) turned round and said, Very well—we shall insist on having all this embodied in a private agreement, which will not be disclosed to the Board of Trade at all, and you will have to run a dust destructor on the terms we prescribe. That was agreed to, and it was provided that the particular dust destructor to be put down should be approved in detail by the Lambeth Vestry's own officials, which was done. They approved even the detailed drawings. Then, in October, 1900, after issuing a number of summonses against the Company for working the destructor, as they said, to the detriment of the public health, they took out a summons before the magistrate, and asked him to provide that the destructor should not be worked any more. The magistrate took that view, and ordered that the destructor should not be worked any more, and the Company were rather glad than otherwise. At all events, we were ordered not to work it, and that day we ceased to do so. Then the Borough Council took time to think about it, and in the following July—eight months afterwards—they issued a writ against the Company for damages for not working the destructor. That seemed to us perfectly absurd, and we went on defending it, as you know, the delay bringing it on to early in March, 1902, and when they came before Mr. Justice Wright he gave them to understand that he did not approve their procedure, and adjourned the case in order that a satisfactory settlement might be come to between the Council and the Company, whose interests appeared to be largely the same, and for the benefit of the ratepayers. They would not, however, come to any terms of settlement, and they did not mean to, and they let the whole thing go on sleeping for three years. At the end of the three years they revived it again, and commenced proceedings with their action, and another action they also brought for supplementary damages. They delayed bringing it on as long as they could—until November, 1905—when, as the Chairman has said, those two actions were tried together, and dismissed very promptly by Mr. Justice Bingham, with costs against the Council, and with a pretty strong indication of his view that they ought not to have been commenced at all. The Council had three months left in which to appeal, and they waited until the very last day before giving us notice. Their committee met very hurriedly, and decided to give notice of appeal, and it was carried through at a Council meeting without their having the means of knowing anything about it, it not being on the agenda paper. They were told to approve it, and they did so. There it is. It is now before the Court of Appeal, and we have every hope that they will dismiss the action, as the Court below did. I do think that the shareholders ought to understand the persecuting tactics that have been adopted by the Borough Council towards the Company, and the extraordinary course they have followed. We have no hesitation in feeling that we shall succeed in the end, but it is very vexatious. It interrupts our ordinary business and our ordinary proceedings to have these actions brought against us. I now have the pleasure of seconding the motion for the adoption of the report.

Mr. BERRY asked what the amount was that was involved; was it simply the cost of the erection of the destructor?

The CHAIRMAN: If they had got all they claimed, it would be £4,000 a year. I may say that we have an agreement with the Borough Council which gives them the option of buying this property within 21 years of the date of the transfer of the provisional order at a profit of 25 per cent. to the Company. We do not know what is behind the scenes, and there may be something.

A SHAREHOLDER asked if the low price of gas to which the Chairman had called special attention was lower now, or was it the price that existed at the inception of the Company?

The CHAIRMAN: The present price is about a year old; it has been reduced from nearly 3s. per 1,000 cubic ft. to 2s. since the Company came into existence.

Mr. H. BOOT congratulated the Directors and the engineer on the most excellent work which, in his opinion, had been done by the Company. Would the engineer or the Chairman inform the meeting what the average price was that was obtained per unit sold? He also desired to ask the Directors to bear in mind the importance of maintaining the lamps. Incandescent gas made very little headway until the gas companies took in hand the maintenance of the mantles, but as soon as they began this work at so much per quarter immense strides were made by those companies. He therefore earnestly asked the Directors to give their consideration to this question of the maintenance of the consumers' lamps, although he did not suggest that they should go into any wiring business or business involving risks. Probably a charge of 2d. per lamp would pay, and the consumer would have no trouble as to changing the lamp when it was necessary to do so. In this way the supplying authority would be kept in intimate touch with all its consumers, and no consumer could go back to gas or give up the electric light without the authority knowing it. There was one item in the capital account which he did not quite understand—that was, the installations on consumers' premises, which appeared last year at £3,878. This year the item had disappeared altogether. He hoped he was right in assuming that the amount had been written off.

The CHAIRMAN: I will at once answer the three questions which Mr. Boot has put. The price obtained is 1·85d. per unit. A department for the maintenance of the lamps has already been installed, and we have a very good man at the head of it who is pushing this business for all it is worth throughout our district. Ours is the only company who have started this business, but I know others who are following suit. With regard to his third question the item of installations on consumers' premises is transferred to the general balance-sheet, where it figures at £4,980. We have depreciated that item this year by 10 per cent.

Mr. RIXON asked whether it would not be possible to declare a small interim dividend in the autumn, instead of the whole amount being paid in the spring. He thought that this would maintain the market price of the Company's shares.

The CHAIRMAN: I am glad you mentioned that point, as it has come before the Board. I am with you, but I think I am in a minority on the Board on the question. As the matter has now been raised, and we only meet once a year, I think it would be only fair to put the question to the meeting, and see their feeling in regard to it, because it is important for shareholders whether they receive their money every half-year or only every year. Now, will those shareholders vote who are in favour of paying an interim dividend? It is agreed, then, that we pay an interim dividend, and, personally, I thank you for bringing the matter forward.

The resolution was then carried unanimously.

Resolutions approving the dividend and re-electing the retiring directors and auditors having been passed, a cordial vote of thanks to the Chairman and Directors terminated the proceedings.

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**BOURNEMOUTH & POOLE ELECTRICITY SUPPLY CO. (LTD.)**—Capital expended during 1905 amounted to £45,193. 8s. 8d., making the total expenditure at Dec. 31 £363,487. 18s. 4d. The balance to credit of net revenue, including amount from last year, and after payment of all interest and other charges, reserves for depreciation and redemption, is £18,513. 9s. 8d. The full preference dividends have been paid, and the directors now recommend payment of a dividend on the ordinary shares of 7 per cent. for the year. These payments absorb £16,807. 9s. 3d., leaving £1,706. 0s. 5d. to be carried forward. Considerable progress has been made during the year with the wiring consumers' premises on the rental and prepayment systems introduced in 1904. The total applications at Dec. 31 amounted to the equivalent of 143,116 8 c.p. lamps, an increase of 21,527 for the year, compared with an increase of 21,051 for the previous year. The total units sold for lighting, power and traction was 2,005,025, an increase of 301,696. The Richmond (Surrey) Electric Light & Power Co. has made satisfactory progress during the year, and the directors of that company have declared a dividend of 7 per cent. on the ordinary shares for 1905

**BRITISH INSULATED & HELSBY CABLES (LTD.)**—For the year ended Dec. 31 the profit was £133,902. 12s. 1d. and, with balance from last year (£7,114. 1s. 5d.) the total is £141,016. 13s. 6d. Deducting directors' and trustees' fees and remuneration to works' committee, less directors' fees receivable from other companies (£2,577. 6s.), interest (£22,500), depreciation on buildings, plant, &c. (£22,000), transferring £8,500 to special reserve and £5,000 to debenture stock redemption account, preference dividend to Dec. 31 (£30,000) and interim dividend on ordinary shares to June 30, 1905 (£20,000), the balance available for dividend is £30,439. 7s. 6d. The directors recommend a further dividend of 4 per cent. on the ordinary shares (making 8 per cent. for the year 1905), carrying forward £10,439. 7s. 6d. During the past year the volume of trade has been considerably less than in the previous year, and under these circumstances, the directors consider the result of the year's working satisfactory. Only such additions have been made to the plant and machinery at the company's various works as will facilitate the business and enable its operations to be extended where possible.

**CUMBERLAND POWER SYND. (LTD.)**—Prof. Arnold Lupton, M.P. presided at the statutory meeting last week. The report stated that 649 £5 shares had been allotted and £1,575 paid up. The expenditure to date was £469. 7s. 6d. Referring to the company's bill, he said it was for the benefit of West Cumberland, and there were few districts in which miners were so crowded together, making it possible to reach all from one power station. There were four harbours giving access to the sea, and that would encourage the establishment of electro-metallurgical and electro-chemical works, which in other districts had followed the formation of companies similar to theirs. The waste gases of blast furnaces in the district gave them a source of power which other districts did not possess, and they would be able to manufacture electricity at very low cost.

**DAVIS & TIMMINS (LTD.)**—The chairman (Sir Henry Mance) stated at the meeting on Wednesday that the company had made substantial progress during the year, notwithstanding the period of depression the country had passed through. They had decided on a considerable increase in their works capacity at Wood Green. Few companies were in a better position to feel the commercial pulse than Davis & Timmins; they dealt with a large number of businesses in varying classes, and it was easy to see when times were improving by the increased activity generally shown among all classes of work. It struck them during last year that there were evidences of approaching improvement in business.

**DIRECT SPANISH TELEGRAPH CO. (LTD.)**—After providing for interest the balance to credit of revenue for the year ended Dec. 31 was £9,415. 7s. 2d. Adding the usual £5,000 to reserve the balance is, with £795. 1s. 11d. balance of contingencies account and £375. 14s. 11d. transferred from reserve, £5,586. 4s., which enables the directors to recommend a dividend of 10 per cent. on the preference shares and of 4 per cent. (tax free) on the ordinary shares for 1905. Half this amount was distributed on Oct. 1 as interim dividend. Traffic receipts show an increase of £118. 7s. 3d. compared with 1904, and ordinary working expenses an increase of £115. 0s. 6d. A fault, which seriously interfered with the working of the Bilbao cable, was noticed on April 7, and this was located about 213 knots from Bilbao. The cable was cut on April 18 by the Eastern Telegraph Co.'s c.s. "Norse," and communication restored the next day. On Oct. 31 the Bilbao cable became interrupted about 29 knots from Bilbao. The repair was carried out by the Eastern Co.'s c.s. "John Pender" on Nov. 9, the interruption having lasted 10 days. The cost of these repairs (£4,721. 19s. 8d.) has been charged against reserve. On Dec. 28 a further fault was dicovered in the Bilbao cable about 12 knots from Bilbao, and although this fault did not stop communication, it was considered prudent to remove it, the work being carried out by the c.s. "Norse" on Jan. 7. The cost of this repair will appear in the current year's account.

**EDWARDS AIR PUMP SYND. (LTD.)**—The directors recommend a dividend at the rate of 20 per cent. for 1905, against 15 per cent. in 1904. The income from royalties was £10,589, compared with £9,489. Of the 1,213 pumps booked in 1905, 691 (or 57 per cent.) were for land installations and 522 (or 43 per cent.) for marine engines. The pump has also been installed in most of the leading electric lighting and traction stations in Great Britain and the United States, and is being largely adopted for turbine installations.

**GATESHEAD & DISTRICT TRAMWAYS CO.**—At the meeting last week Mr. C. R. Greene said the revenue for the year was £49,752, against £48,318 in 1904. New energy supply arrangements had been completed at 0·85d. per unit, compared with 1,21d. previously.

**LIVERPOOL DISTRICT LIGHTING CO. (LTD.)**—At the meeting on Wednesday the directors' report stated that during the past year 287,057 units of current were sold, an increase of 34,114 over the previous year. It is proposed to pay a dividend at the sate of 5 per cent, less tax, for the half-year ended Dec. 31 (making 4½ per cent. for the year).

**NATIONAL TELEPHONE CO. (LTD.)**—At an extraordinary meeting yesterday (Thursday) resolutions were confirmed empowering the board to convert shares into stock without previously obtaining the consent of the shareholders in general meeting, giving the directors power to recover travelling and other expenses incurred in the service of the company, and providing for an increase of capital of the company.

**NEWCASTLE & DISTRICT ELECTRIC LIGHTING CO. (LTD.)**—During the past year 5,533,702 units of electrical energy were sold, compared with 3,259,389 units in 1904. The profits of the Newcastle works were £14,835, and a final dividend of 2½ per cent. is proposed, making 5 per cent. for the year. The reduced dividend is due to capital expenditure necessary to convert the company from a simple lighting concern to a cheap working power company. The Newburn station resulted in a debit of £766, and this, with interest on capital outlay (£2,610), has been paid out of reserve. The Newcastle works for the two last months have had profits greatly in excess of the corresponding period of last year, and the Newburn station is now working at a profit.

**NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY CO. (LTD.)**—It was stated at the meeting yesterday (Thursday) that the Castner-Kellner Chemical Co., Widnes, would shortly establish works on the Tyne, and take from the company 13,000,000 units a year. This statement has been denied, but is now very persistently repeated in the public journals.

**NORTHERN COUNTIES ELECTRICITY SUPPLY CO. (LTD).**—The working operations for 1905 at Alnwick, Ashington, Bedlingtonshire, Blyth, Felling, Hebburn, Hartlepool, Malton, Morpeth, Shildon, Spennymoor and Thirsk show a substantial increase compared with 1904. At Dec. 31 there were 5,251 consumers connected, compared with 3,783 at the beginning of the year (without Whitley), and the connections in equivalent 8 c.p. lamps were 125,381 and 85,034 respectively; 2,054,011 units were sold, against 986,873 in 1904. The gross receipts for current sold were £19,327. 13s., compared with £12,280. 12s. 2d. By an agreement with the Cleveland & Durham County Electric Power Co., the working of certain areas in North-west Durham (consisting of Consett, Annfield Plain, Benfieldside, Stanley and Leadgate undertakings) has been disposed of to that company, by which arrangement a large capital expenditure has been avoided, while the transaction leaves a surplus. After an apportionment of charges and interest between construction and revenue accounts, the credit balance for the year is £5,210. 7s. 10d., making, with £256. 16s. 5d. from last year, £5,467. 4s. 3d. The directors recommend a final dividend at the rate of 3 per cent. (less tax), making 3 per cent. for the year, placing £1,500 to reserve, writing £380 off preliminary expenses and carrying forward £128. 16s. 5d.

**PERTH (W. AUSTRALIA) ELECTRIC TRAMWAYS (LTD.)**—The gross receipts for 1905 were £74,484. 18s. 11d., yielding a profit of £32,041. 14s. 1d., against £69,411. 5s. 8d., and £29,360. 4s. 6d. in 1904. From Jan. 1 to March 2, 1906, the receipts show an increase of £643 compared with the same period of 1905. After paying interest and sinking fund, &c., the balance profit is £15,212. 3s. 5d., which with £3,462. 18s. 7d. from last year makes £18,675. 2s. Deducting £6,000 for preference dividend, the balance is £12,675. 2s., and the directors propose to add £5,000 to reserve, to set aside £2,500 as first instalment of a cash reserve fund, and recommend a dividend of 2½ per cent. (tax free) for the year on the ordinary shares, leaving £2,675. 2s. to be carried forward. During the year the construction of the 17½ miles of track authorised under the original concession was completed. The suburban concessions of Subiaco and Leederville (4¼ miles) were also completed and are now in operation. The North Perth concession of 1 mile 13 chains is being proceeded with. The construction of the Victoria Park extension has also been completed. Important additions to the power plant have been installed and five new cars built locally were put in operation in January. An attempt to inaugurate a system of motor 'buses to compete with the tramway proved a failure and the 'buses have been withdrawn.

**SOUTH WALES ELECTRICAL POWER DISTRIBUTION CO. (LTD.)**—At the meeting on Friday last Mr. R. Forrest, D.L., said the delays and protracted negotiations as to the installation of power plant by customers had been disappointing, but it was clear that the business of the company was developing in such a way as to bring in a good revenue in the long run from all the mains which had been laid, though they had to wait until the colliery companies had their electrical plant installed before the company could supply them with power. The directors were convinced that the demand for electrical power existed, but the change-over from steam was a slow process, and that would explain why the shareholders had not received any return before now. Mr. T. O.Callender stated that the experiences of the South Wales Co. in regard to delays were not unique, the same trouble occurring all over the country with manufacturers who desired to change over from steam to electricity.

**VICKERS, SONS & MAXIM (LTD.)**—Col. T. E. Vickers, C.B., presided at the meeting on Wednesday and moved the adoption of the report (abstracted in our last issue) recommending a dividend at the rate of 15 per cent. for the year. The report was adopted, and at a subsequent extraordinary general meeting a resolution was passed guaranteeing from time to time the payment of dividends on any stocks, shares, debentures or other securities issued by any company with whom the company might contract for the manufacture or supply of goods or material. The chairman explained that it was absolutely necessary for them to have that power in connection with many of the large contracts which came to the company.

**YORKSHIRE (WEST RIDING) ELECTRIC TRAMWAYS CO. (LTD.)**—The profit for the period from the opening of the lines on Aug. 15, 1904, to Dec. 31, 1905, was £19,461, of which £8,110 was earned prior to the formation of the company on April 6, 1905, and is only available for capital purposes. After paying revenue charges and interest, the balance is £1,306, which is carried forward.

## NEW COMPANIES, STATUTORY RETURNS.

### NEW COMPANIES.

**COPE-COLLIS SYND. (LTD.)** (87,870)—Reg. March 7, capital £10,000 in £1 shares, to acquire from W. Cope the benefit of certain inventions relating to electric shallow tramway conduits, and to develop and turn same to account. First directors, E. Simons, H. T. Brickwell, J. Chapman, J. F. Webb, Annie Brickwell, E. Kenyon-Collis and Gertrude Chapman. Reg. office, 12, Pall-mall, London, S.W.

**WILSON-WOLF ENGINEERING CO (LTD.)** (87,897)—Reg. March 8, capital £3,000 in £1 shares, to carry on the business of electrical, mechanical and general engineers, constructors of electrical tramcars, motor cars, carriages, &c., manufacturers of and dealers in electric light cables, telegraph and other wires and accessories, dynamos, motors, telephones, bells, electroliers, arc and other lamps and fittings, &c. First directors, J. H. Wilson, R. Wolf, H. Wilson and L. J. Wolf. Reg. office, Laycock's Mill, Thornton-road, Bradford.

### STATUTORY RETURNS.

**ANGLO-AMERICAN TELEGRAPH CO. (LTD.)**—In the return to Feb. 16 capital is £7,000,000 in £634,500 consolidated ordinary, £3,182,750 preferred ordinary and £3,182,750 deferred ordinary stock, all of which has been issued and paid up in full. Mortgages and charges nil.

**TYPEWRITING TELEGRAPH CORPN. (LTD.)**—In return to Dec. 31 capital is £100,000 in £1 shares, of which 69,833 have been taken up, exclusive of 1,167 forfeited. £1 per share has been called up on 25,533 and £25,872. 17s. 6d. has been received, including £339. 17s. 6d. paid on the said forfeited shares. 44,300 shares are considered as fully paid. Mortgages and charges, £740.

**UNIVERSAL TELEPHONE & ELECTRICAL CO. (LTD.)**—Return to Feb. 22 gives capital as £10,400 in 2,000 ordinary shares of £5 each and 400 founders' shares of £1 each, of which 400 £5 and 400 £1 shares have been taken up. £2. 10s. per share has been called up on the £5 shares and £1,000 has been received. The £1 shares are considered as fully paid. Mortgages and charges, nil.

**WESTINGHOUSE ELECTRIC CO. (LTD.)**—Return to Dec. 31 gives capital as £600,000 in 30,000 preference and 30,000 ordinary shares of £10 each, of which 18,955 preference and 27,500 ordinary have been taken up. £10 per share has been called up on 3,155 preference and £31,550 has been received. £433,000 is considered as paid on 15,800 preference and 27,500 ordinary. Mortgages and charges nil.

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. | | |
|---|---|---|---|---|---|---|
| | | | | No. of weeks. | Amount. | Inc. or Dec. (a) |
| | | £ | £ | | £ | £ |
| Aberdeen Corporation | March 10 | 1,119 | + 85 | 42 | 55,524 | − 811 |
| Airdrie | ,, 2 | 209 | + 28 | 9 | 1,905 | + 196 |
| Anglo-Argentine | ,, 11 | 14,963 | + 1,685 | 10 | 147,690 | + 15,625 |
| Ayr Corporation | ,, 10 | 192 | + 17 | 48 | 12,542 | − 65 |
| Barnsley | ,, 2 | 154 | − 9 | 9 | 1,312 | + 6 |
| Barrow | ,, 2 | 201 | + 7 | 9 | 1,729 | + 157 |
| †Bath Electric Trams, Ltd. | ,, 7 | 782 | + 201 | 10 | 6,344 | + 1,045 |
| Birkenhead Corporation | ,, 11 | 964 | + 15 | 10 | 10,095 | + 94 |
| Birmingham Corporation | ,, 10 | 890 | + 34 | 49 | 18,388 | + 2,789 |
| *Birmingham & Mid. | ,, 2 | 1,859 | − 358 | 9 | 11,708 | − 2,988 |
| Blackpool Corporation | ,, 8 | 355 | + 39 | 10 | 48,559 | + 2,073 |
| Blackpool and Fleetwood | ,, 10 | 209 | + 80 | 10 | 1,832 | − 9 |
| Bolton Corporation | ,, 11 | 1,809 | + 180 | 50 | 95,252 | + 5,071 |
| Bournemouth Corporation | ,, 8 | 1,406 | + 466 | †49 | 68,627 | + 16,299 |
| Bradford Corporation | ,, 10 | 4,177 | + 412 | 49 | 212,096 | + 1,911 |
| Brighton Corporation | ,, 11 | 744 | + 17 | 50 | 48,153 | + 492 |
| Bristol Trams & Carriage | ,, 9 | 4,968 | + 482 | 4 | 18,975 | + 1,807 |
| Buenos Ayres & Belgrano | ,, 11 | 3,492 | + 62 | 10 | 35,110 | + 3,382 |
| Buenos Ayres Elec. Trms | Feb. 10 | 1,436 | + 593 | 6 | 8,387 | + 1,977 |
| Burnley Corporation | March 10 | 1,126 | + 180 | 49 | 63,775 | + 3,695 |
| Burton Corporation | ,, 11 | 269 | − 87 | §49 | 14,911 | − 1,692 |
| Bury Corporation | ,, 4 | 848 | ... | §48 | 36,584 | ... |
| Calcutta Tramways Co. | ,, 10 | R42,410 | + R280 | 10 | R445,988 | + R44,377 |
| Camborne-Redruth | ,, 10 | 182 | + 4 | 19 | 2,043 | + 47 |
| Cardiff | ,, 8 | 1,561 | + 86 | 49 | 69,253 | + 848 |
| | ,, 10 | 1,916 | + 45 | | | |
| Carlisle Tramways Co. | ... | ... | ... | ... | ... | ... |
| Cavehill | ,, 2 | 54 | + 16 | 9 | 336 | + 21 |
| Central London Railway | ,, 10 | 6,857 | − 328 | 10 | 69,692 | − 2,366 |
| Chatham & Dist. Lt. Rys. | ,, 8 | 615 | + 18 | †10 | 5,530 | − 40 |
| *City of Birm'gh'm Tram Co. | ,, 2 | 5,236 | − 213 | 9 | 44,935 | − 899 |
| City & South London Rly. | ,, 11 | 2,832 | − 173 | 10 | 29,928 | − 40 |
| Colchester Corporation | ,, 8 | 172 | + 17 | 30 | 5,802 | − 1,463 |
| Cork Electric Trams Co. | ,, 1 | 419 | + 20 | 10 | 3,931 | + 5 |
| | ,, 8 | 433 | + 13 | | | |
| Devonport & Dist. Trams | ,, 2 | 887 | − 19 | 9 | 3,516 | − 214 |
| Dover Corporation | ,, 11 | 189 | + 20 | ‡49 | 10,804 | + 108 |
| Dublin & Lucan Railway | ,, 9 | 91 | − 2 | §10 | 851 | − 70 |
| Dublin United | ,, 9 | 4,626 | + 248 | ‡10 | 44,278 | + 1 672 |
| Dudley—Stourbridge | ,, 2 | 745 | + 26 | 9 | 6,449 | + 326 |
| Dundee Corporation | ,, 7 | 932 | + 142 | §42 | 89,624 | + 8,624 |
| East Ham Council | ,, 10 | 859 | + 216 | 49 | 40,469 | + 5,815 |
| Gateshead & Dist. Trams | ,, 2 | 909 | + 40 | 9 | 7,965 | + 485 |
| Glasgow Corporation | ,, 10 | 15,470 | + 1,563 | 41 | 622,991 | + 41,412 |
| Glossop | ,, 10 | 128 | + 15 | 10 | 1,234 | + 186 |
| Gloucester Corporation | ,, 7 | 246 | + 25 | 49 | 13,886 | + 1,180 |
| Gravesend—Northfleet | ,, 2 | 193 | + 14 | 9 | 1,620 | + 91 |
| Gt. Northern & City Rly. | ,, 10 | 1,824 | + 75 | 10 | 18,173 | + 510 |
| Greenock & Port Glasgow | ,, 2 | 604 | + 26 | 9 | 4,920 | + 424 |
| Halifax Corporation | ,, 7 | 1,426 | + 194 | 49 | 75,482 | + 5,600 |
| Hartlepool Tramways | ,, 2 | 249 | + 12 | 9 | 2,187 | + 112 |
| Hastings Elec. Trams Co. | ,, 8 | 403 | ... | 10 | 8,519 | ... |
| Huddersfield | ,, 10 | 1,875 | + 174 | 49 | 66,735 | + 8,985 |
| Hull Corporation | ,, 10 | 2,184 | + 45 | 49 | 109,117 | + 2,229 |
| Ilford Dist. Coun. | ,, 11 | 444 | + 81 | 49 | 22,678 | + 1,124 |
| Ipswich Corporation | ,, 10 | 851 | + 15 | 49 | 20,406 | − 1,870 |
| Isle of Thanet Co. | ,, 10 | 800 | + 65 | 22 | 5,938 | − 481 |
| Kidderminster & District | ,, 2 | 83 | − 1 | 9 | 777 | ... |
| Kilmarnock Corporation | ,, 10 | 139 | + 3 | 43 | 6,663 | ... |
| Kirkcaldy Corporation | ,, 7 | 191 | − 1 | 1 | 191 | − 1 |
| Lanarkshire Trams Co. | ,, 8 | 813 | + 152 | †10 | 8,141 | + 1,866 |
| Leamington | ,, 2 | 128 | + 60 | 9 | 1,121 | + 849 |
| Leeds Corporation | ,, 10 | 5,786 | + 830 | 50 | 292,662 | + 9,469 |
| Leicester Corporation | ,, 10 | 2,167 | + 249 | 10 | 19,328 | + 2,639 |
| Leith Corporation | ,, 3 | 406 | + 201 | 41 | 15,278 | + 11,150 |
| Liverpool Overhead Rly. | ,, 11 | 1,378 | − 96 | 10 | 13,892 | − 746 |
| Liverpool Corporation | ,, 3 | 10,317 | + 489 | 9 | 90,565 | + 8,560 |
| *London County Council | ,, 3 | 14,653 | + 2,483 | 48 | 703,452 | + 92,518 |
| Lowestoft | ,, 10 | 111 | − 2 | 24 | 3,145 | − 56 |
| Maidstone Corporation | ,, 8 | 97 | + 2 | 49 | 5,771 | ... |
| Manchester Corporation | ,, 10 | 12,848 | + 1,156 | 49 | 628,629 | + 83,086 |
| Merthyr | ,, 2 | 160 | − 7 | 9 | 1,491 | − 16 |
| Metropolitan Dist. Railway | ,, 11 | 8,061 | + 811 | 10 | 81,385 | + 4,845 |
| *Metropolitan Elec. Trams | ,, 2 | 2,887 | + 1,091 | 9 | 28,623 | + 7,304 |
| Middleton | ,, 2 | 268 | + 18 | 9 | 2,402 | + 184 |
| Nelson Corporation | ,, 10 | 134 | + 27 | 10 | 6,524 | + 759 |
| Newcastle-on-Tyne Corp. | ,, 10 | 3,669 | + 59 | 49 | 185,939 | + 4,503 |
| Newport (Mon.) | ,, 10 | 558 | + 36 | 23 | 12,558 | + 982 |
| Northampton Corporation | ,, 9 | 890 | + 89 | 49 | 20,633 | + 5,518 |
| Oldham, Ashton & Hyde | ,, 2 | 500 | + 20 | 9 | 4,378 | + 202 |
| Oldham Corporation | ,, 11 | 1,537 | + 158 | 50 | 81,147 | + 1,810 |
| Perth (N.B.) Corporation | ... | ... | ... | ... | ... | ... |
| Perth (W. A.) Elec Trams | ,, 9 | 1,527 | + 41 | ‡10 | 15,453 | + 684 |
| Peterborough | ,, 2 | 92 | − 7 | 9 | 829 | − 87 |
| Portsmouth Corporation | ,, 10 | 1,522 | + 124 | 49 | 93,088 | + 1,870 |
| Potteries | ,, 2 | 1,737 | + 158 | 9 | 15,038 | + 932 |
| Preston Corporation | ,, 7 | 650 | + 8 | 9 | 5,282 | ... |
| Reading Corporation | ,, 8 | 569 | + 44 | ... | ... | ... |
| Rotherham Corporation | ,, 8 | 448 | + 44 | 49 | 22,217 | − 19 |
| Rothesay | ,, 2 | 42 | − 9 | 9 | 427 | + 87 |
| Salford Corporation | ,, 12 | 8,951 | + 83 | 50 | 211,718 | + 12,445 |
| Sheerness | Feb. 28 | 43 | − 9 | 9 | 400 | − 51 |
| Sheffield Corporation | March 1 | 4,917 | + 536 | 50 | 246,767 | + 15,079 |
| Southampton Corporation | ,, 7 | 871 | + 95 | 22 | 19,427 | + 187 |
| Southend Corporation | ,, 7 | 265 | + 87 | 49 | 17,684 | + 1,103 |
| Southport Tramways | ,, 2 | 245 | − 10 | 9 | 2,016 | + 39 |
| S. Staffordshire Trams. | ,, 2 | 783 | + 184 | 9 | 6,686 | + 1,116 |
| Stockport Corporation | ,, 9 | 868 | + 424 | 49 | 37,832 | + 10,993 |
| Sunderland Corpn. | ,, 11 | 1,243 | + 131 | 49 | 64,336 | + 8,056 |
| Swansea Trams | ,, 2 | 707 | + 244 | 9 | 6,180 | + 2,268 |
| Swindon Corporation | ,, 7 | 175 | + 18 | 49 | 9,419 | ... |
| Taunton | ,, 2 | 40 | ... | 9 | 361 | + 22 |
| Tynemouth and District | ,, 2 | 153 | − 15 | 9 | 1,380 | − 74 |
| Tyneside Trams Co. | ,, 7 | 375 | + 24 | 10 | 8,274 | + 112 |
| Wallasey District Council | ,, 10 | 723 | + 87 | 49 | 87,019 | + 1,653 |
| Warrington Corporation | ... | ... | ... | ... | ... | ... |
| West Ham Corporation | ,, 8 | 2,096 | + 966 | 48 | 90,372 | + 39,020 |
| Weston-super-Mare | Feb. 28 | 30 | + 6 | 9 | 228 | − 4 |
| Wolverhampton Corpn. | ... | ... | ... | ... | ... | ... |
| *Wolverhampton District | March 2 | 893 | + 68 | 9 | 3,221 | + 290 |
| *Worcester | ,, 2 | 222 | − 23 | 9 | 2,034 | − 118 |
| Wrexham | ,, 2 | 83 | − 14 | 9 | 778 | − 30 |
| Yorkshire W.R. Trams | ,, 11 | 727 | + 187 | 10 | 6,172 | + 2,059 |
| Yorkshire Woollen District | ,, 2 | 788 | + 243 | 9 | 7,019 | + 2,419 |

(a) These comparisons are with the corresponding period last year. † Minus 8 days. ‡ Minus 2 days. § Plus 2 days. ¶ Plus 8 days. * Partly electrical.

## CITY NOTES.

◆

**MEMORANDA** (March 8).—Bank rate 4 per cent. (since Sept. 28, 1905). Price of silver 29⅜d. per oz. Consols $90\frac{1}{16}$—$90\frac{3}{16}$ for money, $90\frac{5}{16}$—$90\frac{7}{16}$ for account; 2½ per cent. annuities 89¼—89⅛. Consols Pay Day, April 4. Stocks and Shares Continuation Day, March 26; Ticket Day, March 27. Pay Days, March 28 and April 11; Mining Share Carry-over Day, March 23.

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**COUNTY OF LONDON ELECTRIC SUPPLY CO. (LTD.)**—During the week applications were invited for 10,000 £10 6 per cent. cumulative preference shares at a premium of £2 per share.

**STOCK EXCHANGE NOTICES.**—The Stock Exchange committee have appointed March 21 a special settling day in 7,362 £1 fully-paid 6 per cent. cumulative preference shares of the *Sir Hiram Maxim Electrical Co. (Ltd.)*, and have granted a quotation to $53,000,000 $1,000 collateral trust 4 per cent. bonds of the *American Telephone & Telegraph Co.* The committee have been asked to appoint a special settling day in and grant a quotation to a further issue of £185,000 5 per cent. cumulative perpetual preference stock of the *British Columbia Electric Railway Co. (Ltd.)* and to grant a quotation to a further issue of 1,500 £5 fully-paid ordinary shares of the *Oxford Electric Co. (Ltd.)*.

**WESTERN UNION TELEGRAPH CO.**—The receipts for the March quarter (partly estimated) were $1,500,000, a decrease of $100,000. There is a deficit of $48,000, compared with a surplus of $83,000. The usual quarterly dividend of 1¼ per cent. has been declared.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Mar. 14. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Mar. 14. | |
|---|---|---|---|---|---|---|---|
| | | | | | | Highest. | Lowest. |
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | £ s. d. | | | |
| 5 | 8/0 | Anglo-Argentine Ord. Shares | 8⅞—9⅛ | 4 7 6 | Ap, Oct | [illegible] | 8⅞ |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞—6⅛ | 4 10 0 | — | $6\frac{3}{32}$ | 6 |
| St. | 6% | Do. Permanent 6% Deb. Stock | 141 —144 | 4 3 3 | — | .. | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 104 —106 | 4 14 3 | — | 105 | .. |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1 —1½ | .. | .. | .. | .. |
| 5 | 3/6 | Do. 5 per Cent. Cum. Pref. | 3⅞—4⅛ | 6 1 4 | — | $4\frac{1}{16}$ | 4 |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 93 —96 | 4 13 9 | — | 92¼ | — |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 120 —123 | 4 17 6 | — | — | .. |
| St. | 5% | Do. Pref. Ord. Stk | 110 —113 | 4 8 4 | — | .. | .. |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock | 108 —111 | 4 10 0 | — | — | — |
| 40 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%—105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 102 —105 | 4 5 0 | — | 105 | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | 3½—3¾ | 5 6 6 | — | $3\frac{11}{16}$ | .. |
| 5 | 3/0 | Do. 6 per Cent. "A" Cm. Pref. | 5⅞—6⅛ | 4 13 0 | — | .. | .. |
| 5 | 3/0 | Do. "B" | 5¼—5¾ | 5 4 0 | — | .. | .. |
| St. | 5% | Do. 5 per Cent. Debs. | 106 —108 | 4 12 6 | — | 108½ | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102 —105 | 4 15 0 | — | 101½ | 104 |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 100 —102 | 4 19 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 102 —106 | 5 4 3 | .. | .. | — |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 102 —106 | 5 13 0 | .. | .. | .. |
| 5 | 3/6 | Calcutta Tramways (Nos. 1 to 105) | 9⅝—10⅛ | 4 4 0 | — | $9\frac{13}{16}$ | 9¾ |
| 5 | 2/6 | Do. Nos. 105,001 to 137,610 | 9 —9½ | .. | .. | .. | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 106 —108 | 4 3 8 | — | 106¾ | .. |
| 1 | 0/6 | Cape Electric Tram Shares | ⅝— ⅞ | 5 14 0 | — | .. | — |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 102 —104 | 4 16 0 | — | .. | — |
| .. | 5% | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 96 —98% | 5 2 0 | .. | 96½ | 96 |
| St. | .. | Kalgoorlie Elec. Trams 5% "A" Deb. Stock | 91 —93 | .. | .. | .. | .. |
| St. | .. | Do. 6% "B" Ditto | 83 —88 | .. | .. | .. | .. |
| 1 | .. | Lisbon Elec. Trams Ord. | $1\frac{7}{16}$—$1\frac{9}{16}$ | .. | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛—1⅜ | 4 7 4 | .. | $1\frac{9}{32}$ | 1¼ |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 100 —103 | 4 17 0 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 101 — 103 | 4 17 0 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101 —103 | 4 17 0 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102 —104 | 4 6 6 | — | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 105 —108 | 4 12 6 | .. | .. | .. |
| .. | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 147 — 149 | 5 7 3 | .. | .. | .. |
| .. | 3/0 | Do. 5% 1st Mt. $500 Dbs. | 99%—101% | 4 19 0 | .. | 100 | .. |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | 3/0 | †Adelaide Elec. S'ply Co. 6% Cu.Pr. | 4¾—5¼ | 5 14 6 | .. | .. | .. |
| 5 | 3/3 | Calcutta Elec. (1-50,000) | 9 - 9½ | 4 6 6 | — | .. | — |
| 10 | 6% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbr. | 50 —52 | 4 16 0 | .. | .. | .. |
| .. | 5% | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 94 —96 | 5 4 0 | .. | .. | .. |
| [illegible] | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½— 3 | .. | .. | .. | — |
| St. | 5% | Do. 5% Debs. | 88 —92 | 5 9 4 | — | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | 7¾ - 8¾ | — | — | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92 —94 | 5 6 8 | .. | .. | .. |
| St. | 26/2 | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. | 110 —113 | 5 6 0 | .. | .. | .. |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞ —1 | 6 0 0 | — | .. | .. |
| 1 | 1/0 | Rand Electric | $1\frac{5}{16}$—$1\frac{7}{16}$ | .. | — | [illegible] | — |
| 1 | .. | River Plate Electricity Co. Ord. | [illegible] | .. | .. | .. | .. |
| 1 | 1/2⅞ | Do. 6% Non. Cum. Pref. | [illegible] | .. | .. | .. | .. |
| St. | 5% | Do. 5% Deb. Stock | 101 —103 | 4 17 0 | .. | .. | .. |
| 5 | 3/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5½—5¾ | 5 4 4 | .. | .. | — |
| 5 | 9·23d | Do. (12,001-20,000) | 5 —5½ | 8 8 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100 —103 | 4 7 5 | Ap, Oct | .. | ... |
| .. | 5% | Shawinigan Water and Power 5% Bds., Scrip | 102 —104 | 4 16 0 | .. | 102¼ | .. |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Shre. | Last Dividend | Name. | Price Wed., Mar. 14. | Rate % Yielded. £ s. d. | Dividend Due | Business, Week to Mar. 14. Highest | Lowest |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 10 | 14/0 | Bournemouth & Poole Elec. Sup. Ord. | 12½—12⅝ | 6 6 0 | | .. | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10—10½ | 4 5 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11—12 | 5 0 0 | .. | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 106—108 | 4 3 3 | .. | .. | — |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5½—5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 103—106 | 4 5 0 | .. | .. | .. |
| 5 | 5/6 | †Brompton & Kensington Elec. Sup. Ord. | 8½—9½ | 5 8 6 | — | .. | .. |
| 5 | 3/6 | † Do. 7 per Cent. Pref. | 8½—9¼ | 3 15 6 | — | .. | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 102—105 | 3 16 3 | Mar, Sept | 104½ | .. |
| 5 | 2/6 | CharingCross (W.End&City) El. Sup. Co. | 4⅞—5⅜ | 4 18 0 | — | 5¼ | 4 15/16 |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 4⅞—5⅜ | 4 8 6 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 101—103 | 3 17 6 | Feb, Aug | .. | .. |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4¼—4¾ | 4 14 9 | — | .. | .. |
| 5 | 2/3 | Do. Do. (1903) | 4¼—4¾ | 4 14 9 | — | .. | .. |
| 5 | 3/9 | †Chelsea Electric Supply Ord. | 5⅝—5⅝ | 5 7 0 | .. | 5½ | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 108—110 | 4 1 6 | March .. | .. | .. |
| 10 | 5/0 | City of London Electric Lighting Ord. | 10¾—11¾ | 5 2 0 | Jn, Dec .. | 11¼ | 11⅛ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13¾—14¼ | 4 4 2 | Feb, Aug | .. | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 123—126 | 3 19 4 | Jan, July | 124½ | 123½ |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 101—103 | 4 8 0 | Jn, Dec .. | .. | .. |
| 5 | 4% | County of Durham Elec. P.D. Ord. £2 pd. | 2 1/16—2 3/32 | 3 17 8 | .. | 2 1/16 | — |
| 5 | 5% | Do. Do. 5% non cum. pref. | 5½—5⅞ | 4 18 0 | April, Oct | .. | .. |
| 10 | 4/0 | County of London Elec. Supply Ord. | 8½—9½ | 4 6 6 | April, Oct | 8 31/32 | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅛—12⅝ | 4 17 0 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 109—112 | 4 0 4 | Mar, Sept | 111¾ | 110¼ |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 101—103 | 4 7 6 | .. | 102½ | 102 |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5—5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101—104 | 4 6 6 | .. | .. | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8½—9 | 4 14 0 | — | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100—103 | 4 7 5 | .. | .. | .. |
| 5 | 5/0 | †Kensingtn. & Kngtsbdg. Ord | 9¼—10¼ | 4 18 0 | — | .. | — |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½—7 | 4 5 9 | .. | .. | .. |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98—101 | 3 19 2 | Jan, July | — | — |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 103—105 | 3 16 0 | .. | .. | .. |
| 3 | 2/4½ | †London Electric Supply Ord. | 2½—2¾ | 6 5 0 | .. | .. | .. |
| 5 | 3/0 | † Do. 6 per Cent. Pref. | 5¼—5¾ | 5 4 3 | .. | 5¾ | 5⅝ |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 98—101 | 3 19 2 | — | 99⅞ | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 8½—9½ | 5 10 6 | Mr, Jn, S, D | 9¼ | 8⅞ |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5⅝—5⅝ | 4 0 0 | April, Oct | 5 9/16 | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 110—114 | 3 19 0 | Jan, July | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 95—97 | 3 12 8 | Jn, Dec .. | [illegible] | .. |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 101—103% | 4 7 4 | — | .. | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 11⅝—11⅝ | 5 18 1 | — | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 101½—102½ | 4 6 6 | Feb, Aug | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 7½—8½ | 5 0 0 | Jan, July | .. | .. |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 5⅞—6⅛ | 4 3 4 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99—101 | 3 19 7 | Feb, Aug | .. | .. |
| 1 | 8% | Northern Counties Elec. Sup. | 15/16—31/32 | 3 2 6 | Jan, July | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 101—102 | 4 7 6 | Mar, Aug | .. | .. |
| 10 | 9/0 | †Notting Hill Electric Ord. | 13—14 | 6 8 0 | Jan, July | — | — |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98—100 | 4 0 0 | March | .. | .. |
| 5 | 4/6 | †Oxford Electric Ord. | 6¼—6¾ | 5 0 0 | .. | 6¾ | .. |
| St. | 4% | Do. 4% Deb. Stock | 99—101 | 3 19 0 | March .. | .. | .. |
| 5 | 7/6 | St. James' & Pall Mall Elec. Ord. | 9¼—10¼ | 6 0 0 | — | 9⅝ | 9¼ |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 7—8 | 4 7 0 | Feb, Aug | 7¼ | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 96—98 | 3 12 0 | Feb, Aug | .. | .. |
| 5 | 4/0 | †Smithfield Markets Electric Sup. Ord. | 5¼—5¾ | 8 4 0 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76—80 | 5 0 0 | .. | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 8¼—8¾ | 5 6 8 | — | 8⅝ | .. |
| 1 | 0/3 | †South Metrop'n Elec. Lt. & Power Ord. | ¾—⅞ | .. | .. | .. | .. |
| 1 | 0/8¾ | † Do. 7% Cum. Pref. | 1¼—1⅜ | 5 2 0 | .. | .. | — |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105—108 | 4 3 8 | .. | .. | .. |
| 5 | 2/6 | Urban Electric Supply Ord. | 4½—4¾ | 5 5 0 | — | 4 9/16 | — |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5—5¼ | 4 15 8 | — | 5⅛ | .. |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 104—106 | 4 5 0 | — | 105¾ | 105 |
| 5 | 6/6 | †Westminster Elec. Sup. Ord. | 9½—10½ | 6 4 0 | .. | 9⅞ | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5 5/16—5 9/16 | 4 10 0 | Mar, Sept | 5 15/32 | 5⅜ |
| 5 | .. | Do. £1 and 7/6 premium paid | 1⅛—1½ | .. | .. | .. | .. |
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| 1 | — | Bath Elec. Trams Pref. Ord. | 15/16—1 1/16 | .. | .. | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 1—1⅛ | 4 10 0 | .. | 1 1/32 | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 103—106 | 4 6 0 | .. | 103½ | 103 |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 101—103 | 4 7 9 | .. | .. | .. |
| 10 | 9½% | Bristol Tramways and Carriage Ord. | 15—15½ | 4 8 8 | Feb, Aug | .. | .. |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10—10¼ | 3 18 0 | .. | .. | — |
| St. | 4% | Do. 4 per Cent. Debs. | 104—106 | 3 15 6 | Feb, Aug | — | — |
| 10 | 6/0 | British Electric Traction Ord. | 7—7½ | 4 0 0 | — | 7 13/16 | 6½ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 9¾—10¼ | 5 17 0 | Feb, Aug | 10 | 9⅞ |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 117—120 | 4 8 4 | .. | 118½ | 118 |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 98—100 | 4 10 0 | .. | 98¼ | 97½ |
| St. | 4% | Central London Ordinary Stock | 91—93 | 4 6 0 | June, Dec | 93 | 91½ |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 103—105 | 3 16 0 | .. | 104⅜ | 104⅛ |
| St. | 4% | Do. Deferred Stock | 81—84 | 4 15 0 | .. | 83¾ | 82 |
| 100 | 4% | Do. 4 per Cent. Debs. | 110—112 | 3 11 3 | .. | .. | .. |
| St. | 4% | Charing X, Euston & Hmpstd Per Db. Stk. | 96—98 | 4 1 6 | .. | 96 | 95½ |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 5⅛—5⅜ | 4 18 0 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 101—104 | 3 17 0 | .. | .. | — |
| St. | 1¾% | City and South London Rly. Con. Ord. | 41—43 | 4 7 0 | Feb, Aug | 41½ | 41¼ |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 120—123 | 4 1 4 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 115—118 | 4 4 8 | .. | .. | .. |
| St. | 5% | Do. (1901) | 113—116 | 4 6 0 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 106—109 | 3 13 4 | May, Nov | .. | — |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13¾—14¾ | 4 1 6 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½—15½ | 3 17 8 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 4½—5 | 8 0 0 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8—9 | 4 8 11 | — | .. | .. |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 103—105 | 4 5 8 | .. | 104½ | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 15½—16½ | 5 9 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 12—12½ | 4 17 0 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 107—108 | 4 8 0 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2½—2¾ | 9 8 6 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 80—85 | 4 14 0 | — | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8[illegible]—8[illegible] | 8 18 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾—10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99—102 | 3 19 8 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9—9½ | 5 5 0 | .. | 9 15/32 | 9¼ |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 93—96 | 4 4 0 | — | 95½ | 95 |
| St. | .. | Mersey Con. Ord. Stock | 6—8 | — | — | 5 | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8—11 | — | — | .. | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 3/32—9/32 | .. | — | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16—1 1/16 | 4 14 6 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104—106 | 4 5 0 | — | .. | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ⅞—1½ | .. | — | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8½—9 | 5 1[illegible] 0 | May | .. | .. |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9¼—9¾ | 5 2 6 | .. | 9¼ | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103—106 | 4 5 0 | Feb, Aug | .. | .. |
| 100 | 5% | Sunderland Dst. Elc. Trms. 5% 1st Mt. Db. | 92—95 | 5 5 0 | — | .. | .. |
| — | 5% | Underground Elec. Rys. Co. of London | 98—100 | 5 0 0 | — | .. | .. |
| St. | 3½% | Waterloo and City Ord. | 101—104 | 3 7 8 | .. | .. | .. |
| St. | 4½% | Yorkshire W.R. El. Trs. Co. 4½% 1st Debs. | 95—97 | 4 13 0 | June, Dec | .. | .. |

| Shre. | Last Dividend | Name. | Price Wed., Mar. 14. | Rate % Yielded. £ s. d. | Dividend Due | Business, Week to Mar. 14. Highest | Lowest |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝—⅞ | 5 6 6 | — | — | .. |
| 1 | 10½d. | Aron El. Met. 6% Cm. Pf. | 7/16—9/16 | .. | — | .. | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 4—4¼ | 4 16 0 | .. | [illegible] | [illegible] |
| 1 | 7½d. | Do. Pref | 1 7/16—1 9/16 | 3 16 10 | .. | .. | .. |
| 5 | 4/0 | British Insulated & Helsby Cables Ord | 6¾—7¼ | 5 10 0 | July, Feb | 7 | .. |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾—6¼ | 4 16 0 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103—106 | 4 4 11 | .. | .. | .. |
| St. | 4½% | †British Thoms'n-Houst'n 4½% 1st Mt. Db | 96—98 | 4 12 0 | .. | .. | .. |
| 5 | .. | British Westinghouse 6% Pref. | 1⅞—2⅜ | .. | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 80—85 | 4 14 0 | .. | 81 | .. |
| 2 | — | Brush Electrical Engineering | ¾—1 | — | March .. | [illegible] | [illegible] |
| 2 | 2/4½ | Do. 6 per Cent. Pref. Non-Cum. | 1½—2 | 6 0 0 | Mar, Sept | [illegible] | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 97—99 | 4 11 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 82—84 | 5 7 4 | Jan, July | .. | .. |
| 5 | 5/0 | Callender's Cable Con. Ord. | 11—12 | 5 0 0 | Jan, July | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5¾—6 | 4 8 4 | Jan, July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 108½—110½ | .. | Nov, May | — | .. |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1 1/16—1 3/16 | 5 1 0 | .. | .. | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 95—100 | 4 10 0 | — | 98 | .. |
| 1 | 9⅜d. | Chadburn's (Ship) Telegraph Ord. | 1 3/16—1 5/16 | 7 10 0 | — | .. | .. |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1 1/16—1 3/16 | 5 8 0 | .. | .. | .. |
| 3 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 2—2¼ | 3 9 0 | Jan, July | .. | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 9[illegible]%—9[illegible]% | 5 2 0 | Jan, July | .. | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8¾—9¼ | 5 8 0 | Sept .. | .. | .. |
| 5 | 3/0 | Do. 6% Cum. Pref. | 6—6½ | 4 14 0 | Sept .. | 6⅛ | [illegible] |
| St. | 4½% | Do. 4½% Deb. Stock | 104—106 | 4 5 0 | .. | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅝—1⅞ | — | Feb, Aug | [illegible] | .. |
| 5 | 2/6 | Do. (£5 paid) | 2½—3 | — | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 86—88 | 4 11 0 | June, Dec | — | .. |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92—97 | 5 3 1 | .. | .. | .. |
| 5 | 2/6 | Edmundson's Elec. Corp. Ord. | 4½—4¾ | 7 7 0 | H'lf-yearly | [illegible] | .. |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5¼—5½ | 5 4 6 | .... | [illegible] | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 104—106 | 4 5 0 | .. | .. | .. |
| 2 | 1/7½ | Electric Construction Co. | ½—¾ | 9 6 0 | July .. | .. | .. |
| 2 | 2/9½ | Do. 7 per Cent. Cum. Pref | 2—2½ | 5 12 0 | July .... | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 89—92 | 4 7 0 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9⅝—9⅞ | 5 3 0 | .. | [illegible] | [illegible] |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 95—99 | 4 1 0 | — | 98¼ | .. |
| 5 | 10/0 | †Henley's Telegraph Works Ord. | 12½—13½ | 5 11 0 | Feb, Aug | 13⅜ | [illegible] |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼—5½ | 4 2 0 | Feb, Aug | 5¼ | .. |
| St. | .. | Do. 4½ per Cent. 1st Mt. Db. St. | 108—110 | .. | .. | .. | .. |
| St. | .. | Do. Do. Scrip (50% paid) | 57—59 | .. | .. | 58⅜ | .. |
| 10 | 15/0 | India Rubber, Gutta Percha, &c., Wrks. | 17½—18½ | 5 9 0 | Feb, Aug | 18⅜ | [illegible] |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99—102 | 3 18 5 | Mar, Sept | .. | .. |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¾—12¼ | 4 1 8 | Mar, Sept | .. | .. |
| 1 | 1/2[illegible] | Richardsons, Westgarth & Co., Ltd. Ord. | 29/32—31/32 | 6 4 0 | .. | [illegible] | .. |
| 1 | 7⅕d. | Do. 6% Cum. Pref. | 15/16—1 1/16 | 5 15 0 | .. | 1 1/32 | 1 |
| St | 4½% | Do. 4½% Perp. Deb. Stock | 99—101 | 4 10 0 | .. | .. | .. |
| 12 | 4/0 | †Telegraph Construction & Mainten'ce. | 32½—34½ | 5 5 0 | Mar, July | 34⅜ | [illegible] |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 100—102 | 3 18 6 | Jan, July | .. | .. |
| 1 | 1/0 | Vickers, Sons & Maxim, Ltd., Ord. | 2⅝—2¾ | 4 8 6 | .. | [illegible] | [illegible] |
| 1 | 6d. | Do. 5% Non-Cum. Preference | 1⅛—1¼ | 4 0 0 | .. | [illegible] | [illegible] |
| St. | 5% | Do. 5% Non-Cum. Preferred | 122—125 | 4 0 0 | — | .. | .. |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock Red. | 105—107 | 3 14 8 | .. | 106 | 105 |
| 100 | 4½% | Do. 4½% 2nd Mort. Debs., Red | 106—108 | 4 3 8 | — | [illegible] | [illegible] |
| 5 | — | Willans and Robinson Ord. | 2¼—2¾ | — | Apr, Oct | .. | .. |
| 5 | — | Do. 6 per Cent. Cum. Pref. | 4—4½ | — | Apr, Oct | 4¼ | 4 |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 82—87 | 4 12 0 | May Nov | 85 | [illegible] |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | *African Direct Tel. 4% Mrt. Deb. (red.) | 98½—101½ | 3 18 6 | Jan, July | .. | .. |
| 10 | — | Amazon Telegraph | 3¾—4¼ | .. | Jn, Dec .. | .. | .. |
| 100 | 5% | Do. 5% Debs. (red.) | 83—88 | 5 18 6 | .. | .. | .. |
| St. | 21/0 | Anglo-American | 66½—67½ | 4 16 6 | F, My, Ag, N | 66 | [illegible] |
| St. | 32/0 | Do. Preferred | 113½—114½ | 5 5 0 | F, My, Ag, N | 114½ | [illegible] |
| St. | 10/0 | Do. Deferred | 20⅛—20⅝ | 2 9 0 | F, My, Ag, N | [illegible] | [illegible] |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 97½—98½ | 4 0 6 | Jn, Ap, Jy, O | .. | .. |
| 10 | 5/0 | Cuba Submarine Ord. | 8½—9 | 5 11 0 | Feb, Aug | .. | .. |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17—18 | 5 11 2 | Feb, Aug | [illegible] | .. |
| 5 | 2/0 | Direct Spanish Ord | 3⅜—3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 8½—9 | 5 11 0 | April, Oct | .. | .. |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 100%—103% | 4 7 8 | Jan, July | .. | .. |
| 20 | 3/6 | Direct United States Cable | 16¼—16¾ | 4 6 0 | Ja, Ap, Jy, O | 16⅜ | [illegible] |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 99½—101½ | 4 8 6 | Jn, Dec .. | .. | .. |
| St. | 25/0 | Eastern Ordinary | 147—150 | 4 13 8 | Ja, Ap, Jy, O | 149 | 147½ |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 90—92 | 3 16 6 | Ja, Ap, Jy, O | 92 | 91½ |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 107½—109½ | 3 13 0 | May, Nov | 108⅜ | 108 |
| 10 | 2/6 | Eastern Extension | 15—15½ | 4 10 0 | Ja, Ap, Jy, O | 15⅛ | 15 |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 105—107 | 3 14 8 | Feb, Aug | [illegible] | 106 |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 99—101 | 3 19 3 | Feb, Aug | .. | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101%—103% | 3 18 3 | May, Nov | .. | .. |
| 10 | 5/0 | G. N. (of Copenhagen) with coupon 66 | 38—40 | 6 0 0 | Jan, July | .. | .. |
| 100 | 4½% | Halifax & Bermudas 4½% 1st Mt. Db. (red.) | 99½—101½ | 4 8 9 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57—59 | 5 10 0 | May, Nov | [illegible] | 58 |
| 100 | $1 | Mackay Companies Common | 61[illegible] | 3 5 0 | Jan, July | — | .. |
| 100 | 4% | Do. Preference | 7[illegible]⅛ | 5 4 0 | Ja, Ap, Jy, O | .. | — |
| 1 | .. | Marconi's Wireless Telegraph Co. | 1—1¼ | .. | .. | 1⅛ | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 99—102 | 3 18 6 | June, Dec | .. | .. |
| 10 | 4/0 | West African Telegraph Shares | 9½—10 | 5 0 0 | .. | .. | .. |
| 2½ | — | West Coast of America | ⅝—¾ | .. | — | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100—102 | 3 18 3 | Jan, July | 100½ | .. |
| 10 | — | West India and Panama | ⅜—⅝ | .. | May, Nov | .. | .. |
| 10 | 6/0 | Do. 6% 1st Pref. | 8½—8¾ | 6 6 8 | May, Nov | [illegible] | .. |
| 10 | — | Do. 6 per Cent. 2nd Pref. | 6½—7½ | .. | May, Nov | .. | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 100—103 | 4 17 0 | Jan, July | .. | .. |
| 10 | 3/0 | Western Telegraph | 14½—15 | 4 13 0 | Mr, Jn, O, D | 14⅞ | [illegible] |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 100—102 | 4 18 0 | June, Dec | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 102—104 | 3 16 10 | .. | [illegible] | [illegible] |
| | | **TELEPHONES.** | | | | | |
| St. | .. | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 103—105 | .. | .. | — | — |
| 5 | 8/0 | Chili Telephone (fully paid) | 8—8½ | 4 17 0 | August — | .. | .. |
| 1 | 0/9⅜ | Monte Video Telephone Ord. | ⅞—1 | 4 0 0 | — | 1 | [illegible] |
| 1 | 1/0 | Do. 5% Pref. | ⅞—1 | 5 0 0 | .. | .. | .. |
| St. | 6% | †National Co. Pref. Stock | 110—111 | 5 8 0 | — | [illegible] | 110 |
| St. | 6% | † Do. Def. Stock | 112—114 | 4 7 6 | — | [illegible] | [illegible] |
| 10 | 6/0 | † Do. 6 per Cent. Cum. 1st Pref. | 12—14 | 4 5 6 | Feb, Aug | [illegible] | .. |
| 10 | 6/0 | † Do. 6 per Cent. Cum. 2nd Pref. | 10½—12½ | 4 16 0 | Feb, Aug | .. | .. |
| 5 | 2/6 | † Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅝—5⅞ | 4 0 0 | Feb, Aug | [illegible] | [illegible] |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 99—101 | 3 9 8 | June, Dec | 100 | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 103—105 | 3 16 8 | — | [illegible] | [illegible] |
| 1 | 0/7½ | Oriental | 1½—1⅝ | 4 12 0 | April, Oct | [illegible] | .. |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1½—1⅝ | 4 7 0 | — | .. | .. |
| St. | 24/7⅔ | Do. 4% Red. Deb. Stock | 97—99 | 4 1 0 | .. | [illegible] | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 103—106 | 4 4 9 | .. | .. | .. |
| 5 | 8/0 | United River Plate | 7¼—7½ | 5 6 8 | July .... | 7⅜ | [illegible] |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5½—5¾ | 4 7 0 | June, Dec | — | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 110—112 | 4 9 3 | June, Dec | .. | — |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 4¾—5¼ | 5 14 0 | .. | .. | .. |
| 10 | 9/0 | Globe Telegraph and Trust | 11⅛—11⅜ | 4 16 6 | Ja, Ap, Jy, O | [illegible] | [illegible] |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14¾—15 | 4 0 0 | Ja, Ap, Jy, O | 15 | [illegible] |
| 10 | 6% | Submarine Cables Trust (Cert.) | 128—131 | 4 18 6 | April, Oct | [illegible] | — |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote the

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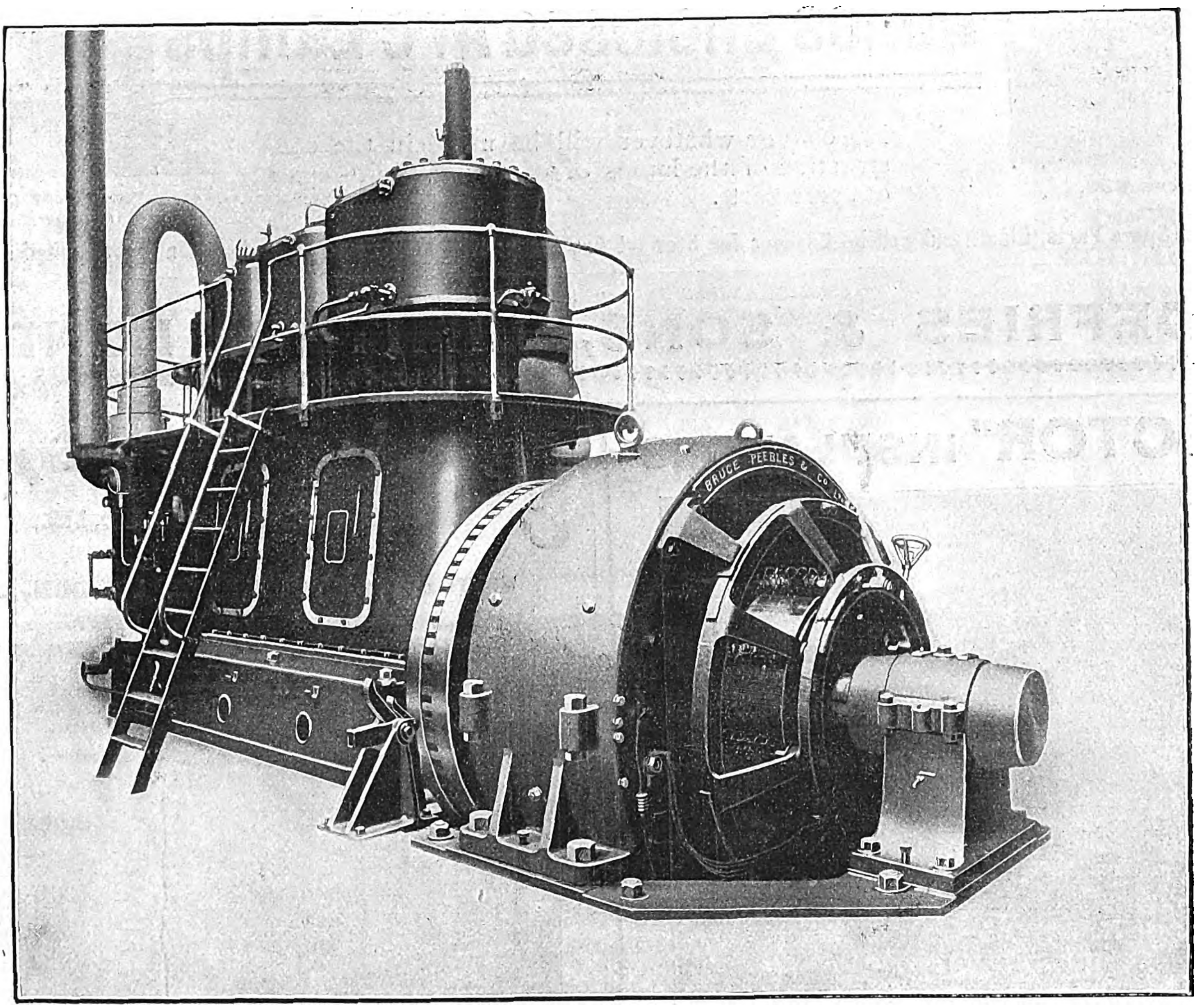

Peebles-Belliss 750 kw. Steam Dynamo.

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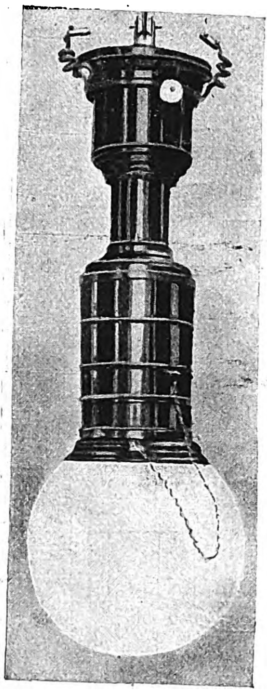

TYPE 632.

In consequence of the decision of Mr. JUSTICE JOYCE, whereby the Original Manufacturers of the STEWART ENCLOSED ARC LAMP have been restrained from selling their lamps by that name for the future, the original

## Enclosed Arc Lamps

manufactured for and during the existence of the STEWART ELECTRICAL SYNDICATE, LTD., by the HELIOS MANUFACTURING COMPANY, and then sold in England as STEWART ENCLOSED ARC LAMPS, will henceforth be known as

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No change whatever will be made in the construction of the lamps or of any of their repair or spare parts.

TYPE 652.
(*Single Enclosed.*)

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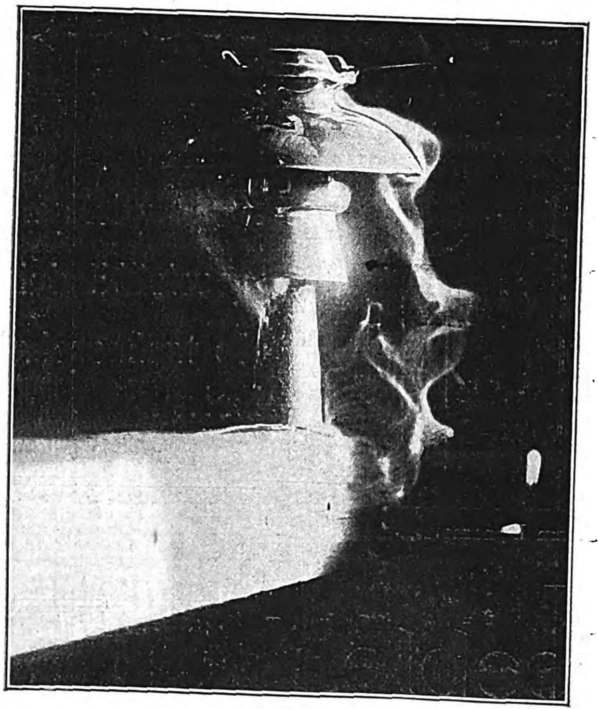

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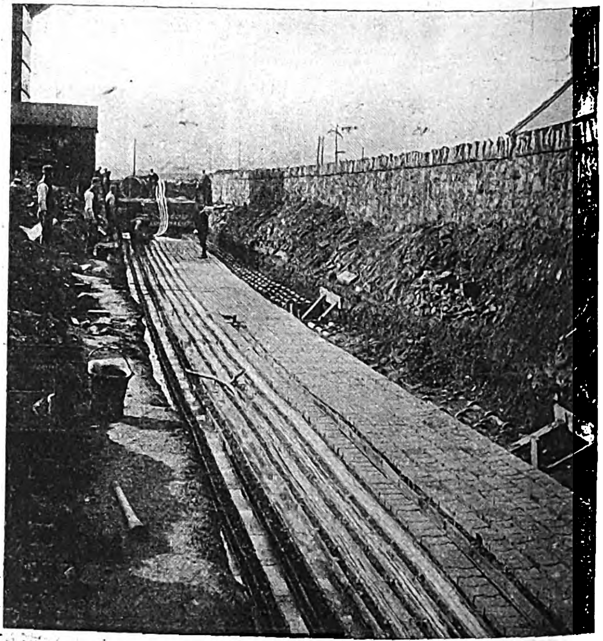

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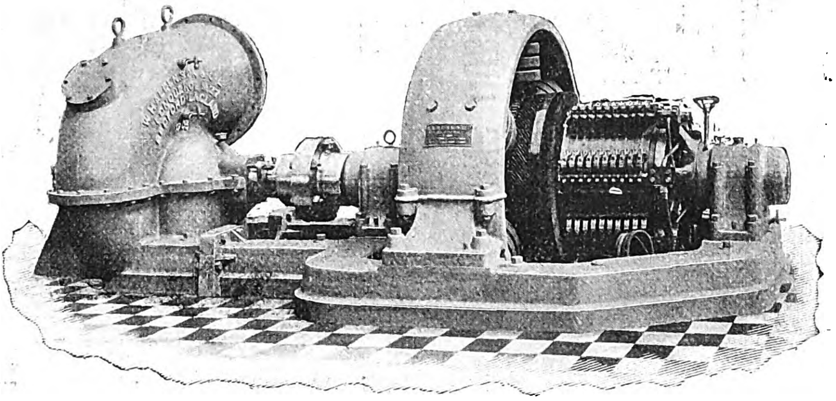

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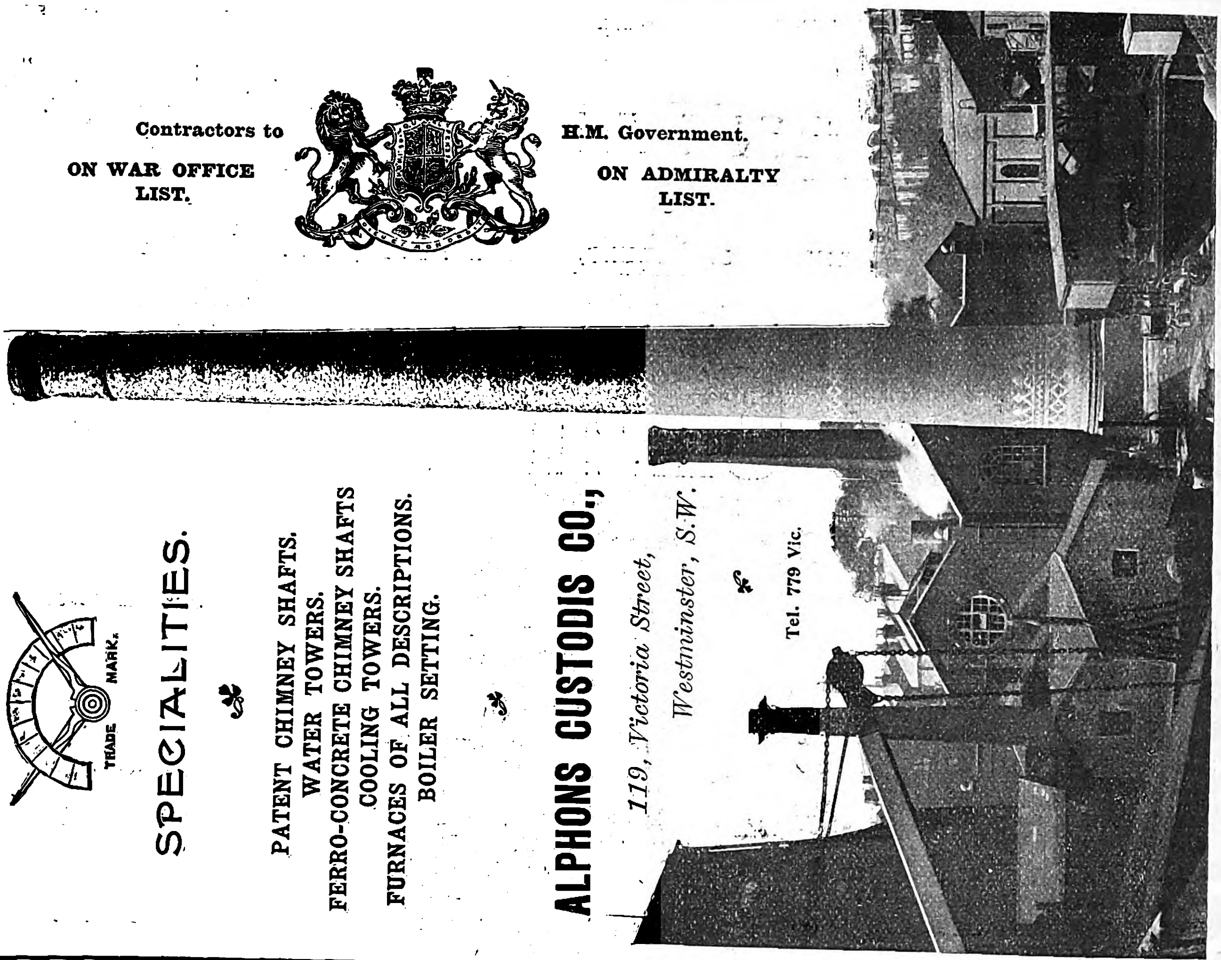

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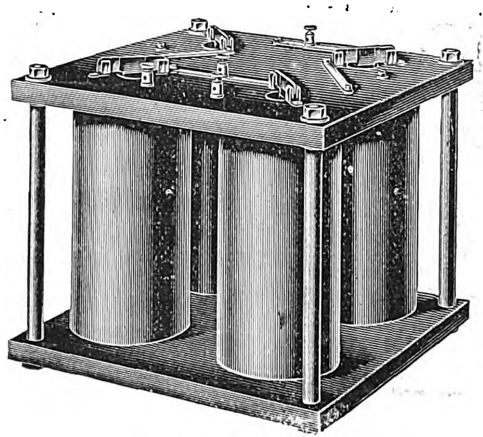

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# THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,453. [No. 23. Vol. LVI.] FRIDAY, MARCH 23, 1906. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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## NOTES.

THE application of the well-known Hopkinson method of testing dynamos to the testing of alternators has been suggested on several occasions. A Paper dealing with the subject was read before the Institution of Electrical Engineers in 1893 by Mr. W. M. MORDEY, and work has been done on the same subject by Prof. AYRTON. An improved form of Mr. MORDEY'S arrangement was applied, some three years ago, by Mr. B. A. BEHREND to a 3,000 kw. alternator. In these cases one machine only was used, half the coils being arranged to act as generator and the remainder as motor. An interesting article by Mr. STANLEY P. SMITH, which was given in Vol. LV. of *The Electrician*, p. 508, treated the problem in a more general way, and pointed out the various combinations of connections which might be employed to produce the required result. Although these systems possessed the advantage of requiring only a single machine instead of a pair, the impossibility of relatively shifting the phases of the generator and motor portions did not enable the circumstances to represent so fully the conditions of running on actual load as the method described in our columns this week and applied by Dr. M. KLOSS to the pair of large two-phase alternators for Johannesburg. The arrangement is remarkably simple and enables either non-inductive or inductive full-load conditions to be closely imitated. The scheme is very similar to that employed by Mr. H. F. PARSHALL in testing the two 385 kw. alternators made for the Bankside Station of the City of London Company. In this case a graduated coupling was employed by which the relative angular position of the rotors could be varied, instead of one stator being packed up at an angle as was done at Stafford. The fact that two similar machines are required of course limits the general usefulness of the method, but there can be no doubt that many cases arise in practice in which Dr. KLOSS' test will be found of great service.

◆

ELECTRIC supply station engineers will welcome the judgment delivered by Mr. Justice FARWELL on Monday in the action for damages brought by the General Hydraulic Power Co. against the St. James' & Pall Mall Electric Lighting Co., and the counterclaim by the latter company. One of the walls of a manhole in Piccadilly-circus, built many years ago and belonging to the electric light company, rested on a high-pressure water main belonging to the hydraulic company, but the main was 6 in. in diameter and 1½ in. thick, and all the wall had to do was to help to support the manhole cover. Needless to say, the additional stress on the pipe (which had been tested to 2,500 lb. per square inch and was worked at 750 lb. per square inch) could not have been great. Last summer, however, the main burst at a point a few feet away from the manhole and the hydraulic company wished to make the electric lighting company liable for the breakage, loss of water and the subsequent damage due to the extensive flooding that ensued. An ingenious hypothesis was put forward by the plaintiffs—viz., that the damage had been caused by the persistent vibration and pressure of the road traffic being communicated to the pipe through the wall of the manhole, which produced molecular fatigue in the metal. The judge found that the present state of scientific knowledge on this abstruse point would not justify him in endorsing this view, and gave judgment for the electric light company, not only exonerating them from liability for the damage, but ordering the hydraulic company to pay the plaintiffs compensation for the damage done by the water to the inspection boxes and lighting mains. Up to the time of going to press no appeal has been lodged against this judgment.

So much has been recently said in praise of auxiliary poles as a panacea for sparking troubles that it is distinctly interesting to find a designer with the experience of Dr. M. Breslauer reverting to methods not involving their use to cure what promised to be a bad case of sparking. The special form of pole-piece described in his article, which we conclude in this issue, is a far less expensive device than the addition of separate commutation poles, besides conducing to a better efficiency. There should be a considerable number of what may be called intermediate cases, where the application of some such method would be effective, although for extremely high speeds or very great variations of excitation, auxiliary poles undoubtedly form the best solution to the problem. Another device contributing to diminution of sparking in the machine described was the introduction of resistances in the commutator leads. This is a point on which there has been a good deal of argument, and it will be remembered that Prof. Silvanus Thompson was emphatic in his condemnation of the practice in his recent Cantor Lectures on high-speed machines at the Society of Arts. Dr. Breslauer admits their uselessness in cases where commutation depends solely on variation of brush resistance, but makes a good case for their application when the greater part of the commutation is effected by variations of flux. Altogether, there is much of interest to the designer in the article, for, as the author points out, little data has been published relating to high-speed machines of about the size in question, and indeed it is seldom that such complete details of really modern machines of any type are made available for publication.

The negotiations by the National Telephone Co. and the Postmaster-General for the acquisition of the municipal telephone undertakings at Hull and Swansea respectively, reported in a later part of this issue, serve to emphasise the failure of the attempt to introduce municipal telephony into Great Britain. It is now taken for granted by the authorities owning telephone licences that no extension will be granted by the Postmaster-General on their expiry, and it is merely a question of arranging terms for the sale of all the municipal systems in order to give the Post Office a clear field when it has acquired the undertaking of the National Company in 1911. Of the five licences which are now being worked, two expire in 1926, one in 1920, one in 1913, and one in 1911, and in view of the terms of the licences it seems a wise policy to make the best bargain for a sale at as early a date as possible. To judge by the difference in the two estimates in the case of Swansea, however, it would appear that the loss to be written off will be a large one.

A Paper on "Single-phase Railway Motors," recently contributed to the Manchester Local Section of the Institution of Electrical Engineers, and published in abstract in this issue, was followed by a short discussion, to which Mr. W. Cramp made an interesting contribution, but we cannot agree with some of his remarks. In classifying the various types of single-phase motors of the commutator type, for instance, he describes the well-known Winter-Eichberg motor as a compensated series motor. As a matter of fact, it is a compensated repulsion motor similar to the Latour motor. Then Mr. Cramp is reported to have said that, "for anything like reasonable efficiency at full load, the series motor had to run well above synchronism, while the repulsion motor had only to run at about three-quarters synchronous speed." Now, theoretical considerations, as well as a glance at Mr. Schoepf's characteristic curves, will show that the efficiency of a single-phase series motor drops but slightly with the decrease in speed. This falling off is largely due to the diminution of the power factor, the value of which certainly remains comparatively low as long as the motor runs below synchronous speed. The best speed for the repulsion motor, on the other hand, is undoubtedly synchronous speed, both from the efficiency and commutation point of view, and, if run much above or below this speed, it is not satisfactory. Quite recently efforts have been made to produce a repulsion motor with various synchronous speeds, and a motor of this kind has recently been described by Mr. F. Punga. In this motor the two brushes (for a two-pole machine) are not directly short-circuited in the usual manner, but are connected at two points to the exciting winding on the stator. By suitably altering the distance between the two junction points the commutation can be rendered practically perfect at any speed.

In certain quarters there is considerable insistence that the telephone must constitute a fire danger to the subscriber. Our readers will remember the endeavour to prove this at the time of the unfortunate outbreak of fire at the Bank exchange and the Oxford-court junction room, when an unlucky contact was made between a telephone cable and a live rail on the District Railway. The new scare, announced by headlines—"Fire Risks in London: The Telephone Danger"—in several newspapers, is even more ingenious. When a fire breaks out, the people in the building naturally fly to the telephone to give the alarm. This, it is pointed out, may occasionally be less expeditious than sending out to a fire-alarm post—and we can at any rate endorse this statement, for only yesterday it took us 30 minutes to get into communication with another department of the London County Council. The alarmists point out that, as people may think that the telephonic call for the fire brigade is sufficient in itself, and may not send to the fire-alarm post as well, the presence of the telephone increases the danger. We can hardly think, however, that this will lead to the abolition of telephones, although no other remedy is suggested for counteracting this terrible risk.

**Wireless Control of Submarines.**—According to the *Echo de Paris*, successful trials have been completed in the harbour at Antibes with a new experimental submarine controlled by means of electric waves from the shore. The vessel has been built at the Creusot works to the designs of M. Lalande.

**Royal Society.**—The following Papers were read yesterday: "On Methods whereby the Radiation of Electric Waves may be Mainly Confined to Certain Directions, and whereby the Receptivity of a Receiver may be Restricted to Electric Waves emanating from a Certain Direction," by Chevalier G. Marconi, communicated by Prof. J. A. Fleming, F.R.S.; "A Note on the Theory of Directive Antennæ or Unsymmetrical Hertzian Oscillators," by Prof. J. A. Fleming, F.R.S.

**Personal.**—Dr. W. M. Thornton, who has been head of the electrical engineering department of the Armstrong College, Newcastle-on-Tyne, for over seven years, has been unanimously appointed to the newly-created Professorship of Electrical Engineering in the College.

Among the honours conferred, on the conclusion of the Prince of Wales' visit to India, was a knighthood to Mr. S. H. C. Hutchinson, Director-General of Telegraphs in India.

**Cable Interruptions and Repairs.**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Tarifa—Tangier | Jan. 18, 1904 | — |
| Jamaica—Colon | Jan. 10, 1905 | — |
| Cadiz—Teneriffe | July 20, 1905 | — |
| Puerto Plata—Martinique | Dec. 15, 1905 | — |
| Tangier—Cadiz | Feb. 17, 1906 | — |
| Santa Lucia—St. Vincent | Feb. 19, 1906 | — |
| St. Vincent—Grenada | Feb. 19, 1906 | Mar. 19, 1906 |
| Porto Rico—St. Croix | Feb. 26, 1906 | — |
| Alexandria—Larnaca | Feb. 28, 1906 | Mar. 20, 1906 |

**Obituary.**—We regret to announce the death of Mr. Carl von Siemens, brother of the late Sir William Siemens and Dr. E. Werner von Siemens, which occurred at Mentone on Wednesday last from inflammation of the lungs. Born in 1829, he spent a large portion of his career furthering the interests of Siemens & Halske in Russia, and laid for the Russian Government an extensive network of telegraph lines. He was also prominently connected with some of the early transatlantic cable enterprises of Messrs. Siemens Brothers & Co., of which company he was still chairman at the time of his death.

**Exhibition by the Société Française de Physique.**—Following the practice of former years, the French Physical Society has arranged to hold a short exhibition of new apparatus and instruments relating to physical research. The days chosen are April 19th, 20th and 21st, and meetings will be held on the evenings of these days, at which the principal experiments of last year will be repeated. The first evening meeting is for members of the Society only, but visitors may be introduced to the other two evening meetings. Further information may be obtained from the general secretary, M. Henri Abraham, 15, Rue d'Ulm, Paris.

**Energy Consumption of Electric Carriages.**—In order to test the energy consumption of electric carriages under unfavourable conditions, a 100 km. (62 mile) test run was recently organised in Paris over dirty snd slippery roads, fog prevailing at the time. A number of carriages carrying four passengers, and weighing complete over 2 tons, covered the entire distance at an average speed of nearly 15 miles an hour, and consumed less than 160 watt-hours per ton-mile. The first prize was gained by a carriage entered by M. Védrine, which required 155 watt-hours per ton-mile. According to *L'Industrie Electrique*, the energy consumption of this vehicle in ordinary conditions is from 110 to 120 watt-hours per ton-mile.

**Electricity v. Gas.**—At the last meeting of the Metropolitan Asylums Board the Works committee reported that the engineer-in-chief had prepared a statement showing the relative cost of gas and electricity at the Eastern Hospital during 1903, 1904 and 1905. The total expenditure for gas and electricity combined for 1905 was £591. 19s. 7d. less than for 1904 (when gas was used until September), and £639. 7s. 2d. less than for 1903, when gas only was used for lighting and cooking. These results the committee considered most satisfactory, more particularly when regard is had to the many other advantages, such as greater purity of atmosphere and reduced cost of annual cleaning and decorative works with which the introduction of electricity was inseparably associated. The total cost of the electric lighting installation was £3,445. 0s. 1d.

**The Aluminium Production of the World.**—A report has recently been prepared by Mr. Guenthner, American Consul-General, on the output of the various aluminium-producing works. The figures as given in the *Chamber of Commerce Journal* are as follows: The Aluminium Industry A.G., with works at Neuhausen, Switzerland, Land-Gastein, Austria, and Rheinfelden produce 3,675 tons per annum. The British Aluminium Co. has works at Foyers, Scotland, and also at Sarpfos, in Norway, and its total estimated annual out put is 2,250. The Société Electro-Metallurgique Française produces 2,325 tons per year at its works at La Praz and Les Sordrettes. The other French company, the Société des Produits Chimiques d'Alois et de la Camargne has works at Calypse and St. Felix, whose combined output for one year is given as 2,100 tons; but we understand that the French works were recently closed for some months owing to a strike. The Pittsburg Reduction Co, of Niagara Falls, Shavenigan, Canada and Massena is stated to have a combined output of 4,200 tons.

**An Electric Capstan.**—A recent number of *l'Electricien* contains a description of an electric capstan on the "Pieper" system similar to those in use at Antwerp. Owing to the small amount of the excavation allowed for the capstan pit, a very compact arrangement had to be adopted. In order to facilitate examination of the working parts all the apparatus is attached to the cover of the pit, which is pivoted about a horizontal axis so that the whole can be turned bottom upwards for inspection. The current is brought in through slip rings so that the motor can be run in the reversed position if required. The tractive effort obtainable is 1,250 kg. at the periphery of the capstan, at 60 revs. per min. The compound wound motor is rated at 27 B.H.P. and runs on a 220 volt circuit. It drives the capstan head through a worm gear—control is effected by a pedal. In its normal position the contacts attached to the pedal short circuit the series field coil of the motor with the effect of producing a braking action sufficiently powerful to stop the capstan in a quarter of a revolution. The depression of the pedal closes the contacts which put the starter into action. The starter itself, which is not inside the capstan pit, is of the multiple switch type controlled by a main relay, each switch being successively actuated by a shunt solenoid as the motor gets up speed and the back E.M.F. increases. The relay is also arranged to trip the starter in case of overloads. Both the starter contacts and the pedal contacts are provided with magnetic blow-outs.

**Measurement of Telephonic Currents.**—An interesting discourse on the measurement of telephonic currents was given by Mr. W. Duddell at the Royal Institution last Friday. The chief experiment of the lecture consisted in showing simultaneously on a screen four series of waves indicating respectively the motion of the transmitter diaphragm, the wave-form of the current entering the line, the wave-form of the current at the receiving end of the line and the motion of the receiver diaphragm. Various vowel sounds were spoken into a speaking tube connected to the transmitter, and the effect of adding inductance and capacity in the artificial line was demonstrated by the shape of the curves. A thread was fixed to the diaphragm in each case and transmitted the motion to a light mirror fastened to a wire round which the thread was wound once, and the time element was given by a moving mirror driven at a uniform speed by an electric motor. The line currents were measured by oscillographs, and the same moving mirror was used to give the time element. The whole arrangement of apparatus was a marvel of ingenuity and of fine adjustment. Mr. Duddell's lecture was mainly devoted to emphasising the necessity of measurement in telephonic research, and he described various methods of making these measurements, the delicate micrometer due to Prof. P. E. Shaw for measuring the amplitude of the motion of a telephone diaphragm (*The Electrician*, Vol. LV., p. 549), the thermo-galvanometer and the oscillograph. For producing a pure sound Mr. Duddell uses either Mr. A. Campbell's vibrating bar or his own toothed-wheel inductor alternator. Incidentally also the lecturer called attention to the results recorded in Dr. H. B. Hayes' St. Louis Congress Paper in 1904 (*The Electrician*, Vol. LIV., p. 362), in which the advantage was shown of "tapering off" at the ends the inductance of a "loaded" telephone line.

**A new Petrol-Electric Railway Car.**—A new petrol-electric car which differs considerably in detail from that in use on the Delaware and Hudson Railway (described on p. 811 of *The Electrician* of March 2nd) has recently completed an extensive trial trip over a number of railways in the western part of the United States. The car was built for the Strang-Electric Car Co. by the Brill Co. and forms one of a number which are being supplied to various American railways. The petrol engine is only called upon to exert the average power required, as a battery is provided to take up the peaks of the load. The engine is of the six-cylinder three-crank "V" type with cylinder 8 in. diameter by 10 in. stroke, and the carburettor is arranged so that with a slight change of adjustment either paraffin, alcohol or crude oil can be used. High-tension ignition, with separate coils for each cylinder, is used and a belt-driven pump effects the water circulation. The 50 kw. continuous-current 250 volt generator is coupled direct to the engine and runs at 400 revs. per min. The storage battery of 112 cells has a capacity of 200 ampere-hours. Starting up is effected by the battery, and when the set is up to speed the battery and generator remain in parallel, the engine being provided with automatic governing devices dependent entirely upon the condition of the batteries and the consumption of current. The two driving motors are rated at 50 H.P. each and are of standard railway type, controlled by an ordinary series-parallel controller from either end of the car. The maximum speed is 50 miles per hour, and the average petrol consumption, according to the *Street Railway Journal*, is 0·45 gallon per car; 100 gallons of fuel are carried, so that the radius of action is 225 miles.

**Double-gauge Electric Locomotive.**—The Maschinenbauanstalt at Ustron (Silesia) is connected to the adjacent railway station by a system of railway lines whose gauge is partly 1,435 mm. (4 ft. 8½ in.) and partly 700 mm. (2 ft. 3⅝ in.). Altogether, the connecting lines between the station and the works are just over one mile in length. These lines are now to be "electrified," and the same locomotive is to travel over both the standard and the narrow-gauge portion of the system. To this end the locomotive is equipped with four axles, of which the two outer ones correspond to the standard-gauge and the inner ones to the narrow-gauge. All eight wheels are 650 mm. (25⅝ in.) in diameter, and the "standard-gauge" wheels are outside the locomotive frame, while the "narrow-gauge" wheels are inside the frame. Either pair of axles can be raised or lowered by the motorman in the cabin by a simple screw mechanism. The arrangement is as follows: Each of the outer axles is connected to the neighbouring inner axle by two substantial levers, and these levers are pivoted at their centres to the frame, and extended beyond the inner axles towards the centre of the locomotive, where they engage with a strong screw operated manually by the motorman. The two 6 H.P. continuous-current motors are bolted to the locomotive frame and drive the wheels by means of double-reduction gearing of the ratio 11·5:1. The teeth are always in mesh, and either the one or the other pair of axles is running idle. When fully equipped, the locomotive weighs 5 tons and is capable—according to *Elektrische Bahnen & Betriebe*—of hauling two fully-loaded railway goods waggons or 20 narrow-gauge trucks at a speed of about 4 miles an hour. Some of the leading dimensions are as follows: Wheel-base of standard-gauge wheels 2,010 mm. (6 ft. 7 in.), wheel-base of inner (narrow-gauge) axles 750 mm. (2 ft. 5½ in.), overall length of locomotive 4,180 mm. (13 ft. 8½ in.), total height above rail 2,940 mm. (9 ft. 7½ in.). The mechanical part of this interesting locomotive weighs some 8,400 lb., while the electrical equipment accounts for about 2,660 lb. It was built by the Austrian Siemens-Schuckert Co.

**A New Distance Switch.**—Herr W. Multhauf describes in a recent article in the *Elektrotechnische Zeitschrift* an improved switch mechanism for acting at a distance, invented by himself in conjunction with Dr. H. Kempf, and made by Messrs Hartmann & Braun. It is based on the action of steel reeds to vibrate at a given frequency, a principle which is now often used in frequency tellers. The author uses at the far end, where it is desired to switch in or switch off any kind of apparatus (transformers, double-tariff meters, motors, &c.) at certain times, a mechanism consisting principally of two reeds, one of which responds to a frequency slightly higher than the normal supply frequency, the other vibrating when the frequency is slightly diminished. The vibration of one or the other of the reeds then causes—by simple mechanical or electrical means—the switch to operate one way or the other. If it is desired to perform more than two operations, the author proposes to use a number of reeds of different natural periods. As it takes a couple of seconds for a reed to attain its maximum vibration, a reed of lower frequency may be passed without setting it into violent vibration if only the increase in the frequency is sufficiently rapid. There are also other means of preventing a reed of lower frequency from acting when it is desired to actuate a reed of higher frequency. Assuming the normal supply frequency to be 50 ∿ per second, it would be possible, for instance, to switch in transformers at 49 ∿ per second, street lighting at 48¾ ∿ per second and double-tariff meters at 48½ ∿ per second, switching the apparatus off again by raising the supply frequency to 51¼ ~ per second, 51 ~ per second and 51½ ~ per second respectively. Herr Multhauf acknowledges, of course, that the daily variations in the frequency of ordinary supply stations usually exceed the differences indicated above, and in such cases he advocates widely different frequencies, such as 30, 40, 60, 80 ∿ per second, &c. These frequencies he superimposes on the ordinary alternating or continuous current supply by a small generator of variable frequency connected across the 'bus bars or by a small transformer whose primary winding is in series with the feeder, while its secondary is fed with current at the frequency necessary to operate the desired reed at the far end.

**Specific Electrical Resistance of Coal, Ores, &c.**—Last summer the council of the Institution of Mining Engineers thought it desirable to have an accurate knowledge of the electrical resistance of coal, as well as of the rocks above and below any given seam of coal. As no data was available, Mr. G. C. Wood, B.Sc., undertook on request an investigation of the specific electrical resistance of coal, ores, &c., and suitable samples were obtained for experiment. The results were embodied in a Paper read by Mr. Wood before the Institution of Mining Engineers last August, which has just been sent us for review:

> The specific electrical resistance of coal, for the cases examined, is, in comparison with the layers above and below the coal, exceedingly high; in fact, so high that coal may be regarded as a very fair insulator. This fact, among others, is one worthy of note in connection with electrical work underground. When the coal is damp, its conductivity is practically wholly due to the water present. The specific resistance of a carboniferous limestone from the Barton quarries, near Darlington, was so high that the material was found very suitable for use as ballast on electric railways employing a live rail. Tests were carried out with high and low voltage continuous and alternating currents and by various methods, and the results are stated to have agreed well. The following table contains the average specific resistances of minerals found in coal mines:—

**Table I.**—*Specific Resistances of Minerals found in Mines.*

| Name of Mine. | Description of Mineral. | Sp. Resistances per Cubic Centim. |
|---|---|---|
| | | Ohms. |
| Cowpen Mill Pit .. | Roof: black shale ............ | 446,000 |
| " " .. | Steam coal .................. | 36,000,000,000 |
| " " .. | Thill: grey sandstone ........ | 20,300 |
| Murton .......... | Roof: soft blue shale.......... | 432,900 |
| " .......... | Coal ....................... | 33,900,000,000 |
| " .......... | Thill: blue shale.............. | 13,000 |
| St. Hilda ........ | Roof: black shale ............ | 337,000 |
| " ........ | Steam coal: top panel ........ | 80,100,000,000 |
| " ........ | " bottom panel .... | * |
| " ........ | Gas coal ..................... | 33,000,000,000 |
| " ........ | Coarse coal .................. | 3,395,000,000 |
| " ........ | Thill: bluish-grey posty shale .. | 105,900 |
| Skelton Park .... | Roof: dogger rock ............ | 52,100 |
| " " .... | Ironstone .................... | 167,000 |
| " " .... | Thill: bottom rock............ | 52,000 |
| Greenside ...... | Lead ore ..................... | 7⅓ |
| Penrith .......... | Permian Sandstone ........... | 8,375,000 |
| " .......... | Carboniferous Limestone ..... | 2,900,000 |
| Barton .......... | " " ..... | 1,014,000 |

* This value is omitted from the table, as the specimen contained iron-pyrites.

From an examination of the tests it will be seen that lead ore is the only ore which, by practical tests based on differences in electrical resistance of large masses could, with certainty, be distinguished from the rocks surrounding it. The following values in megohms per cubic centimetre indicate the magnitudes of the specific resistance of coal and other well-known bodies: Gutta-percha, 400,000,000; arc-light carbon, 0·000,000,004; and coal, say, 40,000. Coal has, consequently, ten million million times greater resistance than arc-light carbon and ten thousand times less resistance than gutta-percha of the same dimensions.

**Asynchronous Generators in a Power Transmission Scheme.**—The Rheinthalische Binnenkanal is the name of a canal which has been built in the upper valley of the Rhine (Switzerland) for conducting the waters, which sometimes accumulate here with surprising rapidity, in a safe and quick manner to the Lake of Constance. On its way to the lake, the canal drops in three steps of about 10 ft. each, and it was decided to utilise these falls for the generation of electric power. Accordingly, three generating stations were built, and they have been in regular service since the beginning of this year. The main station, which is situated at Montlingen, is equipped with three three-phase 250 H.P. alternators of the rotating field type, while the two other stations, which are at Blatten (about 2½ miles from Montlingen) and at Lienz (about 3·1 miles from Montlingen) have each been provided with two 250 H.P. asynchronous generators. These are simply induction motors with short-circuited rotors driven above synchronous speed. They supply electric energy to the network in much the same manner as a railway motor of the induction type returns energy to the line when the train runs at an increased speed down hill. Such asynchronous generators, as is well-known, do not require a voltage regulation and they have not to be synchronised. According to the *Schweizerische Elektrotechnische Zeitschrift*, all three stations generate at 10,000 volts between the phases and supply energy into a distribution network of a total length of about 35 miles. The voltage and frequency of the network is determined by the synchronous generators at the main station, and the current delivered by each of the asynchronous generators depends simply on the power of the turbine by which it is driven. If the energy taken from the network drops, the alternators at the Montlingen station show a tendency to race, and the normal state of affairs is re-established by simply cutting out one or more of the asynchronous generators or by shutting down their turbines. In each of the two stations with the asynchronous generators there is only one man in attendance and the switchboard contains only ammeters and switches.

**The Corpuscular Theory of Matter.**—Continuing his discussion of the existence of ultimate positive particles of electricity, Prof. J. J. Thomson, in his third lecture at the Royal Institution, pointed out that recent experiments showed that the $\alpha$-rays from polonium give the same ratio $e/m$ as the $\alpha$-rays from radium—namely, 1,000. But Wien's measurements in a hydrogen tube proved that $e/m$ may be 10,000. On the other hand, this ratio is often much smaller. Since positive and negative electricity are always produced in equal amounts, the variability of $e/m$ can scarcely arise from difference in the value of $e$. Thus the atom of hydrogen, say, being neutral, must contain as many positive as negative corpuscles. That the number of corpuscles in an atom is large has been shown in many ways. For instance, the Zeeman effect occurs simultaneously in a great many lines of the spectrum of an element; Barkla's experiments on secondary Röntgen radiation furnish data for computing the number of corpuscles in a cubic centimetre of gas and yield a high figure per atom; and again, the measurements of the rotation of the plane of polarised light in gases yield a similarly big figure. Thus the number of positive particles in an atom must be great, and thus the mass of each particle must be a small fraction of that of the material atom. In explanation of the fact that the positive particle has not yet been detected, the lecturer offered the suggestion that the difference under experiment between the positive and negative corpuscles might arise from a difference in distribution. We know that the negative electricity is highly concentrated at the point of space assigned to the corpuscle; perhaps the positive electrical action is diffused; and as the electrical mass is proportional to $e^2$/(radius), that of the positive electricity, if the electricity is spread over a comparatively large volume, would be very small. Thus the material atom may be pictured as a sphere of diffused positive electricity in which the negative corpuscles swim. Here the question arises whether Kaufmann in measuring the electrical mass of the negative corpuscle really proved that there is no mechanical mass at all. As a fact, by experimenting on extremely small bodies, the electrical mass $e^2$/(radius) is given great prominence in the experiments while the mechanical mass, however great, is eliminated. For example, even if the corpuscle possessed a mechanical density as great as that of lead, particles the size of corpuscles would have a mechanical mass less than a million-millionth of their electrical mass, though charged spheres as large as atoms would, on the other hand, have a mechanical mass enormously greater than the electrical mass. Thus we are not at liberty to assume that the mass of objects in bulk arises from the negative corpuscle; some portion may be due to positive electricity. Prof. Thomson then turned to the architecture of the atom, and explained his views by Meyer's well-known magnetic experiments, where small mutually-repelling magnets are floated on water and bound in stable configurations by the force due to a large central magnet. In this illustration small numbers of the little floating magnets are used, whereas in actual atoms there are many corpuscles. Probably these numerous corpuscles are disposed in groups that act as the units in the illustrative experiment.

## ARRANGEMENTS FOR THE WEEK.

**(To-day) FRIDAY, March 23rd.**

PHYSICAL SOCIETY OF LONDON.

*5 p.m.* Meeting in the Pender Electrical Laboratory, University College, Gower-street, London. Agenda: (1) "On Unilateral Electric Conductivity over Damp Surfaces," by Prof. F. T. Trouton, F.R.S. (2) "The Construction and Use of Oscillation Valves for Rectifying High-frequency Electric Currents," by Prof. J. A. Fleming, F.R.S. (3) "On the Use of the Cymometer for the Determination of Resonance Curves," by G. B. Dyke.

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER STUDENTS' SECTION.

*7:30 p.m.* Meeting at the Municipal School of Technology, Sackville-street, Manchester. Paper to be read: "Lubrication and Lubricants," by R. C. C. Yates.

**SATURDAY, March 24th.**

TRAMWAYS AND LIGHT RAILWAYS ASSOCIATION.

*1 p.m.* Trip over the Aylesbury & Chesham lines and a visit to the Neasden power house. Special train leaves Marylebone Station at 1 p.m.

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture IV., by Prof. J. J. Thomson, F.R.S., on "The Corpuscular Theory of Matter."

**MONDAY, March 26th.**

ENGINEERING AND SCIENTIFIC ASSOCIATION OF IRELAND.

*7:45 p.m.* Meeting at the Royal College of Science, Stephen's Green, Dublin. Paper to be read: "Power Gas Plants: their Present Application and Future Possibilities with Special Reference to Ireland," by Thomas Rigby.

**TUESDAY, March 27th.**

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER LOCAL SECTION.

*7:30 p.m.* Meeting at the University. Paper to be read: "Alternating Current Motors," by L. J. Hunt.

TRAMWAYS AND LIGHT RAILWAYS ASSOCIATION.

*8 p.m.* Meeting at the Society of Arts, when a Paper will be read on "Motor Services in Relation to Tramways," by N. C. Macdonald.

**WEDNESDAY, March 28th.**

INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.

*7:30 p.m.* Meeting at 92, Victoria-street, Westminster, London. Paper to be read: "Electric Ignition," by M. G. Tweedie.

SOCIETY OF ARTS.

*8 p.m.* Ordinary General Meeting. Paper to be read: "Coal Conservation, Power Transmission and Smoke Prevention," by A. J. Martin.

**THURSDAY, March 29th.**

ROYAL INSTITUTION.

*5 p.m.* Afternoon Lecture II., by Professor Bertram Hopkinson on "Internal Combustion Engines."

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Extra Meeting, when the adjourned discussion will be taken upon the following Papers: (1) "Electrical Equipment of the Aberdare Collieries of the Powell Duffryn Co.," by C. P. Sparks; (2) "Electric Winding Considered Practically and Commercially," by W. C. Mountain (abstract of a Paper read and discussed at meeting of Manchester Local Section on Jan. 16, 1906)

**FRIDAY, March 30th.**

ELECTRO-HARMONIC SOCIETY.

*8 p.m.* Last Smoking Concert of the Season at Holborn Restaurant (King's Hall). Sir W. H. Preece, K.C.B., F.R.S., will preside.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse by Prof. P. Zeeman on "Recent Progress in Magneto-Optics."

**SATURDAY, March 31st.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture V., by Prof. J. J. Thomson, F.R.S., on "The Corpuscular Theory of Matter."

# CABLE GEAR FOR A NEW JAPANESE CABLE SHIP.

The cable gear and equipment for the new cable ship which the Japanese Government are building in Japan has been just completed by Messrs. Johnson & Phillips, and we recently had an opportunity of seeing the combined picking-up and paying-out machine under steam at their works at Charlton. This is the second cable gear which the firm have made for the Japanese Government. The first was made about ten years ago for a ship built in Scotland, named the "Okinawa Maru," and was described in *The Electrician*, Vol. XXXIII., p. 816. In the present case, however, the steamer is being built entirely in Japan, the only parts coming from this country being the cable machinery, the bow and stern sheaves, dynamometers, bell mouths and tank fittings, which were ordered from Messrs. Johnson & Phillips through Messrs. A. R. Brown, McFarlane & Co., of Glasgow.

The vessel is 240 ft. long and 34 ft. beam. A plan and elevation of the ship is given in Fig. 1, and Fig. 3 shows a view of the cable gear erected for testing in the works. The gear is in many respects similar to that supplied ten years ago, but embodies some improvements in design and is driven by two independent steam engines. Also, the parts are slightly differently arranged to suit the space available between decks in the particular ship. The details of the gear are shown in Fig. 2.

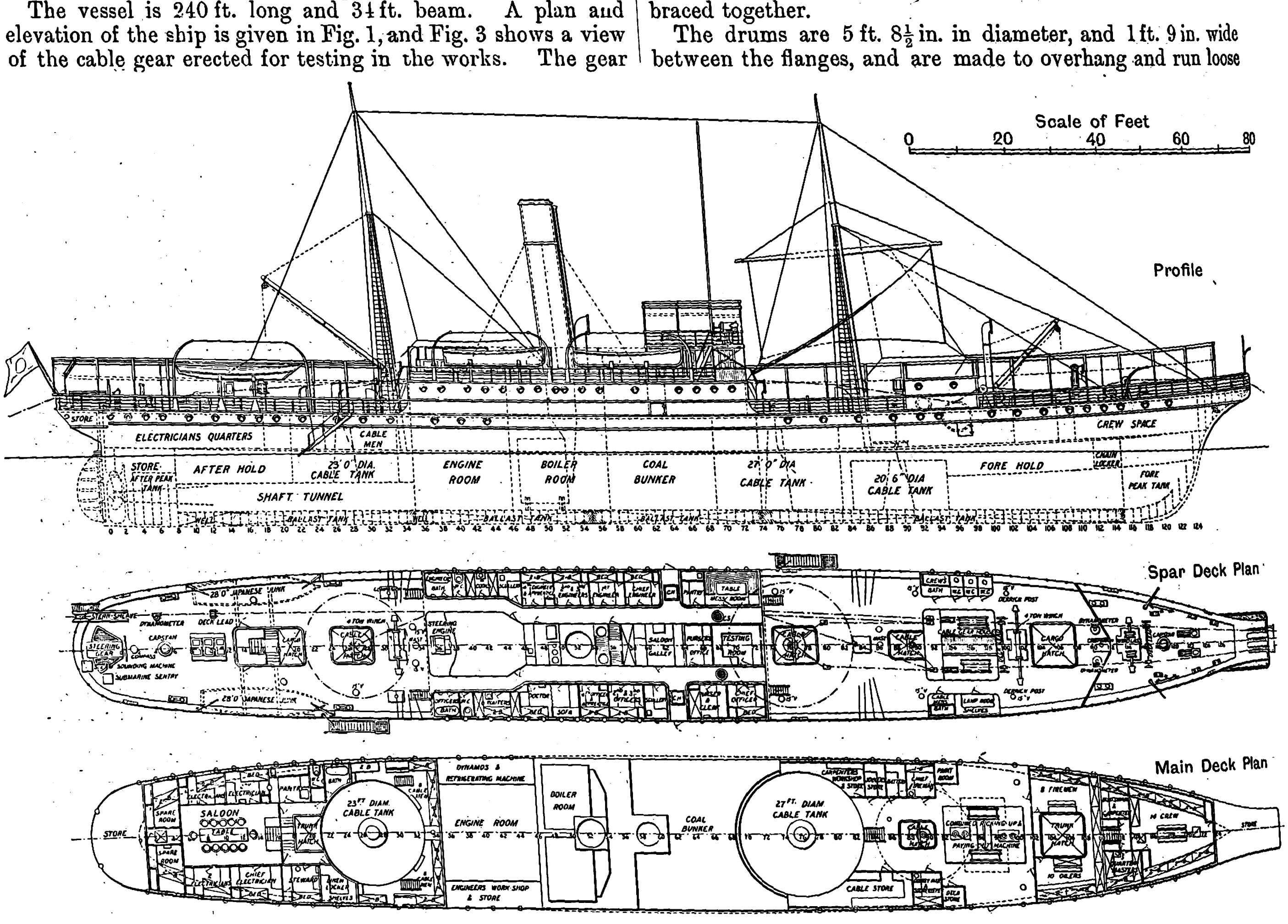
Scale of Feet
0
20
40
60
80
Profile
STORE
ELECTRICIANS QUARTERS
CABLE MEN
CREW SPACE
STORE AFTER PEAK TANK
AFTER HOLD
23' 0" DIA. CABLE TANK
ENGINE ROOM
BOILER ROOM
COAL BUNKER
27' 0" DIA CABLE TANK
20' 6" DIA CABLE TANK
FORE HOLD
FORE PEAK TANK
SHAFT TUNNEL
Spar Deck Plan
STEERING GEAR
CAPSTAN
DYNAMOMETER
DECK LEAD
SOUNDING MACHINE
SUBMARINE SENTRY
28' 0" JAPANESE LAUNCH
STEERING ENGINE
SALOON
GALLEY
TESTING ROOM
CABLE HATCH
CARGO HATCH
Main Deck Plan
STORE
SALOON
TABLE
23FT DIAM CABLE TANK
DYNAMOS & REFRIGERATING MACHINE
ENGINE ROOM
BOILER ROOM
COAL BUNKER
ENGINEERS WORK SHOP & STORE
27FT DIAM CABLE TANK
CABLE STORE
14 CREW

Fig. 1.—Elevation and Plans of new Cable Ship being built for the Japanese Government.

The two engines are each of the double cylinder high-pressure type, as considerations of starting under heavy load are more important than the gain in steam consumption that would be obtained by the use of compound engines. The cylinders are 8 in. diameter by 8 in. stroke, and each engine can develop 110 B.H.P. with steam at 150 lb. pressure. With the two engines in action the gear will lift against a strain of 25 tons at the rate of 1 knot per hour, which will be found sufficient to deal with cables in any depth of water. The gear practically comprises two separate machines, arranged so that either one or both of the engines may work either or both of the drums through any one of the four gears, the combination effectually providing against the possibility of a total breakdown at any time. Each engine drives on to its first gear shaft by a cast-steel double-helical bevel gear, with machine-moulded but uncut teeth, arrangements being provided so that the driving pinion can be shifted out of gear when required. Each machine has two different reduction gears, either of which can be put into action by sliding the spur wheels in and out of mesh after the manner of the gears employed on automobiles. A sliding gear wheel on an intermediate shaft is provided, by which the two systems can be connected together, so that either engine can drive either drum through any one of four different gears, which are all of different ratio, the maximum giving 4 knots per hour, at which speed a pull of $6\frac{1}{4}$ tons can be exerted. In this system of gearing all wheels not required for actual driving are completely out of gear. The frame is substantially constructed, with steel-plate sides well braced together.

The drums are 5 ft. $8\frac{1}{2}$ in. in diameter, and 1 ft. 9 in. wide between the flanges, and are made to overhang and run loose on their shafts. Each is driven by a pinion gearing into an internal gear-ring attached to the drum, these pinions sliding in an axial direction in and out of gear. It will thus be seen that no clutches of any kind are employed. As the brake ring is attached to the drum, it is only necessary to have the drum and "holding back" gear running when paying out. Another advantage of the fixed shaft is that the drum shaft and the intermediate shaft also act as ties, and greatly strengthen the frame. Lubrication of the drum bearings is effected by large grease cups which are attached to the fixed shaft, so that they can be tightened up while running. It should be mentioned that the position of the internal gear-rings on the drums allows of the pinion shafts being supported by outer bearings, a point of great importance, since the provision for the sliding of the pinion prevents the inner bearing being close up to the pinion when in the driving position.

The main brakes consist of steel bands lined with elm blocks. They are made to close on the drum by means of a double-thread screw, actuated by a hand-wheel through a worm gear, which gives a very fine regulation for the lighter strains, and at the same time gives enormous holding power. The back of each brake band is fitted with a water service pipe, with nozzles at intervals, which direct jets of water between the joints of the brake-blocks inwards, right on to the surface of the drum. Water is supplied by a small Worthington steam pump. It is possible to utilise the effect of both brakes at once on one drum by coupling the drums together. The brake bands are held away from the drum when off by springs at several points.

The "hauling off" and "holding back" gears are mounted on the spar deck, and are each driven by a silent saw-tooth chain from a shaft carrying a pinion, which can be made to slide into engagement with the internal gear-ring on one of the main drums. They are provided with a friction brake and "free wheel" arrangement so that they are driven in one direction only, that is to say the "picking-up" direction, then revolving with a slightly higher peripheral speed than the main drum and thus keeping the cable tight. When paying out, however, they are held back by the brake and allowed by the "free wheel" to revolve with a slower peripheral speed than that of the main drum. When, therefore, it is necessary on a picking-up job to reverse and pay out a little slack, the gear acts quite automatically. This is a great advantage over the older system, in which it was necessary to put a clutch in and out of gear. A screw gear is also provided for traversing the haul off sheave across the face of the drum to suit either an "inside" or "outside" lead, and this can be worked while the machine is running.

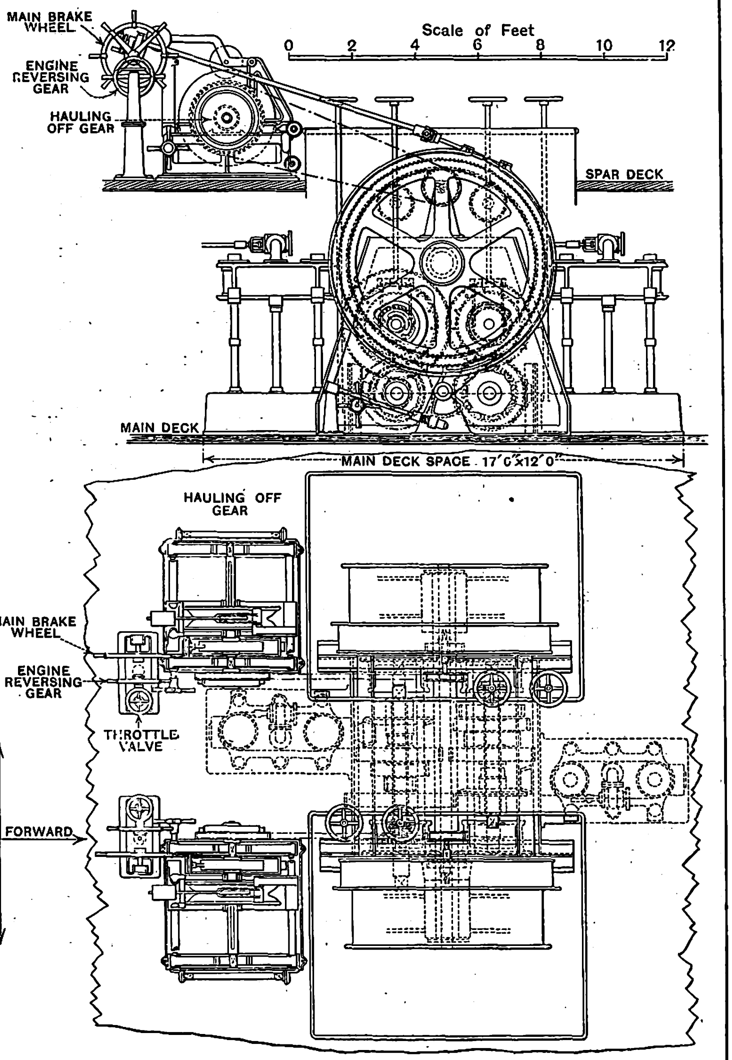

Fig. 2.—Elevation and Plan of Combined Picking-up and Paying-out Machine.

As will be seen from the figures, practically the whole of the actuating gear is operated from the spar deck. The two main brake wheels, the two steam stop valves, the engine reversing gears and drain cock handles are all within reach from one position. The hand-wheels for putting the various gears into action are all close by, as well as the levers for the putting into action and regulating of the hauling-off gear. It is only necessary to go below to couple the two engines, or to adjust the fleeting knives when the cable is being first passed round the drum. The total weight of the machine is about 31 tons, and the equipment is generally similar to that supplied by the same firm to the c s. "Pacific" of the Great Northern Telegraph Co. and the c.s. "Patrol" and c.s. "Restorer" for the Eastern Extension Telegraph Co., see *Electrician*, Vol. L, p. 757.

The bow gear has three sheaves, each 4 ft. 3 in. diameter, the two outer sheaves are of **V** section and the middle one of **U** section. These sheaves all run loose on a fixed shaft. Cast-iron whiskers or guards are provided between each sheave and at the outsides, to prevent the cable getting out of the grooves. These whisker castings are bolted to steel girders which are built into the ship, and the shell plating will be brought up and attached to the whiskers. The stern gear has only one sheave, which is 3 ft. 2½ in. diameter. This is provided with whiskers and built on girders similar to the bow gear, but is not connected to the hull plating.

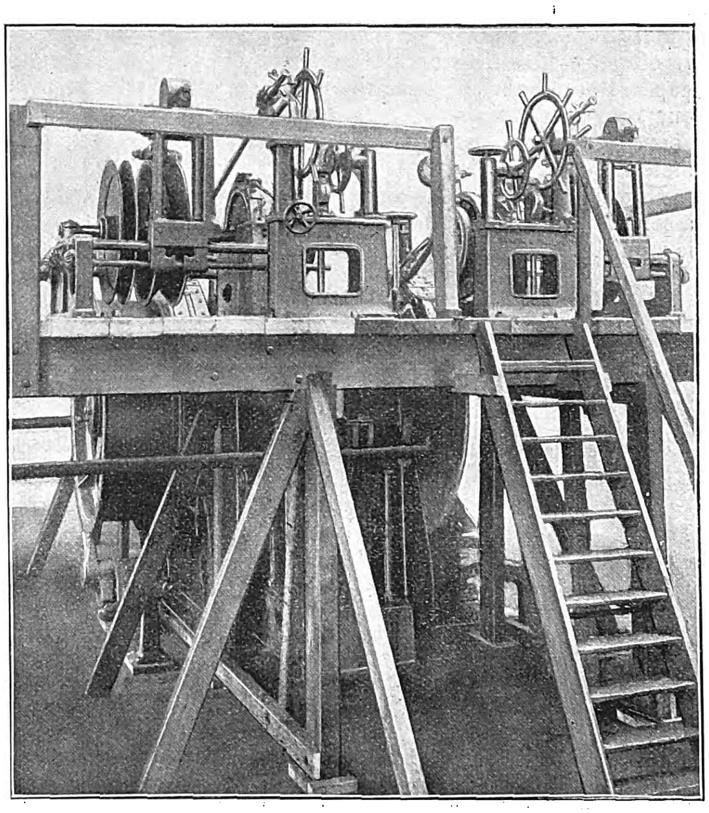

Fig. 3.—Cable Gear Erected for Testing.

Three dynamometers for registering the strains on the cables are provided, and these are fitted with an internal spring, which comes into compression as the moving part of the dynamometer descends and gradually reduces the effective weight, thus allowing very low as well as very high strains to be registered without the need of adding or removing weights.

The usual leads consisting of **A** frames with sheaves are provided at each side of the dynamometers and at the forward part of the gear, while single and double-roller leads on pedestals are provided, over which the cable passes from the tanks to the machine. Another part of the equipment consists of two electric hauling gears for hauling the cable from the picking-up machine to the tanks, or for turning over the cable from one tank to another. Each of these is worked by a 6 B.H.P. fully-enclosed watertight continuous-current motor running on a 110 volt circuit at 1,200 revs. per min.

The gear has been designed by Mr. G. C. Pearson, to whom our thanks are due for the information and drawings kindly placed at our disposal. We understand that a similar equipment is in hand for the new c.s. "Burnside," which is being built for the United States Government.

# A STUDY IN THE DESIGN OF A 500 KW. CONTINUOUS CURRENT GENERATOR.

BY DR. MAX BRESLAUER.

(*Concluded from page 838*).

## SPECIAL DEVICES TO OBTAIN GOOD COMMUTATION.

The satisfactory behaviour of the generator, in spite of these apparently bad features, is to be attributed in the first instance to the shape of the pole horns as shown in Fig. 3. It will be noticed that the air-gap varies between 4 mm. and 9 mm., and thus a strong commutating field is created just at the point where the short-circuit has to take place.

The effect of this device, as is well known, is to prevent field distortion by creating an artificial distortion on the opposite direction at no load which will be partly or completely balanced at full or overload as may be desired. If, for instance, as in this case, the distorting AT of the armature are approximately equal to the AT for air, teeth and core, one would have to make the gap on the leading horn of the pole half as great as on the trailing horn. This has the same effect as if on the leading horn the field AT were doubled at no load. When the load comes on, half of these AT will be balanced, and the resultant field will be normal and just the same as if the air-gap had been equal all along the periphery of the pole face. In our case this ratio was made 4 : 9, which, according to the above considerations, leaves, even at overload, a strong commutating field.

Now, in order to make proper use of this commutating field, a considerable lead of the brushes in the direction of rotation is required. This, on the other hand, would cause sparking at no load if the induced E.M.F. due to the commutating field were too strong. Given the reactance voltage, however, the counter E.M.F. is also fixed, and is bound to be about twice as great at no load than at full load owing to the inequality of the air gap. Hence a further well-known artificial device had to be employed to keep down the current generated at no load by the outer commutating E.M.F. This consisted of resistances fixed in the commutator lugs. There was plenty of room for these connections, the commutator diameter being 1,040 mm. and the armature 1,400, a distance of 1/2·360 = 180 mm. was available for the manganin strips used, which had a section of 0·8 × 30 mm. As the specific resistance of manganin is 0·39 per metre length and millimetre cross-section each coil gets an additional resistance of $\frac{0{\cdot}39\times0{\cdot}2}{24}=0{\cdot}325\times10^{-2}\omega$; the free length of the strips is 100 mm., each coil being short circuited through two strips and the brushes. As the resistance of the coil itself may be taken as $0{\cdot}12\times10^{-2}\omega$, the total resistance to be shorted by the brushes will be $0{\cdot}45\times10^{-2}\omega$; or almost four times as much as without the strips.

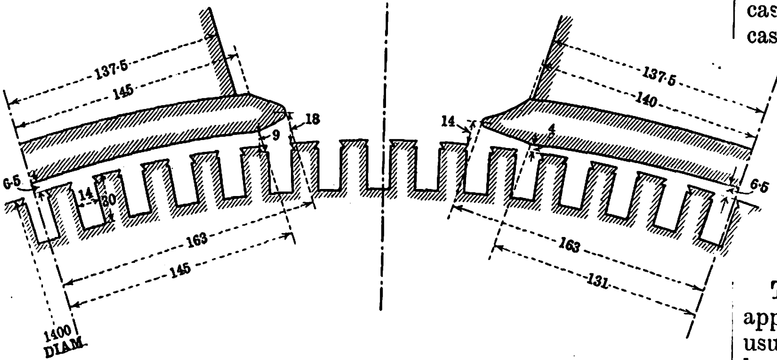

FIG. 3.—SECTION SHOWING SHAPE OF POLE FACES.

An external E.M.F. as induced in the coil by the commutating field can, therefore, if the brush resistance is small, produce only a comparatively small current. One is tempted to argue that the brush reactance, specially in the critical moment of leaving the segment, is infinitely higher than any resistance which can be inserted in the coil circuit. This is true, but one must not forget that at no load there is no current to be commutated; any short circuit current at no load can only be produced by the external E.M.F. Hence, it is not so much the current at the trailing tip of the brushes which must be considered, but more particularly the maximum current generated at any time during the short circuit, because such current would of itself produce a reactance voltage owing to its own rise and fall. Now, during the time the coil is short circuited, say just at the middle point, the brush resistance is really small compared with the increased resistance of the coil, and, owing to this, one can easily see that the external field at no load can be made if not four times, at least twice as great as without the resistances.

It has been asserted that such resistances between armature and commutator are not only useless, but, on the contrary, prevent good commutation. This is quite true for simple commutation, which depends only on the variation of the brush resistance, as is the case if the brushes have to be left in the geometrical neutral zone as in tram, crane or lift motors. In such cases the resistances would introduce a constant resistance into the short circuit path, causing the percentage variation of the brush resistance to be smaller. A few figures will make this clear at once: Take, for the sake of argument, the contact resistance at the middle of the time of short circuit to be 0·1ω and near the end of this time, when only a small part of the brush touches the leaving edge of the segment, to be 10ω. Now, assume the resistance of the coil itself to be 1ω, one finds a variation of resistance from 1·1 to 11ω, or exactly 1 : 10. Having, however, inserted a constant resistance of, say, 3ω between armature and commutator, which renders the metallic resistance four times greater, we get a variation from 4·1ω to 14ω, or only about 1 : 3·5, as compared with 1 : 10.

This, however, as already explained, applies only to cases where no external commutating E.M.F. is employed—viz., in cases where the reactance voltage is sufficiently low. In our case, where it was certain from the beginning that without a counter E.M.F. good commutation would be impossible, only a part of the commutation was to be effected by the variation of the contact resistance of the brushes; the greater part by the external E.M.F. Hence, in designing the machine it appeared to be quite reasonable to sacrifice a small part of the resistance commutation on load, but to then have available twice the counter E.M.F. so as to reduce the harmful effects of this external E.M.F. at no load.

The extremely good test results obtained showed that by applying those two simple devices the bad effects of an unusually high reactance voltage and large armature reaction can be perfectly counteracted.

It can, morever, be easily shown that the loss caused by the insertion of those resistances is quite negligible. The resistance of one strip was calculated above to be $1{\cdot}63\times10^{-3}\omega$. Now as each brush covers, as a minimum, three segments, three strips are paralleled with regard to the armature current by each set of brushes, and as there are in all five sets of brushes in parallel, 15 strips will be paralleled at both the positive or negative poles. Therefore, the total additional resistance from pole to pole will be $2.\frac{1{\cdot}63.10^{-3}}{15}=0{\cdot}216.10^{-3}\omega$, causing an additional loss at full load of 910 amperes of $910^2.0{\cdot}216.10^{-3}$ = 180 watts, or about 0·03 per cent. of the output.

In this connection, the material of the brushes also deserves attention. They consisted of a new material brought out by the Morgan Crucible Co., and behaved surprisingly well, reducing the brush friction, and running smoothly and noiselessly. The first official test at Loughborough was made with ordinary hard carbon brushes, but the "Morganite" brushes were used in the final test at Perth. Although good commutation was obtained in both cases, the commutator kept considerably cooler and smoother in the final test.

## LOSSES AND EFFICIENCY.

In order to ascertain its efficiency, the generator was coupled to a motor before leaving the shops and driven at a speed of 360 revs. per min. or 20 per cent. higher than normal. Then, by measuring the difference between the watts input of the motor when the generator runs excited or unexcited, one can obtain the iron losses, allowing, of course, for the small increase in the losses of the motor, which were quite negligible owing to the large size of the motor used.

The curve Fig. 5 shows the losses in kilowatts plotted against the flux in megalines. Analysing this curve one finds that it follows pretty closely the law given in the formula

$$\text{Loss} = 8{\cdot}8 N^{1{\cdot}6} z + 0{\cdot}0156 N^2 z^2,$$

where N is the flux in megalines and $z$ the number of alternations, the first part representing the hysteresis the second part the eddy current loss.

With a flux of 9·75 megalines, corresponding to 550 volts, and at 300 revs. per min. one obtains a total iron loss of 20,500 watts—16,800 watts due to hysteresis and 3,700 watts to eddy currents. In this case the loss at no load will be rather greater than at full load, the distortion of the field artificially produced at no load being neutralised at full load. Assuming it to be only 5 per cent. smaller one obtains the constant losses as follows:—Iron loss = 19,500 watts; excitation, 4,200 (7·5 amperes being the full load exciting current measured on test): friction on commutator, 1,800, total constant losses, 25,500 watts and the variable losses; loss in armature copper, 7,360; in brushes, 1,820; total, 34,680. Output, 500,000; input, 534,000; efficiency, 94·0 per cent. at full load and 94·2 per cent. at 600 kw.

After six hours' full-load run with 910 amperes and 550 volts the temperature rises were found to be 52°F. (= 29°C.) on the armature, 58°F. (= 32°C.) on the commutator and 50°F. (= 28°C.) on the field coils, all measured by thermometer. When the machine was on full load at its normal voltage and running at 300 revs. per min. the pressure across the field coils was 420 volts at the commencement of the test and 485 volts at the end of the run under the same conditions, indicating an increase of resistance of 15 per cent. or a mean rise in temperature in the shunt windings of 37·5°C. (= 68°F.). After 4½ hours' running the temperature kept fairly constant owing to the exceedingly good ventilation. After half an hour's shut down while the above temperatures were taken, the generator was further run with 1,100 amperes, corresponding to 20 per cent. overload, for two hours, at the end of which time the armature showed a rise of 64°F. (= 35·5°C.), the commutator 62°F. (= 34·5°C.), the field 52°F. (= 29°C.).

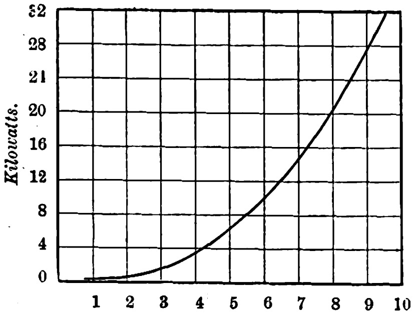

FIG. 5.—IRON LOSSES AT 360 REVS. PER MIN.

An analysis of above results leads to the following conclusions:—The iron losses, as measured in the armature, were 19,500 watts, and those in armature copper 7,360 watts, total 27,000 watts. Taking as radiating surface the total surface of the stampings, the armature outside diameter being 1,400 mm. and the inside diameter 982 mm., we obtain a total iron length, without ducts, of 275 mm., with five ducts of 10 mm. each. Hence the total cooling surface is 570 dm.², and

$$\frac{27{,}000}{57{,}000} = 48{\cdot}5 \text{ watts per dm.}^2$$

Having a peripheral speed ($v$) of 22 metres per second, the usual formula for temperature rise would give

$$t = \frac{3{\cdot}3 \times \text{watts/dm.}^2}{1 + 0{\cdot}1v} = \frac{3{\cdot}3 \times 48{\cdot}5}{3{\cdot}2} = 50°\text{C. rise},$$

against 32 deg. observed, which shows the influence of the air ducts, not taken into account in calculating the cooling surface.

The diameter of the commutator is 1,040 mm., its useful length 304 mm. and its peripheral speed 16·3 metres per second.

Taking the usual assumption of 2 volts drop by brush resistance one obtains with 910 amperes a loss of 1,820 watts and a friction loss of 1,800—total 3,620. Having a cooling surface of 116 dm.², and, therefore, $\frac{3{,}620}{116} = 40$ watts/dm.², the rise to be expected was $\frac{3{\cdot}3 \times \text{watts/dm.}^2}{1 + 0{\cdot}1v} = 50°\text{C.}$ The observed rise was 28°C, showing that the figure 3·3 does not hold good for the radiation occurring in case of commutator surface, and the figures quoted by Fischer-Hinnen of 1·5–1·8 appear to be nearer to the truth.

The field coils are of special interest from the standpoint of heating. The thickness or height of the coil is 70 mm., whereas 60 mm. is generally regarded as a safe limit. Now, as the observed excitation was 7·5 amperes at an average of 470 volts across the field terminals, the total field loss was 3,520 watts. The winding length of the shunt coils being 170 mm. and its height 70 mm., the cylindrical surface exposed to the air works out to 250 dm.² for the 10 coils. Each coil was wound with 1,470 turns of 5·8 sq. mm. section. Thus we get $\frac{3{,}520}{250} = 14$ watts/dm.², and assuming the ventilating effect in the field-magnet frame to be only half as great as in the armature, one would have expected a rise of

$$\frac{3{\cdot}3 \times \text{watts/dm.}^2}{1 + 0{\cdot}05v} = \frac{3{\cdot}3.14}{1{\cdot}55} = 30°\text{C.},$$

whereas the observed rises were 28°C. by thermometer and 37·5°C. by resistance.

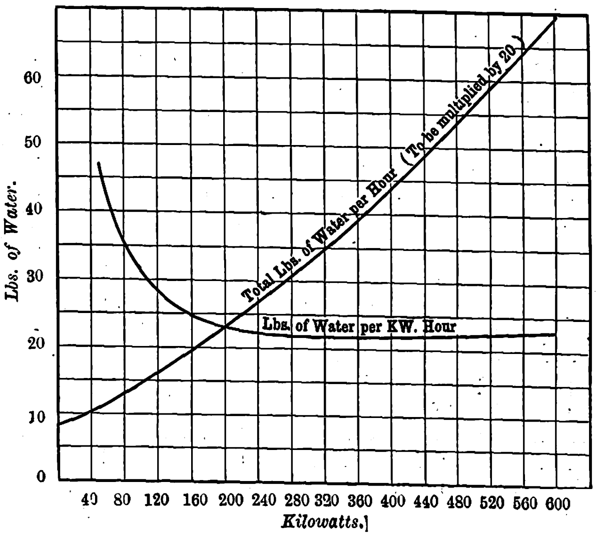

FIG. 6.—OFFICIAL TEST OF 500 KW. 300 REVS. PER MIN. CONTINUOUS-CURRENT GENERATOR COUPLED TO THREE-CRANK TRIPLE EXPANSION ENGINE

By courtesy of the Brush Engineering Co., Loughborough, the makers of the engine to which the generator was coupled, I am able to produce in Fig. 6 the curves giving the steam consumption per kilowatt-hour at different loads, as ascertained during the official tests in Loughborough by Mr. John Lambert, the borough engineer of Perth, under whose responsibility the heating and sparking tests were also made. At full load the consumption was 22 lb. per kilowatt-hour.

### MECHANICAL CONSTRUCTION.

All essential details of the mechanical construction, for which Mr. W. E. Robson is responsible, were shown to scale in Figs. 1 and 2. The yoke is of cast iron, the poles of cast steel, with laminated pole shoes of the shape described above screwed on to the pole limbs, the section of the latter being shown in Fig. 2. The proper section of the limbs with which the machine was originally standardised was, of course, circular. Owing, however, to the condition that the machine had sometimes also to run as compound generator, room had to be provided for the series windings which, as a rule, are lying idle. The section of the pole limbs is 730 cm.², and the induction with a mean leakage coefficient of 1·15 was 15,400 lines per square centimetre.

### ACTIVE MATERIAL.

An analysis of the active material used in this machine is given below :—

| | |
|---|---|
| Armature sheets | 1,376 kg. |
| 1/2 useful cast iron (corresponding to cast steel) | 2,360 kg. |
| Pole facings | 122 kg. |
| Pole limbs | 1,510 kg. |
| Total iron | 5,368 kg. = 5·4 tons. |
| Armature copper | 240 kg. |
| Shunt copper | 830 kg. |
| Total copper | 1,070 kg. = 1·1 tons. |
| Total active material | 6,438 kg. = 6 5 tons. |

As the machine has an output per revolution of $\frac{500,000}{300}$ = 1,667 watts, 3 2 kg. (= 7 lb.) of active iron and 0·64 kg. (= 1·4 lb.) of active copper, or 3·8 kg. (= 8·4 lb.) total active material were required for each watt per revolution.

It will be observed that only one-half of the active cast iron is taken into account, reducing this item to the amount which was actually required according to design. Further, the idle series copper, amounting to 360 kg., is not taken into consideration so as to allow a fair comparison with other designs.

In comparing these results, one should be careful to take machines of nearly the same size—that is, of the same watts per revolution. There is, however, a great lack of published data for high-speed generators of this size, although any amount can be found for slow-speed machines. This is owing to the fact that British firms are, as a rule, very chary of giving away any information. Continental firms, on the other hand, seldom hesitate to publish complete data of their newest types. This, therefore, has led to the absence of information on high-speed generators of this size, as high-speed machines, although largely used in England, are very seldom met with abroad. It is, moreover, not quite fair to compare a slow-speed generator, even if of the same watts per revolution, with a high-speed one. Still, as the comparison may be of interest, I have chosen two generators from Parshall and Hobart's book on "Electric Generators," and two from Arnold's latest work on "Direct-current Machines," the result being contained in the following table :—

| — | Parshall and Hobart. | | The writer's machine. | Arnold. | |
|---|---|---|---|---|---|
| Size—watts per rev. | 780 | 1,480 | 1,667 | 400 | 5,000 |
| Kilowatts | 250 | 200 | 500 | 100 | 500 |
| Speed | 320 | 135 | 300 | 250 | 100 |
| Active iron per watt per rev | 12 5 | 13·4 | 7·0 | 11·2 | 5·8 |
| Active copper „ | 2·4 | 1·66 | 1·4 | 2·2 | 0·76 |
| Number of poles | 6 | 6 | 10 | 6 | 10 |

The nearest in size to the machine under consideration is Hobart's 200 kw. generator, and with this it compares favourably in point of weight of iron, and is practically the same as regards copper weight. The economy of Arnold's design of the 400 size giving 100 kw. at 250 revs. per min., as compared with Parshall and Hobart's 780 size giving 250 kw. at 320 revs. per min., is very well shown, both having practically the same "specific weight." This shows the superiority of slow-speed machines, proving that high-speed machines are dearer per watt per revolution. In this case a high-speed machine of twice the size of the slow-speed machine shows the same "specific weight." Taking this into account, the writer's generator compares very well even with Arnold's 500 kw. 100 revs. per min. generator, which is three times as large in size, although, of course, better economy could be obtained on the larger-sized machine.

A proper comparison can only be made if more data of the current high-speed types generally used in England were supplied by British firms, and here only machines which have passed their tests equally well ought to be taken into account. Compensated generators can, of course, be built considerably cheaper, and can, therefore, not be compared with ordinary machines.

The writer's thanks are specially due to the British Electric Plant Co., Alloa, N.B., the makers of this generator, for generously giving him permission to publish all the above data.

## A SMALL PORTABLE ELECTRIC GRINDER.

A useful self-contained electrically-driven grinding tool, which can be used in connection with machines for taking ordinary cutting tools, is being introduced by the British Thomson-Houston Co. The apparatus consists simply of a small enclosed continuous-current motor carrying an emery wheel on a projection of its shaft, the whole being mounted on a suitable cross slide provided with a screw feed for traversing the whole motor in an axial direction. The fixed part of the slide is mounted on a square bar so that the complete apparatus can be held in the ordinary tool holder of a lathe or other machine. The accompanying figures show three applications of the grinder on a lathe, planer and boring mill respectively. The motor is cylindrical in form and the driving end bearing is split and double-cone sealed. Adjustment is effected by

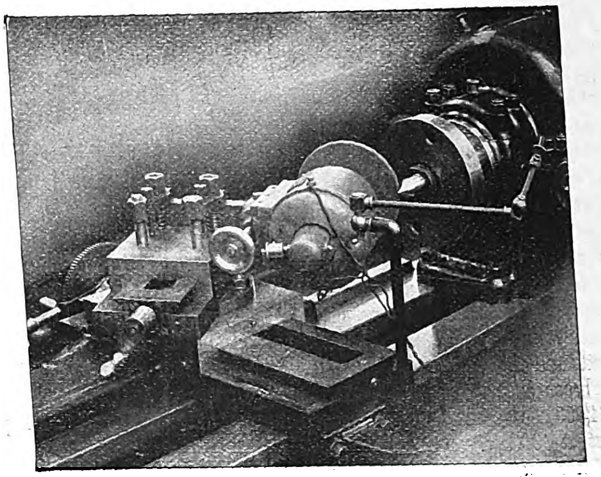

FIG. 1.—GRINDER ARRANGED FOR CENTRE GRINDING ON LATHE.

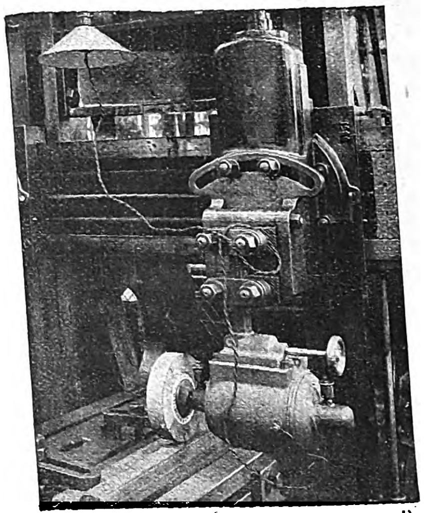

FIG. 2.—GRINDER ARRANGED FOR SURFACE GRINDING ON PLANING MACHINE

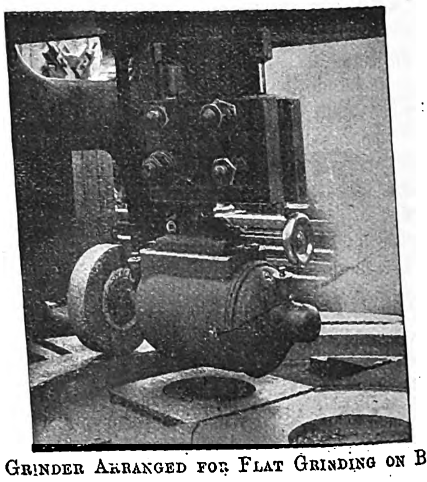

FIG. 3.—GRINDER ARRANGED FOR FLAT GRINDING ON BORING MILL.

means of a threaded bush which may be readily locked in position. Both bearings are dust-proof and lubrication is effected by grease cups. The $\frac{1}{4}$ H.P. size runs at 2,200 revs. per min., and is only $16\frac{3}{4}$ in. long over all, including emery wheel, and $6\frac{1}{4}$ in. diameter. A smaller size for $\frac{1}{8}$ H.P. is also made running at 2,200 revs. per min. The lead to the motor is provided with a plug for connection to an ordinary lamp holder. In view of the increasing importance of grinding operations this apparatus should have a wide field of usefulness, as it does not entail any alteration in the existing machinery.

## SINGLE-PHASE RAILWAY MOTORS AND METHODS OF CONTROLLING THEM.*

BY T. H SCHOEPF.

In the earlier single-phase motors the armature speeds were rather high, the full-load armature speed of a 150 H.P. Westinghouse series motor being 930 revs. per min. (see Fig. 1), which made it more suited for long runs with few stops and speeds of 60 miles an hour. These are the characteristics of the motor with which the locomotive supplied to Swedish State railways was equipped.† For suburban work with frequent stops and short runs, demanding a high rate of acceleration and high schedule speeds, a 150 H.P. series motor has been developed with a full-load armature speed of 535 revs. per min. the characteristic curves of which are shown in Fig. 2. For goods trains, a motor is required developing very great torque with high power factors and efficiencies at low speeds. The characteristic curves of such a motor are shown in Fig. 3. It may be mentioned that the continuous capacity of this motor is 140 H.P. The characteristic curves of a 250 H.P. motor for the same class of service are shown in Fig. 4.

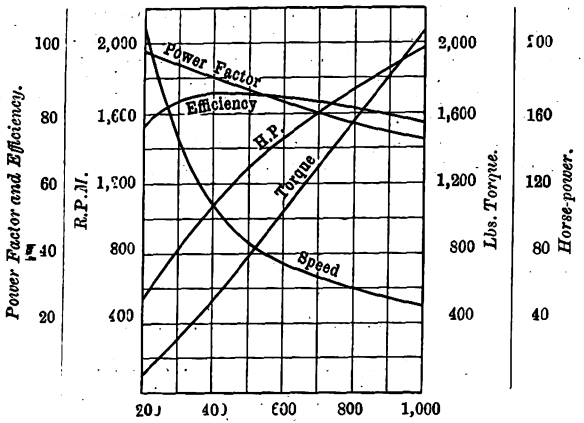

FIG. 1.—CHARACTERISTIC CURVES OF A WESTINGHOUSE 150 H.P. SINGLE-PHASE SERIES MOTOR, HIGH SPEED, DESIGNED FOR 250 VOLTS.

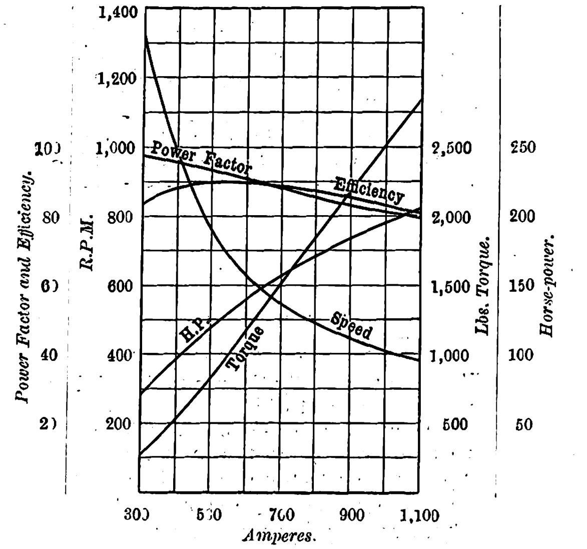

FIG. 2.—CHARACTERISTIC CURVES OF A WESTINGHOUSE 150 H.P. SINGLE-PHASE SERIES MOTOR, SLOW SPEED, DESIGNED FOR 250 VOLTS.

The ideal method of voltage variation in the supply of power to a single-phase motor is by means of an induction regulator, which provides a uniformly increasing voltage without interruption to the supply. At starting, the voltage of the regulator is directly opposed to that of the auto transformer, but as the secondary is rotated at a predetermined rate through an arc of 180 degrees, the opposing voltage gradually becomes less until at 90 degrees it is nil. When rotated through the second quadrant the regulator voltage is gradually increased and added to that of the auto-transformer until a position is reached diametrically opposed to that at starting, when full voltage is applied to the motors. This is the running position. There are, however, objectionable features in the induction regulator. It introduces an additional reactance in the circuit, and, therefore, materially lowers the power factor of the system. During the period of acceleration when the secondary is being rotated the regulator vibrates and "hums" loudly, and the torque varies so that it is difficult to maintain uniform rotation.

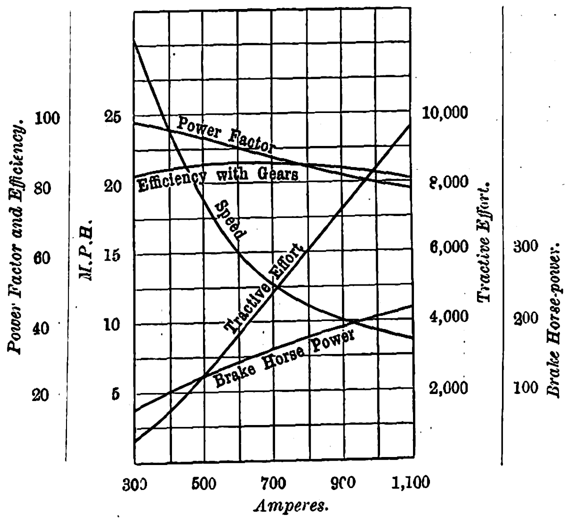

FIG. 3.—CHARACTERISTIC CURVES OF A WESTINGHOUSE 180 H.P. SINGLE-PHASE SERIES MOTOR DESIGNED FOR 250 VOLTS.

In trains provided with the multiple unit control any number of similar motor coach equipments may be controlled by the manipulation of a single master controller situated at any point in the train and electrically connected to the multiple control train line.

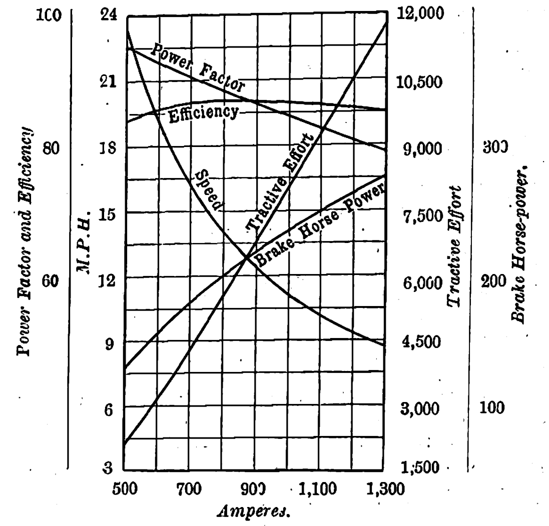

FIG. 4.—CHARACTERISTIC CURVES OF A WESTINGHOUSE 250 H.P. SINGLE-PHASE SERIES MOTOR DESIGNED FOR 250 VOLTS.

In this system of control the current is interrupted in the low-tension circuit, and a fuse only is necessary in the high-tension circuit, this being placed as near as possible to the current collector. The power necessary for the auxiliary multiple control circuits is supplied at a pressure of 50 volts and obtained from a tap at the low-tension side of the auto-transformer. This power, through the manipulation of the master controller, is utilised to energise the operating magnets, whose movements actuate the needle valves which regulate the admission and exhaust of the compressed air to work the unit switches. There are usually six unit switches, all contained in one case, but arranged in two groups of three switches each. The moving arms of the switches are connected to the taps from the auto-transformer, through the range of 160, 180, 200, 220, 240 and 280 volts. The stationary contacts of the switches in each group of three are connected to a common omnibus line; these two omnibus lines are connected to the opposite ends of a preventive coil, the middle point of which is connected with the reverser, and thence with the motors.

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* Abstract of a Paper read before the Manchester Local Section of the Institution of Electrical Engineers on February 27th, Mr. S. L. Pearce in the chair.

† A description of this locomotive will be found in *The Electrician*, Vol. LV., p. 206.

Fig. 5 is a diagram showing the electrical connections between the auto-transformer and the preventive coil for the various positions of the master controller. A series transformer is inserted in the high-tension circuit, and its secondary is connected to the operating coil of an overload relay which interrupts the circuits of the operating magnets when the current passing through the primary of the series transformer exceeds a predetermined value. The relay is provided with a holding coil which prevents the switches being closed, once they have opened on overload, until the master controller is returned to the "off" position. The operating magnets for actuating the needle valves are provided with laminated cores, and the unit switches which have to interrupt the motor currents when it is necessary to shut off power from the motors are provided with a powerful magnetic blow-out.

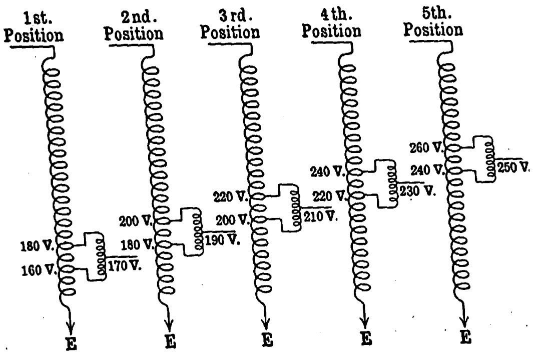

FIG. 5.—DIAGRAM SHOWING RELATIVE ELECTRICAL CONNECTIONS BETWEEN AUTOTRANSFORMER AND PREVENTIVE COIL, AND VOLTAGES APPLIED TO MOTORS FOR THE SEVERAL POSITIONS OF MASTER CONTROLLER.

Special attention may be called to the magnet for brake valve. This is so interconnected with the master controller and driver's brake valve that the power will be shut off from the motors and the brake applied throughout the train should the driver remove his hand from the master controller for any reason.

## DISCUSSION.

Mr. S. L. PEARCE (the chairman) said he would be very glad if Mr. Schoepf would enlarge on the points of difference between the straight series single-phase motors and repulsion motors for the main line working and their relative advantages and disadvantages. The fact that the engineers of both the General Electric Co. of America and the Westinghouse Co. favoured the former for railway work was rather noticeable as against the Continental firms' advocacy of the latter. It would be interesting to the meeting to know of any of the technical considerations which induced the engineers for the London, Brighton & South Coast Railway to adopt the Winter-Eichberg system of single-phase motors.

Mr. W. CRAMP said that to those who, like himself, had the opportunity of seeing the single-phase locomotive at Old Trafford, the Paper was especially interesting. For in this equipment one was struck by the perfect control, all operated from a tiny box on the dashboard not one quarter the size of the ordinary tramcar controller. The beautiful way in which the electro-pneumatic switches closed in proper order, and the absolutely perfect commutation under most trying conditions, were points which appealed to anyone acquainted with traction problems. While they were all much indebted to Mr. Schoepf for his Paper upon this ingenious series-motor equipment, he thought the author was not quite fair to other types of single-phase commutator motor. He (Mr. Cramp) classified the various types of single-phase commutator motors as follows: (A) 1. Plain series. 2. Neutralised series (Westinghouse, Finzi, &c.) 3. Compensated series (Eichberg). (B) 1. Plain repulsion. 2. Neutralised repulsion. 3. Compensated repulsion (Latour). In this classification "(B) 1" was the original repulsion motor consisting of laminated alternating-current field with direct-current type armature and commutator, the brushes being short-circuited and set at an angle to the main field. Thus the excitation was not provided by the armature. The motor "(B) 2" could fairly lay claim to the advantages of both series and repulsion type. Now in comparing these various motors they had to consider six points—viz.: (1) Torque, (2) efficiency, (3) power factor, (4) starting conditions, (5) commutation and (6) frequency. Taking these points in order, all the motors had the same torque characteristics, and in respect to torque per ampere they were about equal. With regard to efficiency, the compensated and neutralised motors were usually slightly less efficient than other forms by the loss in their extra windings. The power factor of the repulsion motor was not quite so good as that of the straight series motor, but, of course, compensated motors were the best in this respect. At starting, the repulsion motor was quite as good as its rival, possessing excellent torque and accelerating smoothly and well; but it was in commutation that the series motor scored, as salient poles could be used, while a small air-gap and a resultant practically rotating field were essential for the repulsion motor. Lastly, for different frequencies the repulsion motor was far better, since for anything like reasonable efficiency at full load the series motor had to run well above synchronism, while the repulsion motor only ran at about three-quarters synchronous speed. Thus repulsion motors could be built for frequencies of 40∽ per second, in which case series motors were almost out of the question. This was of special importance in England, where they might wish to use alternate-current commutator motors in connection with ordinary lighting circuits. Coming now to the matter of control, almost any system suitable for one type of motor was suitable for the others; but they had a choice of systems with repulsion motors that did not exist with series machines. For they might effect the control by rotor resistances as was done in the Schüler motor and the ordinary induction motor. It was this which enabled us to put a high voltage on the stator and get rid of the bulky transformer. He did not understand Mr. Schoepf's statement that a given repulsion motor must have its field winding adapted to one voltage. What was the objection to grouping a multipolar field in series or parallel for different pressures? He should like to call attention to the use of the "preventive coil," which seemed to fulfil the same function as the resistance coil in the ordinary accumulator switch.

Mr. COWAN referred to the Paper read eight years ago by Mr. Atkinson and to experiments which he and Mr. Atkinson had carried out on similar problems. They could not get over the excessive sparking, although they obtained variable speed and variable torque.

Mr. H. E. O'BRIEN asked if the author used air-cooled transformers. He thought the man who was responsible for the repair and maintenance of repulsion motors, arranged as Mr. Cramp suggested, with tappings on the 6,000 volt stator winding, would be likely to go stark staring mad.

Mr. CRAMP said his proposed arrangement was shown diagrammatically for a two-pole motor in Fig. 6. The high-tension mains were connected to the coil E, which excited not only the field FF, but also the secondary coil B in series with the usual armature and neutralising coils NN. It seemed to him that by this arrangement excellent commutation could be secured with a good series characteristic, while a high-tension stator winding, E, was possible without any fear of the attendant being driven stark mad.

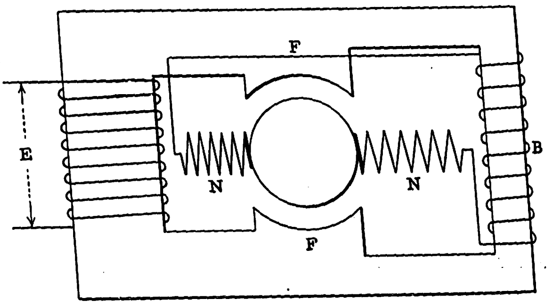

FIG. 6.

Mr. SCHOEPF, in reply, said he could give no reason for the London, Brighton & South Coast Railway adopting the A.E.G. system. The straight series motor was a good starting motor, but the repulsion motor was a better running motor. Lighting had not to be considered in dealing with motors which were for tramway work. At 40 ∽ per second the commutation would be bad for all types of motors. The London, Brighton & South Coast Railway, however, ran arc lamps off their 25 ∽ supply, and had no trouble with the lighting. He preferred oil-insulated air-cooled transformers.

# A NEW SINGLE-PHASE COMMUTATOR MOTOR.*

BY V. A. FYNN.

*(Continued from page 891).*

In order to illustrate more fully the properties of these motors, a number of curves are appended which have been obtained by actual tests on some of the smaller motors built. These machines have not been chosen as exemplifying the best results which can be secured, but were selected because comparative tests are available, and these, it is thought, will present the greater interest.

The motor No. 1 was built into the frame of a standard 50-cycles 4-pole machine, which, as an asynchronous squirrel-cage single-phase motor, gives ¾ B.H.P. continuously, at some 1,460 revolutions. It was fitted with an experimental continuous-current armature, and tested both as a plain shunt-induction motor, with a rotor short-circuited along two axes stationary in space and displaced by $\pi/n$ degrees (see Fig. 1), and as such an induction motor, with the addition of the improvements described in this Paper. (See Fig. 15 or 17.)

The armature was not of the most suitable design, but as the same one was used in both cases, the comparison is fair, and clearly shows the enormous advantage of the compensation. The curves relating to the first test are shown in Fig. 18; those relating to the second in Fig. 19. It can be seen that the addition of the author's compensating winding caused the no-load current to fall from 9·8 to 3·7 amperes, and the power factor to rise from 0·38 to 0·78, while the maximum efficiency rose from 32·8 to 49·5 per cent. Whereas, without compensation the output at maximum efficiency was 0·7 B.H.P., with compensation it reached 1·25 B.H.P. In the first case the speed dropped to 1,235; in the second, and notwithstanding the greater output, to only 1,285; the respective power factors being 0·665 and 0·935. With a more satisfactory armature both motors would be improved; their relative performances, however, would remain the same. With such an armature the compensated motor gives a continuous output of 1·25 B.H.P., and shows a smaller drop in speed. The efficiency in this case is about 3 per cent. less than than that of the corresponding squirrel-cage motor.

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* Paper read before the Institution of Electrical Engineers, March 8th.

A comparison between an asynchronous induction motor with squirrel cage and a motor of this new type is afforded by Figs. 20 and 21. The same frame, No. 2, has been used in both cases; it is that of a standard single-phase motor giving continuously 1·5 B.H.P. at 50 cycles and about 1,460 revolutions when wound for four poles. This machine had never been built with six poles, on account of the bad performance expected at the lower speed.

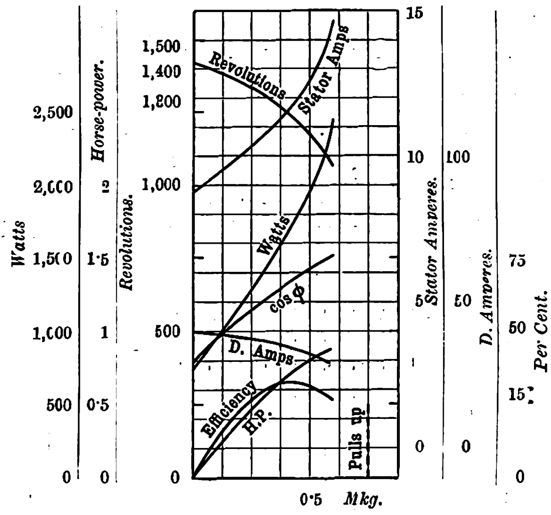

FIG. 18.—MOTOR NO. 1. 220 VOLTS. 50 ∾ PER SEC.

As an experiment it was wound for six poles, and the result of the tests is shown by the curves in Fig. 20. The machine in this form is of no practical value, as can be gathered from these curves, and it gets too hot. The densities would have to be much reduced to keep within the limits of temperature rise, and to reduce the no-load current as far as possible. With six poles an output of about 0·95 B.H.P. could be obtained, with a no-load current of not less than 70 per cent. of the full-load value. Preliminary tests showed that sufficiently good results would be obtained with the addition of the author's improvements. This stator was re-wound for 250 volts (to suit a certain supply circuit), the densities being kept practically the same; speaking exactly, they were lowered by 4 per cent. The result was a good commercial machine, and is illustrated by the curves in Fig. 21. In this form 1·3 B.H.P. can be obtained continuously from that frame when wound for six poles. Comparing the two sheets of curves, and reducing the stator current of the first to 250 volts, we find that at no load the speed has risen from 950 to 1,060, the power factor from 0·2 to 0·78, whereas the current has fallen from 7 to 2·5 amperes. At full load the speed is now 950 instead of 960, the power factor 0·952 instead of 0·68, the current 6·8 instead of 9 amperes, the efficiency 59·5 per cent. instead of 62·5 per cent., whereas the maximum torque which the motor can exert before pulling up has risen from 1·75 to 2·25 mkg. The maximum output, which of course takes the speed into consideration, has only increased by some 8 per cent. This improved motor, which is one of a standard series, easily starts with a pull of 2·5 mkg., that is 2·5 times the normal, while there is no sparking at the commutator either at starting or under normal running conditions.

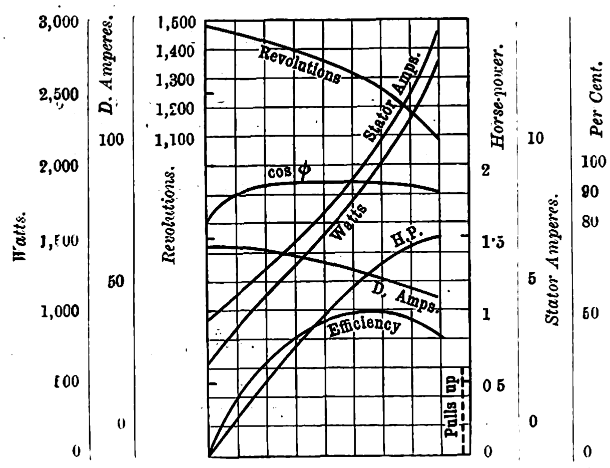

FIG. 19.—MOTOR NO. 1. 220 VOLTS. 50 ∾ PER SEC.

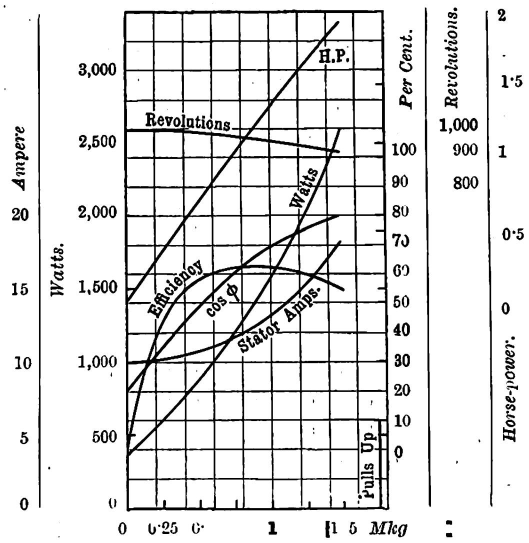

FIG. 20.—MOTOR NO. 2. 175 VOLTS. 50 ∾ PER SEC

Motor No. 3 shows another case where an ordinary squirrel-cage single-phase motor absolutely fails, whereas the new compensated motor gives excellent results. Frame and winding are identical in both cases. The results with the squirrel-cage are shown in Fig. 22, those with the new motor connected as in Figs. 15 or 17 are illustrated in Fig. 23. The frame used is that of a standard single-phase four-pole motor generally wound for four poles 50 cycles, and giving under these conditions 6 B.H.P. continuously. This frame was now wound for eight poles and 85 cycles; the test with the squirrel-cage showed that the machine was practically useless, whereas the results obtained with the new arrangement are quite good. This particular machine was designed for intermittent load. A comparison of the main data shows the following results at no-load: the speed of the squirrel-cage was 1,270 as against 1,355, the no-load current 41 as against 12·8 amperes, the power factor 0·19 as against unity. The maximum brake-horse-power available was 5·5 and 8 respectively, so that the squirrel-cage could not be worked normally at the required normal load of 5 H.P. The maximum efficiency is better by 2 per cent. for the compensated motor, reaching 66 per cent. at full load. The curves, Fig 23, also show the variation in the rotor currents in the C and D axes, as well as the value of the auxiliary E.M.F. (D volts) impressed on the D circuit. It has already been said that the overload capacity of these motors depended greatly on the value of this E.M.F. In this case the experiment was tried. With 10·38 auxiliary volts on the D brushes the power-factor was unity,

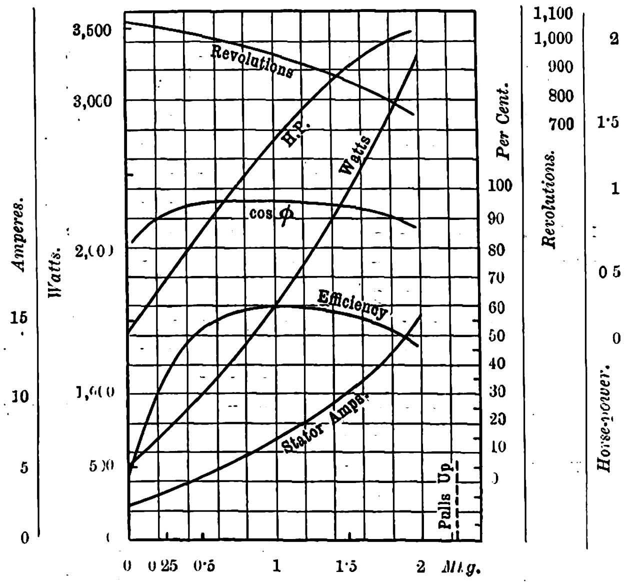

FIG. 21.—MOTOR NO. 2. 250 VOLTS. 50 ∾ PER SEC

the speed 1,266 revolutions, the output 7·97 B.H.P. at 63·1 per cent. efficiency, and the overload capacity 9 B.H.P. The current in the D axis rose to 110·5, that in the C axis to 174·5 amperes. It is owing to this large current in the latter axis that the efficiency was a little lowered. At lighter loads the current taken by the motor was leading. These last results have been added with the object of showing that care must be exercised in the predetermination of the auxiliary E.M.F.: if this be chosen too high the efficiency might suffer for the reasons already set forth. Particular care is required when high densities are adopted. The current in the field axis follows the same laws as an ordinary magnetising current.

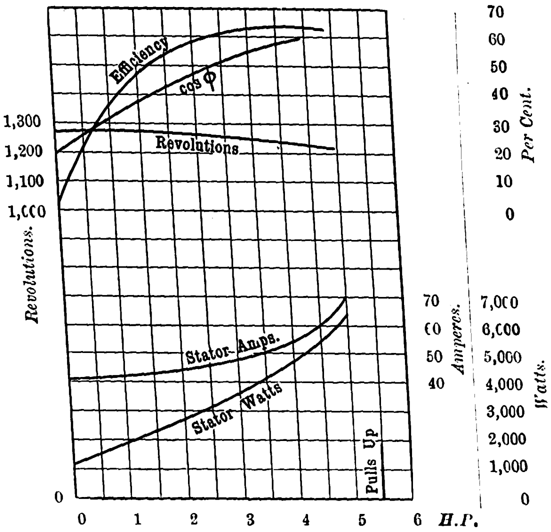

Fig. 22.—Motor No. 3. 150 Volts. 85 ∾ per sec.

We have so far been comparing the performance of the squirrel-cage motor with the new motor without auxiliary short-circuits in the armature, and have found that, at least for the smaller sizes and the lower periodicities, the latter is at a slight disadvantage with regard to efficiency; but even this disadvantage nearly disappears if, after the machine has been converted into a shunt-induction motor by short-circuiting the rotor along two stationary axes, several points of the rotor are also short-circuited according to the diagram in Fig. 12. This increases the efficiency of the motor by several per cent. But even then the comparison is not really a fair one, since the starting properties have not at all been considered. There is no known method of starting an ordinary asynchronous single-phase motor which will bear the least comparison with the one here described; the most effective all make use of rotors provided with slip-rings; and it would be more correct to compare with this new type that form of the ordinary induction motor which allows of the best starting torque being obtained. If this be done the ordinary induction motor entirely loses its one remaining advantage, since the use of the slip rings at once lowers its efficiency.

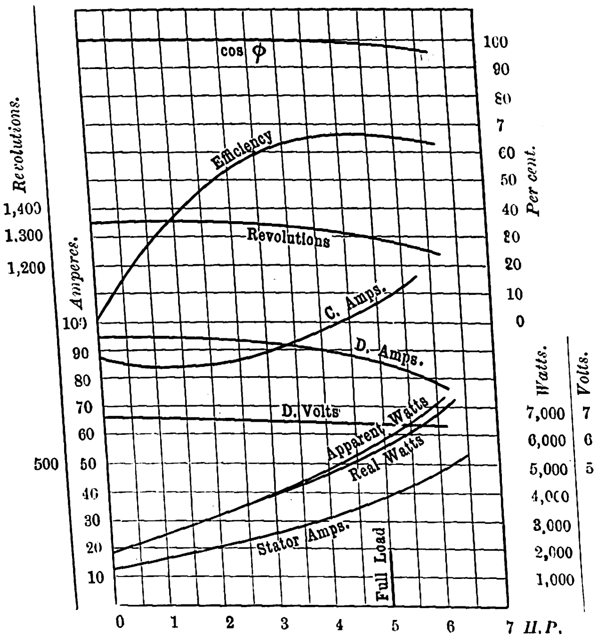

Fig. 23.—Motor No. 3. 150 Volts. 85 ∾ per sec.

In Fig. 24 is shown a set of curves illustrating the starting performance of motor No. 3. The point of the starting switch to which this set of curves corresponds is one for which the proportion of ampere-turns in the $S_2$ and $S_1$ windings is as 1 to 3·5. Similar sets of curves would be obtained for other points of the starting switch. The full-line curves illustrate in detail the performance of the motor with varying load as a series-induction motor (D circuit open). The speed for any given torque could be increased or decreased by moving the switch forward or backward. The dotted curves were obtained by gradually closing the shunt-exciting circuit, beginning with a resistance of half an ohm in circuit when a speed of 860 revolutions (two-thirds of normal) had been reached, reducing this to 0·15 ohms and then cutting it out altogether. It is seen that the available torque never sinks under 2·78 mkg., which corresponds to the full load, and that the speed curve is regular enough for all purposes. The maximum torque obtainable, however, only just reaches twice the normal. The auxiliary E.M.F. employed was the normal—*i.e.*, 6·5 volts—and was practically constant. Had the auxiliary E.M.F. been raised a little at starting and the shunt circuit closed sooner, say at about 600 revolutions, a rather more gradual speed curve would have been obtained. Such fine adjustment is, however, quite unnecessary for practical purposes; it is, indeed, quite sufficient to directly close the shunt circuit at about two-thirds of the normal speed; the dotted curves remain much the same; the kick in the stator-current curve is, however, more pronounced, and as nearly as could be observed the current rose momentarily to 68 amperes when the torque was kept nearly constant. In practice the torque required decreases as a rule with the speed, so that in reality the current would not rise to 68 amperes, and it is thought that the dotted curves represent more nearly the conditions which would obtain in actual practice if the shunt circuit were closed at two-thirds of the normal speed without the interposition of resistances.

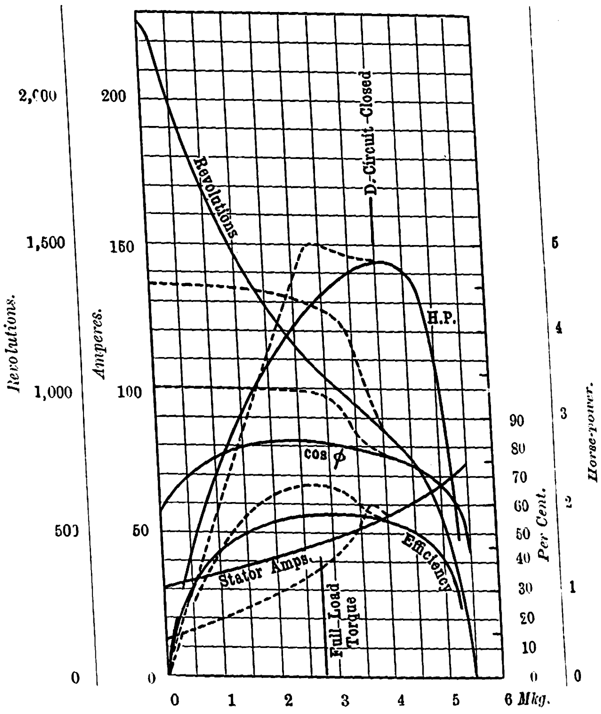

Fig. 24.—Motor No. 3. 150 Volts. 85 ∾ per sec.

It remains for us to deal with a modification of this motor, but capable of developing without increase of pressure at the terminals, and without starting apparatus of any kind, a torque at starting at least four times the normal on circuits of 50 periods. This machine is particularly well suited to do duty where a series characteristic is required, and since it can be converted into a constant-speed machine at any time, and with the greatest ease, it is also suited for ordinary work, more particularly, however, or elevator service on high-periodicity circuits, and where specially great starting efforts are needed, together with freedom from racing. It has been shown that the rotor winding in the axis DD is made use of in the shunt-induction machine as the field winding. It is clear that if it can be used as a shunt-exciting winding it can be also used as a series-exciting winding. The author has found that, for the purpose of starting and speed regulation, a very marked improvement can be secured by connecting the rotor winding along the axis DD in series with the field winding $S_2$ disposed on the stator, and also in series with the transformer winding $S_1$. Going a step further, he also connected the winding $S_3$, providing the auxiliary E.M.F. for improving the power factor when working at a constant speed, in series with the windings already enumerated. These connections are shown diagrammatically in Figs. 25 and 26 for both directions of rotation.

By this change of connections the nature of the machine is not altered in any way; it is still nothing more than a series-induction motor. As before, the stator group $S_1$ induces the armature current, but instead of all the motor field winding being disposed on the stator, part of it is also disposed on the rotor; the rotor winding itself in the axis DD doing duty as such.

The winding $S_3$ has a small E.M.F. generated in it which is cophasal and of the same direction as the E.M.F. impressed on the motor, and consequently increases the total active E.M.F. The advantages secured are manifold. As before, the machine can be designed to take as little current as may be desired on the first point of the starting-switch without the help of external resistances, transformers and the like, and with less turns in the group $S_2$ than were previously required. Whereas before, when the rotor field winding was not in series with the stator field winding, the starting torque fell to zero as soon as all the stator field winding was cut out, now the starting torque reaches a maximum at that point. This last difference is of extreme importance for heavy work, and particularly so for lift work. This modified motor also shows a very much better power factor when running as a series machine, the reason being that the E.M.F. (ER) generated at the D brushes is nearly opposed in phase to those components of the E.M.F. impressed on the terminals which go to balance the E.M.F.'s of self-induction generated in the motor windings. The phase of the E.M.F. due to $S_3$ tends to coincide more and more with the motor field as the motor speed increases. The field brushes D, which before were idle during the greater part of the starting period, are now made use of from the very beginning and with the greatest benefit. As to the conversion of the motor into a shunt-induction machine, it is almost simpler than before; all that is necessary is to short-circuit gradually, or suddenly, the points in the connections marked 5 and 6. If a resistance W is connected in parallel to these points, the speed can also be regulated to some extent by its help. The higher the resistance, the nearer will the characteristic of the motor approach to a series characteristic. A reduction of this resistance tends to bind the motor more and more to its natural constant speed; decreasing its speed if the same happens to be above the normal, and increasing it if it happens to be below the normal.

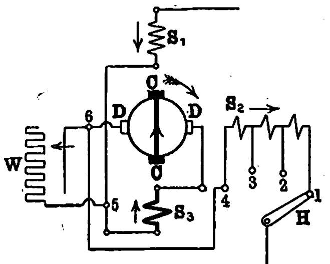

Fig. 25.

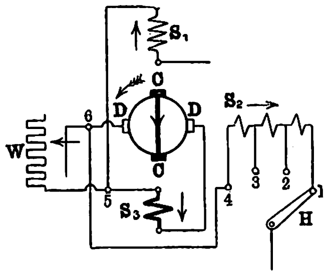

Fig. 26.

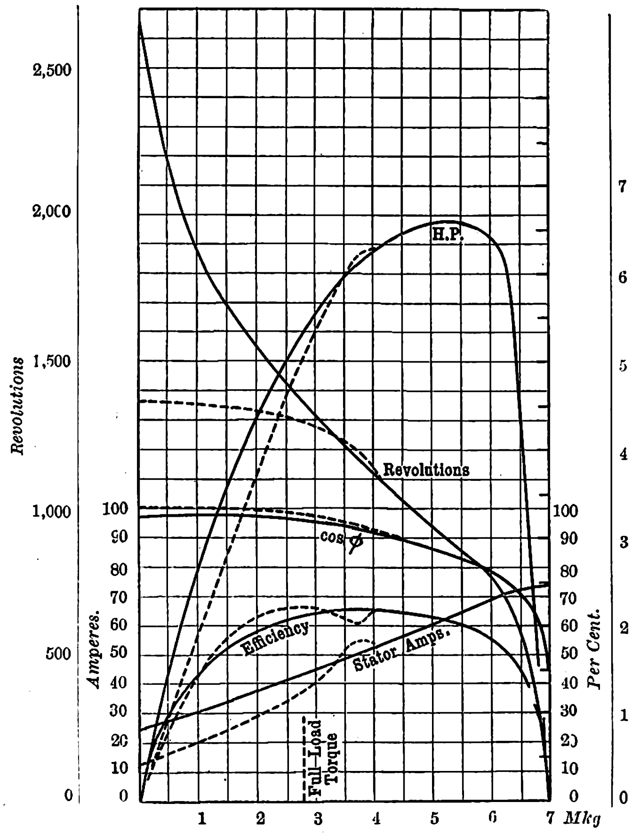

Fig. 27.—Motor No. 3. 150 Volts. 85 ∼ per Sec.

For the purpose of short-circuiting the points 5 and 6 at approximately the natural or synchronous speed, the author has devised a very simple centrifugal arrangement which can be fixed on the motor-shaft outside the frame and which secures a quick make and break; in this way the controllers for lift work, for example, are greatly simplified. Such a short-circuiting device will operate well within 15 per cent. (up or down) of the prescribed speed, so that every shock is absolutely avoided. It is only necessary for the various windings which have been enumerated to be in series relation to each other; they need not be connected in series directly, it being possible and sometimes very useful to interpose series transformers.

As an illustration of the advantages to be gained by this improved means of starting, some tests carried out on No. 3 motor are graphically reproduced in Fig. 27. The transformation ratio from stator to rotor was 2·6 to 1. Notwithstanding that no transformer was used to feed that part of the field winding which is disposed on the rotor, the connections being exactly as shown in Fig. 25, the improvement secured is very marked indeed—with the same starting current a 27 per cent. greater torque was obtained; in other words, a torque 2·5 times the normal, with rather less than twice the normal current, and this with a small 8 pole motor on an 85 cycle circuit. Apart from this, the properties of the motor as a series-induction machine (full lines) are vastly improved, the maximum power factor rising from 0·82 to 0·975, the maximum efficiency from 57 to 66 per cent., and the maximum brake horse-power from 6·56 to 7·6 The dotted curves show what would happen if the centrifugal device referred to acted at 15 per cent. below the normal speed. In order to carry out this test the rise of speed was watched on a tachometer, and the points 5 and 6 were short circuited at a speed of 1,100 revolutions. The transition to shunt operation is even more perfect than in the previous case.

*(To be concluded.)*

## ELECTRIC WINDING CONSIDERED PRACTICALLY AND COMMERCIALLY.*

BY GERALD HOOGHWINKEL.

For an electrical winding plant designed for a daily output of 2,000 tons from a depth of 600 yds., the writer calculated a steam consumption per *useful* horse-power-hour in *ordinary* every-day practice of 30 lb. dry steam at 160 lb. pressure. The corresponding figure for the Zollern II. Colliery, which was obtained much later by an official test of the German Boiler Insurance Co. in the beginning of last year, during an ordinary day's (24 hours) running, including the winding of 1,000 men (at reduced speed), rope inspection and the lowering of materials, came to 29 lb. of steam by an output of 2,500 tons from 330 yds. This engine, however, is designed for nearly double that output, so the figures would have been considerably better for the full output. During an eight hours' shift, raising 1,300 tons of coal, the steam consumption was only 24 lb. A still lower figure was obtained at the De Wendel Colliery, where 25 lb. of steam were required per useful horse-power-hour in 24 hours (3,000 tons, 770 yds.). For electrical winders of this class and output, 25 lb. of dry steam of 150 lb. pressure per *useful horse-power-hour on the rope* may, therefore, be considered a correct figure proved in actual every-day practice.

The other figure previously obtained by the writer was 100 lb. of steam (at 100 lb. pressure) as an average figure of *existing* steam winders per useful horse-power-hour on the rope in every-day working. This figure was obtained by averaging over 50 collieries, while discarding all those above 200 lb. Steam-winder makers have challenged this figure, giving 40 lb. or even 30 lb. of steam per horse-power-hour, but even granted that such a figure per *useful* (coal only) horse-power-hour on the rope could be obtained during steady winding, the long stops and slower winding of miners and timber would soon bring this figure to a level of at least 50 lb. with the best winding engine, running condensing.

The very examples of modern steam winding given by Mr. Mountain in his recent Paper† and taken from actual practice correspond to steam consumptions of from 140 lb. to 150 lb. steam per useful horse-power-hour, while 125 lb. of steam was required by the winding engine at the Hulton Colliery, the manager of which put his steam consumption at 25 lb. per horse-power-hour. The enormous savings in steam consumption and coal may, therefore, be estimated by these practical results. But wages are also reduced. The engineman at the winding engine need not be such a highly-paid mechanic as necessitated by the steam-winding engine, as the winding is much simpler and easier, and nearly all automatic, so that overwinding and too quick braking need not be feared. As no separate boilers are needed for the winding plant (the electric power station supplying the total plant at the colliery), no separate stokers are required, but only a small proportionate part of the wages at the power house. Less wear and tear, and, therefore, maintenance, on steam engines (steady load), winding ropes (no jerkings and vibrations due to piston throw) and frame complete the other savings.

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* Abstract of a Paper read before the Newcastle Local Section of the Institution of Electrical Engineers last Monday.

† See *The Electrician* for February 9th, p. 658.

The fact that the results of Mr. Mountain's comparisons show such a disadvantage to the electrical winder, notwithstanding savings on every item in the running costs, points, therefore, only to an absolutely incorrect system of comparing the various figures and results. To compare costs of steam winders with outputs varying between 350 and 3,360 tons per day, and lifting from depths varying between 372 yds. and 673 yds., and the same costs of a single electric winder winding from great depth and of an uneconomical type, is, to say the least of it, unfair. A separate generating plant for the winding engine is out of the question, at least in new collieries. In his example of the Zollern Colliery, Mr. Mountain saddles the winding plant with the cost of one generating set of 1,100 kw., or half of the total plant installed, while the actual requirements were only 200 kw.

Having obtained the number of useful horse-power-hours, either per 100 tons in 24 hours or per year, the question is the amount of steam required per horse-power-hour in the case of steam winding, and the number of kilowatt-hours in the power station in the case of electric winding. The first figure can be obtained in Mr. Mountain's examples from the amount of coal burnt per 100 tons wound, and the other figure is either given by the existing power supply or may be easily estimated. The efficiency between useful horse-power-hours and units at the balancer terminals in the Zollern winding engine was 60 per cent., and 50 per cent. may, in all cases, be considered normal, so that 1·5 units at the balancer are required per useful horse-power-hour on the rope. Moreover, it has been found that this figure does not vary materially with the capacity of the winding engine, and may be taken as correct for four, six or eight-tub winders.

The value of the coal used for steam-winding purposes has generally been fixed in a very arbitrary manner. As a rule it will be found that it does not pay to use unwashed slack and dirt in boilers, even putting the value at the very low price of 1s. 6d. per ton. In modern collieries on the Continent and in the States washed clean coal is used in the boilers, priced at 6s. to 8s., and the slack and dirt is coked in coke ovens or burnt in gas producers. This is a point the writer wishes to impress on the minds of all colliery managers. To take two extreme cases, the writer proposes to treat the case where the fuel has a value of 10s., and another where the fuel is supposed to have no market value at all. If the case is proved for these two cases, the same may be said for all intermediate fuel values.

*Steam Winding.*—Taking coal at 10s., the generating costs per 1 ton of steam, including wages, coal, maintenance of boiler house, interest, &c., are about 2s. 6d., or taking 60 lb. per horse-power-hour as a minimum with the best modern engines about 1d. per useful horse-power-hour. With fuel costing nothing, this figure will be about 0·4d. per useful horse-power-hour.

*Electric Winding.*—Taking coal at 10s., the generating cost per unit in a colliery power station or larger public power supply station (but with much lower load factor), including interest and depreciation, as before, is about 0·4d., or as we have 1·5 units per useful horse-power-hour, 0·6d. per horse-power-hour. With fuel costing nothing this figure becomes 0·2d. As a test we may take the Hulton Colliery with fuel at 5s. 6d. per ton, which would mean 0·75d. for steam generating per horse-power-hour in the writer's calculation, or per 100 tons wound 9s. for boiler-house costs, add 1s. 7d. for winder's wages. and we get 10s. 7d., while the actual figure was 10s. 7¾d. We can see that, compared on a correct and logical basis, with figures taken from *actual* practice in *both cases*, the savings in fuel are considerable, and very much more than shown by Mr. Mountain's calculations, based on a wrong application of the otherwise correct figures of steam-winding costs. The winder's wages may, for the present, be taken as equal. The only result of actual electric winding given is the Grand Hornu Colliery, which is equipped on the pure three-phase system, and, therefore, wasteful, as the starting and stopping losses are not compensated. This system, which has since been discarded by the makers, is unfit to be compared as a modern electric-winding engine. The fuel consumption given per 100 tons wound is four times as much as even in Mr. Mountain's own calculated example; surely a proof that either the plant must be hopelessly wasteful or Mr. Mountain's figures wrong. Against this the writer wishes to put two more modern winding engines on the Ilgner system—the Zollern engine and a larger one at the De Wendel Collieries—and compare these results with Mr. Mountain's calculated one (Table I.). The cost of coal has been taken at 2s. 6d. per ton, having an evaporative power of 7½, while double shifts are worked in both cases.

**Table I.**

| —— | Zollern II. electric winder. | Mr. Mountain's case. |
|---|---|---|
| Coal wound per day of eight hours...... | 1,350 tons | 1,500 tons |
| Depth of shaft .................... | 330 yds. | 500 yds. |
| Weight of coal per wind .............. | 4·6 tons | 3 tons |
| No. of winds per day of 24 hrs. (two shifts) | 521 | 1,000 |
| Weight of cages, &c.................. | 3·5 tons | 3 tons |
| Time of wind........................ | 104 seconds | 57 seconds |
| Maximum speed at present............ | 35 ft. per sec. | 36 ft. per sec. |
| Coal burnt per day of 24 hours ........ | 5 tons | 8·50 tons |
| Cost of coal burnt per 100 tons wound.. | 6d. | 1s. 4d. |
| Cost of winding plant ............... | £10,000 | £10,500 |
| Total cost of proportionate part of generating station .................. | £4,000 | £5,700 |
| Wages per 100 tons wound, oil, &c. .... | 11½d. | 1s. 4½d. |
| Total cost of winding per 100 tons .... | 1s. 6½d. | 2s. 11½d. |
| Ditto, including interest and depreciation | 5s. 7½d. | 10s. 11½d. |

The winding plant at the De Wendel Colliery cost £15,000 complete, and is doing at present 1,400 tons in eight hours from 770 yds. The current supplied from the colliery power station costs, including depreciation and interest, 0·2d. (coal at 1s. 6d. per ton) per unit, or per useful horse-power-hour at the shaft, 0·3d. This gives us per 100 tons wound, 6s.; wages of winder, oil, &c., 6d.—total 6s. 6d.; and including interest and depreciation on £5,500 (excess of electric over steam winder), 7s. 7½d. Now, taking into account that the engine is built for 50 per cent. more output, and is winding at present from 70 yds. more depth than in Mr. Mountain's case, his figure for modern steam winding may easily be reached on the full output, and superseded, if one includes stops for rope inspection. At all events, it compares very favourably with his estimated 12s. 5d. for electric winding. Some comparative figures of modern steam and electric winders are given in Table II.

The writer considers main winding not only a suitable application of electric driving, but the principal and most urgently needed application of electricity to colliery work. At the present time over 35 electric winders of heavy outputs are being constructed by one firm alone, several being repeat orders. Surely, although it may not be a proof, it must be admitted that those facts do not confirm Mr. Mountain's gloomy conclusions as to the future of electric winding.

## DISCUSSION.

Mr. **VESEY BROWN** was of Mr. Mountain's opinion that, for heavy winding, steam plant was more convenient and simpler than electric plant. There was no double conversion, less risk of auxiliary machinery going wrong, and a more experienced staff would be required for electric than for steam drive. Another point which would somewhat be against a centralised power house was that the Board of Trade required a separate unit at each pit to raise the men in case of an accident at any one pit.

Mr. **MOUNTAIN** said he had seen the Zollern II. power house, which was one of the finest of its kind. It was necessary to have duplicate plants in case of accidents, and that put out of the question the use of a single generating station. The winding engine, which could be coupled directly to the winding drum, could be of as high a class and as high efficiency as that connected to the generator, and the conversion loss which Mr. Hooghwinkel stated as 40 per cent. was entirely eliminated. With costly coal, small outputs, long distances and grouping of collieries, there might be a future for electric winding, but with heavy loads and large outputs he considered steam to be preferable. In Table I. of

**Table II.**—*Modern Steam Winders.*

| Name of colliery. | Coal raised per 24 hours, in tons. | Depth of shaft, in yards. | Value of coal per ton. | Lb. of steam per useful H.P. hr. | Total cost per 100 tons. | Mr. Mountain's estim'd figures. |
|---|---|---|---|---|---|---|
| Bolsover Colliery ............ | 2,000 (10 hr. shift) | 372 | 2s. 6d. | 140 | 5s. 3½d. | .. |
| Hulton Colliery............. | 310, later 1,000 (10 hr. shift) | 440 | 5s. 6d. | 125* | 19s., later 12s. | 6s. 9½d. |
| Silkstone Colliery............ | 1,800 (10 hr. shift) | 335 | 5s. | 80 | 6s. 4½d. | .. |
| Denaby and Cadeby Colliery .. | 3,360 (14 hr. shift) | 763 | 1s. 6d. | 70 | 5s. 7d.‡ | 7s. 2½d. |
| H. Rhodes' Colliery .......... | 3,186 (11 hr. shift) | 550 | 3s. | 60 | 4s. 6d. | 5s. 6d. |
| Sherwood Colliery........... | 3,600 (17½ hr. shift) | 440 | 3s. 7½d. | 50† | 6s. 3½d. | .. |
| | | *Modern Electric Winders.* | | | | |
| Zollern II. Colliery .......... | 2,500 (16 hr. shift) | 330 | 2s. 6d. | 29 | 5s. 9½d. | 13s. 9½d. |
| Zollern Colliery (full output) .. | 4,000 (16 hr. shift) | 550 | 2s. 6d. | 25 | 4s. 4½d. | 17s. 7d. |
| De Wendel Colliery .......... | 3,000 (16 hr. shift) | 770, later 990 | 1s. 6d. | 25 | 7s. 5½d. | 12s. 5d. |

* Running at present at 30 per cent. load. † Superheated steam and forced draught. ‡ If coal at 3s., costs would be 7s. 3d.

the Paper under discussion, some figures were not correct. For instance, 1,350 tons should be 1,280 tons in the first column, and the maximum speed was more like 9 ft. per second than 35 ft. per second as mentioned. Then the wages per 100 tons wound, oil, &c., were given as 11½d. This was too low. Under the column relating to Mr. Mountain's case, the weight of coal per wind should be 3·6 tons instead of 3 tons, and the weight of cages, &c., should be 5·5 tons instead of 3 tons. The total cost of winding per 100 tons should be 2s. 7d. instead of 2s. 11½d. Taking into consideration these alterations, the figures would work out very near each other. Many boilers were made to burn dirty coal, and some collieries would have to cart dirt away if it were not burnt. At one colliery it cost as much as 3d. a ton to deal with dirty coal, a considerable amount of which was burnt in the boilers for steam raising. He did not think that the term of useful horse-power hour applied itself to colliery work, as it was the cost per 100 tons wound what the colliery manager or engineer wanted.

Mr. RUTHERFORD had been over the German mines mentioned in the Paper and noticed that the Germans were very slow at banking, and also that too many men were employed at the bank.

Mr. FUTERS said the colliery manager required to get the coal out of the pit as quickly as possible. It was very often a matter of output against time, in which case the manager was willing to spend extra money to increase the output.

Mr. HOOGHWINKEL, in reply, said that all the wages were taken from Mr. Mountain's Paper, and were not German rates, which were not quite so high as English rates. Colliery winding was the worst example for an engine to be applied to. As regarded electric machinery breaking down, it was his experience that it was the steam side of a station which broke down more frequently.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

*Resonance in Wireless Telegraphy.*—Continuing his resonance researches, G. W. Pierce has passed from the electromagnetically-connected wireless telegraph circuits to the direct-coupled type. The sending station consisted of an auto-transformer instead of the Tesla arrangement of the previous experiments. The high-frequency oscillations in the sending antenna were produced by the discharge of a condenser through some of the turns of an inductance in the mast circuit, a form employed in several commercial systems. He finds that the resonance is by no means as sharp as it is in the electromagnetically-connected type. Tuning the receiver by a variable capacity shunted about the instrument, he found that with a constant sending circuit and a constant source of waves the current received in a circuit, brought to resonance by a capacity in shunt, is proportional to the square of the height of the receiving antenna measured from the "effective ground." The author proceeds to discuss the image theory, which supposes that the action in the grounded circuit with the receiving instrument near the ground is the same as it would be if, instead of being grounded, it should be symmetrically duplicated below the surface of the earth. Of course, in actual systems the grounding is not perfect, and, therefore, the symmetrical image gives only approximately an equivalent system. This theory was submitted to tests by comparing resonance curves with various forms of grounded circuits with the corresponding curves taken with an "image circuit" in the place of the ground. The results show a good agreement with the theory.

[G. W. Pierce, *Physical Review*, March, 1906.]

*Sparking at Break.*—Lord Rayleigh has discussed the relation between the energy given to the secondary of an induction coil when the primary current is broken and the velocity of separation of the contacts of the break of the primary. He showed qualitatively, breaking the primary circuit by means of a rifle bullet, that in some cases a greater potential was produced in the secondary than when an ordinary break was used with its *optimum* capacity, and he came to the conclusion that if the break were made with sufficient abruptness, we might do away with the primary condenser altogether. J. C. Hubbard has further studied this question in the hope of finding relations between the constants of an oscillatory electric circuit, such as the primary of an induction coil, the initial current, and the velocity with which the contacts of the break are separated, when the conditions are just sufficient to prevent sparking at the break. By neglecting the "lag" effect in the spark, a theoretical relation was found, and may be roughly expressed by saying that the velocity of break necessary to prevent a spark will be proportional to the frequency of oscillation and a linear function of the maximum induced potential, the latter implying a linear relation between velocity of break and inital current. The necessary velocity of break was found experimentally to be: A linear function of the initial current; for given current, increasing in value in a manner consistent with the equation when the capacity is diminished; and diminishing according to the equation when the inductance is diminished. The assumption that the lag of the spark might be neglected did not hold true, but would do so if the time were great enough to allow the gas to be sufficiently ionised. The velocity of break is lessened by any condition which causes the absorption of energy from the primary, such as a closed secondary, hysteresis and heat losses.

[J. C. Hubbard, *Physical Review*, March, 1906.]

*Internal Energy of Elements.*—F. Soddy discusses the unknown store of energy contained in the chemical elements, and the prospect of making it available. Since all matter can be regarded as built up out of component elements, it is usual to regard the latter as the starting points from which the energy-content of all matter is reckoned, and, as a convention, to give all the elements zero energy-content. This, of course, as the chemical reactions sufficiently show, does not imply that the elements are devoid of energy. By a similar convention the earth is regarded as possessing zero potential. None of the material changes dealt with in chemistry are very profound. Radio-activity has brought more fundamental changes into view. The large internal energy exhibited by the radium atom cannot be regarded as peculiar to radium. Radium in its chemical properties is a completely normal and typical element, and possesses a chemical nature almost identical with the inactive element barium. Uranium was known long before its radio-activity was discovered, and represents another perfectly normal chemical element. Yet uranium, since it produces radium with evolution of energy, must possess all the internal energy of radium and more. It is probable that the elements as a class all possess great internal energy, and that their characteristics of stability and permanence, and the failure of all attempts to change them by artificial means, are due to the existence of this internal energy. The forces at our disposal compared to those which are exhibited when an atom suffers change, are of a different and lower order of magnitude, and it is not to be expected therefore that transmutation will become possible until we can control more powerful agencies than are at present available. Suppose that a way were known in which the element uranium, for example, which disintegrates to the extent of a thousand-millionth part annually, could be made completely to disintegrate in the course of a year. From 1 gramme of the element more than a thousand million calories could be evolved, and this, if it could be converted into electrical energy, would be equivalent to more than 1,000 kw.-hours, and would suffice to keep a 32 c.p. lamp burning continuously throughout the year. By the expenditure of about 1 ton yearly of uranium, costing less than £1,000, more energy would be derived than is supplied by all the electric supply stations of London put together.

[F. Soddy, Paper read before the Glasgow Section, Institution of Electrical Engineers, March 13, 1906.]

*Heusler's Magnetic Alloy.*—Andrew Gray has made some very curious observations in the case of a Heusler alloy containing about 16 per cent. manganese, 8 per cent. aluminium, a little lead and the remainder copper. It was originally almost non-magnetic. It was heated to 400°C. in a furnace and allowed to cool slowly. After having been placed in a magnetic field it was found to retain a considerable amount of magnetism. It was next heated to 340°C. for about 20 minutes and allowed to cool, when it was found that the magnetic properties were much more pronounced. The magnetic properties were destroyed by quenching from a temperature of 400°C. The effect produced by the temperature of liquid air upon the material in its quenched and, at ordinary temperatures, nearly non-magnetic condition was now investigated and found to be very remarkable. When tested at the temperature of liquid air the specimen was found to be more susceptible to magnetism than in its previous best condition, while it exhibited very much less hysteresis and retentiveness. The structure of the alloy is well brought out by etching with ammonia.

[A. Gray, *Proceedings* Royal Society, March 6, 1906.]

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## SINGLE-PHASE COMMUTATOR MOTORS.

Now that single-phase commutator motors are generally appreciated and have an assured future before them, it is interesting to recall in a brief retrospect the early struggles through which they had to pass, to inquire into the reasons which retarded their progress, and to venture on a modest prophecy as to the direction further developments are likely to take. The history of commutator motors for alternating currents may be said to date back to 1887, the year when Prof. ELIHU THOMSON took out his first American patent for the repulsion motor, although the possibility of running a continuous-current series motor with single-phase current had been pointed out by Mr. A. SIEMENS in 1884 at the Institution of Electrical Engineers, in the course of a discussion on a Paper by Prof. W. GRYLLS ADAMS on "The Alternate-Current Machine as a Motor." This Paper described some successful experiments in paralleling three De Meritens magneto-alternators and subsequently running one of them as a synchronous motor. Single-phase networks were already numerous in 1887, but they were used in connection with lighting only, for the single-phase induction motor had not yet made its appearance. In view of this, it is easily imagined how Prof. THOMSON'S idea took hold of the minds of electrical engineers of nearly two decades ago who were in search for a motor that would run from a single-phase supply. And in the years which followed quite a number of eminent electricians were striving hard to evolve from the crude idea a practical reality. These included such familiar names as EICKEMEYER, STEINMETZ, ARNOLD and ATKINSON, to mention only a few. The reasons why one and all failed to make a commercial success are manifold and complex. The chief technical difficulties related principally to questions of sparking, power factor and efficiency. These are now being overcome, and at that time they were accentuated by the high frequencies adopted to keep down the lighting transformers in size and cost. However, we have far too good an opinion of the resource and ingenuity of those pioneers in electrical industry to suppose for one moment that they would not have ultimately overcome the difficulties mentioned with the same success that has attended the labours of recent workers during the last few years—*i.e.*, since electric traction gave such a mighty impetus to the problem, and has made it once more a question of considerable commercial importance. The real cause of the early failures, in this country at least, lies much deeper, and is closely associated with the reaction against single-phase systems in favour of continuous-current supply, which was largely due to the inefficiency at light loads and the large no-load losses in the small lighting transformers used in the early days. The introduction and gradual development of the single-phase induction motor did little to stem the wave of reaction, for its low power factor, poor starting torque and cumbersome starting devices prevented it from ever becoming popular. Single-phase networks were then frequently supplemented by a continuous-current or polyphase supply, so that there was less incentive than previously to improve the single-phase motor and to return to the commutator motor as a means of solving the single-phase motor problem. Among the few who still carried on a forlorn struggle was Mr. LL. B. ATKINSON, who developed in the nineties a few small single-phase commutator motors whose performances compare favourably with some of the machines now on the market. To those interested in the general theory of alternating-current motors of the commutator type we strongly recommend the study of Mr. ATKINSON'S Paper on the "Theory, Design and Working of Alternate-current Motors," which was read at the Institution of Civil Engineers in 1898, and is published in the *Proceedings* of this Institution, Vol. CXXXIII., p. 113. It is a model of lucidity of exposition, and has probably not been excelled in this respect by any of the later publications, which, unfortunately, are often apt to render a difficult subject more complicated than it really is. We cannot but think that if Mr. ATKINSON had chosen a more suitable manner of publishing his results, more attention would have been paid to them. Electrical engineers look to the proceedings of the Institution of Electrical Engineers and to the electrical Press for an account of the progress that is being made in every branch of their profession. The acceptance of his Paper by the Institution of Civil Engineers and their consequent acquisition of the copyright made it impossible for us to publish more than the colourless "official abstract," which gave no indication of the trend of the author's arguments or of the particular value of certain parts of the Paper. Moreover, the circumstances also prevented him from publishing articles dealing with the same subject, although he was at the time an occasional contributor to *The Electrician*. Mr. ATKINSON'S work, therefore, received scant attention, and he actually allowed his patents to expire. But after the lapse of a few years, electric traction, which had been adopted in the first instance for strictly local service, began to be considered for interurban and heavy railway work, and the demand grew for a practical single-phase traction motor which would enable a single trolley wire to be used. Even then the Ward-Leonard system of converting alternating to continuous current on the locomotive itself was suggested at first instead of the use of motors built on Mr. ATKINSON'S principles, and it was even put to the test on an experimental track by the Oerlikon Company. But something simpler and cheaper was required, and single-phase commutator motors, which had in the meantime fallen practically into oblivion, were then energetically taken up again. FINZI in Italy, and LAMME in America, were foremost in perfecting the single-phase series motor, while LATOUR in France, and Messrs. WINTER and EICHBERG in Germany invented and developed the compensated repulsion motor. The repulsion motor pure and simple has not been employed for traction purposes, as far as we are aware. To-day single-phase traction motors have reached a high state of perfection, and are being unhesitatingly used for electric traction schemes.

Spurred by the popularity of the motor just mentioned, various designers set themselves the task of inventing a single-phase commutator motor with a shunt characteristic, and it is satisfactory to note that the first Paper on this class of motor was read at our own Institution. We refer, of course, to Mr. V. A. FYNN'S Paper on "A New Single-phase Commutator Motor" read a fortnight ago. Mr. FYNN'S theoretical expositions, considered as a whole, lack that logical arrangement and clearness of expression which one might wish, but the characteristics of actual motors, taken together with the author's assurance that the commutation is satisfactory, atone for this, and we now only await one further assurance from him—namely, that the machines are made in quantities and are purchasable at a reasonable price. The author's remarks as to the commutation of these machines were confirmed by Mr. W. M. MORDEY in the discussion, who had had the opportunity of testing a 6 H.P. motor of Mr. FYNN'S design in Switzerland some months ago, but particulars of a more commercial nature are still desirable. No figures were mentioned in the Paper as to the weight and cost of these constant-speed motors, but there is no doubt that they are inferior to continuous-current or polyphase motors in these respects. Another disadvantage, which is more or less inherent to alternating-current motors of this class concerns the low efficiency. It is conceded on all sides—by Mr. FYNN also—that the alternating type must always remain inferior to its continuous-current rival in this connection. But the difference need not be as large as is the case at present, and the immediate development will lie no doubt in the direction of improving the efficiency, and the weight and cost per horse-power. Still, the need for a single-phase commutator motor with shunt characteristics has not yet become as great as that for the series type used for traction purposes.

Since the excellent results of Mr. J. E. NOEGGERATH'S 300 kw. 500-volt continuous current homopolar dynamo, with its eight slip-rings, have become widely known, various attempts have been made both in this country and on the Continent—on paper at any rate—to design an alternating-current motor on a similar principle. On first thoughts this would seem fairly simple, considering that the alternating supply voltage can be easily and economically reduced to a figure most suitable for these machines. But it is much easier to design a continuous-current slip-ring motor of this type than an alternating-current motor. This is due to the fact that it is practically impossible to laminate the magnetic path in such machines. The field flux enters axially into the armature, then bends round, and leaves the armature again in a radial direction. It is at once apparent that the stampings, in order to follow the curvature of the lines, would have to be of a complicated conical shape and the individual stampings would, moreover, differ in size from one another. An alternate-current motor built on this principle, but with a solid armature core, would be out of the question owing to the excessive iron losses; so that we fear that the homopolar alternate-current motor will long remain what it is now, an interesting academic problem.

## THE GREENWICH POWER HOUSE OF THE L.C.C. TRAMWAYS.

(*Concluded from page 881.*)

As has already been mentioned, the low-tension switchboards supply not only the two classes of motors on the works and the controlling circuit for high-tension switch gear, but also distribute current to the tramways near the power house. The 220 volt three-phase motor panels are connected to the secondaries of static transformers placed behind the low-tension switchboards on the first gallery of the engine room, in a position which was shown in Fig. 18. The D.C. panels are supplied from what is practically a local sub-station in the power house building. Three 500 kw. Dick Kerr induction motor-generators have been put in for this purpose. The machines run at 300 revs. per min., and have short-circuited rotors, so that they are started from the D.C. side. They follow, in all respects, Messrs. Dick, Kerr & Co.'s standard practice for machines of this class. The battery charged by these sets has already been referred to when describing the exciter arrangements. Adjoining this sub-station is a fine workshop fitted with a planer, lathes, drilling machine and other tools and accessories for repairs. The office accommodation is very ample, and baths, mess-rooms, lockers, &c., have been provided for the workmen. When the present half of the works is in running order, and while the second half is in process of erection, it is probable that there will be 300 workmen employed on the site. Mention may also be made, in passing, to the oil store, which is kept apart from the main stores, and so arranged that the oil can be delivered directly from the yard outside. In the oil stores, also, an elaborate arrangement has been fitted for straining the oil for the engines.

We now come to the pump house, which supplies the circulating water from the river for the condensing plant. As was seen from the block plan of the works, which we published in the first part of this article, the strainer house, pump house, and valve house are situated on the wharf between the main buildings and the river. The river part of the contract has been executed to the specification and under the supervision of Mr. Maurice Fitzmaurice, C.M.G., the chief engineer to the Council. Four 30 in. pipes have been laid in the river, sufficiently far out to be covered even at the very lowest tide. Three are used as suction pipes, one for each of the centrifugal pumps that have been installed, and the fourth serves as a common discharge. As a matter of fact, only two 24 in. centrifugal pumps have been put in at present, but there is space for a third, which will be erected when the second half of the power house is built. One pump is sufficient to supply one half of the power house, and, of course, one spare is sufficient. The pumps were supplied by Messrs. Drysdale & Co , and are driven by E.C.C. three-phase motors. The capacity of each is 11,220 gallons per minute when running at a speed of 365 revs. per min. All the condenser pipes are on the siphon principle, so that once the system is full of water the pumps have only to overcome the friction of the pipes and the losses in the pumps themselves.

The straining gear is necessarily of an elaborate kind, owing to the variety of floating matter in the river at that point. Two kinds of strainers are used, fixed and rotary. There is a fixed strainer in the suction pipe of each pump. It is a sheet-steel box lined with concrete, and the grids on either side are of 4 in. mesh, and are removable for cleaning purposes. When any pump is not working, the arrangement of pipes is such that the other pumps can be made to discharge through the suction pipe of the pump not in use, and thus wash out the strainer. Each of these fixed strainers is placed in a room by itself to facilitate frequent cleaning and inspection. There is a water seal on each of the strainer boxes so that leakage may be detected as soon as it occurs. The ends of the pipes in the river are bell-mouthed, and are laid in a concrete groin, the end of which is hollowed out to form a basin.

The rotary strainers are on the delivery side of the pumps, one to each pump. They are of the reverse flow pattern—*i.e.*, the discharge passes through the same strainer as the suction water. These strainers are of what is known as the revolving disc type, and have been built in accordance with a patent by Messrs. Frank Bailey and F. H. Jackson, and it may be added that the designers of the condensing plant profited considerably by the experience which the City of London Electric Lighting Co. have had in this connection, which was placed at the disposal of the County Council's engineers. The delivery pipes from the three pumps converge into two main pipes in the station, one for supplying the present half of the station and the second one the newer half. Branches from these main pipes lead to the condensers, and the pipes are always kept under pressure from the pump room, the water being turned on by valves on the engine room floor level. On the discharge side of each condenser-pipe range there is a Venturi water meter. This consists of a short length of pipe of restricted section in the discharge pipe, and the fall of pressure in this short piece is recorded by a piston arrangement which makes a record on a chart turned by clockwork, much in the same way as a recording ammeter connected across the shunt in a main circuit. The pump room is connected to the engine house by a tunnel and the pipes are anchored to girders which extend from wall to wall. Two dry-air pumps, made by Messrs. Isaac Storey, working on to a common suction pipe, are used to take any air out of the suction pipe of the main pump, to help it at starting, and also to get the air out of the condenser-pipe system altogether. The suction of this air pump is connected to the highest point of the circulating water system through a vertical 34 ft. pipe. The artesian well which supplies the feed water is also in the pump house, and in connection with the water system may also be mentioned a cast-iron sump into which the whole of the station system drains. This is emptied by a 3 in. centrifugal pump, as the basement of the works is at a lower level than high-water mark.

With the exception of the buildings and the pump house, which were to the specifications of Mr. W. E. Riley, the superintending architect of the Council. Mr. John H. Rider, the electrical engineer to the London County Council Tramways Department, was responsible for the whole of the design and construction of the works, with the cordial support of Mr. A. L. C. Fell as chief officer to the London County Council tramways. Mr. Rider has assisted us considerably in the preparation of these articles, has personally shown us every detail of the works, and has put every source of information at our disposal. We have also to thank the contractors for considerable assistance, and also Mr. J. Shepherd, the chief assistant electrical engineer, and Mr. E. W. Dickinson, superintendent at the power house, for courtesy shown to us on our numerous visits to Greenwich.

## LARGE ALTERNATORS AT SIEMENS BROS.' DYNAMO WORKS.

(*Concluded from page 873.*)

The following account of the tests on the alternators decribed in the first portion of our article has been contributed by Dr. Max Kloss, under whose supervision the machines were constructed and tested, and who, partly in conjunction with Mr. C. Rodgers, was responsible for their design.

It is common practice to test large direct-current generators by the Hopkinson method, if there are two of the same size, by running one of the two machines as a generator and the other one as a motor, the two machines being coupled together so that the necessary torque is transferred through the common shaft; whilst the losses are supplied either mechanically by driving the complete set by means of a small motor coupled to the shaft, or electrically from the mains or by means of a booster which feeds the circuit of the two machines with the necessary circulating current. The load of the system can be adjusted by regulating the field currents. A similar method was employed for testing the two large machines for Johannesburg.

To our knowledge the Hopkinson method has not been applied up to now for alternating-current machines of such a large output, and it may be of interest to know how the tests were carried out and by what means the proper output was obtained under test. A view of the two alternators, together with the driving direct-current motor and a cross section of the generator, was given on pages 872-3 in last week's issue of *The Electrician*, together with the main dimensions of the machines and a specification of the design. In the meantime, in the presence of Mr. Mordey, the official trial has taken place, the results of which are given below.

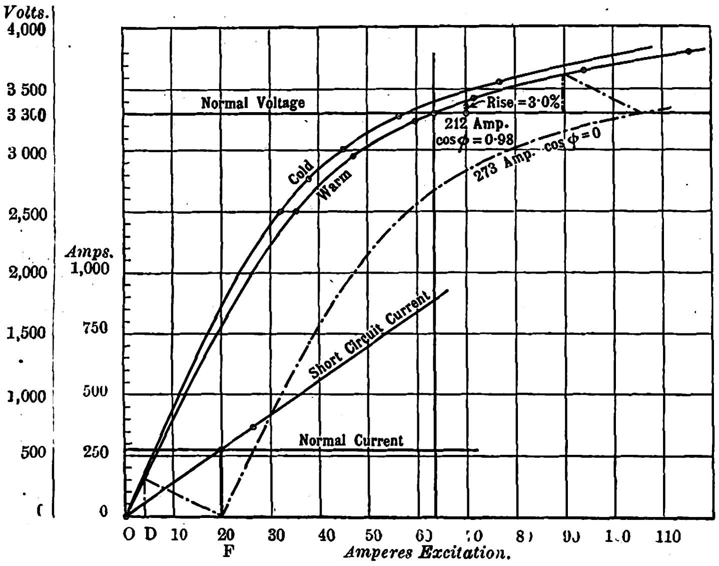

FIG. 3.—OPEN CIRCUIT AND SHORT CIRCUIT CHARACTERISTICS OF GENERATOR.

Fig. 3 gives the open-circuit and short-circuit characteristics of the alternator which was run as a generator. It will be noticed that there is a distinct difference in the open-circuit characteristic when the machine was cold and when it was warm, after the 12 hours' run. This effect is caused by the expansion of the stator frame due to heating. The diameter of the machine is 260 in. (6,604 mm.), and the temperature rise of the stator was about 28°C. The possible increase of diameter can be calculated by the formula

$$\delta' = \alpha t D$$
$$= 0{\cdot}000012 \times 28 \times 6{,}604 = 2{\cdot}2 \text{ mm},$$

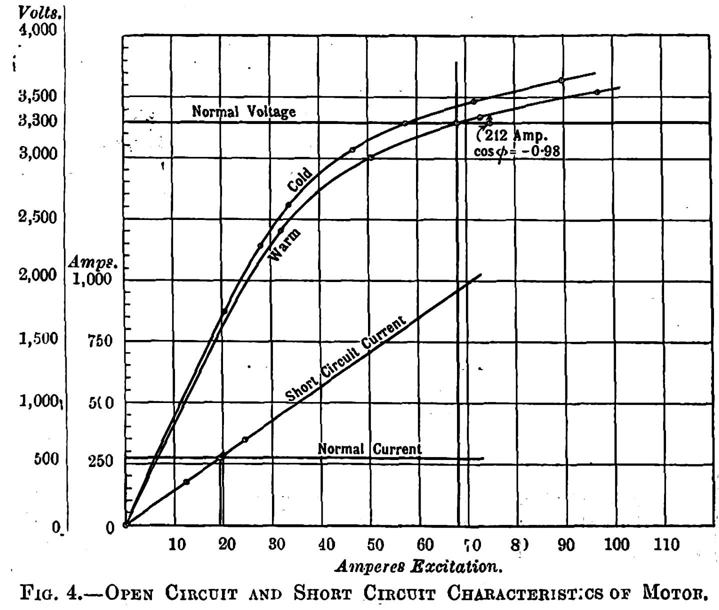

FIG. 4.—OPEN CIRCUIT AND SHORT CIRCUIT CHARACTERISTICS OF MOTOR.

Where $\alpha$ is the coefficient of expansion for iron.

Now, even if one considers the stiffness of the cast-iron frame, which would not allow the stator core to expand quite as much as calculated by the above formula, it may be quite within reasonable limits that the increase of the air-gap due to heating may be of the order of 0·8 mm. to 1 mm. on each side. The air-gap of the machine when cold was found to be about 6·6 mm. as a mean. From the two open-circuit characteristics it can be calculated that the air-gap has actually increased to about 7·4 mm., which quite agrees with the above figures.

The machines were run under full load for 12 hours, and the readings at the end of the run were as follows:—

| | | | |
|---|---|---|---|
| Phase 1 .... | 3,303 volts .... | 214 amperes .... | 686 kw. |
| Phase 2 .... | 3,295 volts .... | 209 amperes .... | 676 kw. |

thus making a total output of 1,362 kw. at a mean power factor of 0·98. The exciting current was 70·1 amperes for the generator and 74·9 amperes for the motor. From this figure it can be seen that the rise in voltage from full load cos $\phi = 0{\cdot}98$ at 3,300 volts to no load is only 3·0 per cent. The guaranteed figure for cos $\phi = 1$ was 5 per cent. Fig. 4 gives the corresponding characteristics for the motor. In comparing these with Fig. 3 it will be noticed that at the same voltage this machine requires more excitation than the first one, owing to the air-gap being slightly larger. For the same reason, the machine had to be excited with a larger current on the full-load test, whilst if the machines were exactly alike, one would expect the exciting current of the motor to be less than that of the generator.

For the temperature run there were two thermometers used for measuring the temperature of the surrounding air. The mean of the two readings has been taken as the air temperature for working out the rises. The final rises as obtained on the generator after shutting down were:—

| | |
|---|---|
| Back of stator core .................................. | 27·0°C. |
| Front of stator core .................................. | 24·5°C. |
| Stator winding .................................. | 12·8°C. |
| Rotor winding .................................. | 8·9°C. |

The temperature rises of the windings were also determined by the resistance method and gave the following figures:—

| | |
|---|---|
| Stator winding—straight coils ...................... | 17·8°C. |
| " " bent coils ...................... | 18·0°C. |
| Rotor winding .................................. | 18·4°C. |

From these figures it can be seen that the temperatures are well within specified limits.

*Determination of Phase Displacement.*—The set can be regarded as two machines running in parallel. If the two vectors of E.M.F. of the two machines were alike, no current would circulate between the machines. In order to get a current through the circuit it is not sufficient to vary the excitation of the two machines, as is the case with direct-current machines. In the case of alternators, the phase difference between current and pressure must also be considered, and owing to this reason the two machines must have a certain phase displacement in order to get the required current at the required power factor.

Fig. 5 shows the diagram of the E.M.F.s of the two machines. OA gives the direction of the vector of the P.D. (terminal voltage), which, of course, is alike for both machines. $OB_1$ is the vector of the E.M.F. of the generator, which has a certain lead, $\alpha_1$. $OB_2$ is the corresponding vector of E.M.F. of the motor which is almost opposite to the vector $OB_1$ but lagging behind the P.D. vector by the angle $\alpha_2$. The resultant E.M.F. of both machines is represented by the vector OC; this pressure sets up the circulating current OI, which, owing to the combined action of ohmic and inductive drop, lags behind the vector OC by the angle $\alpha_3$ being slightly less than 90 deg. From this diagram it can be seen that by choosing the proper value of the angles $\alpha_1$ and $\alpha_2$ and by adjusting the two exciting currents one can get any current at any power factor. In order to obtain cos $\phi = 1$ (supposing the two machines to be exactly alike) the exciting currents should be very nearly equal. By over-exciting the generator and under-exciting the motor one can shift the phase of the current so that it will be lagging behind the P.D., whilst by over-exciting the motor and under-exciting the generator one can get a leading current. The pressure diagram given in Fig. 5, however, has not more than a limited application, inasmuch as it only has an explanatory character and is not fit for working out the

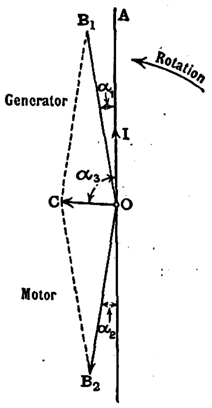

FIG. 5.—DIAGRAM SHOWING PHASE DISPLACEMENT OF MOTOR AND GENERATOR.

respective quantities—that is to say, it cannot be used for finding the required angles of phase displacement between the two machines, the reason being that all diagrams of a similar kind which are in common use can only be regarded as correct as long as the machines dealt with have low saturations. However, as soon as one has to deal with highly-saturated machines and apparatus the pressure diagrams are no longer reliable. The only way to obtain correct results is to construct a diagram of the fluxes and corresponding ampere-turns. This has been done in the diagram given in Fig. 6 for the actual working conditions which were obtained in the official trial. In the diagram OA represents the flux which would produce the required voltage of 3,300 volts on open-circuit. The vector of the E.M.F. OE produced by the flux OA is 90 deg. behind this vector. For unity power factor the current OI must be in phase with the vector OE. This current of 212 amperes produces an ohmic drop in the generator which must be overcome by an increase of the E.M.F. of the generator, and therefore the flux must be increased accordingly. By this means we get the flux $OB_1$ where $AB_1$ corresponds to the ohmic drop of the generator. Besides this, the current sets up a leakage flux which is in phase with it, and therefore the flux passing through the air-gap of the machine must have a component to balance this leakage flux. This component is given by the vector $B_1C_1$, thus making the flux through the air-gap to $OC_1$. The necessary excitation for this flux can be taken from the open-circuit characteristic, and is to be plotted in phase with the vector $OC_1$, thus obtaining the distance $OD_1$ in a certain suitable scale. This is, however, only a close approximation, as will be seen below. This excitation, which really produces the flux, is the resultant of two components—viz., $OF_1$ and $F_1D_1$ where $OF_1$ represents the real number of ampere-turns on the field, whilst $F_1D_1$ being in phase with OI represents the ampere-turns of the armature, this distance being taken from the short-circuit characteristic (Fig. 3) by reducing the distance DF in the ratio of the currents—namely, from 273 to 212. However, there is a correction to be made owing to the fact that the increase of field ampere-turns which is required to overcome the component $F_1D_1$ increases the leakage of the field, which means that the saturation of the pole limbs is higher than it would be if the machine would run with the same flux $OC_1$ through the air-gap, but with no current in the armature. This must be allowed for when plotting the distance $OD_1$, which, therefore, is actually bigger than would follow from the open-circuit characteristic corresponding to the flux $OC_1$. This correction has been allowed for in the diagram of Fig. 6, so that the distance $OF_1$ represents the required excitation of the generator as constructed on the basis of the open-circuit and short-circuit characteristic. By this construction the required excitation for the generator works out at 70·0 amperes, whilst the actual figure as given above was 70·1 amperes.

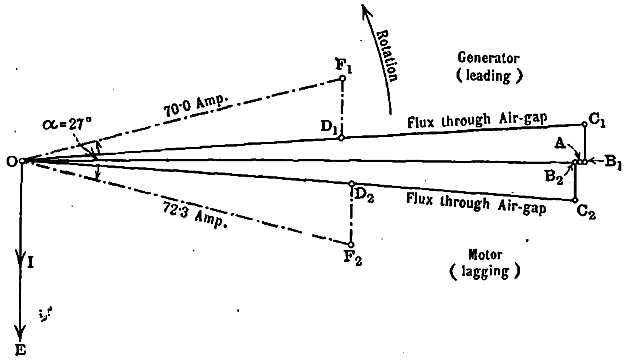

FIG. 6.—VECTOR DIAGRAM FOR TWO 1,800 KW. SIEMENS TWO-PHASE ALTERNATORS UNDER HOPKINSON TEST WITH A LOAD OF 212 AMPERES 3,300 VOLTS AT UNITY POWER FACTOR. 100 REVS. PER MIN., 50 PERIODS PER SEC.

Below the line OA the corresponding diagram has been plotted for the motor. For this machine the excitation works out at 72·3 amperes, whilst actually the current was measured as 74·9 amperes. The difference may be accounted for by the fact that it is very difficult to adjust the current so as to give actual unity power factor, because even an angle of several degrees of phase difference between current and voltage only alters the power factor so little that it is within the limit of error of reading.

Furthermore, the two vectors $OF_1$ and $OF_2$ not only show the quantity of the exciting current, but also the relative positions of the two field systems. This angle works out from the diagram at 27 deg.; that means that the two field systems should be displaced by a small angle corresponding to 27/180 of one pole pitch. Actually the rotors were keyed to the shaft in the same position, but the stator frames were angularly shifted from their middle position so as to give the necessary phase displacement between the two machines. It was found that the angle had to be set to 26 electrical degrees in order to obtain the proper working conditions. From this it can be seen that the method of working out the angle by means of the above diagram gives a very close result.

If the two machines were to be run with inductive load, this could be done by simply varying the two exciting currents. The diagram would have to be constructed in a similar way, with the exception that the vector OI would have to be plotted at the angle $\phi$ to the vector OE, and the vectors $AB_1$ and $B_1C_1$ turned by the same angle, so that $B_1C_1$ keeps parallel to OI. The armature ampere-turns $F_1D_1$ are also to be kept parallel to OI. The motor diagram is to be constructed accordingly. If this is done for the full-load conditions at inductive load—namely, 273 amperes at $\cos\phi = 0·75$—one finds from the diagram that the angle of phase displacement between the two machines works out at approximately the same figure as was found for non-inductive load. However, the excitation current would have to be 93·3 amperes for the generator and 47·5 amperes for the motor (calculated).

A set of readings was taken on a preliminary run before the official trial, with the following results:—

Phase 1: 3,292 volts, 257 amperes, 665 kw.
Phase 2: 3,288 „ 248 „ 626 „

Thus giving a power factor of 0·77 with not quite full load current. The two exciting currents were 95·4 in the generator and 44·5 in the motor.

As we have already pointed out, the circulating current kept remarkably steady throughout the tests.

It is thus seen that the testing of large alternators can be very satisfactorily carried out under full load conditions even on inductive loads with a very small expenditure of power.

[In the first portion of our article on p. 372, we gave the total losses of the alternators as 93kw. This should, of course, have been 83kw., as will be seen from the addition of the separate losses.]

# ELECTRICAL EQUIPMENT OF THE ABERDARE COLLIERIES OF THE POWELL DUFFRYN CO.*

BY CHARLES P. SPARKS.

The group of collieries dealt with in this Paper are situated 20 miles north-west of Cardiff; they have been worked by the Powell Duffryn Co. since 1864, and are now raising 1¼ million tons of coal out of the company's output of 2¾ million tons per annum. Before the present scheme was put in hand, six of the nine pits in this valley had isolated direct-current plants generating at 200 or 400 volts for lighting and power purposes. In place of extending these plants for the more general use of electric power, it was decided to erect a power station to supply the whole of the company's pits in the Aberdare Valley, to obtain the advantage of a higher load factor by concentrating the generating plant in one power house, in place of having plant, together with reserves, capable of dealing with the maximum power required at each pit, the direct result being to lower the capital and generating costs, due to the decreased amount of generating plant required, the lower cost per kilowatt, and greater economy of the larger units erected at a single power station.

The district to be served was 8 square miles in area, some points being 4 miles from the proposed power station; and as a considerable demand for power might develop at any point in this area, it was decided to use the three-phase system at 50 periods 3,000 volts, with overhead transmission lines, the existing D.C. motors being utilised, grouping 19 motors of 210 B.H.P. at one pit and driving them from the three-phase system by a motor generator supplied at 3,000 volts. Electric power is now being supplied to seven of the pits from a power station which has been erected close to the coal-washery, which is situated fairly centrally to the company's property, as shown in Fig. 1.

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* Paper read before the Institution of Electrical Engineers last night.

The scheme was projected in 1903, before the issue of the Home Office Regulations for the use of electricity in mines, and a contract for the whole work given to the Electrical Company in the autumn of the same year. The power station was started and the first motors put to work in May, 1905. Owing to the nature of the business, the drives could only be gradually transferred from steam to electric, and at the end of 1905 some 4,600 B H.P. of motors were at work out of a total of 6,000.

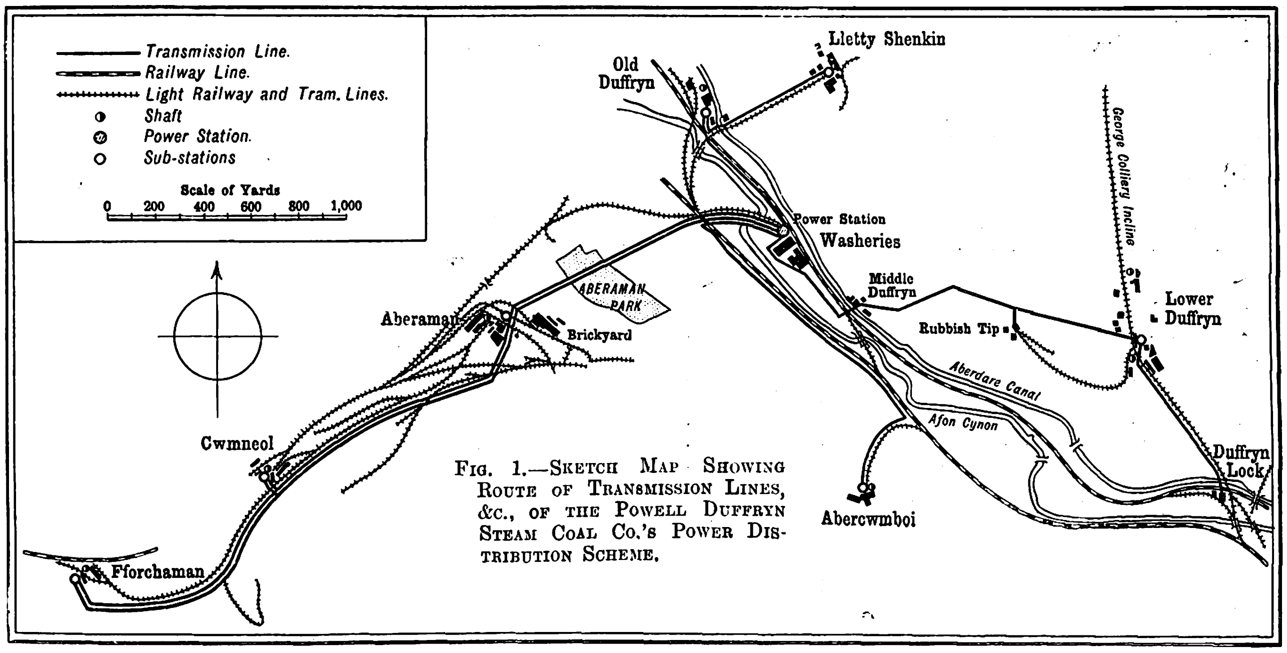

Fig. 1.—Sketch Map Showing Route of Transmission Lines, &c., of the Powell Duffryn Steam Coal Co.'s Power Distribution Scheme.

The total horse-power at present in use at these collieries amounts to 12,170, and while the most uneconomical drives, amounting to over one-third of the total, have been converted from steam to electric driving, resulting during December, 1905, in putting 25 Lancashire boilers out of use, displacing the boiler plant entirely at five points, 32 Lancashire boilers, 30 ft. by 8 ft., or their equivalent, still remain driving the balance of 7,570 H.P. Now that the power station has been started there is little doubt that, as occasion arises, a large part of the remaining steam plant will be superseded by electric driving. The present records show the colliery requirements to average 1,000 units per annum per brake horse-power in use, with a load factor on the power station of 37 per cent. Were the whole of the driving electric, the output of the power station would be about 12 million units per annum, the load factor on the station being between 40 and 50 per cent., the latter figure being reached if pumping was confined to the hours when the haulages were not at work, 10 units being required for all power purposes per ton of coal raised with the present output of $1\frac{1}{4}$ million tons per annum.

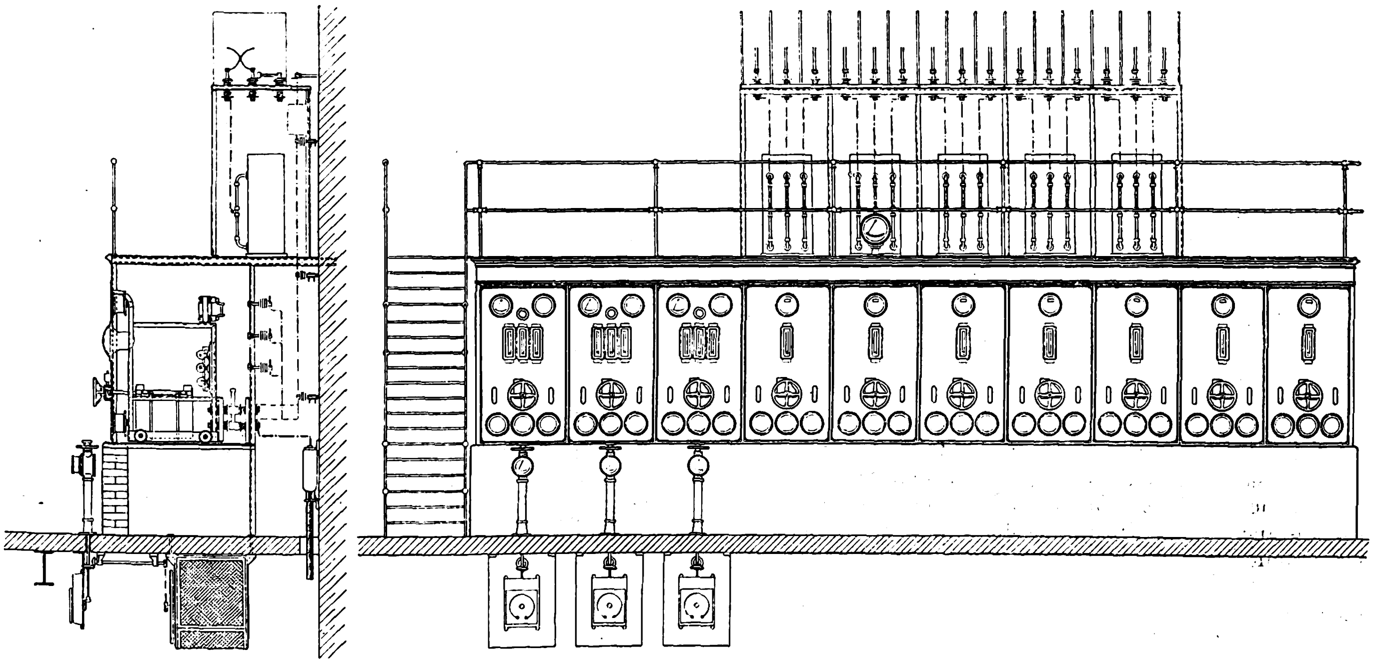

Fig. 2.—Main Switchboard at the Aberaman Power Station.

When the cost of power is compared with the labour cost incurred in winning a ton of coal, the importance of increasing the application of power makes the use of electricity a matter of interest to all colliery owners, as no other means of power transmission is available that has equal flexibility in distribution or is so well adapted to every form of drive above and below ground. The capital outlay necessary for the change has been an important factor in deterring changes on a large scale, but as the cost of electric machinery has been largely reduced in recent years there is every reason to believe that rapid progress will now be made in the conversion of collieries to electric driving.

*Power Station.*—The power station is equipped to deal with an average load of 1,500 kw., this demand being met either by a 1,500 kw. or two 750 kw. sets during the day, and one 750 kw. set during the night and on Sundays. The alternators, one of 2,000 and two of 1,000 k.v.a., are three-phase star connected (with neutral earthed). The regulation of these machines is 6 per cent. on non-inductive and 16 per cent. on inductive load, 0·75 power factor. The field magnets are carried by the engine flywheel, the machines being mounted between the cylinders of slow-speed engines; excitation for each set is provided by a rope-driven exciter (110 volts).

The engines are horizontal cross-compound jet-condensing, made by Yates & Thom, of Blackburn. They are governed on both high and low-pressure cylinders so as to carry momentary overloads of 50 per cent. The air pumps on the larger set are of the Edwards type, driven from the tail rod of the high-pressure cylinder. The parallel running of these sets is satisfactory under all conditions, while the steady pressure of supply gives satisfactory results in starting and running the largest motors under heavy overloads without interference with the general good working of the system.

The leading details of these sets are given in the following table:—

**Table I.**

| | | |
|---|---|---|
| *Alternator* | 1,500 kw. | 750 kw. |
| Output | 2,000 k.v.a. | 1,000 k.v.a. |
| Pressure | 3,300 volts | 3,300 volts |
| Frequency | 50 | 50 |
| Speed | 83 | 94 |
| Slots per pole and phase | 2 | 2 |
| *Engine*— | | |
| Steam pressure, lb. per square inch | 120 | 120 |
| Superheat | 60°F. | 60°F. |
| Diameter of cylinders— | | |
| H.P. | 45 in. | 26 in. |
| L.P. | 56 in. | 47 in. |
| Stroke | 54 in. | 42 in. |
| Diameter of piston rod | 8 in. | 5 in. |
| Diameter of crank shaft bearings | 22 in. | 17 in. |
| Length of bearings | 38 in. | 30 in. |
| Length of connecting rod | 12 ft. | 9 ft. 6 in. |
| Flywheel effect in foot-tons | 5,500 | 2,200 |
| Floor space occupied by combined set, in square feet | 988 | 720 |
| Height of alternator above floor line | 17 ft. | 13 ft. |

Steam is supplied from Babcock & Wilcox boilers each having a grate area of 49 sq. ft., heating surface 3,080 sq. ft., with 350 sq. ft. of superheating surface, five boilers being used at time of maximum load. The boilers are set in pairs and are hand-fired with unwashed small coal, the fuel being delivered from overhead bunkers filled by a bucket conveyor. The feed is heated by a Green's economiser. Water for condensation is obtained from a reservoir directly connected with the river.

The switchboard is of the carriage type (Fig. 2). The board is of cellular construction with the 'bus bars running along the back in a separate chamber, from which contacts project into each division. The whole of the switch gear, instruments and transformers for each panel are mounted on a carriage which can be withdrawn as a whole on to a trolley should any adjustment become necessary. With the panels in position the exterior of the board consists of brick or earthed metal work. This system is a safe one for the employés, as no adjustment can be made on the working parts of the switch gear unless it is dead, the panel being only movable when the main switch is in the "off" position. All panels are equipped with three-phase oil-break switches, fitted with overload relays, which actuate solenoids, worked by D.C. (supplied from a small battery charged from the exciters), the machine panels having in addition reverse current cut-outs; synchronising is effected by a synchroscope. The machine panels have ammeter, wattmeter and voltmeter; the circuits, ammeters and watt-hour meters. The top of the board is enclosed and is used as a platform to obtain access to the lightning arresters and their resistances. These are protected by divisions, but are not enclosed.

The maximum demand reached during 1905 has been 1,400 kw., momentary demands reaching 1,750 kw., this demand on the power station being one-third of that required to drive all the motors erected if they were all run simultaneously at maximum load. The output of the power station is now at the rate of 4½ million units per annum so that the load factor of the station when the original equipment of motors is completed will lie between 35 and 40 per cent., and when the percentage of pumps and fans driven electrically is increased, and the pumping confined as far as possible to the night, a load factor of over 40 per cent. will be reached. Tests of the power station show a fuel consumption with unwashed small coal having a calorific valve of 13,000 B.Th.U., with the sets operating at full load, of 2·7 lb. for the 1,500, and 3 lb. with the 750 kw. sets, the weekly coal figure per unit delivered to the transmission lines averaging 3¾ lb. of the above coal, with an output varying between 87,500 and 92,000 units per week.

*Transmission Lines.*—The transmission lines are designed to supply 6,000 B.H.P. of motors, based on a motor efficiency of 87 per cent., power factor 75 per cent., with a maximum drop of 10 per cent. in pressure with 70 per cent. of the motors working at full load simultaneously at any individual point. Table II. gives the distance between pits and the power station, the cross-section of each feeder, and the brake horse-power of motors now in use, the greatest distance to a centre of distribution (above ground) from the power station being 2¼ miles. As the conductors radiate ¾ mile beyond this point, the longest transmission is 3 miles. In addition, the lighting load above and below ground amounts to 125 kw.

**Table II.**

| —— | Distance from power station in yards. | Cross section feeder. Sq. inches. | B.H.P. of motors supplied Dec., '05 |
|---|---|---|---|
| Lower Duffryn | 1,870 | 0·08 | 1,131 |
| Abercwmboi | 1,930 | 0·04 | 205 |
| Old Duffryn and Lletty Shenkin | 620 | 0·11 | 561 |
| Upper Lletty Shenkin | 1,268 | 0·04 | 441 |
| Aberaman | 1,325 | 2 × 0·15 | 960 |
| Cwmneol | 2,715 | 2 × 0·15 | 316 |
| Fforchaman | 3,770 | 2 × 0·15 | 821 |
| Treaman | .. | .. | .. |
| George | .. | .. | .. |
| Washery (power station) | .. | .. | 105 |
| | | | 4,540 |

The overhead transmission lines are bare hard-drawn copper conductors, wires up to 0·042 sq. in. (4 S.W.G.) being solid, any wires over this size being stranded. Fig. 3 shows the general construction of the transmission line. The wires are supported on wooden poles, except at points of special strain, where lattice steel poles are used. The poles are creosoted, and average 33 ft. long by 7 in. in diameter at the top; 6 ft. to 7 ft. are embedded in the earth, and where the foundation is doubtful they are set in concrete. The poles are erected an averave of 40 yds. apart, the maximum distance in straight runs not exceeding 45 yds. The wires are supported on porcelain insulators mounted on wrought-iron supports (Fig. 4).

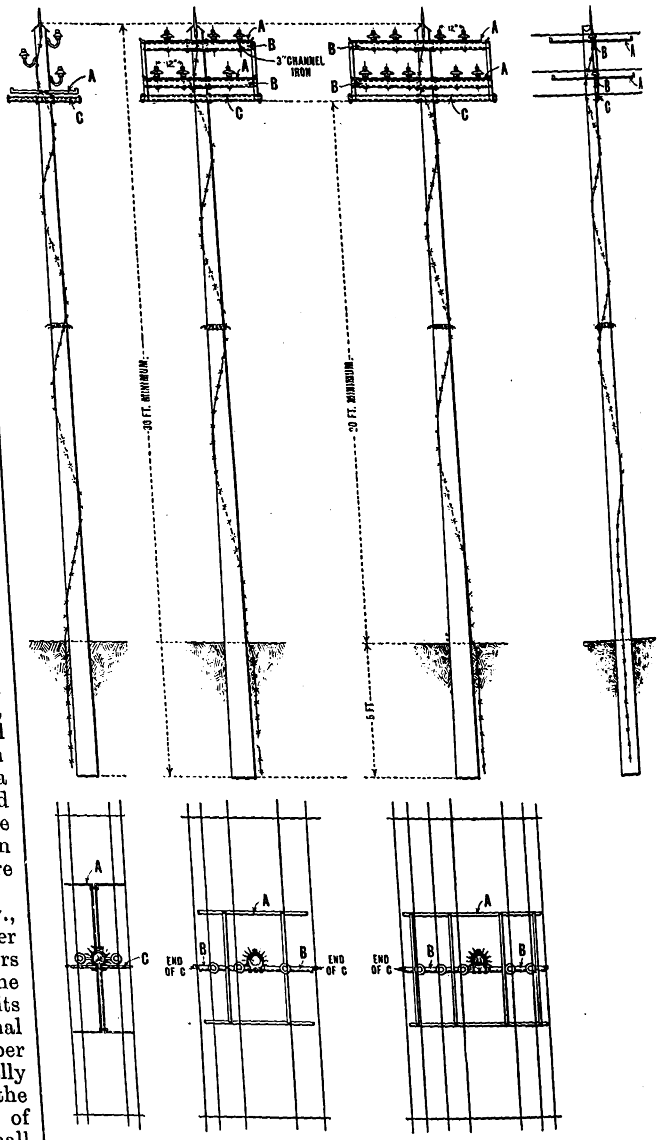

FIG. 3.—TRANSMISSION POLES.

A. Earthing Device. B. Insulator Cross-arms. C. Screen-work Cross-arms. Scale 1 : 100 approx.

The insulators are set at 12 in. centres horizontally, and 18 in. vertically, the wires being carried 20 ft. from the ground level.

Guard netting is erected below the transmission lines at all points where existing wires are crossed, or in the vicinity of the colliery premises where there is traffic. This guard netting consists of two steel wires, $\frac{3}{16}$ in. in diameter, stretched below the transmission wires with transverse ¼ in. diameter wires every 6 ft., the ends of the transverse wires being turned up to ensure any broken wire being caught by the netting. Where guard netting is not used steel catchers are fitted at each pole to ensure a broken wire striking the catcher, thus becoming earthed. To prevent anyone climbing the poles they have barbed wire spiralled round them, and are further protected by having a ring fitted with spikes fixed on each pole 10 ft. from the ground. At one point, where the wires cross a number of telegraph lines on a public road, the transmission wires are carried through a lattice bridge, provision being made for 12 conductors, of which six are erected at present. The total length of the pole route is 8¾ miles, on which 33 miles of wire have, so far, been erected. In addition to the transmission wires the poles carry telephone wires connecting the power station and the various sub-stations; these wires are crossed every 200 yds. to minimise induction. The whole of the overhead wires are erected on colliery property, except where public roads are crossed.

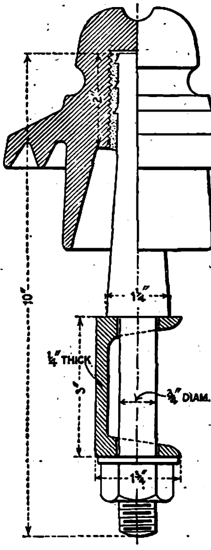

FIG. 4.—INSULATOR SHOWING METHOD OF SUPPORT.
Scale ¼ Full Size.

*(To be concluded.)*

## CAVEHILL AND WHITEWELL TRAMWAYS.

The above line of tramways, which was opened for traffic on February 13, 1906, commences at the termination of one of the principal routes of the City of Belfast Tramways, at Chichester Park.

The company was incorporated in 1881 for the purpose of constructing tramways in the County of Antrim. The purchase clause in this case does not apply. The Act of 1902 authorised the company to electrify their existing tramways in the County of Antrim, and to enter into agreements with the local and road authorities and the British Electric Traction Co. (Ltd.)

Proceeding northwards along the Antrim road, the track passes through the small village of Whitewell, and shortly afterwards reaches the terminus at Glengormley, where the Cavehill Tramways Company possess spacious grounds and gardens, which they have decided to develop on American lines into a pleasure park.

The tramway has a total length of approximately 3½ miles, and consists of a single line, 4 ft. 9 in. gauge, with 16 side turnouts. The length of these turnouts is 220 ft., with the exception of two which are 900 ft. long and one which is 450 ft. long. The rails, which are of British standard section, weigh 105 lbs. per yard, supplied by the North Eastern Steel Co. They are anchored with three intermediate riveted anchors per rail, with a new design of anchor, viz., Walker-Grant anchor, fixed on either side of and close to the rail joint. The rail joint employed is of the type known as the patent continuous rail joint, being a fish plate and sole plate combined. Concealed bonds are used at all joints. Standard points and crossings by Hadfield's are used throughout; the points have a radius turnout of 200 ft., and the crossings an angle of one in six.

The total rise of the road from Chichester Park to Glengormley is 252 ft., the latter place being 415 ft. above the sea level. The gradient of the road has an even rise of about 1 in 72 all the way. Where the City of Belfast Tramways and the Cavehill and Whitewell Tramways meet there is at present a gap of 35 ft.

The overhead construction is practically identical with that adopted for the Belfast tramways. For the most part trolley wire is carried on span wires, no rosettes being used on any portion of the system. The poles are of three sizes, each having a total length of 31 ft. They were supplied by Spencer's and Stewart's and Lloyd's. All the poles are planted 6 ft. deep in concrete, resting on a "biscuit" of 6 in. of the same material. The trolley wire, which is of hard-drawn copper, is 0·40 in. in diameter, and has a breaking strain of 24 tons per square inch. It weighs 1,450 lbs. per 1,000 yds., and is strung 22 ft. above the ground. Flexible suspension has been adopted throughout. Span wires are of mild steel, galvanised, in stranded cables of 7/12 S.W.G. To avoid leakage, the whole of the line is doubly insulated.

The section insulators are of the double air-gap type, supplied by the British Electric Tramway Equipment Co. The line is divided into the customary half-mile sections, the boxes being fitted with 200 and 400 ampere quick-break switches, a Garton lightning arrester, a kicking coil, copper 'bus bars and connecting board for telephone and test-wire terminals and telephone plug box. The current-density for all switches and connections is 500 amperes per square inch. Separate doors provide for access to the telephone plug boxes. The pull-off insulators have a span of 10 in. between the eyes, and the bodies are of strong gunmetal. Brooklyn strain insulators, gunmetal clamps and globe strain insulators are used on line terminals, and the connections between the section pillars and the trolley wires are made with 37/16 S.W.G. cable. The cables connecting the sub-station to the line were laid by Messrs. Callender's, and are of their well-known vulcanised-bitumen make laid solid.

The overhead wiring of the shed is separated from the street wiring by section insulators. The car depot is situated about midway on the route, and is built on the Cavehill side of the road. It is capable of housing 12 cars, and is fitted with workshop, stores, &c. The total length of the shed is 110 ft., breadth 61 ft. There are four pits, three 56 ft long and one 90 ft. long. There are at present 10 cars, furnished by the Brush Company, five short and five long; the long cars being supplied with radial trucks of the Lycett & Conaty type. Current is supplied by the Belfast Corporation from a sub-station near Chichester Park.

The general manager of the line is Mr. F. P. Comber. The resident engineers during the construction, as representatives of the British Electric Traction Co., were Mr. A. V. Mason and Mr. R. W. Thompson. The whole of the work was carried out by Messrs. J. G. White & Co. under the supervision of Mr. I. H. Fisher.

## CORRESPONDENCE.

### GRADING LAMP VOLTAGES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to your editorial note in the issue of Friday, March 16th, I notice that you very kindly refer to some remarks made by the writer on Mr. Wilkinson's Paper. I am very pleased, indeed, that a paper of the standing of *The Electrician* has taken up this matter of the closer grading of voltages of supply stations, although your remarks are not quite in agreement with the points I particularly wish to raise. Please do not class us among the manufacturers who are continually bewailing their fate of having to work under bad conditions. I hold, and always will hold, that we British manufacturers turn out lamps, despite the present conditions, equal or better than the best which can be produced in either the United States or on the Continent.

The point, however, to which I particularly wish to draw attention has been raised by the efforts of the Standards Committee to obtain a closer grading of electric lamps, and these efforts are being rightly backed up by central station engineers. The Standards Committee are seeking for a more closely graded lamp, and the writer, in his remarks, simply points to a method by which this grading can be carried out in a practically perfect manner. In fact, provided the central station engineers run their voltages at approximately the declared pressure, and grade the voltage of the different stations in sufficiently small steps, we as manufacturers can guarantee to give people practically 16 c.p. without variation.

Taking the figures which you have been to the trouble of preparing from various tables you will notice that the 100 volt and 200 volt stations figure very largely and out of all proportion to other voltages.

I attach herewith a table which I have prepared, taking your figures as being correct, and working out the number of stations at each voltage as a percentage of the total number of stations. By the side of these figures I give a column of the percentage of different voltage lamps sold, taken over the whole output of the "Robertson" factory for the past year, which was just over four million lamps. These figures can therefore be taken as representative of the whole trade of this country.

From these figures you will see that we have no stations with a voltage on the low side of 100 or 200 volts, although the stations at these voltages take the biggest percentage of lamps. This table also shows the very small percentage of lamps which are demanded at the intermediate voltages. I think that these figures speak for themselves, and show the great necessity for a greater sub-division of the voltages of electric supply stations.

| Declared pressure. | No. of stations according to *Electrician* list. | Percentage of total voltage to total of supply stations. | Percentage of lamps sold at each voltage. |
|---|---|---|---|
| 90 | .. | .. | 0·15 |
| 95 | .. | .. | 0·10 |
| 100 | 51 | 10 85 | 23·00 |
| 105 | 9 | 1·92 | 4·00 |
| 110 | 8 | 1·70 | 5·50 |
| 115 | 3 | 0 64 | 0·40 |
| 120 | 1 | 0·21 | 1·00 |
| 150 | 2 | 0·43 | 0·40 |
| 190 | .. | .. | .. |
| 195 | .. | .. | 0·05 |
| 200 | 77 | 16·40 | 17·40 |
| 205 | 5 | 1·06 | 0·90 |
| 210 | 28 | 6·00 | 3·25 |
| 215 | 2 | 0·43 | 0·275 |
| 220 | 81 | 17·24 | 13·80 |
| 225 | 8 | 1·70 | 0·64 |
| 230 | 125 | 26·60 | 10·50 |
| 235 | .. | .. | 0·10 |
| 240 | 60 | 12·77 | 11·40 |
| 245 | .. | .. | 0·01 |
| 250 | 10 | 2·13 | 4·50 |

Remaining 2·6 per cent. consist of other voltages, battery lamps, &c.

The table I have prepared shows that there has been barely any demand for lamps in grades of fives, the principal demand being in tens. I pointed out in my original remarks the big difference a small percentage change of voltage makes in the candle-power, and feel sure that when some of our leading station engineers become well acquainted with these figures they will endeavour to assist the electric lighting portion of the engineering profession generally by giving greater attention to these points.

There can be no question that the ideal arrangement would be for an equal number of stations of each voltage in grades of five, from 90 to 120 volt and from 190 to 250 volt, in steps of five, or even these limits can be narrowed to bring it well within the proposed limits of the Standards Committee. The main point to which I wish to draw attention is the great disproportion between 100 volt and the 200 volt stations, with no outlet for lamps which come on the low side of these figures. Such points as these are of general interest to the whole trade, and if Mr. Wilkinson's valuable Paper, together with the discussion which has been raised, tends to closer co-operation between station engineers and the lamp manufacturers, the time and trouble spent will not have been in vain.—Yours, &c., C. WILSON.

Robertson Electric Lamp Works,
Hammersmith, March 21.

## ELECTRIC WINDING IN COLLIERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I note in your issue of the 16th inst. that you give some prominence to the Paper which I read on "Electric Winding" in main shafts, considered practically and commercially, and I think that your readers will probably form an entirely erroneous impression of my views from the remarks you make.

My object in reading the Paper in question was to arrive (if possible) at some definite conclusion, based upon actual facts, as to whether electric winding can be economically adopted for heavy work.

I am quite aware that electricity can be adopted, and has been by my own firm, in connection with small winding gears for staple winding, and also under certain circumstances for main-shaft winding, with results which are extremely satisfactory, but I do strongly object to the suggestion conveyed in your remarks that, because I question the economy of electric winding for heavy work, I throw the slightest doubt upon the economy of the application of electricity to colliery work generally.

As a matter of fact, I believe that the figures which Mr. Mercer quotes are figures in connection with two installations carried out by my own firm, and I could bring forward hundreds of illustrations to prove conclusively that electricity, when applied to its proper uses, is most economical, in fact the only power which can be used under the circumstances.

In your remarks you further refer to what you describe as an "obvious absurdity" in connection with the application of electricity to winding in a Belgian mine.

I would point out that the figures which I quote in my Paper are not mine at all, but were given to me by the makers of the plant in question. These figures refer to a winding plant driven by three-phase current, working 24 hours per day, which it will be admitted are the most economical conditions under which winding can be done, but notwithstanding the favourable circumstances under which the plant is operating, the cost of winding is fully three times as much as it would be with economical steam engines.

It must be perfectly clear to all the readers of your paper that as my business for the last 20 years has been principally in connection with the application of electricity to mining purposes, it would be absurd if I were to oppose any application of electricity which I might consider was of advantage to our customers, but I do think that the electrical profession is bound to consider the interests of its customers, and it only means bringing discredit upon the whole profession if we recommend people to spend large sums of money which will not produce results which are of commercial value.—Yours, &c., W. C. MOUNTAIN.

Close Works, Gateshead-upon-Tyne, March 19.

## NEW LAMPS FOR OLD.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I trust that you will consider the subject matter of this letter sufficiently important and sufficiently technical to merit the honour of publication in your columns.

It is my fortune to dwell in the territory of the Marylebone Borough Council. Some nine or ten months ago I received an intimation from the Electricity Department that my pressure of supply would shortly be increased from 200 to 240 volts. As requested, I sent in an exact list of my requirements in regard to lamps, specifying the candle-power and the make of those I then had.

Early in the autumn, being anxious to lay in a stock of lamps for the winter, I inquired when the change over would take place. I was politely informed—and here I must say that the Electricity Department would appear to have engaged a descendant of the late Lord Chesterfield to conduct their correspondence with angry customers—that the event was expected to occur some time after Christmas and that any reasonable number of spares I might have at that date would be made good. So I laid in my store and lived happily on 200 volts a year.

About a month after Christmas, I returned home one evening to find the place in darkness and sundry candles stuck in bottles making that darkness visible. I will not dwell on the domestic disturbance. My grievance is quite another one.

When I left home in the morning I was the proud possessor of a sturdy little family of Ediswans all, with one or two exceptions, of the 8 c.p. variety. When I returned on that ill-omened day, it was to find that I was bereft of my little Englishmen and that their place was filled by a crowd of big 16 c.p. anonymous abominations which, by the guttural noise they made when they gave up the ghost, were evidently of German parentage.

An interchange of letters resulted, in due course, on the substitution of 8 c.p. lamps for 16 c.p.'s. But to this day, nearly two calendar months after the outrage, I am still without Ediswans and still without the promised spares.

Sir, I am not learned in the law, especially in the law of electric lighting, but in these days of protection I ask: Is it right that the poor consumer should alone be left unprotected? I would appeal to Cæsar if only I knew his address; I do not see it in the Big Blue Book, so perhaps he is dead. I am credibly informed that it is a legal axiom that there is no grievance without a remedy. Well, sir, I have ventilated my grievance, because an unventilated grievance is as insanitary as an unventilated sewer, and I would ask you: "What is my remedy?"—Yours, &c., W. G. BOND.

187, Clarence Gate-gardens,
Upper Baker-street, N.W., March 17.

[Mr. Bond has set us a difficult conundrum. If his solicitor can advise him that the letters written by Lord Chesterfield's descendant are in the nature of an agreement, he can doubtless obtain the lamps by procedure under common law. As an alternative to this, we presume that the correct course must be taken to be indicated by the Board of Trade regulations B 3 and 5, and the conditions (published in *The Electrician* for November 25, 1904, p. 237), under which the London County Council declared its consent to the change of pressure. These conditions include replacement of the old lamps and a reasonable number of spares by new ones of the same make. Apparently he can choose between an application for the appointment of an arbitrator to settle the points in dispute between himself and the Marylebone Borough Council, or he can apply to a magistrate for the enforcement of the penalty "not exceeding £5 for every such default and a daily penalty not exceeding £5." It will be a cheaper course, however, for him to buy the lamps he wants and to find a friend upon the Marylebone Borough Council who will continue to ventilate the grievance until proper satisfaction is obtained. We may add, however, that Mr. Bond's is not the first complaint that we have received as to the inconsiderate way in which the change-over has been carried out. There are, of course, considerable difficulties in making so extensive an alteration in a network of this magnitude, but this is no excuse for negligence or for the Council's omission to fulfil its obligations.—ED. *E.*]

## PHASE MEASUREMENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. J. W. Waghorn refers in your last issue to the method of finding the power factor of a multiphase circuit from a comparison of the readings of two wattmeters. The method can be applied in various ways, and seems to have been independently discovered by several experimenters, as reference to back numbers of *Science Abstracts* will show. I do not know to whom it is originally due, but it is certainly quite an old method now. I have taught it in my classes for several years past. I believe it to be of Continental origin.

It is a convenient and simple method for workshop and laboratory testing, but like most other methods of measuring power factor, its simplicity is largely due to the ruthless assumption made—that the currents of the multiphase system are equal in magnitude and in power factor. When the load currents are unbalanced the method does not give accurate results.—Yours, &c., W. E. SUMPNER.

Technical School, Birmingham, March, 19.

## VIBRATING REED FREQUENCY INDICATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We note in your abstract of Mr. Edgcumbe's Paper on recent electrical measuring instruments that the vibrating reed type of frequency indicator, which we have put on the market here, is described as due to Messrs. Kempf & Hartmann. Would you kindly allow us to point out that the apparatus in question is the outcome of Dr. Hartmann-Kempf's researches. Full details of his investigation on vibrating reeds excited by electromagnets will be found in his book on "Elektro-Akustische Untersuchungen." The apparatus is manufactured by Messrs. Hartmann & Braun, of which firm Dr. Hartmann-Kempf is now a member.—Yours, &c., UNION ELECTRIC CO.

London, E.C., March 13.

## TRANSFORMER FUSE BOX.

The British Westinghouse Co. have recently placed on the market a new and very convenient fuse or switch box, which can either be fixed to an existing wall or mounted on a pillar. Intended for use in transformer sub-stations and similar positions, it provides a convenient and safe means of protecting and isolating both the high and low-tension sides of a transformer or other apparatus. The box was originally designed for the requirements of the County of London Electric Supply Co. (Ltd) for use in their sub-stations, but the design covered so many novel points, and filled so many requirements, that the British Westinghouse Co. decided to make it a standard manufacture.

Fig. 1, in which is seen the cast-iron frame work of the box, shows also the inspection windows, the cable bushes, the division of the door, and the lugs for fixing to wall, and in Fig. 2 are shown the high-tension and low-tension connections and the mountings. The cables from the transformer are led in through insulating bushes. The high-tension terminals are mounted on porcelain insulators, and the low-tension on treated marble slabs. These terminals are combined with jaw clips into which the knife-blade ends of the fuses or isolating switches enter. The fuses or switch blades are carried upon porcelain insulators on marble bases fixed to the inside of the hinged cover. The action of closing the box automatically completes the circuit, and similarly the circuits are broken on opening the box. The fuses are of the enclosed type, the rupture of the circuit taking place inside a totally closed tube, thus rendering flashing or arcing impossible. In the box illustrated, one fuse is provided in the high-tension circuit, and two in the low-tension circuit, but any combination of fuses or isolating links can be arranged.

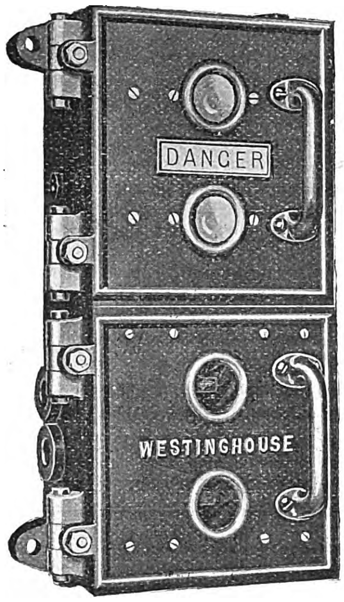

FIG. 1.—FUSE BOX CLOSED.

An important feature of the box is the construction of the cover. This is in two halves, and it is impossible to open the lower or low-tension half without previously opening the upper or high-tension portion. Thus, none of the fuses can be replaced until the high-tension supply to the transformer is cut off. Inspection windows are provided in each half of the box, so that the condition of the fuses may be ascertained without opening the doors. Convenient handles and bolt lugs are provided. The whole arrangement is compact and the workmanship of the usual high quality. The over-all dimensions of the box shown in the illustrations are 2 ft. by 11 in., and this size is suitable for all purposes up to 2,500 volts on the high-tension side.

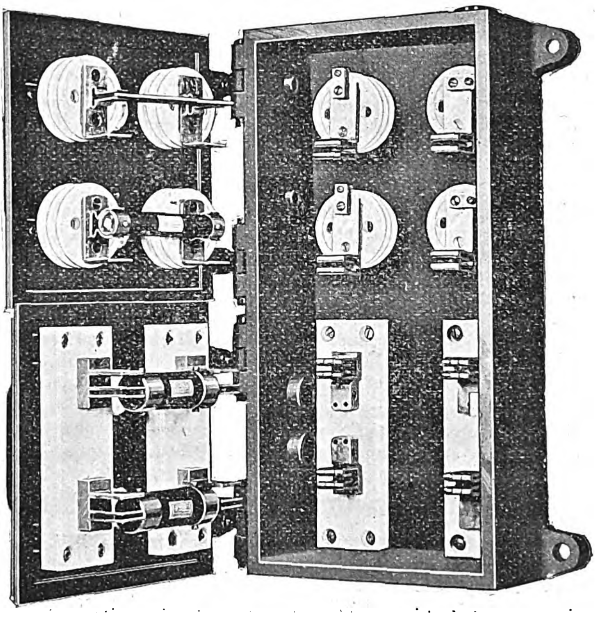

FIG. 2.—FUSE BOX OPEN.

# PARLIAMENTARY INTELLIGENCE.

## BREAKDOWNS ON THE DISTRICT RAILWAY.

Some questions have been asked this week in the House of Commons concerning the recent breakdowns on the District Railway, and also with regard to the provision of a second man in the motorman's cab.

Mr. KEARLEY, who replied to one of the questions, pointed out that the responsibility for the working of the line rested with the company, but he was communicating with them with regard to the accidents in question. He was advised that the presence of only one man in the driver's cab was not a source of danger, and that none of the breakdowns were attributable to this cause.

Mr. LLOYD-GEORGE, in reply to the other questions, said that the company, in expressing their regret for the accidents, pointed out that they were due to the difficulties of substituting electric for steam traction. The difficulties were being steadily overcome, however, and the number of delays had now been greatly reduced. The company explained that the stoppages and delays had been mainly caused by a number of small (remediable) defects in the mechanical and electrical equipments, and by the necessity of training by experience in new work a large number of men in various grades. They were making every effort to remedy the defects, and hope that the train services would soon be worked with no more than the normal percentage of failures which must occur on every railway on which a train mileage of such density was run.

## THE LONDON POWER BILLS.

The bills relating to electric power supply in London have been further postponed. Both the Administrative County of London Bill and the Additional Electric Supply Bill have motions for their rejection on second reading down on the Paper, and Mr. W. F. D. Smith has now notified that he will move the rejection of the London County Council (Electric Power) Bill.

## MISCELLANEOUS.

**Hull Municipal Telephones.**—Mr. Belloc will shortly ask the Postmaster-General whether his attention has been drawn to the recent offer of the National Telephone Co. for the purchase of the municipal telephones at Hull, and whether, seeing that the offer was higher than the offer made by the Post Office for the same property, and that the assets of the National Telephone Co. are purchasable in full by the State a few years hence, he will in the public interest take steps to secure that this company shall not offer, in competition against the State, sums which the State itself is pledged to reimburse.

**Todmorden Corporation Bill.**—This bill was considered by the Police and Sanitary Committee of the House of Commons last week. The measure is of an omnibus character, but Part III. contained several clauses of a non-contentious character relating to electric supply, such as the refusal to supply electrical energy in certain cases, power to lay mains in private roads, conditions regarding supply to persons having independent plant, and so on. Another portion of the bill asked for powers to run a system of motor omnibuses within and without the borough. Col. Crompton gave evidence on behalf of the Corporation, and put the cost of four omnibuses and a shed at £4,800. The Committee granted this part of the bill.

**Standing Orders.**—The London County Council (Tramways) Bill and the Middlesex County Council (Tramways) Bill were before the Standing Orders Committee of the House of Lords on Monday. Both bills propose to construct tramways along the Edgware-road to Cricklewood, and in neither case have the requisite consents of the local and road authorities been obtained. The Willesden Urban District Council and the Hampstead Borough Council opposed. The Standing Orders have already been dispensed with by the House of Commons, and the present application to the House of Lords was to settle the question of Standing Orders before the Committee stage in either House was reached. It was eventually decided to dispense with the Standing Orders in both cases, so that the merits of the two proposals will now be discussed before the same Private Bill Committee. Folkestone, Sandgate and Hythe Tramways Bill (No. 1) is also allowed to proceed.

**The Telephone Agreement.**—In the House of Commons on Tuesday the Postmaster-General stated that he has arranged to present to Parliament a copy of the supplemental agreement with the National Telephone Co., dated Aug. 8, 1905, which was made in order to give effect to one of the recommendations of the Select Committee which considered the original agreement.

**Rathmines and Rathgar (Extensions and Improvements) Bill.**—This bill included clauses to give the Rathmines and Rathgar Urban District Council power to purchase the rights of the National Electric Construction Co. in Rathmines, under an agreement dated May 17, 1899, and subsidiary agreements, and to supply electrical fittings, &c. The bill was rejected by the House of Commons on the motion for second reading, however, exception having been taken by the Irish members to other clauses in the bill.

**Railway Companies and Municipal Electric Tramway Undertakings.**—A Committee of the House of Lords, presided over by Earl Cawdor, has had under consideration this week two bills by railway companies, in which powers were asked to run motor omnibuses to facilitate the passenger traffic on their lines, both of which were opposed by municipal authorities owning electric tramway systems. The first bill was that of the Mersey Railway Co., to which opposition was offered by the Birkenhead Corporation, but the Committee granted the powers without calling upon the promoters to reply to the case for the opposition. The second case was that of the Wirral Railway Co., which was opposed by the Wallasey Corporation, but in this instance the Committee decided to reserve their decision until the Wallasey Tramways & Improvements Bill comes before them for consideration next week.

**Huddersfield Corporation Bill.**—This bill has been under consideration by the Police and Sanitary Committee of the House of Commons this week. It is an omnibus bill, and contains a section relating to the construction of some short lengths of additional tramways, for which £5,340 will be borrowed, repayable in 60 years, and £822 for electrical equipment, repayable in 20 years. There was no opposition to this section of the bill, and it was allowed to go forward.

**Electric Lighting Provisional Orders.**—Dr. Macnamara will ask the President of the Board of Trade whether he will grant a return showing the appeals to the Board of Trade in respect of provisional orders for electricity purposes by local authorities and companies during the ten years ended March, 1906, and also particulars of the names of local authorities and companies, objects of applications in appeals, dates when made, and decisions of the Board of Trade respecting them.

**Macclesfield and District Tramways Bill.**—A Committee of the House of Commons, of which Sir John Dickson Poynder is chairman, met yesterday to consider this bill, but it was announced that all opponents have now been settled with. The bill seeks the incorporation of a company with a capital of £135,000 in £10 shares to construct a network of tramways in and around Macclesfield. The promoters are W. L. Madgen and Alfred Christian Hobson. The works are to be completed in five years. The carriage of goods and animals will be undertaken and 1d. stage fares arranged. Purchase is to take place in 42 years from date of act at fair market value. General powers are taken for agreements with local authorities as to the supply of electrical energy and with contiguous undertakers. Interest out of capital during construction to the extent of £15,000 will be paid.

**London County Council Tramways Bill.**—Owing to certain circumstances, including the opposition of the bill on second reading, the Committee of the House of Commons, presided over by Sir John Dickson Poynder, has decided to postpone the consideration of this bill together with the Corporation of London (Blackfriars and other Bridges) Bill until after Easter.

The London County Council (Tramways) Bill and the Middlesex County Council Tramways Bill were read a first time in the House of Commons on Thursday last week.

The West Cumberland Electric Tramways Bill was read the second time in the House of Lords on Monday.

# LEGAL INTELLIGENCE.

## Application of the Truck Act.

The House of Lords delivered judgment on Tuesday in an important matter, "Williams and others *v.* North's Navigation Collieries (1889) Ltd." Originally plaintiffs (workmen in the defendant company's employ) were sued by the company for breach of contract by abstaining from work on a particular day. The county court judge awarded the company 30s. damages in each case, to be paid in three fortnightly instalments. The company accordingly on the first pay day deducted 10s. from the wages of each man. The men protested, and contended that the deduction was a contravention of the Truck Act. They brought an action, and Mr. Justice Bucknill held that the deduction was illegal. The Court of Appeal, however, reversed this decision, hence the present appeal.

The LORD CHANCELLOR, in giving judgment, said sec. 23 of the Truck Act provided with elaborate care, and under strict safeguards, the cases in which debts due from workmen might be deducted from wages. Those provisions would be wholly unnecessary if an employer were already authorised by sec. 3 to deduct anything that the workman owed him, and to pay in coin merely the balance. It appeared to him that an obligation rested upon the employer under the Truck Act to pay in coin all the money payable as wages, and that he could subtract nothing except the deductions expressly sanctioned by sec. 23. The deduction of 10s. for fines was therefore in the present case illegal. Mr. Lush, the county court judge, had argued that this construction would be very anomalous. He urged that if the employer did not pay the wages at all, and was sued, he would be entitled to set off in the action anything due to him, except such sums as fell within the prohibition of sec. 4. It would be strange, said Mr. Lush, if an employer could, by breaking his contract and forcing litigation, obtain an advantage denied to him if he fulfilled his contract. No doubt this would be an anomaly, as were the Truck Acts themselves and some other acts which interfered in a limited degree with freedom of contract. It was necessary to distinguish between the clauses of the act relating to a set off in an action and those relating to stoppage or deduction when the wages were paid. It was enough to say that, assuming the acts of Parliament had so provided, the fact that the provision was anomalous did not permit them to disregard the plain meaning of the words used. Accordingly he moved that the judgment of the Court of Appeal be reversed.

Lords MACNAGHTEN, DAVEY, ROBERTSON and ATKINSON concurred.

The appeal was accordingly allowed, with costs against defendant company both in the Court of Appeal and the House of Lords.

### London Hydraulic Power Co. v. St. James' & Pall Mall Electric Light Co.

The hearing of this case (reported on p. 897 of our last issue) was concluded on Monday. The question at issue was as to who was responsible for the considerable mischief caused in the west end of London by the bursting of one of the plaintiff company's water mains in Piccadilly-circus on July 10 last.

For the defendants expert evidence was given with a view to proving that there had been a subsidence in the neighbourhood which was quite sufficient to have caused the breakage of plaintiffs' main. Several of defendants' witnesses further stated that, having regard to the point at which the break occurred, it could not have been occasioned by vibration arising from the passing of traffic over the defendants' inspection box.

His LORDSHIP held that plaintiffs had failed to prove that the bursting of the main was due to any act of defendants. The action would, therefore, be dismissed with costs. On defendants' counter-claim for £35 odd judgment would be entered for defendants, also with costs.

### Tramway Centre Poles.

At Shoreditch (London) County Court on Monday, Mr. Hy. Gould, cab proprietor, sued the Metropolitan Electric Tramways (Ltd.), for the value of a horse killed and for compensation for damage done to a hansom cab by a collision with one of the company's iron standards in October last.

The cab-driver (Miles) said he did not see the post until his horse's head dashed against it.

His HONOUR (Judge Smyley) said it was an important action, as, although the Tramway Co. had power to erect posts in the middle of the road by act of Parliament, they must not be erected to the danger of the King's subjects.

The jury found for plaintiff for £63 damages, and judgment was given for this amount with costs.

### Tube Railway Construction.

The High Bailiff for Westminster (Sir Thomas Raleigh) and a special jury heard last week a claim by Mr. H. I. Coburn against the Great Northern, Piccadilly & Brompton Railway Co. for compensation for interference with the subsoil at a depth of 120 ft. below the pavement of premises in Long-acre, London, of which complainant is the leaseholder. An award of from £1,200 to £1,400 was asked for.

Mr. ROSKILL, K.C., for respondents, denied the right of a leaseholder to claim. The company had already settled with the freeholder by paying him £1 per foot run.

Mr. W. W. SZLUMPER, Sir JOHN WOLFE BARRY and Sir DOUGLAS FOX gave evidence as to the absence of danger to claimant's property, and the jury then found for respondents.

### Dudley, Stourbridge and District Electric Traction Co. v. Dudley Corporation.

Mr. Justice Kekewich concluded the hearing of this case on Wednesday. Plaintiffs claimed a declaration that they were not under an agreement of Oct. 17, 1898, or otherwise bound to sell to the Corporation, and that Dudley Corporation were not, under the agreement or otherwise, entitled to require or compel the sale to it of a portion of the plaintiff company's system.

After hearing the legal arguments, Mr. Justice KEKEWICH held that the particular light railway in question (known as No. 5) was part of a scheme of railways, and was intended to be connected with several others. To carry out that scheme the Corporation had, under the agreement, the right to purchase No. 5 railway, and judgment would, therefore, be for the Corporation, with costs.

**Child v. A. J. Harris & Co. (Ltd.)**—On Friday, Mr. Justice Warrington appointed a receiver and manager of the company's assets until the second motion day of Trinity Sittings.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT AND FILLED.

A driver, capable of running Parsons direct-current turbos and surface-condensing plant, is required at Loughborough electricity works. Applications to the borough electrical engineer. See advertisement.

Croydon Education committee invite applications for the chief lecturership in electrical engineering at Croydon Polytechnic for three evenings per week for a session of about 30 weeks. Payment £1 per evening. Forms of application up to March 31.

An assistant is wanted in the mathematics department of the Northern Polytechnic Institute, Holloway, London, N. Applications by 29th inst.

Mr. Sidney Russ and Mr. Herbert Stansfield, B Sc., have been appointed junior demonstrators in physics at Manchester University.

**Electrical Standardising, Testing and Training Institution.** The following special lectures have been arranged at Faraday House:—Mr. W. R. Cooper, M.A., B.Sc., on "Electrical Accumulators," March 23; Mr. J. B. C. Kershaw, on "Fuel Economy in Electric Lighting and Power Stations," on March 30.

**Argentina**—The "Review of the River Plate," says:—The Pacific Railway Co. have applied to the municipality for permission to undertake the supply of electricity in Bahia Blanca. It is proposed to employ underground mains. Five per cent. of the gross receipts is offered to the municipality. There is already a company supplying electricity in the town.

It is proposed to connect up all the telephone exchanges in the south of the province of Buenos Ayres.

Buenos Ayres Electric Tramways Co. are about to adopt trailers for holiday and Sunday service.

Messrs. R. von Wentzky & Co. having asked for an extension of six months for the signing of their contract for an electric tramway in Buenos Ayres and for a reduction of the guarantee from $1,000 to $500 per kilometer, it is stated that the petition has been rejected, and the contract declared void.

**Australasia.**—Our Australian correspondent reports that a scheme for a light electric railway from Nhill to Netherby and North Yanac (Victoria), a distance of 30 miles, has been submitted to Nhill Council by Mr. J. C. Lockley, engineer and manager of the local electricity works.

Prahran (Victoria) Council, whose application for an electric tramway order has been refused by the Government, have asked the Public Works Department to receive a deputation on the subject, and have been informed that no steps for the construction of Government tramways in the district will be taken until the Council have been heard on the matter. A proposal for a joint tramway scheme to be carried out by Prahran and Malvern has been discussed by Malvern Council and adjourned.

Negotiations are proceeding for the purchase of the Adelaide tramways by the South Australian Government. The price asked by the companies for their undertakings is £416,000.

Balmain (N.S.W.) Council decided some time ago to erect combined destructor and electricity works, but a poll of the ratepayers recently decided in favour of permitting a company to carry out the project. Subsequently an offer by Kenway & Co. to erect works was provisionally accepted, but this has not yet been ratified.

An arrangement has been made for the students in electrical engineering at Melbourne University to proceed, after two years at Melbourne, to take their third year's course at Sydney University.

The "Australian Mining Standard" says application has been made for the registration of the North Melbourne Electric Tramways & Lighting Co,

Subiaco (W. Australia) Council are about to increase their electrical plant at a cost of £6,500.

The Government have been asked by a local company for authority to generate electrical energy at Collie, and supply it to the eastern goldfields of Westralia, via Perth.

The South Australian Post Office telephone wires in Adelaide and suburbs are to be laid underground at a cost of about £30,000 The work will be spread over five years.

**Bermondsey (London).**—Condensing plant is to be installed at an estimated cost of £2,350.

The borough electrical engineer (Mr. W. E. J. Heenan) estimates that this plant will reduce the fuel bill (which is £3,600 per annum) by at least £360, besides effecting other economies.

From 31st inst. the lighting of the arc lamps is to be extended from midnight till 1 a.m., and the charge for current is to be reduced from 3d. to 2¼d. per unit.

The committee has been authorised to arrange special terms for supply of current to large firms.

**Beverley.**—The Board of Trade have granted an extension of one year for the Council to comply with the terms of their provisional electric lighting order.

**Birmingham.**—Cars have this week commenced running on a new extension of the tramway system. The Birmingham & Midland Tramways Co.'s cars are also to be allowed to run on these lines in return for running powers for the Corporation's cars on some of the company's lines as soon as the lines are ready John Aird & Sons are at work on the construction of various other lines in the neighbourhood of Small Heath Park, which will eventually be practically encircled by the tramways. The same firm have contracts for various new lines in the city, some of which will shortly be commenced. Meanwhile, Dick, Kerr & Co. are making good progress with the overhead equipment, having finished the Lodge road route and nearly finished the Balsall Heath, Mosely-road and Stratford-road sections. The erection of the Rosebery-street car depot, where the cars running on the Dudley-road route (which becomes the Corporation's property on July 1) will be housed, is also nearly completed.

**Bradford.**—The city elective auditors (Messrs. W. Goodison & John Lund) have presented a supplementary report to the City Council on electric lighting finances, suggesting that the electricity department be brought under the direct control of the city treasurer. The city treasurer will report upon the proposal.

**Broughty Ferry (N.B.).**—The Council have decided to expend £2,500 in extending the electricity works.

**Cardiff-Penarth Tramways.**—The Penarth & Cardiff Tramway Synd. intend to apply for a provisional order for the construction and working of tramways between Penarth and Cardiff.

**Carrickfergus (Ireland).**—At the District Council on Monday Mr. T. S. Jack moved that the offer of Curran Bros., Belfast, to erect and maintain for five years electricity works in the district be accepted. Messrs. Curran Bros. offer to fit up and maintain any number of lamps for street lighting at £1. 10s. per lamp per annum, 12 of the lamps to be 50 c.p. and the remainder 30 c.p. An amendment to refer the matter back was defeated by 10 votes to 6, and a further amendment to accept the tender of the Town Gas Co. for gas lighting at £1. 7s. 6d. per annum was lost by 10 votes to 5. Mr. Jack's resolution was then carried.

**Conway Valley Power Scheme.**—The survey for this power scheme has now been completed. The work comprises the construction of a large reservoir which will receive its supply from Lake Cwmeigian and Lake Cowlyd, the whole of the water rights of the former source and the overflow of Cowlyd having been acquired by the promoters. The capital required for the scheme, estimated at £126,000, has been subscribed.

**Customs Decisions.**—Under the new tariff of the Australian Commonwealth marble switchboards with current-measuring instruments, synchronising apparatus, &c., complete, are classed as electrical machinery and appliances, n.e.i., and are dutiable at 12½ per cent. ad. val.

A recent customs decision of the Ecuador authorities has fixed a duty of 2 centavos per kilo, gross weight, on all apparatus and materials for electric lighting except electroliers.

**Electrical Contractors' Association.**—The third annual dinner of the Glasgow branch of the Scottish section of this Association took place on Wednesday, Mr. Thos. Wright presiding.

Mr. W. W. Lackie, city electrical engineer, proposed the toast of the Glasgow branch, and said he looked upon the electrical contractor as the best friend of the electricity department. Very often electricity stood or fell by the manner in which the electrical contractor did his work. The association had done a great deal of useful work, but there still remained much for it to do. The meetings of electrical contractors were bound to promote the best interests of the whole profession.

The Chairman, in reply, said the Association had done much good work during the past six years, and had more than justified its existence. He referred especially to recent meetings between the Association and outside contractors. They succeeded in persuading two or three of these outside contractors to join the Association. They could never rectify the difficulties and troubles connected with their business until they got all the members of the trade to join the Association.

**Exeter.**—At a meeting of the Council last week a recommendation of the Special committee on public lighting that the whole of existing tramway routes should be lighted by arc lamps, was discussed. An amendment referring the matter back, because the Gas Co. had not had an opportunity of tendering, was carried.

**Exhibitions.**—Particulars are published concerning the Engineering and Machinery Exhibition which is to be held at Olympia from Sept. 15 to Oct. 17 next. Messrs. Bridges & Smith are organisers of the show.

On Saturday Cordingley's Motor Car Exhibition will open at the Agricultural Hall, London, when nearly 300 exhibitors will demonstrate the progress made by the automobile. In addition to motor cars, motor 'buses, &c., there will be a large display of motor boats and airships. Nearly all the leading British engineering firms seem to be entering the motor vehicle industry, and a very complete representation of this section of English enterprise has been brought together. Special lighting arrangements are being made. The offices of the exhibition are at 27-33, Charing Cross-road, London, W.C.

An exhibition of electric light fittings, electric motors, arc and incandescent lamps, cooking and heating apparatus, &c., was held at Pudsey last week. Among the exhibitors were Veritys Limited, the Edison & Swan Co., Siemens Bros. & Co., Electromotors Limited, British Thomson-Houston Co., Dowsing Radiant Heat Co., Witting, Eborall & Co. and Thomas Broadbent & Sons. The exhibition, organised by the Corporation electricity department, attracted a large number of visitors.

An electrical exhibition, organised by the local electricity department, will be held at Maidstone between April 2 and 7 inclusive.

**Fire.**—A fire occurred on Tuesday on the premises of the Reliance Electrical Wire Co., Spital-square, London, E.

**Hackney (London).**—The generating station and destructor works are to be insured for £77,000 with the Alliance Insurance Co. at an annual premium of £76. 4s.

**Halifax-Huddersfield Tramways.**—Representatives of the West Yorkshire Tramways Co. had an interview with a sub-committee of Halifax Tramways committee on Friday last in reference to proposal of the company to obtain powers to run tramcars over sections of the Corporation tramway system between West Vale and Halifax and Brighouse and Bailiffe Bridge. The company offered to guarantee the Corporation a profit in return for the concession of the required running powers, and also offer to take full charge of the traffic, so that passengers can travel in through cars from Halifax to Huddersfield and from Bailiffe Bridge to Huddersfield.

**Hornsey (London).**—The Council have received sanction to a loan of £10,000 for electricity supply.

**Infirmary Lighting.**—Eton guardians will light their new infirmary by means of electric current taken from the Windsor Electrical Installation Co at 5d. per unit.

**Italian and French Combine.**—The Officine Elettro-Ferroviare of Milan and the Societe Anon. Westinghouse of Paris have entered into a combination under the name of L'Alliance Westinghouse-Finzi, the primary object of the joint undertaking being the manufacture and installation in Italy of monophase electric traction plant.

**Light Railways.**—Gillingham Council consent to the Chatham & District Light Railway Co.'s extension to Rainham, subject to certain road improvements being undertaken by the company.

Middlesbrough Council are considering the proposal for the erection of a transporter bridge (in conjunction with a light railway) across the Tees, and are to take expert advice as to the type of transporter most suitable.

**Llandudno.**—The Council have decided to support the application of Messrs. Bruce Peebles & Co. for an extension of time for commencing the construction of the Colwyn Bay–Llandudno Light Railway, the project having been taken over by the company from the original promoters.

**London County Council.**—At Tuesday's meeting it was agreed to loan Marylebone £48,545 for electric lighting.

*Tramways.*—It was reported, in regard to the contract of the Brush Co. for the supply of single-deck car bodies, that there was some difficulty in ascertaining the precise labour rates and hours of working recognised at Loughborough. The company had intimated its desire to conform to all district rates of labour which they employ, and the Highways committee recommended that the provision in the contract be worded to carry out this object.—This was opposed, and stood over.

On the reception of the Highways committee's report, Mr. Thomas asked the chairman of the Highways committee whether it was a fact that, owing to the limited amount of money placed at their disposal by the Finance committee, the construction of tramways in London was not proceeding with the rapidity which the necessities of the public demanded, and whether under those circumstances the Highways committee would be prepared to recommend the Council to assist private companies to obtain facilities and powers for carrying out the necessary work.

Mr. Collins asked if the attention of the chairman of the committee had been called to the newspaper statement that in Berlin they were now running motor omnibuses in competition with their own tramways previous to pulling them up.

Capt. Hemphill, in reply, said that he believed Mr. Collins' statement was without foundation. It was quite possible that the Council would at some time ask Parliament for powers to run 'buses as feeders for the tramways. It was true that there were under 30 miles of electric tramways in London, whereas 300 miles were needed to give an adequate service. This was greatly due to the opposition of the borough councils. He did not think that the County Council would ever consent to private companies coming into London.

*Highways Committee.*—Capt. the Hon. Fitzroy Hemphill has been appointed chairman of the Highways committee for the year, and Mr. E. Browne vice-chairman.

**London County Council Tramways.**—Stoke Newington Council, at their meeting on Tuesday, resolved to ask the London County Council to adopt the side-slot conduit system on their tramways in a narrow portion of the High-street, thereby reducing the number of lines to be laid down from six to four. It was decided to ask Hackney Council to make a similar request.

Preparations are being made for carrying an electric tramway over the new Vauxhall Bridge, the first portion of the work having been commenced on Monday.

**London Electrical Engineers (Ltd.)**—The Registrar of Friendly Societies notifies that the registry of this society was, at its request, cancelled on 13th inst.

**Loughborough.**—On Saturday, 17th inst., at 1:50 p.m., a fault occurred on the lighting mains. It was located one length of distributor by 4:30 p.m., and the remainder of the town reconnected in the ordinary way. The fault was located and repaired by 9:30 p.m. and that length of cable then made alive. Only five consumers were without light during this time. The fault occurred in a service box, and it is thought that some damage must have been done to the box when the pavement in the immediate neighbourhood was reinstated.

Negotiations are in progress between the Corporation and the Brush Co. with respect to the supply of electric current to the company's works. If the Corporation undertake to supply current to the company it will necessitate extensions to the plant, but the Corporation have the alternative of transferring their undertaking to the company.

**Manchester.**—The City Council on Wednesday increased the salary of Mr. Jas. Wood, financial superintendent under the Tramways committee, from £375 to £400, and increases of £25 per annum were also granted to six other officials of the tramways department. Proposals to increase the salaries of Mr. J. T. Oakes, tramway traffic superintendent, and Mr. F. E. Hughes, secretary of the electricity department, from £400 to £425 were rejected on the ground that the maximum had been reached. Other advances were granted in the electricity department, chiefly in salaries under £200.

**Municipal Telephony.**—A special meeting of *Hull* City Council on Monday considered a recommendation from the Telephones committee that the municipal telephone system be sold to the National Telephone Co. upon the following terms :—

1. The Corporation to sell and the company to buy the telephone undertaking of the Corporation, with all its telephone plant, property and assets of every description.
2. The company to pay therefor such a sum of money as shall be equivalent to a reimbursement to the Corporation of its outlay upon the undertaking, that is to say, such a sum of money as shall be sufficient to indemnify the Corporation from making any loss upon the undertaking.
3. The company to take over all obligations of the Corporation in respect of the undertaking.
4. The company to continue to supply telephonic service to the existing unlimited rate subscribers of the Corporation at the Corporation tariff rates for unlimited service for a period of three years from the date of the completion of the purchase.
5. The company to take over the staff and employés of the Corporation whose services are wholly employed in the telephone undertaking of the Corporation at their present salaries and with equivalent positions in the company's service.
6. A formal contract to be approved by the Postmaster-General to give effect to these terms to be entered into.
7. These terms to be submitted for approval to the Town Council of Hull and to the Board of the National Telephone Co. within one month from this date.

The chairman of the Telephones committee (Mr. Brown) moved the adoption of this recommendation, and said they were only 12 days from the end of the financial year, and they found that, after paying £697 to the Postmaster-General for royalties, they had still a balance of £2,894, of which they could set aside £1,331 for interest and £1,109 for sinking fund. This would leave them with a balance of £450, and it showed that they were in a sound position. Their service had been gradually improving, and the number of subscribers had always been and was still increasing. The committee had been considerably hampered by Government officials, who, in his opinion, should have been more loyal and more patriotic than to have tried to rush them into the hands of monopolists. The officials of the Post Office seemed determined to oust the municipalities which had helped them to get at the National, and which had helped them also to reconstruct the telephone system of the country. He looked upon the attitude of the Post Office as a grave public scandal. He showed that when in April last they applied for power to borrow some £20,000 for extensions there was considerable delay. It took as many months as it should have taken weeks to get the assent. With these two departments working hand in band, with the difficulties thrown in their way, it was questionable whether they would be able to continue till 1911 without loss. If there had been 55 municipalities, instead of five, with their own telephones, there would be no need to bother their heads about a few Government officials. They could have run the risk, and if the ratepayers liked to take it he would not demur. Had Parliament been willing to listen to them he would have advised them not to sell their concern for any consideration.

Ald. Massey opposed the motion, and moved that the recommendation be referred back. He thought the action of the Government officials complained of by Mr. Brown should have been reported to their Parliamentary representatives and fully investigated by the House of Commons. He protested against their having to come to a decision before they had seen the agreement. Were the wayleaves part of the property to be handed over?

The Mayor: No.

Ald. Massey: If they were, the Corporation would be selling assets to the National Co. which the National might sell to the State.

The Mayor said he was perfectly satisfied with their present position, provided the licence could be extended. He did not blame entirely the Post Office officials. The Corporation had expended £52,000 upon the telephone system; and within the next two years they would have to spend £15,000 upon extensions. They desired to reconsider their position before expending more money. He quoted the letter of the secretary of the Post Office pointing out to the Corporation the desirability of making arrangements with the company which would secure the unification of the two systems. In the face of that, he asked, what hope was there? In 1911 the Government had agreed to buy the National system; but they had only to take that plant of the municipality which was "necessary and suitable." If they sold upon the terms in the agreement they would receive from the National Co. such a sum as would cover entirely the direct and indirect expenditure incurred.

Mr. Brown having replied, the amendment referring the minutes back was carried by 32 votes to 17.

A meeting of *Swansea* Corporation was held on Wednesday, when a report by the Telephone committee was discussed.

The report had reference to an offer by the Postmaster-General of £17,000 for the purchase of the Swansea municipal telephone system complete, but recommended that the following conditions should be insisted upon in the event of sale :—

1. That the whole of the capital expended be repaid to the Corporation.
2. Existing rates to be maintained until the system of the National Telephone Co. is taken over by the Post Office, and future rates to new subscribers to be specified.
3. Staff to be taken over on terms not less favourable than those agreed to in the case of the National Telephone Co.
4. Post Office to work the system.
5. The Postmaster-General to obtain intercommunication between the Post Office system and the National Telephone Co.

The chairman of the Telephone committee (Coun. D. Jones) described the offer of the Postmaster-General as a ridiculous one, and asked for the sanction of the Council to require from the Postmaster-General a sum which would repay the Corporation the whole of the capital expended by them on the undertaking. A statement was submitted showing this to amount to £26,961. 9s. 6d. A letter from the Postmaster-General was read, which stated that deductions must be made for depreciation and also for the Corporation exchange building, which would probably be of no use, and that therefore 60 per cent. of the total capital expended by the Corporation was a liberal offer.

The Telephone committee's report was agreed to.

On Thursday last *Glasgow* Corporation again discussed the recommendation of the Finance committee that £690 be taken from the Common Good to pay the expenses in connection with the representations made on behalf of the Corporation before the House of Commons Committee on the agreement between the Postmaster-General and the National Telephone Co. for the purchase of the company's undertaking.

Mr. King now moved that the recommendation be not approved, as the Telephone committee did not go to London in the public interest, but, at the most, in the interest of the telephone department and its 10,000 subscribers.

Mr. W. F. Anderson said the opposition to the committee's recommendation was an attempt to belittle the municipalisation of the telephone, which had cost Glasgow £380,000.

The committee's recommendation was adopted.

*Portsmouth* Corporation have received sanction to expend over £18,000 upon extensions to the municipal telephone service.

**Musselburgh.**—The Council have withdrawn their opposition to the National Electric Construction Co.'s proposal to extend the local tramways to Port Seton, on condition that the company make annual application for permission to run Sunday cars.

**Nairn.**—The Board of Trade have given the Council until the end of the year to decide upon the steps to be taken in connection with their provisional order obtained in 1902.

**Oldham.**—An inquiry was recently held into the application of the Corporation for sanction to a loan for electricity supply, and the L.G. Board have now refused consent with respect to £10,000 out of the £48,000 applied for.

**Ormesby.**—The Council have decided to transfer their electric lighting order of 1901 to the Cleveland & Durham County Electric Power Co., who will pay the Council £316 to cover cost of order.

**Panama Canal.**—Mr. C. Mallet, C.M.G., British Consul at Panama, reports that authorisation has been given for the laying and working of a military cable between Key West, Guantenamo and the Panama Canal zone. This cable is, it is stated, to be used for commercial purposes, a maximum rate of 40 cents per word being charged.

**Plymouth.**—The Tramways committee decided on Monday to convert the West Hoe route to electric traction, to work it with the Pennycomequick route as one section, and to substitute demi-cars for the present type of car.

**Poplar (London).**—The borough electrical engineer (Mr. J. H. Bowden) has submitted to the Lighting committee a statement showing comparative costs of electricity and gas for public lighting.

In September, 1900, all the street lighting was by gas. The number of lamps was 1,742 and the total candle-power was 29,824. In September, 1905, the number of lamps was 1,775 (899 electric, 876 gas), and the total candle-power was 657,984 (629,952 electric, 28,032 gas). The cost per candle-power in 1900 worked out at 55 96d. The cost of the candle-power in September, 1905, worked out at 4·37d. (3·59d. electric, 21·99d. gas) per candle-power.

An offer by the London & India Dock Co. to take current at 0·885d. per unit, subject to a three years' agreement and a guarantee to take a minimum of 300,000 units per annum, with a maximum load not exceeding 100 kw., has been accepted.

**Post Office Telegraphs and Telephones Statistics.**—A return has been issued showing the gross amount received and expended on account of the telegraph service of the State in the year ended March 31, 1905. The account shows a balance on expenditure over receipts of £919,435 10s., making, with the amount expended on account of the charge for the year (£271,691 2s.), the total deficiency of telegraph revenue for the year £1,191,126 12s.

**Power-Gas Installations in the East.**—The Power-Gas Corpn. (Ltd.), 39, Victoria-street, London, S.W., and Stockton-on Tees, have obtained an order for the power-gas installation for the shipyard of the China Steam Navigation Co. at Hong Kong.

The plant is capable of producing 300,000 cubic ft. of gas per hour, 75 per cent. of which will be specially cleaned for use in four gas engines (having a total capacity of 3,300 B.H.P.) and 25 per cent. will be used in furnaces and other heating appliances. As the working conditions require continuous running day and night throughout the year the plant is designed so that any of the main parts can be isolated without interfering with its operation. The installation at present includes three producers of the Mond patent type. Eastern fuels of a bituminous character are to be used. The engines are of the Cockerill type, made by the main contractors in the work (Richardsons, Westgarth & Co.) and will be direct-coupled to Dick, Kerr dynamos. The whole of the installation is to the requirements of Messrs. Swire & Sons, of London, agents for the China Steam Navigation Co. This is the first important gas-driven power station for the east.

**Presentations.**—Mr. H. H. Arthur, charge engineer at Ilford electricity works, was recently presented with an oak chiming clock as a wedding present. Mr. A. H. Shaw, the chief engineer, made the presentation on behalf of the staff.

A silver coffee service has been sent out to Mr. A. E. Gibbs, the newly-appointed distribution engineer of the Johannesburg lighting and tramways undertaking, from the staff of W. T. Glover & Co., accompanied by a mahogany chiming clock from the directors, in appreciation of his $9\frac{1}{2}$ years' service with the company.

On behalf of the Sunderland Corporation tramway employés, Mr. A. R. Dayson (the manager), on Wednesday, presented Councillor T. Summerbell, M.P. (formerly chairman of the Tramways committee) with a silver tea set, to signify the gratification of the subscribers at Mr. Summerbell's election to Parliament.

Mr. DAYSON, in making the presentation, referred to the great success that had attended the tramway undertaking since its municipalisation, and said it had contributed a considerable sum to the relief of the rates.

The borough electrical engineer (Mr. J. F. C. SNELL) said that in about 12 months' time he would be following Mr. Summerbell to Westminster, but not in the capacity of a member of Parliament.

**Provisional Order Transfer.**—Official notice is given of the intention of Ormesby Council to transfer to the Cleveland & Durham County Electric Power Co. their provisional electric lighting order, 1900, the consideration being £315. 16s. 3d. Objections to the Board of Trade before April 15.

**Queenborough.**—The Board of Trade have approved the electricity supply scheme of the Sheerness and District Electric Power and Traction Co. for this district.

**Ship Lighting.**—The contract for the electric lighting of the new Cunard steamer "Mauritania" (building by Swan, Hunter & Wigham Richardson at Wallsend-on-Tyne) has been placed with W. C. Martin & Co., Glasgow.

The generating plant, which will consist of four Parsons turbo-generators, each capable of giving 4,000 amperes at 110 volts, will be placed in the aft end of the engine room in two separate compartments divided by a watertight bulkhead, so that the supply of current will not be cut off in the event of either engine room being flooded with water. There will be two switchboards, one in each compartment. A large portion of the auxiliary machinery will be driven by electric motors, including 16 forced draught fans of 50 H.P. each for the stokeholds, and about 60 H.P. of refrigerating machinery, two electric passenger hoists working between the six decks, six smaller hoists for stores, mails, &c., and two large luggage hoists. Electric motors are also to be used for raising and lowering boats, heaving in sounding line, and driving machines in the bakery galley and pantry. There will also be about 60 large electrically-driven ventilating fans and Stewart's patent thermo-tanks, for heating and ventilating. For lighting 5,000 16 c.p. lamps will be required. The state rooms will each be lighted by three lamps, and will contain an electric fan, electric curling-tong heaters and electric radiators. The electrical equipment will also include electric bells, telephones, searchlights and masthead and side lights. The steam whistle will be electrically controlled, as will the watertight doors.

**Spen Valley Tramways.**—Cleckheaton Council propose to discuss with Bradford Tramways committee a suggestion that the Spen Valley tramways of the Yorkshire (Woollen District) Electric Traction Co. and the Bradford tramways be extended to meet at Oakenshaw, forming a second route between Dewsbury and Bradford and taking in all the Spen Valley towns—viz., Heckmondwike, Liversedge and Cleckheaton.

**Sunderland.**—The Electricity and Lighting committee recommend the Council to reduce the charge for current for the tramways from $1\frac{3}{4}$d. to $1\frac{11}{16}$d. per unit, and the charge to lighting consumers will in future range from $3\frac{1}{2}$d. to $2\frac{1}{2}$d. per unit. To reach the $2\frac{1}{2}$d. minimum consumers must use 7,500 units a quarter. The committee estimate that the net profit on the year, before these reductions are allowed for, will be £2,638, and but for the increased price of coal the profit would have been about £1,000 more. Even after the reductions referred to the electrical engineer, Mr. J. F. C. Snell, estimates that the net profit on the year will be at least £1,870.

**Surface Condensers.**—A Paper on the efficiency of surface condensers is to be read by Prof. R. L. Weighton before the Institution of Naval Architects in the Hall of the Society of Arts, John-street, Adelphi, W.C., on Thursday evening, April 5:—

The paper is a record of a very exhaustive series of tests carried out by Prof. Weighton and his staff at Armstrong College, Newcastle, on the ordinary type of condenser and a new type known as the "Contraflo." The tests have occupied fully a year and afford an illustration of the influence on engineering progress of research work as carried out by technical colleges, and especially by the Armstrong College, Newcastle-on-Tyne, which has the largest plant in connection with steam engineering of any college in the world. The results obtained by the "Contraflo" system have already attracted considerable attention, and Armstrong College has, during the experiments, been visited by many engineers, including some from the Continent and America.

**Swinton and Pendlebury.**—As the Council are unable to transfer their order to the Lancashire Electric Power Co, they have decided to take electricity in bulk from the company and distribute it themselves.

**Taunton.**—The Corporation have received sanction to a further loan for electric lighting extensions, but an endeavour is being made to induce the L.G.B. to extend the period of the loan.

**Telegraphs in China.**—The "North China Herald" states that it has been decided to largely extend the telegraphic system in China in order to connect up every important district in Mongolia with Pekin.

**Tramways Departments and Maintenance of Highways.**—The manager of Bradford Corporation tramways (Mr. C. J. Spencer) proposes that he shall in future have charge of the construction and maintenance of the permanent way of the tramways instead of the city surveyor (Mr. J. H. Cox), and refers to Leeds, Manchester and Glasgow as examples where the system he proposes is in successful operation. Mr. Cox, however, points to 50 other towns with municipal tramways, including Liverpool, Birmingham, Sheffield, Nottingham and Leicester, where the present Bradford system is in vogue, and argues against the change.

**Uruguay.**—Plans of the Monte Video Telephone Co. for underground mains have been approved.

**Walthamstow.**—Electric light cables are to be laid to Higham's Park. Application has been made for sanction to a loan of £10,146, the estimated cost of the work.

**Walton-on-Thames.**—The Council have assented to the application of the Camberley Electric Supply Co. for a provisional order for the district. Yorktown & Blackwater Gas Co. also asked for the the Council's assent to their application for a provisional electric lighting order. The Council have peremptorily refused such consent.

**Waterford.**—The Corporation have withdrawn their opposition to the application of the National Provincial Electricity Corpn. for a provisional electric lighting order.

**Watford.**—The electrical engineer, Mr. W. H. F. Colebrook, recommends the Council to adopt charges for current for power at 2d. per unit for not exceeding 1,000 units per quarter, $1\frac{7}{8}$d. for over 1,000 units, $1\frac{3}{4}$d. for 2,000, $1\frac{5}{8}$d for 3,000, $1\frac{1}{2}$d. for 4,000, $1\frac{3}{8}$d. for 6,000, $1\frac{1}{4}$d. for 10,000, $1\frac{1}{8}$d. for 15,000, and 1d. for 25,000 and over, less $2\frac{1}{2}$ per cent. cash discount.

The Electric Light committee, in recommending this proposal, also recommended that a reduction of 20 per cent. be made in charges for current for lighting used in conjunction with a supply for power, provided the demand for lighting did not exceed 20 per cent. of the total demand. The committee also recommended for adoption Mr. Colebrook's proposal that instead of the present system of charging meter rents in proportion to the number of lamps installed, the charges should be according to the ampere capacity of the meters and vary from 1s. 6d. for a three-ampere meter per quarter to 10s. 6d. for a 500 ampere meter.

The recommendations were referred back.

**Wisbech.**—The Council have entered into a provisional agreement with the National Electric Construction Co. for the erection and maintenance of electricity works.

**Wolverhampton.**—The Council have extended their "free" wiring system to premises under the previous minimum rental of £40 per annum.

**Yardley.**—The Electric Lighting and Tramways committee have appointed the manager of Birmingham Corporation Tramways (Mr. Alfred Baker) to advise them, and the committee hope in a few weeks to report as to the advisability or otherwise of purchasing the tramways in the district.

**Electro-Harmonic Society**—The twentieth season of this flourishing society will be brought to a conclusion at the concert on Friday, the 30th inst., when unusual interest will attach to the proceedings by reason of the presentations which it is intended to make to those gentlemen whose efforts, sustained over a long period of years, have been the main factor in the striking success of the society. Members of the E.-H.S. are reminded that the subscription list must close within a few days, and those few who have not already forwarded their remittances are invited to send them to one of the undermentioned:—Mr. Robert Kaye Gray (*hon. treasurer*), 106, Cannon-street, E.C.; Mr. Robert Hughman, 8, Bream's-buildings, Chancery-lane, E.C.; Mr. Sidney Rentell, 36, Maiden-lane, W.C.; or Mr. Geo. Tucker (*hon. sec. of Fund*), 1, 2 and 3, Salisbury-court, Fleet-street, E.C., London.

**Dinners, &c.**—The staff at Loughborough Corporation electricity works dined together on the 14th inst. in the workshop, which had been artistically decorated for the occasion. The chief engineer (Mr. W. H. Allen) presided, and Ald. A. A. Bumpus (chairman of the Electric Lighting committee) was the guest of the evening.

On Saturday evening a number of the staff and employés of the Liverpool electric supply department dined together, with Mr. Alfred Clough (city electrical engineer) in the chair. A concert followed.

At Holborn (London) Town Hall on Monday a concert and dance took place in aid of the funds for the extension of the Post Office Central Telegraph Office library. The Postmaster-General was unable to be present, but most of the leading members of the staff attended, including Mr. Babington Smith, Mr. J Gavey, Mr. John Ardron, Mr. King, Mr. J. Newlands, &c.

**Football.**—On Saturday the annual inter-works match between employés of the General Electric Co., Witton, and the Robertson Electric Lamp Works, took place on the ground of the latter at Acton, London. From start to finish the game was of an exciting nature and ended in a victory for the Wittonites by four to one. After the game the teams dined together, and a dance (the last of the season) followed.

## TRADE NOTES AND NOTICES.

### NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1906 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is even more complete and accurate than in previous issues, and has been revised up to day of publication. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Traders' purposes. The valuable large sheet Tables, &c., have been very carefully revised and extended, making the 1906 Edition of this indispensable work the most complete book of the kind ever published.

A full Digest of Contents will be sent post free on request.

### TENDERS INVITED.

The directors of the *Lancashire & Yorkshire Railway Co.* invite tenders for 12 months' supply of various stores and requirements, including signal and telegraph fittings, signal, telegraph and electric light wires, steel tubes for boilers, cold and hot drawn weldless steel tubing, iron castings, lead, engine packing, &c. Further particulars and forms of tender from Mr. Duffin, Stores Department, Osborne-street, Manchester. Tenders, addressed to the directors, to be lodged by 10 a.m. April 2 with the secretary (Mr. R. C. Irwin), Hunt's Bank, Manchester. See also an advertisement.

*Salford* Electricity committee invite tenders for supply and erection of 750 kw. steam turbo-generator and condensing plant. Plans, specification, &c., from the borough electrical engineer, Pendleton. Tenders by April 21 to the town clerk, Mr. L. C. Evans, Town Hall, Salford. See also an advertisement.

*Sunderland* Corporation invite tenders for supply and erection of steam exhaust and other pipes in connection with the extension of their Hylton-road electricity station. Specifications from the borough electrical engineer, Mr. John F. C. Snell. Tenders, addressed to chairman of Electricity and Lighting committee, to the town clerk (Mr. Fras. M. Bowey), Town Hall, Sunderland, by noon April 4. See also an advertisement.

*Sunderland* Corporation also invite tenders for one 750 kw triple-expansion engine, direct-coupled to three-phase generator (5,000 volts), with exciter; one 300 kw. static transformer, and two portable air compressors. Tenders to chairman of Electricity and Lighting committee by noon March 30.

*Leyton* Urban District Council invite tenders for supply and erection of a traction switchboard. Specifications from the electrical engineer (Mr. F. Harman Lewis), electric light and power works, Cathall-road, Leytonstone. Tenders to be delivered at the meeting of the Electric Light committee to be held at the Town Hall, Leyton, on April 9, at 7:30. Further particulars are given in an advertisement.

*Belfast* Tramways and Electricity committee invite tenders for supply and erection of coal and ash conveying plant, bunkers and chain grate mechanical stokers. Specification, with form of contract, from the city electrical engineer, Mr. Victor A. H. M'Cowen, M.I.E.E., M.I.Mech.E. Tenders by 11 a.m. April 16 to Sir Samuel Black, Town Hall, Belfast. See an advertisement.

*London* County Council invite tenders for the manufacture and erection of three low-tension feeder switchboards for tramway sub-stations; also for eleven 500 kw. and three 50 kw. induction motor-generators for tramway sub-stations, and for about 65,000 tons of coal for the tramways generating station, East Greenwich. Tenders to the Clerk, County Hall, Spring-gardens, S.W., by 10 a.m., 27th inst.

The Asylums committee of *London County Council* invite tenders for the installation of electric lighting and power (including generating plant) at Long Grove Asylum, Epsom. Tenders to 6, Waterloo-place, London, S.W., by March 26.

*Leeds* Electricity committee invite tenders for one or two sets of electric generating and condensing plant, each comprising a steam turbine, two-phase alternator and exciter of 3,000 kw. capacity, electrically-driven surface-condensing plant, and the necessary pipes and valves. Preference will be given to tenders for plant of British manufacture. Tenders to town clerk (Mr. Robert E. Fox) by 10 a.m. April 9.

*Briton Ferry* Urban District Council invite tenders for supply, delivery, erection and laying of sub-station switchboard, non-rubber feeder and distributor cables, feeder pillars, joint boxes, arc standards, arc lamps, &c. Tenders to the clerk (Mr. Trevor H. Hunter), Council Offices, Briton Ferry, Glam., by noon March 26.

*Bolton* Electricity committee invite tenders for one continuous current electric generator, and also for one steam engine, complete. Tenders to the chairman of the Electricity committee, Town Hall, Bolton, by noon March 29.

*Walsall* Corporation invite tenders for a 500 H.P. high-speed steam engine, a 350 kw. high-pressure continuous-current dynamo, and high-pressure feeder cables, low-tension distributors and pilot wires. Tenders to the town clerk (Mr. John R. Cooper) by March 30.

*Yarmouth* Corporation want tenders for supply of hard Welsh steam and Scotch anthracite peas coal for their electricity and tramways departments. Tenders by noon 29th inst. Forms of tender from the borough electrical engineer.

*Portsmouth* Corporation want tenders by 10 a.m. April 10 for 12 months' supply of stores, including brake shoes, engine-room stores, ironmongery, oils, chemicals, &c. Forms of tender from the Town Hall

*Dublin* Lighting committee want tenders by noon 27th inst. for the electric lighting of Montgomery-street buildings. Forms of tender from city electrical engineer.

*Wallasey* District Council want tenders by noon April 18, for 500 kw. steam alternator, boilers and extension of engine and boiler house at the electricity works.

*Hackney* (London) Council want tenders by 4 p.m. April 5 for construction of condensing water supply works.

*Nottingham* Corporation went tenders by 31st inst. for steel girder tramrails, tramway poles, granite setts, &c.

*Stockport* Corporation require tenders by noon 29th inst. for electric motors and steam-driven condensing plant.

Tenders are required for supply of about 14,000 tons of small coal to *Copenhagen* electricity works. Conditions may be seen at the Board of Trade Commercial Offices, Basinghall street, London, E.C. Tenders to the Director of Public Lighting, 22B, Vestre Boulevard, Copenhagen, by midday 26th inst.

H.B M. Consul at Stockholm notifies that tenders are invited for the supply of 7,200 kilos of sal ammoniac, to be delivered 4,800 kilos in April and May, 300 in June, 600 in July, 600 in August and 900 in October. Tenders have to be in by noon March 26 to the Kungl Telegrafstyrelsen, *Stockholm.* The chemical must be free from iron and the percentage of impurities must be stated Samples have to to sent with tenders.

Tenders are invited for providing electricity supply for lighting, power and traction to the City of *Luxemburg.* Particulars from the Burgomaster, Luxemburg.

The "Madrid Gazette" for March 15 notifies that tenders will be opened in July next for the supply of eight electric cranes for the Port Works Board, *Huelva*, in accordance with a specification contained in the "Gazette" of date mentioned.

Tenders will be opened on May 21 by the Director-General of Public Works, *Madrid*, for a concession for the construction and working of an electric tramway in Madrid, for which application has already been made by the Mercados Tramways Co. The "Madrid Gazette" of March 17 contains further particulars.

Tenders by 28th inst. to the Bourse de Bruxelles for supply of wires, cables, &c., for the electric lighting of *Namur*, Belgium.

## TENDERS RECEIVED AND ACCEPTED.

London County Council have received the following tenders for the supply of side-slot rails for the reconstruction of the first portion of the northern tramways :—

| | | |
|---|---|---|
| Frodingham Iron & Steel Co. | £2,750 | 1* |
| Steel, Peach & Tozer | 3,640 | 14 |
| P. & W. MacLellan | 3,640 | 3 |
| Estimate (comparable with tenders) | 2 914 | 12 |

* Recommended for acceptance.

It was further recommended to accept the offer of Dick, Kerr & Co. to execute the road work and platelaying in connection with the reconstruction of the tramways in Goswell-road, on the same general conditions and the same schedule of prices as those contained in the contract for the reconstruction of the tramways from Bloomsbury to Poplar.

The two recommendations, being opposed, stood over.

Walthamstow Council have accepted the following tenders for tramway stores :—

British Westinghouse Co., brass dust caps, brush holders, field coils, resistances, armature pinions, gear wheels, axle and armature bearings ; Brush Co., bearing springs, spiral truck springs, gear wheels, gear wheel axles, axle springs, brake blocks, axle-box covers, axle brasses, &c.; Good Bros., plate glass and indicator glass ; Player & Mitchell, dash lights, passenger bells, bell pushes, indicator fuses, crab and door handles ; General Electric Co., carbon brushes ; Brecknell, Munro & Rogers, trolley wheels, standards, heads, poles and pole springs, trolley-head vulcanised brushes, trolley boom sleeves, trolley boom collars and trolley rope, overhead equipment accessories ; R. F. Coulston, trolley-head rubber sleeves, coat screws, washers, &c. ; I. Bentley & Co., oils, motor axle grease, &c. ; Croager Bros., rubber compound for joint boxes, &c.; R. W. Blackwell & Co., tools for tower wagon, &c.

The following orders for switch gear have recently been placed with Ferranti Limited, Hollinwood, Lancs:—

H.T. c c. 2,000 volt switch gear, 36 panels, for Hull Corporation ; electrically-operated switch gear for St. Andrew's Cross station of Glasgow Corporation ; l.t. c.c. switchgear for ditto. ; l.t. c.c. switch gear for Waterloo-street sub-station of Glasgow Corporation ; h.t. switch gear for main station and h. and l.t. switchgear for sub-station for Lancashire United Tramways Co. ; h. and l.t. sub-station switch gear for Manchester Corporation (eight boards); c.c. switchboard for Richard Johnson & Nephew, Manchester ; c.c. switchboard extension for National Gas Engine Co., Ashton-under-Lyne ; extension h.t. switch gear for East Greenwich stations of South Metropolitan Electric Light & Power Co. ; and extension h.t. three-phase switch gear for Taylor's-lane station of North Metropolitan Electric Power Supply Co.

Noyes Bros., of Melbourne and Sydney, have in hand contracts for Westinghouse power plant for the Broken Hill Proprietary Co. ; two 100 kw. Westinghouse generators, coupled to 150 H P. Belliss engines, and complete a.c. arc lighting system for Newcastle (N.S.W.) ; two 40 kw. Westinghouse generators, coupled to Willans engines, and Wheeler condensing plant for Lyttelton (N.Z.) Harbour Board and a 200 kw. Westinghouse Peache set, to be added to Christchurch (N.Z.), combined destructor and electric lighting plant. Noyes Bros. are at present putting down an electrical installation for Grace Bros , Sydney, including a battery of 110 Tudor cells having a capacity of 2,900 ampere hours.

Battersea (London) Council have accepted the following tenders (at schedule prices) for annual supplies of stores for their electricity department :—

A. Duckham & Co., lubricating oils ; Middleton Bros., engine-room stores ; Charrington, Sells, Dale & Co., coal ; Geipel & Lange, arc lamp carbons ; Electrical Co., electricity meters, Nernst lamps (renewals), &c.; Callender's Co., service joint-boxes, cables, &c. ; and T. Rowatt & Sons, arc lamp globes.

Hampton District Council have accepted the tender of Stuart & Moore for supply, erection and maintenance for seven years of four fire-alarm posts and transmitters in the streets, fire-alarm receiving instrument, telephone instrument and four-line annunciator at the Water Board's watch office, and telephone instruments at isolation hospital and police station, for £40 on completion of work and 13 half-yearly instalments of £22.

Hammersmith (London) Council have accepted the following tenders for annual supplies :—

Wm. Cory & Sons, coal (Crynant or Brynsci, hard dry, large), 14s. 8d. per ton ; Powell Duffryn, free burning, large, 16s. 7d. per ton ; Wynant, do. small, 13s. 3d. per ton ; Crynant Colliery Co., Crynant through and through, hard dry, small, 12s. 10d. ; Crynant Welsh, small, do. do., 11s. 1d. ; Main Colliery Co., No. 1 main through and through, free burning, small, 14s. 4d.

The Chain Belt Engineering Co., Derby, recently installed a coal-handling plant at Manningham Mills, belonging to Lister & Co., Bradford, and have now received instructions to proceed with a second boiler house plant for the same mills The same firm has also in hand a complete coal elevating and conveying plant for Grimsby Corporation electricity works.

The Metropolitan Asylums Board have accepted the tender of R. Waygood & Co. to inspect, clean and oil the two electric bed-lifts at the Southern Hospital, and to supply new motor brushes at £6 per annum.

Westminster Council have accepted the following tenders for annual supply of electrical stores, fittings, &c.: G. Angus & Co., H. A. Jackson & Co., London Electric Wire Co., Sunbeam Lamp Co., United Asbestos Co. and R. Wood & Co.

The Shelton Iron & Steel Co. are installing a large electrical plant, and an order for a chimney shaft 170 ft. high with an internal diameter of 8 ft. has been placed with the Ferbeck Chimney Construction Co , London, E.C.

Poplar Lighting committee have accepted the offer of Charles Webster (Ltd.) to purchase for £300 an electric crane, which was installed at the Bromley depot in 1901.

Whitehaven Council have accepted the tender of the General Electric Co. for one year's supply of incandescent lamps, and that of the Reason Mfg. Co. for fuse boxes.

Paddington (London) Council have accepted the tender of Mr. C. Mickleburgh, at £604, for removing the existing electric lighting installation and supplying and fixing a new installation.

Bermondsey Council have accepted the following tenders for annual supplies for the electricity department: Ironmongery, F. Bird & Co. ; oilmen's sundries, H. Franklin & Co.

Croydon Corporation Tramways committee have placed an order with the British Westinghouse Co. for 15 double-deck single-truck tramcars at £7,822. 10s.

Battersea (London) Council have accepted the tender of Mather & Platt for a 850 kw. direct-current steam dynamo (Belliss engine), Körting condenser, spare armature, &c., at £7,342.

The Asylums committee of London County Council have accepted the tender of Edmundsons Electricity Corpn. for extending and adding to the electrical generating plant at their central station at £5,715.

Hackney Council have accepted the tender of Phillips & Co. for the supply of Butterley fine slack coal at 9s. 6d. in barge alongside works.

Bridgwater Council have accepted the tender of Thompson Bros. for wiring the free library.

Mansfield Council have accepted the tender of Alley & McLellan for overhauling engines at electricity works.

Gravesend Council have placed an order with the General Electric Co. for additional generating plant at £2,044.

Potteries Electric Traction Co. have placed an order with the Brush Co. for five tramcars at £800.

Dartford Council have accepted the tender of Johnson & Phillips for lighting, cables and fittings.

Croydon Corporation have accepted the tender of H. Casbert for wiring the fire station.

The tender of Ferranti Limited for supply of electricity meters has been accepted by Hammersmith Council.

Brighton Corporation have accepted the tender of W. Cory & Sons for Methley washed nuts at 13s. 4d. per ton.

**Gas Power Plant.**—In connection with the Swanscombe works of the Associated Portland Cement Cos., Mason's Gas Power Co. have received instructions to erect a 2,400 B.H.P. bituminous coal gas power plant required to work in connection with seven Oechelhauser gas engines of 350 B.H.P. each. The gas plant will consist of three gas generators each of 800 B.H.P. with cooling and cleaning plant.

**Electricity in Mills.**—The order for the complete electrical equipment of the cotton and bleaching mills being erected by Coddington & Lamb at Bucharest has been placed with Veritys Limited, of Manchester.

## BUSINESS NOTICES.

The British Prometheus Co. (Ltd.) have now removed their works and head offices from Kingston to Birmingham, and all future communications should be addressed to Salop-street Works, Highgate, Birmingham. Telegraphic address, Cooking, Birmingham ; telephone, 4,236 Central. The company's London showrooms are at 27, Ely-place, Holborn-circus, E.C. Telegraphic address, Reprisal, London ; telephone, 2,216 Holborn.

Mr. G. O. Donovan, M.I.E.E., informs us that he has resigned his position as works director of the Electrical Trades Supply (Ltd.), Birmingham, and has started in business as Donovan & Co. at 12, Barwick street, Birmingham, as electrical manufacturers and suppliers. Mr. Donovan was with Veritys Limited at Aston from 1897 to 1905, and for some years, as works and business manager, was in entire control of their electrical factory, manufacturing motors, switchboards, arc lamps, &c.

Mr. R. W. Gauntlett has resigned his position as West of England representative for the British Westinghouse Co, and has joined the staff of Bruce Peebles & Co , whose representative he will be in the above district, and also in London, and the southern, south-eastern and eastern counties.

The International Electrical Engineering Co., London and Liège, have appointed Messrs. Oxley & Wilde, 37, Surrey-street, Sheffield, to be their sole representatives in the Midlands.

The Union Electric Co. desire it to be known that a Mr. J. Harwood, who has been calling on various firms, ostensibly in the Union Co.'s interest, is not and has not been in their employ.

After March 26 the London address of Gillies & Hornidge and the Buckingham Electric Light Co. will be 6, Holborn Viaduct, E.C.

The Adams Mfg. Co. (Ltd.) have removed their works to Elstow-road, Bedford.

Mr. H. N. Howlett, A.I.E.E., informs us that he has resigned his position with Mr. G. Braulik to join G. Straus & Co.

The reg. offices of the Provincial Tramways Co. (Ltd.) have been removed to 214 228, Moorgate Station Chambers, London, E.C.

## BANKRUPTCIES, LIQUIDATIONS, &c.

Geo. Aaron Benton, electrical engineer, Hatherton House, Shareshill, Staffs., formerly of 8, The Exchange, Muswell Hill, London, N., has been adjudicated bankrupt. The first meeting of creditors will take place on 28th inst. at the O.R.'s, Wolverhampton, and the public examination on the same date at the County Court, Wolverhampton.

Shadrach Ferris, electrician, formerly of 25, Fleet-street and 12, Wellington-street, Swindon, has been adjudicated bankrupt. The first meeting of creditors will take place on 28th inst. at 38, Regent-circus, Swindon, and the public examination on the same date at the Town Hall, Regent-circus, Swindon.

The discharge of Geo. Warsop Griffiths Booker, formerly electrical fittings maker, &c. (trading in partnership with S. F. H. Farmer, C. H. Farmer and A. H. Newey) at 16, Regent-parade, and 94, Vyse-street, Birmingham, has been granted, subject to debtor consenting to a judgment against him for £100.

A second and final dividend (5s. 5d.) is payable on March 30] at 58, Coleman-street, London, E.C., in the winding up of the M'Guire Mfg. Co. (Ltd.)

Claims against the Pollok-Virag Telegraph Synd. (Ltd.) are to be sent by May 5 to Mr. W. S. Ogle, 90, Cannon-street, London, E.C.

The Clift Mfg. Co. (Ltd.) is being wound up voluntarily. Mr. F. C. Harper, 27, Chancery-lane, London, W.C., is liquidator.

A meeting will be held on April 20, at 17, Warwick-street, London, W., to receive an account of the winding up of the National Co. for the Distribution of Electricity by Secondary Generators (Ltd.).

A meeting will be held on April 26, at 19 and 21, Queen Victoria-street, London, E.C., to receive an account of the winding up of the British Autovolt Co. (Ltd.)

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**Plant, &c., for Sale.**—Some particulars of a complete electric lighting plant, which is for disposal owing to the proprietors having decided to take their supply from the municipal mains, are given in an advertisement. Applications to Mr. Ellor, Market-street, Manchester.

The New Spa & Gardens (Ltd.), Bridlington, have some electric lighting plant (a dynamo, gas engine, switchboard, &c.) for sale. See an advertisement.

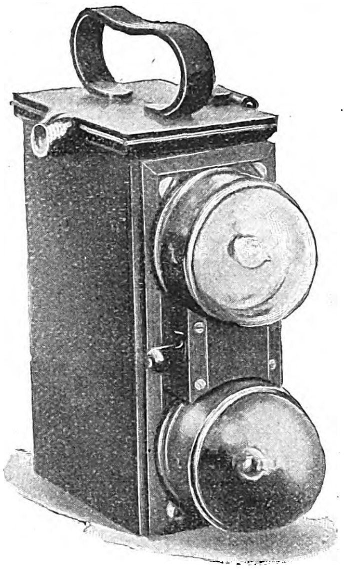
**Factory Land for Sale or to Let.**—Messrs. Leopold Farmer & Sons, 46, Gresham-street, London, E.C., have for sale (or letting) factory land at Ilford, with frontage to the river Roding.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from March 14 to 20, with the ports of destination :—

*Africa*—Alexandria, £27; Cape Town, £378; Delagoa Bay, £59; Durban, £2,842 (including £1,536 telegraph material); East London, £98; Mossel Bay, £19; Port Elizabeth, £456; Port Said, £93. *Argentina*—Buenos Ayres, £1,476 (including £82 telegraph material); Rosario, £34. *Ascension*, £16 (telegraph material). *Australasia*—Adelaide, £55; Brisbane, £260 (telegraph material); Christchurch, £27; Lyttelton, £60; Melbourne, £1,164 (including £54 telegraph material); Napier, £35; Perth, £2,257; Sydney, £1,812 (including £12 telegraph material); Wanganui, £24; Wellington, £941. *Belgium*—Antwerp, £143; Ghent, £18. *Brazil*—Rio Janeiro, £69 (telegraph material); Santos, £10. *Burma*—Rangoon, £39. *Canada*—Montreal, £62. *Ceylon*—Colombo, £65. *China*—Shanghai, £54 (telegraph material). *France*—Boulogne, £27. *Gibraltar*, £45. *Holland*—Amsterdam, £110 (telegraph material); Rotterdam, £161 (including £125 telegraph material). *Hong Kong*, £108. *India*—Bombay, £218; Calcutta, £983; Karachi, £53; Madras, £14. *Italy*—Naples, £215. *Jamaica*, £34. *Japan*—Kobe, £3,624; Yokohama, £511. *Malta*, £58 (telegraph material). *Mauritius*, £14 (telegraph material). *Portugal*—Lisbon, £140. *Roumania*—Braila, £147. *Russia*—Batoum, £12; Kureh, £1,414. *St. Helena*, £8. *Siam*—Bangkok, £102. *Straits Settlements*—Penang, £20; Singapore, £258 (including £43 telegraph material). *Sweden*—Gothenburg, £37. *U.S.A.*—New York, £92. *West Indies*—St. Thomas, £14,000 (telegraph material). Total, £34,998, against £14,393 in the corresponding week last year (March 16 to 22).

**Ceylon as a Field for Rubber Cultivation.**—Mr. Henry A. Alleyne, planter, of Masheliya, Ceylon, has issued in book form an essay originally contributed to the "Times of Ceylon" on the subject of the prospects of rubber cultivation in that country. In forwarding a copy of this reprint, Mr Alleyne informs us that he will be pleased to communicate with any of our readers who may be interested in this subject or who may desire to invest in rubber plantations in Ceylon. The essay deals briefly but comprehensively with the subject of cultivation, marketing and prices of this commodity. We may add that Mr. Alleyne ranges himself amongst those who have no faith in the discovery of an artificial substitute for rubber.

**Catalogues, &c.**—A new list of electric signalling hand lamps for railway use, shunting purposes, &c., has been issued by the Electrical Power Storage Co., 4, Great Winchester-street, London, E.C. In these lamps the lanterns are arranged so that either a red or a white light is shown as desired. One example of the lamp is illustrated in the accompanying figure. This lamp is fitted in an enamelled metal outer case with handle as shown, the filament for the lamp being a high efficiency "Osmi." Another type of lamp supplied is in a polished wood outer case with handle in similar form to the example illustrated. Each is fitted with two lamps of 2·5 c.p., the battery capacity being 10 ampere hours at 4 volts, the approximate period of burning being 27 lamp hours.



E.P.S. Electric Signalling Hand Lamp.

E. Kalker, of Much Park-street, Coventry, have ready a new list of E.K. insulated wires and cables, including flexibles specially made for motor cars, motor 'buses, motor lorries, motor vans and all classes of marine motors, besides a large range of rubber-covered, lead-covered and braided cables and wires for general electrical uses. The sheet lists include particulars of the E.K. sparking plug for motor vehicles, for which several particular advantages are claimed.

The "Venner" time switch is illustrated and described in a new circular list issued by Venner & Co., 6, Old Queen-street, Westminster, S.W. Instructions for setting up and starting the switch are included in the list.

The Chloride Electrical Storage Co., Clifton Junction, Manchester, and 39, Victoria street, London, S.W., have prepared a shipping catalogue of Chloride storage batteries and accessories, giving prices and particulars of these goods, including packing for shipment and delivery f.o.b. English port, and also including full shipping specification of all standard sizes of these batteries. Clients and potential clients of the company abroad will find the list of special interest as likely to save them considerable loss of time in submitting their requirements home for quotation before placing orders.

Lists Nos. 105 and 106, issued by Ferranti Limited, describe low-tension sub-station fuse boards (type D) and high-tension sub-station fuse boards (type E). Both lists are illustrated.

A new moving coil portable galvanometer is listed by Elliott Bros., Century Works, Lewisham, S.E., in pamphlet G 62. The instrument has been designed with the object of providing a portable instrument of the highest possible sensibility at an exceedingly low price. The construction of the galvanometer is exactly the same as the firm's well-known moving coil instruments, but being made in large numbers, of standard parts, and enclosed in light wood cases, Messrs. Elliott Bros. are enabled to offer them at a low figure. The instruments are stocked with a coil having a resistance of from 1,200 to 1,500 ohms.

A new list of portable electric hand drills, made in six sizes, for drilling holes up to $\frac{3}{4}$ in. diameter is issued by the Crypto Electrical Co., 3, Tyer's Gateway, Bermondsey-street, London, E.C. A complete three-speed electric hand-drilling machine is illustrated.

A porcelain bridge fuse box for pressures up to 250 volts is illustrated and described in a circular list issued by Ernest F. Moy (Ltd.)

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**WINCHESTER ELECTRIC LIGHT & POWER CO. (LTD.)**—The equivalent of 5,676 8 c.p. lamps were added to the connections during the year, bringing the total to 47,363 8 c.p. lamps. The net profit was £6,027. 7s. 4d. A dividend for the half year at the rate of 7 per cent. per annum has been declared (making $5\frac{1}{2}$ per cent. for the year).

## BRITISH ELECTRICAL SUPERANNUATION FUND.

The fifth annual general meeting of the members of this fund was held on Friday last, Viscount Emlyn, one of the managing trustees, presiding.

The Chairman said that the membership of the fund at the close of 1905 was 203, but they had made no endeavour to obtain the support of new companies pending the receipt of the actuaries' report on their recent valuation, and pending the adoption by the members of the recommendations about to be presented with regard to a revision of the rules. The income of the fund for the past year was £4,626, compared with £4,178 in the previous year. The total assets at Dec. 31, 1905, were £15,098, an increase of £4,031 on the year. Investments, distributed over 48 different securities, amounted to £14,468, yielding an average return of 3·83 per cent. Despite market fluctuations, the value of the quoted securities at Dec. 31 was only £120 less than the investments stood in the books of the fund, showing how carefully these investments had been chosen.

He moved the adoption of the report of the managing trustees, and this was carried unanimously.

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At the special meeting held subsequently to receive the reports of the actuaries on the valuation of the fund and to consider, and, if thought fit, to adopt the recommendations of the managing trustees and actuaries as to the revision of the rules, Mr. W. G. Bond presided, and after reviewing briefly the report of the actuaries (Messrs. T. G. Ackland and J. Bacon) proceeded to deal with the proposed alterations in the rules. These alterations, Mr. Bond explained, had been prepared with a view (1) to improving the working and administration of the fund, (2) to improve the position of individual members, and (3) to strengthen the financial position of the fund. The proposed alterations affected many important rules of the fund, and the chairman pointed out, especially with regard to the question of pensions, that the members of this fund belonged to a class, which had in the past been squeezed, was being squeezed, and in the future would be squeezed still more. There would be no State old-age pension for them, and he therefore urged upon them to seek to mend the British Electrical Superannuation Fund rather than to end it, and to adopt the suggestions of the actuaries in that regard. It was advisable to do now what was necessary to strengthen the fund rather than five years hence when the fund might be much bigger and the amendment of the rules would be more difficult.

After a brief discussion,

Mr. Emil Garcke (a contributing member) said he had listened carefully to Mr. Bond's statement, and the way in which he had placed the matter before the members had put an entirely new light on the actuaries' report, so far as he was concerned. He had come prepared to criticise, but he was satisfied now that the proposed alterations were fully justified. They were not only advisable in the interests of the stability of the fund, but on the ground of fairness to the large body of members. He realised the large amount of work that had been done by those responsible for the management of the fund, and thanked them for it.

Mr. Bond, having replied to the various points raised, put the resolutions, which were carried with one dissentient.

## COMPANIES' MEETINGS AND REPORTS.

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### Direct Spanish Telegraph Co. (Ltd.)

The fifty-fourth ordinary general meeting was held on Tuesday, under the presidency of the Most Hon. the Marquis of Tweeddale, K.T.

The SECRETARY (Mr. Fred. Thos. Preddle) read the notice calling the meeting and the auditors' certificate.

The CHAIRMAN: Gentlemen, the traffic receipts for the past year show an increase of £118. This is satisfactory, more especially as last year I had to report a decrease of £266. Moreover, on the Bilbao section of the system there was a decrease of £650 owing to the reduction in the tariff, which came into operation in July, 1904. Happily, the traffic on the Marseilles-Barcelona section showed an increase of £750, making up for the loss we sustained on the Bilbao section. This increase is due to the absence of those numerous and costly interruptions which have frequently occurred in the past few years. I hope that we have seen the last of these interruptions now that the cable has been put into a thoroughly efficient condition. The cost of carrying out this work has been large, but when I mention that during four years the average cost of the repairs was £5,000 a year, I think you will all recognise that the expense is fully justified. Turning to the ordinary expenses, there is a small increase of £115. The result of the year's operations is that we are able to recommend the usual dividend on the preference shares of 10 per cent. and on the ordinary shares of 4 per cent. The reserve fund now amounts to £49,279, being nearly £2,000 more than it stood at a year ago. The improvement in trade which I referred to in my speech at this time last year happily continues, and is reflected in the considerable increase in our income during the current year as far as it has gone. We may, therefore, I think, look for a prosperous year. I now move the adoption of the report and accounts.

In reply to a question from Col. PEARSON regarding the expenditure connected with the Marseilles-Barcelona cable,

The CHAIRMAN said the £20,000 of second mortgage debentures had been raised for the purpose of placing this cable in perfect condition. That work had been accomplished with complete success.

The motion was then carried unanimously, as were resolutions approving the dividends recommended by the directors and re-electing the retiring directors and auditors.

A hearty vote of thanks to the chairman terminated the proceedings.

### British Insulated & Helsby Cables (Ltd.)

At the meeting on Wednesday, the chairman (Mr. E. K. Muspratt) moved the adoption of the report, which appeared in our last issue, and said that the profit was £133,902 compared with last year, £129,817, and he thought they would consider that result to be, under the circumstances, a satisfactory one. There had been a further increase in the price of some of their raw materials, which they had not been able to cover in the prices obtained for their sales, mainly on account of contracts made by customers, and he thought they would be still more satisfied on this account with the result of the year's working. It would be observed that £22,000 had this year been written off freehold and leasehold property, plant, machinery, &c., against £21,000 in previous year; but in addition to depreciation they had written off a further £8,500, placed to special reserve account, which sum had been transferred, as last year, it being thought under all the circumstances prudent to do so. They had also transferred the usual amount of £5,000 to debenture redemption account. After providing these sums, and having paid the debenture interest and preference dividend, as well as the interim dividend on the ordinary shares, there remained £30,439 available for distribution; and the payment of a further dividend on the ordinary shares was recommended of 4 per cent., making with the interim dividend already paid 8 per cent. for the year, which would leave a balance of £10,439 to be carried forward, against £7,114 last year. He thought he was safe in saying that the balance-sheet as a whole would compare very favourably with those of other companies engaged in the same line of business. As to other items in the balance-sheet, it would be seen that there had been during the past year an increase in the capital expenditure of £14,475 only. This was necessary to provide new machinery, &c., and was only authorised after careful consideration and being satisfied that such expenditure was justified with the view of extending the company's business as far as possible. The result, after deducting depreciation, showed a total in the balance-sheet of £462,686, against £470,210 last year, being a decrease of £7,524. It might be as well to remark, in reference to those figures, that their freehold and leasehold property, machinery, &c., taken altogether, had been well depreciated, no less than £149,000 having been written off since the reconstruction of the company in 1897. In addition to that, since the amalgamation in 1902, they had put to special reserve £35,000, and to the debenture redemption fund £20,000, and had also increased the amount carried forward by £8,000, all out of profits. He was pleased to say that they continued to do a satisfactory business with all their customers, including the great corporations and Government departments. The figures under the heading of investments now stood at £463,348, against £470,383 last year. This money was invested principally in the Midland Electric Corpn. for Power Distribution (Ltd.) and the Electric Supply Co. of Victoria (Ltd.) As regarded the Midland Co., the sum invested in that company had somewhat increased, such increase being necessary for the extension of the business of the company, and it would be interesting to that meeting to know that there was now connected or applied for some 5,652 H.P., against 3,681 H.P. last year, an increase of 1,971 H.P. He had previously told them that the rate of progress of the company was slow, partly owing to the depression of trade in Midlands. They had also to contend with rival schemes for supplying gas motive power; and, owing to the discussion in the public Press on various power schemes of exceptional size for the County of London, consumers changed their views as to the price they should be called upon to pay per unit. They were firmly convinced that a little over ½d. was the utmost that they should be called upon to pay, not knowing that that figure, which was named during the discussion, could only be arrived at under the most favourable conditions. As a consequence, in order to extend their connections the Midland Co. were obliged to revise their scale of charges, and this had met, he was glad to say, with success. As there was every prospect of a further increased demand the company had ordered new plant of the latest type of turbine generators, which they trusted would place the Company in a profit-earning condition. With regard to the Electric Supply Co. of Victoria, last year they had invested in that company £284,728 and during the current year this had been increased by £13,000. The position in regard to that company had entirely changed for the better. During the past year they had issued £160,000 debenture stock, and this had all been taken up. This had enabled them to pay off their overdraft at the bank; and as a consequence, it would be noticed, the guarantee given by this company last year on behalf of the Victorian Company had disappeared from the balance-sheet. It also had enabled them to complete the greater part of the tramways in Ballarat as well as in Bendigo, still leaving them with a substantial sum in hand; and they were now in a position, had it been thought advisable, to pay over to this company a considerable sum in reduction of the amount owing; but they had not thought it advisable to take this at present in view of a further extension of the tramway network and lighting systems of Ballarat and Bendigo; and more especially as they were not in need of the money. The Victorian Company was doing very well, and the earnings they were now making showed that besides paying their debenture interest they would have a considerable sum available for dividend purposes this year. Practically the whole of the share capital was in the hands of this company; and they considered it a very sound investment. He thought he had now dealt with the most interesting items in the balance sheet, and he could only further say that this favourable result could not have been brought about except for the very hard work both of their working directors, Messrs. Taylor and Stitt, and also of their whole staff, from Mr. Sinclair, who was indefatigable, downwards. They all worked well together; and he was sure the thanks of the company were due to the staff of the company for the very satisfactory results which they had been able to place before the meeting. He moved the adoption of the report.

Mr. J. S. H. BANNER, M.P., seconded the resolution, which was carried unanimously; as were also resolutions approving the dividend recommended in the report; re-electing the retiring directors, Mr. E. K. Muspratt and Mr. S. Z. de Ferranti; and re-appointing the retiring auditors, Messrs. Chalmers, Wade & Co.

A hearty vote of thanks to the chairman and directors for their services was carried, and the proceedings terminated.

## Bournemouth & Poole Electricity Supply Co, (Ltd.)

The ninth ordinary general meeting was held on Wednesday under the presidency of Dr. J. ATKINSON HOSKER.

The SECRETARY (Mr. H. B. Renwick) read the notice convening the meeting and the auditors' report.

The CHARMAN then said: I regret the absence of our chairman, who is detained abroad owing to illness, which, however, I am pleased to say, is only of a temporary character. Turning to the report and accounts, my task is a pleasant one, as I have only to present to you details in connection with an exceedingly prosperous company. You will see from the balance-sheet that there is a considerable increase in both gross and net revenue, a satisfactory increase in the number of units sold and lamps applied for, and an exceedingly gratifying decrease in works costs. In regard to the revenue account, it will be seen that the gross receipts have increased from £40,414. 4s. 6d. to £46,385. 13s. 5d., and of this £4,154. 5s. 5d. has been brought in from sales of current. There is an item of £999 "compensation from contractors." This means that we have had to demand penalties from a firm of contractors for delay in delivery of some plant ordered from them. This delay was not due solely to those contractors, but was also caused by delay by some of the sub-contractors. We do not consider that our contractors have done badly with us, and we have placed other orders with them, but we were compelled to exact these penalties on account of loss to which we had been put in working the station owing to this delay. Turning to the debit side of the account, there was a decrease in coal, fuel and oil, waste and water, and this is a most satisfactory feature. We sold something like £4,000 worth more current and coal has cost us £300 less. Units of current unaccounted for have decreased from 15 to 14 per cent., which indicates more economical working. The principal increase in expenses has been in rates and taxes, but this is an item, unfortunately, over which we have no control. The total amount of the increase on this head shown in the accounts is £265. 8s. 6d. Taking the whole of the expenditure, the increase amounts to only £1,138. 2s. 10d., bringing up the total to £17,762. 19s. 5d., against £16,624. 16s. 7d. in 1904. The total credit to net revenue account after all outpayments is £18,513. 9s. 8d. We have placed to reserve for depreciation £6,935, against £3,500 last year. Last year, however, the whole of the £3,500 was taken from premium reserve account, whereas this year £3,000 of the £6,935 was taken from revenue, and the balance only from premium reserve account. In addition to this, £1,223 has been written out of revenue in respect of leasehold and special redemption fund account; so that, altogether, the sum written off to reserve and redemption is £8,158. This year we have spent a large sum in mains, something like £17,881. There is no doubt that in a progressive town like Bournemouth and the surroundings of Bournemouth it is important that the company should be in a position to show builders that as soon as their houses are occupied electric current is ready. The wisdom of this course is shown by the way in which we find consumers coming on our mains when they find them at their doors. Our total connections during 1905 for which no mains extensions were necessary were as follows: Total consumers connected 362, equivalent 8 c.p. lamps 9,305, motor and heating current 103¼ H.P. The connections for which extensions were carried out during the same period were: Total consumers 340, equivalent 8 c.p. lamps 8,193, motor and heating current 20¼ H.P. So that more than one-half of our total connections for the year were in respect of mains previously put down. We have now 2,798 consumers connected, and are supplying over 400 H.P. of current for power. As to the general progress of the company's business, the position is equally satisfactory. Our total 8 c.p. lamps connected are equivalent to 143,116, and units sold for all purposes during the past year were 2,005,025, an increase of 301,696 for the year. With regard to our future work, we have already got a provisional order for Wimborne and we are applying for one for Swanage. In the report of the directors this year you will notice that attention is called to a scheme of wiring consumers' premises on the rental and prepayment systems, in the latter case by means of slot meters. This overcomes the difficulty of the initial cost of wiring, and leads to a largely-extended use of electric light, &c. We have expended on this branch of our business during the past year £1,699. 12s. 11d. We are also prepared to supply electric motors on the rental or hire-purchase system. In this and all other ways the company is endeavouring to push the adoption of electric driving by assisting traders and manufacturers in the initial cost of installation. To summarise briefly our position, there has been an increase of 14·7 per cent. in the gross receipts, of 20·3 per cent. in gross revenue, of 17·4 in net revenue, while there has been a decrease of 5 per cent. in generation costs, despite the fact that we have generated and sold over 300,000 additional units. There was an increase of 17·7 per cent. in the number of units sold, of 17·8 per cent. in lamps applied for, and of 25 per cent. in the number of consumers. This progress has continued since the end of our past financial year. I now move the adoption of the report and accounts.

Mr. F. W. REYNOLDS seconded the motion, which was carried unanimously.

Resolutions approving the dividends set out in the report, re-appointing the retiring directors (Mr. R. Percy Sellon and Mr. F. E. Savory) and agreeing to an increase in the directors' remuneration from £700 to £1,000 per annum were also adopted. The retiring auditors having been re-appointed, a cordial vote of thanks to the chairman, directors and staff was proposed by Mr. PAGE and seconded by Mr. SCOTT, and carried unanimously.

The CHAIRMAN, in response, referred to the valuable services of Mr. H. B. Renwick as secretary, Mr. Brightman as assistant and Mr. Ingram as engineer, and said he was sure that these gentlemen would greatly appreciate the recognition of their services by the shareholders.

The proceedings then terminated.

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**AIRDRIE & COATBRIDGE TRAMWAYS CO.**—The report for 1905 states that the capital expenditure during the year was £5,742, bringing the total expenditure to Dec. 31 last to £61,441. The total revenue was £11,018 and expenditure £9,672, including £2,948, interest payable to the British Electric Traction Co. A dividend of 4 per cent. is declared.

**ANGLO-ARGENTINE TRAMWAYS CO. (LTD.)**—The net revenue account on Dec. 31, including £5,922 brought from 1904, and after deducting £50,000 carried to depreciation renewal funds, is £261,538. The directors recommend a final dividend on the ordinary shares of 5s. per share (tax free), making 8 per cent. for the year, carrying forward £10,214.

**BRUCE PEEBLES & CO. (LTD.)**—The net trading profit for 1905, after providing for depreciation and all necessary charges in connection with the management of the business, amounted to £43,142. 14s. 2d. Deducting directors' and managing directors' remuneration and auditors' fees, interest and income-tax, the balance is £36,430. 17s. 4d., to which is added £3,854. 6s. from 1904, making £40,285. 3s. 4d. Preference dividend to June 30 required £3,037. 7s. 11d., and the directors now recommend payment of the balance preference dividend at the rate of 7 per cent. (making 6½ per cent. for the year), a dividend of 6½ per cent. on the new issue of preference shares absorbing £1,559. 7s. 5d.; placing to preference special reserve (being not less than 10 per cent. of net profits, bringing this reserve up to £7,722. 6s. 6d.) £3,643. 1s. 9d.; a dividend on the ordinary shares of 6½ per cent., less tax, requiring £6,358. 4s. 7d.; writing off all preliminary expenses and one-half expenses in connection with new issue of shares and debentures £8,090. 19s. 7d.; transferring to general reserve £7,000 (which now amounts to £15,000); and carrying forward £7,271. 2s. 1d. The directors consider the position of the company to be satisfactory. The turnover for the year has again been greatly increased, and the value of current contracts and orders in hand exceeds that of any previous year. Several new and valuable channels of business have been opened up, and a great amount of development work in connection with new types of machines have been carried out during the year, necessitating considerable expenditure, all of which has been charged to revenue. The shares in power and traction companies acquired by the company in part payment of certain contracts have been valued by the directors at considerably under par, and they believe the valuations to be reasonable. Since Dec. 31 £10,000 of these have been sold.

**BRUSH ELECTRICAL ENGINEERING CO. (LTD.)**—The directors recommend, subject to audit, the full 6 per cent. dividend on the preference shares, and a dividend at the rate of 2½ per cent. on the ordinary shares for the year ended Dec. 31, placing £7,550 to general and £6,893 to depreciation reserve, and carrying forward £3,114.

**BUENOS AYRES & BELGRANO ELECTRIC TRAMWAYS CO. (LTD.)**—The revenue for 1905, including £2,086. 0s. 11d. brought from previous year, is £77,884. 11s. 2d. Debenture charges account for £28,259. 12s., renewals £9,000, and preference dividends £20,250. The directors recommend a dividend of 3s. per share (tax free) on the ordinary shares (at the rate of 3 per cent. per annum) and that £5,374. 19s. 2d. be carried forward.

**COUNTY OF DURHAM ELECTRICAL POWER DISTRIBUTION CO.**—Dr. J. T. Merz presided at the meeting last week and congratulated the shareholders on the great increase of business, which would probably have been greater had the new agreement with the Newcastle Electric Supply Co. been in force all the year instead of for only half. Most of their large consumers were now on 15 year agreements. During the year over £50,000 had been expended in new works, and £58,480 in taking up shares in the Durham Power Supply Co., which took power from the Newcastle Co. and supplied it to them. There company were now sole owners of the Durham Supply Co.

**FOLKESTONE ELECTRICITY SUPPLY CO. (LTD.)**—At Dec. 31 the equivalent of 76,937 8 c.p. lamps was being supplied with current, against 64,915 at the same period of 1904. After providing preference dividend, &c., and carrying £1,500 to depreciation, the net balance for distribution, after allowance is made for the interim dividend already paid, enables the directors to recommend the payment of a dividend at the rate of 7 per cent. (less tax) for the December half-year (making 5½ per cent. for the year).

**W. T. GLOVER & CO. (LTD.)**—The directors' report for the year to Dec. 31 states that the manufacturing profit was £47,264. 11s., and with £2,779. 0s. 10d. from dividends on investments, rents, &c., the total was brought up to £50,043. 11s. 10d. General expenses came to £25,370. 14s. 7d., and interest, bankers' charges, &c., to £2,074. 19s. 3d. After adding to the balance (£22,597. 18s.) the amount from last account (£7,976. 10s. 9d.) and deducting directors' remuneration and expenses (£1,100) £29,474. 8s. 9d. is available to pay interest (4¼ per cent.) on first mortgage debenture stock (£4,250) and interest on loans

(£1,522. 5s. 9d.), leaving £17,290. 10s. 1d. to be added to investments contingency fund. The investments of the company are largely in concerns allied with electrical industries, and were made some years ago. Being unquoted securities, it is not possible to establish their value accurately, but by the creation of an investment contingency fund the directors believe they have made full provision for any loss that may arise. The directors purpose issuing the £100,000 5 per cent. second mortgage debentures already authorised for repaying overdraft at bank and temporary loans, the time for which these were originally advanced having long since expired. The directors' first consideration having been to strengthen the company's financial position, they do not recommend the payment of a dividend.

**HADFIELD'S STEEL FOUNDRY CO. (LTD.)**—At the annual meeting on Monday a dividend at the rate of 22½ per cent. was declared, and the chairman (Mr. R. A. Hadfield) said they had entered upon what he believed would be a record year.

**HOVE ELECTRIC LIGHTING CO. (LTD.)**—The chairman (Col. A. J Filgate) stated at the meeting last week that the directors did not anticipate any large expenditure during the current year, but had found it desirable to make a further call of £1 per share on the last issue of shares at an early date. The net profits on the year's working had been £12,490, or £683 more than in 1904. The units sold last year amounted to 901,384, an increase of 9·8 per cent. over 1904. The gross revenue was £21,040, or £1,044 in excess of 1904, while the expenditure diminished by £25. The company had recently placed another proposal before Hove Corporation to make a further reduction in the charge for current if that body would support them in obtaining an order for the compulsory change-over of all consumers now on the 110 volt system to the higher voltage.

**JOHNSON & PHILLIPS (LTD.)**—The directors' report for the year ended Dec. 31 states that the profit on trading account, &c., after making provision for bad and doubtful debts, and after charging to revenue upwards of £4,000 for maintenance of buildings, plant, &c., amounts to £32,064. 14s. 4d. Deducting depreciation on buildings, plant, &c. (£5,200), remuneration of directors and auditors (£785), interest on debenture stock to Dec. 31 (£3,078. 13s. 10d.), reserve for debenture sinking fund (£1,062. 10s.), and the proportion of net profit earned from Jan. 1 to July 5, 1905, not available for distribution (£10,169. 5s. 3d.), the balance is £11,769. 5s. 3d., which it is proposed to appropriate to payment of a dividend at the rate of 7 per cent. per annum on the 175,000 ordinary shares issued (£5,739. 0s. 10d.), leaving £6,030. 4s. 5d. to be carried forward. The above results may be considered satisfactory in view of the period of unsettled management during the earlier part of the year previous to the registration of the company. The directors report that the orders in hand are of a satisfactory nature, and there are signs of improved trade in the near future. The fire which occurred on Feb. 27 in the cable department was fortunately confined to one building, and arrangements have been made to carry out the various contracts in hand. The damage done was covered by insurance.

**MARCONI'S WIRELESS TELEGRAPH CO. (LTD.)**—The directors' report for the year ended Sept. 30, 1905, has just been issued, and states that the profit on the year's working again shows an increase, the net profit being £16,750, against £12,681 for the previous year. There is therefore for the year a return on the issued capital of about 7 per cent., which, with the balance forward of £12,681. 5s. 3d., would be sufficient to pay a dividend of about 12 per cent. In view, however, of the large expenses for development, it is thought inadvisable for the present to make any distribution to the shareholders. The company (the report states) is making satisfactory progress all over the world, and the organisation for carrying on by means of the Marconi system the business of a telegraph company is being extended wherever profitable traffic seems likely to result and concessions can be secured. It will be readily understood that in many instances your directors are unable to give particulars of advantageous contracts, either because they are specifically precluded by agreement from publishing them, or because other arrangements of advantage, the outcome of these contracts, are under negotiation, the completion of which would be prejudiced by publicity. This is especially the case with regard to contracts with foreign governments, but, wherever possible, with due regard to these considerations, information with regard to the progress of the company's affairs is communicated from time to time to the Press.

*Improvements.*—Very important improvements have been made by Mr. Marconi in the system during the past year. Notably, complete specifications have recently been filed for patents for an invention by means of which the waves, instead of radiating with equal strength in all directions, are primarily confined to a particular direction. A demonstration of the capabilities of this new invention has been given by Mr. Marconi to representatives of the Amiralty and Post Office, and he has shown that by its means it is practicable not merely to direct the waves in a particular direction, but to localise the position of a ship out of sight of land, working wireless telegraph apparatus.

*Transatlantic Communication.*—The new station in Canada, referred to in last year's report as in course of completion, is now finished and has been working satisfactorily day and night for many months past. The station has been thoroughly tested by transmission of messages to England, and the directors are satisfied that the difficulty of transmitting signals in bright sunlight has been surmounted, and that a good and regular service can be maintained. A new station, practically identical with that in Canada, is in course of erection in Ireland, and when completed should give results similar to those now obtained from the Canadian station, affording, with the Canadian station, satisfactory commercial communication both ways between the United Kingdom and the Continent of America. The erection of the station in Ireland has been delayed through difficulties in securing a suitable site for which Government sanction could be obtained; it is, however, anticipated that the station will be completed and ready for commercial working before the end of the present year (1906).

*Admiralty.*—Considerable developments have taken place in the use of the Marconi system throughout His Majesty's navy, particularly in connection with the transmission of messages over long distances to ships at sea from the company's high-power station in Cornwall.

*Board of Trade.*—A contract has been entered into with the Board of Trade and Trinity House for the equipment of lightships round the coast. The Sunk, the Gull, and the South Goodwin light-vessels are already installed, and installations on the Tongue, Cross Sand and East Goodwin light-vessels will shortly be completed.

*Lloyd's.*—The action brought by Lloyd's against the company and against the Marconi International Marine Communication Co. has been settled, on terms completely satisfactory to the directors.

*Canada.*—The relations with the Canadian Government continue excellent. Great satisfaction with the wireless service has been officially expressed. New stations have been equipped, particularly one at Sable Island, having a range of about 500 miles, and specially useful for ships following the southern route. Further extensions of the service are now under consideration by the Canadian Government.

*Italy.*—The Government service from coast stations to ships at sea fitted with the Marconi apparatus has been extended to meet the growing demands of the Italian mercantile marine. The erection of the high-power station at Coltano for the Italian Government is proceeding.

*Patent Action.*—Reference follows in the report to the patent action in the U.S. Courts against the De Forest Co.

*China, Chili and Dutch East Indies.*—Seven stations have been erected in China, estimates for stations required by the Chilian Government are under consideration, and a concession has been granted for wireless telegraphy throughout the Dutch East Indies to persons under contract with the company. A company is being formed for working the concession.

*New Works.*—Freehold works at Dalston (London, N.E.), valued at £82,000, have been acquired on highly favourable terms. The works at Chelmsford, which have been found insufficient for the company's requirements, will shortly be closed and the whole manufacture carried on at Dalston.

*Marconi Ship Equipments.*—A long list of steamers equipped with Marconi apparatus follows.

*Issue of Capital.*—After the close of the financial year the company made an offer of 128,063 shares to the shareholders at par. This issue was guaranteed by a group in which six of your directors were directly or indirectly interested, the consideration being an option to take a further 115,810 shares at 30s. each.

*Share-holdings in Associated Companies.*—Special attention is drawn to the item "Shares in Associated Companies" of the par value of £1,439,285, which are taken in the balance-sheet at only £62,286. 16s. 4d. It is anticipated (the report continues) that when the transatlantic stations are opened for commercial work such of these holdings as the company is prepared to sell will be marketable at prices which will represent substantial profit.

**MERSEY RAILWAY CO.**—For the half-year ended Dec. 31 the train mileage was 417,683, compared with 415,625 in the corresponding period of 1904. The number of passengers conveyed during the half year was 4,937,840, including omnibus passengers, against 4,657,876 for the corresponding period of 1904, exclusive of season ticket holders. Total receipts were £44,060, compared with £41,788. Working expenses (exclusive of charges for pumping, ventilation and lifts) were £30,471, equal to 69·16 per cent., against £29,029, or 69·17 for the corresponding six months.

**NEWCASTLE & DISTRICT ELECTRIC LIGHTING CO. (LTD.)**—Sir John D. Milburn, Bart., at the meeting on Tuesday said the company had increased their sales from 3,250,000 units to about 5½ million units last year, owing mainly to the campany having been converted from a purely lighting undertaking to a working power company. Last year and this year had been rather critical periods in their history, but they hoped now that they were nearly through their troubles, the economies effected, taken together with the increased revenue receivable for current, should put the company into a better position than it had ever been before. They were in the position of being able to produce electricity almost, if not as cheaply as anyone else, and they felt themselves more secure than had been the case for a long time past.

**POTTERIES ELECTRIC TRACTION CO. (LTD.)**—The gross receipts for the past year were £104,479. After deducting all expenses chargeable to revenue, including repairs and maintenance and interest, the profit is £27,302. £5,000 is put to depreciation and reserve fund, £21,250 is required for preference dividend, and a dividend on the ordinary shares of 4 per cent. absorbs £9,800.

## CITY NOTES.

**MEMORANDA** (March 22).—Bank rate 4 per cent. (since Sept. 28, 1905). Price of silver 30$\frac{1}{16}$d. per oz. Consols 90$\frac{5}{16}$—90$\frac{7}{16}$ for money, 90$\frac{7}{16}$—90[illegible] for account; 2½ per cent. annuities 89¼—89½. Consols Pay Day, April 4. Stocks and Shares Continuation Days, March 26 and April 9; Ticket Days, March 27 and April 10. Pay Days, March 28 and April 11; Mining Share Carry-over Day, March 23.

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**COUNTY OF LONDON ELECTRIC SUPPLY CO. (LTD.)**—Letters of allotment and regret in respect of the recent issue of 10,000 £10 6 per cent. cumulative preference shares have been posted.

**DIRECT UNITED STATES CABLE CO. (LTD.)**—The Board have resolved to pay an interim dividend of 4s. per share, tax free (at rate of 4 per cent. per annum) for the quarter ended 31st inst., payable April 26.

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. | | |
|---|---|---|---|---|---|---|
| | | | | No. of weeks. | Amount. | Inc. or Dec. (a) |
| | | £ | £ | | £ | £ |
| **Aberdeen Corporation** | March 17 | 1,122 | + 15 | 48 | 56,645 | − 798 |
| **Airdrie** | ,, 9 | 208 | + 7 | 10 | 2,118 | + 203 |
| Anglo-Argentine | ,, 18 | 15,270 | + 1,186 | 11 | 162,960 | + 16,811 |
| **Ayr Corporation** | ,, 17 | 179 | − 8 | 48 | 12,542 | − 65 |
| **Barnsley** | ,, 9 | 164 | − 1 | 10 | 1,476 | + 6 |
| **Barrow** | ,, 9 | 215 | + 16 | 10 | 1,944 | + 173 |
| **Bath Electric Trams, Ltd** | ,, 14 | 596 | + 45 | 11 | 6,940 | + 1,090 |
| Birkenhead Corporation | ,, 18 | 972 | − 10 | 11 | 11,087 | + 84 |
| **Birmingham Corporation** | ,, 17 | 405 | + 23 | 50 | 18,794 | + 2,812 |
| *Birmingham & Mid. | ,, 9 | 1,468 | − 316 | 10 | 13,176 | − 3,304 |
| Blackburn Corporation | ,, 14 | 818 | + 54 | †51 | 48,115 | − 2,680 |
| **Blackpool Corporation** | ,, 15 | 362 | + 29 | 11 | 3,562 | + 215 |
| **Blackpool and Fleetwood** | ,, 17 | 195 | − 2 | 11 | 2,027 | − 11 |
| **Bolton Corporation** | ,, 18 | 1,948 | + 127 | 51 | 97,196 | + 5,198 |
| **Bournemouth Corporation** | ,, 14 | 1,220 | + 256 | †50 | 69,847 | + 16,555 |
| **Bradford Corporation** | ,, 17 | 4,000 | + 25 | 50 | 216,097 | − 1,885 |
| **Brighton Corporation** | ,, 18 | 700 | − 134 | 51 | 48,853 | + 357 |
| **Bristol Trams & Carriage** | ,, 16 | 4,593 | + 166 | 5 | 23,568 | + 1,473 |
| **Buenos Ayres & Belgrano** | ,, 18 | 3,658 | + 200 | 11 | 38,768 | + 8,538 |
| **Buenos Ayres Elec. Trms** | Feb 17 | 1,444 | + 408 | 7 | 9,831 | + 2,385 |
| **Burnley Corporation** | March 17 | 1,011 | + 18 | 50 | 64,816 | + 3,653 |
| **Burton Corporation** | ,, 18 | 269 | − 43 | §50 | 15,180 | − 1,726 |
| Bury Corporation | ,, 11 | 853 | ... | §49 | 37,446 | ... |
| **Calcutta Tramways Co.** | ,, 17 | R43,240 | + R4,243 | 11 | R489,228 | + R49,620 |
| **Camborne-Redruth** | ,, 17 | 105 | + 6 | 20 | 2,148 | + 53 |
| Cardiff | ,, 17 | 1,903 | + 5 | 50 | 101,157 | + 348 |
| **Carlisle Tramways Co.** | ... | ... | ... | ... | ... | ... |
| Cavehill | ,, 9 | 71 | + 85 | 10 | 403 | + 57 |
| **Central London Railway** | ,, 17 | 6,911 | − 159 | 11 | 76,603 | − 2,525 |
| **Chatham & Dist. Lt. Rys.** | ,, 15 | 570 | − 30 | †11 | 6,100 | − 71 |
| *City of Birm'gh'm Tram Co | ,, 9 | 5,537 | − 80 | 10 | 50,472 | − 979 |
| **City & South London Rly.** | ,, 18 | 2,900 | + 16 | 11 | 32,823 | − 24 |
| **Colchester Corporation** | ,, 15 | 151 | − 9 | 31 | 5,954 | − 1,476 |
| **Cork Electric Trams Co.** | ,, 15 | 897 | − 10 | 11 | 4,557 | − 4 |
| Derby Corporation | ,, 17 | 682 | + 58 | 50 | 36,067 | + 10,136 |
| **Devonport & Dist. Trams** | ,, 9 | 427 | + 14 | 10 | 3,943 | − 199 |
| **Dover Corporation** | ,, 17 | 172 | + 3 | ‡50 | 10,977 | + 106 |
| **Dublin & Lucan Railway** | ,, 16 | 101 | − 8 | §11 | 952 | − 78 |
| **Dublin United** | ,, 16 | 4,592 | − 147 | ‡11 | 48,870 | + 1,833 |
| **Dudley—Stourbridge** | ,, 9 | 818 | + 50 | 10 | 7,226 | + 376 |
| **Dundee Corporation** | ,, 14 | 881 | + 109 | §43 | 40,506 | + 3,783 |
| **East Ham Council** | ,, 17 | 804 | + 73 | 50 | 41,273 | + 5,888 |
| **Gateshead & Dist. Trams** | ,, 9 | 937 | + 49 | 10 | 8,902 | + 424 |
| **Glasgow Corporation** | ,, 17 | 15,056 | + 512 | 42 | 638,048 | + 41,924 |
| Glossop | ,, 17 | 120 | + 5 | 11 | 1,854 | + 191 |
| Gloucester Corporation | ,, 14 | 220 | + 11 | 50 | 14,122 | + 1,185 |
| **Gravesend—Northfleet** | ,, 9 | 216 | + 20 | 10 | 1,906 | + 111 |
| **Gt. Northern & City Rly.** | ,, 17 | 1,835 | + 113 | 11 | 20,008 | + 628 |
| **Greenock & Port Glasgow** | ,, 9 | 501 | + 7 | 10 | 5,422 | + 431 |
| **Halifax Corporation** | ,, 14 | 1,252 | + 90 | 50 | 76,766 | + 5,696 |
| **Hartlepool Tramways** | ,, 9 | 266 | + 9 | 10 | 2,453 | + 121 |
| Hastings Elec. Trams Co. | ,, 15 | 846 | ... | 11 | 8,895 | ... |
| **Huddersfield** | ,, 17 | 1,814 | + 94 | 50 | 65,019 | + 4,079 |
| **Hull Corporation** | ,, 17 | 2,174 | − 38 | 50 | 111,291 | + 2,190 |
| Ilford Dist. Coun. | ,, 17 | 424 | + 85 | 50 | 28,102 | + 1,159 |
| **Ipswich Corporation** | ,, 17 | 827 | − 6 | 50 | 20,732 | − 1,869 |
| **Isle of Thanet Co.** | ,, 17 | 248 | − 18 | 23 | 6,186 | − 449 |
| **Kidderminster & District** | ,, 9 | 101 | + 10 | 10 | 878 | + 9 |
| Kilmarnock Corporation | ,, 17 | 142 | − 6 | 44 | 6,805 | ... |
| **Kirkcaldy Corporation** | ,, 14 | 167 | ... | 2 | 388 | − 1 |
| **Lanarkshire Trams Co.** | ,, 15 | 757 | + 149 | †11 | 8,898 | + 2,015 |
| Leamington | ,, 9 | 155 | + 69 | 10 | 1,276 | + 418 |
| **Leeds Corporation** | ,, 17 | 5,540 | + 172 | 51 | 298,102 | + 9,641 |
| **Leicester Corporation** | ,, 17 | 2,067 | + 157 | 11 | 21,896 | + 2,836 |
| Leith Corporation | ,, 10 | 437 | + 230 | 42 | 15,716 | + 11,881 |
| **Liverpool Overhead Rly.** | ,, 18 | 1,368 | − 129 | 11 | 15,260 | − 875 |
| Liverpool Corporation | ,, 10 | 10,676 | + 824 | 10 | 101,240 | + 4,377 |
| ***London County Council** | ,, 10 | 15,037 | + 2,584 | 49 | 718,589 | + 95,052 |
| **Lowestoft** | ,, 17 | 1[illegible]3 | − 13 | 25 | 8,249 | − 71 |
| **Maidstone Corporation** | ,, 15 | 82 | − 9 | 50 | 5,854 | ... |
| **Manchester Corporation** | ,, 17 | 12,196 | + 319 | 50 | 640,825 | + 33,670 |
| Mersey Railway | ,, 17 | 1,679 | + 48 | 11 | 18,633 | + 797 |
| **Merthyr** | ,, 9 | 191 | + 7 | 10 | 1,682 | − 10 |
| Metropolitan Dist. Railway | ,, 18 | 8,071 | + 377 | 11 | 89,486 | + 4,722 |
| ***Metropolitan Elec. Trams** | ,, 9 | 3,810 | + 1,547 | 10 | 26,933 | + 8,762 |
| **Middleton** | ,, 9 | 317 | + 54 | 10 | 2,719 | + 288 |
| **Nelson Corporation** | ,, 17 | 129 | + 13 | 51 | 6,654 | + 778 |
| **Newcastle-on-Tyne Corp.** | ,, 17 | 3,608 | − 11 | 50 | 189,543 | + 4,497 |
| **Newport (Mon.)** | ,, 17 | 567 | + 28 | 24 | 13,115 | + 1,010 |
| Northampton Corporation | ,, 16 | 350 | − 22 | 50 | 20,983 | + 5,296 |
| **Oldham, Ashton & Hyde** | ,, 9 | 552 | + 52 | 10 | 4,980 | + 255 |
| **Oldham Corporation** | ,, 18 | 1,683 | + 149 | 51 | 82,830 | + 18,241 |
| Perth (N.B.) Corporation | ... | ... | ... | ... | ... | ... |
| **Perth (W. A.) Elec Trams** | ,, 16 | 1,480 | + 73 | ‡11 | 16,988 | + 757 |
| **Peterborough** | ,, 9 | 103 | − 1 | 10 | 982 | − 28 |
| Pontypridd District Coun. | ,, 17 | 155 | ... | 50 | 7,970 | ... |
| Portsmouth Corporation | ,, 17 | 1,468 | − 22 | 50 | 94,556 | + 1,848 |
| **Potteries** | ,, 9 | 1,812 | + 131 | 10 | 16,845 | + 1,113 |
| Preston Corporation | ... | ... | ... | ... | ... | ... |
| **Reading Corporation** | ,, 16 | 562 | − 19 | ... | ... | ... |
| **Rotherham Corporation** | ,, 15 | 409 | + 17 | 50 | 22,627 | − 2 |
| **Rothesay** | ,, 9 | 46 | + 1 | 10 | 473 | + 88 |
| **Salford Corporation** | ,, 19 | 4,166 | + 66 | 51 | 215,884 | + 12,511 |
| **Sheerness** | ,, 7 | 48 | − 12 | 10 | 449 | − 68 |
| **Sheffield Corporation** | ,, 18 | 4,986 | + 245 | 51 | 251,758 | + 15,824 |
| **Southampton Corporation.** | ,, 14 | 815 | − 12 | 23 | 20,212 | + 174 |
| **Southend Corporation** | ,, 14 | 288 | + 9 | 50 | 17,918 | + 1,114 |
| **Southport Tramways** | ,, 9 | 285 | + 11 | 10 | 2,261 | + 51 |
| **S. Staffordshire Trams.** | ,, 9 | 819 | + 157 | 10 | 7,455 | + 1,273 |
| **Stockport Corporation** | ,, 16 | 747 | + 819 | 50 | 88,071 | + 11,304 |
| Sunderland Corpn. | ,, 18 | 1,179 | + 86 | 50 | 65,515 | + 8,091 |
| **Swansea Trams** | ,, 9 | 787 | + 262 | 10 | 6,918 | + 2,525 |
| **Swindon Corporation** | ,, 14 | 155 | − 6 | 50 | 9,578 | ... |
| Taunton | ,, 9 | 40 | − 4 | 10 | 401 | + 18 |
| **Tynemouth and District** | ,, 9 | 173 | ... | 10 | 1,553 | − 74 |
| **Tyneside Trams Co.** | ... | ... | ... | ... | ... | ... |
| **Wallasey District Council** | ,, 17 | 680 | + 20 | 50 | 88,380 | + 1,673 |
| **Warrington Corporation** | ,, 15 | 358 | + 87 | 52 | 17,126 | + 1,203 |
| **West Ham Corporation** | ,, 15 | 1,846 | + 706 | 50 | 92,218 | + 39,786 |
| **Weston-super-Mare** | ,, 7 | 85 | + 6 | 10 | 257 | + 2 |
| Wolverhampton Corpn. | ,, 14 | 705 | ... | ... | ... | ... |
| ***Wolverhampton District** | ,, 9 | 412 | + 59 | 10 | 3,633 | + 850 |
| ***Worcester** | ,, 9 | 240 | − 16 | 10 | 2,274 | − 134 |
| **Wrexham** | ,, 9 | 91 | − 18 | 10 | 864 | − 48 |
| **Yorkshire W.R. Trams** | ,, 18 | 751 | + 147 | 11 | 7,468 | + 2,206 |
| **Yorkshire Woollen District** | ,, 9 | 866 | + 284 | 10 | 7,885 | + 2,705 |

(a) These comparisons are with the corresponding period last year. † Minus 8 days. ‡ Minus 2 days. § Plus 2 days. ¶ Plus 3 days. * Partly electrical.

**EASTERN TELEGRAPH CO. (LTD.)**—This company announces the payment on April 14 of dividend at the rate of 3½ per cent. per annum (less tax) on the preference stock for the quarter ending 31st inst., and an interim dividend of 1¼ per cent. on the ordinary stock (tax free) in respect of profits for the quarter ended Dec. 31. The transfer books of the ordinary stock will be closed from April 5 to 12 inclusive.

**ELECTRICAL DEVELOPMENT CO. OF ONTARIO (LTD.)**—During the week $2,500,000 first mortgage sinking fund 5 per cent. gold bonds of this company were offered for sale at 96½.

**GREAT NORTHERN TELEGRAPH CO. (LTD.)**—The directors propose to recommend, at the meeting to be held on April 28, the same dividend as last year—namely 24 per cent. (including 5 per cent. already paid). £55,555 is to be placed to reserve and a like amount to dividend equalisation fund.

**SAO PAULO TRAMWAY, LIGHT & POWER (CO.)**—A quarterly dividend of 2 per cent. has been declared on the ordinary shares.

**STOCK EXCHANGE NOTICES.**—The Stock Exchange Committee have appointed April 4 a special settling day in and have granted a quotation to £160,000 5 per cent. first mortgage debenture stock of the *Electric Supply Co. of Victoria (Ltd.)*. The committee have been asked to allow scrip (fully and partly paid) for £250,000 5 per cent. construction debenture stock of the *Madras Electric Supply Corpn. (Ltd.)* to be quoted.

**UNDERGROUND ELECTRIC RAILWAYS CO. OF LONDON (LTD.)**—An extraordinary meeting has been summoned to authorise an increase of £5,000,000 in the company's borrowing powers.

**WOKING ELECTRIC SUPPLY CO. (LTD.)**—This company is placing privately at par an issue of £20,250 4½ per cent. debenture stock.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Mar. 21. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Mar. 21. | |
|---|---|---|---|---|---|---|---|
| | | | | £ s. d. | | Highest. | Lowest. |
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | | | | |
| 5 | 8/0 | Anglo-Argentine Ord. Shares | 9 —9¼ | 4 6 6 | Ap, Oct | 9 7/32 | 9 |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞—6⅛ | 4 10 0 | — | 6 1/16 | 6 |
| St. | 6% | Do. Permanent 6% Deb. Stock | 141 —144 | 4 3 3 | — | 143 | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 104 —106 | 4 14 3 | — | 104½ | .. |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | 1 —1½ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 3⅞—4⅛ | 6 1 4 | — | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 93 —96 | 4 13 9 | — | 5 | 94½ |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 120 —123 | 4 17 6 | — | — | .. |
| St. | 5% | Do. Pref. Ord. Stk | 110 —113 | 4 8 4 | — | .. | .. |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock. | 107 —110 | 4 11 0 | — | 107¼ | — |
| 40 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%—105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 102 —105 | 4 5 0 | — | .. | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | 3½—3¾ | 5 6 6 | — | 3¾ | 3 11/16 |
| 5 | 8/0 | Do. 6 per Cent. "A" Cm. Pref. | 5⅞—6⅛ | 4 18 0 | — | 6 1/16 | .. |
| 5 | 8/0 | Do. "B" | 5¼—5¾ | 5 4 0 | — | .. | .. |
| St. | 5% | Do. 5 per Cent. Debs. | 106 —108 | 4 12 6 | — | 107¼ | 107 |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102 —105 | 4 15 0 | . | 104 | 103½ |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 100 —102 | 4 19 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 102 —106 | 5 4 3 | .. | .. | — |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 102 —106 | 5 13 0 | .. | 104¾ | .. |
| 5 | 8/6 | Calcutta Tramways (Nos. 1 to 105) | 9⅝—10⅛ | 4 4 0 | — | 9 1/16 | .. |
| 5 | 2/6 | Do. Nos. 105,001 to 137,610 | 9 —9½ | .. | .. | .. | .. |
| 100 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 106 —108 | 4 3 8 | — | 107½ | .. |
| 1 | 0/6 | Cape Electric Tram Shares | ⅝—⅞ | 5 14 0 | — | [illegible] | [illegible] |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 102 —104 | 4 16 0 | — | .. | — |
| .. | 5% | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 96 —98% | 5 2 0 | .. | 97 | 96½ |
| St. | .. | Kalgoorlie Elec. Trams 5% "A" Deb. Stock | 91 —93 | .. | .. | .. | .. |
| St. | .. | Do. 6% "B" Ditto | 83 —88 | .. | .. | 85½ | 85 |
| 1 | .. | Lisbon Elec. Trams Ord. | 1 7/16—1 9/16 | .. | .. | 1 13/32 | 1½ |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛—1⅜ | 4 7 4 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 100 —103 | 4 17 0 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 101 —103 | 4 17 0 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101 —103 | 4 17 0 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102 —104 | 4 6 6 | — | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 105 —108 | 4 12 6 | .. | .. | .. |
| . | $2 | Sao Paulo Tramway, Light and Power Co. $100 Stock | 147 —149 | 5 7 3 | .. | .. | .. |
| .. | 5% | Do. 5% 1st Mt. $500 Dbs. | 99%—101% | 4 19 0 | .. | 100⅛ | 99¾ |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | 3/ | †Adelaide Elec. S'ply Co. 6% Cu. Pr. | 4¾—5¼ | 5 14 6 | .. | .. | .. |
| 5 | 3/3 | Calcutta Elec. (1-80 000) | 9 — 9½ | 4 6 6 | — | .. | — |
| 10 | 5% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50 —52 | 4 16 0 | .. | .. | .. |
| . | 5% | Cordoba Lt. and Power Co. 1st Mt. Stk. £100 000 5% Bds. | 94 —96 | 5 4 0 | .. | .. | .. |
| 5 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½—3 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Debs. | 88 —92 | 5 9 4 | .. | .. | — |
| 10 | .. | Havana Electricity Co. Shares | 7¾—8¾ | — | — | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92 —94 | 5 6 8 | — | .. | .. |
| St. | 20/2 | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. | 111 —114 | 5 5 0 | .. | 113 | 112¾ |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞—1 | 6 0 0 | .. | .. | .. |
| 1 | 1/0 | Rand Electric | 1⅛—1¼ | — | — | .. | .. |
| 1 | .. | River Plate Electricity Co. Ord. | [illegible] | .. | — | ⅝ | — |
| 1 | 1/2⅔ | Do. 6% Non. Cum. Pref | [illegible] | .. | .. | — | .. |
| St. | 5% | Do. 5% Deb. Stock | 101 —103 | 4 17 0 | .. | .. | .. |
| 5 | 8/0 | Rosario Elec. Co. 6% Pref. (1-12,000) | 5¼—5¾ | 5 4 4 | .. | .. | .. |
| 5 | 9·23d | Do. (12,001-20,000) | 5¼—5¾ | 8 5 0 | .. | .. | — |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100 —103 | 4 7 5 | Ap, Oct | — | ... |
| .. | 5% | Shawinigan Water and Power 5% Bds., Scrip | 101 —103 | 4 17 0 | .. | 101½ | .. |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Shre. | Last Divi-dend | Name. | Price Wed., Mar. 21. | Rate % Yielded £ s. d. | Dividend Due. | Business, Week to Mar. 21. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 10 | 4/0 | Bournemouth & Poole Elec. Sup. Ord. | 12⅛—12⅝ | 6 6 0 | .. | .. | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10 —10½ | 4 5 9 | .. | 10 3/16 | 10⅛ |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11 —12 | 5 0 0 | .. | .. | – |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 106 —108 | 4 8 3 | .. | 107⅞ | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 103 —106 | 4 5 0 | – | .. | .. |
| | 5/6 | †Brompton & Kensington Elec. Sup. Ord. | 8¾—9¼ | 5 8 6 | – | .. | .. |
| | 3/6 | † Do. 7 per Cent. Pref. | 8¾—9¼ | 3 15 6 | Mar, Sept | .. | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 102 —105 | 3 16 3 | – | 103¼ | .. |
| | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 4¾—5¼ | 4 7 0 | Feb, Aug | 5 3/16 | 5 |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 4½—5 | 4 10 0 | Feb, Aug | 4⅝ | 4¾ |
| St. | 4% | Do. 4% Deb. Stock (red.) | 101 —103 | 3 17 6 | – | 102¾ | .. |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4½—4¾ | 4 14 9 | – | .. | – |
| 5 | 2/3 | Do. Do. (1908) | 4¼—4¾ | 4 14 9 | .. | – | .. |
| 5 | 3/9 | †Chelsea Electric Supply Ord. | 5½—5¾ | 5 6 0 | March .. | 5 15/32 | 5⅝ |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 107 —109 | 4 2 6 | Jn, Dec .. | 108½ | 108 |
| 10 | 5/0 | City of London Electric Lighting Ord. | 10¾—11¾ | 5 2 0 | Feb, Aug | 11½ | 11 1/16 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 13¾—14¼ | 4 4 2 | Jan, July | 13 15/16 | 13 11/16 |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 123 —126 | 3 19 4 | Jn, Dec .. | 125 | 124½ |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 101 —103 | 4 8 0 | .. | .. | .. |
| 5 | 4% | County of Durham Elec. P.D. Ord. £2pd. | 2 1/16—2 3/32 | 3 17 8 | April, Oct | 2 1/16 | 2 3/32 |
| 5 | 5% | Do. Do. 5% non cum. pref. | 5¼—5⅜ | 4 13 0 | April, Oct | 5 7/16 | 5¼ |
| 10 | 4/0 | County of London Elec. Supply Ord. | 8½—9½ | 4 6 6 | – | 9 | 8 13/16 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 12⅛—12⅝ | 4 17 0 | Mar, Sept | 12½ | .. |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 109 —112 | 4 0 4 | .. | 111 | 110½ |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 101 —103 | 4 7 6 | .. | 102½ | 102 |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5 —5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101 —104 | 4 6 6 | – | – | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8½—9 | 4 14 0 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100 —103 | 4 7 5 | – | .. | – |
| 5 | 5/0 | †Kensingtn. & Kngtsbdg. Ord | 9½—10¼ | 4 13 0 | .. | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½—7 | 4 5 9 | Jan, July | – | – |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98 —101 | 3 19 2 | .. | .. | .. |
| St | 4% | Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 103 —105 | 3 16 0 | – | .. | .. |
| 8 | 2/4½ | †London Electric Supply Ord. | 2 —2½ | 6 15 0 | .. | 2⅜ | 2¼ |
| 5 | 3/0 | † Do. 6 per Cent. Pref. | 5⅛—5⅝ | 5 7 0 | .. | 5⅜ | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 98 —101 | 3 19 2 | Mr, Jn, S, D | .. | .. |
| 5 | 10% | Metropolitan Electric Sup. Ord. | 9 —10 | 5 0 0 | April, Oct | 9 7/16 | 9 |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5⅜—5⅝ | 4 0 0 | Jan. July | 5 9/16 | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 110 —114 | 3 19 0 | Jn, Dec .. | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 95 —97 | 3 12 3 | – | 96¾ | 96 |
| 100 | 4½% | Midland Elec. Corp. for P. D. 1st Mort. Db. | 101 —103% | 4 7 4 | – | 102¼ | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 11⅜—11⅝ | 5 18 1 | Feb, Aug | 11½ | .. |
| 100 | 4½% | Do. 4½% Deb. | 101½—102½ | 4 6 6 | Jan, July | .. | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 7⅞—8 | 5 0 7 | Feb, Aug | 8 | 7 15/16 |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 6⅛—6¼ | 4 0 8 | Feb, Aug | 6⅛ | 6 |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99 —101 | 3 19 7 | Jan, July | .. | .. |
| 1 | 3% | Northern Counties Elec. Sup. | 15/16—31/32 | 3 2 6 | Mar, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 101 —102 | 4 7 6 | Jan, July | – | – |
| 10 | 9/0 | †Notting Hill Electric Ord. | 13 —14 | 6 8 0 | March | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98 —100 | 4 0 0 | .. | .. | .. |
| 5 | 4/6 | †Oxford Electric Ord. | 6½—7 | 4 16 0 | March .. | 6¾ | 6⅝ |
| St. | 4% | Do. 4% Deb. Stock | 99 —101 | 3 19 0 | – | .. | .. |
| 5 | 7/6 | St. James' & Pall Mall Elec. Ord. | 9¼—10¼ | 6 0 0 | Feb, Aug | 10 | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 7 —8 | 4 7 0 | Feb, Aug | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 96 —98 | 3 12 0 | – | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2¼—2¾ | 8 4 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76 —80 | 5 0 0 | – | .. | .. |
| 5 | 4/0 | South London Electric Supply Ord | 3¼—3¾ | 5 6 8 | .. | 3 7/16 | .. |
| 1 | 0/3 | †South Metrop'n Elec. Lt. & Power Ord. | ¾—⅞ | .. | .. | .. | – |
| 1 | 0/8¾ | † Do. 7% Cum. Pref. | 1¼—1⅜ | 5 2 0 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Db. Stk. Red. | 105 —108 | 4 3 8 | – | .. | – |
| 5 | 2/6 | Urban Electric Supply Ord. | 4½—4¾ | 5 5 0 | – | 4½ | .. |
| 5 | 2/6 | Do. 5% Cum. Pref. | 5 —5¼ | 4 16 8 | – | 5 3/16 | 5⅛ |
| St. | 4½% | Do. 4½% 1 Mort. Deb. | 104 —106 | 4 5 0 | .. | .. | .. |
| 5 | 6/6 | †Westminster Elec. Sup. Ord. | 9½—10½ | 6 4 0 | Mar, Sept | 10¼ | 9 15/16 |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref | 5 5/16—5 9/16 | 4 10 0 | .. | 5½ | 5⅜ |
| 5 | .. | Do. £1 and 7/6 premium paid | 1⅛—1½ | .. | .. | .. | .. |
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| St. | 4% | Baker St. & Waterloo 4% Perp. Db. St. | 100 —102 | 3 18 6 | .. | 101⅝ | 100¾ |
| 1 | .. | Bath Elec. Trams Pref. Ord. | 15/16—1 1/16 | .. | .. | 15/16 | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16—1 1/16 | 4 12 3 | .. | 1 1/16 | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 103 —105 | 4 5 6 | .. | 103½ | 103 |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 101 —103 | 4 7 9 | .. | .. | .. |
| 10 | 2½% | Bristol Tramways and Carriage Ord. | 5 —5¼ | 4 8 8 | Feb, Aug | – | – |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10 —10¼ | 3 18 0 | .. | .. | – |
| St. | 4% | Do. 4 per Cent. Debs. | 104 —106 | 3 15 6 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 7⅛—7⅜ | 8 17 6 | – | 7⅝ | 7 1/16 |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 9½—10 | 6 0 0 | Feb, Aug | 9¾ | 9⅝ |
| St. | 5% | Do. 5 per Cent. Perpetual Debs | 117 —120 | 4 8 4 | .. | 119 | 118½ |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 97 —99 | 4 11 0 | .. | 98¼ | 98 |
| St. | 4% | Central London Ordinary Stock | 91 —93 | 4 6 0 | June, Dec | 92½ | 91½ |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 103 —105 | 3 16 0 | .. | 103½ | 103⅛ |
| St. | 4% | Do. Deferred Stock | 82 —85 | 4 14 0 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 110 —112 | 3 11 3 | .. | .. | .. |
| St. | 4% | Charing X, Euston & Hmpstd Per. Db. Stk. | 95 —97 | 4 2 6 | .. | 96¼ | 96 |
| 5 | 2/0 | City of Birmingham Trams. 5% Cm. Prf. | 5⅛—5⅜ | 4 18 0 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 101 —104 | 3 17 0 | .. | .. | .. |
| St. | 1¾% | City and South London Rly. Con. Ord. | 41 —43 | 4 7 0 | Feb, Aug | .. | .. |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 120 —123 | 4 1 4 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 115 —118 | 4 4 8 | .. | .. | .. |
| St. | 5% | Do. (1901) | 113 —116 | 4 6 0 | – | 114⅝ | 113 |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 106 —109 | 3 13 4 | May, Nov | 107 | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord | 13¾—14¾ | 4 1 6 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½—15½ | 3 17 8 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 4¼—4¾ | 8 8 0 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8 —9 | 4 8 11 | .. | .. | .. |
| St. | 4½% | Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 103 —105 | 4 5 8 | .. | 104 | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 15 —16 | 5 12 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 12 —12½ | 4 17 0 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 107 —108 | 4 8 0 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼—2¾ | 9 8 6 | – | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 80 —85 | 4 14 0 | – | .. | .. |
| 10 | 1¾% | Liverpool Overhead Railway Ord | 3 11/16—3 13/16 | 8 13 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾—10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99 —102 | 3 19 8 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9¼—9¾ | 5 2 0 | – | 9 7/16 | 9⅜ |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 95 —98 | 4 2 6 | – | 97 | .. |
| St. | .. | Mersey Con. Ord. Stock | 6 —8 | – | – | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8 —11 | – | – | – | .. |
| 1 | – | Metropolitan Elec. Trams Def. | 3/16—¼ | .. | – | – | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16—1 1/16 | 4 14 6 | – | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104 —106 | 4 5 0 | – | .. | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½—1½ | .. | May | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8½—9 | 5 15 0 | .. | – | .. |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9 —9½ | 5 5 0 | Feb, Aug | – | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103 —106 | 4 5 0 | – | .. | .. |
| 100 | 5% | Sunderland Dst. Elc. Trms. 5% 1st Mt. Db. | 92 —95 | 5 5 0 | .. | .. | .. |
| .. | 5% | Underground Elec. Rys. Co. of London | 98 —100 | 5 0 0 | .. | 95½ | .. |
| St. | 3½% | Waterloo and City Ord. | 98 —101 | 3 6 0 | June, Dec | .. | .. |
| St. | 4½% | Yorkshire W.R. El. Trs. Co. 4½% 1st Debs. | 95 —97 | 4 13 0 | .. | 96¼ | .. |

| Shre. | Last Divi-dend | Name. | Price Wed., Mar. 21. | Rate % Yielded £ s. d. | Dividend Due. | Business, Week to Mar. 21. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝—⅞ | 5 6 6 | – | | |
| 1 | 10½d. | Aron El. Met. 6% Cm. Pf. | 7/16—9/16 | .. | .. | | |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3⅞—4⅛ | 4 17 9 | .. | | |
| 1 | 7½d. | Do. Pref | 1 7/16—1 9/16 | 3 16 10 | .. | | |
| 5 | 4/0 | British Insulated & Helsby Cables Ord | 6¾—7¼ | 5 10 0 | July, Feb | | |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾—6¼ | 4 16 0 | Jan, July | | |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103 —106 | 4 4 11 | .. | | |
| St. | 4½% | †British Thoms'n-Houst'n 4½% 1st Mt. Db. | 96 —98 | 4 12 0 | .. | | |
| 5 | .. | British Westinghouse 6% Pref. | 1⅞—2⅜ | .. | .. | | |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 80 —85 | 4 14 0 | .. | | |
| 2 | .. | Brush Electrical Engineering | ¾—1 | .. | March | | |
| 2 | 2/4¾ | Do. 6 per Cent. Pref. Non-Cum. | 1½—2 | 6 0 0 | Mar, Sept | | |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 97 —99 | 4 11 0 | Mar, Sept | | |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 82 —84 | 5 7 4 | Jan, July | | |
| 5 | 5/0 | Callender's Cable Con. Ord. | 10½—11½ | 5 4 0 | Jan, July | 11 | |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5¾—6 | 4 3 4 | Jan, July | | |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 108½ —110½ | .. | Nov, May | | |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1 1/16—1 3/16 | 5 1 0 | .. | | |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 95 —100 | 4 10 0 | – | | |
| 1 | 9⅜d. | Chadburn's (Ship) Telegraph Ord. | 1 3/16—1 5/16 | 7 10 0 | .. | | |
| 1 | 7½d. | Do. 6% Cum. Pref. | 1 1/16—1 3/16 | 5 8 0 | .. | | |
| 8 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 2 —2¼ | 3 9 0 | Jan, July | | |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 95%—98% | 5 2 0 | Jan, July | | |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8¾—9¼ | 5 8 0 | Sept | | |
| 5 | 3/0 | Do. 6% Cum. Pref. | 6 —6½ | 4 14 0 | Sept | | |
| St. | 4½% | Do. 4½% Deb. Stock | 104 —106 | 4 5 0 | .. | | |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅝—1⅞ | – | Feb, Aug | | |
| 5 | 2/6 | Do. (£5 paid) | 2½—3 | – | Feb, Aug | | |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 86 —88 | 4 11 0 | June, Dec | | |
| St. | 5% | Do. 5 per Cent. 2nd Deb. Stock | 92 —97 | 5 8 1 | .. | | |
| 5 | 2/6 | Edmundson's Elec. Corp. Ord. | 4 —4½ | 7 15 6 | H'lf-yearly | | |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5¼—5¾ | 5 4 6 | .. | | |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 104 —106 | 4 5 0 | .. | | |
| 2 | 1/7½ | Electric Construction Co. | ½—¾ | 9 6 0 | July | | |
| 2 | 2/9⅜ | Do. 7 per Cent. Cum. Pref | 2 —2½ | 5 12 0 | July | | |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 89 —92 | 4 7 0 | Jan, July | | |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9⅜—9⅞ | 5 8 0 | .. | | |
| St. | 4% | Do. 4 per Cent. 1st Mort. Debs. | 94 —96 | 4 2 0 | – | | |
| 5 | 10/0 | † Henley's Telegraph Works Ord. | 12½—13½ | 5 11 0 | Feb, Aug | 13 | |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼—5½ | 4 2 0 | Feb, Aug | | |
| St. | .. | Do. 4½ per Cent. 1st Mt. Db. St. | 108 —110 | .. | .. | | |
| St. | .. | Do. Do. Scrip (50% paid) | 57 —59 | .. | .. | | |
| 10 | 15/0 | India Rubber, Gutta Percha, &c., Works. | 17½—18½ | 5 9 0 | Feb, Aug | | |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | 99 —102 | 3 18 5 | Mar, Sept | | |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum Pref. | 11¾—12¼ | 4 1 8 | Mar, Sept | | |
| 1 | 1/2⅔ | Richardsons, Westgarth & Co., Ltd. Ord. | 29/32—31/32 | 6 4 0 | .. | | |
| 1 | 7½d. | Do. 6% Cum. Pref. | 15/16—1 1/16 | 5 15 0 | .. | | |
| St. | 4½% | Do. 4½% Perp. Deb. Stock | 99 —101 | 4 10 0 | .. | | |
| 12 | 24/0 | †Telegraph Construction & Mainten'ce. | 82½—84½ | 5 5 0 | Mar, July | | |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds. 1909 | 100 —102 | 3 18 6 | Jan, July | | |
| 1 | 1/0 | Vickers, Sons & Maxim, Ltd., Ord. | 2⅝—2¾ | 4 8 6 | .. | | |
| 1 | 6d. | Do. 5% Non-Cum. Preference | 1⅛—1¼ | 4 0 0 | .. | | |
| St. | 5% | Do. 5% Non-Cum. Preferred | 122 —125 | 4 0 0 | – | | |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock Red. | 106 —107 | 3 14 8 | .. | 107 | |
| 100 | 4½% | Do. 4½% 2nd Mort. Debs., Red | 103 —108 | 4 3 8 | .. | | |
| 5 | – | Willans and Robinson Ord. | 2 —2½ | – | Apr, Oct | | |
| 5 | – | Do. 6 per Cent. Cum. Pref. | 3¾—4¼ | – | Apr, Oct | | |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 80 —85 | 4 14 0 | May Nov | | |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | *African Direct Tel. 4% Mrt. Deb. (red.) | 98½ —101½ | 3 18 6 | Jan, July | | |
| 10 | – | Amazon Telegraph | 3¾—4¼ | .. | Jn, Dec | | |
| 100 | 5% | Do. 5% Debs. (red.) | 83 —88 | 5 18 6 | .. | | |
| St. | 21/0 | Anglo-American | 65½—67½ | 4 16 6 | F, My, Ag, N | | |
| St. | 32/0 | Do. Preferred | 113 —114 | 5 5 6 | F, My, Ag, N | | |
| St. | 10/0 | Do. Deferred | 19⅝—19⅞ | 2 10 0 | F, My Ag, N | | |
| St. | 4% | Commercial Cable 4 per Cent. Deb. Stk | 97½—98½ | 4 0 6 | Jn Ap, Jy, O | | |
| 10 | 5/0 | Cuba Submarine Ord. | 8½—9 | 5 11 0 | Feb, Aug | | |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17 —18 | 5 11 2 | Feb, Aug | | |
| 5 | 2/0 | Direct Spanish Ord | 3⅜—3⅝ | 5 11 9 | April, Oct | | |
| 5 | 5/0 | Do. 10 per Cent. Cum. Pref. | 8½—9 | 5 11 0 | April, Oct | | |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 100%—103% | 4 7 8 | Jan, July | | |
| 20 | 3/6 | Direct United States Cable. | 16½—16 | 4 4 0 | Ja, Ap, Jy, O | | |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 100 —102 | 4 8 0 | Jn, Dec .. | | |
| St. | 25/0 | Eastern Ordinary | 147 —150 | 4 18 8 | Ja, Ap, Jy, O | | |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 90 —92 | 3 16 6 | Ja, Ap, Jy, O | | |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 107½—109½ | 3 13 0 | May, Nov | | |
| 10 | 2/6 | Eastern Extension | 15 —15½ | 4 10 0 | Ja, Ap, Jy, O | | |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 105 —107 | 3 14 8 | Feb, Aug | | |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 99 —101 | 3 19 3 | Feb, Aug | | |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101%—103% | 3 18 8 | May, Nov | | |
| 10 | 5/0 | G. N. (of Copenhagen) with coupon 66 | 38 —40 | 6 0 0 | Jan, July | | |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 100 —102 | 4 8 0 | June, Dec | | |
| 25 | 12/6 | Indo-European | 57 —59 | 5 10 0 | May, Nov | | |
| 100 | $1 | Mackay Companies Common | 60⅜ | 3 6 0 | Jan, July | | |
| 100 | 4% | Do. Preference | 74 11/16 | 5 7 0 | Ja, Ap, Jy, O | | |
| 1 | .. | Marconi's Wireless Teleg. Co. ex rights | 1⅜—1⅝ | .. | .. | | |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 99 —102 | 3 18 6 | June, Dec | | |
| 10 | 4/0 | West African Telegraph Shares | 9¾—10¼ | 4 17 6 | .. | | |
| 2½ | – | West Coast of America | ⅝—¾ | .. | – | | |
| 100 | 4% | Do. 4 per Cent. Debs. | 100 —102 | 3 18 3 | Jan, July | 100 | |
| 1 | – | West India and Panama | ⅜—⅝ | .. | May, Nov | | |
| 0 | 6/0 | Do. 6% 1st Pref. | 8¼—8¾ | 6 6 8 | May, Nov | | |
| 10 | – | Do. 6 per Cent. 2nd Pref. | 6½—7½ | .. | May, Nov | | |
| 100 | 5% | * Do. 5 per Cent. Debs. | 100 —103 | 4 17 0 | Jan, July | | |
| 10 | 8/0 | Western Telegraph | 14½—15 | 4 18 0 | Mc, Jn, O, D | | |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 100 —102 | 4 18 0 | June, Dec | | |
| St. | 4% | Do. 4% Deb. Stock (red.) | 102 —104 | 3 16 10 | .. | | |
| | | **TELEPHONES.** | | | | | |
| – | .. | Amer. Telephn. & Telegh. Coll. Trust $1,000 4% Bonds | 93 —98 | .. | .. | | |
| St. | 5% | †Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 101 —103 | 4 17 0 | .. | | |
| 5 | 8/0 | Chili Telephone (fully paid) | 8 —8¼ | 4 17 0 | August | | |
| 1 | 0/9⅜ | Monte Video Telephone Ord. | ⅞—1 | 4 0 0 | – | | |
| 1 | 1/0 | Do. 5% Pref. | ⅞—1 | 5 0 0 | .. | | |
| St. | 6% | †National Co. Pref. Stock | 110 —111 | 5 8 0 | – | | |
| St. | 5% | † Do. Def. Stock | 112 —114 | 4 7 6 | – | | |
| 10 | 6/0 | † Do. 6 per Cent. Cum. 1st Pref. | 12 —14 | 4 5 6 | Feb, Aug | | |
| 10 | 6/0 | † Do. 6 per Cent. Cum. 2nd Pref. | 10½—12½ | 4 16 0 | Feb, Aug | | |
| 5 | 2/6 | † Do. 5 per Cent. Non-Cum. 3rd Pref. | 5⅜—5⅝ | 4 9 0 | Feb, Aug | | |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 99 —101 | 3 9 8 | June, Dec | | |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 103 —105 | 3 16 8 | .. | | |
| 1 | 0/7½ | Oriental | 1¼—1⅜ | 4 12 0 | April, Oct | | |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1¼—1⅜ | 4 7 0 | – | | |
| St. | 24/7⅔ | Do. 4% Red. Deb. Stock | 97 —99 | 4 1 0 | .. | | |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 103 —106 | 4 4 9 | .. | | |
| 5 | 8/0 | United River Plate | 7¼—7½ | 5 6 8 | July | | |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5½—5¾ | 4 7 0 | June, Dec | | |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 110 —112 | 4 9 8 | June, Dec | | |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 4¾—5¼ | 5 14 0 | .. | | |
| 10 | 2/0 | Globe Telegraph and Trust | 11 —11½ | 4 17 0 | Ja Ap, Jy O | | |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14¾—15 | 4 0 0 | Ja Ap, Jy, O | | |
| 10 | 6% | Submarine Cables Trust (Cert.) | 128 —131 | 4 18 6 | April, Oct | | |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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COMPLETE S.H. ELECTRIC PLANT WANTED, for a country house, oil or suction gas engine, from 8 to 10 brake, with dynamo, switchboard, and accumulators for 60 16 c.p., 100—110 volt lamps for 8 hours (approx.).—W. M. HERD & CO., Electrical Engineers, 3, Redcross-street, Liverpool.

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WANTED TO SELL, ELECTRIC PLANT in first-class condition, consisting of dynamo. 17½ kilowatts, 110 volts, speed 780 Crossley's gas engine (three tanks) 28 B.H.P., exhaust box and silencer, self-starter, and switchboard complete; 8 new Jandus arc lamps and 20 old type. Only reason changing to higher voltage.—NEW SPA AND GARDENS, LTD., Bridlington.

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THE TELEGRAPHISTS' AND TELEPHONISTS' NOTE BOOK has just been PUBLISHED. Useful to every operator. Full of facts and data. Price 1s. 1d., post free, from RENTELL, 36, Maiden-lane, London, W.C.

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Messrs. E. & F. N. SPON, Ltd., 57, Haymarket, S.W.

## TENDERS INVITED, &c.

### COUNTY BOROUGH OF SALFORD.

The Electricity Committee invite TENDERS for the Supply, Delivery and Erection of a

**750 KW. STEAM TURBO-GENERATOR AND CONDENSING PLANT.**

Plans, Specification, and Form of Tender may be obtained from the Borough Electrical Engineer, Electricity Works, Frederick Road, Pendleton, on payment of a deposit of Two Guineas, which will be returned on receipt of a bona fide Tender. All enquiries in connection therewith to be addressed to the Borough Electrical Engineer at the above works.

Sealed Tenders endorsed "Tender for Turbo-Generator" to be delivered at the Office of the undersigned on or before SATURDAY, April 21st, 1906.

The Committee do not bind themselves to accept the lowest or any Tender.

L. C. EVANS, Town Clerk, Salford.

Town Hall, Salford, March 19th, 1906.

### CITY AND COUNTY BOROUGH OF BELFAST.

TRAMWAYS AND ELECTRICITY DEPARTMENT.

The Tramways and Electricity Committee of the Belfast Corporation are prepared to receive TENDERS for

**COAL and ASH CONVEYING PLANT, BUNKERS and CHAIN GRATE MECHANICAL STOKERS.**

Specification, with Form of Contract, may be obtained from the undersigned, on payment of Two Guineas, which will be refunded provided a bona fide Tender has been sent and not withdrawn.

Sealed Tenders, endorsed "Conveying Plant," shall be lodged with Sir Samuel Black, Town Hall, Belfast, not later than 11 a.m. on MONDAY, the 16th day of April, 1906.

The Council do not bind themselves to accept the lowest or any Tender.

VICTOR A. H. M'COWEN, M.Inst.E.E., M.I.Mech.E.
City Electrical Engineer, Belfast.

ASTON.—The Guardians of the Aston Union invite TENDERS for a **COMPLETE TELEPHONE INSTALLATION** to connect the various blocks of buildings forming their Workhouse, Gravelly-hill, Birmingham.

Plans and Specifications may be seen and Forms of Tender obtained at the office of the Consulting Electrical Engineer, Mr. W. H. Whitehouse, M.I.E.E., 37A, Waterloo-street, Birmingham; and Tenders must be received by the Clerk to the Guardians, not later than MONDAY, the 2nd proximo.

**TENDERS INVITED** continued on next page.

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## TENDERS INVITED—*continued.*

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The Corporation of Exeter invite TENDERS for the following:—

CONTRACT No. 8.

For the **ELECTRICAL OVER-HEAD EQUIPMENT** of about five-eighths of a mile of route length.

Specifications and Forms of Tender can be obtained and plans inspected at the office of Mr. H. D. Munro, City Electrical Engineer. 184, Sidwell-street, Exeter, on and after the 31st March inst., on payment of a deposit of one guinea, which will be returned on receipt of a bona-fide Tender.

The Contractor whose Tender is accepted will be required to pay not less than the minimum standard rate of wages for the time being in force in each branch of the trade.

The Corporation do not bind themselves to accept the lowest or any Tender, and the person whose Tender is accepted will be required to enter into a formal agreement under seal with sufficient sureties for the due performance of the Contract.

Sealed Tenders, endorsed "Tramways, Contract No. 8," must be received at my office, No. 8, Southernhay West, Exeter, on or before WEDNESDAY, the 11th day of April next.

By order,

H. LLOYD PARRY, Town Clerk.

Exeter, March 28th, 1906.

## APPOINTMENT VACANT.

### CORPORATION OF DUBLIN.

The Lighting Committee are prepared to receive APPLICATIONS for the position of **STATION SUPERINTENDENT** of their Pigeon House Generating Station under the direction of the City Electrical Engineer.

No application will be considered from other than thoroughly qualified Engineers (both Mechanically and Electrically) who have had charge of a station equipped with extra high-pressure three-phase plant of at least 1,000 k.w. capacity.

Salary offered, £200, and residential quarters will be provided at the Station, which is situated three miles from the Central Distributing Station.

Applications, stating age and full details of training and qualifications, and when services would be available, to be sent in not later than TUESDAY, 3rd April, to the SECRETARY, Lighting Committee, 3, Cork-hill, Dublin.

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WANTED, EXPERIENCED ELECTRICIAN, with thorough technical and scientific training, to undertake standardising of accurate resistance coils and shunts, &c. Salary about £150.—6,085, *Electrician* Offices, Salisbury-court, Fleet-street, London.

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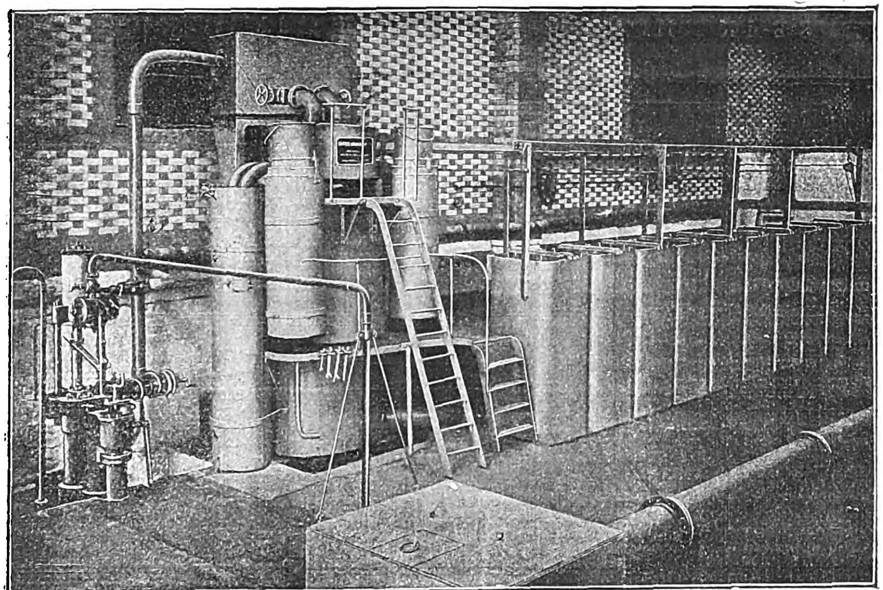

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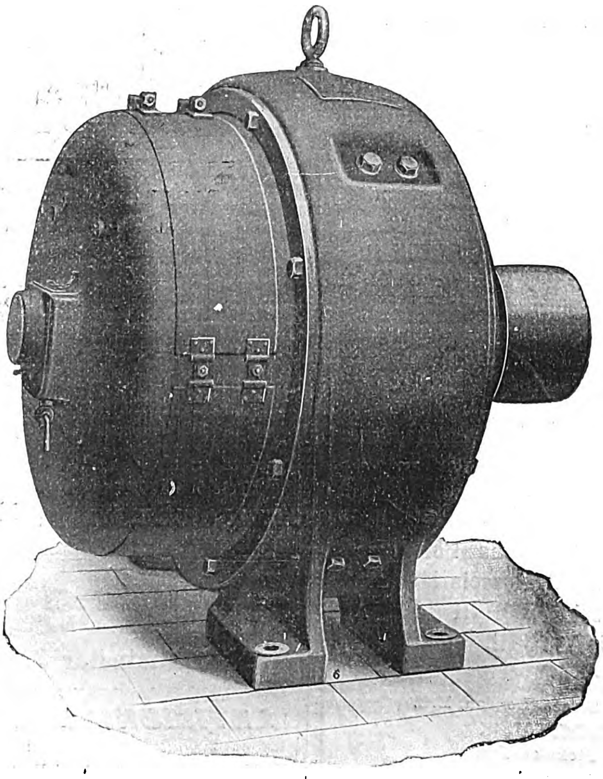

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# THE LANCASHIRE UNITED TRAMWAYS, LIMITED.

NOTICE IS HEREBY GIVEN that the above-named Company is ISSUING a PROSPECTUS, dated the 28th day of March, 1906, inviting Subscriptions at par for £250,000 Prior Lien Five per Cent. Debenture Stock. The said Prospectus contains, among other things, statements to the effect following :—

**The SUBSCRIPTION LIST will OPEN on the 31st MARCH, 1906, and will CLOSE on or before the 4th APRIL, 1906.**

**CAPITAL.**—£192,871 in ORDINARY SHARES of £1 each, forming part of an authorised issue of £200,000 ; £296,500 SECOND MORTGAGE DEBENTURE STOCK, forming part of an authorised issue of £300,000 ; £83,330 DEFERRED DEBENTURE STOCK, to be issued and to form part of an authorised issue of £100,000.

**ISSUE (AT PAR) of £250,000 PRIOR LIEN 5 per Cent. DEBENTURE STOCK.** part of an authorised issue of £300,000. Payable as follows :—5 per cent. on application ; 35 per cent. on allotment ; 30 per cent. on 1st June, 1906 ; 30 per cent. on 1st August, 1906.

The Debenture Stock will be secured by a Trust Deed, constituting it a first charge upon the whole of the Company's assets, both present and future. It will be redeemed at par on the 1st July, 1926, and will be redeemable at the Company's option at any time after 1st July, 1916, on six months' notice at £105, and, in the event of a voluntary liquidation, will be repayable at the same rate. It will be transferable in any multiple of £1. Interest on the Stock will be payable on the 1st January and 1st July, the first payment calculated from he various dates for payments of the instalments being made on the 1st July, 1906.

### Trustees for the Prior Lien Debenture Stockholders.

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MICHAEL BOWDEN SNELL, Esq.

### Solicitors to the Trustees.

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**Directors.**—Hon. ARTHUR STANLEY, M.P., Knowsley, Chairman ; Edwin Adam, 11, Hillside-crescent, Edinburgh, advocate ; Joseph Beecham, J.P., St. Helens, merchant ; John Macdonald Henderson, M.P., 2, Moorgate-street-buildings, E.C., chartered accountant ; Robert Watson, J.P., Linwood, Renfrewshire, paper manufacturer.

**Bankers**—Parr's Bank, Ltd., Bartholomew-lane, E.C., and Branches. **Solicitors to the Company**—Alfred Bright & Sons, 15, George-street, E.C. : Ayrton, Radcliffe & Wright, 9, Cook-street, Liverpool. **Auditors**—Chalmers, Wade & Co., 5, Fenwick-street, Liverpool, and 24, Coleman-street, London, E.C. **Brokers**—Snell & Swaffield, 5, Copthall-buildings, E.C. **General Manager**—J. R. Salter, A.M.I.M.E., M.I.E.E. **Secretary and Offices**—H. P. Conibear, 9, North John-street, Liverpool.

The Company has been formed for the purpose of acquiring the undertaking of the South Lancashire Electric Traction and Power Company, Limited (herein referred to as "The Old Company").

The Old Company, by owning the whole of the issued share capital of two subsidiary Companies, namely the South Lancashire Tramways Company and the Lancashire Light Railways Company, Limited, was in effect the owner of the tramways belonging to the two latter Companies, which now comprise 24½ route miles (31½ track miles) of electric tramways. These subsidiary Companies have no loan or Debenture Capital, except a mortgage on the undertaking of the South Lancashire Tramways Company, which has been taken over by the Company, and therefore does not alter the position. These tram- ways form a part of what was intended to be a much larger system, but the Old Com- pany found itself unable to find the requisite capital to proceed with the work, and in July, 1904, passed into the hands of receivers, appointed by the Court at the instance of Debenture Holders. The undertaking was eventually sold by order of the Court, and purchased for the purpose of resale to this Company by the Hon. Arthur Stanley, acting with the approval and on behalf of the great majority of the Debenture Holders of the Old Company. These Debenture Holders, who held all but about £11,382 out of a total of £600,562, agreed to accept payment for their Debenture Stock in second Debentures and Ordinary Shares of this Company.

The existing tramways, as shown on the Map accompanying the Prospectus, connect Liverpool with the tramways constructed by the St. Helens Corporation, and the latter tramways with the Wigan and Bolton tramway systems, and further connect Bolton to Leigh and Lowton, with a branch from Atherton to Tyldesley.

For the year ending 30th June, 1905, during the existence of the Receivership, the Undertaking of the Old Company (including the Undertakings of the two subsidiary Companies) earned a profit of about £8,500, after payment of £1,000 as Receivers' remuneration and deducting working expenses, but excluding interest on loans which will now be repaid or vested in this Company. That the earnings were not greater is attributed to the fact that the system is incomplete, and does not provide the through connections which were an essential part of the original scheme.

In order to remedy this, and supply the more essential through connections, the Direc- tors have decided to apply a part of the proceeds of the present issue in furnishing the requisite capital for building about 12½ miles of new track, making a total system of 34 route miles, or 44 miles of track. The proposed extensions are as follows : (1) An exten- sion from Tyldesley to Eccles and Swinton, at which places it will connect with the Manchester and Salford Tramway systems, giving a thorough connection from Liverpool to Manchester. (2) Small extensions at Hindley and at Lowton. (3) An extension con- necting Farnworth, Little Hulton, Walkden, and Swinton with the Manchester Tramway system, and giving a through connection between Manchester and Bolton. The General Manager, Mr. Salter, estimates the cost of these extensions, together with the increase of the installation of the Power Station from 2,500 to 4,000 horse-power as below mentioned, at £165,000.

The General Manager anticipates that the proposed extensions of the tramway lines will be completed before the 6th day of August next, but inasmuch as the period originally provided by the South Lancashire Tramways Acts for the construction of the greater part of the lines expires on that date, a Bill to extend the period has been deposited.

An Agreement has been made for acquiring the undertaking of the New St. Helens and District Tramways Company, Limited, which operates, under two Leases, the Tramways (about 20 miles), owned by the St. Helens Corporation, at the price of £15,000 payable in cash. The present issue will provide the funds required for this purchase. The Directors do not, however, regard the acquisition of this undertaking as an essential feature of the proposed extensions, and in certain events the Agreement may not be carried into effect.

The Directors believe that in some places Motor Omnibuses can be profitably employed as auxiliaries to the Tramways, and they have decided to purchase some of these vehicles for use on certain parts of the system, some of which have already been delivered.

The Old Company has for some time supplied electricity in bulk to the Urban District Council of Atherton and to two large manufacturers there, and the Contracts for such supply have been assigned to this Company. At present the demand from Atherton is comparatively small, but negotiations are in progress for largely extending the present supply. The Directors also believe that there is a large scope for a profitable business in the carriage of goods and coal, especially the latter, upon various sections of the Tram- ways. The want of funds has hitherto prevented anything being done in this direction. In the immediate neighbourhood of the existing and proposed Tramway routes are situated about one hundred mills and collieries, and at present the coal is conveyed from the collieries to the mills in carts. By building a few inexpensive sidings in connection with such tramways, and providing the necessary rolling stock, it will be possible to trans- port coal at a material reduction on the present rates. Negotiations with one colliery are in progress on the basis of a guarantee of a minimum of 50,000 ton miles per annum.

The Generating Station, which with its plant and accessories cost the Old Company upwards of £90,000, is the absolute property of this Company. The Generating Station is at present equipped with plant of a total capacity of 2,500 horse-power, and it is proposed to increase this installation out of the funds provided by the present issue to 4,000 horse- power. The plant is of so efficient a character that the cost of generation was, according to the calculation of the General Manager, Mr. Salter, ·449 of a penny per unit sold for the six months ending December, 1905, and it is anticipated that, with the larger supply which the new tramways will require, it will be possible to reduce materially even this low cost of production. The Company also has at present one sub-station with a plant capacity of 600 horse-power, and it is proposed to provide a second sub-station with a capacity of 1,000 horse-power, which will be provided out of the present issue. The Generating Station adjoins a colliery, and coal is obtained for the price at the pit's mouth.

In forming an estimate of the future earnings of the undertaking of the Company (in- cluding that of the subsidiary Companies), the Directors have relied mainly upon the judg- ment of Mr. J. R. Salter, the General Manager of the Company, confirmed by the opinion of Mr. Stephen Sellon, as shown in his report printed in extenso in the Prospectus. Mr. Sellon estimates the profits at £21,575 dealing only with the South Lancashire Tramways, and not including profits arising from the Lancashire Light Railways, the St. Helens lines or the supply of electric energy to outside consumers. Mr. Salter estimates that these profits should amount to at least £3,300 per annum, provided that the agreement for the acquisition of the St. Helens lines is carried into effect. The total profits would thus amount to £24,875, while £12,500 only is required to meet the interest on this issue.

The Security for the present issue of Prior Lien Debenture Stock will consist of (1) A first Mortgage of the whole of the Share Capital of the South Lancashire Tramways Company and the Lancashire Light Railways Company, Limited, which the Trustees for the Debenture Holders will have the right to have transferred into their names, with the exception of a small proportion proposed to be held by other persons in order to comply with the Companies Acts, or to form a quorum at general meetings, and to afford quali- fications for directors. (2) A First Mortgage of the Generating Station, which is lease- hold, for 999 years at a ground rent of £300 per annum. (3) A First Mortgage on the sub-station at Hindley, which is freehold, subject to a perpetual rent of £50 2s. per annum. (4) A floating charge on all the other assets of the Company, present and future.

The Directors believe that the money provided by this issue will suffice for all the present requirements of the Company, but the possibility of development in various branches, especially in the carriage of coal, may entail a further expenditure, and they have made arrangements to increase the issue to £300,000 should they require it. The actual cost of constructing and equipping the lines above-named, including the proposed extensions, and including the Power Station, sub-stations, and car-sheds (which are the property of this Company and not subject to any right of purchase, though forming part of the present security) is, according to the General Manager's estimate, equivalent to about £15,000 per mile of track. The amount of the present issue is equal to about £5,600 per mile of the existing and proposed Tramways.

In compliance with Section 10 of the Companies Act, 1900, notice is given by the Prospectus that the following contracts have been entered into, viz.: (1) A Contract con- stituted by a tender dated 2nd October, 1905, and made by the Hon. Arthur Stanley, for the purchase of the undertaking of the South Lancashire Electric Traction and Power Company, Limited, for the sum of £150,000, and the Certificate dated 14th October, 1905, of the Registrar of the Chancery of the County Palatine of Lancaster, certifying the acceptance of such Tender. (2) A Contract dated 2nd January, 1906, and made between the Hon. Arthur Stanley of the first part, Alfred Adam, Joseph Beecham, and Robert Watson of the second part, and the Company of the third part, being the Contract for the sale of the Undertaking to the Company, and a Supplemental Contract dated 1st February, 1906, and made between the same parties, giving particulars of Shares and Second Debentures allotted under the Contract of 2nd January, 1906. (3) A Contract dated 2nd January, 1906, made between the Company of the one part, and John Wynford Philipps of the other part, being a Contract guaranteeing partly in consideration of £83,330 of the Deferred Debenture Stock, as mentioned below, and partly in considera- tion of a cash payment of 10 per cent. on this issue as therein mentioned, the present issue of Prior Lien Debenture Stock. (4) A Contract, dated 26th March, 1906, and made between the New St. Helens and District Tramways Company, Limited, of the one part and the Company of the other part.

Copies of the said Prospectus and Forms of Application may be obtained at the Offices of the Company or from the Bankers, Brokers or Solicitors.

This Notice is not to be regarded as an invitation to the Public to subscribe for Shares. —Dated the 28th March, 1906. No. 9, North John-street, Liverpool.

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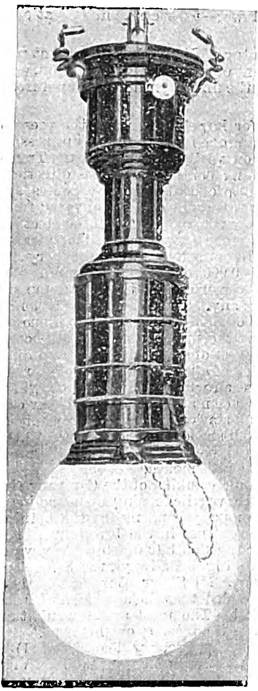

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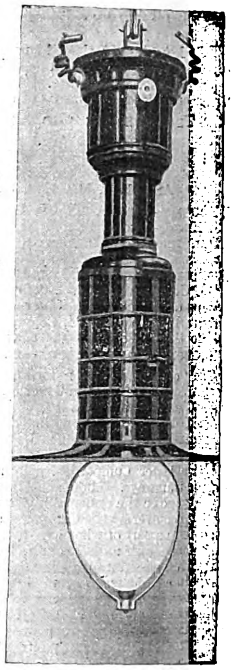

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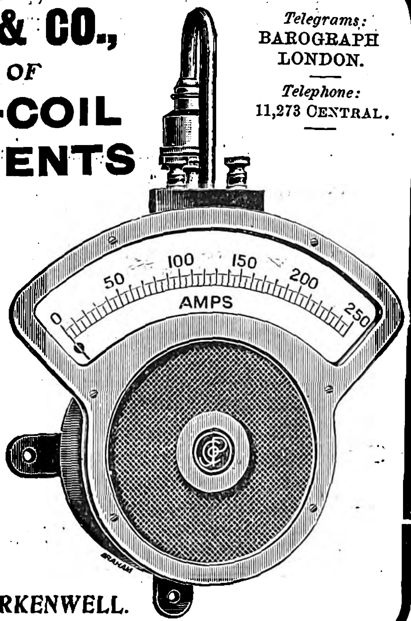

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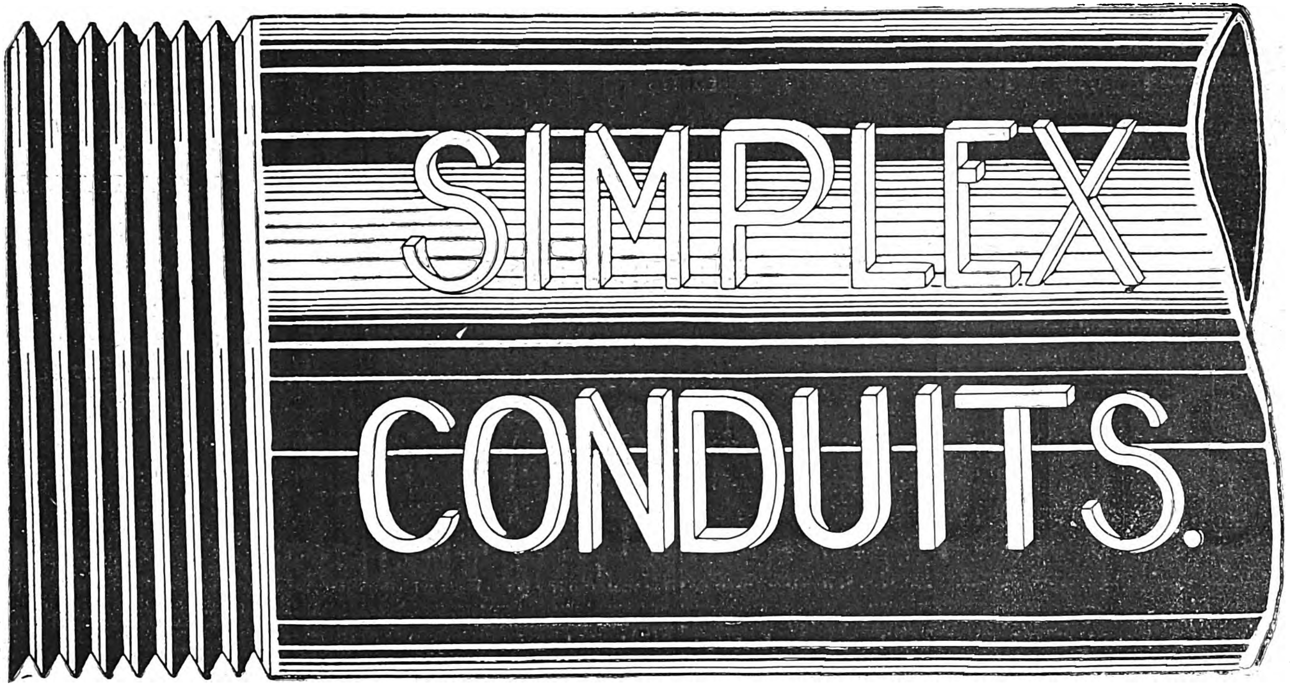

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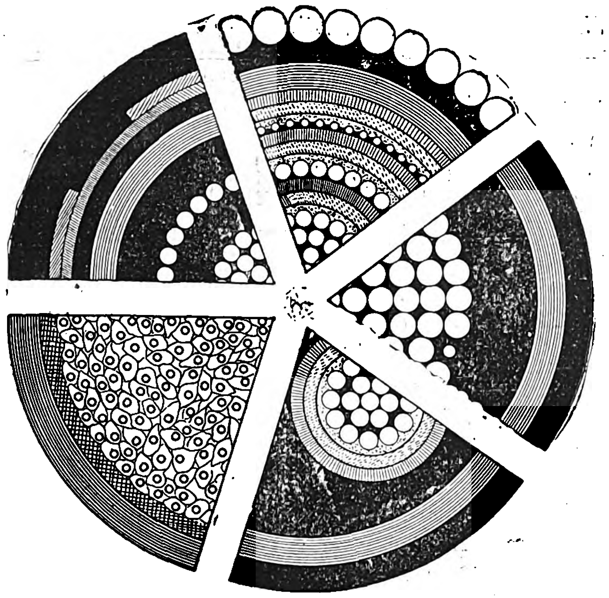

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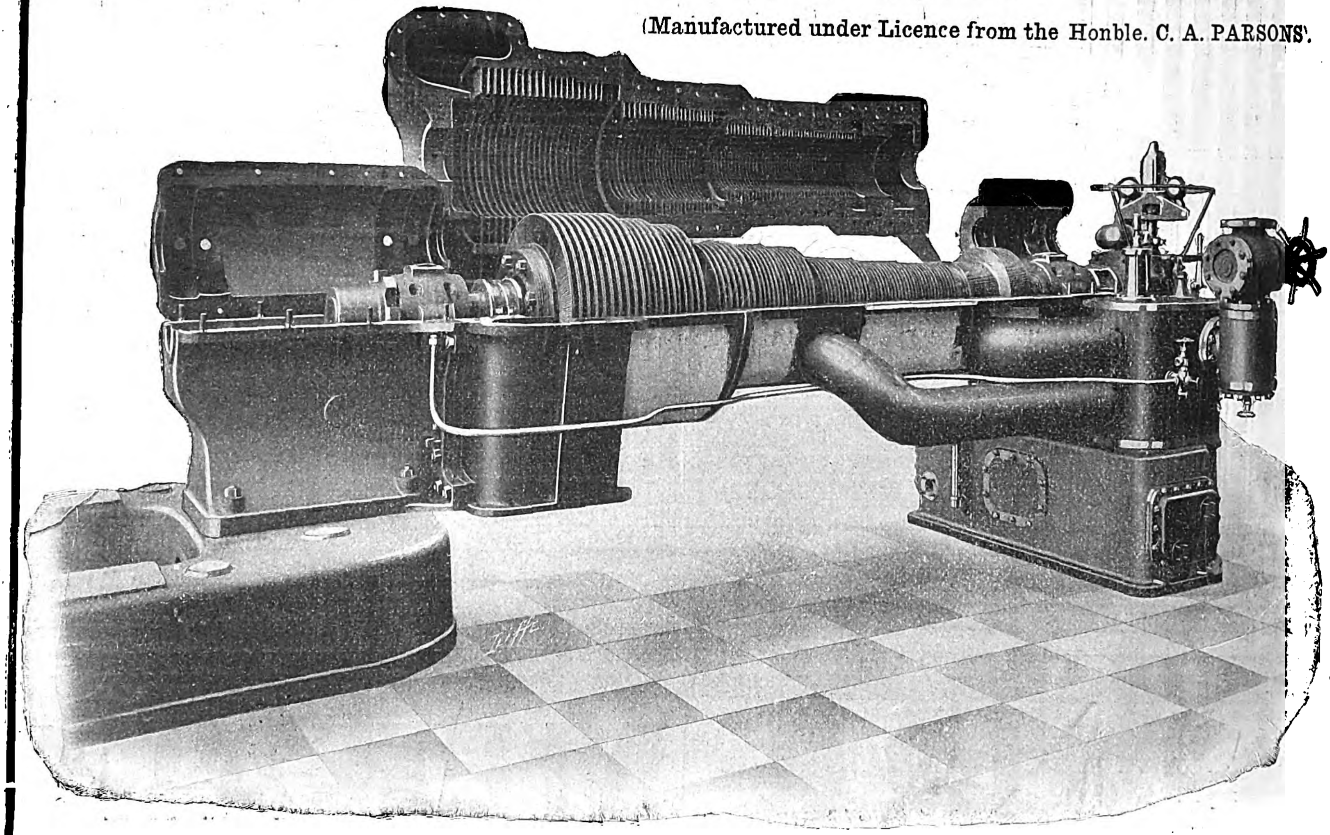

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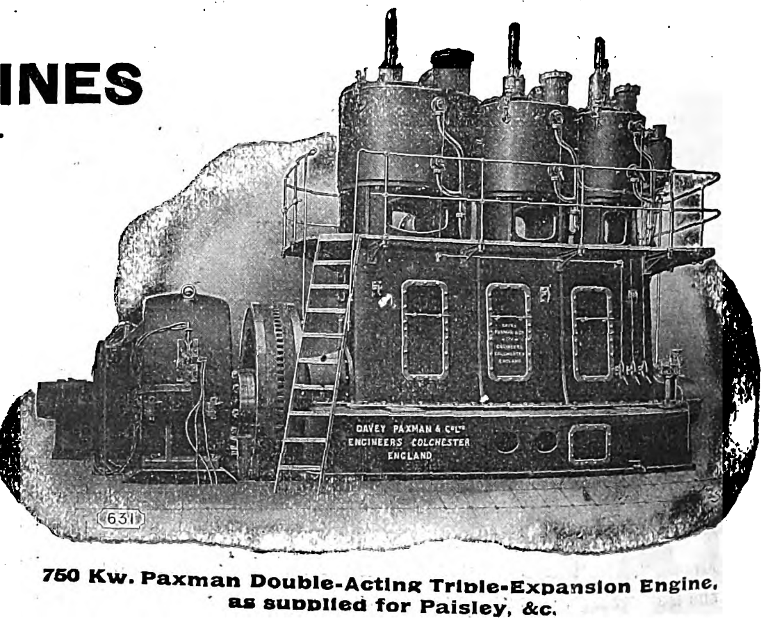

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## "THE ELECTRICIAN" COMPANY.

After a period of 28 years in the ownership of a number of well-known leaders of electrical enterprise in the early days of the industry, proprietorship in *The Electrician* and the books and publications and general business owned and operated by "The Electrician" Printing and Publishing Company (Ltd.), has undergone a change, and Mr. George Tucker, who has been intimately connected with the production of *The Electrician* from its first number, and who has managed the Company's business for many years, has purchased the entire interest of the former proprietors.

This change will effect no material alteration in the conduct of *The Electrician*. Arrangements are, however, in progress for extending the field of usefulness of *The Electrician*, which has, from the first issue of the second series in May, 1878, occupied the first place amongst the electrical engineering journals of the world. Mr. George Tucker will be assisted in the conduct of *The Electrician* Company's general business by his son, Mr. J. E. W. Tucker, and by many of the other members of the staff who have been with the company for many years.

## NOTES.

THE letters which appear in our Correspondence columns this week with regard to the "grading" of supply-station voltages represent only a portion of the communications that we have received on the subject; the balance have been sent us with the express stipulation that they should not be published over the authors' signature. In this latter category are four letters from the engineers-in-chief of leading London electricity supply companies, all of them characterising the proposal to be unworkable under the conditions of electricity supply in this country. One of them reviews the matter in such clear and forcible language that we make no apology for quoting from it:—

> The lamp makers appear to consider that the duties of a so-called central station engineer consist of pouring water into the boilers and oil into the engines, shovelling coal on the fire and handling a rheostat. These duties being so obviously simple, it must be quite as easy to run the supply at any required voltage to suit the lamp maker. The suggestion, therefore, of grading the voltage of certain undertakings in order to suit the scrap-heap of the lamp makers is rather amusing, and it opens out an interesting prospect in future for the sellers of coal to define a form of furnace or stoker best adapted for their fuel, and for the oil merchants to define the correct type of plant and the best form of lubricator not only to use their special productions, but also to take as much of them as possible. Applying this principle to other industries, we might have shops graded, some to sell large oranges, and others to sell small oranges, &c. Surely there are more serious questions requiring discussion than this perverted view of the supply of one detail.
>
> The growth and perfection of the lamp industry has been already sufficiently remarkable, without much coddling; and, after all, there are far more serious considerations governing the selection of the best pressure of supply than the limitations of any particular type of lamp, and the development of some of the new filaments may quickly change the whole aspect of the question.

Another says:—

> What use is there in lamps or stations graded by 5-volt steps if undertakers do not keep their pressure within the limits imposed by the Board of Trade? I have now before me a record taken on a consumer's terminals where the pressure is no less than 8 per cent. higher than the declared pressure. It will be evident that no scientific selection of lamps can improve the position unless the consumer can rely on getting the declared pressure with reasonable accuracy.

A third says that it appears to be difficult, even now, for the consumer to remember his voltage, and the fourth suggests that if a number of intermediate nominal voltages in 5-volt steps had been initially proposed by the supply station engineers or consulting engineers, the lamp makers would have "gone for' the makers of this proposition for choosing voltages that would be awkward for them to supply, for "they could hardly say in cold blood that they would supply such places with the lamps which had been made for other voltages, but had failed to fit them."

◆

Mr. **Wilmshurst** asks a very pertinent question: What is the lamp makers' monetary loss caused by the "outfalls," and by how much would the price of lamps be reduced if all the outfalls were disposed of? We are not aware that lamps for intermediate voltages are offered for sale at a cheaper rate than those of standard voltage. At present we think that Mr. **Wilson** was not well-advised in bringing forward this contentious subject at a time when the defect in carbon lamps which makes them particularly susceptible to voltage variation is about to be overcome in the new lamps which will compete with them. The controversy has done much to emphasise the advantages which these new lamps will bring when they are perfected.

◆

In our description of recent extensions at the Manchester electricity works on p. 956 of this issue, the cascade type of converter, which is being made in this country by Messrs. Bruce Peebles & Co., is gone into in detail. This motor-converter was invented by Mr. **La Cour** some two or three years ago in Germany in conjunction with Mr. **Bragstad**, and appears to have become a commercial reality almost at once. A small set of this kind, of about 80 kw. in size, was described in our issue of January 5th in the course of an account of the "Kaiserwerke" electricity works in the Tyrol. But the largest sets yet made, at least so far as our knowledge goes, are those now running so satisfactorily at Manchester. We must congratulate Mr. S. L. **Pearce** on being the first in this country to perceive the advantages of the new machine and to put it to a practical test.

◆

With the idea of raising the standard of house wiring and of exterminating jerry work, the Sydney (N.S.W.) Corporation have framed bye-laws for the licensing of electric wiremen, and these bye-laws have now been gazetted. In order to obtain a licence, application must be made to the city electrical engineer, with proof of having served at least two years at the trade, while evidence of good personal character must also be submitted. If these are considered satisfactory, a licence for 12 months will be issued on payment of 5s., subsequent renewals being obtainable for 1s. annually. Licences will not be issued to persons under 21 years of age, and may be cancelled if scamped or careless work is proved against the holder. It is to be hoped that in carrying out the Council's recent decision to inaugurate a "free wiring" system the actual installation work will be done through contractors, and not by the Council's own employees, for trouble is almost certain to arise if the Council are in active competition with men whose licences they have power to cancel.

◆

Ever since the early days of the electrical industry, attention has been paid to the distribution and fluctuations of the magnetic fluxes which traverse a rotating armature, and to the hysteresis losses to which these fluctuations give rise. But although many formulæ have been announced from time to time for calculating these losses—formulæ which were generally sufficiently accurate for the practical man—this particular field of investigation has by no means been fully explored. A successful attempt to throw some additional light on this subject was made by Dr. W. M. **Thornton** in a Paper recently read before the Newcastle Local Section of the Institution of Electrical Engineers and reported elsewhere in this issue. In addition to studying the problem directly by means of search coils distributed at various points within the armature, the author made use of Prof. **Hele Shaw's** stream-line method. The discussion was disappointing, and a strong spirit of suspicion against the stream-line method seemed to pervade the meeting. But this method is at present the only method which represents the unseen magnetic phenomenon by a vivid and graphic analogy. It is unsuited, of course, to give quantitative results owing to the fact that the changing permeability of iron cannot be imitated in the hydrodynamical analogy, but it is well able to furnish the student with a picture of what occurs in an armature core. The wavy form of the lines from one pole to the other through the teeth is of much theoretical interest, and the usefulness of the stream-line method could not be stronger emphasised than by Dr. **Thornton's** remark that some obscure points which cropped up during the direct experiments were only cleared up by the stream-line pictures. The chief conclusion arrived at by the author is that the Steinmetz rule for calculating iron losses yields results which are too high in the case of the armature teeth. This is due to the fact that the flux through the teeth is not alternating, as is generally supposed, but rotating and fluctuating at the same time. This announcement is worth noting, for it happens occasionally that the flux-density in the teeth of a particular machine is kept comparatively low so as to reduce the imagined losses in the teeth and the expected high rise in temperature. But if the losses are actually less than implied by the Steinmetz formulæ, the flux-densities may be increased correspondingly. Dr. **Thornton's** other points are also interesting and worth studying.

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Last week the Physical Society met, at the invitation of Prof. **Fleming**, in the Pender Laboratory, University College. Of the Papers read, one by Prof. **Trouton** on the "Surface Leakage over Damp Glass" was remarkable chiefly on account of the author's explanation of the phenomena observed. He has found that across narrow gaps the application of a steady E.M.F. produces a gradually falling current, and that sudden reversal of the E.M.F. yeilds a reversed current of the old value which again gradually fades. Prof. **Trouton** ascribed the phenomenon to mechanical movements of the conducting-surface film, but he confessed that the assumed movement had proved to be ultra-microscopic. A more commonplace explanation was offered by Prof. **Perry**, who suggested that the effect might be due to polarisation occuring between the minute drops of water of which the film may be regarded as made up. The phenomenon is evidently akin to the "electrification" familiar in cable-testing rooms, which is due to a polarisation effect and not merely to the capacity of the cable.

ANOTHER Paper, by Prof. FLEMING, described a variety of his application of the Edison effect to the rectification of high frequency oscillations. One point that calls for remark is that it appears to be necessary to connect the oscillation circuit to the negative pole of the glowing filament. This would seem to imply that the rectifying effect is in some degree dependent on the absolute potential of that part of the filament which exercises the valve action; but we presume Prof. FLEMING possesses some simpler explanation of a point that seemed to his hearers rather unexpected.

THERE is no need to dwell upon the importance of separating the total loss of an electric machine into its components. This separation can be done in several ways. A method often used is to drive the electric machine by external means, first unexcited and then excited. The friction losses and the iron losses at no-load are obtained in this way, Another method of arriving at the same quantities is the retardation method. and other ways of solving the problem have been suggested, When once the friction and iron losses at no-load are known, it is a comparatively simple matter to arrive at the various losses at any other load, for the friction losses remain substantially constant, the iron losses increase but little with the load, while the copper losses can be determined with ease and accuracy. Whereas, however, these tests can be carried out in a staightforward way with continuous-current machines, the case of induction motors presents some slight difficulties. These are dealt with in an article elsewhere in this issue by Mr. G. W. O. HOWE, whose article is, on the whole, a free translation of a Paper read by Herr JENS BACHE-WÜG before the Elektrotechnischer Verein of Carlsruhe some time ago. The object of the article is twofold. In the first place it demonstrates the inaccuracy of Dr. BENISCHKE'S assumption that the slip at no-load can be taken as a measure of the no-load losses. Secondly, it describes a new method of separating these losses accurately. The method propounded requires the use of a variable speed motor for driving the induction motor to be tested, and this is a limitation to its use, but it is an interesting addition to our stock of testing-room knowledge. The jump in the curves 3 and 4, representing the iron loss in the teeth and in the stator iron respectively, is at first sight rather puzzling, but this point is lucidly explained by Mr. HOWE. It is simply due to the transference of energy from the stator to the rotor when the speed passes through synchronism owing to the rotating field dragging the armature along when the motor runs below synchronous speed and opposing the rotation of the rotor when the latter moves faster than the rotating flux.

**Non-Worked British Patents.**—On Monday, April 9th, a deputation will wait upon Mr. Lloyd-George, the President of the Board of Trade, to urge the necessity of legislation to compel patentees to work their patents in this country, and not to continue indefinitely to supply the British consumer from works established abroad. The deputation will be representative of the Association of Chambers of Commerce and leading industrial associations, and it will contend that patents granted in England and not worked here should lapse automatically.

**Portrait of Mr. R. Kaye Gray.**—A portrait of Mr. R. Kaye Gray, painted by Miss Beatrice Bright, daughter of the late Sir Charles Bright, and subscribed for by the members of the Institution of Electrical Engineers, will be presented to the Institution next Thursday.

**Australian Submarine Telegraph Cable Matters.**—Reuter announces, under date of March 28th, that the Eastern Extension, Australasia and China Telegraph Co. has informed the Commonwealth authorities that it does not propose to accept the cable agreement with the Commonwealth Government as amended by the Senate.

**Birmingham Local Section of the Institution.**—The meeting of the Section originally arranged for April 4th has been postponed until April 25th. This meeting will be held in the new University Buildings, by kind permission of Prof. Kapp, and a Paper by Messrs. D. K. Morris and G. A. Lister on "The Testing of Transformers and Transformer Iron" will be read.

**Wireless Telegraph to Lightships.**—It is announced that the Trinity House authorities have commenced the important work of fitting up the Goodwin lightships with wireless telegraphy for communication with the shore. It will be remembered that the experimental installations on some of these vessels proved of considerable use prior to their removal a short time ago.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Tarifa—Tangier | Jan. 18, 1904 |
| Jamaica—Colon | Jan. 10, 1905 |
| Cadiz—Teneriffe | July 20, 1905 |
| Puerto Plata—Martinique | Dec. 15, 1905 |
| Tangier—Cadiz | Feb. 17, 1906 |
| Santa Lucia—St. Vincent | Feb. 19, 1906 |
| Porto Rico—St. Croix | Feb. 26, 1906 |

**Electric Railways in Sweden.**—A Reuter telegram from Stockholm on Wednesday states that the Swedish Government has introduced a bill authorising a grant for the purchase of waterfalls belonging to private persons with a view to utilising them for supplying power for State electric railways. It is further proposed to empower the Government to expend a sum not exceeding 5,000,000 kroner (£277,000) to purchase waterfalls which may be considered necessary for working the State railways in the immediate future.

**A Projected Monorail Line in America.**—A scheme is proposed, according to *Electricity* of New York, to establish an electric railway on the Behr Monorail system between Brooklyn and Coney Island. A two-minute headway is contemplated, and the journey of 9 miles is to be accomplished in six minutes. The maximum speed allowed for is 110 miles per hour, and the eight 150 H.P. motors with which the car will be provided are expected to enable full speed to be attained in two minutes. The cars, which are to be run singly, are designed to carry eighty passengers. The cost of the line is estimated at about $5,000,000.

**Commercial Teaching at Birmingham University.**—The *Birmingham Daily Post* states that it has been announced by Prof. Ashley that the engineering department of the University of Birmingham, recognising the desirability that the engineering experts whom it trained should have some acquaintance with business methods, has decided to require all engineering students in their last year to take a simple course in accountancy under Prof. Dicksee. They were thus feeling their way towards a union of commercial thinking and scientific knowledge, and they hoped that their friends in business would give them encouragement and support.

**A New Damping Arrangement for Instruments.**—A damping arrangement which is stated to give excellent results in practice is described by Herr F. Dessauer in a recent issue of the *Elektrotechnischer Anzeiger*. It consists of a short metallic cylinder which is fixed concentrically to the axle carrying the pointer. It is closed on all sides, and is partly filled with oil or other liquid. When the pointer is deflected, the liquid is entrained to some degree by the friction between it and the cylinder walls, and this produces a retarding movement. By using different liquids, and varying the quantity of liquid in the cylinder, the damping can be adjusted within wide limits.

**Civil Service Estimates.**—Amongst the Civil Service estimates for the year ending March 31, 1907, the amount devoted to science and art buildings shows a net increase of £23,628, which includes fittings, furniture, lighting, &c., for the new buildings of the Royal College of Science. Post office and telegraph buildings have decreased by £20,000, but purchase of sites under Post Office estimates has been raised by £25,000. Amongst other public buildings, £12,000 is set down for the Magnetic Observatory, Eskdale Muir. The grant in aid of equipment of the National Physical Laboratory has been increased from £5,000 to £10,000, and a new grant of £2,000 has been included in aid of Sheffield University.

**The Kuzel Lamp.**—Dr. Hans Kuzel seeks leave to amend his patent No. 28,154 of 1904 for "Improvements relating to the manufacture of light emitting bodies for electric incandescent lamps" (the contents of the patent were given in our issue of February 19th, p. 655), alleging as the reason a misunderstanding on the part of his Vienna patent agent. He desires to insert the following words after the description of the means for reducing the refractible metals to a colloidal state:—

> These colloidal metals can be used either in a more or less liquid or gelatinous form containing more or less of the imbibition liquid or in a solid form obtained as usual, for instance, by cautiously evaporating colloidal solutions, or drying such precipitated sols, gels or colloidal suspensions.

Notice of opposition, if any, must be left at the Patent Office by April 21st.

**Students' Section of the Institution of Electrical Engineers.**—The Council of the Institution of Electrical Engineers have again sanctioned a proposal of the Committee of the Students' Section to organise a visit to Manchester and district, the period arranged being from Monday, April 23rd, to Saturday, April 28th. A break will be made in the journey at Rugby to visit the works of the British Thomson-Houston Co., and permission has also been obtained to visit the following works:

> Tuesday, April 24th: Messrs. Crossley Bros. (Ltd.) and the Chloride Electrical Storage Co. (Ltd.) Wednesday, April 25th: The British Westinghouse Co. (Ltd.) and the General Electric Co. (Ltd.). Thursday, April 26th: The Lancashire Dynamo & Motor Co. (Ltd.), and Messrs. John Musgrave & Sons (Ltd.), Bolton. Friday, April 27th: The United Electric Car Co. (Ltd.) (Preston) and Messrs. Dick, Kerr & Co. (Ltd.) (Preston). Saturday, April 28th: The Manchester Corporation Electricity Supply Stations.

It is anticipated that the cost of the visit, excluding railway fares, need not exceed £3 per head. Students wishing to partake in the visit should communicate with Mr. E. W. Moss, the students' honorary secretary, at 20, Huddleston-road, Tufnell Park, N., before April 1st.

**Proposed Legal Restrictions for the Medical Use of Röntgen Rays.**—With a view to checking the evil effects likely to be produced by the application of "X" rays in medicine and surgery by their use in the hands of unqualified persons, the following resolution was proposed and carried at a recent meeting of the British Electro-Therapeutical Society:—

> It having been established that the use of "X" and other rays by persons without a registered qualification constitutes a grave social and public danger, and that medical men alone are capable of administering such rays to the public benefit, this society is of opinion that the use of the "X" and other rays should be by Act of Parliament confined absolutely to registered medical practitioners and to dental surgeons in the practice of dental surgery.

The *Lancet* points out that the danger of producing an undesired "X" ray dermatitis is a very real one, but one that medical men engaged in this class of work find no special difficulty in avoiding. Attention is also called to results of investigations in which it has been proved that Röntgen rays can cause atrophy of the testicle in the white rat and of the ovary in rabbits, and the assertion that those who work constantly with the rays are after prolonged exposure rendered sterile. Legislation on this subject has already been made on the Continent, and at the present time efforts are being made to introduce a similar bill in France. The *Lancet* expresses the hope that now that the matter has been definitely brought forward by a responsible body consisting entirely of medical men, the efforts of the society will meet with due support from the medical profession generally, and at no distant date of the House of Commons.

**Coal Conservation and Power Transmission.**—A Paper was read on the above subject on Wednesday last at the Society of Arts by Mr. A. J. Martin:—

> Recapitulating the report of the recent Royal Commission on Coal Supplies, he pointed out that if the consumption of coal in the British Isles should continue to increase at the rate prevailing during recent years, the supply would last a little over a century. In putting forward these figures he did not suggest that our stock of coal will actually run out at the end of the time indicated, since the pressure of the demand upon the supply, for the exhaustion of the beds which are most easily worked will bring about a rise in price which will act as a powerful brake upon consumption. Regarding the possibility of finding an alternative source of energy the author quoted the Commission's conclusion, "We are convinced that coal is our only reliable source of power and that there is no real substitute. There are, however, some possible sources of power which may slightly relieve the demand for coal." The Paper then briefly referred to the effect of coal shortage on the supply of certain by-products, and passed on to the consideration of how the great waste attendant on present modes of consumption could be diminished. Electric transmission of power was only briefly dealt with, as the main object of the Paper was to present the author's detailed estimates on the cost of transmission of producer gas on a large scale from the pit's mouth either for distribution or for driving electric power stations, in which case he shows that there is a prospect of economy, as against the use of coal transported from the collieries by ordinary means.

**The Telephone Agreement.**—In the report of the Select Committee of the House of Commons last year which considered the agreement between the Postmaster-General and the National Telephone Co., whereby the undertaking of the latter will be absorbed by the State after December 31, 1911 (*The Electrician*, Vol. IV. p. 633), it may be recalled that an alteration was asked for in Clause 4, the purchase clause. Some exception was taken to the wording of this, the Committee wishing the exact expressions of the Tramways Act of 1870 to be more explicitly employed. Both the Postmaster-General and the Company were agreed that the public exchange plant should be acquired upon terms which left out of consideration any question of goodwill, and as a result of negotiations, a new clause has been agreed upon as substituting Clause 4 of the agreement. Its effect will be the same as if the original clause had remained, and in no other respects has the agreement been modified or altered. The new clause makes it quite clear that all plant, land, buildings, stores and furniture are to be purchased at their then value (exclusive of any allowance for past or future profits, or any compensation for compulsory sale or other consideration). Sub-sec. 2 provides for the acquisition by the Postmaster-General of any licensed telephonic business which the company is entitled to carry on after 1911 at a price to be agreed upon, but all plant, land and buildings in connection therewith is to be assessed as per sub-sec. 1. Sub-sec. 3 provides that any private wire business of the company (apart from any plant, land and buildings used in connection therewith) shall be acquired on the basis of three years' purchase of the net profits, on the average of the three years ending December 31, 1911. All matters of difference are to be determined by arbitration.

**The Corpuscular Theory of Matter.**—In the fourth lecture of the series Prof. J. J. Thomson, at the Royal Institution, on Saturday, went with some detail, by the aid of columns of figures, into the consideration of model atoms possessing about 60 corpuscles in stable orbital motion. He showed that atoms having from 59 to 67 corpuscles inclusive are all stable with 20 corpuscles in the outermost ring. The 59 atom easily accepts an additional corpuscle, that is, is "electropositive," while the 67 atom already possesses as many as it can hold, and, in fact, easily parts with one, that is, is "electronegative." Between these extreme atoms of the set there are intervening atoms of intermediate character. Passing from a 67 to a 68 atom it is found, by calculation, that the outer ring must now contain 21 instead of 20 corpuscles; and, moreover, the new arrangement is strongly electropositive, as is proper in an atom at the beginning of a new series. This division of elements into series recalls the periodic table of the chemist, and the transition from the 67 atom to the 68 atom above resembles the step from fluorine to sodium among the chemical elements. The transition from one stable configuration to another more stable, as seen in the radioactive elements, is quite another matter however. Probably the break-up of the atom of a radio-active substance is strictly analogous to the sudden fall of a spinning top, which descends catastrophically immediately a certain critical velocity is reached by loss of spin. Thus the radium atom, which during its life loses energy by radiation from its rotating corpuscles extremely slowly, liberates at its collapse a great quantity of energy; in other words, the radium atom pays no taxes but the death duties. Prof. Thomson then proceeded to the discussion of a possible explanation of the valency of the chemical elements. This subject he treated at a Royal Institution evening discourse that was reported in our issue of March 17, 1905 (Vol. LIV., p. 884).

**The Preservation of Niagara Falls.**—We understand from *The Times* that the Canadian members of the International Waterways Commission disagree with their United States colleagues as to the measures which should be taken to preserve the scenic beauty of Niagara Falls. They contend that if the beauty of the Falls is impaired it is due to the works now existing on the American side. They suggest that no more charters should be granted to power companies on the Canadian side, and that if any arrangement is entered into with the United States, it should include all international waterways from the Atlantic to the Pacific. The report of the American members recommend the limitation of the diversion of the waters on the American side to 28,500 cubic ft. per second, and that on the Canadian side to 36,000 cubic ft. per second. The opinion is also expressed that the works already authorised are likely to injure the Falls and may possibly even leave the American Fall dry. It is estimated, however, that five-sixths of the total of 60,900 cubic ft. per second already authorised chiefly affects the Canadian Horseshoe Falls. In the meantime, according to the *Electrical Review* of New York, the Senate of New York State passed on March 12th a series of bills repealing the charters of several companies to which rights had been granted to utilise Niagara water for power purposes, leaving only the Niagara Falls Power Co. and the Niagara Falls Hydraulic & Mfg. Co. This action has yet to be sustained by the lower house and approved by the Governor. Owing, however, to the crest of the Horseshoe Fall being some 10 ft. lower than that of the American Fall, about nine-tenths of the total flow of water passes over the former. Our contemporary points out that unless similar action is taken by the Canadian authorities no limitations imposed on the American side can affect to any great extent the flow in the Canadian half of the stream. Another report on the subject lately issued by the Commissioners of Victoria Park, Canada, estimates the total amount of water required for the full operation of the works completed or in process of construction at 23 per cent. of the present total flow, although some years will elapse before this maximum amount will be required. On the whole, according to the *Western Electrician*, the trend of opinion expressed in this report is to the effect that the power developments now in progress will not seriously detract from the beauty of the Falls, but sees a source of danger in the ten additional chartered undertakings which have not yet commenced operations. In view of these different expressions of opinion it is interesting to recall a statement made by Mr. P. N. Nunn in a Paper before the American Institute of Electrical Engineers on the Ontario Power Co.'s new installation, in which he remarked that the variation in the height of the water, due to the direction of the wind, is much more than that which would be caused by the water drawn off by the power houses, yet nobody notices the difference at the fall.

**Generation and Distribution of Music by Electricity.**—A novel system of "generating" music by electrical means at a central station and distributing it to subscribers has been developed in the United States by Dr. Cahill. The transmitting apparatus is not a musical instrument in the ordinary sense of the term, as instead of producing sound directly by mechanical vibrations, it simply generates currents with oscillations of suitable wave-form, the actual sounds being only produced in receiving instruments resembling telephones. A large battery of inductor alternators of the toothed disc type is used to initiate the vibrations, and their action is controlled by two or more keyboards similar to those of an organ, in fact, the whole arrangement may be regarded as a purely electrical organ, in which the alternators take the place of the pipes. The performer judges of the effect by listening to a receiving telephone similar to those with which the distant listeners are provided. The alternators are of simple construction. The stators carry both the field and armature windings, and the rotors consist only of toothed iron discs. The rotors are mounted in groups on shafts geared together and the various numbers of teeth are arranged to cover a range of five octaves. The depression of a key closes a ground tone circuit and one or more other circuits corresponding to various harmonics. A number of "tone-mixing transformers" are also provided, which serve to build up from the simple sinusoidal waves of the alternators the complex vibrations required, thus several alternators contribute their waves to produce a single note when this is to be of a rich string-like quality. The tone mixers are of various different sorts, some with closed iron magnetic circuits, and some entirely without irons. The intonation is said to be remarkably pure, and without the least suggestion of the friction and diaphragm noise commonly associated with the phonograph or loud-speaking telephone and the tuning is, of course, unalterable. The synthetical method of building up the tone from the constituent harmonics renders the variety of timbre obtainable most remarkable; not only can the whole range of combinations of orchestral instruments be reproduced, but a skilled performer can mix the harmonics so as to call forth musical "tone colours" previously unknown. The control of the expression obtainable is said to be most striking, the slightest variation of pressure on the keys affecting the intensity of the note. In the inventor's laboratory at Holyoke a power instrument has been installed comprising 145 direct-coupled alternators, arranged in eight sections and controlled by nearly 2,000 switches. This whole plant weighs nearly 200 tons, and the internal arrangements are complicated in the extreme. Our contemporary is strong in its praise of the quality of the music produced, and looks forward to the time when the production and distribution of music on a large scale by this method will be an accomplished fact in American cities.

## ARRANGEMENTS FOR THE WEEK.

**(To-day) FRIDAY, March 30th.**

ELECTRO-HARMONIC SOCIETY.

*8 p.m.* Last Smoking Concert of the Season at Holborn Restaurant (King's Hall). Sir W. H. Preece, K.C.B., F.R.S., will preside.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse by Prof. P. Zeeman on "Recent Progress in Magneto-Optics."

**SATURDAY, March 31st.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture V., by Prof. J. J. Thomson, F.R.S., on "The Corpuscular Theory of Matter."

**WEDNESDAY, April 4th.**

DYNAMICABLES.

*7:15* for *7:30 p.m.* Anniversary Dinner at the Gaiety Restaurant, Strand, London.

**THURSDAY, April 5th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Ordinary General Meeting, when the discussion upon the following two Papers will be concluded: (1) "Electrical Equipment of the Aberdare Collieries of the Powell Duffryn Co.," by C. P. Sparks; (2) "Electric Winding Considered Practically and Commercially," by W. C. Mountain (abstract of a Paper read and discussed at meeting of Manchester Local Section on Jan. 16, 1906).

INSTITUTION OF ELECTRICAL ENGINEERS: DUBLIN LOCAL SECTION.

*8 p.m.* Meeting at the Royal College of Science, Stephen's Green, Paper to be read: "Coal Testing," by John Holliday.

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.

*8 p.m.* Meeting at Caxton Hall, Westminster, when a Paper on "Steam Turbines" will be read by G. D'A. Meynell.

**FRIDAY, April 6th.**

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER STUDENTS' SECTION.

*8 p.m.* General Meeting, when Mr. D. L. Sands will read a Paper on "Some Automatic Devices for Electricity Control."

**SATURDAY, April 7th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture VI., by Prof. J. J. Thomson, F.R.S., on "The Corpuscular Theory of Matter."

## RECENT EXTENSIONS AT THE MANCHESTER ELECTRICITY WORKS.

During a recent visit to Manchester, we made use of the opportunity to view the electricity works; and by the courtesy of Mr. S. L. Pearce, the city electrical engineer, who devoted the greater part of a day to showing us the various stations and sub-stations, we are enabled to give our readers an account of some of the more important extensions that have been made recently. Our thanks are also due to some of the contractors who have responded generously to our request for detailed information with regard to some of the new machines.

There are three generating stations, at Dickinson-street, Bloom-street and Stuart-street respectively; the Bloom-street station adjoins that at Dickinson-street, however, and may practically be regarded as an extension of the latter. The Dickinson-street station was originally the only one, and it was opened in 1893 to supply directly the five-wire lighting network which the late Dr. John Hopkinson had put down Four of the old 250 kw. sets in which the dynamo is driven through a short belt with a jockey pulley, are still in the station, and are even put into service occasionally for night loads. As the engine room also contains sets of various periods down to modern turbo-generators and La Cour converters, it furnishes an interesting comparison of old and new methods. The capacity of the works is at present 9,100 kw., and supply is given from it to part of the tramway network as well as to the lighting network. All the machines in this station generate at low pressure, that is to say, for use directly on the 400 volt outers of the five-wire and three-wire network, or supply directly to the tramway lines. The Bloom-street station contains four 1,800 kw. continuous-current sets which are available for both lighting and traction purposes. Finally, the Stuart-street station contains six 1,500 kw. machines and two 3,750 kw. sets, all supplying three-phase current at 6,500 volts and 50 ∾ per second. This is converted into continuous current at 20 sub-stations, and also at the Dickinson-street station to supplement the supply to the central area. The total capacity of the three works is, therefore, 32,800 kw. The number of consumers is 6,318, with private lighting equivalent to 563,036 8 c.p. lamps and motor connections of 10,000 H.P. To this must be added 12,500 H.P. for traction, and 94 arc lamps of various sizes for public lighting, making a total approaching 40,000 kw. The maximum load on all three works together this last winter was 20,855 kw. There are 85½ miles of tramway route supplied from these stations, equivalent to 150 miles of single track, and the total mileage of mains on the system is about 301 miles, equivalent to 700 miles of single conductor.

Among the most interesting additions that have been made to the plant are the 500 kw. La Cour motor-converters, of which three have been put in at the Dickinson-street station, and nine more have been ordered from the makers, Messrs. Bruce Peebles & Co., for various sub-stations. Briefly, the system on which this converter works is as follows: The machine consists of an induction motor coupled to a continuous-current generator. The stator of the motor receives current directly at high pressure (in this case at 6,500 volts three-phase) and the generator supplies continuous current at low pressure in the ordinary manner. So far the machine might be an ordinary induction motor-generator. The particular feature is this: Instead of the rotor being short-circuited, it is connected to the armature of the continuous-current machine, and the effect of this is to improve the efficiency and the power factor of the set as compared with an ordinary motor-generator, and to reduce the size of both the motor and generator. The machine in question has an efficiency of 91 per cent. at full load, and it gives a slightly leading current. Its cost is of the same order as a rotary converter equipment if the price of the static transformers for the latter be included. A wide range of pressure regulation is possible on the continuous-current side—about 10 per cent. up or down, and this alteration has no effect on the power factor as it has in the case of a rotary converter. The machine is started on the alternating-current side, and its normal speed is considerably below the synchronous speed that the induction motor would have if run by itself, as it depends on the sum of the number of poles on the motor and generator owing to the two armatures being virtually connected "in cascade." It is thus seen that if the field circuit of the generator becomes interrupted the machine will race, and to provide for this contingency an electric knock-off is provided which opens the oil switch on the high-tension side at a certain speed.

The three machines in the Dickinson-street station have now been running in regular service for some months, and we understand from Mr. Pearce that they have given him every satisfaction, and the results certainly reflect considerable credit on the makers. Fig. 1 shows the connections between the alternating-current rotor and the continuous-current armature. In this diagram three points of the continuous-current armature are connected to the rotor winding, while in the Manchester sets 12 equi-distant points of the continuous-current side are connected to the twelve-phase rotor winding. The principle, of course, remains the same. To explain the principle let us suppose, for a moment, that the cross connections between armature and rotor are interrupted, but that armature and rotor are still mechanically coupled and so compelled to run at the same speed. In the rotor winding of the induction motor there are then induced E.M.F.s and currents of a frequency corresponding to the slip—*i.e.*, the difference between synchronous speed and the speed at which the rotor runs. The *greater* the slip—*i.e.*, the *lower* the speed, the higher the frequency of these secondary currents. Pursuing this principle to its logical conclusion, we see that at standstill the frequency of the rotor currents will be the same as that of the primary current, which is obviously true, as in these circumstances the motor will act simply as a transformer. In the continuous-current armature, alternating E.M.F.s are induced as in an ordinary dynamo, and alternating currents consequently flow in the coils, these being converted to continuous current by passing the commutator. Now, as the frequency of these currents is evidently proportional to the speed and the number of poles, it will be seen that in the armature the *lower* the speed the *lower* will be the frequency. At a certain speed, therefore, the frequency of the E.M.F. induced in rotor and armature of a motor-converter will be the same, and should this speed be altered either way, the frequency of the E.M.F. in the rotor will differ from that in the armature. Further, the ratio of transformation between stator and rotor winding of the induction motor, and the relation between the field and armature systems of the continuous current end are so chosen that the magnitudes of the E.M.F.s induced in rotor and armature are identical. Hence, when the set runs at the definite speed above referred to, the connections between armature and rotor can be closed, and the armature and rotor will operate simply as two alternators running in parallel. In the actual machine, of course, the connections between armature and rotor are never interrupted. At no-load no current will flow through these, except a synchronising current such as flows between two ordinary alternators in parallel. The system will evidently remain in synchronism for the reason that any alteration in the speed would cause the frequency of the E.M.F.s induced in one part to be greater or smaller than that induced in the other part, and this is prevented by the synchronising currents.

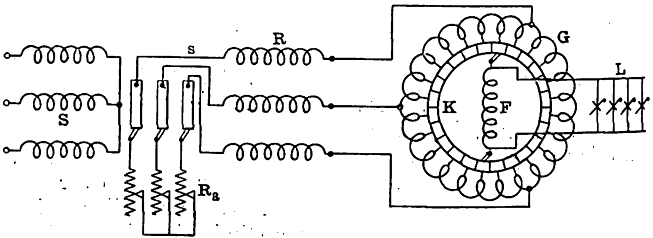


FIG. 1.—DIAGRAM OF CONNECTIONS OF THE LA COUR CONVERTER.
G = continuous current armature. R = rotor. S = stator. $R_a$ = starting resistances.

We may here mention that the principal reason for winding the rotor nine or twelve phase instead of three-phase is that this ensures a very much stronger synchronising force than could be obtained were the windings of the alternators in parallel connected up at three points only. A simple analogy to this is furnished by two flywheels running side by side and connected by indiarubber couplings of a certain strength. The larger the number of these couplings the more closely will the speeds of the two flywheels coincide.

At starting, the star point of the rotor winding is opened by withdrawing a short-circuiter of the plug and socket type within the slip-rings, and three of the nine or twelve-phase windings are connected to slip-rings, to which an ordinary three-phase motor starter is connected up. Were the resistance in this starter cut out very rapidly, the rotor would run up to the full speed corresponding to the number of the poles in the stator winding. A large proportion of the resistance is, therefore, kept in circuit so that the motor slip will be large and the speed be low. In the meantime the continuous-current machine becomes self-excited, and the converter speeds up until the E.M.Fs induced in rotor and armature respectively synchronise. After this, of course, the machine will not rise to a higher speed, being prevented from doing so in the manner already explained. Up to the moment of synchronism, large currents, out of phase with each other, flow through the windings, being only held in check by the considerable resistance in the starter. As soon, however, as the E.M.Fs are in synchronism, they oppose each other, and the resultant E M.F. is very small, giving rise only to a small current.

In order to indicate the moment at which the short-circuiter which closes the star point of the rotor winding should be operated, a voltmeter is provided across part of the rotor resistance. As long as large rotor currents are flowing, this voltmeter gives high and heavily fluctuating readings, but as soon as the currents fall to a small value—*i.e.*, as soon as synchronous speed is reached, the voltmeter reading comes nearly to zero and remains steady. The short-circuit device is then pushed home and the converter synchronises. The time taken for synchronising from rest is about three minutes.

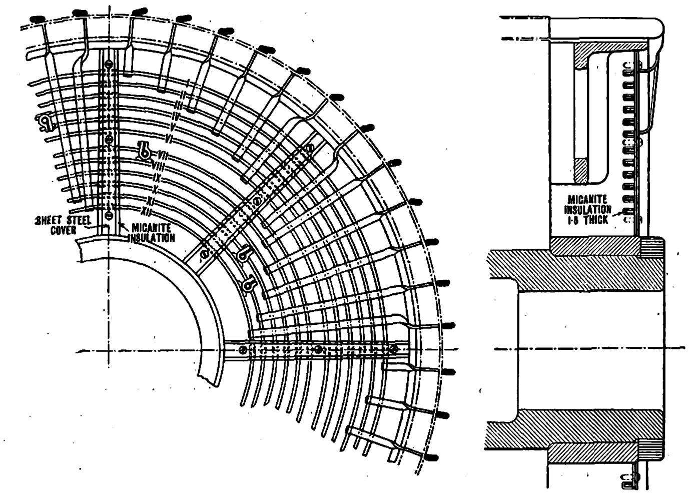
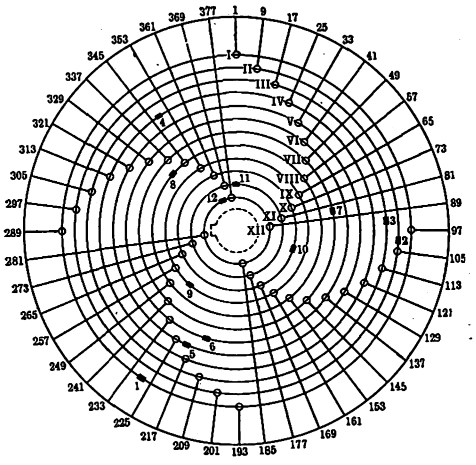


FIG. 2.—ARRANGEMENT OF A.C. ROTOR CONNECTIONS ON THE CONTINUOUS-CURRENT ARMATURE OF THE MOTOR-CONVERTER.
Scale 1 in. = 1 foot.

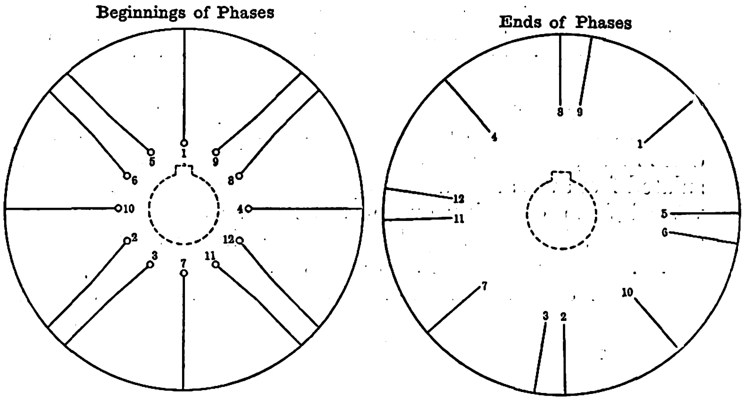
To return to the theory of the machine, the inter-action between the alternating-current rotor and the continuous-current armature may be rendered still more clear by a consideration of the case of a pair of bi-polar machines. These will be run at a speed corresponding to half the primary frequency; half the electrical energy supplied to the induction motor is converted into mechanical energy to drive the continuous-current end of the machine, while the other half of the energy supplied is transferred to the rotor winding and thence to the converter armature in the form of electrical energy. Thus the motor works half as a motor and half as a combined transformer and frequency changer, while the converter acts half as a continuous-current generator and half as a rotary converter. As the dimensions of the induction motor depend on the primary frequency and not on the number of revolutions of the motor, the size will be half as large as if with a given number of revolutions it had to convert the whole of the energy to mechanical energy. The converter, again, running, as it does, at a speed equal to half the primary frequency (which is more advantageous with regard to commutation) can be made of smaller proportions than an ordinary continuous-current generator or converter for the same output. For these reasons it is possible to build motor-converters at less cost than motor-generators of either the synchronous or induction type.

We have already mentioned the 91 per cent. efficiency at full load. The efficiency of a 500 kw. motor-convertor at one-quarter full load is stated by the makers to be 85 per cent.—an exceptionally high figure.

The neutral of the three-wire network is connected to the slip rings, and also to the star point of the rotor winding. In this connection the converter acts as balancer as well as generator, the balancing effect being so good that with the one side of the circuit fully loaded and the other unloaded the difference in the voltages between the middle wire and the two outers can be made as little as 2 per cent.



Back of D.C. Armature
Indicates connections of phases to rings.



Front of Rotor

Back of Rotor

Nos 1, 5 and 9 are connected to the rings, all others being insulated.

FIG. 3.—DIAGRAM OF D.C. ARMATURE AND A.C. ROTOR CONNECTIONS OF THE MOTOR-CONVERTERS.

After thus explaining the principle on which the new converter works, we will turn our attention to the actual design of the 500 kw. motor converters designed for Manchester. The alternating-current stator core is of the distributed slotted type with semi-closed slots; the 6,500 volt high-tension winding is wound by hand in mica tubes of sufficient thickness to withstand a 30,000 volt test. The rotor core is also of the distributed slotted type with semi-closed slots, the bar winding being insulated from the iron by presspahn and empire cloth. Some of the leading dimensions are :—

*Stator.*—Number of poles, six; inside diameter, 1033·8 mm.; outside diameter, 1,550 mm.; number of slots in stator, 72; number of slots per pole per phase, four; size of slots, 65 mm. deep by 28 mm. broad, contracted to 5 mm. at mouth of slot.

*Rotor.*—Twelve-phase; inside diameter, 610 mm.; outside diameter, 1,029·8 mm.; width of core, 325 mm.; width over end plates, 365 mm.; number of slots in rotor, 96; size of slots, 39 mm. deep by 18 mm. broad, contracted to 5·5 at mouth of slot.

*D.C. Machine.*—Number of poles, eight; diameter of armature, 950 mm.; length of core, 330 mm.; number of armature slots, 108; size of slot, 13 mm. by 42 mm. open; coils per slot, six; commutator bars, 324; commutator diameter, 660 mm.; commutator length, 500 mm.

Each set has two outer bearings and one centre bearing, and the rotor shaft and the armature shaft are coupled together at the centre. The centre bearing is dispensed with in the more recent machines, and the alternating-current rotor and continuous-current armature will be built on the same spider. The 12 connecting wires from the rotor pass through three holes into the hollow shaft, and, after proceeding first through the rotor shaft and then through the armature shaft, they finally emerge through three holes and are joined up to the 12 rings, which are fixed into the end plate of the continuous-current armature by means of small brass sockets riveted and soldered to the rings (Fig. 2). The rings are of delta metal, riveted and soldered at the joints. They are insulated from the armature end plate by micanite, and are prevented from dropping out of the circular slots by pieces of sheet steel, arranged radially across the rings as indicated in Fig. 2. The same figure also shows the arrangement and size of the soft copper connections between the rings and the continuous-current armature winding. Fig. 3 represents the diagram of connections of the Manchester machine. Terminals No. 5, 1 and 9 on the front of rotor are connected to slip-rings for starting purposes. The continuous-current dynamo has eight poles, the shoes of which are laminated and provided with a short-circuited compensating winding in the manner shown in Fig. 4. Motor and converter are mounted on a common base plate of cast iron, and the over-all dimensions of each set are 13 ft. 6 in. long, 7 ft. 3 in. wide, and about 6 ft. high. Fig. 5 shows the regulation curves of the Manchester set.

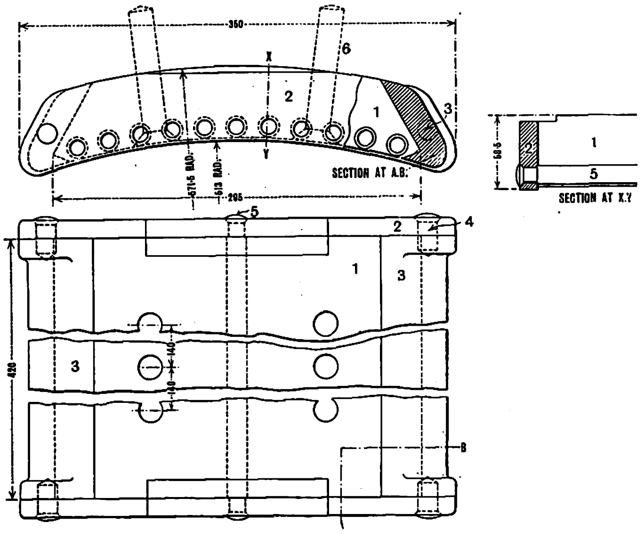


FIG. 4.—LAMINATED POLE SHOES OF THE 500 KW. MOTOR-CONVERTERS. Scale One-sixth Full Size.

1. Pole shoes of sheet steel. 2. Cast copper connectors. 3. Cast copper cross flanges. 4. Copper rivets. 5. Conductors of copper rod.

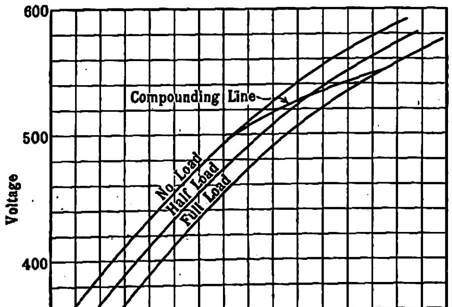


FIG. 5.—VOLTAGE CHARACTERISTICS OF MANCHESTER 500KW. MOTOR-CONVERTER.

The following temperature rises were observed at the official tests conducted under the supervision of Mr. S. L. Pearce after 5½ hours' full-load run: Continuous-current field, 36°F.; commutator, 28°F.; armature, 42°F.; stator iron, 56°F.; stator winding, 68°F.; rotor winding, 52°F. The high-tension winding was tested at 13,000 volts and the armature winding at 3,000 volts to iron.

*(To be continued.)*

# THE SEPARATION OF THE LOSSES IN INDUCTION MOTORS.

BY G. W. O. HOWE.

The power taken by an induction motor when running light is the sum of the various losses occurring in the motor, and the separation of the total loss into its several components is of the greatest importance to the designer.

Various methods of doing this have from time to time been proposed and tried, and considerable light has been thrown on the problem during the last two or three years. In 1901 Dr. Benischke* described a method of separating the friction losses due to bearings, brushes and windage from the remainder of the losses, due principally to hysteresis and eddy currents in the stator and rotor. This method consisted in measuring the slip at no load and with a small known load applied to the brake pulley; then assuming that the slip of a frictionless motor would be nil, and that it would increase proportionately with the load, the actual slip of a motor at no load must be a direct measure of the friction. In other words, if the slip be plotted against the output, a straight line is obtained, which, produced backwards, cuts the base line at a point representing the power lost in friction.

In 1903 Messrs. Bragstad and la Cour,† while advocating the retardation method of finding the friction losses by opening the circuit and plotting the retardation curve, pointed out at the same time that Dr. Benischke's method gave incorrect results, owing to the hysteresis torque exerted on the rotor by the rotating magnetic field. We shall return to this question presently, and turn our attention now to another point. When the rotor is revolving synchronously, it is generally assumed that no iron loss occurs in it; this is true of the core but not of the teeth, especially if the slot openings are wide. In the latter case, owing to the rotor teeth passing across the stator teeth, both are subjected to a pulsating flux of extremely high frequency, causing losses which may easily exceed the normal iron loss in the stator. The result of experiments on a number of motors, with a view to obtaining accurate information on the above-mentioned points, was given in November, 1905, by Herr Bache-Wüg before the Elektrotechnischer Verein in Carlsruhe.‡ The method employed is due to Bragstad, and is really an adaptation of the well-known method of finding the losses in one motor by driving it from another, which has been accurately calibrated. The motor used was a direct-current separately excited one, directly coupled to the induction motor under test. Four sets of readings were taken: (1) the power taken by the D.C. motor running light; (2) the power taken by the D.C. motor when coupled to the induction motor, both stator and rotor being open-circuited; (3) the power taken by the D.C. motor when the stator was connected to the polyphase supply, the rotor being open; and (4) the A.C. power supplied to the stator in the latter case. Readings were made in all cases for various speeds both above and below synchronism. The results obtained in this way on a 20 H.P. six-pole 50 cycle three-phase motor, are shown in the figure, in which the curves are numbered the same as the four sets of readings mentioned above.

Perhaps the most striking peculiarity of the figure is the sudden break in curves (3) and (4) when passing through the synchronous speed. This is due to the above-mentioned torque exerted on the rotor by the rotating field. To understand this clearly, we may imagine the rotor to be magnetised at any moment by the rotating field and by virtue of its hysteresis to resist any change in its magnetic polarity at any point. In other words, the rotor acts somewhat like a permanent magnet, which it really is to a degree, depending on its hysteresis, and it is, therefore, subjected to a torque tending to keep it running at the synchronous speed. If the friction be made small enough, or the rotor hysteresis large enough, the torque will be sufficient to keep the motor running synchronously. If the friction increase beyond a certain limit, the rotor begins to slip. The hysteresis torque remains the same, however, and the power given from the stator to the rotor remains constant, being equal to the product of the torque and the angular velocity of the field. The speed of the rotor has decreased, and with it the power given to it mechanically by the torque. The difference—viz., the product of torque into angular velocity of slip, appears now as heat in the rotor iron. Hence we see that just below synchronism a certain part of the frictional losses is supplied by the stator, and is read on the A.C. wattmeter in addition to the stator iron loss, with the result that the D.C. motor is relieved of so much of the frictional load. We see, then, that the assumption that the slip is proportional to the load (including friction) is not true, for the motor can be loaded up to a certain point before slipping begins.

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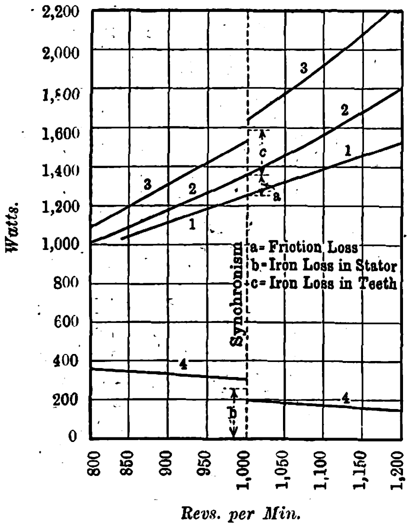
* *Elektrotechnische Zeitschrift*, 1901, pp. 226, 698. † *Ibid.*, 1903, pp. 35, 174. ‡ *Ibid.*, 1906, p. 106.

If now the motor be rotated above synchronism, the direction of the torque is obviously reversed and work is done on the stator by the D.C. motor. It may be noted, however, that as both the slip and the torque have changed sign, their product which gives the power dissipated in the rotor remains unchanged. It is thus evident that the sudden decrease in the A.C. power supplied to the stator, on passing through synchronism, must be equal to the sudden increase in the load on the D.C. motor, and, further, that both are double the hysteresis loss in the rotor at rest. The stator iron loss is the mean of the two readings of the A.C. power supplied to the stator at synchronism. The friction loss is given directly as the difference between curves (1) and (2). The mean difference between curves (2) and (3) at synchronism gives the generally neglected loss in the teeth of the stator and rotor due to their rapidly-pulsating flux. As the loss is caused by the rotation of the rotor, the power necessary to cover it must be supplied by the rotor, and will be included in the load on the D.C. motor in experiments (3) and (4) without affecting the reading of the stator iron loss on the A.C. wattmeter. In the case of an ordinary induction motor running light, this loss in the teeth will have exactly the same effect as an increase in the friction and windage. The various losses in the example given work out as follows: Friction loss 100 watts, stator iron loss 250 watts, loss in teeth 230 watts. The sum of these three amounts to 580 watts, whereas when running light in the ordinary way the losses amounted to 575 watts. This close agreement was found in all cases. The sudden break in curves (3) and (4) at synchronism amounts to 100 watts, corresponding to a hysteresis loss in the stationary rotor of 50 watts; at synchronous speed this loss is non-existent. In this example, therefore, two-fifths of the no-load losses were due to the rapidly-pulsating flux in the teeth. This loss will depend largely on the design of the motor with regard to the shape and number of the teeth and slots in both the stator and rotor. The iron loss in both the stator and teeth can be separated in the usual way into hysteresis and eddy-current loss. Bragstad has done this for the teeth, but, as might be expected, the results obtained for various motors are widely divergent, and even for two motors made under exactly similar conditions the tooth loss will vary from a half to double the stator iron loss. The mechanical treatment during manufacture, and the insulation between the laminations, is specially uncertain in the case of the teeth.



CURVES OF FRICTION AND IRON LOSSES.

The importance of this subject with regard to the heating of the motor winding is evident, and it is to be hoped that further investigations will be made along the same lines.

## THE DISTRIBUTION OF MAGNETIC INDUCTION AND HYSTERESIS LOSS IN ARMATURES.*

BY DR. W. M. THORNTON.

In a Paper read before the British Association at Cambridge in 1904 (see *The Electrician*, Vol. LIII., p. 749), I described an investigation on the distribution of magnetic induction in a solid, smooth-core armature. The chief conclusions were as follows:—(1) The flux densities through a section of the core midway between the poles are in no case uniform, reaching a maximum at a short distance within and falling both towards the centre and circumference; (2) the internal distribution is practically the same with long and short air-gaps, though the leakage varies; (3) the ratio of the maximum density in the core to that in the gap is greatest when the pole pitch is small; (4) the variation of magnetisation in passing from one pole to the next is widely different at different depths, so that hysteresis and eddy-current losses are still more unevenly distributed.

The present Paper contains an examination of the cases of toothed cores, hollow and solid, by the method of the previous Paper, using search coils wound in small holes drilled through the core parallel to the shaft. A set of observations are shown in Fig. 1. They give the distribution across a radial section midway between the poles. (The experimental motor had six poles.)

Experiments were also carried out by means of Prof. Hele-Shaw's method of observing stream lines in viscous liquids, which has been fully described in a Paper before the Institution.† The well-known effect of large air-gap increasing leakage is illustrated by Figs. 2 and 3. The same effect is produced by increasing the density in the poles. This is shown by Fig. 4, in which, though the core is solid, the leakage is greater than in Fig. 2 with poles worked at higher permeability.

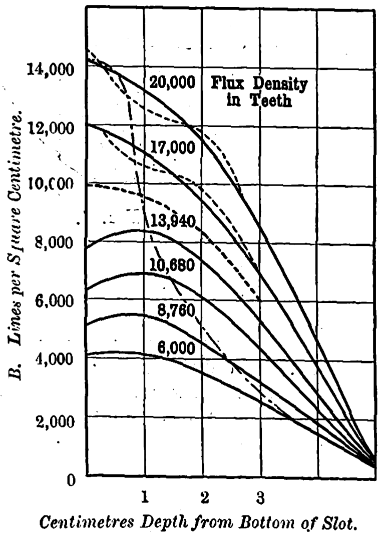


FIG. 1.—DENSITIES IN TOOTHED SOLID CORE.

Curves 5 and 6 give the distribution in slotted cores of different radial depth. The refraction of the lines in the fringe in their attempt to reach the core, and the nature of the interpolar induction as compared with that for smooth cores, are of most interest. The chain-dotted line in Fig. 1 is the distribution of magnetic potential obtained from the stream-line photographs. They are a first approximation to the actual case, differing from it because the permeability in iron cannot be fully imitated. In Fig. 1 the agreement is not very good, but in other curves which were taken to represent the distribution of magnetic induction in toothed armatures the agreement was better. The difference is no doubt due to the constant and comparatively low permeability of the slide. It may even be seen without measurement that in some of the curves (Figs. 5 and 6) the lines which pass through the teeth into the core are denser than those which are in line with the slot.

The loss of hysteresis in an armature may be dealt with in two parts—teeth and core. So long as the number of lines in the tooth does not change, as, for example, in passing under a pole, there is no dissipation of energy. Approaching the pole-tip the lines become oblique, and midway between the poles horizontal, though the density never drops to zero. There is, therefore, a rotating magnetisation in the teeth which is at the same time fluctuating between limits which can be found from the photographs.

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* Abstract of a Paper read before the Newcastle Local Section of the Institution of Electrical Engineers on February 26th.

† Hele-Shaw, Hay and Powell, "Magnetic Flux Distribution," *Journal of the Institution of Electrical Engineers*, Vol. XXXIV., p. 21, and *The Electrician*, Vol. LIV., pp. 213, 307 and 350.

There have been many calculations of loss based on assumptions as to the manner in which the teeth density changes, but all assume an alternating flux. The fact that, as shown by the photographs, it is rotating is likely to reduce the estimate of hysteresis loss in teeth, which, though too small to affect the efficiency to any marked extent, does influence the temperature of the insulation of the armature conductors. The loss in any case cannot follow Steinmetz's law as generally assumed. Consider the variation of density in the teeth passing from pole to pole. Without having regard to sign, it can be represented by Fig. 7. Under the pole the density is constant in magnitude and direction; between the poles it is changing rapidly and rotating. In the hyteresis loop obtained by rising and falling magnetisation, the dissipation of energy is very greatly increased by the molecular movement at reversal, but when, as in the case considered, the density never passes through zero one must take as basis the loss due to a rotating field. Hawkins and Wallis in "The Dynamo" give a curve showing the loss of energy by rotating and alternating magnetisation. The ratio of maximum to minimum density in the teeth is found from the photographs to be about 4·5. Assuming, then, a maximum of 18,000 and a minimum of 4,000 with a rate of change as in Fig. 7, the mean dissipation coefficient is 0·00105 joule per cubic centimetre per pair of poles. If, on the other hand, the teeth are considered to have alternating magnetisation only, the rate of dissipation is increased to 0·0022 over the given range of density. The influence of the rotation is then to very much reduce the rate of heating in the teeth so far as this is caused by hysteresis.

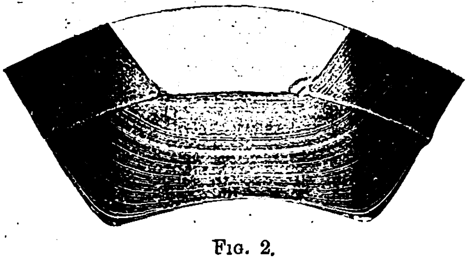

FIG. 2.

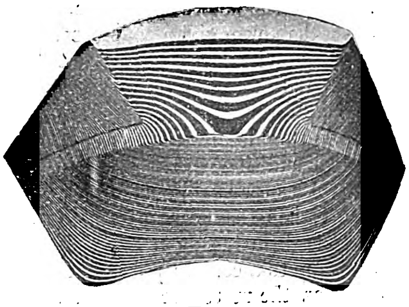

FIG. 3.

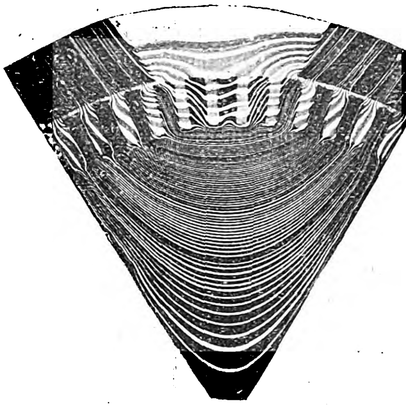

FIG. 6.

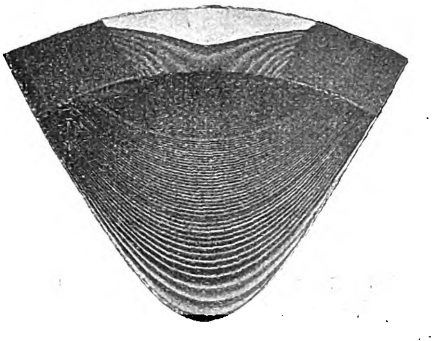

FIG. 4.

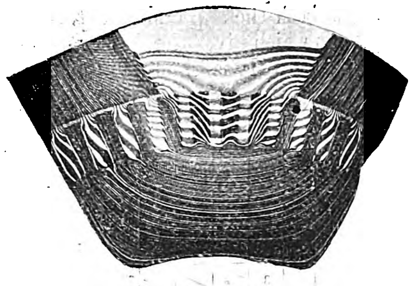

FIG. 5.

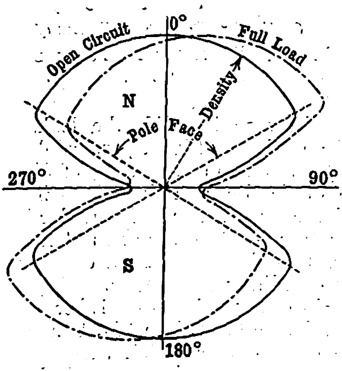

FIG. 7.—DISTRIBUTION OF DENSITY IN TEETH BETWEEN POLES.

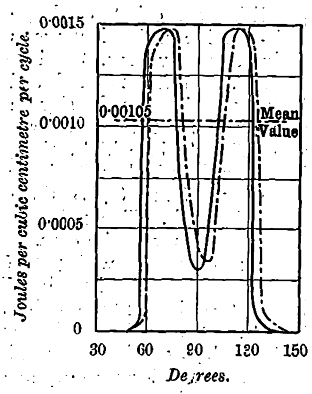

FIG. 8.—VARIATION OF HEATING WITH ROTATING MAGNETISATION OF TEETH.

When the machine is on load, the distribution of the lines in the gap being somewhat changed, there is also a variation of density in the teeth from point to point under the pole, though there is no rotation. The effect is to shear the distribution over, as in Fig. 7. For all practical purposes, the hysteresis loss in the teeth may be considered to be unaffected by the change, as shown in Fig. 8. The fact that the loss by rotating magnetisation decreases after reaching a maximum contributes to this. In the foregoing the change of density from top to bottom of the tooth has not been considered as affecting hysteresis loss. On approaching and leaving the pole-tips the distribution of flux becomes more uniform in the teeth, and since the molecular movement is confined to the interpolar space, this change of density will not make any marked difference.

The hysteresis loss in the parts of the core below the teeth also depends on the manner in which the cycle of magnetisation is carried through at each point. There is, however, much less variation than in the teeth.

The results in the Paper may be summarised as follows: The magnetisation of the teeth in slotted armatures is not alternating, but rotating, and at the same time fluctuating; that of the core is rotating, but by reason of the distribution of density in the core not being uniform, it is unevenly distributed, being greatest at the outer parts below the teeth. The ratio of the mean dissipation coefficient to that corresponding to the mean density is about 0·8. The coefficient for the teeth alone is about 0·00105 joule per cubic centimetre per cycle; that for the core 0·00108. The low value for the teeth is caused by the drop in density between the poles and by the fact that it is rotating.

In conclusion, I wish to thank Mr. O. J. Williams and Messrs. G. H. and C. Wilson for much help in taking the readings and the photographs.

## DISCUSSION.

Mr. **STONEY** said the stream-line method was not the only method of showing the distribution of magnetism in a revolving armature. This had also been done by drilling holes in the armature core and winding exploring coils in them. He did not consider the stream-line method of much practical use. Losses in actual work were always far greater than the calculated losses, but he hoped Dr. Thornton would carry on his researches, as at present most practical men knew very little about the actual conditions upon which hysteresis losses depend.

Mr. **TURNBULL** thought the Paper of great interest. He asked whether the drilling of holes in the armature core, as suggested by Mr. Stoney, would not rather alter the mass of iron in the core and render the test inaccurate owing to distortion.

Mr. **CARTER** thought a great help would be rendered to designers if some general results for the total iron loss could be obtained from experiments such as Dr. Thornton described, which would be correct within 10 per cent. of the true facts.

Mr. **EUGENE BROWN** thought that these results were not of much use for rotating armatures, and considered that for practical purposes transformer coils in holes in the armature would give more practical results.

Mr. **RALPH** wished to ask in what way proof was obtained that the stream-lines exactly represent the distribution of magnetism.

Dr. **THORNTON**, in reply, said that drilling holes in the armature would alter the working conditions, making the armature, as it were, spongy. In reply to Mr. Ralph, he said that the stream-line experiments had been proved to be mathematically correct.

## A FOLDING STEP FOR TRAMCARS.

An ingeniously arranged folding tramcar step, known as the Leicester folding step, which interlocks with the gate, is shown in the accompanying illustrations. The lever B (Fig. 1), which actuates the step, lies alongside the car end when the step is down and serves as a handrail, being locked in this position by the spring bolt G which engages with the cam L. When, however, that gate is closed, the catch J on the gate presses the spring bolt back, allowing the lever B to be brought forward in line with the gate, and thus raise the step and at the same time lock the gate by bringing the cam L into the slot catch J. The step is at the same time locked by the pedal lever N which engages with the cam M, the face of which is hooked behind the pedal N after having been given a quarter of a turn. The gate cannot again be opened till the step is lowered, as the cam M on the vertical rail A must be released and the lever B replaced alongside the car end before the gate becomes unlocked. This movement of the hand lever lowers the step by means of the bevel pinion D, which is keyed to the trunnion F and the toothed quadrant E keyed to the vertical rail A. The cam M and pedal lever N then automatically engage and the step is locked in the position shown in the figure, and the gate, being free, automatically collapses owing to the spring O. Thus the step cannot be folded up till the gate is closed, nor can the gate be opened till step is unfolded. Enlarged views of the locking box are shown separately. The step is manufactured by Messrs. Brecknell, Munro & Rogers, of Bristol, who have kindly sent us the drawings and photographs from which our illustrations are taken. The cars of the Exeter Corporation tramways are fitted with these steps, and Figs. 2 and 3 show the appearance of the step open and closed, the photographs being taken from one of the Exeter cars. The arrangement has also been used at Hastings and on some other systems.

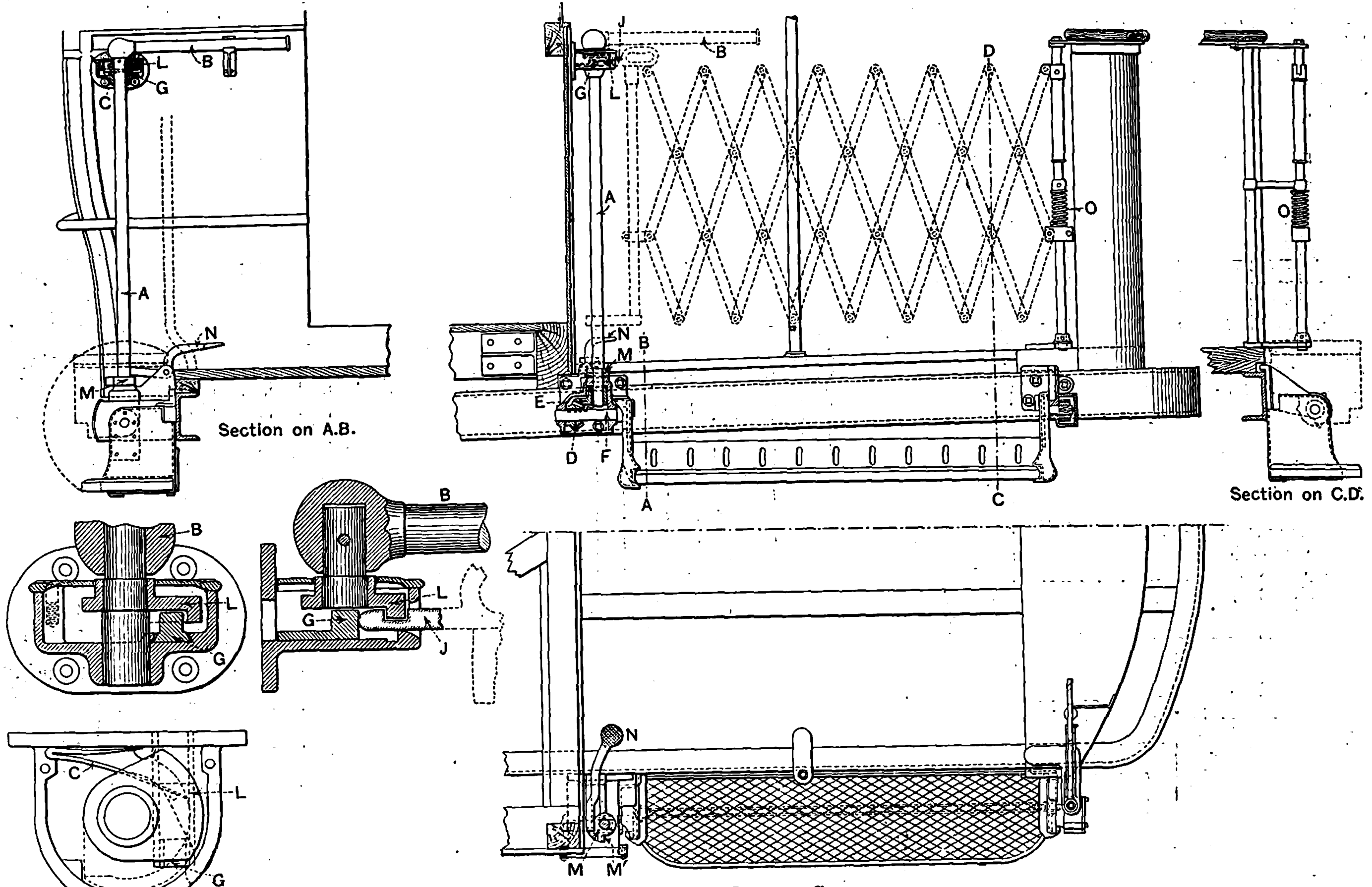

Fig. 1.—Details of Folding Step.

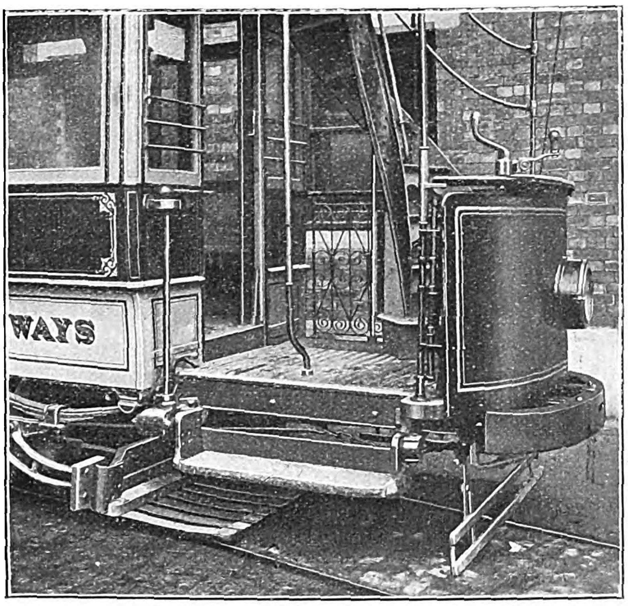

Fig. 2.—Step Down ready for use.

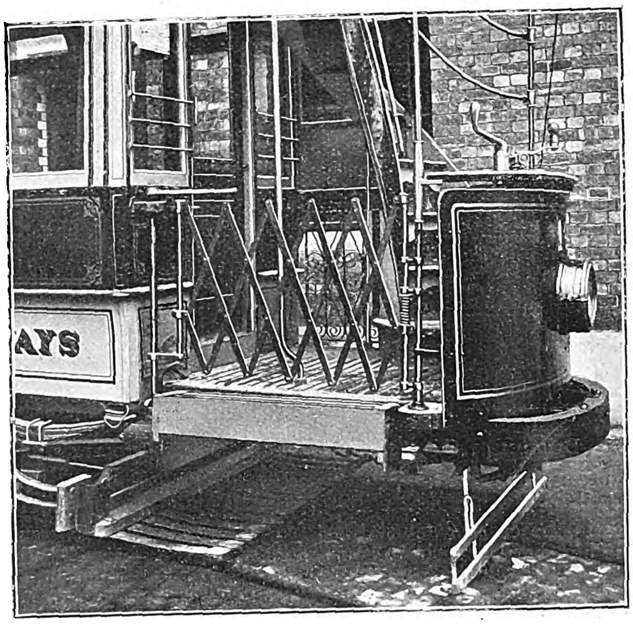

Fig. 3.—Step Folded up and Gate Closed.

# ELECTRICAL EQUIPMENT OF THE ABERDARE COLLIERIES OF THE POWELL DUFFRYN CO.*

BY CHARLES P. SPARKS.

(*Concluded from page 935.*)

*Sub-stations.*—The sub-stations are either separate buildings or rooms to which ordinary employés have no access. Each sub-station is fed from the power station by one or more high-tension feeders, as shown in Fig. 5, the feeders being protected at each end by lightning arresters. Before connection to the sub-station 'bus bars, the incoming feeders are controlled by oil break switches, and that all exposed metal is dead when the switch is opened for the renewal of fuses. Each sub-station is provided with one voltmeter for each pressure and two ammeters.

*Underground Sub-stations.*—The general arrangement is the same as for those above ground, but in this case each panel of the switch gear is placed in a separate brick compartment, closed by a lock-up metal case, the whole switchboard being independently roofed in. These sub-stations are placed close to the downcast shaft to admit of their being well ventilated. The switch gear of each panel consists of oil break switch and enclosed fuses, the latter contained in a cast-iron gas-tight case. Access can only be obtained to the fuses of each individual panel when the switch is in the "off" position. Fuses are used at the sub-stations in place of by fuses in the case of sub-stations fed by two feeders. The sub-station 'bus bars branch to: (1) 3,000 volt sub-stations below ground, connected by armoured cables; (2) 3,000 volt motors, connected by overhead distributors; (3) three phase transformers reducing the pressure to 500 volts (for motors below 50 H.P.); (4) single-phase 110 volt lighting transformers.

Each high-pressure panel for outgoing feeders or transformers is equipped with oil break switch, enclosed fuse and series ammeter transformer, so that the demands on the individual circuits can be checked. The back of each panel is only accessible when the controlling switch is in the "off" position. The low-pressure circuits have three-pole enclosed fuses, combined with switches, arranged so "automatics," as continuous attendance is not provided at these points; each motor being protected by an "automatic," a feeder fuse only blows when something is seriously at fault. Three-phase power transformers of 500 volt secondary pressure and 670 k.v.a., are erected in these sub-stations to supply the smaller motors, together with 170 kw. of single-phase lighting transformers of 110 volt secondary pressure.

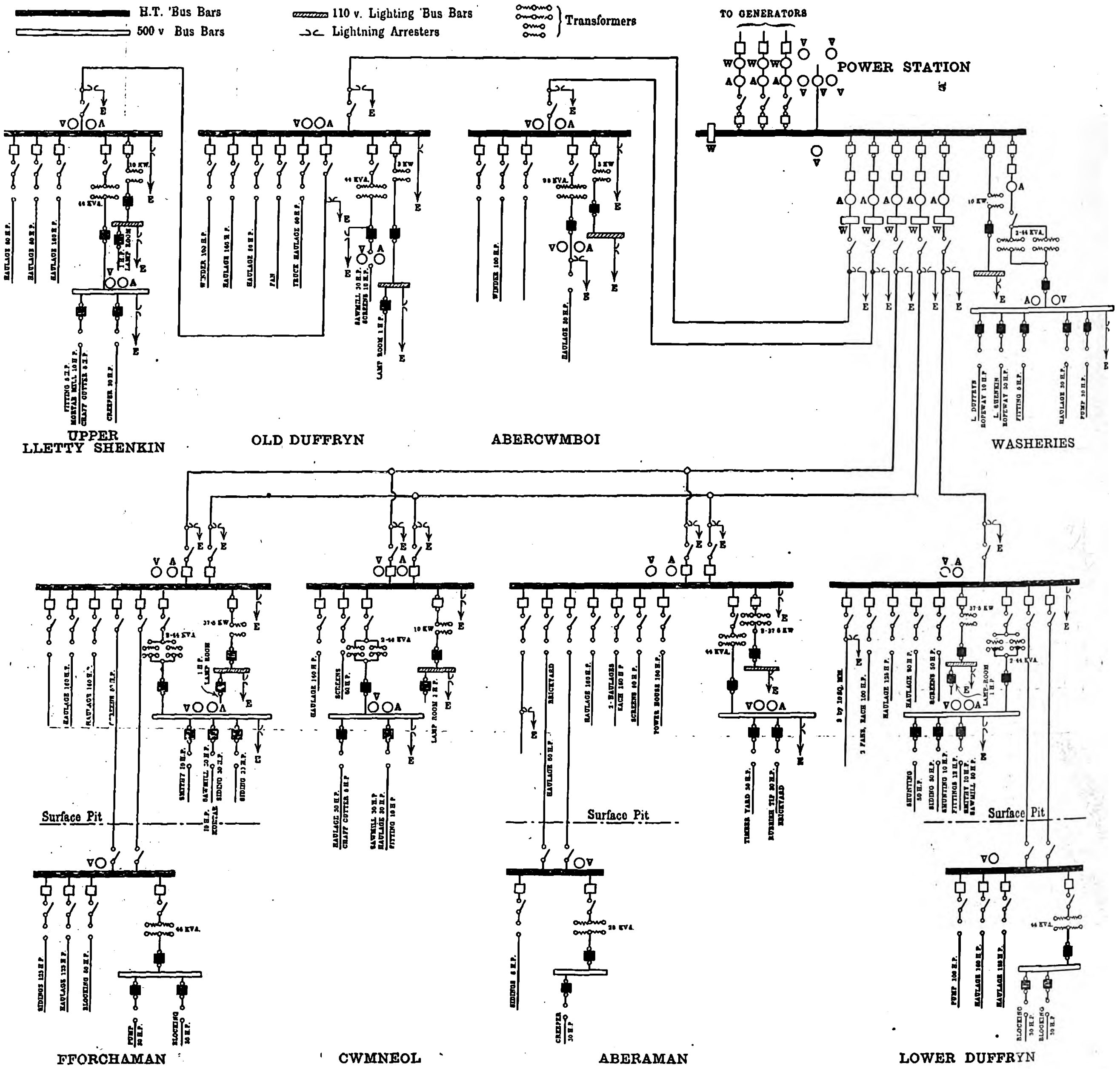

FIG. 5.—DIAGRAM OF CONNECTIONS OF THE ABERDARE COLLIERIES, SHOWING THE CHARACTER OF THE TRANSMISSION LINES AND THE NUMBER AND SIZE OF MOTORS ABOVE AND BELOW SURFACE AND THE USES TO WHICH THEY ARE PUT.

*Distribution—Mine Cables.*—Each shaft has duplicate three-core cables, 0·08 sq. in. section, insulated with impregnated paper covered with copper tape 15 mils thick, the whole lead-sheathed and armoured with 50 of No. 12 S.W.G. galvanised steel wires separated from the lead. These cables are carried in the shafts by wrought-iron cleats attached to the beyots placed from 7 yds. to

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* Paper read before the Institution of Electrical Engineers March 22nd.

10 yds. apart, the cleats being bushed with hardwood bushes; the cables are jointed in cast-iron joint-boxes, both the armouring and the copper tape being kept electrically continuous at the joints. The 3,000 volt armoured cables are carried down four of the pits and extend a distance of 700 yds. from the pit bottom. The cables are hung along the roadways, supported to leather thongs, so that in case of a fall the support will give way without putting serious strain on the cable.

The pit lighting is independent of the power cables; the original wiring (used when the pits were supplied with D.C.) is now fed with A.C. current from the sub-stations above ground. Mine cables have been provided for the following pits:—

| | Depth of shaft. |
|---|---|
| Aberaman | 300 yds. |
| Lower Duffryn | 348 „ |
| Abercwmboi | 300 „ |
| Fforchaman | 200 „ |

Motors of 1,000 B.H.P. were in use below ground in December last.

*Overhead Distribution.*—The distribution from the sub-stations to the various motors, both 3,000 and 500 volt, consists of bare wires supported on insulators attached to wooden poles or to the existing buildings. These wires are guarded in a similar manner to the transmission wires, and are protected by lightning arresters at the sub-stations. Where high-tension wires are supported on the existing buildings, the conductors are kept 9 in. apart and supports 6 yds. apart, the conductors in all cases being kept well above the ground level.

The connections between the switch gear and the individual motors consist below ground of three-core armoured cable, special care being taken to see that the frame of the motor, controller and sheathing of the connecting cable are all in electrical contact with one another and with earth. Above ground the same method is used for the high-pressure connections, the low-pressure connections being made by single rubber-covered wires mounted on insulators, protected by expanded metal guards where accessible.

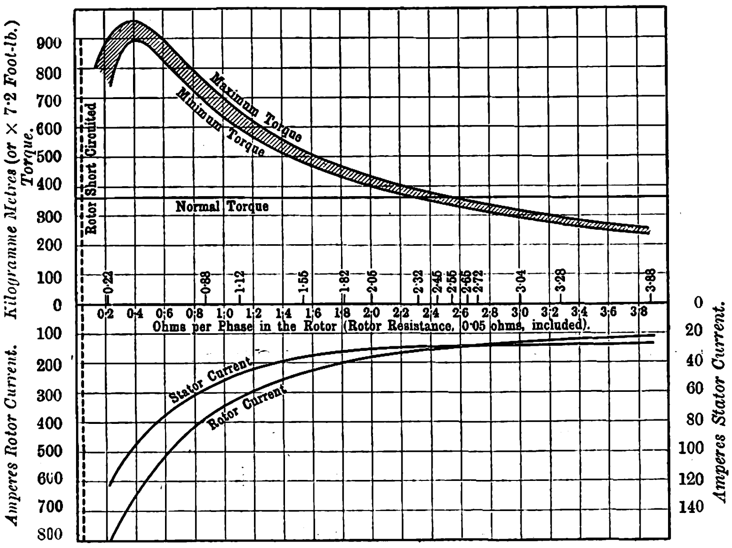


FIG. 5A.—TORQUE OF THREE-PHASE SLIP-RING INDUCTION MOTOR, K.S.M. 300/300, 150 H.P., 3,000 VOLTS, 50 ∿.

*Earth Connections.*—In order to provide a good earth connection in each pit, in addition to the armouring, which has been carefully bonded, a bare copper conductor of 0·1 sq. in. section has been taken down each shaft, from which earth wires, having 25 per cent. greater area than the individual wires in the distributor, have been laid to each motor so as to insure a good earth connection for the motor frames, switch gear and controller cases. The neutral point of the star-winding of the generators is earthed at the power station, and the neutral point of the 500 volt transformers is earthed at each sub-station.

*Motors.*—Three-phase motors aggregating 4,600 B.H.P. were specified for in the first instance, and since the work has been in hand further motors have been added, bringing up the total to date to 6,000 H.P.

The motors may be divided into two classes: (1) Variable speed, for haulage and winding; (2) constant speed for driving fans, pumps, screens, conveyors, workshops and brickyard.

Forty motors of the first type were at work in January, 1906, varying in power from 300 B.H.P. to 25 B.H.P., totalling 3,260 B.H.P., and 37 of the second type, from 180 B.H.P. to 5 B.H.P., totalling 1,450 B.H.P. Table III. gives a classification of the total power used at these pits in January last, 4,710 B.H.P. being electric, the balance of 7,460 being steam driven, of which a further 1,000 H.P. is being converted to electric driving. Total, 12,170 B.H.P.

**Table III.**

| — | No. of Motors. | Electric. | Steam. | Total. |
|---|---|---|---|---|
| Winding | 3 | 280 | 4,400 | 4,680 |
| Haulage (above ground) | 28 | 2,400 | 300 | 4,030 |
| „ (below ground) | 5 | 580 | 750 | |
| Fans | 3 | 380 | 500 | 880 |
| Pumps | 6 | 340 | 450 | 790 |
| Screens | 4 | 240 | . . . | 240 |
| Washery | .. | .. | 430 | 430 |
| Air compressors | .. | .. | 470 | 470 |
| Auxiliary motors, conveyors, workshops, brickyards | 46 | 490 | 160 | 650 |
| Totals | 5 | 4,710 | 7,460 | 12,170 |

In addition, 170 kw. of transformers are used for lighting above and below ground. 26 of the motors given in Table III., of 3,500 B.H.P., are wound for 3,000 volts, all motors below 50 B.H.P. being wound for 500 volts.

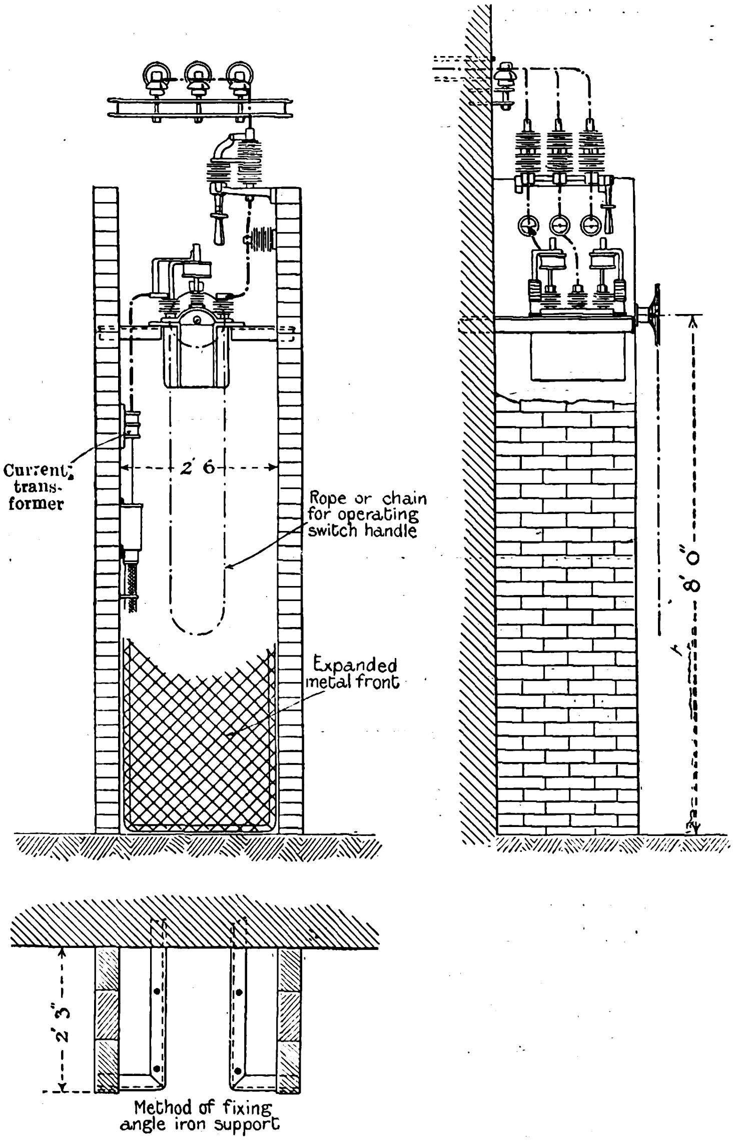

Current trans-former
2' 6"
Rope or chain for operating switch handle
Expanded metal front
8' 0"
2' 5"
Method of fixing angle iron support

FIG. 6.—THE SWITCH GEAR FOR VARIABLE SPEED MOTORS.

*Gearing.*—The general method of drive is by cut-steel gear, and in order to reduce the ratio of reduction as far as possible, a motor speed (at full load) of 121 revs. per min. was chosen for the 300 H.P. and 290 for the 150 B.H.P. haulage motors. The motors have been fitted in all cases to existing haulage gears, replacing a steam engine, arrangements being made so that the haulage could be worked with steam up to the end of the week, the electric driving commencing the following Monday by dismantling the engine and putting the motor and gear in its place. The high-tension motors are of the protected type, those over 75 B.H.P. having bearings separate from the frame; the slip-rings are carried at the end of the shaft and are enclosed when the motors are used underground.

Table IV. gives particulars from the tests of both types of motors, and Fig. 5A is a torque diagram of one of the 150 H.P. high-pressure haulage motors.

### Table IV.

| | Haulage Motors. | | | Motors for Continuous Service. | | |
|---|---|---|---|---|---|---|
| | Variable speed | | | Constant speed | | |
| Rated B.H.P. | 150 | 75 | 50 | 100 | 50 | 25 |
| Volts | 3,000 | 3,000 | 3,000 | 3,000 | 3,000 | 500 |
| Diameter of rotor | 42·5″ | 30″ | 25″ | 42″ | 24″ | 19·25″ |
| Speed (at full load) | 290 | 365 | 365 | 290 | 485 | 485 |
| Efficiency: Full | 89·5% | 89% | 85% | 90% | 91% | 87·5% |
| ,, ¾ | 89% | 88% | 84% | 91% | 90% | 88% |
| ,, ½ | 87·5% | 86% | 82% | 91% | 88·5% | 87% |
| Cos $\phi$: Full | 0·78 | 0·82 | 0·72 | 0·87 | 0·83 | 0·85 |
| ,, ¾ | 0·71 | 0·78 | 0 63 | 0·86 | 0·77 | 0·80 |
| ,, ½ | 0·60 | 0·68 | 0·5 | 0·82 | 0·65 | 0·70 |
| Max. starting torque | 2·55 | 2·7 | 3·3 | 1·8 | 3·6 | 2·5 |
| Air-gap (inches) | 0·08 | 0·06 | 0·06 | 0·05 | 0·04 | 0·04 |
| Temperature rise | 35°C. | 39·5°C. | 45°C. | 37°C. | 60°C.* | 30°C. |
| Weight of motor in lbs. without bedplate | 6,900 | 3,600 | 2,900 | 6,000 | 3,800 | 2,150 |

* 70 B.H.P. motor rated at 50 B.H.P. totally enclosed.

The switch gear provided for the variable-speed motor control is in each case as shown on Fig. 6. The control panels are erected in brick chambers with an expanded metal front, each high-tension panel having an "isolating" switch (in the case of the motors underground, operating under oil) to allow the whole of the switchgear, &c., for each individual motor being entirely disconnected from the system; three-phase oil switch combined with "overload" relay, and series transformer for measuring current. Each haulage has an ammeter to act as a guide to the driver, the dial being marked to show the rated working current of the motor and the overload point at which the circuit breaker will operate, the motor not breaking out of step unless an overload of 2½ times its working current is exceeded. The controller and high-pressure reversing switch are combined (Fig. 7), and are operated by one handle through gear and levers. The rotors of the haulage motors are wound for two-phase.

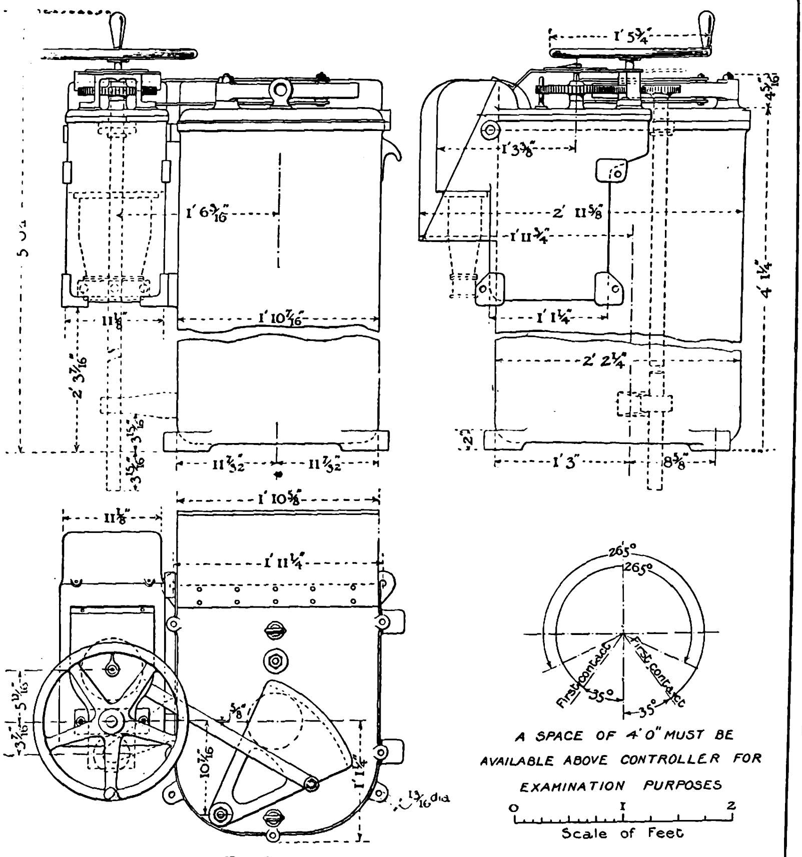


Fig. 7.—Combined Controller and H.-T. Switch.

The controller consists of a metal case in which is mounted a revolving drum on which two lines of rubbing contacts are fixed, arranged in parallel spirals; 15 fixed contacts connected to the rotor resistance are placed vertically at each side of the drum (the whole of the contacts operate under oil when used underground). Each of these contacts carries three copper fingers, reinforced by an adjustable flat steel spring. The tips are copper wedges screwed to the end of the fingers, all contacts, both stationary and revolving, being designed to be easily renewable. The first four sets of contacts are arranged to cut out whole sections of resistance, the remaining contacts cutting out half sections, the reverse action taking place when the resistance is being put in. The high-tension reversing switch is bolted to the side of the controller. Four contacts controlling two of the three phases supplying the stator are reversed under oil by a revolving switch. In order to provide for smooth operation the controller provides for 26 motor speeds.

The resistances for the rotor circuit are cast metal grids. These are mounted in frames placed close to the controller, the frames being well ventilated and protected by expanded metal guards; the connections between the resistances and the controller are carried in an earthed iron pipe or protected by expanded metal guards. Fig. 8 gives the characteristic curves of the 150 B.H.P. haulage motor, showing when working from three quarter load to 25 per cent. overload an average efficiency and power factor of 89 and 78 per cent. respectively, the slip at full load being 3 per cent.

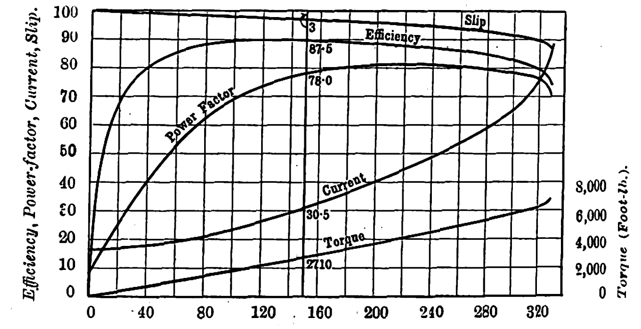
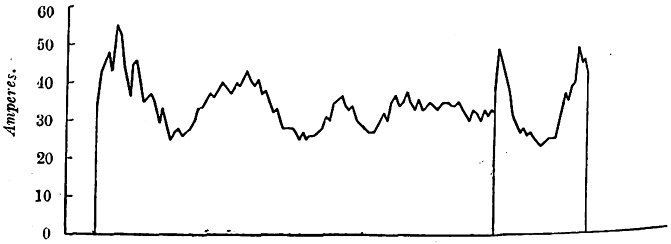


Fig. 8.—Characteristic Curves of a 150 h.p. Three-phase Haulage Motor.

The following are representative instances of drives for haulage, fans, pumps, winding, &c.

*Main and Tail Haulage.*—Fourteen of these are driven by 150 B.H.P., 3,000 volt, 290 revs. per min. variable speed motors.



Aberaman Haulage from the Yard Seam.

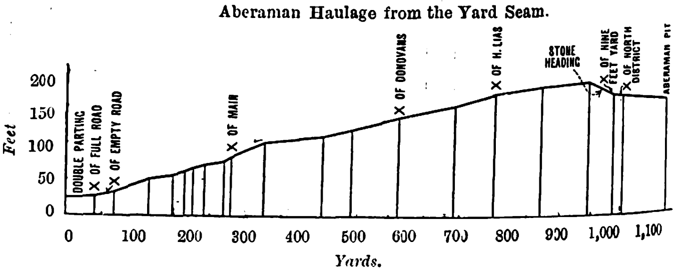


Fig. 9.—Section of Road.

The leading details of the gearing and weight handled by one of these haulages, arranged with two drums in tandem, are given in Table V.

### Table V.

| | |
|---|---|
| Diameter of drums | 4 ft. 6 in. |
| Drum, cast-iron helical gear | 100 teeth, 2½ in. pitch × 9½ in. wide. |
| Drum pinion | 24 teeth, 2½ in. pitch × 9½ in. wide. |
| Motor cut steel spur wheel | 66 teeth, 2⅝ in. pitch × 9⅞ in. wide. |
| Motor pinion | 22 teeth. |
| Length of rope | 1,450 yds. |
| Weight of rope | 2·12 tons. |
| Diameter | ¾ in. |
| Number of trams | 20. |
| Weight of trams | 20 × 9 cwt. = 9 tons. |
| Number of shackles | 19. |
| Weight of shackles | 19 × 30 lb. = 0·25 ton. |
| Weight of coal per journey | 20 × 26 cwt. = 26 tons. |
| Total weight hauled | 37·3 tons. |
| Time occupied per journey | 4½ minutes. |
| Speed of journey | 5½ miles per hour. |

The gradient is shown in Fig. 9, and the readings corresponding to the different points on the journey were obtained by signalling as the tram passed. It will be noticed that when five-sixths of the journey is complete the trams are stopped and the tail rope put on, the journey being completed with trams under brake control.

The energy required averages 1 unit per ton of coal hauled, Table VI. giving representative instances.

**Table VI.**

| | | |
|---|---|---|
| Length of road in yards | 1,100 | 1,320 |
| Gradient, inches per yard | 1 to 4½ | 1 to 4 |
| Time per journey, minutes | 7½ | 9 |
| Coal per journey, in tons | 27 | 27 |
| Completed journeys per day | 17 | 19 |
| Coal hauled per day | 460 | 520 |
| Units per day | 425 | 490 |
| Units per ton of coal hauled | 0·92 | 0·94 |
| Maximum kilowatt input into motor | 286 | 242 |
| Load factor of haulage (250 working days) | 4·25% | 5·8% |

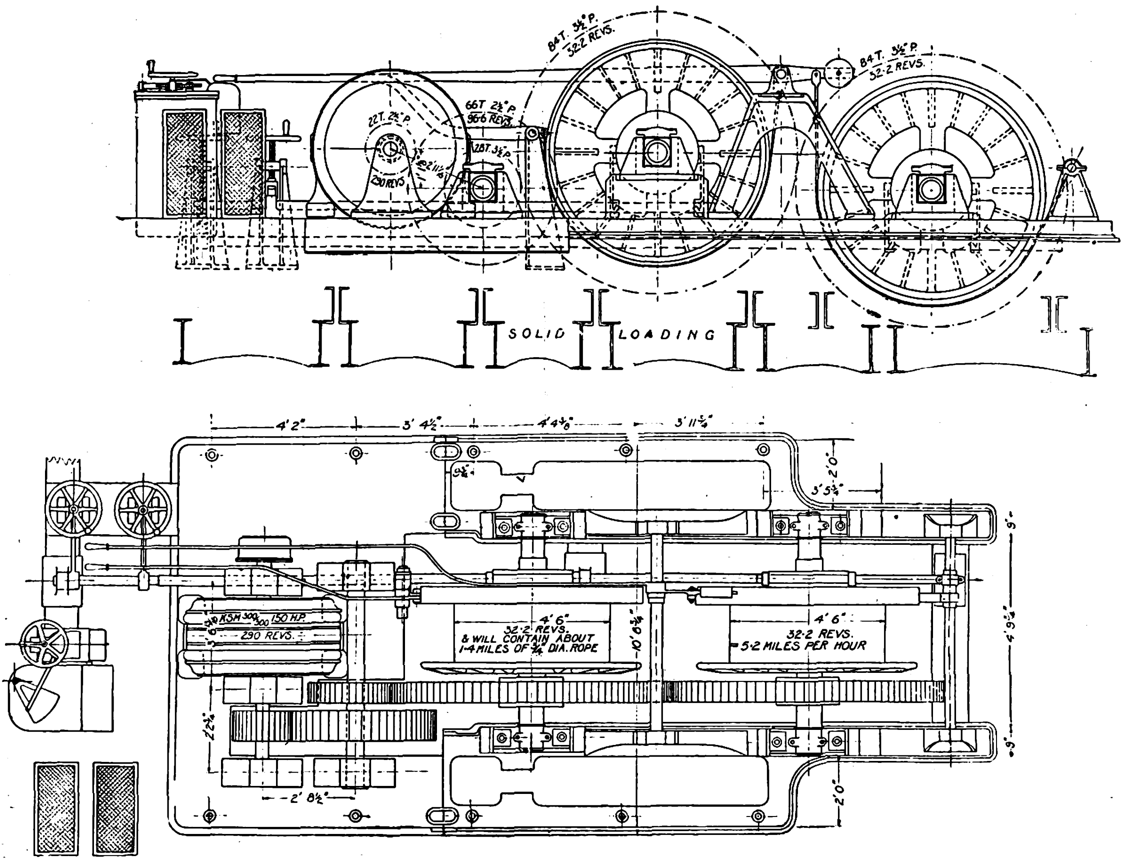


Fig. 10.—Electrically-driven Double-drum (Main and Tail) Hauling Engine, Motor 150 b.h.p., for Use Underground at Lower Duffryn

These low load factors are due not only to the intermittent working of the journeys, but to the power required at starting and on mounting a gradient. Before conversion, when the haulages were steam driven, the engines slowed down at each heavy gradient, but now the haulage is electric three-phase, the speed is maintained whatever the gradient, and, in consequence, the power taken momentarily is great. The large power taken by "main and tail" haulage shows the great advantage of the continuous haulage system where roadways will allow this method of operation Fig. 10 shows the general arrangement of one of the underground haulages which has been converted from steam. Drum speed 32 revs. per min., equivalent to 5 miles per hour.

*Gearing.*—Drum cast iron double helical: Teeth 100, pitch 3½ in., width 9½ in. Drum pinion: Teeth 24. Motor spur wheel, cut steel: Teeth 66, pitch 2⅝ in., width 8⅝ in. Motor pinion, cut steel: Teeth 22. The operator faces the motor, having the clutches on his left, brake levers and ammeter in front of him, and the controller on his right.

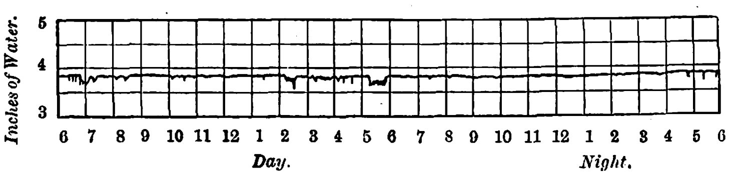


Fig. 11.—Air-pressure Chart of 24 Hours of a Fan driven by a 180 h.p. 3,000 volt Motor.

*Fans.*—180 b.h.p., 3,000 volt motor, protected type, running at 290 revs. per min., fan being rope driven at 175 revs. per min. Air delivered by fan, 150,000 cubic ft. per minute with 3¾ in. water gauge. Fig. 11 shows air-pressure chart for 24 hours. This chart gives a direct indication of the regularity of speed of the power station. The air pressure secured by this method of drive is more uniform than is usually obtained with steam-driven fans. The switch gear used is of the same type as that employed for the haulage motors, with the exception that the starter is a liquid resistance. The fan motors are run at full load continuously, being shut down for examination and cleaning for 10 minutes every three weeks.

*Screens.*—60 b.h.p. 3,000 volt enclosed motor, 485 revs. per min., the screens being rope driven. Switch gear as above. Liquid starter employed.

*Aerial Rope Ways.*—15 b.h.p. 500 volt motor, 575 revs. per min., belt driven. Liquid starter.

*Pumps.*—100 b.h.p. 3,000-volt motor, 485 revs. per min. Three-throw Uskside ram pump, rope driven, 9 in. cylinders, 15 in. stroke, 22 revs. per min., delivering 13,000 gallons per hour against a head of 1,020 ft. 40 b.h.p. 500 volt enclosed motor, 720 revs. per min., driving centrifugal pump direct against head of 100 ft.

*Winding.*—100 h p. 3,000 volt motor, 290 revs. per min. full load). Depth of pit, 90 yds. Time occupied in wind, 40 seconds. The cage holds one tram. Output, 70 tons of coal per hour. As the workings are being opened out only 200–300 tons per day are being dealt with, out of the daily capacity of 600–700 tons. A similar winder is used for men only. Depth of pit, 270 yds.

An underground winder is in use at Fforchaman in a staple pit. Depth 100 yds. The winder is driven by 80 h.p. motor, 360 revs. per min. (full load), 3,000 volts, working a single cage holding one tram, the load being balanced by a weight. Fig. 12 shows the current taken per wind. The time occupied is 50 seconds. The maximum speed of the rope is 486 ft. per minute. Output at the rate of 30 tons per hour.

*Load Factor on Power Station.*—Fig. 13 shows that with motors of 1,366 b.h.p. connected, a daily output of 4,400 units, and maximum demand of 800 kw., the load factor is 22·5 per cent. With motors of 3,900 b.h.p. connected, a daily output of 14,900 units, and maximum load of 1,200 kw., the load factor is 51 per cent. The annual load factor is lower than the above figures, as the power station only supplies for ventilating, pumping and a small amount of lighting on 1½ days of each week; in addition, stop days and holidays have to be allowed for. Tests on individual "main and tail" haulages working 17–20 journeys per day give load factors (based on 250 working days) of 4½–6½ per cent. Ventilating fans give a load factor of nearly 100 per cent. With pumping, the load factor depends on position and quantity of water, the best load factor being obtained when storage allows the pumping to be confined to the night shift, the pumps only being run when the haulages are not in use. By this means no extra capacity in generating plant is required for driving the pumps. Screens and conveyors have a load factor of 30 per cent. Workshops and auxiliary motors taken collectively have a load factor of 33 per cent. (load factor for individual motors being one-quarter of this figure).

The maximum sustained load on the power station reached during the last quarter has been 1,400 kw.; the output being at the rate of 4,500,000 units per annum, this gives a load factor of 37 per cent., and if a year is taken without addition of further motors, the load factor with the present methods of working would lie between 35 and 40 per cent. This high load factor is obtained by supply to seven pits, and results from the combined supply of a number of drives, many of which have exceedingly low load factors. These figures indicate the difficulty a small colliery has in converting from steam to electric driving, as the capital charges due to the low load factor, extra cost of reserve plant, and greater cost per kilowatt for small units, will result, even with cheap fuel, in much higher costs than those given in this Paper; and it is works of this description that offer the best opportunity to power companies, as it is only in cases where a considerable proportion of the power is required for pumping that an isolated pit requiring main and tail haulage could obtain a sufficiently high load factor to give low working costs when generating with its own plant.

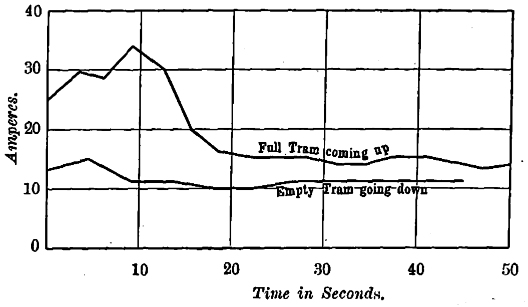


FIG. 12.—CURRENT TAKEN PER WIND.

COSTS.

*Power Station.*—Buildings, steam plant, generators, and switchboard per kilowatt of plant erected (normal rating), £11. 10s. per kilowatt; the cost of the equipment per brake horse-power outside station, transmission and distribution (overhead and underground) sub-stations, transformers, and switch gear, £2. 12s.; motors, controllers, switch gear, and gearing, per brake horse-power, £3. 18s.—£6. 10s. per brake horse-power.

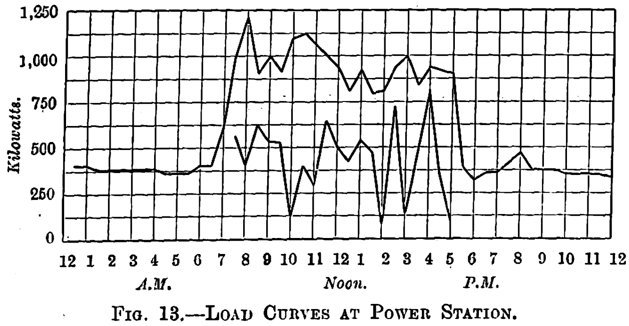


FIG. 13.—LOAD CURVES AT POWER STATION.

The cost per unit delivered to the colliery transmission lines, with an output of 4½ million units per annum, load factor of 37 per cent., using unwashed small coal (calorific value 13,000 B.Th.U.) costing 4s. 2d. per ton:—

| | |
|---|---|
| Works costs ........................................ | 0·18d. |
| Interest and depreciation 10 per cent. on power station | 0·185d. |
| Total ............................ | 0·365d. |

The reserve plant in the power station at present is 100 per cent.; this will fall to 66 per cent. when the power station is completed by the addition of a further 1,500 kw. unit, and the cost will be reduced to under 0·3d. per unit delivered to the colliery mains at a load factor of 45 per cent.

The whole of this contract has been carried out by the Electrical Company under the supervision of Mr. A. E. Hadley, with Mr. F. J. Rynd as resident engineer. My best thanks are due to these gentlemen for the assistance given me in preparing this Paper, and also to Mr. E. M. Hann, the engineer and general manager of the Powell Duffryn Co., in conjunction with whom I have carried out this work.

# A NEW SINGLE-PHASE COMMUTATOR MOTOR.*

BY V. A. FYNN.

(*Concluded from page 925*).

In introducing his Paper on the above subject at the Institution of Electrical Engineers on March 8th, Mr. Fynn showed some additional diagrams, and made the following remarks. The Paper was published in our issues of March 9th, p. 839, March 16th, p. 889 and March 23, p. 922.

In order to throw additional light on my views with regard to the phase compensation of these motors as expressed in my Paper, I will go over the same ground again, approaching the subject this time from a different direction and with the help of a few simple diagrams.

The conditions which are of the greatest interest are those prevailing in the rotor along the armature axis. Let us assume, to begin with, that the back E.M.F. (EB) is, as regards phase, exactly in opposition to the working E.M.F. (ET). The conditions then prevailing in the rotor along the armature axis are shown in Fig. 28 where TF indicates the phase of the transformer field. The motor is supposed to run sufficiently slowly for the E.M.F. (EX), which in this case is equal to (ET−EB) algebraically, to have the value indicated. Now, we know that the other two E.M.F.s (EW and ES), which must be taken into account in this circuit, are always at right angles to each other, and they will consequently meet somewhere on a half circle described about the centre of EX and having a diameter equal to EX. It is easy to see that under these conditions phase coincidence between ET and the armature current AC can only be attained when the self-induction of the rotor along that axis is zero; EX would then be in phase with AC. Supposing for the moment that ES could be eliminated, it would still be quite impossible to obtain in the primary or stator a power factor equal to unity. Of course ES can never be zero in a shunt-induction motor, no more than the rotor resistances can ever be nil, so that, for the case of Fig. 28, AC would never be in phase with ET, and this phase difference would be the greater the greater ES relatively to EW. With increasing load, EX would have to become larger; this would necessitate a decrease of EB, and consequently a decrease in speed. In the case of a shunt-induction motor this decrease would not be proportional to the decrease of EX, because in those machines the motor field also decreases with the speed, and EB depends on the latter as well as on the speed. Then, again, with increasing load AC would have to increase, not only on account of the increase in load, but also for the reason that as AC increases it also lags a little further behind ET on account of ES, which, owing principally to increasing leakage, rises somewhat faster than AC, whereas EH only increases in the same proportion with AC, if we disregard the increase in resistance due to heating. In order to fully recognise this fact it is only necessary to remember that EB is co-phasal with the motor field and that the more AC lags behind ET the more the working current gets out of phase with the motor field, and therefore the greater is the armature current required for a given torque and with a constant motor field.

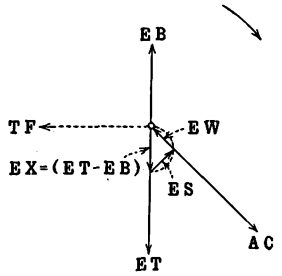


FIG. 28.

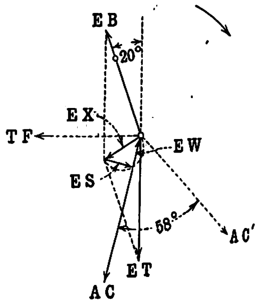


FIG. 29.

It is altogether clear that a shunt-induction motor (or, for that matter, any alternate-current motor) in which the phase difference between transformer and motor field is exactly 90 deg. can never be satisfactory. In such a motor, and without the help of external devices, the power factor can never be unity and can only be made at all acceptable by sacrificing the efficiency; further, the output for weight must be small, for AC can never be in phase with the motor field. Yet the rotary field theories advanced to explain the action of the shunt-induction motor lay stress on the desirability of as perfect a rotary field as possible; this, of course, can only be achieved when the phase difference between the two fields is exactly 90 deg. and when they are equal in magnitude.

Let us turn now to Fig. 29. The motor field is here shown as lagging by about 110 deg. behind TF; AC, EW, ES have been chosen of the same magnitude as before. This small change in the phase of the motor field brings with it a change of phase of EB amounting to 20 deg. and causes AC to move through about 58 deg. from AC′ to AC. Here we obviously have a very much more favourable state of things. Under the conditions chosen AC now leads ET, and it is clear how a corresponding and opposed component added to the stator no-load current will bring the resultant stator current nearer to the phase of the E.M.F. (E) impressed on the terminals of the motor, and it is clear also how, if desired, this resultant stator current can be made to lead E. Under these conditions unity power factor can be obtained with as small a rotor resistance as desired, and therefore without for that reason sacrificing the efficiency. It is important, however, not to shift the phase of the motor field too far in the direction indicated, for if at full load the phase of AC still lags much behind the phase of the motor field the machine will require a greater armature current for the same torque. In Fig. 29 AC is considerably out of phase with the motor field, but then the conditions in all these figures are much exaggerated in order to secure clearness, and it is quite possible in practice to secure extremely high power factors without introducing such a phase difference between AC and the motor field as to impair the efficiency. It is to be noted that whereas the phase difference between AC and ET, and AC and the motor field was practically constant in Fig. 28, it becomes variable as soon as EB ceases to be co-phasal with ET, the reason being that as EB increases or decreases, EX not only varies in magnitude but also in phase, and although at light loads AC may lead the motor field considerably, this phase difference decreases with increasing load.

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* Paper read before the Institution of Electrical Engineers, March 8th.

Now the method I have described in my Paper takes advantage of these very conditions in order to improve the power factor of these machines. In order to bring about the necessary phase displacement of the motor field an auxiliary E.M.F. is introduced into the field circuit, and this E.M.F. is preferably so chosen as to lag by about 90 deg. behind ER, which otherwise would alone be responsible for the motor field. The resultant of these two E.M.F.s sets up a field displaced as regards phase to an amount depending on the phase and magnitude of the auxiliary E.M.F.

Before leaving Fig. 29 it should be noted that over and above the advantages already enumerated the same armature current can now be obtained with a smaller reduction of EB. This, of course, means that the motor now does its work with a smaller drop in speed. Superposing EB of Fig. 28 on EB in Fig. 29 the former would only reach to the small circle indicated on the line EB in Fig. 29. It is quite obvious that much more power can be obtained from a motor working under the conditions shown in Fig. 29 than from one working under those shown in Fig. 28, not only for this reason, but also because as the load increases AC approaches the phase of the motor field instead of receding from it.

In Fig. 30 I have indicated what would tend to happen if the phase of the motor field were displaced in the opposite direction; even at no load the motor might come to a standstill, or even tend to reverse its direction of rotation. The conditions shown are, however, entirely fictitious, because EB could not be maintained at the value allotted to it in the diagram, and would drop very rapidly with the speed, thereby slightly improving matters, inasmuch as the motor would not go so far as to reverse, but would only run very slowly, much against its will, to the detriment of its commutator, and taking a large current. All this sounds very gloomy indeed for the ordinary shunt-induction motor, such, for instance, as the squirrel-cage motor, because it would seem at first sight that the conditions in Fig. 28 must necessarily prevail in such motors. Happily this is not the case, and in order to recognise this fact it is only necessary to study the no-load diagram of an ordinary transformer. This is shown in Fig. 31 and the main point to be noted is that when the E.M.F of self-induction (*es*) of the primary winding is large as compared with the E.M.F. (*er*) representing the ohmic drop in that winding, then the transformer field TF lags by *more* than 90 deg. behind the impressed E.M.F. (E). In an ordinary transformer, with its almost perfect magnetic circuit, (*es*) will be very small, but, in the induction motor for instance, this E.M.F. will be very considerably greater already on account of the necessary air-gap. Whereas in an ordinary transformer E will lead TF by practically 90 deg., in an induction motor it will lead TF by more than 90 deg. Now in the motor field axis of the shunt-induction motor, we have a transformer under no-load conditions, and the more the motor field lags behind the E.M.F. (ER), which is co-phasal with TF, the better will the motor be, not only as regards power factor, but also as regards output and efficiency. In this axis, (*er*) should be as small as possible, and (*es*) as large as possible, also the greater the phase difference between $I_0$ and TF the better. I think I can say that this is the most vital point in the design of these motors. Conditions approaching those in Fig. 30 are absolutely to be avoided; the conditions in Fig. 28 are unsatisfactory, and what the designer must aim at is to approach the conditions shown in Fig. 29 as nearly as possible. I venture to think that the whole crux of the matter lies in the phase relation between ET and EB, and there is no other theory of which I am cognisant which has brought out this most important fact.

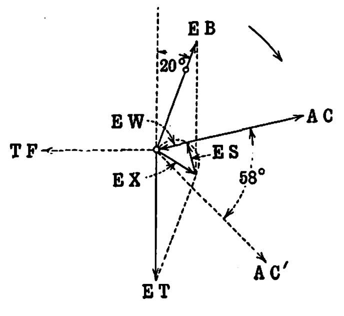

FIG. 30.

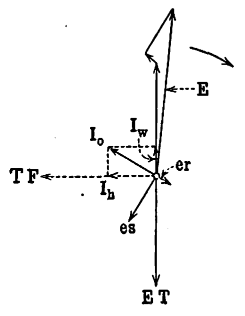

FIG. 31.

For the sake of completeness I will call attention to another point which must be taken into consideration. The conditions I have just decribed with regard to the motor field axis are practically constant for all loads, since the excitation for a shunt motor is constant, and therefore the phase difference between TF and the motor field will be constant, but in calculating the resultant phase difference between stator and current and the E.M.F. (E) impressed on the stator, account must be taken of the fact that the phase relation between E and TF varies not only with the magnitude of the load, but also with its nature. These conditions have been fully investigated for the ordinary transformer, for instance, by Steinmetz, and are set down in his book, "Alternating-current Phenomena," p. 202. The phase of the impressed E.M.F. (E) being constant, the phase of TF will have to vary, but the relative phase relation between TF and the motor field will be preserved. The phase variations I am referring to will be exaggerated for the imperfect transformer with which we are dealing.

As stated above, the phase relation between AC and ET varies with the load; it is, therefore, not at once apparent that, notwithstanding, it is possible to obtain a nearly constant and high-power factor for all loads and with a constant phase difference between ET and EB. The diagrams Figs. 32, 33 and 34 will show how this can be achieved. The three diagrams show the effect of a constant secondary current AC of varying phase on the phase difference between the resultant stator current (I) and the E.M.F. (E) for a constant stator no-load current ($I_0$). Even at no-load there must be a certain armature current flowing in the rotor along the transformer axis in order to keep the motor in motion and supply the excitation for same; it is obvious from these diagrams that AC must be a leading current if (I) is to be even nearly co-phasal with E. It might be objected that at no-load AC ought to be so small that even if it were leading ET by very much, it ought not to be able to bring (I) into phase with E. It must, however, be remembered that the more AC leads ET, the more it gets out of phase with the motor field, and consequently the more must AC increase, notwithstanding that the torque required at no-load remains constant. The result is that (I) not only decreases as the lead of AC over ET increases, but its phase comes into closer coincidence with E.

These conditions at no-load can be secured by choosing the phase relation between ET and EB indicated in Fig. 29. We have seen that the phase of AC in that diagram approaches that of ET with increasing load, a glance at Fig. 34 will show that if the lead of AC is reduced whilst at the same time its magnitude is increased, the phase relation of (I) to E will remain much the same. As a matter of fact it will vary to a certain extent, but for all practical purposes this method of phase compensation secures a phase difference between stator current and impressed E.M.F. which can be called constant, decreasing at first and then increasing with increasing load. It should also be noted that with this method of phase compensation the phase difference between EB and ET increases a little with decreasing speed, because ER decreases whilst the auxiliary E.M.F. remains nearly constant; this, of course, is an advantage, and tends to improve the power factor at higher loads. It may sometimes be necessary to make (I) lead E at no-load in order to obtain a high power factor at full load; these conditions are determined by the constants of the motor, and can be ascertained by calculation.

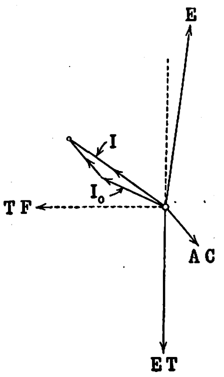

FIG. 32.

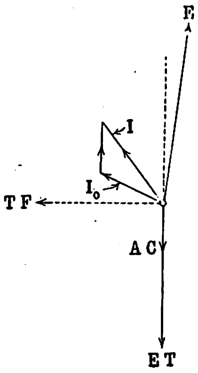

FIG. 33.

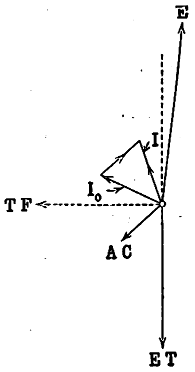

FIG. 34.

I should like to add a few words about sparking: I have shown in my Paper that the reactance voltage only need be considered under the normal running conditions of this motor; we may take it that just as in the continuous-current machine, this voltage is in phase with the armature current, and can, therefore, be counteracted by the same means—*i.e.*, by the use of commutating poles. To be absolutely effective under all loads, these poles ought to carry windings disposed in series relation to the rotor currents, the commutation of which they are to assist. This would be inconvenient for many reasons, and in practice sufficiently good results are obtained by making use of the corresponding stator current (I). Commutating poles excited in this manner will not induce E.M.F.s absolutely in phase with the reactance voltage, but this disparity of phase will decrease with increasing load and is at the heavier loads that their help is mostly needed. No kind of commutating coils will, however, help to reduce the tendency to spark at the moment of starting and at that particular stage nothing but a heavy armature current, weak motor field and resistances between commutator segments and rotor winding will be of the slightest use. Now the use of resistances between commutator and rotor winding is detrimental to the efficiency of these motors once they have attained their normal speed. We have, however, ready means at hand for reducing this harmful influence to a negligible quantity by making use of the auxiliary revolving short circuits indicated in Figs. 12 and 13. It is, therefore, quite easy to construct this particular motor for very large sizes, being able at the same time to guarantee perfect commutation.

## DISCUSSION.

Mr. Ll. B. ATKINSON, who opened the discussion, said the author had alluded in very generous terms to the Paper which he (Mr. Atkinson) read in 1898 before the Institution of Civil Engineers. At that time, however, practically all the explanations and theories of these motors rested on the idea of a rotary field, and this had retarded the progress and design of electric motors of this type, because this idea was only really adaptable to polyphase motors with symmetrically disposed currents. As long ago as 1888 he had taken out his first patent, which was clearly based on the idea of a transformer with a rotating secondary coil and with a magnetic field acting upon these wires carrying current induced in that secondary coil. A small machine of that kind was built in 1888. He recognised at that date the necessity of small air spaces, but the experiments had to be suspended because the shaft of the machine used to bend badly and touched the poles, so that not much result could be got out of it. As often happened, if a thing did not go well at first, it was put upon the shelf, and for various reasons it was not taken up again. Then there came to England from France a little shunt generator which was intended to generate continuous currents. Mr. Ravenshaw and he carried out some experiments as to how it would work with alternating currents. They found it could not be used as a series machine, and the only way they could make it work was to connect the shunt coils to the alternating supply, short-circuit the brushes and tilt them from the neutral axis. Then it ran very beautifully, although it sparked badly. At that time, also, everyone was brimful of the repulsion motor of Elihu Thomson. One of his (the speaker's) greatest difficulties was that he could never arouse anybody's interest in the type. Some people thought they could not be built. Then came the moment when the commutatorless motor filled everybody's mind, and they did not want to discuss motors with a commutator. However, he went on with this work with Mr. E. Cowan and Mr. E. Steele and others, and did a good deal of experimenting, and in 1896 and 1897 they built a motor at Manchester which would be called, in the terms of the present nomenclature, a series-inductive motor, and he had with him particulars of the tests made upon it. Its maximum power was 4½ H.P. The efficiency was low, about 65 per cent; the power factor was low also, from 57 to 70 per cent., but they got a very good starting torque. The torque corresponding to 4½ H.P. was equivalent to a weight of 18 lb. at 1 ft. radius. He had figures of one test which gave 20 lb. at 1 ft. radius with exactly the same current in the armature as when running. They had had a great deal of trouble with sparking, but all the same very good results were achieved, and on December 13, 1897, Mr. Cowan wrote to him as follows: "I think there can be no doubt that sparking troubles are at an end. I have had nice runs up to 3 H.P. without sparking. . . ." The brushes on this machine were taken out of stock belonging to a continuous-current machine. There were two reasons why the thing was dropped, however—viz., the facilities for carrying out the tests came to an end, and difficulties were experienced with the patents. Patents were taken out in England, where there was no examination. When they went to Germany for patents they were told that everything was known and that there was really nothing novel about it whatever. Consequently, only limited patents were granted. As to America, he carried on a struggle with the Examiners of Patents there for two years with regard to a patent for compensating the ends of the fields, and the final letter he received stated that they did not understand, either from the original specification or from the amendments filed, what the compensating winding was or what it was intended to accomplish. It was not seen, the letter continued, why this had no inductive effect on the armature nor how it could regulate the phase of the current. Its objects were not understood, he was told, and "until the applicant complied with the requirement of a full, definite and intelligible description of his invention, the examiner is unable to take any action on the merits." Turning to Mr. Fynn's Paper, he said that the author had succeeded by exceedingly clever design, in getting over sparking difficulties. In the second place, the author had succeeded in solving in a remarkable way the combination of a compensated motor—one in which the power factor was brought to unity without condensers—along with motors giving good torque at starting and good efficiencies. The idea of putting on an additional field was new at the time he himself was working at the problem and he had tried to do it in the way Mr. Fynn had referred to—viz., to bring the primary current into phase with the primary E.M.F.; to give the secondary current a lead by directly, as it were, acting on it. The difficulty was that, as the lead varied, the compensating effect had to be varied very considerably to do it, and it was difficult to get this variation. The author had not tried directly to bring the secondary current in phase with the primary current, but he had altered the phase of the motor field. He did not think the Paper exhausted the possibilities of this motor, however.

Mr. W. M. MORDEY said he had been able to test some of the author's machines when he happened to be in Switzerland at Christmas. On his way home, by the kindness of Messrs. Alioth and Mr. Fynn, he stopped at Basle and saw some of Mr. Fynn's motors in the works there. He found that a machine which was run with fixed brushes, under the conditions of an ordinary shunt motor, at a load of 6 H.P. and at 1,430 revs. per min., gave a power factor of 95 per cent., and at 12 H.P., when the speed had dropped only by 100 revs. per min., the power factor was 94 per cent. That would be a very good performance for a direct-current machine. The efficiency was low, 66 or 67 per cent. At no load that same machine had a power factor of 93 per cent. The commutation was as good as in an ordinary direct-current motor, and at the overload quite as good as a direct-current motor overloaded to the same extent. The starting torque he had not tested himself, but he saw a good many references to tests, which showed that the full-load starting torque was obtained with about the full load current. The low efficiency was about the only unfavourable point about the machine. 66 or 67 per cent. was not a high efficiency for a 6 H.P. machine, but a high efficiency was not always obtained even with direct-current motors for that power, and on this question of efficiency he thought they ought to be thankful for what they had got, and that by using alternating currents the energy could be sent to the motor with less loss than, under many conditions, with direct current. The causes of the low efficiency were now receiving attention, and he would like to say that none of the ordinary induction motors that were being sold largely in this country, for either one, two or three phases, had anything like the efficiency they ought to have, and in many cases the losses are needlessly high. In the case of commutation motors there were the additional losses under the brushes. In these days of very high densities—20,000 lines per sq. cm. or more—it was of advantage to reduce the thickness of the iron stampings. People had made a stand against using iron less than No. 28, or 0·0134 in. But a thickness of 0·01, or even less, was quite practicable. The following figures showed that the losses at a density of 10,000 line per sq. cm. and 50 ∽, and for a thickness of 0·008 in. were 1 watt per lb.; for a thickness of 0·026 in., 2 watts per lb. These losses were low even in ordinary direct-current work. With the higher densities to keep the machines down in size, the losses might be 5 or 10 watts per lb., but these could be very largely reduced by using thinner iron.

Mr. F. CREEDY said he had read Mr. F. Fynn's Paper with the greatest interest, as he had been working for practically a twelvemonth in conjunction with the Rhodes Electric Mfg. Co. upon exactly the same subject—viz., the production of a satisfactory constant-speed single-phase commutator motor. He had encountered precisely the same difficulties as Mr. Fynn, and had sought relief in very nearly the same way. For the past 10 or 11 months he had been employing for lift work motors of the type shown in Fig. 5 of the Paper, converting them when running into induction motors by means of slip-rings in the usual way. It had not been found necessary to use a variable number of turns on the field coil $S_2$ as several stops in the controller were not needed, and it was amply sufficient to design the field and transformer coils to give the specified torque while taking not more than the specified current. The controller was still further simplified if the field and transformer coils were left in series while running as well as while starting. This produced no ill effect, as it only shifted the transformer field through the angle $\alpha$. Mr. Fynn's figures for the starting torque represented very well the results he had been obtaining, erring if anything on the side of moderation, with the coils $S_1$ proportioned for full-load running in series with $S_2$. With special designs, however, it was possible to get twice full-load torque with less than full-load current, or three, four, or five times full-load torque with two to two and a-half times full-load current. On the question of starting torque, he saw no reason why Mr. Fynn's series motor, Fig. 27, should have a torque greatly in excess of that obtainable by a proper design of Fig. 5. In Fig. 27 the field winding was on the rotor, and there was no leakage between the field and the armature circuit. This, of course, was an advantage in small motors, and was the obvious cause of the improved torque obtained with motor No. 3, which naturally, as an 8 pole 6 H.P. machine, would have a high leakage factor. In designing a suitable compensating arrangement for small motors one had to consider these two practical points: (1) The undesirability of using a complicated stator winding requiring a complicated controller; and (2) the impossibility, due to the small diameter of the commutator, to have the brushes at small angular distances apart. This necessitated the use of a wave winding. In small motors one need not use more than two brushes per rotor circuit. For these reasons an arrangement of five equally spaced brushes on the commutator had been adopted by him, as shown in the diagram. Five brushes at 72 deg. had the unique property of being equally adaptable for two, four, six or eight poles, as could easily be seen on working out the spacing. The connections and controller for such a compensated motor were as shown in the diagram. It could be started in one or the other direction by joining brush A to one of the opposite brushes C or D, the other two brushes B and E being open circuited. When up to speed B and E were joined to two of three tappings on the stator coil, producing a suitable E.M.F. for compensating, while A was joined to the remaining brush D or C. In practice these changes of connections were effected by a double-pole two-way switch, and a three-bladed centrifugal switch, practically the same controller being required as for the uncompensated motor with slip-rings. The results obtained with these motors were very similar to those of Mr. Fynn. Lastly, he would like to offer a few remarks on the commutation of these motors, especially at very high frequencies. No difficulty occurred with the commutation of these machines, at any rate up to 20 H.P. His firm had used single-turn bar windings of the two arc type throughout (except in the smallest sizes) even up to the 20 H.P. and 100 ~ per second. This applied to a motor with slip-rings. They had as yet no experience of 20 H.P., 100 ~ motors without slip-rings, but he did not anticipate any difficulty, as the starting

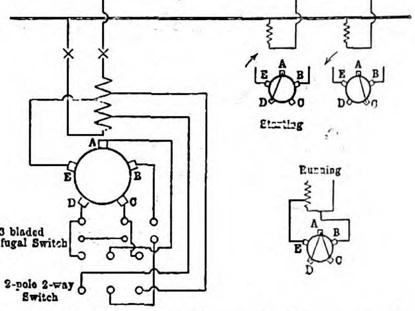

FIG. 35.—ARRANGEMENT OF CREEDY'S REPULSION MOTOR.

period was universally acknowledged to be the most critical, and a motor which would start up and accelerate under load sparklessly as the slip-ring motor did, would usually run sparklessly at full load. He need hardly say that such unmechanical devices as high resistance commutator connections were quite unnecessary in any properly proportioned rotor. In small machines, such as those whose tests Mr. Fynn described, extraordinary liberties might be taken with the commutation. He had succeeded in getting good commutation on a 1·5 H.P. four-pole 50 ∽ machine having no less than six turns per commutator section, though he did not recommend the practice. He had even used copper gauze brushes on several small machines of about this size.

Mr. C. F. **JENKIN** thought a little more attention might have been drawn in the Paper to the fact that there was nothing new in the starting of the motor as a repulsion motor, and that Mr. Fynn's motor, at starting, had all the defects of the repulsion motor. These defects were common to all commutator motors—viz., they were due to the transformer effect of the current in the short-circuited coils. These would exist in Mr. Fynn's motor exactly as in any other. At the end of the Paper the author made a sudden and complete rearrangement of his connections in Figs. 27 and 28, and the result was to get a compensated repulsion motor—*i.e.*, the ordinary Latour or Winter-Eichberg motor. If the series characteristic which the author promised was merely the arrangement shown in the last figures of the Paper, then, of course, there would be nothing new in it. It would be merely an ordinary compensated repulsion motor—a very good motor, but nothing better than what we had already. In this connection he would like to mention that Mr. Eichberg had, in an article published in the *Elektrotechnische Zeitschrift*, of January, 1904, shown the connections for the compensated repulsion motor which would make it work as a constant-speed motor.

Mr. H. M. **HOBART** said Mr. Mordey had spoken of a 6 H.P. motor which he tested at Basle, which had an efficiency of 67 per cent. This meant 33 per cent loss. An ordinary 6 H.P. polyphase or continuous-current motor would have 84 per cent. efficiency, or a loss of 16 per cent.—*i.e.* half the former value. Therefore, if the means for ventilating were about the same same in both designs, and the specified temperature rise the same, then the single-phase motor would have to be something like twice the weight of the continuous-current or polyphase motor. Hence, until greater improvements were effected, they had to pay about $1\frac{1}{2}$ times more for a single-phase motor than for a continuous-current or polyphase motor of the same output and speed. But the single-phase motor would be less economical, due to its lower efficiency. He had prepared the diagram below to show the weight of various types of motors at various periods.

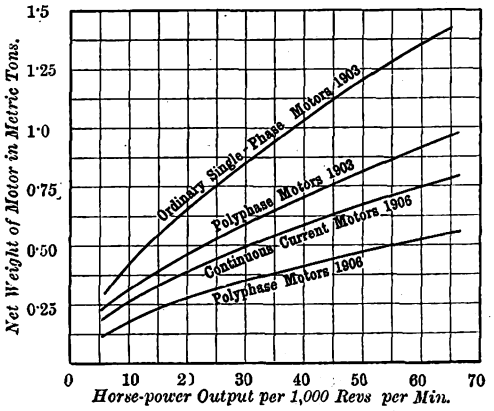

FIG. 36.—CHART SHOWING THE COMPARATIVE WEIGHTS OF ALTERNATING-CURRENT AND DIRECT-CURRENT MOTORS.

Open protected type stationary motors. Ultimate temperature rise by thermometer=45°C. Weights do not include pulley and slide rails. One metric ton=2,200 lb.

Mr. V. A. **FYNN**, in replying to the discussion, said he had to admit that single-phase motors did stand behind continuous-current machines in respect to efficiency, and he did not see for the time being how it was possible to get over that particular difficulty to any great extent. In these motors there was one—if not two—alternating fields which produced losses throughout the whole of the frame. Even if it were possible to cut down the transformer field it was necessary to have a motor field. He had made some 60 H.P. motors which gave an efficiency of 86 per cent. at full load. He did not think that an alternating-current machine would ever come up to a continuous-current machine in efficiency. At the same time, a good alternating-current machine ought not to be more than 4 or 5 per cent., or at most 6 per cent. behind. He agreed with Mr. Jenkin that his motor started as a repulsion motor, and the sudden rearrangement about which Mr. Jenkin spoke did certainly come very close to the Winter-Eichberg machine. In fact, if in Figs. 27 and 28, the $S_2$ winding were omitted, it would simply be the Winter-Eichberg machine. But although this $S_2$ winding looked a simple affair it was a very important feature with a small machine such as was used for lift work. If they did not use an $S_2$ winding it was quite impossible to start the motor gradually; it had to be banged on to the circuit or else transformers had to be used. But the price of these motors was important, for in many cases they had to compete with continuous-current motors, and any additional apparatus outside the motor was rather an important point in this connection. And that was why this simple addition was of great importance. The only difference between the Eichberg motor as described in the *Elektrotechnische Zeitschrift* and his, was that his (Mr. Fynn's) motor was a 1902 motor while the Eichberg was a 1904 motor. He could not agree with Mr. Creedy that in Fig. 5 the effect of leaving the $S_2$ winding in circuit was not deleterious. He had tried this experiment over and over again, and found that it had a most distinct effect. If, as he supposed, Mr. Creedy did not use any tappings with the $S_2$ winding, and that he started his motor by reducing the voltage or something similar, or banged it on to the mains, there must be rather a big rush of current. (Mr. **CREEDY**: Not more than 50 per cent. overload.) Some of the companies might object very strongly, and his particular $S_2$ winding was got out for the very purpose of avoiding this contingency. He had pointed out in the Paper why and how this $S_2$ winding reduced the efficiency of the motor. All these motors, including the Winter-Eichberg and his own, suffered under the drawback that the armature carried not only the armature current but also the field current. The result was that the armature got very hot indeed, and it would be a very good thing if a motor could be constructed which only carried the armature current in the armature. He believed that he would shortly be able to place before the public a motor of that description. Mr. Creedy had asked whether the series winding was to be preferred to the parallel. Decidedly the latter was of very little use with these machines. It was difficult, indeed, to balance all the circuits, and almost impossible to compensate such a machine. With regard to resistances in the commutator leads he certainly made use of them, but only in the larger machines. There was always the danger of burning them out, but as they were only used for a very short time, and then only at starting, this was very much reduced. This was so because (as in Fig. 12), by making use of rotary short-circuits or slip-rings, the greater part of the current took its way over these short-circuits, and so relieved the commutator and consequently the resistances. With regard to Mr. Creedy's diagram, he did not quite see the difference between that and the motor he himself had described. There were a different number of brushes, but otherwise it was very much the same. If they took a motor of that sort and short-circuited it along the two axes, one coinciding with the transformer axis and the other with the field axis, they turned it into an induction motor. If it were short-circuited along three axes it was still an induction motor, and along six or any number of axes the result was always the same. By increasing the number of short-circuits they were only approaching the conditions existing in the ordinary squirrel-cage motor.

## THE WIDNES AND RUNCORN TRANSPORTER BRIDGE.*

BY J. J. WEBSTER.

As the only convenience for vehicular traffic between the Lancashire and Cheshire sides of the River Mersey was by means of the cumbersome ferries at Liverpool, or by the bridge at Warrington, considerable inconvenience was experienced by manufacturers, farmers and others on both sides of the river; and in 1817 Telford was asked to design a suitable scheme for crossing the river at Runcorn. He proposed a suspension bridge, of 1,000 ft. span, having a 30 ft. roadway; but the scheme was never carried out. Several other schemes for bridges and tunnels have since been proposed, but in each case the cost has prevented the scheme from being proceeded with.

Application was made to Parliament for powers to construct a transporter bridge between Widnes and Runcorn, and after much opposition the act was obtained in July, 1900; a company was formed, strongly supported financially by the Corporations of both Widnes and Runcorn; and the contract for the work was let in November, 1901. The principle of the transporter bridge was designed by Mr. Charles Smith, of Hartlepool, who in 1873 planned one to cross the River Tees at Middlesbrough. This was not constructed, but similar bridges have been erected at Bizerta, Portugalete, Rouen and Rochefort, and one on this principle is now being erected at Newport, Mon.

The Widnes and Runcorn bridge crosses the River Mersey and the Manchester Ship Canal with one span of 1,000 ft. and approach viaducts, 35 ft. wide, on both sides of the river. The bridge is similar in construction to an ordinary cable-stiffened suspension bridge; but instead of the costly high-level approaches, the traffic is carried across by means of a car suspended from a trolley running on the underside of the stiffening girders, and driven electrically.

The cables are supported by two towers on each side of the river, the towers being square in plan, with braced legs at each corner having a curved profile; the width at the bottom is 35 ft., and at the top 9 ft., the height from high-water line to the centre of the cables being about 175 ft. Each pair of towers is braced together with two double-braced curved girders at the top, and at the level of the top of the stiffening girder. The towers rest upon four cast-iron cylinders, 9 ft. in diameter, which are founded on the rock.

There is one cable from tower to tower, each cable carrying a stiffening girder, 19 ft. deep, hinged at the centre. Each cable has an area of 50 sq. in. made of 19 strands laid parallel, and clamped together; the steel wires (0·162 in. in diameter) having a breaking strength of 95 tons per square inch. The cables are attached to forged steel cross-heads, to which are coupled the steel links taken down to anchor-plates in pits excavated in the rock and filled in with concrete.

The suspenders from the cables to the stiffening girders are steel wire ropes $1\frac{3}{4}$ in. in diameter, spaced 18 ft. apart, and are coupled to bridles attached to the cast-iron clips of the cables. The cables are coated with a bituminous compound, and wrapped with two layers of strong sailcloth saturated with the same solution. A number of experiments were made with different forms of steel ropes and connections, details of which are given in the Paper. Some interesting experiments were also made with steel pins, the results of which show that in designing pins for bridgework, although they would fail by shear, they should be designed to withstand the bending-moments.

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* Abstract of a Paper read before the Institution of Civil Engineers on March 13th.

The car trolley, which runs on rails on the bottom flange of the stiffening girder, is 79 ft. long, articulated in five sections, and 4 ft. 10 in. deep; there are bogie wheels on each side 18 in. in diameter. The motive power consists of two electric motors of 36 B.H.P., each driving, through gearing, one pair of wheels. The trolley is fitted with electric and hand brakes, the whole of the machinery being under the control of the man in the cabin at the top of the car. The car is 55 ft. long and 24 ft. wide, and travels at a speed of 7 miles per hour.

The generating machinery is contained in a building at the bottom of one of the Widnes towers, and consists of two gas engines of 75 H.P. each (one being spare), two dynamos of 48 kw. capacity (one being spare), one booster, and an accumulator with a battery of 245 cells. The machinery supplies the necessary current for driving the car and illuminating the structure, and was designed in consultation with Dr. Edward Hopkinson.

The total cost of the structure, including the cost of obtaining the act, was about £130,000.

The engineers for the work were the author and Mr. John T. Wood, M.Inst.C.E., the resident engineer being Mr. L. H. Chase, M.Inst.C.E. The contractors for the masonry, &c., were Messrs. W. Thornton & Sons, Liverpool; the contractors for the superstructure were Messrs. Arrol's Bridge & Roof Co., the cables being constructed and erected by the St. Helens Cable Co. The electric machinery was constructed and erected by Messrs. Mather & Platt, of Manchester.

## PHYSICAL SOCIETY.

At a meeting of the Physical Society on March 9th, Dr. C. Chree, vice-president, in the chair.

Prof. H. A. Wilson read a Paper on

**"The Velocities of the Ions of Alkali Salt Vapours at High Temperatures."**

This Paper contains a summary of previous work on the velocities of the ions of alkali salt vapours in flames and gases at high temperatures. It is shown that all the results so far obtained are consistent with the view that any salt of cæsium, rubidium, potassium, sodium, or lithium gives in a Bunsen flame negative ions having a velocity of 1,000 cm. per second for one volt per cm., and positive ions having a velocity of about 80 cm. per second. This result can be explained by supposing that each salt molecule emits a negative corpuscle which forms the negative ion, and that the rest of the molecule forms the positive ion.

Mr. D. OWEN asked Dr. Wilson how, in reference to the theory that the positive ion is the salt molecule minus an electron, he accounted for the fact, shown in his experiments, that the velocity of these ions was independent of their mass.

Dr. WILSON remarked that the positive ion probably acted as a centre of condensation and formed an aggregate of molecules whose size depended only on the positive charge.

Dr. J. A. Harker read a Paper on

**'Some Experiments on Earth Currents at Kew Observatory."**

Dr. Harker gave an account of experiments made some years ago at Kew Observatory on the earth currents produced by electric traction schemes, and on the disturbances they cause on the self-recording magnetic instruments which are kept continuously running there to register the variations in the declination and the horizontal and vertical forces. For these experiments two large earth-plates were buried in the ground about 4 ft. deep and 200 yds. apart. These were connected through a photographic recording voltmeter of high resistance. On the traces given by this instrument the effect of the trains on the Central London Railway was strikingly shown, and specimen records exhibited clearly indicated the time-table of that railway and also any accidental breakdowns. The nearest point to Kew, namely Shepherd's Bush, is about 6 miles distant. The same disturbances, and also those due to special traction experiments carried out on the system of the London United Electric Tramway Co. during the period when the Central London Railway was shut down, were also clearly shown on magnetograph curves. The effects are much greater on the vertical force than on the horizontal force or the declination, the latter being only slightly affected. A second system of investigation was to connect the earth plates through the primary of a transformer, the secondary terminals of which were connected to sensitive moving coil galvanometer of suitable period and damping. Under these conditions the galvanometer recorded a ballistic throw for each movement of a tramway controller, while the slower variations due to magnetic storms and other causes were without effect. A telephone similarly connected gave a perceptible sound for each controller movement.

Dr. CHREE expressed his interest in the Paper, and remarked that Dr. Harker had shown how magnetic records were disturbed by earth-currents due to electric-traction schemes some years ago. The state of affairs at the present time was very much worse, and the vertical-force records were so disturbed as to be useless. The author's curves showed that there was a quiet time at night, and Dr. Chree suggested this time for the determination of the absolute values of the magnetic elements.

## THE NATIONAL PHYSICAL LABORATORY.

The annual meeting of the General Board of the National Physical Laboratory took place at Bushy House on Friday, March 16th, Lord Rayleigh in the chair. The report of the executive committee for 1905 and the scheme of work for 1906 were approved.

After summarising the work done in the researches on wind pressure and resistance of materials to alternating stress and the steam researches carried out by Mr. Jakeman, the report stated that progress has been made in a number of researches in the physics department. Mr. Smith has completed the ampere balance, and Prof. Ayrton and Mr. Mather have carried out with him a series of determinations of the E.M.F. of a cadmium cell, in terms of the international ohm, and of the amount of silver deposited by a current of 1 ampere in a silver voltameter. The results are highly satisfactory. It is, perhaps, sufficient to say that 50 determinations of the E.M.F. of the cell have been made and the greatest difference between any two is only 3 parts in 100,000. The result for the electro-chemical equivalent of silver depends upon the form of voltameter used, and the accuracy attained, though not so great as in the case of the cell, is far in excess of anything needed for practical work. Mr. Smith is now engaged in some subsidiary experiments on the voltameter. It is hoped that when these are completed, a Paper may be prepared giving details of the work. Among other interesting electrical investigations may be mentioned Mr. Campbell's experiments in the use of cast iron for magnets and on the inductive capacity of paper; difficulty in obtaining suitable material has led to delay in the hysteresis research. This has, however, in a great measure been overcome. Mr. Rayner's researches into the dielectric strength of various insulators, and the distribution of temperature in field coils and in transformers afford valuable data to the electrician and cannot fail to be of real use.

In the thermometric division, Dr. Harker has extended his work on high-temperature furnaces; his application of the cascade principle of heating to these furnaces has proved very fertile. The small furnaces first constructed were described in a Paper read early in the year before the Royal Society. These led to a re-determination of the temperature of the melting-point of platinum, which was found to be 1,710°C. ±5°C. Some experiments by Profs. Holborn and Henning, at the Reichsanstalt, published in 1905, give the figure 1,710 deg. Thus it seems clear that the value 1,780 deg. usually accepted is 70 deg. too high.

Reference was made to Dr. Harker's work on the specific heat of iron at high temperatures, and the investigations carried out for the Engineering Standards Committee on standardisation of shafts and journals and the inquiries on screw threads.

In the metallurgical division, the nickel steel research of Dr. Carpenter, Mr. Longmuir and Mr. Hadfield was concluded during the early part of the year.

In the chemical department, Dr. Caspari has continued his work on the chemistry of the hydrocarbons of gutta percha, balata and caoutchouc, undertaken for the India Rubber, Gutta Percha & Telegraph Works Co. A Paper dealing with this was read before the Society of Chemical Industry, and a further research into the crystallisable constituents of balata resin has been begun.

There have also been a number of investigations undertaken for private firms or public bodies, including an investigation by Dr. Harker for Messrs. Johnson & Matthey on the thermoelectric properties of some extremely pure platinum and platinum alloys, the determination of the heating and cooling curves and critical ranges of a series of nickel steels, certain investigations on pressure gauges, started at the suggestion of the Manchester Steam Users' Association, and a series of tests of various materials used in lagging steam pipes.

An important inquiry was also carried out on behalf of the Institution of Gas Engineers on the relation between the candle-powers of the Pentane, Hefner and Carcel lamps, while a series of comparative tests of arc-light carbons of English and foreign manufacture led to satisfactory results. A number of tests have been declined, some of these for want of sufficient equipment, and others as being outside the scope of the laboratory.

The report announced the intention of the Government, communicated to the Royal Society in December last, to grant a sum of £5,000 for buildings during the year and the increase of the annual grant by £500. It referred also to the very successful meeting in the House of Commons last August, under the chairmanship of Mr. Haldane, which led up to a petition signed by 150 members of the House asking that the grants should be increased, and the chairman was able to announce that the Chancellor of the Exchequer had recently intimated his intention of of making the building grant for the year £10,000 instead of £5,000 as originally contemplated. It was also stated that the Goldsmiths' Company had very generously made a donation of £1,000, with the request that it should be devoted to some specific object.

It is hoped that the new electrical buildings may be opened on June 25th, on the occasion of the visit of the foreign guests of the Institution of Electrical Engineers. The scheme of work for 1906 includes a research into the resistance of materials of construction to impact, the continuation of the wind pressure and steam researches, the completion of the work with the ampere balance and some experiments of great interest on the effect of the continued application of high pressure to insulators. In the metallurgical division a research into the properties of aluminium bronze promises interesting results.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

*Effect of Heat on Radium Emanation.*—Curie and Danne showed that the rate of decay of radium C can be altered by subjecting it to a temperature of 630°C. Bronson, on the other hand, states that heating to temperatures between 700 deg. and 1,100 deg. is without effect. W. Makower has investigated the influence of temperature on the activity of radium emanation when in radio-active equilibrium with radium A, B and C, and when sealed up in a quartz tube so that there can have been no possibility of the escape of any volatile product. The results show clearly that the activity as measured by the $\beta$ and $\gamma$ rays can be changed by high temperatures, the observed effects being consistent with the explanation offered by Curie and Danne, that the rate of decay of radium C is increased by high temperatures. The experiments do not, however, prove that it is this particular product which is affected, as the results could be equally well explained if one or more of the other radio-active bodies present underwent some alteration. Further experiments will be necessary before this question can be definitely settled, but there can be no doubt that the rate of decay of one of the products is affected by temperature. The effect increases with the temperature up to 1,200°C. and with the time of heating, but not after the first hour.

[W. Makower, *Proceedings*, Royal Society, 516, March 6, 1906.]

*Heavy Canal Rays.*—To account for the large masses of canal-ray particles, E. Gehrcke supposes that they consist originally of metallic particles liberated by the disintegration of the cathode, and charged positively by the loss of electrons under the influence of ultra-violet light. They are expelled from the cathode with a negative charge, but this is soon lost and converted into a positive charge, whereupon the particles are driven back towards the cathode. The varying size of the expelled particles accounts for the magnetic "spectrum" observed by Wien. The circumstance that the particles are derived from the metal, and not from the gas, explains why the material of the canal rays is able to exceed the total gaseous contents of the vacuum tube, and also why the mass of the canal-ray particle may be as much as 650 times that of the hydrogen atom. These particles are large enough to be made visible by the ultra-microscopic method devised by Siedentopf and Szigmondy. That they occur in front of the electrode was already known to Goldstein, and their slow motion there is accounted for by their having to proceed for some distance against the electric force. When proceeding with it, they must show the Doppler effect discovered by Stark. The process by which the cathode disintegrates is still obscure. It is not solely due to the electric field, since disintegration may be produced by simple heating.

[E. Gehrcke, *Physikalische Zeitschrift*, March 15, 1906.]

*Nature of Osmotic Pressure.*—A. Battelli and A. Stefanini incline to Traube's view, which attributes all osmotic phenomena to differences of surface tension. They do not, however, hold that the liquid always passes from the side of lesser to the side of greater surface tension. They substitute the principle that the liquid always proceeds in such a manner that the surface tensions on both sides of the membrane are equalised. They quote experiments with water and alcohol, separated either by an animal membrane or a semi-permeable membrane of nickel ferrocyanide or porous earthenware. That liquid diffuses most quickly which, with an equal number of molecules, produces in the other the smallest change of surface tension. In the case of alcohol and water, the reduction in the surface tension of water by the addition of one molecule alcohol to N molecules of water is larger than the increase of the surface tension of alcohol by the addition one molecule of water to N of alcohol. Water, producing the smaller change per molecule, is the more active in diffusing through membranes. Solutions having the same surface tension are always in osmotic equilibrium even when they are not equimolecular, as, for instance, a 1·11 per cent. solution of $K_2SO_4$ and a 1·78 per cent. solution of $M_gSO_4$. The authors conclude against the probability of osmotic pressure being purely kinetic.

[Battelli and Stefanini, *Physikalische Zeitschrift*, March 15, 1906.]

*Phosphorescence.*—A. Debierne advances a theory of phosphorescence based upon thermoluminescence and the colouration of phosphorescent bodies by the radiation which excites them. Many phosphorescent bodies are coloured during phosphorescence. This colouration is attributable to the formation of a new body, which persists after phosphorescence has ceased. When, however, the phosphorescent body is heated up to a certain temperature, the new body is decomposed, and gives up the energy consumed in its formation in the shape of thermoluminescence. When no colouration is produced, and there is yet a thermoluminescence, it may be assumed that the new body is colourless, or has the same colour as the original body. When there is no thermoluminescence the probability is that the new substance is decomposed as fast as it is formed. This theory embraces all the facts of luminescence under a single aspect. It is well known that most phosphorescent substances are mixtures in which the real phosphorescent body is present in very minute proportions. It is this body that is sensitive to the exciting radiation. It may be transformed into several different bodies according to the exciting radiation used.

[A. Debierne, *Comptes Rendus*, March 5, 1906.]

*Battery for Electrostatic Measurements.*—F. Krüger describes a battery of small standard cells suitable for electrostatic measurements involving potentials up to 100 volts. Each cell is 5 mm. wide and a few centimetres high. A platinum wire passes through the bottom into the cadmium amalgam, which is covered with finely-powdered cadmium sulphate. This is surmounted by wadding soaked in a saturated solution of cadmium sulphate, followed by mercurous sulphate paste and a few drops of mercury into which the second platinum wire dips. The cell is sealed with marine glue. The battery is mounted on ebonite, and is divided into five sets of 20 cells each. Its internal resistance is 0·1 megohm.

[F. Krüger, *Physikalische Zeitschrift*, March 15, 1906.]

*Polarisation of Secondary Röntgen Rays.*—C. G. Barkla has succeeded in proving the polarisation of secondary Röntgen rays by choosing carbon as s secondary and tertiary radiator. A thick square plate of carbon was placed near an excited X-ray tube so as to be subject to a primary beam of considerable intensity. It was then the source of a secondary radiation, the total energy of which was quite a large fraction of the energy incident upon it. A beam of this secondary radiation proceeding in a direction perpendicular to that of propagation of the primary falling on the carbon was studied. In this secondary beam was placed a second plate of carbon, and the intensities of tertiary radiation proceeding in two directions at right angles and perpendicular to the direction of propagation of the secondary beam were observed by means of electroscopes placed in its path. The X-ray tube was turned round the axis of the secondary beam, while everything else was fixed, and the relative intensities of the tertiary radiations observed for different positions of the tube. It was found that the intensity of tertiary radiation reached a maximum when the directions of propagation of the primary and tertiary were parallel, and a minimum when they were at right angles, showing the secondary radiation proceeding from carbon in a direction perpendicular to that of propagation of the incident primary to be polarised. The results show that the amount of polarisation was enormous in comparison with what had been found in the primary beam proceeding direct from an X-ray tube, and indicated almost complete polarisation of the secondary beam. Such polarisation cannot be traced in iron, since the electrons are there no longer mutually independent.

[C. G. Barkla, *Proceedings*, Royal Society, 516, March 6, 1906.]

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## ELECTRIC POWER SUPPLY IN LONDON.

It is a matter for extreme regret that the important question of electric power supply in London should have become subsidiary to the never-ending fight between municipal and private trading interests, and that it should finally have come to be regarded as a matter of party politics. This was clearly revealed in the debate which took place in the House of Commons on Monday night, and is reported in our Parliamentary columns. Four London electric power Bills were deposited this session: the Administrative County of London Co.'s Bill, which is practically identical with that which was brought before Parliament last year, and seeks sanction to supply electric power over the whole of London and suburbs either through existing supply authorities or directly in certain circumstances; the Additional Electric Power Supply Co.'s Bill, in which it is proposed to erect a large generating station at St. Neots for furnishing electric power to a number of railways and "in bulk" to any of the existing supply undertakers; the Charing Cross, West End and City Electricity Supply Co.'s Bill, seeking an extension of area for power supply purposes under similar conditions to the Administrative Company; and, lastly, the London County Council Electric Power Bill, which seeks power for the Council to supply electrical energy in "bulk" over the whole county of London and a wide area surrounding it. The main issue, however, is practically between the Administrative Company and the London County Council, for there are indications that the Charing Cross Company's Bill will eventually be limited to the "linking-up" clauses, similar to those which are being brought forward by the other electricity supply companies in London, while the promoters of the Additional Bill attach greatest importance to the portions which are of the nature of a confirmation of the agreement made with the Great Northern Railway, and give power to enter into similar arrangements with other railways for the supply of electricity. On this account, the Charing Cross Bill is to be taken later on together with the Bills of the other existing supply companies, and the consideration of the Additional Company's Bill was also postponed, so that only the L.C.C. and the "Administrative" Bill came up for second reading debate on Monday. In ordinary circumstances, two Bills such as these would have passed their second reading with but slight opposition and be considered in detail by an impartial Committee in the ordinary course. But this did not suit the members of the London County Council, who exert considerable influence on the Ministerial side of the House of Commons, and a movement was on foot to throw out the company power Bills on second reading. The promoters of the companies' bills knew that their best chance would be to act on the offensive instead of on the defensive, and obtained considerable support on the Opposition benches to a motion for the rejection of the London County Council Bill. Thus, as we have said, the debate followed party lines, and in fact the Government officially supported the County Council Bill, and have declared their intention of sending it to a "Hybrid" Committee in order that its clauses may be investigated. A "Hybrid" Committee is a "cross" between an ordinary impartial and unprejudiced Private Bill Committee selected by the Committee of Selection, and a "Select" Committee of the House in which members are chosen by the party whips. It will in all probability consist of five members chosen by the Committee of Selection of the House of Commons and four party members nominated by the party whips. If this is the arrangement, the pair of members from each side of the House would neutralise one another in the divisions, and the five non-party men will control the voting; but if the converse were to be the case, and there are five members selected by the House and four by the Committee of Selection, the Hybrid Committee will not have the same judicial character. A statement with regard to the composition of the Committee is therefore awaited with interest. The Committee will have power to pass, modify or reject the London County Council Bill; but although the promoters of the other power Bills are to have a locus standi before the Committee (that is to say, they will have the right to be represented by Counsel and to call witnesses) their Bills are not before the Committee. In addition to the consideration of the London County Council's proposals, the Committee will be instructed to report generally on the question of electric power supply in London, and will have power to call additional witnesses—even, as was pointed out in the House, members of the Finance Committee of the London County Council, which represents a strong minority of the Council, opposed to the Bill. In the meantime it is probable that the Administrative County of London Co.'s Bill will remain suspended between first and second reading until the Committee reports.

Whatever may be the result of the Committee's deliberations, however, the chances are unfavourable to any of the competing Bills passing through Parliament this session. The Hybrid Committee will hardly commence its activities before Easter, and even if it were to pass the London County Council Bill, this would still have to go through the ordeal of a third reading debate in the Commons and to go through all its stages in the Lords. Until broader views prevail, and the subject can once more be considered solely on its merits and in a manner purely devoid of party bias, the prospects of cheap electric power supply in London will not be materially improved. In the meantime we can only hope that the consideration of the proposals to improve the position of the present electricity undertakers by empowering them to give one another mutual assistance and build large joint electricity works on economical lines will not also be deferred until the report of the Hybrid Committee, and that the clauses in these Bills and in the Bills of the new companies relating to the supply of electrical power to railways will be passed also.

## REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign book.

◆

**High-Tension Magneto-Ignition Systems.** 4th edition. (London: F. King & Co.) 2s. net.

This publication is a collection of reprints of descriptions of various forms of ignition apparatus from our contemporary the *Automotor Journal*, and forms Nos. 1 and 2 of the "Automotor Library." The first part opens with a short introduction on ignition of petrol engines in general, pointing out how the old lamp and hot tube system was soon replaced by electric ignition, at first with accumulators and coils and later by means of the magneto-generator. The battery and coil method is explained in the cumbersome manner considered necessary for the non-electrical motorist, the example chosen being the single-coil system with high-tension distributor which is now frequently employed in place of separated coils with multi-cylinder engines. Following this, we have a description of a typical "low-tension" magneto-generator such as is employed in systems where a spark is simply produced by breaking a circuit by mechanical means within the cylinder, and some very clear illustrations are given showing, by means of iron filings, the distribution of magnetism in various positions of the armature or inductor. The function of the "high-tension" magneto, which simply supplies current at the right moment to an induction coil, is then explained, and the difficulties experienced in designing an arrangement to vary the positions of the distributor and armature correctly and simultaneously in order to alter the timing of the spark to suit the speed of the engine are recounted. Several of the well-known forms of high-tension system are described, and excellent illustrations of the various parts are provided. One or two forms dealt with in the earlier pages have been lately superseded by more recent patterns which are described in the second part; we shall, therefore, confine our remarks to these later types. One of the best known is the Eisemann system. In this arrangement the induction coil, with its condenser, is separate from the generator, but the high-tension distributor is attached to the magneto. It is worthy of note that, in the latest pattern, slip rings have been discarded by making one armature terminal an insulated brass knob at the end of the spindle, on which a light brush bears, while the contact cam itself forms the other terminal. Supplementary battery ignition can only be provided by using separate coils and sparking plugs. The new Bassée-Michel high-tension system is, however, arranged with a second primary winding on the coil, which can be used with a battery, and a special switch is provided to change over. A different arrangement is made use of in the Simms-Bosch high-tension system, where the secondary windings are contained within the armature itself, which therefore acts in the double capacity of armature and coil, the condenser being neatly packed away under the magneto. This is facilitated by the fact that the armature is stationary, the only moving part being a soft iron inductor. The Gianoli system has also the combined armature and coil, but in this case the high-tension distributor is not attached to the magneto. A distinctive feature is, however, the employment of a contact maker similar to the ordinary "trembler" actuated by the armature current. Both this and the high-tension distributor can be used with a supplementary battery and coil if desired, but the wiring becomes rather complicated. Some other systems, mostly in the experimental stage, are described, and the publication concludes with some practical hints to motorists, in which some of the shortcomings of high-tension magneto systems are mentioned, such as the liability to break down if run disconnected from the plugs. The work is eminently practical, but lapses here and there, quite unnecessarily, into the semi-popular—for example, in one place the expression "the hot current" is used to describe the spark.

# PORTABLE ELECTRIC TOOLS AND THEIR INDUSTRIAL APPLICATION.*

BY ANDREW STEWART.

The demand for portable electric tools has led many people to place such tools on the market within the last year or two. These are sometimes indifferent tools, from a mechanical point of view; indeed it seems that designers have not hitherto combined the requisite mechanical and electrical knowledge, though in most cases failure on the electrical side of the design has been most conspicuous.

### *Considerations Involved in Design.*

With a view to keeping down the rise of temperature, and therefore the linear dimensions, for the latter is a result of the former in the case of electrical machinery, it is a well-known rule among designers that the fixed losses in any electric motor, subject to a variable load, shall be relatively small in relation to the variable losses, because the average losses fix the temperature, and these will be less the lower the fixed losses become. For instance, it is possible to design an electric motor in which the losses would be distributed in either of the following ways:—

**Table I.**

| | | Example A. Horse-power. | | Example B. Horse-power. |
|---|---|---|---|---|
| Losses variable.— | Brush losses ........ | 0·02 | .. | 0·03 |
| | Armature copper loss | 0·4 | .. | 0·65 |
| | Series field loss ...... | 0·08 | .. | 0·07 |
| Fixed.— | Shunt field loss....... | 0·05 | .. | 0·04 |
| | Bearings, friction and iron losses ........ | 0·45 | .. | 0·21 |
| | Sum of fixed losses .. | 0·5 | .. | 0·25 |
| | Sum of variable losses | 0·5 | .. | 0·75 |
| | Total losses .... | 1·0 | .. | 1·0 |
| | Energy input to motor | 3 H.P. | | 3 H.P. |
| | Efficiency .......... | 67 per cent. | | 67 per cent. |

The efficiency of both machines are the same, yet if machine A is run for half an hour on a fluctuating load where the actual work done is equal only to 15 minutes' steady load the losses will be distributed as follows:—

**Table II.**—*Machine A.*

| | | |
|---|---|---|
| Fixed losses .............. | 0·5 × 35 mins. | 15 H.P. mins. |
| Variable losses ............ | 0·5 × 15 ,, | 7·5 ,, |
| Total for 30 mins.' working .......... | | 22·5 |

*And for Machine B.*

| | | |
|---|---|---|
| Fixed losses .............. | 0·25 × 30 mins. | 7·5 ,, |
| Variable losses ............ | 0·75 × 15 ,, | 11·3 ,, |
| Total for 30 mins.' working .......... | | 18·8 |

The average losses in half an hour's work with these two machines differ by 20 per cent., though at first sight their ought to be no difference at all if only the efficiencies of the machines are taken into consideration. A machine designed on the lines of Example A, working on a varying load would be less likely to last as long as the machine Example B, for its temperature would be higher, and the molecular changes which take place in certain kinds of insulation when subjected to changes of temperatares, especially when the maximum temperature is high, is such as to seriously impair its strength and ultimately ruin it, hence the question of depreciation of the tool is influenced by the care exercised by the designer.

### *Gearing.*

The question of gearing the motor to the drill spindle is equally important, and the writer's firm, after lengthy experiments, decided to adopt a gear which had rendered satisfactory service with the Boyer air drill. The efficiency of this type of gearing is so good that a reduction of 48 to 1 can be obtained with an efficiency of 92 per cent. Of course, the workmanship of such a gear is of the highest order, as it is only by such means that such an efficiency is possible.

### *Gearless Tools.*

Several firms sell a tool the smaller sizes of which have no gearing. Such a practice is permissible for small tools where the armature runs at 1,600 revs. per min. or thereby. One may use such tools for drilling holes up to $\frac{1}{4}$ in. diameter, but it will be found that, notwithstanding the fact that the gearing has been eliminated, no corresponding advantage in the matter of efficiency has been obtained.

### *Forced Ventilation.*

The most important limiting factor with these motors is heating, sparking at the commutator, while a factor does not impose any limit before the heating becomes excessive. Here, owing to a design of some ingenuity, a method of getting over the difficulty was introduced by Mr. W. O. Duntley, of the Chicago Pneumatic Tool Co., into their portable electric tools. By the use of a small four-blade fan on the armature spindle sufficient air is blown through the armature, where quite 80 per cent. of all the internal losses take place, to keep it cool. The result of such an arrangement is that whereas, under normal working conditions, an unventilated motor had to be stopped after 90 minutes' run on varying load, owing to the fear of burning out the insulation, the same machine with the fan had a rise of temperature of only 110°F. at the hottest part, after four-hours' run on a varying load such as drilling holes. These fans consume very little power. Careful tests show a consumption of $\frac{1}{60}$ H.P. to $\frac{1}{70}$ H.P., but notwithstanding this small power, the fan is effective enough in keeping the machine cool. Fig. 1 is a section through the motor, and gives a good general idea of the arrangement. A feature of the larger tools made by the Consolidated Pneumatic Tool Co. (Ltd.) is the use of three armatures running in a common field, the general arrangement of the motor of which will be apparent from Fig. 2. This type presents the outstanding advantage of utilising every available bit of space in the machine; even the small space at the centre can be used to take the feed screw. With such a design an important reduction in the weight is obtained over that of a single armature machine, while the linear dimensions can also be reduced because of the more efficient utilisation of the space. This will be apparent from a comparison of Figs. 1 and 2, the first of which shows a much larger percentage of waste space than Fig. 2.

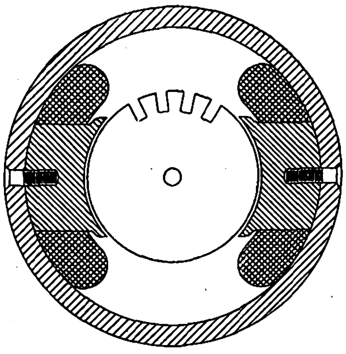

Fig. 1.—Section through Motor of Electric Drill.

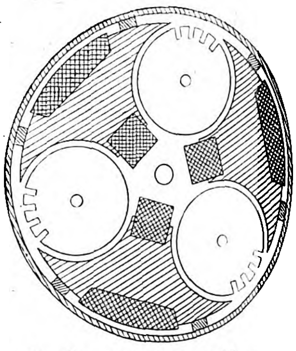

Fig. 2.—Section through Motor of Three Armature Electric Drill.

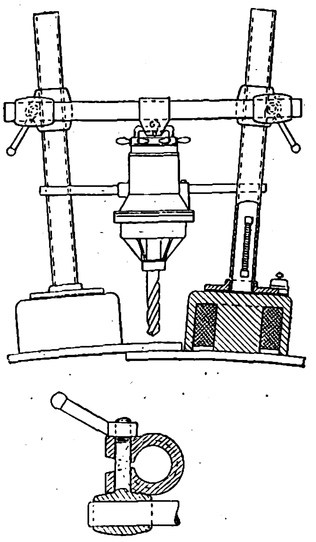

Fig. 3.—Double Magnet Drill Post.

Table III. shows the relative weights of the essential parts of a three-armature and a single-armature drill.

**Table III.**

1·75 B.H.P. motors for electric drills.

| | Single armature. | | Three armature. |
|---|---|---|---|
| Armature ...................... | 7 lb. | .. | 10·85 lb. (3 armatures). |
| Field (including winding) ........ | 30 lb. | .. | 19·5 |
| Total ............ | 37 lb. | .. | 30·35 lb. |
| Weight of machine .............. | 60 lb. | .. | 58 lb. |
| Ratio of active material to total weight ...................... | 0 62 | .. | 0·525 |

In each case the non-magnetic parts were of aluminium as far as possible. The slight disadvantage under which the three-armature drill labours by having three sets of brush gear and additional leads reduces the ratio of the active material to total weight. The pinions of the three armatures gear into a spur wheel, which has a pinion on the same shaft.

### *Breast Drills.*

Breast drills were among the earliest types of portable drill produced, and there are now a large number of such tools in use, though many have not proved conspicuously reliable. While, of course, small armatures of, say, 2 in. or thereby are difficult to wind, there is no reason why they should not prove reliable. It is hardly necessary to say that with 500 volts such tools become nearly impossible. As the drill spindle runs at a fairly high speed, the gearing is simple, and in many cases gearless machines are used, but that involves comparatively slow speed motors, which are not only heavy but inefficient, as has been shown, and the adoption of much higher speeds than practicable with gearless machines, and the introduction of a well-made gear is easily justified on the score of efficiency and reliability.

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* Abstract of a Paper read before the Glasgow Technical College Scientific Society.

### *Large Portable Tools.*

When we come to large tools, the necessity of gearing is recognised by all, but opinions seem to differ as to the extent to which gears should be used. A large ratio of reduction can, in most cases, be justified on the score of efficiency and light weight, as the weight of an increased gearing is not as great as the increase in the weight of a slower speed motor. Some interesting figures (Table IV.), will make this clear, as it shows the speed, weight and efficiency of a standard motor, a light-weight automobile electric power, and a special drilling machine by the Consolidated Pneumatic Tool Co. (Ltd.)

**Table IV.**

| — | Intermittent rating standard. | Intermittent rating special. | Electric automobile motor. | Consolidated Pneumatic Pool Co.'s electric drill. |
|---|---|---|---|---|
| B.H.P. ........ | $1\frac{3}{4}$ | $1\frac{3}{4}$ | $1\frac{3}{4}$ | $1\frac{3}{4}$ |
| Speed ........ | 1,700 | 2,700 | 2,000 | 4,800 |
| Efficiency .... | 70°/ₒ | 69% | 69% | 71% |
| Weight........ | 156 lb. | 132 lb. | 90 lb. | 58 lb.* |

* Including gear reducing to 100 revs.

As a matter of fact the machine marked "Special" is on the verge of impracticability, as the variable losses—*i.e.*, losses which grow as the square of the current, have become so great that the machine has passed the limit at which it can be kept cool without difficulty on loads where the periods of rest equal the periods of work, neither exceeding a few minutes, which is the usual interpretation of term, "intermittent rating," such as is usual for cranes, hoists, &c. The electric automobile motor is also based on the usual traction rating and in practice it derives considerable advantage from the fact that it is exposed to a current of air and so radiation takes place rapidly; moreover, the machine has really a larger radiating surface than its weight implies, for the use of aluminium, wherever possible, reduces the weight with no corresponding reduction in the linear dimensions, and therefore in radiating surface.

### *Magnetic Drilling Pillars.*

Drilling pillars are usually fixed by bolts and nuts in the desired position, but the use of a magnet in the base of the pillar as a substitute for the bolts and nuts possesses so many obvious advantages that its use is inevitable. The design of such posts and the considerations involved in the production of a cheap and efficient type of magnet, led the author years ago to adopt the concentric type of magnet for somewhat similar purposes, and when it became necessary to design magnets for holding down these drill pillars this type suggested itself, not only on account of economy, but because it was the only type which gave good mechanical protection to the windings. The tenacity with which a magnet sticks to anything is roughly proportional to the square of the density of the magnetic induction, hence exciting power is of more importance than mere area of iron, and those magnets where the contact area is increased by the addition of a pole shoe to increase the area at the point of contact, show that the designers forget that the principles which apply to the design of dynamo magnets must be reversed, so far as the air-gap is concerned, when applied to magnets for lifting or pulling purposes. Moreover, owing to the short air-gaps in such magnets the permeability of the steel which forms the magnetic circuit plays a much more important part in the performance of the magnet than is the case with electricial machinery, and the writer has sometimes obtained very erratic results, variations of the order of 30 to 45 per cent. in the pull of two exactly similar magnets having been noticed, hence the chemical composition and physical process through which the steel passes must be carefully considered if uniformly satisfactory results are to be obtained; for instance, a magnet which was designed to give a pull of $1\frac{1}{2}$ tons and weighed 47 lb. with the exciting coil, was found to give this pull, but other magnets, duplicates of this, gave pulls of 1·65 and 0·94 tons respectively. This was found to be due entirely to the steel which formed the magnetic circuit of the magnet, which must be carefully chosen if the high-flux densities which are essential to light-weight magnets are to be obtained. A single magnetic drill post is suitable for tools drilling up to $\frac{3}{4}$ in. or $\frac{7}{8}$ in. holes, and the post itself only weighs 62 lb. For large holes a double post is employed. These can be designed to give pulls of the order of 4 tons or thereby, and will hold down against drills cutting $2\frac{1}{2}$ in. or 3 in. holes. A form of double post is shown in Fig. 3, which will give a good idea of the general arrangement of such posts, and the section shows how the outer pole protects the windings from mechanical injury. In order to make these holding-down magnets more suitable for use on irregular surfaces, the writer some time ago designed magnets with movable cores which would adjust themselves to variations of the surfaces to which they were attached, and so avoid the diminution of pulling power which takes place when the magnet face does not make proper contact with the surface to which it is to be attached.

### *The Efficiency of Small Electric Tools.*

Having shown how many considerations enter into the design of a satisfactory electric drill, it is now necessary to demonstrate the efficiency of these machines. Table V. gives some results obtained with portable electric drills working on steel and cast iron (ordinary tool steel used). The chief feature of these figures is the energy required to remove 1 lb. of metal per minute. It is evident that it varies inversely as the diameter of the hole, but the greater efficiency of the larger size tools would in any case cause the curve which I have plotted from these tables to bend down, as shown in Fig. 4, where in order to make the matter convenient for mechanical engineers the figures are also given as horse-power per pound of metal per hour. The true gauge of efficiency is to separate the machine losses and find out how much is left for work at the drill point. In order to do this I made careful tests on several drills to ascertain their efficiency, and found after deducting all losses that the energy at the drill point varies from 0·07 H P. to 0·1 H.P. per pound of metal per hour for mild steel and 0·035 to 0·06 for cast iron; the first figure referring to holes of the order of 2 in. and the latter to small holes.

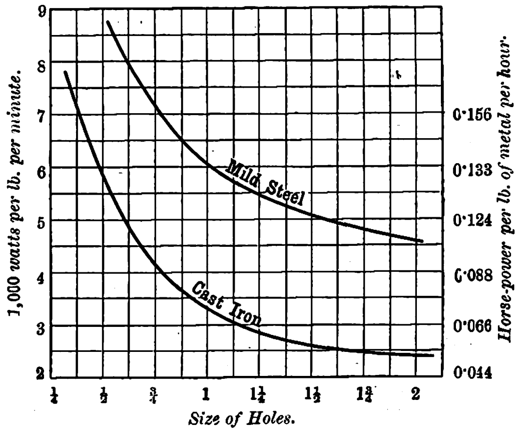


FIG. 4.—POWER REQUIRED FOR DRILLING MILD STEEL AND CAST IRON.

**Table V.**

| Size of tool. | Speed of drill spindle. Revs. | W'ght. of tool Lbs. | Size of hole. Inches | Depth. Inches | Time to drill hole. | Metal. | Volts. × Amps. | Watts per lb. of metal per min. |
|---|---|---|---|---|---|---|---|---|
| Breast | 800 | 13 | $\frac{3}{8}$ | $1\frac{1}{2}$ | 65 sec. | Cast iron | 305 | 7,200 |
| 1 M1 | 450 | 17 | $\frac{1}{2}$ | $1\frac{1}{2}$ | 2 min. | ,, | 330 | 4,230 |
| 1 M2 | 250 | 30 | $\frac{5}{8}$ | $\frac{1}{2}$ | 40 sec. | Steel | 495 | 8,448 |
| 1 M2 | 250 | 30 | $\frac{7}{8}$ | $1\frac{1}{2}$ | 70 ,, | Cast iron | 660 | 3,300 |
| 1 M3 | 150 | 32 | 1 | $1\frac{1}{2}$ | 2 min. | ,, | 550 | 3,666 |
| 1 M3 | 150 | 32 | 1 | $\frac{1}{2}$ | 80 sec. | Steel | 495 | 6,447 |
| 1 M3 | 150 | 32 | $1\frac{1}{4}$ | $1\frac{1}{2}$ | 3 min. | Cast iron | 440 | 4,125 |
| 1 M4 | 100 | 52 | 2 | $1\frac{1}{2}$ | 3 ,, | ,, | 990 | 2,564 |

Table VI. gives the results of a series of tests on three armature drills, which gives no less interesting figures.

**Table VI.**

| Size of tool. | Speed of drill spindle. Revs. | W'ght of tool. Lbs. | Size of hole. Inches | Depth. Inches | Time to drill hole. | Metal. | Volts. × Amps. | Watts per lb. of metal per min. |
|---|---|---|---|---|---|---|---|---|
| 3 M3 | 150 | 48 | $1\frac{1}{4}$ | $1\frac{1}{2}$ | 2 min. | cast iron | 770 | 3,200 |
| 3 M4 | 100 | 58 | $1\frac{1}{4}$ | $2\frac{3}{4}$ | $1\frac{3}{4}$ ,, | ,, | 1,320 | 2,620 |
| 3 M4 | 100 | 58 | $1\frac{3}{4}$ | 3 | 4 ,, | ,, | 1,540 | 3,286 |
| 3 M4 | 100 | 58 | 2 | 2 | $2\frac{1}{2}$ ,, | ,, | 1,880 | 2,940 |
| 3 M4 | 100 | 58 | $2\frac{15}{64}$ | $2\frac{3}{4}$ | 4 ,, | ,, | 2,200 | 3,040 |
| 3 M4 | 100 | 58 | 2 | 1·3 | $2\frac{1}{2}$ ,, | mild steel | 1,860 | 4,650 |

These figures are rather better than the figures given by most authorities on machine tools, but are by no means the best. I have some tools, using high-speed tool steel, which give the remarkably low result of 0·054 H.P. delivered to the tool per pound of mild steel per hour. After deducting internal losses in the tool, the result is 0·035 H.P. hour per pound of metal removed—a result quite as unexpected as it was gratifying, for after many years' experience in dealing with all kinds of electrically-driven machines, I have never before obtained a result so low. It is true it was not an ordinary result, having been obtained with a freshly-ground drill and a good piece of tool steel; but it serves to indicate that, given a really efficient combination of machine and tool steel, excellent results can be obtained. Leaving out of account the power which reaches the drill point—that is, of course, the effective power—interesting, nevertheless, only to the man who wants to look for losses which can be eliminated, the real test of efficiency is the work done per unit of power delivered to the machine—it will be seen that even the average results in Tables V. and VI. are in some cases superior to the best results obtained with larger machine tools. The mechanical losses are, of course, greater, because of the number of bearings, gears, &c., and the difference in favour of the electric tool with its highly-finished compact gear running in oil is evident.

Before leaving the subject of the machine and its work, I might draw your attention to some curves showing the relative merits of ordinary and high-speed tool steel. These were obtained during some tests when several holes were drilled in succession and the work done measured by weighing the block after each hole and taking the time per hole and power used. It will be seen from Fig. 5 that there is an increase of 36 per cent. in the time taken to drill the sixth hole when compared with the first with high-speed tool steel, and 58 per cent. with ordinary tool steel, the power being maintained exactly the same in each case—the difference in favour of the high-speed tool steel being 14 per cent. The time per hole could have been reduced by increasing the feed and power, which would in no way alter the relative inefficiency of the ordinary tool steel. Fig. 6 shows the striking difference when not only time but power is taken into consideration. In this case the ordinates are horse-power minutes at the point of the drill, and show how great are the advantages of high-speed tool steel, necessitating, as will be seen, 38 per cent. increase at the sixth hole, as against 90 per cent. in the case of ordinary steel.

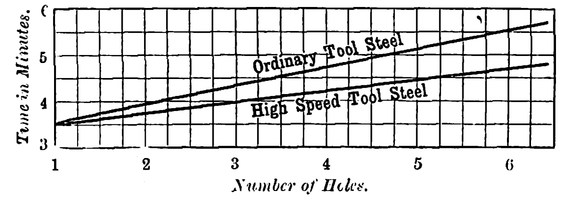


Fig. 5.—Rate of Drilling for Ordinary and High Speed Tool Steel

This brings us to the importance of grinding up the tools, and for places where it is not possible to use an ordinary grinder, or which are remote from the tool room, a line of electrically driven grinders has been designed. These are not only totally enclosed, but have dust-tight bearings in the sizes from $\frac{1}{4}$ H.P. upwards. Smaller machines of $\frac{1}{8}$ H.P. and $\frac{1}{6}$ H.P. are made for small emery wheels of $2\frac{1}{2}$ in. or thereby, which are used to grind up milling cutters. As the latter weigh only about 24 lb., they are specially useful little machines. Drill-grinding attachments may be readily attached to these machines. Another type of grinding machine which has been developed is a portable machine which can be fixed into the tool rest of an ordinary lathe and to some extent convert the lathe into a grinding machine.

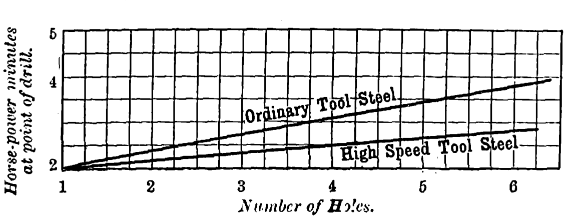


Fig. 6.—Power Required by Ordinary and High Speed Tool Steel.

Another portable tool of great value to engineers is a portable milling machine. The fact that portable electric tools are relatively less costly than the larger tools which they may in some places displace, is an advantage which the works owner cannot fail to appreciate. They are, in addition, more convenient, and therefore tend to assist the prevailing tendency to take the tool to the job instead of the job to the tool, which has hitherto been the governing factor in most workshops. The tool being generally smaller than the job, reduces the amount of crane work necessary and the number of labourers in and around the shop. Moreover, the time of the machinist is saved; and, after all, the saving in labour is worth a considerable expenditure of capital; but when that saving is accompanied by a saving in the cost of the plant, which is the case with many portable electric tools, the economic advantages of such tools are overwhelming.

# CORRESPONDENCE.

## GRADING LAMP VOLTAGES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: It is gratifying to note that you are lending the aid of your influential journal in advocating the introduction and use of more efficient and closely-graded lamps. It has long been the practice amongst the supply stations in America controlled by the Edison interests to so arrange the pressures of supply on their numerous networks that they are able to place immense orders with the lamp manufacturers and accept delivery of lamps varying widely in candle-power and voltage. They thus obtain their lamps at a low price because the makers are not compelled to scrap the large percentage of lamps which come out a little above or below the standard aimed at in manufacture. On receipt of the lamps they are sorted out and alloted to the supply station for which voltage they are best fitted, and inasmuch as the cost of supplying lamps to consumers is included in the tariff charges the system ensures (1) the manufacturer getting a sale for nearly the whole of the lamps he makes except wasters; (2) the supply authority getting a supply of efficient lamps fitted for his pressure of supply within close limits; and (3) the consumer getting a fair return in the form of light for the money he pays for electricity supply, with the provision of new lamps directly those he has in use show signs of age or blackening.

Ever since I had facilities for investigating the American methods in New York, I have been a strong advocate for the introduction of some equivalent system in this country; but the whole industry is on such a radically different basis here that it is difficult to evolve a workable scheme for obtaining the desirable end. I have discussed the question frequently with my electrical brethren both individually and collectively, and while the advantages of a systematic grading of voltages from both the lamp makers' and lamp users' point of view are clearly recognised, one is always met with the question: How is it to be done? If Mr. Wilson or any of our lamp manufacturers can evolve a practical and workable method they will earn the gratitude of all, and I am sertain the supply engineers would readily avail themselves of the advantages so rendered possible.

When the Engineering Standards Committee and the Municipal Electrical Association issue their standard lamp specifications and recommendations, it appears inevitable that one of two things must soon happen—viz., either the price of lamps will go up, due to greatly increased wastage in manufacture, or the voltages of the stations must be fixed in progressive graduations so that the whole output of sound lamps may find a market. The voltages already standardised in this country by the Engineering Standards Committee for lighting are 110 and 220 volts with a permissible variation of 10 per cent. on either side, which means maximum ranges of from, say, 100 to 120 and from 200 to 240 volts. With a proper rearrangement of voltages within these limits by steps of, say, 5 volts, Mr. Wilson, in his letter of last week, tells us that lamp makers could readily promise closer grading than is suggested in the Standards Committee's draft specification, and I assume, at no increase over present sale prices.

It is most unlikely that any undertakers will consent to reduce their present pressure of supply, as it would mean lowering the carrying capacity of both the mains and generators. Many engineers would, however, consent to raise the pressure of supply 5 or 10 per cent. provided such increase was within the limits of their plant without involving extra capital outlay, and that no damage would result in the electricity meters such as the overheating and burning out of shunts.

I desire to mention one other important consideration in conclusion—viz., who would bear the expense in the first instance of changing the thousands of lamps in use on consumers' premises? Undoubtedly the consumer would be the greatest and most direct gainer by gradation of voltages, but it is questionable if, in consideration of the advantages held out to him, he would consent to pay the cost of changing his lamps. If, however, lamp makers could promise him cheaper lamps for all future time, in consideration of the change being made, it would help very considerably in surmounting this initial difficulty so far as the consumers are concerned.

It is possible that the whole question of voltage gradation may straighten itself out by the introduction of lamps with metallic filaments, which, having a positive characteristic will not call for such fine voltage regulation as is found necessary with carbon filaments.—Yours, &c., GEO. WILKINSON.

Corporation Electricity Department,
Harrogate, March 26.

### TO THE EDITOR OF THE ELECTRICIAN.

SIR: I agree that there is something to be done in cheapening lamps and equalising lighting by using lamps of various voltages, and I think, perhaps, the solution of the difficulty may lie rather in using several voltages on the same network than with varying the declared pressures at different towns. Where the supply authority sells the bulk of the lamps used in its area, or has considerable influence over its consumers and the contractors, the former could be divided into groups and lamps of different voltages issued according to the group in which they fall. In this way I think some of the difficulties of distribution and pressure regulation might be met, and at the same time the selling price of incandescent lamps would be kept down. I fear that a difficulty in systematically varying the pressures in different supply systems would arise through there being no authority to decide exactly what pressure should be adopted in any particular case.—Yours, &c.,

S. E. FEDDEN, Manager.

Sheffield Corporation Electric Supply Department,
March 26.

### TO THE EDITOR OF THE ELECTRICIAN.

SIR: I consider Mr. Wilson's proposal that we should grade the voltage of our supply systems presents too many difficulties and objections. Your table on p. 867 of the issue of March 16th shows that already 470 public supplies exist, and it is too much to expect a large number of supply engineers to alter their declared pressure (with the consequent change of all their consumers' lamps) in order to obtain the solitary advantage of a small reduction in the price of lamps, while as regards the new supplies yet to be commenced there would be considerable difficulty in persuading the engineers to depart from one or other of the standard pressures. At a time when a special effort is being made to standardise the various classes of apparatus we employ, the advocacy of a grading of supply voltages is to be deprecated.

I write with some feeling on this subject, as the bulk of the supply at Derby is still given at a voltage and frequency considerably different from that adopted in the large majority of English towns, and so far from benefiting financially by being able to buy the "outfalls" of apparatus of other voltages and frequencies, our machinery, transformers, motors, arc lamps, &c., have to be specially made or adjusted to meet our non-standard requirements.

This question of lamp grading, in my opinion, attains its importance largely owing to the unusual property of the carbon filament lamp, in which the resistance of the filament falls rapidly with increasing voltage, the candle-power of the lamp being in consequence abnormally sensitive to small changes of voltage. With the advent of lamps, such as the osmium and tantalum, in which the resistance rises slowly with increase of voltage, a large measure of self-regulation being thereby secured, I presume a much smaller percentage of outfalls will result. For example, in the osmium lamp a 10 per cent. increase of volts increases the current 6·5 per cent., and the candle-power 40 per cent.; a similar voltage rise will increase the current in a carbon lamp 12 per cent., and the candle-power by 80 per cent. (see *The Electrician*, March 3, 1905). It appears to me, therefore, the difficulty is largely a temporary one, and will tend to right itself with the gradual disappearance of the carbon filament lamp.

For the present a solution of the problem of the disposal of the outfalls might be found in the more extensive recommendation by retail dealers of lamps of different grades of efficiency. By selling lamps of, say, high efficiency, standard efficiency and low efficiency, and by explaining to the consumer the relative advantages as applied to special cases, a large number of present outfalls might be made to drop into the high or the low efficiency class. It would, I think, assist in the solution of the question if Mr. Wilson, as a practical lamp maker, would tell us exactly what is the monetary loss caused by the outfalls. By how much would the price of the lamp be reduced if all the outfalls were disposed of?—Yours, &c.,

T. P. WILMSHURST.

Electricity Department, Derby.
March 27.

### TO THE EDITOR OF THE ELECTRICIAN.

SIR: We have always been in favour of grading operating voltages to approximately suit the output of the lamp manufacturer, and in our opinion the most serious thing operating against the use of carefully rated and properly selected lamps is the so-called "standard operating voltage." It is well known to lamp manufacturers, and should be just as well known to the supply authorities and users, that a lamp manufacturer cannot pre-determine the result of his manufacture with the same precision as may be expected in ordinary machine design, and in making lamps for any particular voltage, such as 220, he knows that only a percentage of the lamps made will be 220, the balance varying in approximately equal percentages either side of the central point. Therefore, if the present operating voltages could be slightly varied to approximately suit the results of reliable manufacturers, so that all lamps when tested at the volts marked on the lamp would give their candle-power within a reasonable percentage of their normal or rated candle-power, it would do more to help electric lighting than almost any other change. There is no advantage gained by operating lamps at 200, 220 or 230 volts as distinguished from 205, 225 and 235 volts. A 205 or 225 volt lamp is just as good as a 200 or 220 volt lamp, and at the present time there is practically no demand for these intermediate voltages.

With reference to the table contained in your Editorial Note of March 16th, it is interesting to note that 73 per cent. of the supply stations operate at only four voltages, 200, 220, 230 and 240. When we consider the variation in pressure allowed by the Board of Trade is 16 volts on a 200 volt circuit, and approximately 20 volts on a 240 volt circuit, we fail to see why lamps should not be supplied in 5 volt ranges, either side of the standard or normal voltage.

We, as manufacturers, require the help and co-operation of the supply authorities, and as soon as they recognise the shortcomings of the present-day carbon filament lamp, the better it will be for both the user and manufacturer.—Yours, &c.,

THE BRITISH THOMSON-HOUSTON CO. (LTD.)
Rugby, March 27. per J. W. HOWELL.

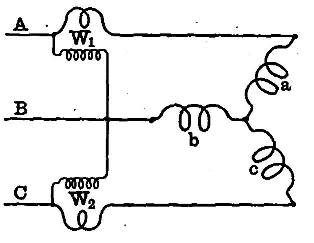
## PHASE MEASUREMENT.

### TO THE EDITOR OF THE ELECTRICIAN.

SIR: Dr. Sumpner misunderstands the method of finding the power factor of any circuit of a polyphase system which I described in your issue of the 16th inst. He says that it depends on the comparison of the readings of two wattmeters, "and involves the ruthless assumption that the currents of a multiphase system are equal in magnitude and in power factor." The advantage of the plan I mentioned lies in the fact, which I pointed out, that it involves only two readings of one wattmeter, and is entirely independent of the equality of the currents and power factors of the multiphase circuits. This can be seen at once from the expression employed, and can be easily verified in practice. For instance, since reading Dr. Sumpner's letter I have measured the power factor of the primary circuit of a transformer included in the A phase of a two-phase supply. The pressure coil of the wattmeter was connected successively to phase A and then to phase B, the current coil always in phase A, as explained in my letter. The quotient of the second reading by the first is the tangent of the angle of lag. Observations were made when the circuit of B was open and when it was gradually loaded up to 20 amperes by the use of a choking coil of variable inductance. The lag of the current in A, as determined under these extreme variations in the circuit B, lay in all cases between the values of 16°50′ and 17°20′, corresponding to power factors of 0·957 and 0·954. So far from requiring an equal current and an equal power factor in each circuit, it does not matter in the least whether the second circuit is open or closed.

Similarly, the power factor of either circuit of a two-phase motor is determined by successive readings of a wattmeter, whose current coil is in that phase and whose pressure coil is connected in turn to the two phases. The equality of the load in the two phases has no effect on the result; one phase may be carrying no current at all.

The same remarks apply to the three-phase circuits; the tangent of the phase angles is then equal to $\sqrt{3}$ times the difference of the wattmeter readings divided by the sum. The phase angle of circuit A is found by the wattmeter readings when one end of the volt coil is successively connected to B and then to C. The results are absolutely unaffected by the currents and phase angles in B and C. Obviously the method which Dr. Sumpner had in his mind and has been teaching is that which I notice is described in Dr. Hay's "Alternating Currents" (1905), p. 55, and doubtless in other published accounts, and which, as Dr. Hay points out, is vitiated by the "reckless assumptions" referred to. A similar expression to the one I have employed is used, but the procedure is different.



In the method described in Dr. Hay's work, if A, B, C are the leads of a three-phase circuit, *a*, *b*, *c* the coils of a motor, $W_1$ and $W_2$ the readings of two wattmeters inserted as shown, then $\tan\phi = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}$, if we can assume the currents and power factors to be the same in all the circuits. As Dr. Sumpner says "when the load currents are unbalanced the method does not give accurate results." In my method, to determine the power factor in the circuit *a*, the volt coil of $W_1$ is connected first to B (as shown) and then to C. Let $W_{1A}$ and $W_{1B}$ be these readings. Then $\tan\phi_A = \sqrt{3}\,\frac{W_{1A} - W_{1B}}{W_{1A} + W_{1B}}$ and no assumption is made of the equality of the currents and power factors. In fact, either B or C may be open.

Similarly the power factor of circuit C is determined by two successive readings of $W_2$.

If we may assume that the motor loads are balanced, then two wattmeters are unnecessary, and successive readings of one instrument will give all the information, with the additional advantage that its constant need not be known; whereas, in the method described by Dr. Hay, the constants of the two instruments are required. The phase angle of any circuit can be determined, as I described, by the use of one instrument with great ease and accuracy, where access can be obtained to the other lead (or leads) of a polyphase system. The method is so simple and obvious that it must, I should have thought, have occurred to many others, but apparently it is not in general knowledge.—Yours, &c.,

Royal Naval College, March 24. J. W. Waghorn.

## A CONDUCTING GLASS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Many experiments have been undertaken, both in England and abroad, with a view to ascertaining the best materials for the production of a glass with extremely high electrical resistance. It does not appear, however, that the utility of a stable vitrious substance, capable of conducting electricity, has been thought sufficient to warrant the expenditure of time and labour necessary for its production. The problem of making a solid transparent conductor is not without physical interest, and I therefore beg to call your attention to a glass which has just been made in my laboratory. Its chief feature is that it readily conducts electricity. The use of this material for the windows or cases of electrostatic instruments is obvious, and in addition, the process by which electricity passes through its mass should form the subject of a useful research. I hope to give more details later as to the production of this glass, but meanwhile to occupy myself with an investigation into its physical properties. The principal constituent is silicate of sodium.—Yours, &c.,

Charles E. S. Phillips.

Shooters Hill, Kent, March 24.

[We have tested a small specimen of the glass which Mr. Phillips was good enough to send us, but find that it has only about 36 times the conductivity of common soda glass, and we think that flint glasses can already be made that have the same order of conductivity. However, we await Mr. Phillips' further researches with interest.—Ed. *E.*]

## VIBRATING REED FREQUENCY INDICATOR.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your issue of March 23rd, the Union Electric Co. point out that the frequency indicator described in your report of my Paper read before the Junior Institution of Engineers, was due to Dr. Hartmann-Kempf, and not to "Messrs. Kempf and Hartmann." I should like to point out that the error was evidently due to your report being based on the proof, as in the final Paper this correction had been made. In this connection, however, I think it is hardly perhaps correct to say, as does the Union Electric Co., that "the apparatus in question is the outcome of Dr. Hartmann-Kempf's researches," since the principle of the vibrating reed frequency indicator was undoubtedly due originally to Prof. Ayrton, who in 1899 stated (*Journal* Institution of Electrical Engineers, Vol. XVIII., p. 310): "A set of such tongues tuned like the vibratory springs of a mouth-organ may be employed to analyse an alternate current sent round a solenoid or electromagnet."—Yours, &c., Kenelm Edgcumbe.

Westminster, S.W., March 26.

## THE NATIONAL PHYSICAL LABORATORY REPORT.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The report of the committee recently published contains a passage which appears far more satisfactory at first sight than it does on further consideration.

> An *impression* prevails in some quarters that the committee is prepared to undertake routine chemical analyses, and so compete with the work of professional chemists. This impression is a mistaken one, except for Government work, and in some special cases which come individually before the committee. Chemical analyses are only undertaken when they are required to elucidate some physical or mechanical question under investigation. . . . The committee has no wish to interfere with the work of professional chemists, and *do not believe* that in the conduct of the laboratory such interference has taken place.

(The italics are mine.) The "impression" was well founded. The National Physical Laboratory did undertake, and freely advertised for, these routine chemical analyses, and having a Government subvention, did them at a lower price than they could be done for commercially. Fortunately for the chemical industry, its interests are carefully looked after by its representative societies, and these promptly put their foot down and stopped this abuse of public money which had been given for a totally different purpose. The committee's "profession of unbelief" is extremely amusing in view of what is perfectly well known to have occurred. The exception is cleverly worded. Structural materials are a very large item in commercial analysis. In order to get routine analyses of these materials by the National Physical Laboratory it is only necessary to say that you want them done "to elucidate some mechanical or physical question under investigation." As a matter of fact in the great majority of cases where a chemical test is required, some mechanical test is equally necessary.

Now to come to our more immediate interests. The National Physical Laboratory is most careful to publish no categorical renunciation of their practice of making subvented routine tests in competition with professional men. They have been forced by the action of the three great chemical bodies to stop the chemical tests. The representative electrical body has made no such protest. Consequently, apparently the National Physical Laboratory intend to continue to make conductivity tests, am- and voltmeter tests *et hoc genus omne* at lower charges than can be made without misapplying a Government grant which was given on condition that no such tests were to be made.

The taxpayer is long suffering. By this time he is more or less resigned to the fact that thousands of pounds have to be poured into Bushey, although if he is connected with any scientific business he well realises that as things are at present there can be no adequate return. There is one remedy which, though it might not ensure a full value for the money expended, would go a very long way towards it. *Let the whole of the work be published.* The National Physical Laboratory is supposed to exist solely for the benefit of the Nation. Its work is useless to them unless published. It is no answer to say that it would be useless to publish a great deal of the work. If it was not worth publishing it is a proof that it was work that should never have been undertaken; and work that never would have been undertaken had it been obligatory to publish it.

The expense of doing so is also no excuse. The work is useless unless published and obtainable by all. I am not suggesting gorgeous large margins and expensive paper, such as were lavished on their last sumptuous one, but plain printing and paper, and, when necessary, small blocks, which cost but little. The entire cost would be covered by the salaries of assistants now employed to do commercial testing.—Yours, &c.,

March 28. C. G. S.

# PARLIAMENTARY INTELLIGENCE.

## THE LONDON ELECTRIC POWER BILLS.

The London County Council (Electric Supply) Bill and the Administrative County of London and District Electric Power Bill came on for second reading in the House of Commons on Monday. The consideration of the Additional Electric Power Supply Bill was postponed.

The Hon. W. F. D. SMITH (Strand) moved the rejection of the London County Council Bill. He explained that the proper course would have been to pass the second reading of all three bills so that they might be properly considered by a Committee, but as the members of the L.C.C. were endeavouring to obtain the rejection of the two companies' bills in order that their own bill might go forward without any of the alternative proposals, he moved the rejection of their measure. He briefly reviewed the history of electric lighting legislation from 1882 onwards, and coming to the present bill characterised it as reckless in its nature owing to its hurried preparation and its lack of financial caution. He pointed out that the area embraced by the scheme was considerably greater than the area for which the L.C.C. was responsible, for it covered no less than 380 square miles, as against 117 square miles of the L.C.C. area. Finally, he enlarged upon the importance of stimulating private enterprise rather than opposing it by measures such as these, and also referred to the fact that the Council's Finance committee had twice reported strongly against the scheme. The L.C.C. had given no evidence of possessing the necessary qualities for managing a great commercial undertaking such as this.

Mr. J. BERTRAM (Hitchin), speaking from the Government side of the House, seconded the motion for the rejection of the measure. Speaking as a London ratepayer, he confessed, amid laughter, that he himself understood very little about these measures, but he thought they should all be sent to a Committee so that they might be properly considered. Should the House select the County Council bill and reject the others, it would be equivalent to saying that in the opinion of the House no enterprising body of people need seek Parliamentary powers within the County of London, and that everything in that area was to be committed to the L.C.C. He suggested that the Council were apprehensive as to the fate of their bill before a Committee if the other two bills were considered at the same time. In the course of his speech he referred to the return recently obtained by Lord Camperdown in another place which showed that the L.C.C. between 1889 and 1902 had spent £185,000 in the promotion of 154 bills, of which no fewer than 87 had failed.

Mr. T. McKINNON WOOD (Glasgow), who supported the measure on behalf of the L.C.C., expressed his surprise that the rejection of the bill should have been seconded by a member on the Ministerial side of the House, and objected to the statement that the bill had been prepared hurriedly. He referred to the conference of local authorities summoned by the L.C.C. in 1898, when a resolution was passed declaring that it was desirable that the County Council should be in a position to supply electricity in bulk, provided it did not come into competition with any of the local authorities. This resolution was re-affirmed at another conference in 1901, and a bill on these lines was introduced by the Council but was withdrawn on representations by the Board of Trade that the matter was being dealt with in a public bill, the Electricity Supply Bill. This Government measure was introduced in 1903, 1904 and 1905, and although it was far from being a satisfactory solution of the question, it was a step in the right direction. As the Government bill had not been proceeded with, the County Council prepared the present bill. He then proceeded to compare the two measures, and pointed out that although the Administrative Co. had a maximum price and a sliding scale, this would not necessarily safeguard the consumer, as the company would, in the same manner as was done last year, enter into agreements with existing companies in such a way that the companies might be supplied at the cheap rate, but the consumer would not benefit. He quoted the statement made by Mr. Merz in the proceedings before the Committee last year that an existing electricity undertaker "must accept the company's terms or go under." The interest of the borough councils in electricity supply now amounted to over £4,500,000, and the companies, which had a capital of £11,500,000, were also entitled to be protected against a great dominating monopoly such as that which now sought to coerce them. He then quoted figures to show that the London borough councils supplied electricity cheaper than the London companies. Referring next to the cost of buying up a large private monopoly, that had been established, he referred to the £1,200,000 paid by the Marylebone Borough Council to the Metropolitan Electric Supply Co., and to the large sum paid by Leeds in buying out the company which had been working there. At Leeds, after the company had been working five years, the capital stood at £207,420, for which the Corporation gave an equal amount of 5 per cent. stock, which was worth a premium of 70, or an extra £152,000. They then found that they had to replace obsolete plant to the extent of £35,000, so that they were paying almost double the value of the undertaking. They wished to avoid that error in London. Although a Free Trader he recognised that certain kinds of business could be conducted most efficiently as monopolies, as, for instance, water supply, telegraphs, and telephones, and electricity supply in bulk came within that category, but such a monopoly should be in the hands of a body that had no interest except the public interest. Moreover, the L.C.C. could raise money cheaper than a company. He noticed that the Administrative Co. proposed to have 4½ per cent. debentures, 5 per cent. preference shares, and a standard dividend of 8 per cent. on the ordinary shares which might be increased if they lowered the price. Against that the L.C.C. could raise money at 3¼ per cent., and proposed that they should take a profit not exceeding 5 per cent. They could obviously supply cheaper than a company with its "water" or a borough council with its sinking fund. Having lent money to the borough councils for their electricity supply they were bound to consider them. They would say to the borough councils and the existing companies "We will give you cheap power to supplement your system, cheaper than you can generate it or extend your system," and this was a proposal of sweet reasonableness. The L.C.C. had already a huge electricity supply business. It was estimated that their tramway system would use 37,000,000 units in 1906, and 89,000,000 in 1915. This was nearly double what the borough councils showed in their last return and was more than all the companies put together. The bill had been brought in with the approval of 14 borough councils. He then referred to clause 35 of the bill to which objections had been raised. This was a proposal that after a certain number of years—five had been agreed upon in some cases—the L.C.C. might go to the Board of Trade if the supply was inadequate or deficient or excessive in cost, point out on what terms the L.C.C. was prepared to supply, and ask the Board of Trade to consider all the circumstances and decide whether some action should not be taken to make the authority supply in a satisfactory way. It was natural that an existing authority should object to that, but it was a power not likely to be parted with. There could be no objection to the bill because the L.C.C. had to go outside its area. Already it did this for drainage purposes, and the Traffic Commission had also said that it must go outside London in connection with tramways. The ratepayers of London had not forgotten the £50,000,000 paid to the water companies, and he asked the House to pursue the settled policy of Parliament and not to place the monopoly of the supply of electricity in bulk in the hands of a private company, which would have to be bought out by some future generation of ratepayers at a great and exorbitant price.

Mr. BURDETT COUTTS (Westminster) said that he held no brief for either of the companies which were seeking powers, but he particularly wished to call attention to the extraordinary change of front which the County Council had executed since last year. Counsel for the L.C.C. had said last year in Committee that they did not desire to advance a claim to be constituted the central authority either for the production or distribution of electricity; but now this precise claim was put forward, and an endeavour was made to deny the House the opportunity of treating the whole matter comprehensively. The Council were simply entering into competition with private enterprise, but when they had succeeded in destroying their competitors they would be under no obligation to supply electric power when it was demanded, as the bill was merely permissive. He could only liken the attitude of the L.C.C. towards the borough councils to that of the wolf towards Little Red Riding Hood. The hon. member who had just spoken had expressed surprise that a member on the Ministerial benches had seconded the rejection of the bill, and that meant that the L.C.C. was a political body. If the House refused to allow the whole question to be examined by a Committee it would be committed to a policy which placed municipal monopoly above private enterprise.

The PRESIDENT of the BOARD of TRADE (Mr. Lloyd-George) said that the Government proposed to support the second reading, and, if it were carried, he should move that it be referred to a Hybrid Committee, with a locus standi to all who had petitioned against it, including all the private enterprises which had been mentioned. There would be a special instruction to the Committee to consider, with reference to the proposals of the bill, the best means of providing for the supply of electrical energy in bulk for power purposes in London and to report thereon.

Mr. W. W. RUTHERFORD (Liverpool): Will you send the other two bills to the Committee?

Mr. LLOYD-GEORGE said he believed that the promoters of the other two bills only wanted a locus standi before the Committee to which the London County Council Bill would be sent. This year they were face to face with a totally different set of circumstances from last year. The body representing the ratepayers of London had brought forward a scheme after mature consideration, and when they came to consider competing schemes the municipality which represented the ratepayers ought, he thought, to have the first consideration. If the Committee came to the conclusion that the considerations which had been urged by hon. gentlemen opposite against this bill were substantiated in the main, the Committee could either reject the bill or make a special report as to what, in their opinion, would be the best method of meeting this great and urgent problem for London.

Mr. BURDETT-COUTTS asked if the Committee would have before them the members of the Finance committee of the L.C.C.?

Mr. LLOYD-GEORGE: The Committee will have power to send for persons and papers. If they like to call these gentlemen they can do so.

Mr. RUTHERFORD: What is the objection to send all three bills to the same Committee?

Mr. LLOYD-GEORGE thought that in a matter of this sort priority ought to be given to the scheme of the ratepayer. He did not want to prejudice the consideration of the matter before the Committee, and thought the hon. gentlemen opposite would be well advised not to challenge a debate upon the other bills at this moment. The L.C.C. and the promoters of the Administrative Bill were both confident [of the strength of their own case, and desired to go to a Committee. He felt bound to say, however, that the Government did not accept the view that had been urged that the municipalities were not capable of going into enterprises of this character. The experience of London did not bear out that contention. Sixteen borough councils sold electricity at 3½d. per unit, while the eight companies supplied at 4d. per unit; and every borough council made a profit out of the enterprise, ranging from £1,000 to £20,000. The hon. member who spoke last seemed afraid that the County Council might crush out the enterprise of the borough councils. He found that the money that had been advanced to the borough councils for the purposes of these undertakings had been advanced to the extent of something like 4½ millions by the County Council, so that the wolf had a vested interest in keeping Red Riding Hood alive. If hon. members opposite thought this was a fair proposal he would put it on the paper, and he trusted the House would pass the second reading of the County Council Bill.

Sir J. DICKSON-POYNDER (Chippenham), on behalf of the promoters of the Administrative Company's Bill, acquiesced in the proposal made by the President of the Board of Trade. He understood that every opportunity would be given to the Select Committee to investigate the whole question fully, so that a practical and economic scheme might be evolved. It was only natural that the County Council, representing the ratepayers, should be given a preference in having their scheme thoroughly discussed and examined. The question was an extremely urgent one. It affected the greatest manufacturing area in the kingdom, an area of small manufacturers to whom electric power supply was of particular importance.

Earl PERCY (Kensington S.) thought that after the last two speeches they had heard his hon. friend (Mr. Smith) might agree to withdraw his motion. But he said that with the proviso that, in withdrawing this motion, they, on the Opposition side of the House, were not to be taken as in any sense pledging themselves to the principle of the supply of electricity in London by a public authority as opposed to private enterprise. It would be foolish to deny, in view of the Acts of Parliament that had been passed, that the supply of electricity was a legitimate subject for municipal trading in certain circumstances; but the supply of electricity might be municipal trading of a very speculative character, involving a very large expenditure, which a private company was justified in undertaking, but which a public body ought not to undertake without very clearly ascertaining that the majority of the ratepayers was in its favour. It was true there was a majority on the Council itself, but the Council was a decadent body, which came to an end next year. The Finance committee of that Council had reported that there were no financial estimates which would justify it in expressing any opinion at all, and the President of the Local Government Board (Mr. John Burns) had said that he regarded it as one of the great virtues of the bill that it was so indefinite that it offered no target for attack. There was no such consensus of opinion on the part of the borough councils as would justify them in saying that the ratepayers were in favour of the scheme. In such an enterprise constant experiments were necessary, and the discarding of old methods in favour of new at the price of a very large expenditure and scrapping.

Mr. ROWLANDS (Dartford) expressed satisfaction at the policy adopted by the President of the Board of Trade, but hoped that when the bill went to the Committee the interests of the municipal authorities of the outlying districts affected would be safeguarded. The bill, as it stood at present, was not quite satisfactory in this respect.

Mr. STUART WORTLEY (Sheffield) said that the promoters of the Additional Electric Power Supply Bill had not yet signified their approval of the proposals of the President of the Board of Trade, and desired to have all their rights saved and not to enter into any particular bargain.

Mr. A. C. MORTON, who spoke amid loud cries of "Agreed," ironic cheers and laughter, was understood to say that he approved of the action of the Government on behalf of the Corporation of London, and that he was glad that they had followed practically the course he himself had suggested.

Mr. Smith's amendment was then by leave withdrawn, and the second reading of the London County Council's Bill was agreed to without a division.

Writing to the daily press on Wednesday, Mr. Stanley Boulter, chairman of the Additional Electric Power Supply Co., states that their locus standi to appear against the London County Council (Electric Power) Bill is regarded as of no practical value whatever by himself and his co-promoters. Unless the second reading is given to the Additional Electric Power Supply Co.'s Bill to allow it to be considered by a committee, it will not be worth their while to enter upon a contest which manifestly could only have an unsatisfactory termination; and it was intended to ask Parliament to read that bill a second time. They did not desire a monopoly, and were so satisfied with the railway portion of their scheme that they were willing, and had offered, to omit from the Bill that part which relates to the supply of current in bulk to all authorised undertakers in the metropolis. This being so, the field of contention was very much narrowed in its compass, and they would go to a second reading as a scheme for supplying the great railways of London as well as tramways and canals with electrical energy, and for no other powers. Even in this they did not ask for monopoly, and it would leave the County Council, assuming their bill passed, without any competition except in respect of railways, tramways and canals, and it was not unreasonable to hope that they would be satisfied with this. It would be found that without the railways, &c., the Council would have their hands quite as full of electrical work for the next 20 years as they would desire.

## WIRELESS TELEGRAPHY BILL, 1906.

This bill as amended (see *The Electrician* for March 2) came before the House of Commons on Wednesday.

Mr. CLAUDE HAY moved that the operation of the bill be limited until 1908 instead of 1912. A short period was necessary, he contended, in view of the present state of wireless telegraphy, which was advancing by leaps and bounds daily.

Mr. W. RUTHERFORD objected to investigators having to apply for licences before they could carry out any experiments.

Mr. DUNDAS WHITE supported Mr. Claude Hay's proposal.

The POSTMASTER-GENERAL (Mr. Buxton) said that the time had not yet come for any material alteration in the Act of 1904. There had been no complaint against that Act, and this bill merely extended the period specified in the 1904 Act. No difficulties would be thrown in the way of any private investigator wishing to carry out experiments; but they must all be licensed in order that the Admiralty might know where all the wireless telegraph stations were, so that in case of emergency they might be able to lay hands on them at a moment's notice. Every facility to experiment on rival systems would be given by the Post Office. Fresh legislation would be introduced if it were found necessary before the end of the year 1912.

Lord BALCARRES contended that it was practically impossible for suitable experiments to be carried out under the Act, and he knew of people who were afraid to apply for licences for this reason. Experiments were now going on for which no licences had been applied for, and the persons carrying them out preferred to run the risk of 12 months' imprisonment rather than submit to the special terms, conditions and restrictions which were imposed.

Sir E. CARSON said that the science of wireless telegraphy was still in its early stages, and that the conditions which applied in 1904 for a tentative Act still applied. He therefore supported the proposal for prolonging the bill by two years only.

Lord R. CECIL spoke to the same effect.

On a division the amendment was lost by a majority of 254.

The bill was read a third time on Tuesday.

## WORKMEN'S COMPENSATION BILL.

In the House of Commons on Monday the Home Secretary (Mr. H. Gladstone) introduced a bill for making further provision with respect to compensation to workmen for injury in the course of their employment. Mr. Gladstone, in the course of his statement concerning the proposals of the Government, said the new bill had a much wider definition and application than the Act of 1897. In order to provide that any workman injured should be certain of getting compensation whether his employer be large or small, he thought a compulsory insurance scheme might be necessary later on, but this would only be proposed when it was seen how the new proposals worked. The bill included industrial diseases as cases for compensation, and certain diseases were defined. The scale of compensation is to be modified, and an application for compensation may now be made within one week of the accident instead of two. Several other points of detail were briefly mentioned, but full consideration was left for the next stage.

## TRADES DISPUTES BILL.

On Wednesday night Sir J. Lawson Walton, on behalf of the Government, introduced a bill for amending the law in relation to trades unions and trades disputes. The main object is to render legal what is known as "peaceful picketing" or "peaceful persuasion," and to enact that a union and its property should not be bound by any act unless it is the act of the executive itself, or the act of some person whom they had authorised to bind them to the conduct impugned. This latter provision implies that no act shall be made the foundation of a claim on the union funds unless it is perfectly clear that the act has been authorised by the officials of the union. The Labour Party are not satisfied with this latter part of the bill, and are introducing their own "Bill to Amend the Law Relating to Trades Unions and Trade and Other Disputes" to-morrow. The bill of the Labour Party, in addition to legalising peaceful picketing and amending the law of conspiracy, provides that an action shall not be brought against a trade union or similar association for the recovery of damage sustained by reason of the action of a member or members of such trade union or association.

## MISCELLANEOUS.

**Electric Tramway Inspection.**—In reply to a question in the House of Commons on Monday, Mr. Lloyd-George said that an inspection of the electrical equipment of all tramway systems was made by the electrical adviser to the Board of Trade, who was a fully qualified electrical engineer, and all questions regarding electrical matters were referred to that officer.

**Liverpool-Southport Railway Accident.**—In the House of Commons on Monday, Mr. Weir asked whether it was the fact that after the accident to an electric express at Hall-road station, Southport, in July last, several minutes elapsed before the live rails were rendered dead, and whether railway companies could be required to adopt some system under which the current could be cut off immediately in case of accident. Mr. Lloyd-George, in reply, said that it was clearly stated in the report of the inspecting officer, that in the case of the accident in question, the electrically-charged rail was not rendered "dead" until about four minutes after the accident. No injury appears to have resulted in this case from the live rail however, but the station-master at Hall-road should have at once made use of the telephone provided from his station to the power stations, and had he done so the current would have been cut off in a few seconds. He understood that iron bars were carried on all the electrically-worked trains on the Lancashire and Yorkshire Railway, and were supplied to the station-masters for the purpose of setting up a short circuit and thereby blowing out the circuit-breakers at the electrical substations in cases of emergency.

**Registration of Patent Agents Bill.**—This bill was read a second time in the House of Lords on Monday. Its object is to enforce more rigorously sec. 1 of the Act of 1888, which provides for the removal from the register of the names of patent agents guilty of disgraceful professional conduct.

**Telegraphic Communication in the West Indies.**—In the House of Commons on Thursday last week, Mr. Mitchell Thomson asked the Under Secretary of State for the Colonies whether his attention had been called to the frequent interruptions of cable communication in the West Indies, owing largely to submarine volcanic disturbances, and whether the Government would consider the advisability of extending the system of wireless telegraphy now in use between Trinidad and Tobago to other islands. Mr. Churchill answered the first question in the affirmative, and said, with regard to the second, that the Colonial Secretary was impressed with the necessity of improved communication, and would not lose sight of wireless telegraphy.

**The Hull Telephone Purchase.**—In the House of Commons on Tuesday Mr. Belloc put the question which we published last week with regard to the recent offer of the National Telephone Co. for the purchase of the municipal telephones of Hull. The Postmaster-General (Mr. Buxton) said he had made no definite offer to the Corporation of Hull for the purchase of their telephone system, although on two occasions there had been discussions between the Post Office and the Corporation. The Corporation had given him to understand that they would not sell their undertaking for less than the full capital expenditure, and as this made no allowance for depreciation and was higher than the valuation made by his engineer, he did not feel justified in offering such a sum. Any sum paid by the National Co. for a municipal telephone service would not in any way affect the price which the State would have to pay in 1911 for the National Telephone Co.'s undertaking. The Government would only pay the then value of the plant, having regard to its suitability for the purposes of the Postmaster-General.

**Wallasey Corporation Bill and Wirral Railway Co.'s Bill.**—These bills have been considered by a House of Lords Committee. The Corporation Bill included a clause conferring power to build some new tramways and to run motor omnibuses, and the railway company's bill also proposed to run motor omnibuses. The Committee decided to pass the Wirral Railway Co.'s bill and to strike the tramway and omnibus portions out of the Wallasey Corporation Bill.

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The London United Tramways Bill was read a second time in the House of Commons on Wednesday.

The Folkestone, Sandgate & Hythe Tramways (No. 2) Bill and the West Yorkshire Tramways Bill were read a second time in the House of Lords on Thursday last week.

The North Metropolitan Tramways Bill was read a third time in the House of Commons on Thursday.

The Folkestone, Sandgate & Hythe Tramways (No. 1) Bill, the Shropshire, Worcestershire & Staffordshire Electric Power Bill and the Kent Electric Power Bill were read a second time in the House of Lords on Monday.

The Preston, Chorley & Horwich Tramways Bill is now unopposed.

## NORTH-EASTERN COUNTIES ELECTRICAL EXHIBITION, NEWCASTLE.

This Exhibition was opened at the Exhibition Hall, St Mary's-place, on Saturday last by Sir Isambard Owen, principal of the Durham College of Science, and will remain open for about four weeks. The organisation has been in the hands of the local electric supply companies and electrical contractors, and the object in view has been to bring before those of the general public who are likely to be consumers the very extended uses to which electricity can be applied as an illuminant and a motive power, both in the factory and the private house.

The three supply companies—namely, the Newcastle Electric Supply Co., the Newcastle & District Electric Lighting Co. and the County of Durham Electrical Power Distribution Co.—have extensive exhibits, each sub-divided into various departments. They show model shop windows, a model kitchen, sitting-room and drawing-room, all fitted up with electric lighting and heating, and applications of power are exemplified by workshops with machines and shafting driven by motors and by electrically-driven lifts.

In one corner the whole process of the production of electricity, from the combustion of the coal to the consumption in the incandescent lamp, is shown through the medium of a model boiler, turbo-generator, switches, cables, house wiring, and fittings.

Messrs. Crosier, Stephens & Co. are exhibiting a novel form of interior roofing. The roof of their stand is of pressed sheet steel, enamelled in several colours. These sheets can be stamped to any design, and decorated accordingly. The fluted columns with Corinthian capitals supporting the roof are stamped from the same material. They also exhibit a mechanical piecework-rate calculator for calculating the rate of wages to be paid to each individual who may be working on the same job but under different wages rates.

Messrs. Robson & Coleman are displaying under working conditions the Snowball (10 ampere) white-flame arc lamp, together with several Cooper-Hewitt mercury vapour lamps. The same firm show a small one-ton electric pulley block, remarkable for its compactness and handiness.

The Thermal Syndicate have on show some specimens of fused quartz made from pure silica sand, the chief features of which are its high melting point of over 1,700°C. and its practically negligible coefficient of expansion. It can also be heated white hot and plunged into cold water without cracking. The material is acid-proof and of great dielectric strength, and can be made on a commercial scale in the electric furnace. The same stand contains pipes for chemical purposes and muffles for gas furnaces, also a number of samples of tubing.

The Post Office have a very interesting exhibit showing the history of their underground cables, with a map showing each section (numbered) from town to town and a number of samples of multi-core cables actually laid in the respective sections.

Amongst the exhibitors in the heavy section are Messrs. J. H. Holmes & Co., W. H. Allen, Son & Co. and the Sunderland Forge & Engineering Co. The two former show ship lighting combined plants and motors, and the latter firm shows a large crab for a four-motor crane.

Colliery engineers will be interested in the three coal cutters exhibited by Messrs. Crosier, Stephens & Co., the Brush Co. and Messrs. Mavor & Coulson, and the pumps shown by Messrs. Frank Pearn & Co. and W. H. Allen, Son & Co.

The Reason Mfg. Co. are showing some special fittings for street lighting with incandescent lamps with silvered glass reflectors, in addition to a good display of house service and cable joint boxes.

For house and shop wiring a very complete outfit is shown by Messrs. Falconar, Cross & Co., with a numerous quantity of fittings and shades in many different styles.

The lighting of the stands is very effective, almost every type of lamp on the market being represented.

About 50 firms are exhibiting, and there are in all about 180 stalls.

The hall itself is brilliantly illuminated and artistically decorated, and, in addition to this, St. Mary's-place, a street of about a quarter of a mile in length leading from the city to the hall, is illuminated with 10 ampere flame arcs, placed alternately on either side of the road, giving a good impression of what street lighting should be, and no doubt in the near future will be.

The catalogue contains an introduction by Prof. W. M. Thornton, but would have been improved by the addition of indexes of exhibitors and subject matter.

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Besides the above, the exhibitors include Messrs. Chamberlain & Hookham, Birmingham; Frank Pearn & Co., Manchester (Agents, Rees & Wilson, Newcastle); Austin & Co., Newcastle; James Keith & Blackman Co., London; Henry Osborn, Newcastle; John Noakes & Co., Newcastle; Edison & Swan Co., London and Newcastle; Synchronome Co., London; R. & J. Dick, Newcastle; Lucy & Co., Oxford; Christian & Phipps, Hampton Wick (local agent, Mr. T. R. Martin, Newcastle); Metallic Seamless Tube Co., Birmingham (local agent, T. R. Martin, Newcastle); H. T. Boothroyd, Hyslop & Co., Bootle; F. Reid, Ferens & Co., Newcastle; Eldon Electric Co., Newcastle; Thos. G. Usher & Co., Newcastle; James Gledson, Newcastle; A. Chisholme-Robson, Newcastle; Walter Fletcher, Newcastle; Electrical Engineering Supply Co., Newcastle; Industrial Engineering Co., Newcastle; Babcock & Wilcox, London (Newcastle branch); and Le Carbone, London.

**Water Power Concessions in Switzerland**—It is stated that the Swiss National Council have decided that no further grant of foreign concessions shall be made for electricity obtained as the result of the use of the power of the Swiss waterfalls without the special sanction of the Federal Council. In any case, the maximum of these concessions must not exceed 20 years. Further, any concession now in operation may be cancelled at any time on payment by the Federal Council of an indemnity.

# NATIONAL ELECTRICAL MANUFACTURERS' ASSOCIATION (INCORP.)

The second annual general meeting of this Association took place on March 20, Mr. C. S. Northcote in the chair. We received no invitation to send a representative to the meeting, but we have been furnished by the Association with some notes from which the following brief account of the proceedings is made up:—

The CHAIRMAN, in moving the adoption of the report and balance-sheet for 1905, reviewed the work of the executive committee during the year. The financial position of the Association, he said, was satisfactory, the expenses of incorporation being entirely borne by current revenue. As deputy-chairman of the executive committee of the Olympia Electrical Exhibition, Mr. Northcote reported that the exhibition accounts had been wound up, the financial result, after returning to the exhibitors 25 per cent. of the amounts paid for space, showing a net profit of £1,515. 7s. 10d. (The disposition of this balance is particularised in the letter from Mr. Davenport, the secretary of the Association, set out below.)

Mr. H. OPPENHEIMER, in seconding the adoption of the report, invited criticism from the general body of members as to the actions of the committee.

A general discussion ensued, a feeling being expressed that the executive committee of the Electrical Exhibition should have consulted the exhibitors as to the disposal of the surplus funds. This view, however, did not meet with the support of the meeting, the general opinion being that the executive committee had exercised a wise discretion.

Mr. L. M. WATERHOUSE reported as to meetings of the conduit makers and an interview they had had with the Engineering Standards Committee. The latter Committee were now in possession of their views, and he thought the result of their labours would be beneficial to the industry.

The question of trade credits was discussed, and a general instruction given to the committee to draw up a scheme to be presented to the members, if possible within two months.

The retiring members of committee were re-elected, viz.:—Mr. T. J. Grainger, Mr. P. A. Lundberg and Mr. F. H. Nalder (Nalder Bros. & Thompson). Mr. Max Byng (General Electric Co.) was elected on the committee in place of Mr. H. Bevis, who had resigned owing to his now being attached to the Company's Manchester house.

The proceedings terminated with a vote of thanks to the Chairman.

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We extract the following from the report of the committee for 1905:—

Your committee, in submitting to you a short review of the business transacted by them during the past year, feel constrained to give expression to the opinion that the facilities offered by the National Electrical Manufacturers' Association, for bringing into closer and more intimate contact the various branches of the vast electrical industry are unfortunately not taken advantage of as frequently and as fully as would be desirable, both in the interest of individual members and of the trade generally. In many instances, questions of policy of vital interest to the trade have failed from sheer lack of concerted action. United action, embodied in and backed up by an influential trade association such as ours, must in course of time yield the most satisfactory and fruitful results. This, however, can only be done by the loyal support and counsel of each member, who must bear in mind that the interests involved are of a mutual character as well as individual.

Early in the year the Electrical Exhibition, which took place in the month of October at Olympia, was originated by your committee, who took an active part in the management and carrying through of the exhibition, and were fully rewarded by its decided success, not only from a financial point of view, but from that of the exhibitors and the members of the Association generally. It being felt that local exhibitions held in various parts of the United Kingdom were prejudicial to the interests of your members, it was agreed, and the members pledged themselves, not to exhibit at local or country exhibitions through 1905-6, unless upon the terms agreed upon by the members of the Association—namely, that they could loan their manufactures for such exhibitions, but that the authorities must free them from all costs, whether for space, current, carriage or damage to material.

The Association in organising the Electrical Trades' Benevolent Institution has met with considerable support.

Further circulars on the matter of Christmas boxes and beanfeast subscriptions have been sent out, and it is hoped that in course of time these irksome taxes may be abolished entirely.

*Income and Expenditure of the* National Electrical Manufacturers' Association (Incorporated) *for Year ended Dec. 31, 1905.*

| Income. | | | | Expenditure. | | | |
|---|---|---|---|---|---|---|---|
| Balance in bank, 1/1/05 | £106 | 2 | 11 | Incorporating expenses.. | £67 | 12 | 2 |
| Subscriptions ........ | 225 | 15 | 0 | Postages and petty cash | 28 | 18 | 6 |
| Entrance fees ........ | 27 | 6 | 0 | Printing and stationery | 44 | 9 | 10 |
| Dividends on investment ............ | 2 | 2 | 3 | Telephone & typewriter | 5 | 0 | 0 |
| | | | | Cost of meetings ...... | 11 | 16 | 9 |
| | | | | Secretary's salary .... | 129 | 3 | 4 |
| | | | | Rent of office.......... | 10 | 0 | 0 |
| Balance in bank, 31/12/05 | 34 | 1 | 3 | Clerk ................ | 12 | 10 | 0 |
| Investment—Consols | 100 | 0 | 0 | Annual dinner.. ...... | 11 | 6 | 10 |
| | £134 | 1 | 3 | Expenses of Dry Battery meetings .......... | 5 | 6 | 6 |
| | | | | Auditor's fee.......... | 1 | 1 | 0 |
| | | | | Balance in bank ...... | 34 | 1 | 3 |
| | £361 | 6 | 2 | | £361 | 6 | 2 |

The financial report of the year shows that, notwithstanding the heavy expenses of incorporation, there is a credit balance of £34. 1s. 3d., in addition to £100 invested in Consols.

The present number of members of the Association is 52, and it is to be hoped that this number will be largely increased by the accession of new names.

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The following report regarding the financial results of the Electrical Exhibition held at Olympia (London) in September-October last, under the auspices of the National Electrical Manufacturers' Association, has been issued:—

TO THE EDITOR.

Sir: I am instructed to inform you that the final balance-sheet of the Olympia Electrical Exhibition, duly audited, was received and adopted at a meeting of the Executive Committee held on the 19th inst. The financial result shows a profit balance of £3,683. 9s. 1d., and after returning to all exhibitors a rebate of 25 per cent. on the amounts paid by them for space, which absorbed a sum of £2,168. 1s. 3d., there remains a balance of £1,515. 7s. 10d., which has been dealt with as follows:—

A donation of £350 has been made to the Benevolent Fund of the Institution of Electrical Engineers, intsead of £250 as previously announced.

A donation of £650 has been made to the Electrical Trades' Benevolent Institution, under the auspices of the National Electrical Manufacturers' Association, Incorporated.

The balance of £515. 7s. 10d. will be invested in the names of trustees to form a nucleus of a fund for starting another Electrical Exhibition, which must be held in London under the auspices of the Institution of Electrical Engineers. In the event of no such exhibition being held within five years, this balance to be divided between the two benevolent funds above mentioned, in the same proportions as now allocated. The trustees are Sir Wm. Preece, Mr. E. Cunliffe Owen, C.M.G., Mr. J. E. Kingsbury, Mr. C. S. Northcote, and a nominee of the Incorporated Municipal Electrical Association.

W. Davenport, Secretary Executive Committee.

# THE RELATION OF PLAY TO WORK.

## THE EASTERN TELEGRAPH SCHOOL'S ATHLETIC CLUB.

The fourth annual dinner of the Eastern Telegraph School's Athletic Club was held in the Holborn Restaurant on Friday, the 23rd inst., Mr. A. R. Hardie in the chair. There was a good muster of members and guests. Among the latter were Mr. J. C. Denison-Pender, Mr. W. Hibberdine, Mr. E. Steer Hodson, Mr. Alex Penney, Mr. J. T. Crowe, Mr. C. W. Adye, Mr. H. St. Lawrence Smith and Mr. J. L. Verne; while letters and telegrams regretting their absence were received from the following: Mr. H. A. C. Saunders, Mr. F. E. Hesse, Mr. T. A. Bullock, Mr. George Jack, Mr. H. W. Sullivan, Mr. S. G. Brown, Mr. W. C. A. Atkins, Mr. C. Frazer and C. W. Schaefer.

After the loyal toast had been duly honoured,

Mr. HARDIE, in proposing the toast of "The Eastern Telegraph School's Athletic Club," said it is now almost 36 years to a day since I had the good fortune to enter the service of one of the four submarine telegraph companies which were afterwards amalgamated and became the Eastern. We had no athletic clubs or highly-organised training schools in those days, no special playing grounds or magnificently-appointed pavilions. Each one had to fend for himself and find his own amusements, because there was no combination of interests in common such as you have in the school's athletic club. In the comparatively early days of submarine telegraphy —I do not refer to the almost prehistoric period when our old friend Mr. Saunders threw in his lot with the few pioneers long before many of the present officials were born, but to the eighteen-seventies—the men who joined the service as telegraphists in those days had not the same advantages as those who join at the present time. There were no set examinations, and we did not insist upon the men spelling correctly such words as "ipecacuanha"; nor did we set them such geographical posers as "Where is Caithness? or the Chiltern Hundreds?" Neither did we insist upon them giving us a treatise upon the Fiscal Policy, nor were they asked to define a "terminological inexactitude." The staff were recruited from the limited number who had had some previous experience of telegraphy, and also from those who were willing to enter the service in exchange for the comparatively restricted inducements which it was possible to offer before submarine telegraphy was proved to be a success, financially as well as scientifically. The selection, therefore, necessarily included a certain proportion of men who were not of a very high standard, and the service was not at first held in such high esteem; neither were the staff received socially by the better class of residents abroad with that cordiality which now exists. However, by process of time, and other less agreeable methods, that class of man has long ago entirely disappeared, and we have now a service of which we are justly proud, and which can compare favourably with any other great commercial enterprise. It was soon recognised that it was in the interests of all concerned to offer further inducements to attract gentlemen into the service, and recognising that there was a time for play as well as work, facilities for healthy exercise and amusements were provided at the various stations, so that muscle, as well as brain, could be developed. When the period of exuberant youthfulness has passed, and when the more onerous duties have to be tackled, then less energetic amusements than football can be indulged in to keep the body as well as the mind in health and vigour. I attach, therefore, great importance to the Eastern Telegraph School's Athletic Club, because it plays a most useful and important part in the proper training of a probationer. Scientific knowledge is all very well, and is essential to attaining some of the higher positions in the service, but scientific attainment accompanied by physical development is infinitely better. The men, therefore, who embrace both these qualifications are the most valuable members of the staff, and are also the most popular, not only with their fellow clerks, but with their superintendents as well. One of our most popular superintendents applied to have his staff strengthened. When he came home our friend Mr. Crowe asked him if he wanted electricians, mechanicians, good recorder clerks, punchers or those gifted in the art of "gumming." He said, "I would like men with all these qualifications, but, *entre nous*, what I also particularly require is a couple of good tricky bowlers." While games and other physical exercises contribute to the enjoyment of life, and at the same time act as a safety valve for that excessive energy which is stored up in the mind and body of the present day probationer, I firmly believe the Athletic Club not only tends to keep them in health, bodily and mentally, but morally as well. It also stimulates the cultivation of that *esprit de corps* which, I am pleased to say, is now one of the characteristics of our splendid service. When the younger men have reached the higher positions in the service, and when neither the desire nor perhaps the necessity for violent athletic exercises exists, their connection with the Club will stand them in good stead and will tend to make them more sympathetic with the junior members of the staff. You will, no doubt, come to the conclusion that these feelings of mutual sympathy between the chief and his staff are an important factor in promoting the interests of the companies. My advice therefore, is, that after devoting a proper portion of your time to work and study, play "footer" and cricket while you can. A time will come when you, like some of us at this table, will have to console yourselves with tennis, even golf, possibly croquet and conceivably bowls. Your connection with this club will tend to make you a more useful member of the staff, and when you arrive at the "umpire stage" you will be better able to see both sides of the question, and deal impartially with the more important questions which will come before you from time to time in years to come. Before concluding, I would like to congratulate the club in having such an admirable president as our friend Mr. Burrell, and also such an indefatigable secretary as Mr. Noble. When I had the pleasure of being present at the annual sports gathering last year, I was greatly impressed by the good fellowship which seemed to exist between the probationers and their instructors, as well as the good-natured rivalry displayed by the various competitors, and I think great credit was due to all concerned in the arrangements. I can assure you, gentlemen, that the chairman, managing director, the other directors, and the officials at head office, take the liveliest interest in your athletic club, and I have great pleasure in wishing continued success to the Eastern Telegraph School's Athletic Club, coupled with the name of our worthy president, Mr. Burrell.

Mr. BURRELL, in replying for the Club, thanked the chairman for his happy speech and expressed the keen appreciation by the Club of the sympathy and goodwill to its aims shown by the presence of himself and the other high officials at the dinner. He referred to the great improvement in the financial status which had been brought about during the year by the kindness of the managing director, and outlined the improvements the committee hoped, in consequence, to be able to effect in the near future. He concluded with a review of the work done by the Club during the year.

Afterwards a pleasant musical entertainment was given by the members of the club, interspersed with toasts of "Our Guests," by Mr. J. C. Denison-Pender, which was replied to by Mr. W. Hibberdine; and of "The Chairman," by Mr. J. T. Crowe.

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Transactions of the Royal Society of Edinburgh; the Ben Nevis Observations, 1893-1897." (London: Williams & Norgate.) 2 guineas.

"Transactions of the Royal Society of Edinburgh. Vol. XL., Part III., 1902-3; Part IV., 1903-4. Vol. XLI., Part I., 1903-4; Part II., 1904-5. (London: Williams & Norgate.) 26s., 20s., 21s., 29s. 6d. respectively.

"Electricity Meters." By Henry G. Solomon. (London: Charles Griffin & Co.) 16s net.

"Proceedings of the Royal Society of Edinburgh." No. 13, Vol. XXV., 1904-5. (London: Williams & Norgate.) 4s.

"The Origin of Life." By John Butler Burke. (London: Chapman & Hall.) 16s. net.

"Wireless Telegraphy." By Gustav Eichhorn. (London: Charles Griffin & Co.) 8s. 6d. net.

"Single-phase Commutator Motors." By Franklin Punga. (London: Whittaker & Co.) 4s. 6d.

"Science Abstracts." March. Section A, Physics. Section B, Electrical Engineering. (London: E. & F. N. Spon.) 1s. 6d. each.

"The Telegraphist's and Telephonist's Note Book." By Jas. Smith. (London: S. Rentell & Co.) 1s. net

"Aufnahme und Analyse von Wechselstromkurven." By Dr. Ernst Orlich. No 7 of "Elektrotechnik in Einzel-Darstellungen." Edited by Dr. G. Benischke. (Brunswick: Friedrich Vieweg und Sohn). 3·50m.

## LEGAL INTELLIGENCE.

### Neale v. Electric & Ordnance Accessories Co. (Ltd.)

At Birmingham Assizes on Friday, before Mr. Justice Ridley and a jury, defendant company was sued for damages for personal injuries. Plaintiff (who sued through his father) was 15 years of age and was engaged in working a circular saw for cutting thin lengths of brass. To prevent the chippings flying the boy took a piece of cardboard from the wall to place behind the saw. While he was fixing the cardboard the sleeve of his smock was caught by the saw and pulled down. The saw, a very thin one, was making 500 revs. a minute. The boy's left hand was cut off just above the wrist. It was contended by plaintiff that had the saw been partially fenced or shielded the accident could not have occurred.

Expert evidence showed that it was not the practice to fence wheels of that character, as such fencing would prevent the proper and expeditious carrying out of the work.

The JUDGE asked the jury to say whether the conduct of the injured lad must be regarded as contributory negligence, and the jury found that the machine was not dangerous, that defendants used reasonable means to protect their workmen, and that the boy had been guilty of contributory negligence.

Judgment was then given for defendants.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT AND FILLED.

Dublin Lighting committee require a station superintendent for their Pigeon House generating station, under the direction of their city electrical engineer. Salary £200, with residential quarters at the station Applications to Secretary of Committee, 3, Cork hill, Dublin, by April 3. See also advertisement.

Owing to the resignation of Mr. J. A. Crowther, mains superintendent at Coventry, Wm. J. Marston, senior charge engineer, has been appointed outside superintendent.

In regard to the appointment of Mr. A. P. MacAlister as acting borough electrical engineer at Battersea (referred to in our issue of 16th inst., p. 898) we should have stated that since June, 1905, Mr. MacAlister has been chief assistant, prior to which time he was mains superintendent.

Mr. W. T. Durrant, who has had control for many years of the buying department of Messrs. Ransomes, Sims & Jefferies (Ipswich), has been appointed to the management of the buying department of the Metropolitan Amalgamated Railway Carriage & Waggon Co., Saltley, Birmingham.

York Electricity committee recommend the appointment of Mr. W. A. Turnbull, of Bury, as works superintendent at £150 per annum.

**Aberdeen.**—The annual inspection of the Corporation electricity works by members of the Council took place on Friday. Lord Provost Lyon presided at a subsequent meeting.

The convener of the Gas and Electric Lighting committee (Councillor Kemp) gave some statistics of the progress of the undertaking. For the year ended July 31, 1905, he said 4,899,050 units were generated, and the total units generated for the 7½ months of the present financial year were 3,499,031. One engineering firm who recently equipped their new foundry electrically had since decided to equip the whole of their engineering shops in the same manner. Supply had already been given to three of the four shipbuilding yards, and the fourth was now going on the mains as a consumer. It was expected that from 800 H.P. to 1,000 H.P. would soon be required to meet the needs of the quarries.

**Acton.**—The Council have refused the offer of the Metropolitan Electric Supply Co. to lease the Acton Provisional Order.

The salary of the resident electrical engineer (Mr. J. Martin Blair) has been increased to £225 per annum, rising by annual increments of £25 to £300.

**Amsterdam**—A company has been formed, with a capital of £625,000, to construct and operate electric tramways radiating from the centre of Amsterdam to many of the most important towns and districts north of the city. The total length of line to be eventually operated by the company is about 40 miles.

From Jan. 1 last the Post Office authorities at Amsterdam have supplied the postmen with continuous blocks of tickets for use on the municipal electric tramways. When the arrangement is completed about 1,000 postmen will be provided with these tickets.

**Argentina.**—The "Review of the River Plate" states that La Flores municipality, who intend to establish electricity works, have been unable to find anyone to provide them with the necessary plant, because no substantial guarantee is forthcoming.

Buenos Ayres Council have accepted the tender of the Cia Transatlantica Alemana de Electricidad for the electric lighting of the sheds and deposits of docks 1 and 2 by 1,435 16 c.p. lamps at $6·50 m/n per lamp per annum.

The construction of the electric tramway between Ardrogue and Buenos Ayres will shortly be commenced. The Cia Transatlantica will supply current.

As we have previously stated, Buenos Ayres municipality have, under the Municipal Tax Law, the right to collect 6 per cent. of the gross revenue of the tramways in the city. The accounts department now report that they do not receive the 6 per cent. on the revenue from rental of lines leased by one company from another, as the contracts between the companies are not accessible to the municipality. The accountant has been instructed to take measures to obtain payment of the tax upon rentals.

**Australasia.**—Our Australian correspondent writes:—

The Electric Lighting & Traction Co. of Australia are appealing against the joint assessment of their Melbourne undertaking by the local authorities of Prahran, Richmond, South Melbourne, St. Kilda and Malvern on the ground that, as no net profit was made on the past year's working, the assessment is unreasonable. The company claim that, under the Local Government Act, when the annual value of a concern is not readily ascertainable, the assessment must in no case be less than 5 per cent. of the capital value of the fee simple, and that, if an assessment is made on this basis, the only rates payable would be in Richmond, where the power house is situated.

Sydney City Council recently decided that the city electrical engineer (Mr. T. Rooke) should carry out and superintend future extensions of the electricity works, but the consulting engineers (Messrs. Preece & Cardew) have been retained to inspect any plant and machinery ordered in Europe.

The city treasurer of Sydney (Mr. A. H. Solomon) recently reported that the capital expenditure to date on electricity supply was £245,866. and the commitments on contract £20,000. To meet capital expenditure made and in sight (£18,524) and the present bank overdraft (£13,711) £32,235 was required. It was decided to adopt Mr. Solomon's suggestion to raise £50,000 by sale of debentures from the treasury.

At a recent meeting of the sub-committee formed from representatives of the Councils of the Melbourne suburban districts of Kew, Hawthorn, Malvern, Caulfield and St. Kilda to discuss the proposed electric tramway scheme it was stated that the capital cost of the proposed line (8¼ miles), with power house and equipment, would be about £8,000 per mile, or a total (including 16 cars) of about £80,000. The cost of operating would be £16,200, interest £3,200, and sinking fund £2,300, making total working expenses £21,700 per annum. The annual receipts were estimated at £21,720. The sub-committee recommended that the Councils form a trust for the construction of the line, or, as an alternative, that they form a trust for the construction of the line by private enterprise.

**Battersea (London).**—After the 1st prox. the charge for current for power is to be reduced from 1½d. to 1d. per unit. Reductions of the charges for current for lighting are under consideration.

**Beckenham.**—The accounts for the past year show that since the electricity undertaking came into the hands of the Council in November last, the gross profit has been about £1,500.

**Blackrock (Ireland).**—The Board of Trade have notified the Council that they will not revoke the 1901 electric lighting order until the end of the year.

Messrs. Mills & Tomlinson have furnished the Council with particulars of their electricity supply scheme, but consideration of the subject has been deferred for a fortnight. The Council's legal position as to transferring their order is to be inquired into.

**Bridlington.**—Sanction has been received to a loan of £5,580 for electricity supply extensions. The period of the loan is 16 years, and a deputation has been appointed to interview the President of the L.G. Board in order to obtain an extension of this period.

**Burton-on-Trent.**—The Corporation have decided to make material reductions in the price of gas for power to compete with producer plants.

In fixing these prices it has been assumed that a producer plant below 10 H.P. cannot compete successfully against town gas, and the annual consumption on which the reduction takes place is what one would expect for producer plants of about 10 H.P. capacity. There are, however, only two producer plants in the town at present. Electric power has prevented two other cases coming in, and the reductions in the price of gas have also stopped several intending purchasers from installing producer plants. The Electricity committee have instructed the borough electrical engineer and tramways manager (Mr. P. J. Pringle) to report on reductions in the present prices for electric power, somewhat on the same basis as the reductions in the price for gas.

**Ceylon.**—Colombo appears to be the only town in Ceylon which possesses a telephone exchange. This is situate in the centre of the business quarter, and has about 130 subscribers connected.

**Dunfermline.**—Fife County Council have given their assent to the application of Dunfermline Council for a provisional electric lighting order, so far as the order relates to districts outside the burgh.

**Edinburgh.**—The Tramways committee last week were informed that the syndicate who are promoting the scheme for constructing electric tramways between North Liberton, Dalkeith, Lasswade, Rosewell and Bonnyrigg, were willing to also construct lines to Waverley Bridge, and from Tollcross to Duddingston, &c. The syndicate are satisfied that the old cable conduit can be used for the surface contact system, which they propose to adopt in the city, and the overhead trolley is to be used outside.

**Electric Traction in Spain.**—The Granada Electric Tramways Co. have been officially authorised to substitute electric traction for the present horse system on tramways between the Plaza Nueva and the Alhambra Granada.

**Fiume (Hungary).**—The Municipality of Fiume are about to erect electricity generating works at an estimated cost of about £92,000, water power being utilised.

**Gosport.**—The Gosport and Fareham Tramways Co. expect to be able to be supply electric current in this district by the end of April.

**Huddersfield.**—A special committee has been appointed to consider and report upon the charges for current for power.

**Inquest.**—On Saturday an inquest was held on Ernest R. Bone, an electrician's assistant, in the employ of the Central London Railway Co., who was killed at Notting Hill Gate sub-station on Wednesday last.

Deceased had worked on the railway for 11 months, and prior to this was in the Navy as a torpedo hand. He was said to be fully acquainted with the usual dangers of his trade.

ROBERT PRINN, electrical engineer at the Notting Hill Gate sub-station, said Bone was one of the day shift and relieved witness on Wednesday morning. They were discussing the advisability of some bolts being tightened on the high-tension board when Bone, in pointing to a bolt above the level of his head, accidentally touched the live bolt, and his hand was drawn to it and he became suspended. Witness dragged him down, and he became unconscious. A doctor was sent for and artificial respiration resorted to for two hours, but without effect. The four men employed at the sub-station were all fully aware of the danger. They had rubber gloves to use, but these would have been no protection against the high-tension current.

Mr. E. P. GROVE, chief engineer of the Central London Railway, said the sub-station was used to convert current of 5,000 volts alternating to 300 and then to 550 continuous. Work on that switchboard would not be attempted without cutting off the current. It was by inadvertence that deceased in raising his hand to point touched the live bolt.

The jury returned a verdict of accidental death.

**Islington (London).**—At a special meeting of the Council this (Friday) evening a proposal to alter the system of charging for electric current will be discussed.

**Kensington (London).**—The Kensington & Knightsbridge Electric Lighting Co. recently offered to substitute arc lamps for incandescent gas lamps in the principal thoroughfares of South Kensington, but the offer has been declined by the Council, notwithstanding the Council's lighting engineer estimated that the change would mean a saving of £100 annually, and the illuminating power would be 54,000 c.p. against the present 14,000 c.p.

**Leek**—An unopposed inquiry was held last week into the Council's application for permission to borrow £4,724 for extensions of their electricity undertaking.

**Light Railways.**—The Board of Trade have confirmed the County of Middlesex (Waltham Cross and Enfield), the County of Hertford (Cheshunt) and the Blagdon and Pensford Light Railway Orders.

The Light Railway Commissioners have rejected the scheme for the construction of a light railway from Bournemouth to Swanage.

**Llanelly.**—An inquiry will be held on Tuesday into the application of the Council for permission to borrow £6,000 for electricity supply. The Council propose to take electricity in bulk from the South Wales Electrical Power Distribution Co.

**London County Council.**—At Tuesday's meeting St. Pancras received a loan of £12,100 for electric lighting.

*Cost of Copper.*—The Highways committee reported in regard to the tenders of the Western Electric Co. and W. T. Glover & Co. for supply of cables (accepted on Nov. 4 last on the basis of the price of copper) that, owing to the rise of copper, an additional capital expenditure of £4,500 would be necessary.

In a report just presented to the Council by the controller it is stated that the total present commitments of the Council amount to £21,008,345:—

Proposals have also been approved which involve a further outlay of £4,018,845, including the construction and equipment of new tramways, £1,010,000; street improvements in connection with tramways, £359,570; and the establishment of an electric supply undertaking, £2,500,000; but the last three schemes will be submitted to the Council again, if Parliamentary powers are obtained, before they become actual commitments. Some of the proposals with regard to tramways have already been struck out of the 1906 bill, owing to the lack of consent by borough councils. An approximate estimate has been included of the cost of the completion of the work of reconstructing and equipping all the tramways in London for electric traction, as well as for the construction of the new lines for which powers have been obtained. The estimate does not contain any provision for street widenings beyond those which have already been approved. The total net liability of the Council after deducting assets, at Dec. 31, 1905, was £44,859,729.

One of the tables deals with the commitments in respect of revenue-producing undertakings. In this case the balances of sums voted and outstanding amount to £4,278,117, including £3,699,530 for tramways. The latter figure is made up of £264,831 as the proportion of cost of street widenings necessitated by the construction of tramways and £3,434,699 for reconstruction works, construction of tramway subway, generating station and other buildings, cars and machinery. The estimated expenditure on tramway schemes approved, but not yet voted, amounts to £5,859,350. £3,600,000 is put down for tramways, showing a total contemplated expenditure on tramways of £7,299,530, excluding expenditure on schemes before Parliament. Assuming that the Council's projects before Parliament are approved and the capital expenditure in connection with them is voted the total gross debt of the Council, added to its commitments, will amount to £98,805,272.

**Marylebone.**—The net revenue account for nine months to Dec. 31 (after allowing for debit balance on March 31, 1905, of £5,143) showed a debit balance of only £3,264.

The Electric Lighting committee anticipate a credit balance on the current quarter's gross revenue of £20,000. Interest charges will absorb £15,500 of this, leaving an estimated net credit balance of £4,500. The balance in hand on the 31st inst. would be £1,236 instead of a debit balance of £3,374 as anticipated.

**Municipal Telephony.**—The revenue statement and balance-sheet of the Guernsey States Telephone Department for the year to Dec. 30 last shows total liabilities of £38,922. 18s., including reserve for depreciation £5,939. 1s. 2d., and a contingencies' reserve of £915. 7s. 6d.. which latter account includes the net profit for the year of £233. 11s. 1d. The assets include £30,956. 7s. 1d. on construction account, cash £3,528. 13s. 4d., Guernsey State bonds £2,700, stores, tools, furniture, &c., bringing up the total to the amount of the liabilities. The balance net profit on revenue account, after contributing £852. 11s. 4d. to reserve for depreciation and writing off £323. 5s. 3d., cost of old switchboard, was, as stated, £233. 11s. 1d. The total receipts for the year amounted to £4,756. 9s. 1d.; working office and general expenses were £1,871. 8s. There was an increase in the number of subscribers' lines on the year of 113, and on extension and other lines 16. The increased mileage of overhead wires was 108¼ miles, underground 31 miles. The total number of calls over the system was 793,976. an increase of 47,578 on the year.

The situation created by the rejection of the Hull Telephone committee's recommendation to sell the municipal telephone system to the National Telephone Co. was considered at the meeting of the Telephone committee on Monday.

The Chairman (Councillor J. BROWN) said he did not propose to take any action beyond placing the Council's resolution on the minutes.

Mr. GRINDELL raised the question as to what authority the sub-committee had to enter into negotiations with the National Co.

Councillor BROWN said that within 48 hours of his speech at the last Council meeting Portsmouth telephone department obtained from the L.G. Board sanction for a loan applied for about 12 months ago.

Mr. OMBLER moved that the special sub-committee be instructed to take the best means of bringing directly before the attention of Parliament the position of the Hull municipal telephane enterprise. They had a progressive and sympathetic Parliament, which, if it did not deal generously, would at all events deal justly and fairly with their case. This was agreed to.

The manager (Mr. T. HOLME) reported that the Sutton exchange had been opened, and that the Anlaby exchange would be open in a week or two.

**Penrith.**—The Council have asked the Board of Trade to defer the revocation of their 1900 provisional order.

**Presentation.**—On Tuesday the staff and employés of Cardiff Corporation tramways presented the traffic superintendent (Mr. Howell J. David) with an illuminated address and a gold watch and chain, to commemorate the 15th year of his service. The presentation was made by the borough electrical engineer and tramways manager, Mr. Arthur Ellis.

**Provisional Order Transfer.**—Notice is given of the intention of Eston District Council to transfer to Cleveland & Durham County Electric Power Co. their 1902 electric lighting order. Objections to Board of Trade by April 27.

**Recognising Bravery.**—In our issue of Jan. 19 we recorded the death, at Bath Corporation electricity works, of an engine driver named J. A. Gibbons, who, on the preceding Sunday, lost his life in a gallant attempt to save a boy from drowning in the Avon We are pleased to announce that the fund for the benefit of the widow and children of deceased, which the mayor promptly initiated, reached £659. 8s. 3d.

**St. Helens.**—The salary of the borough electrical engineer (Mr. E. M. Hollingsworth) has been increased by £50 per annum.

The charge for electric current for private lighting has been reduced from 4½d. to 3½d. per unit.

**St. Pancras.**—For the quarter ended Dec. 31 the Council's electricity department sold 1.520,779 units of electric current for private lighting, against 1,395,017 in the corresponding quarter of 1904, the receipts being £17,918 and £17,419 respectively. 590,856 units were supplied for street lighting, against 481,944 in 1904. The number of consumers was 2,741, against 2,454.

**Shipley.**—The salary of the electrical engineer (Mr. S. D. Schofield) has been increased to £275 per annum.

**Stepney (London).**—After conferring with the consulting engineer (Mr. Arthur Wright) and the borough electrical engineer (Mr. W. C. P. Tapper) the Lighting committee have decided to offer large long-hour consumers of current an alternative rate of charging —viz., 5s. per annum per 8 c.p. lamp demanded, and $\frac{1}{10}$d. per unit for all electricity consumed. Consumers are also to have the option of being charged for electrical energy for power at 5s. per electrical horse-power (taken at 750 watts) demanded per month and ½d. per unit for all electricity consumed, or at the existing rate of 1d. per unit. Prepayment meters are to be introduced into the borough, but the charges for current supplied through these have not yet been fixed.

**Stourbridge.**—A further discussion on electricity supply took place at the Council meeting on Monday.

The Electric Power committee submitted a draft agreement for the transfer of the Stourbridge 1899 Order to the Shropshire, Worcestershire & Staffordshire Electric Power Co. The agreement was, however, referred back to the committee for further negotiations and report, with an instruction that the Council is dissatisfied with the terms of the repurchase clause.

**Tramwaymens' Wages.**—Manchester Tramways committee discussed on Tuesday the demand by employés of the tramways department for payment of 50 per cent. extra for Sunday work. The Tramway Workers' Union representatives have assented to the proposal that the question should be referred to an arbitrator appointed by the Board of Trade.

**Walmer.**—The Council have asked a committee to report upon the possibility of transferring their provisional order, 1903, to a company, as the Board of Trade have refused sanction to the scheme submitted by Edmundson's Electricity Corpn.

**West Bromwich.**—The Corporation decided on Monday to allocate £800 out of the profit on the year's working of the electricity undertaking to relief of rates.

**West Ham.**—From to-morrow (Saturday) the Corporation's charge for electric current will be 3d. per unit, less discounts, and after June 30 the price of current for power will be 1d., less discounts.

The borough treasurer estimates there will be no loss on the electric lighting undertaking for the year ending the 31st inst., and the £2,000 provided as estimated deficiency will not, therefore, be required. In the ensuing year he considers the undertaking will again pay its way.

The estimated profit available from the tramways undertaking for the year is £15,000, and £8,000 of this is to be given in aid of borough rates, the balance being placed to reserve.

Plans are being prepared for the track and overhead equipment for the short length of tramway at Forest Gate, to form a junction with Leyton Council's tramways.

**Willesden.**—Draft forms of agreement for hiring and hire purchase of electric motors were approved by the Council on Tuesday.

The consulting and resident electrical engineers (Mr. Ruthven Murray and Mr. Bruce) submitted a scale of charges for large power consumers. Under this arrangement, for each E.H.P. demanded 15s. per quarter is to be charged, and the price per unit is to vary from 0·9d. for consumers of not less than 4,700 units per quarter to 0·5d. for consumers over 50,000 per quarter. The charge is in no case to exceed 1½d. per unit.

**Wireless Telephony.**—Mr. J. B. Spence, British Consul at Trieste, reports that two residents of that city have invented a new system of wireless telephony. The report states that on March 2nd, experiments were conducted at Trieste in the presence of the governor, the mayor and other leading local authorities, and proved entirely successful.

**York.**—The consulting engineer (Mr. Hutchinson), who was called in to report upon the recent accident to the machinery at the electricity works, reports that

The accident was caused solely by deficient lubrication, and recommends that River Foss water should not be used for the boilers, unless after special treatment. The report also states that it appears that more attention had been paid to, and more money expended upon, labour-saving appliances than to the upkeep of the actual generating plant. The plan of employing students was not one that could be recommended unless they were under the charge of some one with wider and more varied experience. Mr. Hutchinson adds that the staff appears to be ample for the requirements of the station so far as numbers are concerned, but that no shift should be worked without a man in charge of the engines, and these men should be men of greater experience.

**Dinners.**—The Royal Naval electricians held their annual dinner at Portsmouth recently.

The Chairman (Mr. HOWARD OWEN) said the officers of H.M.S. Vernon (some of whom were present) were just and high principled, and the electricians were proud to serve under them. Mr. Owen afterwards gave some particulars of the Royal Naval Electricians' Benevolent Club. With regard to the qualifications of electricians, the course they were going through on the Vernon was a very severe one, but after passing through it and the examination members of their profession would be thoroughly qualified to take up positions as electricians on any first-class battleship or cruiser in the Navy.

The male staff of the Blackburn district of the National Telephone Co. held their annual dinner on Saturday last.

The district manager (Mr. C. Remington, M.I.E.E.), who presided, regretted the inability of Mr. Shepherd and Mr. Prout from being present, but he was gratified to have amongst them Mr. Ashton (Lancaster) and Mr. Arthur (Preston). He alluded to the good feeling existing between the various departments of the huge concern of which they were all representatives. A smoking concert followed the dinner.

**Electro-Harmonic Society.**—We would remind our readers that the last smoking concert of the season will be held this (Friday) evening in the King's Hall of the Holborn Restaurant, London, commencing at 8 o'clock. The occasion will be a memorable one, as presentations are to be made to Mr. Alabaster, Mr. Gatehouse and Mr. Izard, as some recognition of their excellent services to the members of the Society in connection with these concerts, which have now reached the completion of the 20th season. A record gathering of members and their guests is anticipated to support Col. R. E. Crompton, C.B., in the chair.

## TRADE NOTES AND NOTICES.

**NOW READY.**

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1906 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is even more complete and accurate than in previous issues, and has been revised up to day of publication. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Traders' purposes. The valuable large sheet Tables, &c., have been very carefully revised and extended, making the 1906 Edition of this indispensable work the most complete book of the kind ever published.

A full Digest of Contents will be sent post free on request.

### TENDERS INVITED.

*Salford* Electricity committee invite tenders for supply and erection of 750 kw. steam turbo-generator and condensing plant. Plans, specification, &c., from the borough electrical engineer, Pendleton. Tenders by April 21 to the town clerk, Mr. L. C. Evans, Town Hall, Salford. See also an advertisement.

*Belfast* Tramways and Electricity committee invite tenders for supply and erection of coal and ash conveying plant, bunkers and chain grate mechanical stokers. Specification, with form of contract, from the city electrical engineer, Mr. Victor A. H. M'Cowen, M.I.E.E., M.I.Mech.E. Tenders by 11 a.m. April 16 to Sir Samuel Black, Town Hall, Belfast. See an advertisement.

*Exeter* Corporation invite tenders for the electrical overhead equipment of about ⅝ mile of route length of tramway. Specifications from the city electrical engineer (Mr. H. D. Munro), 184, Sidwell-street, Exeter. Tenders to the town clerk (Mr. H. Lloyd Parry), 8, Southernhay West, Exeter, by April 11. See also an advertisement.

*Exeter* Corporation also want tenders by April 11 for construction and bonding of about ⅝ mile single track electric tramway and erection of two additional bays at car depot.

*Aston* Guardians invite tenders for a complete telephone installation to connect the various blocks of buildings forming their workhouse at Gravelly-hill, Birmingham. Plans, &c., from the consulting electrical engineer (Mr. W. H. Whitehouse, M.I.E.E.), 37A, Waterloo-st., Birmingham. Tenders to the Clerk to the Guardians by 2nd prox. See an advertisement.

The directors of the *Lancashire & Yorkshire Railway Co.* invite tenders for 12 months' supply of various stores and requirements, including signal and telegraph fittings, signal, telegraph and electric light wires, steel tubes for boilers, cold and hot drawn weldless steel tubing, iron castings, lead, engine packing, &c. Tenders, addressed to the directors, to be lodged by 10 a.m. April 2 with the secretary (Mr. R. C. Irwin), Hunt's Bank, Manchester.

*Leeds* Electricity committee invite tenders for one or two sets of electric generating and condensing plant, each comprising a steam turbine, two-phase alternator and exciter of 3,000 kw. capacity, electrically-driven surface-condensing plant, and the necessary pipes and valves. Preference will be given to tenders for plant of British manufacture. Tenders to town clerk (Mr. Robert E. Fox) by 10 a.m. April 9.

*Sunderland* Corporation invite tenders for supply and erection of steam exhaust and other pipes in connection with the extension of their Hylton-road electricity station. Tenders (addressed to chairman of Electricity and Lighting committee) to the town clerk (Mr. Fras. M. Bowey), Town Hall, Sunderland, by noon April 4.

Tenders are wanted by April 3 for supplying *Mid Lothian and Peebles* District Asylum (Rosslynlee) with electrical fittings, ironmongery, &c., for six months. Forms of tender from the clerk, 19, Heriot-row, Edinburgh.

*Leyton* Urban District Council invite tenders for supply and erection of a traction switchboard. Tenders to be delivered at the meeting of the Electric Light committee to be held at the Town Hall, Leyton, on April 9, at 7:30 p.m.

*Devonport* Corporation require tenders by noon April 12 for 12 months' supply of stores for the electricity department.

*Bristol* Docks committee want tenders by 10 a.m. April 18 for electric lighting of the tobacco warehouse, Cumberland Basin.

The *Norwegian* State Railway authorities are inviting tenders for supply of telegraph materials, including 40,000 kilos 4 mm. and 6,000 kilos 3 mm. galvanised iron wire and 12,500 large and small insulators. Tenders by April 6 to Statsbanernes Hovedkasserer, 1, Jernbanetorvet, Christiania, from which address copies of the specification can be obtained.

### TENDERS RECEIVED AND ACCEPTED.

In July, 1905, Mussoorie (India) Municipal Board invited offers for the supply and erection of plant, &c., for a hydro-electric and water works scheme, and numerous tenders were received from the undermentioned firms. There were many alternatives offered by the tendering firms. As the price of the pipes differed so considerably they were separated from the main body of the contract. :—

| | Without power pipes. | With power pipes. |
|---|---|---|
| Bruce Peebles & Co. (*accepted*) | **£14,385** | £22,395 |
| T. Scott Anderson | 18,906 | 26,906 |
| Greaves, Cotton & Co. | 18,846 | 23,146 |
| Keymer & Co. | 17,168 | 27,916 |
| R. Hotz | 16,443 | 22,743 |
| Schroder, Smidt & Co. | 16,206 | 23,190 |
| O. Steel & Co. | 16,199 | 25,508 |
| Crompton & Co. | 16,166 | 20,079 |
| Siemens Bros. & Co. | 16,122 | 19,335 |
| Jessop & Co. | 15,457 | 22,442 |
| Kilburn & Co. | 15,162 | 20,341 |
| Bombay Electric Co. | 14,808 | 26,348 |
| Lahmeyer Electrical Co. | 14,482 | — |
| Burn & Co. | 13,994 | 17,982 |
| Gavin, Jones & Son | 13,612 | 20,737 |
| Brush Co | 13,538 | 21,033 |
| Johnson & Phillips | 13,060 | 20,960 |

Glasgow Corporation have placed with Witting, Eborall & Co., Temple Bar House, London, E.C., the construction of all the additional high pressure switch gear required in connection with the extensions to the Port Dundas power station, amounting to about nine completed and ten blank panels. This practically doubles the capacity of the original portion of the board, also executed by Witting, Eborall & Co., and the completed board will control and distribute energy at 6,600 volts from the 3,000 kw. three-phase generating plants, whose total capacity will eventually be 20,000 kw. The value of the work already done and in hand is approximately £10,000.

London County Council have accepted the tender of the Frodingham Iron & Steel Co. at £2,750 for supply of slot rails for tramways along Kingsland-road, N.E. Steel, Peech & Tozer tendered at £3,640. 14s., and P. & W. MacLellan at £3,640. 3s.

The offer of Dick, Kerr & Co. to execute the road work and platelaying for reconstructing the tramway in the Goswell-road, on the same schedule of prices as those on which they are reconstructing tramways in the vicinity, was accepted. It was also agreed that the contract entered into with Reid Bros. on Oct. 10 for reconstruction work for tramways be extended to include the laying of cable ducts on the northern system at a cost not exceeding £33,000.

Battersea (London) Council have accepted the tender of the Falkirk Iron Co. for 80 arc-lamp columns at £910. 6s., and those of the British Thomson-Houston and Edison & Swan Cos. for 8 c.p. and 16 c.p. incandescent lamps, the former at 7¼d. each and the latter at 8½d. each.

Bruce Peebles & Co. have received from C. A. Parsons & Co. an order for an 800 kw. 2,000 volt 50 period single-phase turbo-type alternator for Shanghai municipality. This machine runs at 1,500 revs. and the order includes direct-coupled exciter.

Chepstow Council recently invited tenders for public lighting. The Gas Co. tendered for 27 all-night and 51 short-period lamps, and the Electric Lighting Co. for 9 all-night and 18 short-period lamps. It has been decided to accept the latter tender for the all-night lamps and the former tender for the remainder.

Marylebone (London) Council received 27 tenders for the annual supply of engine room stores for the electricity department, and accepted the offers of the following firms; Hobdell, Way & Co., W. H. Willcox & Co., W. T. Henley's Co., Baxter & Caunter, the British Insulated & Helsby Cables, and Geipel & Lange.

Bruce Peebles & Co. have secured an order from Sunderland Corporation for a 250 kw. motor-generator for the Pallion sub-station. This machine runs at 500 revs. and 50 periods, the alternating-current voltage being 5,000 and the continuous current 250.

The Admiralty have placed with the British Thomson-Houston Co. an order for 5 5 H.P., 10 10 H.P. and 2 50 H.P. motors and rheostats for use at Chatham dockyards.

The following tenders have been received by London County Council for fish plates for side-slot rails :—

| | |
|---|---|
| Continuous Rail Joint Co. (*accepted*) | £523 |
| P. & W. MacLellan | 628 |

The tenders of the Frodingham Iron & Steel Co. and from Steel, Peech & Tozer were not to specification and incomplete respectively.

Great Grimsby Corporation have accepted the tender of the Chain Belt Engineering Co. for an automatic coal weigher and motor for the electricity department at £136.

The D.P. Battery Co,, Lumford Mills, Bakewell, Derbyshire, have secured the order for 230 L.L. 19 plate cells for Newmarket central station.

Topsham Parish Council have unanimously accepted the tender of the Topsham Electric Supply Co. for street lighting, at 27s. 6d. per lamp per annum.

Cardiff Corporation have accepted the tender of Balcke & Co. for a cooling tower at the power station at £2,440.

The tender of Thompson Bros. at £40 has been accepted by Bridgwater Council for wiring the Bridgwater new free library.

Sculcoates Guardians have accepted the tender of H. Hyde for electrical work at the workhouse for the ensuing year.

Leyton Council have accepted the tender of Callender's Co. for underground feeders, and that of S. Zylberlast for condenser and water cooler.

West Ham Corporation have accepted the tender of the General Electric Co. for a motor-generator at £1,190.

Canterbury Council have accepted the tender of the Chloride Electrical Storage Co. for a Highfield semi-automatic booster at £269.

City of London Corporation have accepted the tender of J. H. Golding for wiring the new buildings at the city mortuary.

**Tramcar Brakes.**—The British Westinghouse Co. has received an order from London County Council for 334 brake equipments for as many cars, making, when this contract is completed, in all 400 L.C.C. cars which will be equipped with the Westinghouse magnetic brake.

## BUSINESS NOTICES.

Mr. W. E. Warrilow, A.M.I.E.E., informs us that he is resigning the editorship of the "Electrical Magazine," and will shortly start business as electrical publicity expert and consulting engineer. Mr. Warrilow's business address is 49, Mildred-avenue, Watford, Herts.

Messrs. Harris, Lee & Co. (Ltd.) (electrical and mechanical engineers, of Johannesburg), are expecting one of their directors (Mr. B. F. Botting), at the end of March, at their London offices, 165 Queen Victoria street, E.C., where he can be seen by appointment.

Mr. T. Roland Wollaston, M.I.Mech.E., consulting engineer, has removed to Lord's Chambers, 26, Corporation-street, Manchester.

The address of the Electrofons Co. is now Lord's Chambers, 26, Corporation-street, Manchester.

Chas. Ernest Carr Button and Geo. Hy. Carrington, electrical engineers, 31, High-street, Crewe, have dissolved partnership. Debts by Mr. Carrington, who continues.

Mr. W. P. Durtnall, A.M I.E.E., chief electrical and mechanical engineer for London and South of England branch of Walsall Electrical Co. has resigned in order to take up an appointment with Mr. E. W. Hart, Luton, who is developing the Hart-Durtnall system of power transmission on motor vehicles.

It is announced that the British Automatic Telephone Synd. (Ltd.) has secured the British patent for the Lorimer telephone system.

Messrs. Bowman and A. C. Curtis Hayward, A.I.E.E., solicitors, have removed from 21, Bedford-row, to Maxwell House, Arundel-street, London, W.C.

**Cable Makers' Association.**—We are informed that Messrs. Johnson & Phillips (Ltd.) have been elected members of the Cable Makers' Association, and that the company's standard wires will in future bear the official labels authorised by that association.

## BANKRUPTCIES, LIQUIDATIONS, &c.

Arthur Herbt. Sparkes, formerly of Nightingale Workshops, Hornsey-road, N., and 31, Kirby-street, E.C., London (lately trading with Richd. Bennett as A. Herbert & Co., electricians, and with Wm. Carter, as electrical engineers), has been adjudicated bankrupt. The first meeting of creditors will take place on April 2 and the public examination on May 1 at Bankruptcy-buildings, London, W.C.

Claims against the Atmospheric Electrical Purification Co. (Ltd.) by May 4 to Mr. E. E. Groome, 21, Spring-gardens, Manchester.

Vazson, Easterbrook & Co. (Ltd.) is being wound up voluntarily. W. A. Richards and H. E. P. Beard, Hooles-chambers, Bank-street, Sheffield, are liquidators.

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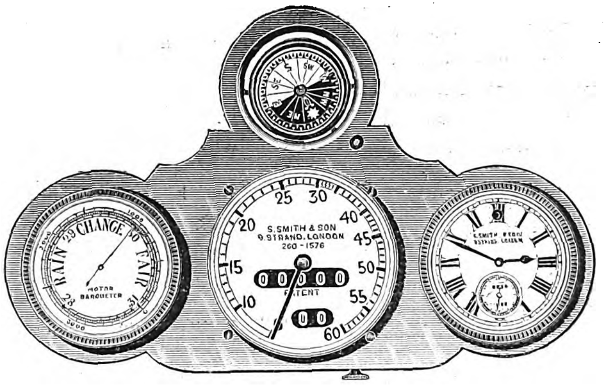
**Plant, for Sale.**—The New Spa & Gardens (Ltd.), Bridlington, have some electric lighting plant (a dynamo, gas engine, switchboard, &c.) for sale. See an advertisement.

**Premises to Let.**—Mr. Alfred Kirkland, 113, Cottenham-road, Upper Holloway, London, N., advertises an extensive new factory to let.

**Automobile Exhibition.**—The Automobile Exhibition now being held at the Agricultural Hall, London, illustrates effectively the rapid advances which are being made in mechanically-propelled vehicles, and, although in point of numbers petrol-engined cars hold the field, for handsomenness of design and generally smart turnout the electrically-propelled vehicles on show easily hold their own. This is particularly the case with the landaulets, victorias and coupés exhibited by the KRIEGER ELECTRIC CARRIAGE SYND. The IMPROVED ELECTRIC TRACTION (LTD.) also show a smart electric delivery van as well as a well-designed cab. This company are prepared to supply their improved electric vans on hire, made and painted to customers' requirements, at an inclusive sum of five guineas per week for van, driver, power, care and upkeep, and all legal responsibility while in use by the hirer. This looks like business



MESSRS. S. SMITH & SONS' NEW COMBINATION WATCH, ANEROID AND COMPASS.

Among the general exhibitors, Messrs. S. SMITH & SON, of 9, Strand, London, W.C. (stand 323), have a large and interesting display of their "Perfect" speed indicators, motor watches, communicators, milometers and other high-class specialities and fittings for motors. We illustrate herewith a new combination of watch, aneroid and compass. Messrs. Smith & Son's exhibit is the largest and finest display of these motor accessories yet made in this country, and includes the firm's new departure, the famous "Radium" lamp. The "Perfect" speed indicator registers up to 10,000 miles, and is an ideal trip recorder. There are now thousands of these instruments in use under the firms's guarantee for one year. These indicators are supplied with a variety of automatic and other simple devices to fit them for all kinds of operations on the car. The combination which we illustrate herewith can be fitted to any of these indicators and is a new and patented idea. The electric communicator, which is employed for communicating from the interior of the car with the driver, comprises different coloured lamps for direction signs, the idea being that the driver, after a short use of the instrument, will learn to understand the meaning of each different coloured lamp. Motor timepieces, chronographs and watches, reflectors, the milometer (a perfect recorder, registering up to 10,000 miles) are also shown by this firm, as well as the latest novelties in motor jewellery.

Of sparking coils there is a goodly number, those shown by Marconi's Wireless Telegraph Co. being excellent examples, giving a "fat and fiery spark." Mr. J. A. Ryley shows "Vita" sparking plugs and "Eclair" coils, and Messrs. John C. Fuller & Son, Wick-lane, Bow, London, E., exhibit accumulators, trembling coils, charging batteries, electric headlights and rearlamps, test lamps, &c. J. C. Lyell & Co. show "Lemale" self-starters, sparking-plugs, coils, &c.; Geipel & Lange "Vulcan" speed indicators, odometers, auto-tremblers and hot-wire voltmeters; Joseph Kaye & Sons their noted oilcans in seamless copper, brass and steel; and the Accessible Battery & Engineering Co. ignition batteries, charging apparatus, ammeters, voltmeters and hydrometers.

The Exhibition remains open until to-morrow (Saturday) evening, and is well worthy a visit.

**A New Switch.**—Messrs. Sperryn & Co., of Birmingham, have brought out a new form of tumbler switch, to which they have given the name "Faultless Switch." The main feature of the arrangement is that all the brasswork is attached to a fibre disc, as shown in Fig. 1, so that the whole may be removed for inspection without disturbing the porcelain base (Fig. 2). There are no screw heads or other metal work at the back of the base, and the screws holding the switch on to the base screw into brass nuts embedded in the china, these having been slipped in through slots from the side and held in place by cement. Altogether, the details are well thought out, and the switch appears substantial and well made. Several sizes up to 30 amperes are made, and these are listed with plain or artistic brass covers. A spring toggle joint provides a quick make as well as a quick break action.

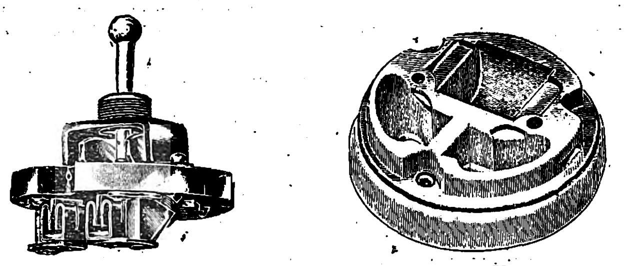
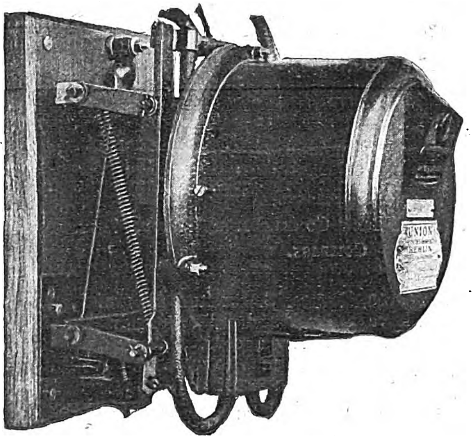


Fig. 1. The "Faultless" Switch. Fig. 2.

**Roller Bearings.**—The subject of "Forced Lubrication" was discussed in a Paper read before the Scientific Society of the Technical College of Glasgow on March 17, and in the course of the Paper it was stated that a large number of roller bearings supplied by the Empire Roller Bearings Co., of Westminster, London, for Nobel's Explosive Factory had been found to give the utmost satisfaction. After ten months' hard running one of the bearings was taken out and examined the day before the lecture and was found to be in perfect condition. Another point made on behalf of roller bearings was that by their use Messrs. Nobel were able to increase the number of cartridge packing machines running from one engine from 19 to 46, with an increase of only two hour-power, and that the percentage of saving in the oil bill had been nearly 90 per cent.

**Tramcar Meters**—We illustrate herewith a new type of tramcar meter which is being placed on the market by the Electrical Co., 121-125, Charing Cross-road, London, W.C. It is claimed for this watthour meter that it possesses some novel points: It is hung on a patent spring base, and the consumption in units is recorded on a cyclometer type dial. The Electrical Co have particulars available, which can be obtained from the meter department at the above address.



**Silvertown.**—The appellation "Silvertown" has come to be regarded in the electrical industry as belonging exclusively to the manufactures of the India Rubber, Gutta Percha & Telegraph Works Co. (Ltd.), whose works at Silvertown occupy an area of more than 17 acres on the north bank of the Thames, close to the Silvertown station of the G.E.R. These are, however, not the only works owned by the company, for at Persan Beaumont, in France, another large block of works premises is devoted to the manufacture of the goods for which the India Rubber Co. is famed all over the world. At Silvertown there are permanently employed about 3,000 hands, and this number is largely exceeded on occasions when large contracts are in hand. At Persan about 800 hands are similarly employed. Besides the extensive office premises at Cannon-street, London, the company have distributing offices in the Boulevard Sebastopol, Paris, and agency premises in Melbourne, Sydney, Perth and Brisbane (Australia), in Calcutta (India), in Buenos Ayres (South America), in Durban and Johannesburg (South Africa), as well as 12 representative establishments in the largest towns of the United Kingdom. It is, however, to a description of the fine Silvertown works of the company that a booklet has recently been devoted, a copy of which is before us. The frontispiece shows the well-equipped electricity generating station at the company's works, where a range of Silvertown dynamos are installed. The Silvertown buildings are arranged in blocks, so disposed as to suit the requirements of the various departments of this huge business, and the whole of the factory and approaches are lighted by electricity, both arc and incandescent lamps being employed. There are over 40 boilers in use at Silvertown, involving a weekly consumption of coal exceeding 1,000 tons. The sections into which the works premises are divided include the india-rubber department, which takes a prominent part in the manufactures of the company, the submarine cable department, and the electric lighting department, which, when originally erected in 1882 was the largest private plant in the United Kingdom. At the present time, in addition to two 250 H.P. marine type engines and two 200 H.P. stand-by direct-coupled sets, the machinery laid down in this department comprises one 1,100 H.P. engine and dynamo and four 500 H.P. sets working at 150lbs. pressure. Current is supplied to the equivalent of 14,000 8 c.p. lamps for lighting and over 200 motors, of 1 to 150 H.P., drive the miscellaneous assemblage of machines which the varied manufactures of the Silvertown Company employ. In this department the Silvertown electric light cables are manufactured, as well as dynamos and motors, which form a very large branch of the company's manufacturing operations. The instrument department at Silvertown is occupied in the manufacture of electrical and other instruments for which the Company have for many years experienced a large and increasing demand. In this department the Company's special type of switchboards are assembled, the heavier work required in the manufacture of the boards being executed in a separate department provided with special tools and machinery. A very large business is done in carbons and batteries, and departments are set aside for the manufacture of these goods. Besides the manufacture of electrical goods in the india-rubber department, this is, as the Company's title indicates, one of the chief branches of the business, and no department has shown greater advance than this, for the company have for many years held a prominent place in the manufacture of india-rubber goods of all kinds, including beltings, hose, waterproof fabrics, tyres, golf and lawn tennis balls, and the multifarious articles of commerce in which india-rubber forms a chief place. Testing departments, torpedo shops, and various other sectional departments, go to make up the large works at Silvertown, and we cannot do better than refer our readers to the booklet under review for a complete description of the works and illustrations of some of the fine machines which are installed therein.

**Jubilee Celebration.**—We have received from Dr. Heinr. Traun & Sons' London agency (of which Mr. F. Winter, 8, Redcross-street, E.C., is manager) a neatly printed and profusely illustrated booklet giving particulars of the history of the founding and development of the firm. The booklet was sent out on the occasion of the celebration of the fiftieth anniversary of the founding of the firm, which took place at Hamburg on Feb. 17 last, when the firm invited about 400 guests to a banquet, and afterwards about 4,000 persons (workmen and their friends) were invited and were present at a concert and ball. The senior partner of the firm (Senator Dr. Traun) divided on that occasion £5,000 among his workpeople.

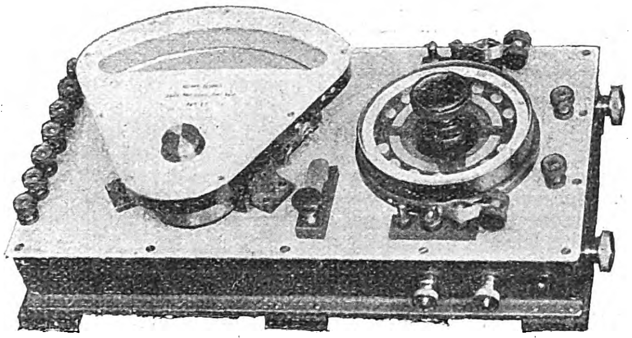
**Catalogues, &c.**—Messrs Crompton & Co. have issued a well-arranged list of open-type continuous-current dynamos from 5 kw. to 250 kw. The various sizes are listed for standard outputs at 110, 220 and 440 volts, and the larger machines also at 500 volts. The smaller dynamos are also standardised for 135 volts for use in charging batteries for 100 volt installations. Opposite the dimension sketches and tables of net and gross weights for each size is to be found the table of outputs at the above voltages with standard windings, and an unusually complete price list of extras and spares. The smaller machines up to about 40 kw. are 4 pole with unsplit frames; above this size they are of 6-pole type with split frames. Channel section yokes are employed above about 120 kw., and in the whole range of sizes, even up to 250 kw., the brush gear is supported from the bearing bracket The temperature rise for which the machines are rated is not mentioned, but the permissible overloads are given as 25 per cent. for one hour and 50 per cent. momentarily.

Another new list issued by Crompton & Co. deals with the company's C.B.H. type circuit breakers. These can also be opened and closed by hand, so that they do not require switches in series, and a quick-make action takes place as well as a quick-break. The switch, however, cannot be held closed in the event of an overload. The main laminated brush contact is of the usual type, but acts vertically instead of springing out away from the board. Two auxiliary contacts are provided, one of which is fitted with a magnetic blow-out. A thermal form of release, having a certain amount of time lag, can be provided in some cases as an alternative to the magnetic release, or a retarding device can be applied to the latter. The circuit-breakers are listed in the single, double and triple-pole forms with overload, minimum, no voltage, or reverse current releases, or a combination of more than one of these, in sizes up to 2,300 amperes. The single-pole type is compact, but the two and three-pole types occupy a rather excessive amount of vertical space, as they practically consist of a series of separate circuit-breakers mounted one above the other.

A new list of current prices of Simplex steel conduit has just been issued by the Simplex Steel Conduit Co., and can be obtained on application. Although consisting of only four quarto pages, the Simplex Co. have, as usual, contrived to include a large range of prices and a mass of illustrations showing the parts of Simplex tubes and fittings which can be supplied from stock at the company's various depots.

Two new price lists have been issued by A. Reyrolle & Co, of Hebburn-on-Tyne. The first of these (No. 25) deals with tank switches of the three-phase oil-break type, the design and manufacture of which this firm have made a speciality for some years past. The switches listed are suitable for use with any class or make of switch gear. The second list (No. 26) deals with motor starters and speed regulators, and includes the firm's special construction of resistance, which is made without resistance wires, and, consequently, reduces the risk of failure and stoppage due to faulty operation or overloading. It is claimed for this apparatus that the mechanical construction is very reliable and strong. Messrs. Reyrolle point out that there is already an increasing demand for this apparatus as a speed regulator and also as a double lever motor starter for use in cases where it is specified that the automatic overload release must operate in all positions during the starting operation. The firm will be in a position shortly to supply all standard sizes from stock.

A set of price lists of new type mechanical, electrical and scientific high-grade instruments of precision have been prepared for publication by Clark Fisher & Wadsworth, Gordon Works, Ealing, London, W. The lists cover a wide range of electrical instruments, including galvanometers, dynamometers, wattmeters, voltmeters, and ampere meters, &c., together with a complete testing set (the "Gordon"). Resistances, rheostats, bridges, &c., keys and switches, are each described and priced in this compact set of illustrated sheets. Copies of the list can be obtained on application. The "Gordon" testing set is shown in the accompanying illustration, and is designed to meet the want of a set in which extreme accuracy, convenience and weight, accompanied by high-class workmanship, are the desiderata. Shunts are provided (fitted in a separate leather case) for 150, 300 and 750 amperes. These have very massive terminals enabling full size cables to be clamped in.


THE "GORDON" TEST SET.

The "Tyacke" water softener is well described and illustrated in a pamphlet issued by James Gordon & Co., 52, Lime-street, London, E.C.

New lists of "Holophane" globes for Nernst electric lamps have been issued by the Electrical Company and by the A.E.G. English Mfg. Co. A good description of a wide range of these radiators, as well as some good illustrations of Nernst lamps fitted with various types of "Holophane" globes, are included.

Catalogues Nos. 111 and 132, issued by Ferranti Limited, Hollinwood, Lancs., deal respectively with Ferranti box type rheostats and Ferranti patent water resistance cut-outs. Both pieces of apparatus are illustrated and described in the lists.

W. F. Dixon & Co., of Manchester, forward two circulars giving particulars of Dixon's Buffalo raw hide silent pinions and gears.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from March 21 to 27, with the ports of destination:—

*Aden*, £120; *Africa*—Alexandria, £145; Chinde, £190 (telegraph material); Durban, £2,469 (including £1,820 telegraph material); East London, £50; Port Elizabeth, £8; Port Said, £10; Sekondi, £7; Suakim, £591 (including £580 telegraph material). *Argentina*—Buenos Ayres, £2,699 (including £652 telegraph material); Rosario, £63 (telegraph material). *Australasia*—Adelaide, £100; Auckland, £77; Brisbane, £744; Fremantle £1,236; Geraldton, £40; Melbourne, £313 (including £224 telegraph material); Newcastle, £10; Perth, £16; Sydney, £1,487 (including £120 telegraph material). *Belgium*—Ghent, £105. *Brazil*—Rio Janeiro, £227. *Canada*—Montreal, £37. *Ceylon*—Colombo, £145. *Chili*—Valparaiso, £254. *China*—Hankow, £689; Shanghai, £208, and 102 tons iron telegraph poles. *Denmark*—Copenhagen, £40. *France*—Boulogne, £55. *Germany*—Hamburg, £18. *Holland*—Amsterdam, £233 (including £173 telegraph material). *Hong Kong*, £62. *India*—Bombay, £1,740 (including £103 telegraph material); Calcutta, £3,456 (including £290 telegraph material); Karachi, £21; Madras, £900 (telegraph material). *Japan*—Moji, £159; Nagasaki, £12; Yokohama, £715. *Malta*, £25. *Mauritius*, £1,596 (including £22 telegraph material). *North Atlantic*, £5,315 (submarine cable). *Norway*—Christiania, £286 (telegraph material). *Peru*—Callos, £170 (telegraph material). *Philippines*—Manila, £1,096. *Portugal*—Lisbon, £83. *Siam*—Bangkok, £91 *Straits Settlements*—Penang, £68; Singapore, £351. *Sweden*—Gothenburg, £29; Stockholm, £39; (telegraph material). *Uruguay*—Monte Video, £70. *U.S.A.*—New York, £485. *West Indies*—Antigua, £20; Trinidad, £57. Total, £29,232, against £15,505 in the corresponding week last year (March 22 to 28).

# PATENT RECORD.

## SPECIFICATIONS PUBLISHED.

### 1905 SPECIFICATIONS.

343 BRUCE PEEBLES & CO. & LA COUR. Converting multiphase into continuous current.
530 COURTEEN. Electric railways and trains.
2,098 BURLEIGH. Brush holders for dynamo-electric machines.
2,339 JOHNSON. Dynamos or motors.
2,432 DOWIE. Electric distribution systems particularly for train lighting.
2,475 YOUNG. Automatic signalling for electric railways.
2,554 HALLOT. Automatic auxiliary electric lighting systems.
2,639 BOUCHER. Electrical lampholders.
2,742 THOMSON & ELLIS. Distributing electric currents and producing electric pulsations.
2,749 BILIOTTI. Time element excess current thermal devices for cut-outs.
2,864 SIEMENS BROS. & CO. & JENKIN. Controlling electric trains.
2,918 VANDERVELL & PROCTOR. Dynamos.
3,088 FULLER. Combined electric switches and fuses.
3,184 SIEMENS BROS. & CO. & JENKIN. Installations for controlling electric trains.
3,189 B.T.-H. Co. (G.E. Co., U.S.) Dynamo electric machines.
3,357 VANDERVELL & HODGSON. Driving dynamos and the like.
3,816 B.T.-H. Co. (G.E.Co., U.S.) Gearing for power-operated switches.
4,100 THOMPSON (Decker Mfg. Co.). Electrolytic apparatus.
4,260 BEAVER & CLAREMONT. Manufacture of cables.
4,700 McFARLANE & WATSON. Electric counterweight fittings.
5,010 CROSS. Operating points of electric railways and tramways.
5,758 BOWELL. Secondary electric clocks and the like.
5,882 CANDAU & CANDAU. Manufacture of lithopones by electrolysis.
5,984 PRICE, COX & MARSHALL. Electric furnaces and electrodes for same.
7,436 DAVIDSON. Dynamo-electric machinery.
7,555 GREY. Sole plates or anchor plates for street tramway rails.
7,605 B.T.-H. Co. (G.E. Co., U.S.) Collecting devices for dynamo-electric machines.
7,721 PHŒNIX DYNAMO MFG. CO. (LTD.) Single-phase motors.
7822A B.T.-H. Co. (G.E. Co., U.S.) Controllers for electric motors. (Date applied for, April 12, 1905.)
7,919 B.T.-H. Co. (G.E. Co., U.S.) Rheostats.
8,732 GEST. Systems and means for laying electrical wires in conduits.
8,759 MAUTZ. Electric distant gas lighting device. (Date applied for, April 27, 1904.)
9,376 ROBINSON. Method of igniting the explosive charge in internal combustion engines.
9,401 WALKER. Electric contact devices.
9,522 BOTTOMLEY & PAGET. Electric resistance furnaces.
9,655 LEITNER & LUCAS. Dynamo construction.
9,657 GOUIN. Accumulators. (Date applied for, May 9, 1904.)
9,865 BERLIN. Electric cables. (Rights not granted.)
9,908 B.T.-H. Co. (G.E. Co., U.S.) Connectors for conductors.
10,118 LEITNER & LUCAS. Electric train lighting.
10,400 BIRNBAUM & BELL. Fire alarm apparatus in connection with central battery telephone systems.
10,747 CUMMINS. Brakes for vehicles on tramways and railways.
10,897 B.T.-H. Co. (G.E. Co., U.S.) Dynamo electric machines.
10,961 EDGAR ALLEN & CO. (LTD.) & WARLOW. Tramway points.
11,040 FULLER. Batteries.
11,907 FOY. Tramcars.

# COMPANIES' MEETINGS AND REPORTS.

## British Electric Transformer Co. (Ltd.)

The third ordinary general meeting was held yesterday at Cannon-street Hotel, London, E.C., Mr. E. PHILLIPS presiding.

The SECRETARY (Mr. J. C. Wrist) read the notice convening the meeting and the report of the auditors.

The CHAIRMAN then said: The accounts were not presented to shareholders quite so early this year as usual. One reason for this is that we were negotiating for the sale of our transformer patents in the United States, and we waited for these negotiations to be brought to a conclusion before meeting the shareholders. A day or two before the issue of our report the sale was completed for a payment in cash, which the directors consider extremely satisfactory. Another reason for the delay is the increased length of time taken up in the audit of our accounts. In our opinion these accounts exhibit a very satisfactory state of affairs, and fully justify a distribution of the same dividend as in 1904. Debts owing by the company are larger on account of the increased business being carried on, but this item is balanced by the larger amount owing to the company appearing on the other side. Depreciation reserve and reserve fund are increased by £1,500 and £2,000 respectively, in accordance with the resolutions passed at our last general meeting. On the other side of the balance-sheet, patents show an increase of £897, which includes the cost of further patents taken out and experimental work in connection with patents already granted. Goodwill is the same as before; preliminary expenses are reduced by £1,500, and will again be reduced by £1,500 this year if you acquiesce in our recommendation, and we hope that this account will disappear entirely at the end of next year. Stock of materials, &c., appears at a smaller figure than in the previous year, due to the fact that we thought it would not be prudent to buy largely in view of the high price of raw materials. Investments represent £4,400 more. Certain interests included in this sum have been acquired with a view to facilitating and securing business. Debts due to the company are £2,300 larger, but as we consider these good we have no anxiety with regard to them. I may say that since the end of the year over £19,000 has been received. Turning to the profit and loss account, little explanation is necessary. Our customers are all corporations, railways or firms of high standing, with many of whom we have done business for several years, so that there is no necessity for making provision for bad debts. The amount of profit earned for the year is somewhat less than during the previous year, but we must not lose sight of the fact that last year was our record year. There are several reasons for the decrease in profits, the principal one being the great increase in the price of copper, and the consequent rise in the cost of production. Copper, as you are all aware, plays an important part in the construction of a transformer. It was unfortunately not possible for us to raise the price of transformers in the same ratio as the price of copper was raised; on the contrary, competition has been very keen, and prices are now cut by some of our competitors to such an extent that they seem to be glad to take orders which cannot leave them a fair trading profit. The output of transformers during 1905 was very much greater than in 1904, but our mercantile business was less. A large number of orders were executed under great pressure for delivery, and I might mention that generally people seem to put off ordering plant until the last moment, and then make quick delivery a condition. We are doing everything to reduce manufacturing charges without jeopardising our high standard of efficiency. We have to thank Mr. Billington for his untiring energy in this direction. During the past year the works have been connected with the Uxbridge and District Electric Lighting Co., and work in our testing shop has thereby been cheapened and facilitated. This shop is now thoroughly equipped and up to date, and we have been complimented by many of our customers upon the excellence of our testing equipment. We intended to pay more attention to the manufacture of instrument and other small-sized transformers, to which branch of the business we have not hitherto applied ourselves. Last year I informed you that Mr. Berry had presented the company with some new patents. These were in respect of what are called the Berry series gear. After exhaustive trials in practical working, this invention is proving of great value. By its use very great economies are effected—in capital expenditure, coal, &c. The system will, it is thought, when better known, appeal in a very forcible manner to all the big lighting and power companies. As I have already informed you, within the last few days we have effected the sale of our transformer patents in the United States. This sale does not include the series gear patents, but only those for transformers; and the transaction does not in any way appear in the accounts now before you. As regards the allocation of the available balance, we recommend that the same amounts as last year be placed to depreciation reserve and reserve fund, that £1,500 be written off preliminary expenses, that (after allowing for preference dividend) a dividend of 7½ per cent. be paid upon the ordinary shares. Nearly £800 will be carried forward. I now move the adoption of the report and account.

Mr. A. F. BERRY seconded the motion, which was carried unanimously.

The retiring director (Mr. E. Phillips) and the auditors (Messrs. Monkhouse, Stoneham & Co.) having been re-elected, the proceedings closed with a vote of thanks to the chairman and directors.

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**BRUCE PEEBLES & CO. (LTD.)**—The third annual general meeting was held at Edinburgh on Wednesday, when the directors' report, which appeared in our last issue, was unanimously adopted, and the following dividends were declared:—On the original preference shares, 7 per cent. per annum for the half-year to Dec. 31 (making 6½ per cent. for the year); on the new preference shares, 6½ per cent. per annum for the period from date of issue to Dec. 31 (including interim dividend already paid); on the ordinary shares, 6½ per cent. for the year 1905, all less tax. The Chairman (Mr. W. Carmichael Peebles) congratulated the shareholders on the year's working. The hydro-electric installation which the company was completing in North Wales amounted in value to over £250,000, and consisted of a central station of 10,000 H.P. to utilise the Falls of Snowdon. A considerable amount of that power had already been sold to the large quarry owners and others, the bulk of the motors for which the company was supplying, and would be in operation during the next two months. The North Wales Power Co. were extending their sphere of operations by building another station of similar capacity at Conway, the contracts for which would be carried out by Bruce Peebles & Co. The Falkirk & District Tramways, the Scottish central power station and the Fife electric power station, all of which had been completed and equipped by the company, had been started during the year, and were in full operation. The company was just completing an installation of 10,000 H.P. for the Durham Collieries Electric Power Co., which was doing remarkably well. Over 20,000,000 units had been already booked before the station started. The whole equipment was supplied and built by the company, which also supplied several of the large collieries with electrical equipments. The Sunderland District Tramways, which were also constructed by Bruce Peebles & Co., were being supplied from that station, and were in course of completion. The Canadian Electric Traction Co.'s line of 30 miles, which the company was building in Ontario (Canada), would be running in the early summer. The company had lately secured the contract for the Shanghai tramways, to the value of, approximately, £300,000. Immediate extensions were already contemplated, which would increase the total value of this contract to, approximately, £500,000. Further recent contracts secured included a hydro-electric installation for Musoorie, India [see our "Tenders Accepted" column this week], the Wemyss tramways and two large tramway concessions in Brazil and Northern India, the benefits from which it was expected would be derived during the present year. The company was interested in several bills for tramways, including extensions to the Falkirk district tramways, Dunfermline and Naval Base tramways, Ardrossan, Saltcoats and Stevenson tramways; and Folkestone, Sandgate and Hythe tramways. The company was also experiencing a good demand for its patented motor converter, and orders to the value of over £50,000 had been either completed or were in course of progress for that particular type of apparatus, representing some 30,000 H.P.

**BROMLEY (KENT) ELECTRIC LIGHT & POWER CO. (LTD.)**—During 1905 the lamp connections increased from 56,198 to 64,957 8 c.p., and the sale of current from £11,366. 5s. 4d. to £12,485. 7s. 11d. The result of the year's trading is a profit of £8,782. 2s. 3d., and the amount available for dividend is £5,938. The directors recommend a balance dividend at the rate of 7 per cent. (making 5½ per cent. for the year.)

**BRUSH ELECTRICAL ENGINEERING CO. (LTD.)**—The gross profit for 1905 was £8,505, general charges, maintenance, interest and £6,893 carried to depreciation absorb £50,331, leaving £34,720. Preference dividend absorbs £18,000, a dividend of 2½ per cent. on the ordinary shares (£5,286), interest on loan of £30,740 from the British Electric Traction Co. £769, general reserve £7,550, carrying forward £3,114. This brings the depreciation reserve fund to £52,000 and the general reserve to £24,000. £6,491. 17s. 8d. has been expended on additions to plant and buildings during the year and further extensions are in progress. The works output for the year has been the largest in the history of the company, and the general turnover of the contracting and other departments has also been satisfactory.

**BUENOS AYRES & BELGRANO ELECTRIC TRAMWAYS CO. (LTD.)**—The total receipts for 1905 were £182,301. 10s., compared with £171,365. 19s. 5d. in 1904. Expenditure was £106,502. 19s. 9d., against £93,452. 5s. 7d. The available balance is £77,884. 11s. 2d. After paying interest and carrying £9,000 to renewals fund, £2,500 to sinking fund, and paying interest on sinking fund and premium on purchase of £4,500 5 per cent. debenture stock, the balance is £40,624. 19s. 2d. Preference dividend absorbs £20,250, and the directors recommend a dividend on the ordinary shares of 3s. per share, tax free, or 3 per cent. per annum, absorbing £15,000.

**EVERED & CO. (LTD.)**—For the year to Dec. 31 (after providing for interest, &c.) the net profit was £8,631, making, with £1,444 brought forward and £3,500 transferred from equalisation of dividend fund £13,575. A dividend of 5 per cent. for the year (tax free) will absorb £8,537. £3,538 is carried forward.

**GREENOCK & PORT GLASGOW TRAMWAYS CO.**—For the year 1905 the expenditure on electrical construction was £2,343, bringing the total expenditure to £188,378. The total revenue was £34,229 and expenditure £25,562, leaving a profit on the year of £8,666. The directors recommend £1,780 be put to reserve (sinking fund), and a dividend of 3 per cent. per annum be paid on the ordinary shares. With regard to the claim of Greenock Corporation in respect to profits, the Board of Trade having refused to state a case for decision on points of law, the High Court came to the conclusion that it had no jurisdiction. Thereupon the Board of Trade issued its award on the lines of the recommendations of their inquirer, and the company was consequently bound to pay over the sum awarded.

**JOHNSON & PHILLIPS (LTD.)**—At the meeting on Monday the chairman (Mr. Robt. W. Blackwell), in moving the adoption of the report given in our last issue, said the company, although registered in June last, did not acquire possession of the business of Johnson & Phillips until two or three months later. The net result had been that the directors had been in charge of the affairs of the company for only some three or four months of the period comprehended by the report and accounts. It was a matter of common knowledge that during the year there was no very great stimulation of trade, and there were no large enterprises which came under the line of work in which Johnson & Phillips had been especially successful in the past, and therefore the results attained had come solely from the ordinary business of the house, and from no special or remarkable opportunities to make lucrative contracts. During the period they had had the most ample assistance from Mr. Claude Johnson, and his assistance and suggestions as to the method of carrying on the business. In addition, the managing directors, who had been so long in charge of the business, had assisted the directors in every possible way in enabling them to get at the bottom of the company's affairs. The result was that the net profits made during the year ended Dec. 31 amounted to £32,064, after paying out during the year, for the keeping in order of the works and their maintenance in first-class condition, £4,000 odd. After deducting from the £32,000 directors' remuneration, interest, and debenture sinking fund reserve, there remained a profit of £21,938. As they were not allowed to divide any profits realised during the period prior to the formation of the company, there only remained £11,769, which was available for dividend, leaving £10,169. They had written off £10,000 in reduction of patents and £5,900 off formation expenses. With regard to the fire at the works, had this not occurred at the moment it did, they should have adopted and been in course of carrying out various schemes for the extension of the works, and for putting it upon an absolutely modern mechanical manufacturing footing. Inasmuch as the fire occurred when it did, none of that work was of any special use to them at the present moment, and the directors were discussing a number of schemes in order that they might decide as to how best the company could take advantage of the present condition of affairs to place its works upon a thoroughly modern basis. They had received during the past year various large orders for the equipment of cable ships for foreign powers and for the equipment of cable works in foreign countries. None of those orders, however, came within the purview of the period under discussion. They could safely say that everything had gone on as well as they could reasonably expect, and that the prospects of the current year were very much brighter than for the past year.

The resolution for the adoption of the report having been adopted, and the retiring director re-elected, Mr. CLAUDE JOHNSON said he should like to propose a vote of thanks to the chairman. The chairman was good enough to say that he (the speaker) had assisted them in their deliberations. He hoped he might still be of some use to them in the future. The conduct of that business had been in his hands as sole proprietor ever since it was formed, and it had naturally been his principal life work. For the first seven or eight months of the year under review he, perhaps, had more to do with the business than the present board, as they only came into power comparatively recently, and he might say that during that period, as would be easily understood, a good deal of time was occupied in connection with the formation of the company. Work of that kind naturally distracted the thoughts and attention of the staff from the ordinary business of the works, and therefore allowance might, he thought, be made for the comparatively smaller amount of profit than, under ordinary circumstances, might have been expected.

**MARCONI'S WIRELESS TELEGRAPH CO. (LTD.)**—At the meeting on Monday Sir C. Euan-Smith said that the net profit for the past year again showed a substantial increase upon recent years. It was £4,000 in excess of the profit for the year ended September, 1904. That satisfactory result proved that the company was making steady progress, though, from the nature of the undertaking, it was inevitable that until the organisation had been fully developed that progress must be slow and sure; and it must always be borne in mind that they were not yet deriving any revenue from that part of the company's undertaking from which the largest profits were anticipated—viz., the use of the Marconi system for carrying on over long distances the service that had been commonly performed by submarine telegraph cables. Although they had not yet been able to complete the installations from which they anticipated their principal profits, they were deriving from other branches of their business a revenue sufficient to pay a satisfactory dividend. The directors wished to strengthen their financial position as much as possible before entering, as they hoped to do, upon the harvest of the large receipts which are anticipated by them on the completion of the necessary installations for transatlantic traffic. Their shares in the associated companies were valued at about £103,000; but that sum must be regarded as a highly conservative estimate in respect of holdings which have a face value of nearly £1,500,000 sterling. Apart from long-distance communication, it would perhaps be difficult to justify the considerable capitalisation of some of these associated companies; but these companies own the Marconi rights over such areas as the United States of America and Canada. The total capitalisation of the Canadian and American Marconi companies was $11,650,000, and of that capital the Marconi Wireless Telegraph Co. owned more than 50 per cent. The operations of those companies, and the stations which they erect and own form part of an organisation of very high prospective earning capacity, of which the parent company's undertaking represented the complement. During the current year they had acquired works, at Dalston, London, for £25,000 in cash and 5,000 ordinary shares of the Marconi Wireless Co. The further Conference on Wireless Telegraphy had not yet been called together, although three years had elapsed since the previous Conference, and in a recent discussion in the French Chamber of Deputies the convention was stated to have been postponed sine die. Whether that was really the case or not, he was not in a position to state. It was evident that the real object of the international convention was to affect injuriously the commanding position which their company had successfully established in connection with wireless telegraphy. Other wireless companies undoubtedly gave it their support; but they did not think they were unjust in assuming that that support was not wholly unconnected with the prospect of securing advantages to themselves from the use of the extensive organisation which has been established solely by the Marconi Company. The development of the company's organisation was attended by countless difficulties and obstacles, concerning which it was not possible for the outside public to have any accurate idea. After referring to the patent litigation with the De Forest Co., Sir Euan-Smith said the strength of their position was not now, by any means, wholly dependent upon the validity of their patents. It is easy to suggest improvements: difficult to find means for carrying them into effect. But Mr. Marconi had devised these means. As to the litigation with Lloyds' they were defendants in the action; but the matter was settled out of Court, at the request of the plaintiffs, on terms which were wholly satisfactory to the Marconi Co.

**MERSEY RAILWAY CO.**—At the meeting on Friday Mr. J. Falconer said the increase in the half-year's receipts (£2,271) was so far satisfactory, as it showed there was a development going on, not only owing to the change from steam to electricity, but also that the continuous service they were giving was developing railway travelling in the Wirral district, and probably was also developing the district itself. During the last full year of steam working (1902) the number of passengers carried was 6,660,000, while during 1905 the number was 11,083,000, an increase of 4,500,000. It was quite true the receipts had not increased in the same proportion, because of the rearrangement of fares. The increase in the number of first-class passengers in 1905, compared with 1902, was just 100 per cent. There had been a difficulty in connection with their traffic, especially at Birkenhead and the districts adjoining, because there were no adequate means of taking the people between the railway station and the places where they lived. To meet that situation the company inaugurated a service of motor omnibuses in order to test whether such vehicles would give the public the necessary facilities. Legal proceedings had been taken against them and an injunction obtained on the ground that the company had not the power to run omnibuses. All the railway companies in the companies in the kingdom had until the last two years, without any express statutory power, thought they were entitled, as part of their business, to run omnibuses, but the Court decided that the railway companies were not so entitled, as part of their buisness. Anticipating this difficulty they had lodged a bill in Parliament and a committee of the House of Lords recently granted the company the right to run 'buses. The bill would now go the Commons and he hoped would successfully pass into law.

**MERTHYR ELECTRIC TRACTION & LIGHTING CO. (LTD.)**—The gross receipts for the past year on the light railways were £10,064, and the revenue from electricity supply was £4,507. After deducting expenses (£13,380) the profit was £1,238. After payment of preference dividend to Oct. 15 last £352 is carried forward.

**NATIONAL ELECTRIC CONSTRUCTION CO. (LTD.)**—The gross profit for 1905 was £32,356. 15. 1d., and after deducting expenses of administration, allowances on contracts, &c., the balance is £23,585. 6s. 9½d. The directors recommend that £6,500 be placed to reserve, £1,000 to reserve from doubtful debts, &c., £6,184. 12s. 7½d. to depreciation (including £4,884. 12s. 7½d. on free-wired installations and £1,000 on stock) and that a dividend of 7 per cent. be paid on a share capital of £123,271. A dividend of 6 per cent. having been earned on the subscribed shares for two consecutive years, the vendors shares now rank parri passu with the ordinary shares, and there is now only one class of shares. Mr. R. Stewart Bain resigned his seat on the board during the year, and Mr. J. Carr Saunders was elected to fill the vacancy.

**NEWMARKET ELECTRIC LIGHT CO. (LTD.)**—At the meeting last week Mr. G. H. Verrall, J.P., stated that during the past year 1,910 8 c.p. lamps had been connected to the mains, bringing the total connected to 20,100. The profit, with £134. 10s. 6d. brought forward, was £2,231 0s. 4d., and it was proposed to pay a dividend of 4½ per cent. The receipts show an increase of £209 on the year.

**NEWQUAY ELECTRIC LIGHT & POWER CO. (LTD.)**—At the statutory meeting last week it was stated that good progress was being made with the erection of the electricity works.

**NORTHERN COUNTIES ELECTRICITY SUPPLY CO. (LTD.)**—Sir John Milburn, Bart., at the meeting last week, said that although the increase in units sold during the year was over 100 per cent., it was disappointing to the directors because several customers had been unable to take the amount expected. During the last few days a new customer (taking 2,000,000 per year) had been connected in the Hebburn area, and this same customer, within another year, would be taking another 4,000,000 units, so that at the end of the year the Hebburn station would be supplying between 5,000,000 and 6,000,000 units. Blyth also was improving, and considerable developments were to be expected from the mining industry. There was likely to be considerable development in the use of electricity in collieries, and those depending on old engines and old methods would be left behind by competition, for considerable savings could be effected in the use of coal-cutting machines and in other ways. There was also a steady advance at Hartlepool, Shildon, and Malton and Norton in Yorkshire, but these smaller stations had been somewhat neglected. As the sales increased the cost per unit decreased, and therefore all they wanted was new customers.

**OLDHAM, ASHTON AND HYDE ELECTRIC TRAMWAY (LTD.)**—The total revenue for 1905 was £30,137. 9s. 3d., and the expenditure (including interest) £23,851. 15s. 6d., leaving a profit of £6,285. 13s. 9d. Amount to be placed to depreciation and reserve £751. 14s. 3d., the preference dividend absorbs £2,500, and a dividend on the ordinary shares at the rate of 7 per cent. for the six months (making 6 per cent. for year) requires £3,000.

**PERTH (W. A.) ELECTRIC TRAMWAYS (LTD.)**—At the meeting last week Mr. Allen H. P. Stoneham said the company now owned 22 miles of tramway, showing traffic receipts of £73,255, with a net profit of £32,041. In that case the extension of 5 miles had resulted in an increase of profit of £12,000, or £2,000 per mile, compared with the original £1,211 per mile. The average profit for the whole system was £1,545 per mile. The traffic receipts showed an increase over last year, and they might look forward to a dividend on the ordinary shares next year. As to the competition of motor omnibuses, he said he did not fear this, for, although they had suffered competition from them, they did not affect the traffic except for a little time, and then they proved a very expensive luxury to the owner of them, and the omnibuses ceased running in November last. Motor omnibuses were useful as feeders, but they could not compete with electric tramways.

**POTTERIES ELECTRIC TRACTION CO. (LTD.)**—At the meeting on Wednesday Mr. G. F. M. Cornwallis-West said that although the dividend had been reduced from 5 to 4 per cent., the amount placed to depreciation and reserve was double what it was last year, and there was also an increase of £253 on the amount carried forward. Repairs and maintenance had increased some £1,300. They had now been working for over seven years, and it was quite natural to expect that the permanent way and rolling stock would require considerable sums each year to keep them in an economical state of repair. They had been able to effect economies in other directions. Their power and running expenses were £35,180, compared with £35,210 last year, although there was an increase of 106,000 car-miles. There was also a saving of some £500 in general administration expenses, but there was an increase under the heading of rates and taxes of £250. The traffic receipts increased by over £1,000. The year's capital expenditure was £9,260. For that they had acquired two motor omnibuses, and had constructed and electrically equipped rather over a mile of line and purchased a valuable freehold site for a new car-shed. The parcels traffic showed an increasing profit, the actual results last year showing a small increase of £14. In regard to their efforts to afford facilities for the transport of heavy merchandise, coal and other minerals, more especially used in connection with the manufacturing industries of the district, the local authorities in whose district they desired to construct the necessary siding refused to meet the company, and, therefore, the directors had to abandon the scheme. As to the effect of motor-omnibus competition he felt perfectly confident in reassuring the shareholders on the matter. There was no doubt that motor 'buses served a very useful purpose in many instances, but their experience in the Potteries had not been satisfactory.

**ERNEST F. MOY (LTD.)**—For the 12 months ended Dec. 31 the profit was £769. 15s. 9d. The directors recommend a 7½ per cent. dividend on the ordinary shares and the full 6 per cent. on the preference shares. The new works in Bayham-street, which were started at the beginning of last year, are now fairly well equipped with machinery.

**ROBEY & CO (LTD.)**—The trading profit for the past year was £30,530. The directors have written £8,298 off for depreciation, and after payment of debenture interest the disposable balance is £13,475. It is proposed to pay a dividend of 6s. each on the ordinary shares and to write £3,000 off investment account. At the meeting on Tuesday (Mr. F. Andrew) attributed the slight falling off in trade profits to the disturbed condition of Russia.

**WEST LONDON & PROVINCIAL ELECTRIC SUPPLY CO. (LTD.)**—The report for 1905 states that the progress made by the Chiswick and Aberystwyth undertakings continues to be satisfactory. During the year £6,554 was expended on machinery, mains, free wiring, &c. At the end of the year the equivalent of 36,244 8 c.p. lamps was connected at Chiswick, compared with 29,658 at the end of 1904. At Aberystwyth the equivalent of 16,613 8 c.p. lamps was connected, compared with 11,902. The total profit for the year was £5,726. A dividend of 5½ per cent. on the ordinary shares for the year is declared.

## NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES, LIENS, &c,

### NEW COMPANIES.

**BRITISH AUTOMATIC TELEPHONE SYND. (LTD.)** (87,976).—Reg. March 15, capital £40,000 in £1 shares, with objects as indicated by the title. Reg. office, 151-153, Dashwood House, New Broad-street, London, E.C.

**S. CALMONT & CO. (LTD.)** (87,972).—Reg. March 14, capital £4,000 in £1 shares (1,000 preference), to acquire business carried on as S. Calmont & Co., to adopt an agreement and to carry on the business of electrical engineers, agents, factors, &c. First directors, T. Sutcliffe, A. J. Mardlin and G. Low. Reg. office, 28, Basinghall-street, London, E.C.

**LUDLOW ELECTRIC LIGHT CO. (LTD.)** (88,018.)—Reg. March 17, capital £8,000 in £1 shares (4,000 4 per cent. cumulative preference), to acquire rights and powers of W. Norton under the Ludlow Electric Lighting Order, 1905, to adopt certain agreements, and to carry on in Ludlow and neighbourhood the business of an electric light and power company. First directors, J. Mitchell, J.P., E. Turford and G. Woolley. Reg. office, 14, Corve-street, Ludlow, Salop.

**PUNJAUB ELECTRIC TRACTION CO. (LTD.)** (87,987).—Reg. March 15, capital £5,000 in 4,991 shares of £1 each and 180 shares of 1s. each, to carry on in India or elsewhere the business of tramway, railway, omnibus and van proprietors, carriers of passengers and goods, suppliers of electricity, &c.

**ZEDECCO BATTERIES (LTD.)** (88,012).—Reg. March 16, capital £2,505 in 2,500 A shares of £1 each and £200 B shares of 6d. each, to acquire certain existing inventions relating to "Zedecco accumulators," to adopt an agreement with A. L. Lambert, and to carry on the business of electricians, engineers, manufacturers of and dealers in electric batteries, suppliers of electricity, &c. Reg. office, 6, Throgmorton-avenue, London, E.C.

### STATUTORY RETURNS.

**BURMAH ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.)**—Return to Jan. 4 gives capital as £200,000 in 20,000 ordinary and 20,000 preference shares of £5 each, of which 18,395 ordinary and 20,000 preference have been taken up. £5 per share has been called up on 20,000 preference and £10,000 has been received. £91,975 is considered as paid on 18,395 ordinary. Mortgages and charges nil.

**ELECTRIC MERCANTILE AGENCY (LTD.)**—Return to Dec. 31 gives capital as £1,200 in £1 shares, of which seven have been taken up. £1 per share has been called up and £7 remains in arrears. No mortgages or charges.

**LOWNE ELECTRIC CLOCK & APPLIANCES CO. (LTD.)**—In return to Feb. 15 capital is £8,000 in £1 shares, of which 6,507 have been taken up. £1 per share has been called up on 1,007 and £950 has been received, leaving £57 in arrears. 5,500 shares are considered as fully paid. Mortgages and charges, nil.

**MACKEY'S ELECTRIC LAMP CO. (LTD.)**—Return to March 31 gives capital as £2,000 in £1 shares, all of which have been taken up. £7 has been received and £1,983 is considered as paid. Mortgages and charges, £2,500.

### MORTGAGES AND CHARGES.

**BRITISH PROMETHEUS CO. (LTD.)**—A memorandum of satisfaction in full of a debenture dated Oct. 17, 1905, to secure £500, has been filed.

**EMPIRE ELECTRIC LIGHT AND POWER CO. (LTD.)**—A debenture dated March 1, 1906, to secure £6,200, charged on company's lands, buildings, machinery, works, plant, orders, acts, undertaking and other assets, including uncalled capital, has been registered. Holder, H. L. M. Tritton.

**PHŒNIX DYNAMO MFG. CO. (LTD.)**—Issue on Feb. 8 of £2,500 4½ per cent. debentures, part of series created same date, to secure £5,000, ranking pari passu with £15,000 debentures secured by a trust deed of July 29, 1903, charged on certain freehold land and premises in Calverley, Bradford, certain British and foreign patents and company's undertaking and property, present and future, including uncalled capital.

A trust deed of even date, covering the £5,000 additional debentures above mentioned, and being supplemental to the said trust deed of July 29, 1903, has also been registered. Trustees, J. Charlesworth and F. Sellers.

**SCOTTISH HOUSE-TO-HOUSE ELECTRICITY CO. (LTD.)**—A charge dated Feb. 28, 1906, to secure £250, has been registered. Property charged: Company's undertaking and property, present and future, including Coatbridge and Airdrie undertakings, benefit of orders and agreements for lighting and otherwise and uncalled capital and book debts. Holders, County of London Electric Supply Co.

## CITY NOTES.

**MEMORANDA** (March 29).—Bank rate 4 per cent. (since Sept. 28, 1905). Price of silver 30⅛d. per oz. Consols 90½—90⅝ for money, 90 9/16—90 11/16 for account; 2½ per cent. annuities 89⅜—89⅝. Consols Pay Day, April 4. Stocks and Shares Continuation Days, April 9 and 24; Ticket Days, April 10 and 25. Pay Days, April 11 and 26; Mining Share Carry-over Day, April 16.

**COMPANIES STRUCK OFF REGISTER.**—The following were removed from the Register of Joint-Stock Companies on 20th inst.:—

Atlas Electric Appliances Co., British Electrical Mfg. Co., British Spiral Telephone Wire Synd., City & Suburban Electric Carriage Co., Denayrouze Light Synd., Electrical Insulator Mfg. Co, Electric Carbon Storage & Apparatus Mfg. Co. of Scotland, Electric Mfg. Co., Electric Portable Battery & Gas Igniting Co., Elwell-Parker, French Electrical Power Storage Co., Moon, Loughlin & Co., Morecambe Electric Launch & Power Synd., Mutual Telephone Co. (reg. Feb. 4, 1890), Railway & Domestic Electric Lighting Co., St. George Telephone Co. and South Kensington Mutual Electric Lighting & Supply Co.

The following will be removed from the list in three months unless cause is shown to the contrary:—

Electric Locomotive & Power Co., Electrified Rooms Co., Electro-Metal Extracting, Refining & Plating Co., London Battery Co. and Telephone Association.

**LANCASHIRE UNITED TRAMWAYS (LTD.)**—An abridged prospectus will be found on another page inviting subscriptions for an issue (at par) of £250,000 Prior Lien 5 per cent. Debenture Stock of this Company. The list opens to-morrow (March 31), and will close on or before Wednesday, April 4. As our readers are aware, the company was recently formed to acquire the undertaking of the South Lancashire Electric Traction & Power Co. (Ltd.), and the board of directors is a strong one, including the Hon. Arthur Stanley, M.P. (chairman), and Messrs. Edwin Adam, Joseph Beecham, J.P., J. M. Henderson, M.P., and Robt. Watson, J.P. The trustees for the present issue are Messrs. J. W. Philipps, M.P., and M. B. Snell. The old South Lancashire Company owned the whole of the issued share capital of two subsidiary companies (the South Lancashire Tramways Co. and the Lancashire Light Railway Co., Ltd.), and was, in effect, the owner of the tramways of the subsidiary companies, which now comprise 24½ route-miles (31½ track-miles) of electric tramways. The subsidiary companies have no loan or debenture capital, except a mortgage on the undertaking of the South Lancashire Tramways Co., which has been taken over by the new company. The existing tramways connect Liverpool with the tramways constructed by St. Helens Corporation, and the latter tramways with the Wigan and Bolton tramway systems, and further connect Bolton to Leigh and Lawton, with a branch from Atherton to Tyldesley. For the year ended June 30 last, during the existence of the receivership of the old company, a profit of about £8,500 was earned, after payment of £1,000 as receiver's remuneration and deducting working expenses, but excluding interest on loans. That the earnings were not greater is attributed to the fact that the tramway system is incomplete and does not provide the through connections which were an essential part of the original scheme. In order to remedy this and supply the more essential through connections the directors have decided to apply a part of the proceeds of the present

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. | | |
|---|---|---|---|---|---|---|
| | | | | No. of weeks. | Amount. | Inc. or Dec. (a) |
| | | £ | £ | | £ | £ |
| **Aberdeen Corporation** | March 24 | 1,179 | + 61 | 44 | 57,825 | − 785 |
| **Airdrie** | ,, 16 | 205 | + 12 | 11 | 2,818 | + 216 |
| Anglo-Argentine | ,, 25 | 15,309 | + 1,725 | 12 | 178,269 | + 18,586 |
| **Ayr Corporation** | ,, 24 | 186 | − 9 | 45 | 12,907 | − 88 |
| Baker St. & Waterloo Ry. | ,, 24 | 1,618 | − 145 | 2 | 8,881 | ... |
| **Barnsley** | ,, 16 | 158 | + 1 | 11 | 1,684 | + 7 |
| **Barrow** | ,, 16 | 216 | + 17 | 11 | 2,160 | + 191 |
| **Bath Electric Trams, Ltd** | ,, 21 | 679 | + 22 | 12 | 7,619 | + 1,112 |
| Birkenhead Corporation | ,, 25 | 942 | − 38 | 12 | 12,009 | + 51 |
| **Birmingham Corporation** | ,, 24 | 387 | + 27 | 51 | 19,181 | + 2,838 |
| *Birmingham & Mid. | ,, 16 | 1,848 | − 420 | 11 | 14,519 | − 3,724 |
| Blackburn Corporation | ,, 21 | 895 | − 62 | †52 | 49,011 | + 2,671 |
| **Blackpool Corporation** | ,, 22 | 882 | + 72 | 12 | 3,944 | + 287 |
| **Blackpool and Fleetwood** | ,, 24 | 214 | − 28 | 12 | 2,241 | − 24 |
| **Bolton Corporation** | ,, 25 | 1,752 | − 22 | 52 | 98,948 | + 5,176 |
| **Bournemouth Corporation** | ,, 31 | 1,830 | + 279 | †51 | 71,177 | + 16,834 |
| **Bradford Corporation** | ,, 24 | 3,999 | + 59 | 51 | 220,096 | − 1,826 |
| **Brighton Corporation** | ,, 25 | 667 | − 193 | 52 | 49,520 | + 164 |
| **Bristol Trams & Carriage** | ,, 23 | 4,657 | − 126 | 6 | 28,225 | + 1,847 |
| **Buenos Ayres & Belgrano** | ,, 25 | 3,588 | + 221 | 12 | 42,856 | + 8,701 |
| **Buenos Ayres Elec. Trms** | Feb 24 | 1,418 | + 293 | 8 | 11,244 | + 2,678 |
| **Burnley Corporation** | March 24 | 1,057 | + 5 | 51 | 65,873 | + 8,658 |
| **Burton Corporation** | ,, 25 | 247 | − 56 | §51 | 15,427 | − 1,782 |
| Bury Corporation | ,, 18 | 860 | ... | §50 | 38,305 | ... |
| **Calcutta Tramways Co.** | ,, 24 | R42,388 | + R4,830 | 12 | R531,616 | + R52,950 |
| **Camborne-Redruth** | ,, 24 | 97 | + 1 | 21 | 2,245 | + 54 |
| Cardiff | ,, 24 | 1,808 | + 123 | 51 | 102,965 | + 471 |
| **Carlisle Tramways Co.** | ... | ... | ... | ... | ... | ... |
| Cavehill | ,, 16 | 52 | + 9 | 11 | 460 | + 65 |
| **Central London Railway** | ,, 24 | 7,038 | + 13 | 12 | 83,641 | − 2,512 |
| **Chatham & Dist. Lt. Rys.** | ,, 22 | 597 | − 58 | †12 | 6,697 | − 129 |
| ***City of Birm'gh'm Tram Co** | ,, 16 | 5,101 | − 491 | 11 | 55,578 | − 1,470 |
| **City & South London Rly.** | ,, 25 | 8,057 | + 224 | 12 | 35,880 | + 200 |
| **Colchester Corporation** | ,, 22 | 161 | − 18 | 32 | 6,115 | − 1,688 |
| **Cork Electric Trams Co.** | ,, 22 | 476 | + 22 | 12 | 4,834 | + 18 |
| Derby Corporation | ,, 26 | 660 | + 12 | 51 | 37,328 | + 10,148 |
| **Devonport & Dist. Trams** | ,, 16 | 890 | − 22 | 11 | 4,388 | − 222 |
| **Dover Corporation** | ,, 24 | 172 | − 1 | ‡51 | 11,150 | + 106 |
| **Dublin & Lucan Railway** | ,, 23 | 106 | + 3 | §12 | 1,058 | − 74 |
| **Dublin United** | ,, 23 | 4,598 | + 65 | ‡12 | 53,468 | + 1 616 |
| **Dudley—Stourbridge** | ,, 16 | 781 | − 27 | 11 | 7,998 | + 849 |
| **Dundee Corporation** | ,, 21 | 986 | + 141 | §44 | 41,448 | + 3,875 |
| **East Ham Council** | ,, 24 | 760 | − 11 | 51 | 42,080 | + 5,874 |
| **Gateshead & Dist. Trams** | ,, 16 | 922 | + 40 | 11 | 9,873 | + 524 |
| **Glasgow Corporation** | ,, 24 | 15,899 | + 1,107 | 48 | 653,947 | + 43,031 |
| Glossop | ,, 24 | 117 | + 1 | 12 | 1,471 | + 190 |
| Gloucester Corporation | ,, 21 | 228 | − 89 | 51 | 14,846 | + 1,147 |
| **Gravesend—Northfleet** | ,, 16 | 192 | − 5 | 11 | 2,098 | + 106 |
| **Gt. Northern & City Rly.** | ,, 24 | 1,851 | + 108 | 12 | 21,859 | + 781 |
| **Greenock & Port Glasgow** | ,, 16 | 621 | + 50 | 11 | 6,043 | + 481 |
| **Halifax Corporation** | ,, 21 | 1,369 | − 29 | 51 | 78,846 | + 5,851 |
| **Hartlepool Tramways** | ,, 16 | 248 | + 4 | 11 | 2,701 | + 125 |
| Hastings Elec. Trams Co. | ,, 22 | 854 | ... | 12 | 4,249 | ... |
| **Huddersfield** | ,, 24 | 1,276 | + 52 | 51 | 69,825 | + 4,181 |
| **Hull Corporation** | ,, 24 | 2,179 | + 90 | 51 | 113,470 | + 2,280 |
| Ilford Dist. Coun. | ... | ... | ... | ... | ... | ... |
| **Ipswich Corporation** | ,, 24 | 817 | − 52 | 51 | 21,048 | − 1,921 |
| **Isle of Thanet Co.** | ,, 24 | 222 | − 119 | 24 | 6,408 | − 168 |
| **Kidderminster & District** | ,, 16 | 86 | − 5 | 11 | 965 | + 4 |
| Kilmarnock Corporation | ,, 24 | 138 | − 6 | 46 | 6 943 | ... |
| **Kirkcaldy Corporation** | ,, 21 | 100 | − 9 | 3 | 588 | − 10 |
| **Lanarkshire Trams Co.** | ,, 22 | 681 | + 172 | †12 | 9,729 | + 2,187 |
| **Leamington** | ,, 16 | 128 | + 46 | 11 | 1,404 | + 464 |
| **Leeds Corporation** | ,, 24 | 5,521 | − 131 | 52 | 308,628 | + 9,610 |
| **Leicester Corporation** | ,, 24 | 2,041 | + 85 | 12 | 28,938 | + 2,897 |
| Leith Corporation | ,, 24 | 426 | + 210 | 44 | 16,667 | + 11,796 |
| **Liverpool Overhead Rly.** | ,, 25 | 1,860 | − 168 | 12 | 16,620 | − 1,043 |
| Liverpool Corporation | ,, 17 | 10,140 | + 65 | 11 | 111,880 | + 4,449 |
| ***London County Council** | ,, 17 | 14,339 | + 1,626 | 50 | 782,880 | + 96,579 |
| **Lowestoft** | ,, 24 | 1[illegible]2 | − 28 | 26 | 8,351 | − 98 |
| **Maidstone Corporation** | ,, 22 | 85 | − 28 | 51 | 5,939 | ... |
| **Manchester Corporation** | ,, 24 | 12,332 | − 183 | 51 | 654 | + 83,461 |
| Mersey Railway | ,, 24 | 1,694 | + 162 | 12 | 20,327 | + 959 |
| **Merthyr** | ,, 16 | 186 | − 1 | 11 | 1,868 | − 11 |
| Metropolitan Dist. Railway | ,, 25 | 8,605 | + 619 | 12 | 97,461 | + 5,841 |
| ***Metropolitan Elec. Trams** | ,, 16 | 2,645 | + 782 | 11 | 29,577 | + 9,548 |
| **Middleton** | ,, 16 | 264 | − 8 | 10 | 2,988 | + 286 |
| **Nelson Corporation** | ,, 21 | 122 | + 1 | 52 | 6,776 | + 774 |
| **Newcastle-on-Tyne Corp.** | ,, 24 | 8,692 | + 51 | 51 | 193,285 | + 4,648 |
| **Newport (Mon.)** | ,, 24 | 521 | − 4 | 25 | 13,686 | + 1,005 |
| Northampton Corporation | ,, 28 | 868 | − 2 | 51 | 21,851 | + 5,276 |
| **Oldham, Ashton & Hyde** | ,, 16 | [illegible] | ... | 11 | 5,480 | + 254 |
| **Oldham Corporation** | ,, 24 | 1,318 | + 314 | 52 | 64,148 | + 18,595 |
| Perth (N.B.) Corporation | ... | ... | ... | ... | ... | ... |
| **Perth (W. A.) Elec Trams** | ,, 23 | 1,477 | + 147 | ‡12 | 18,410 | + 904 |
| **Peterborough** | ,, 16 | 93 | − 9 | 11 | 1,080 | − 47 |
| Pontypridd District Coun. | ,, 24 | 100 | ... | 51 | 8,131 | ... |
| Portsmouth Corporation | ,, 24 | 1,282 | − 409 | 51 | 95,888 | + 1 489 |
| **Potteries** | ,, 16 | 1,767 | + 89 | 11 | 18,612 | + 1,202 |
| Preston Corporation | ,, 21 | 641 | + 61 | ... | ... | ... |
| **Reading Corporation** | ,, 22 | 565 | − 19 | ... | ... | ... |
| **Rotherham Corporation** | ,, 22 | 468 | + 34 | 51 | 23,035 | + 32 |
| **Rothesay** | ,, 16 | 43 | − 1 | 11 | 516 | + 87 |
| **Salford Corporation** | ,, 26 | 8,894 | − 22 | 52 | 219,778 | + 12,489 |
| **Sheerness** | ,, 14 | 46 | − 15 | 11 | 494 | − 78 |
| **Sheffield Corporation** | ,, 25 | 4,685 | + 117 | 52 | 256,438 | + 15,872 |
| **Southampton Corporation** | ,, 21 | 884 | − 41 | 24 | 21,076 | + 188 |
| **Southend Corporation** | ,, 21 | 249 | − 18 | 51 | 18,167 | + 1,096 |
| **Southport Tramways** | ,, 16 | 216 | − 23 | 11 | 2,467 | + 27 |
| **S. Staffordshire Trams.** | ,, 16 | 769 | + 91 | 11 | 8,925 | + 1,808 |
| **Stockport Corporation** | ,, 24 | 829 | + 289 | 51 | 39,298 | + 11,991 |
| Sunderland Corpn. | ,, 25 | 1,198 | + 98 | 51 | 60,713 | + 8,189 |
| **Swansea Trams** | ,, 16 | 706 | + 149 | 11 | 7,621 | + 2,074 |
| Swindon Corporation | ,, 21 | 171 | − 25 | 51 | 9,759 | ... |
| Taunton | ,, 16 | 43 | − 8 | 11 | 444 | + 15 |
| **Tynemouth and District** | ,, 16 | 160 | − 22 | 11 | 1,713 | − 96 |
| **Wallasey District Council** | ,, 24 | 682 | − 24 | 51 | 39,012 | + 1,649 |
| **Warrington Corporation** | ,, 22 | 315 | + 27 | 51 | 17,472 | + 1,231 |
| **West Ham Corporation** | ,, 22 | 1,973 | + 709 | 51 | 94,191 | + 40,495 |
| **Weston-super-Mare** | ,, 14 | 80 | + 1 | 11 | 288 | + 4 |
| Wolverhampton Corpn. | ,, 21 | 750 | ... | ... | ... | ... |
| ***Wolverhampton District** | ,, 16 | 263 | + 16 | 11 | 4,000 | + 866 |
| ***Worcester** | ,, 16 | 229 | − 49 | 11 | 2,503 | − 182 |
| **Wrexham** | ,, 15 | 97 | + 6 | 11 | 960 | − 88 |
| Yorkshire W.R. Trams | ,, 25 | 656 | − 90 | 12 | 8,119 | + 2,862 |
| Yorkshire Woollen District | ,, 16 | 798 | + 284 | 11 | 8,678 | + 2,987 |

(a) These comparisons are with the corresponding period last year. † Minus 8 days. ‡ Minus 2 days. § Plus 2 days. ¶ Plus 8 days. * Partly electrical.

issue in furnishing the requisite capital for building about 12½ miles of new track, making a total system of 34 route-miles, or 44 miles of track. The general manager of the company (Mr. J. R. Salter) estimates the cost of the extensions, together with the increase of the installation of the power station from 2,500 H.P. to 4,000 H.P., at £165,000. This estimate is based, with regard to the greater part of the cost, on actual tenders received, but the direct tenders are conditional on the completion of the company's financial arrangements, and no formal contracts have yet been entered into. The present issue will also provide for the purchase of the undertaking of the New St. Helens & District Tramways Co., which operates the tramways owned by St. Helens Corporation. The profits of the company are estimated at £24,875, including the net revenue of the St. Helens tramways which the company has power to acquire, while the amount required for interest on the present issue is only £12,500. The stock is secured by a first charge on the tramway undertakings and generating stations of the company, and a floating charge on all other assets of the company. Further particulars will be found in the abridged prospectus. The present issue is payable as to 5 per cent. on application, 35 per cent. on allotment, 30 per cent. on June 1, and the balance on Aug. 1. Interest will be payable on Jan. 1 and July 1 in each year, the first payment being made on July 1 next.

**NATIONAL TELEPHONE CO (LTD.)**—At their meeting yesterday (Thursday) the directors unanimously elected the vice-president (Mr. George Franklin) as president of the company in place of Sir Henry Fowler, M.P., resigned. Mr. S. H. Sands has been elected vice-president.

**STOCK EXCHANGE NOTICE.**—The Stock Exchange Committee have been asked to allow a further issue of 10,000 £5 fully paid 6 per cent. cumulative preference shares of *Bruce Peebles & Co. (Ltd.)* to be quoted.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., Mar. 28. | Rate per Cent. Yielded. | Dividend Due. | Business, Week to Mar. 28. | |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS TRAMWAYS, &c.** | | £ s. d. | | Highest. | Lowest. |
| 5 | 8/0 | Anglo-Argentine Ord. Shares | 9 —9¼ | 4 6 6 | Ap, Oct | 9 5/32 | 9 3/32 |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞—6⅛ | 4 10 0 | — | 6 3/32 | 6 |
| St. | 6% | Do. Permanent 6% Deb. Stock | 141 —144 | 4 3 3 | — | .. | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 104 —106 | 4 14 3 | — | .. | .. |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | ¾—1¼ | .. | .. | 1 | 1¼ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 3⅞—4⅛ | 6 1 4 | — | 4 1/16 | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 93 —96 | 4 13 9 | — | 94½ | 93 |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 120 —123 | 4 17 6 | — | — | .. |
| St. | 5% | Do. Pref. Ord. Stk | 110 —113 | 4 8 4 | — | .. | .. |
| 100 | 5% | Do. 5% Cum. Perp. Pref. Stock | 107 —110 | 4 11 0 | — | 107¼ | — |
| 100 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%—105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 102 —105 | 4 5 0 | — | 104¾ | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | 2⅞—3⅛ | 5 10 0 | — | 3 1/16 | 3½ |
| 5 | 8/0 | Do. 6 per Cent. "A" Cm. Pref. | 5⅞—6⅛ | 4 18 0 | — | 6 | .. |
| 5 | 3/0 | Do. "B" | 5¼—5¾ | 5 4 0 | — | .. | .. |
| St. | 5% | Do. 5 per Cent. Debs. | 106 —108 | 4 12 6 | — | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102 —105 | 4 15 0 | — | .. | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 100 —102 | 4 19 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 102 —106 | 5 4 3 | .. | .. | — |
| 100 | 6% | Do. 6% 1st Deb. Bonds | 102 —106 | 5 13 0 | .. | .. | .. |
| 5 | 3/6 | Calcutta Tramways (Nos. 1 to 105) | 9½—10 | 4 5 0 | — | 1⅝ | .. |
| 5 | 2/6 | Do. Nos. 105,001 to 137,610 | 9 —9½ | .. | .. | 9⅛ | 9 1/16 |
| 10 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 106 —108 | 4 3 8 | — | 107 | .. |
| 1 | 0/6 | Cape Electric Tram Shares | ⅝—⅞ | 5 14 0 | — | .. | .. |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 102 —104 | 4 16 0 | — | .. | — |
| .. | 5% | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 96 —98% | 5 2 0 | .. | 97 | .. |
| St. | .. | Kalgoorlie Elec. Trams 5% "A" Deb. Stock | 91 —93 | .. | .. | .. | .. |
| St. | .. | Do. 6% "B" Ditto | 83 —88 | .. | .. | 86 | 85 |
| 1 | .. | Lisbon Elec. Trams Ord. | 1½—1⅝ | .. | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅜—1⅝ | 4 7 4 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 100 —103 | 4 17 0 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 103 —106 | 4 14 8 | Ja, Jul | 105 | 104¼ |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101 —103 | 4 17 0 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102 —104 | 4 6 6 | — | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 105 —108 | 4 12 6 | .. | 107½ | .. |
| . | $2 | † Sao Paulo Tramway, Light and Power Co. $100 Stock | 147 — 149 | 5 7 3 | .. | .. | .. |
| .. | 5% | Do. 5% 1st Mt. $500 Dbs. | 98%—101% | 4 19 0 | .. | 100⅝ | .. |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | 3/ | Adelaide Elec. S'ply Co. 6% Cu. Pr. | 4¾—5¼ | 5 14 6 | .. | .. | .. |
| 5 | 3/3 | Calcutta Elec. (1-50 000) | 9 - 9½ | 4 6 6 | — | .. | .. |
| 0 | 5% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50 —52 | 4 16 0 | .. | 5⅞ | .. |
| . | 5% | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 94 —96 | 5 4 0 | .. | .. | .. |
| 1 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½—3 | .. | .. | .. | — |
| St. | 5% | Do. 5% Debs. | 88 —92 | 5 9 4 | — | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | 7¾—8¾ | — | — | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92 —94 | 5 6 8 | .. | .. | .. |
| St. | 26/2 | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. | 111 —114 | 5 5 0 | .. | .. | .. |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞—1 | 6 0 0 | — | 1 | .. |
| 1 | 1/0 | Rand Electric | 1⅛—1¼ | — | — | .. | .. |
| 1 | .. | River Plate Electricity Co. Ord. | 1 1/16—1⅛ | — | .. | ⅞ | .. |
| 1 | 1/2⅝ | Do. 6% Non. Cum. Pref | 1⅛—1 3/16 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Deb. Stock | 101 —103 | 4 17 0 | .. | .. | .. |
| 5 | 8/0 | † Rosario Elec. Co. 6% Pref. (1-12,000) | 5 —5½ | 5 9 0 | .. | .. | — |
| 5 | 2/6 | † Do. (12,001-20,000) | 5¼—5¾ | 8 5 0 | .. | .. | .. |
| 100 | 4½% | * Royal Elec., Montreal 4½% 1st Mort. Deb | 100 —103 | 4 7 5 | Ap, Oct | — | .. |
| .. | 5% | Shawinigan Water and Power 5% Bds., Scrip | 101 —103 | 4 17 0 | .. | 101½ | .. |

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

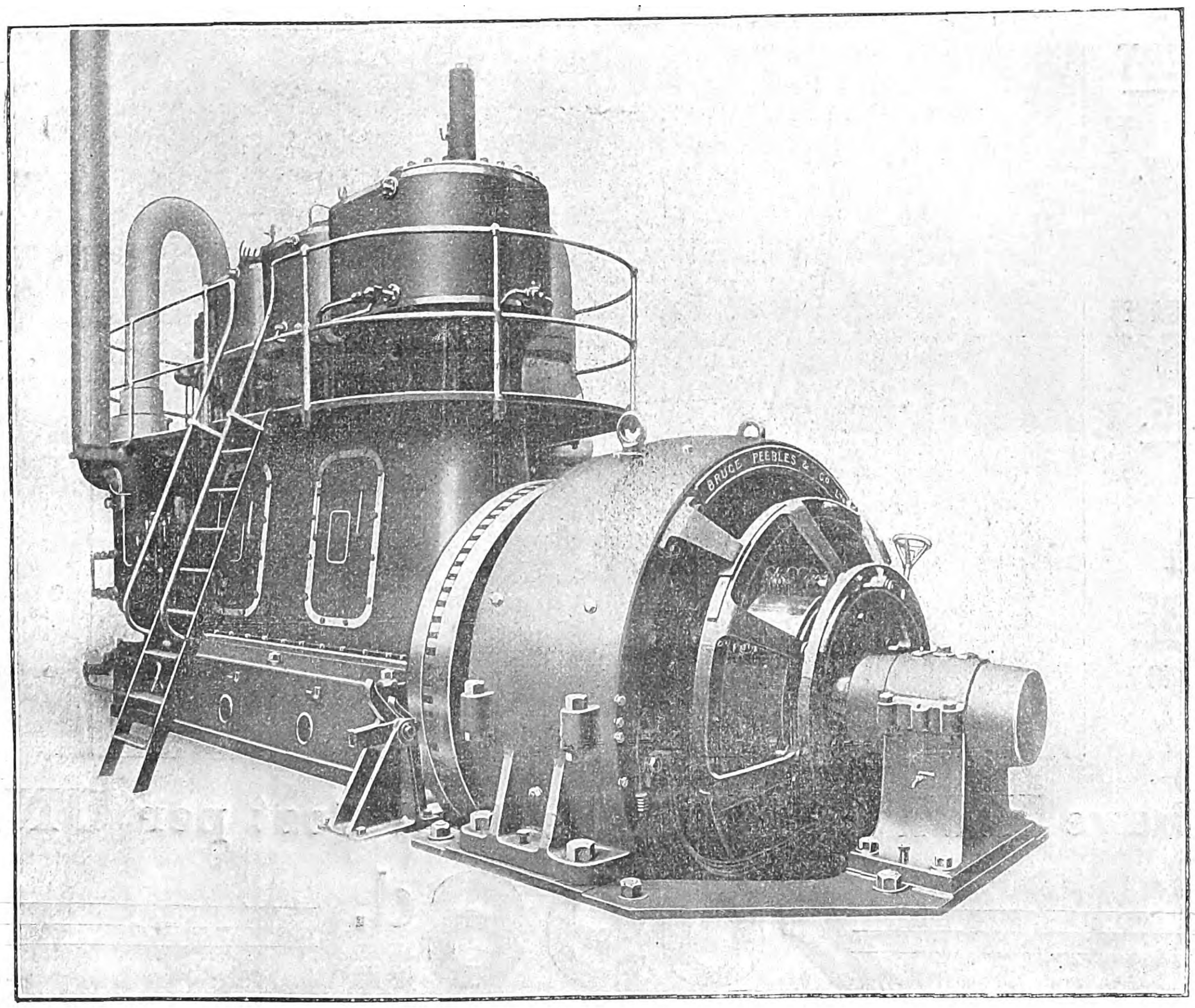
| Shre. | Last Dividend | Name. | Price Wed., Mar. 28. | Rate % Yield-ed. £ s. d. | Dividend Due. | Business, Week to Mar. 28. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 10 | 14/0 | †Bournemouth & Poole Elec. Sup. Ord. | 11½—12 | 5 16 6 | .. | .. | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10 —10½ | 4 5 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11 —12 | 5 0 0 | .. | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 106 —108 | 4 8 3 | .. | 108 | [illegible] |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5¼—5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 103 —106 | 4 5 0 | — | .. | .. |
| [illegible] | 5/6 | Brompton & Kensington Elec. Sup. Ord. | 8¼—9¼ | 5 8 6 | — | .. | .. |
| [illegible] | 8/6 | Do. 7 per Cent. Pref. | 8¼—9¼ | 8 15 6 | Mar, Sept | .. | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 102 —106 | 3 16 3 | — | .. | .. |
| [illegible] | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 4½—5¾ | 4 7 0 | Feb, Aug | . | .. |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 4½—5 | 4 10 0 | Feb, Aug | 4⅝ | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 101 —103 | 3 17 6 | — | 102 | .. |
| 5 | 2/3 | Do. City Undertaking 4½% Cm. Pref. | 4½—4¾ | 4 14 9 | — | .. | .. |
| 5 | 2/3 | Do. Do. (1908) | 4½—4¾ | 4 14 9 | .. | — | .. |
| 5 | 3/9 | Chelsea Electric Supply Ord. | 5¼—5¾ | 5 6 0 | March .. | 5[illegible] | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 107 —109 | 4 2 6 | Jn, Dec .. | 108½ | 107½ |
| 10 | 7/0 | †City of London Electric Lighting Ord. | 10½—11½ | 5 2 2 | Feb, Aug | 11¼ | 10¾ |
| 10 | 6/0 | † Do. 6 per Cent. Cum. Pref. | 13 —14 | 4 5 6 | Jan, July | .. | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 123 —126 | 3 19 4 | Jn, Dec .. | .. | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 101 —103 | 4 8 0 | .. | .. | .. |
| 5 | 4% | †County of Durham Elec. P.D. Ord. £2 pd. | 2³¹⁄₃₂—3¹⁄₃₂ | 4 0 0 | April, Oct | .. | .. |
| 5 | 5% | † Do. Do. 5% non cum. pref. | 5¼—5⅜ | 4 15 3 | April, Oct | . | .. |
| 10 | 6/0 | †County of London Elec. Supply Ord. | 11½—12¼ | 2 9 0 | — | [illegible]½ | .. |
| 10 | 6/0 | † Do. 6 per Cent. Cum. Pref. | 11⅞—12⅜ | 4 17 0 | Mar, Sept | 12 | .. |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 109 —112 | 4 0 4 | .. | 110½ | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 101 —103 | 4 7 6 | .. | 102¾ | 102½ |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5½—5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | † Do. 5 per Cent. Cum. Pref. | 5 —5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101 —104 | 4 6 6 | — | .. | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8½—9 | 4 14 0 | .. | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100 —103 | 4 7 5 | — | .. | — |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 9½—10¼ | 4 18 0 | .. | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½—7 | 4 5 9 | Jan, July | — | — |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98 —101 | 3 19 2 | .. | .. | .. |
| St | 4% | †Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101 —103 | 3 17 6 | .. | .. | .. |
| 3 | 2/4½ | London Electric Supply Ord. | 2 —2¼ | 6 15 0 | .. | 2¼ | 2⅛ |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5⅜—5⅝ | 5 7 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 98 —101 | 3 19 2 | Mr, Jn, S, D | .. | .. |
| 5 | 10% | †Metropolitan Electric Sup. Ord. | 8½—9½ | 5 5 0 | April, Oct | 9¼ | 9⅛ |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5⅜—5⅝ | 4 0 0 | Jan. July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 110 —114 | 3 19 0 | Jn, Dec .. | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 95 —97 | 3 12 3 | — | .. | .. |
| 100 | 4½% | Midland Elec. Corp. for P.D. 1st Mort. Db. | 101 —103% | 4 7 4 | — | .. | .. |
| 10 | 7½% | †Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 11 —11½ | 6 1 11 | Feb, Aug | 11⅜ | .. |
| 100 | 4½% | Do. 4½% Deb. | 101½—102½ | 4 6 6 | Jan, July | .. | .. |
| 5 | 8% | †Newcastle Elec. Supply Ord. | 7⅜—7⅝ | 5 6 8 | Feb, Aug | 7⁷⁄₁₆ | .. |
| 5 | 5% | Do. 5 per Cent. Non. Cum. Pref. | 5¾—6 | 4 5 1 | Feb, Aug | 6⅛ | 6 |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99 —101 | 3 19 7 | Jan, July | 100 | .. |
| 1 | 3% | †Northern Counties Elec. Sup. | ⅞—²⁹⁄₃₂ | 3 6 8 | Mar, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 101 —102 | 4 7 6 | Jan, July | — | — |
| 10 | 9/0 | Notting Hill Electric Ord. | 13 —14 | 6 8 0 | March .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 98 —100 | 4 0 0 | .. | .. | .. |
| 5 | 4/6 | Oxford Electric Ord. | 6½—7 | 4 16 0 | March .. | 6⅝ | .. |
| St. | 4% | Do. 4% Deb. Stock | 99 —101 | 3 19 0 | — | .. | .. |
| 5 | 7/6 | St. James' & Pall Mall Elec. Ord. | 9½—10¼ | 6 0 0 | Feb, Aug | .. | .. |
| 5 | 3/6 | Do. 7 per Cent. Pref. | 7 —8 | 4 7 0 | Feb, Aug | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 86 —88 | 3 12 0 | — | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2¼—2¾ | 8 4 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76 —80 | 5 0 0 | — | .. | .. |
| 5 | 4/0 | †South London Electric Supply Ord | 3 —3½ | [illegible] 14 0 | .. | .. | .. |
| 1 | 0/3 | South Metrop'n Elec. Lt. & Power Ord. | ¾—⅞ | .. | .. | .. | — |
| 1 | 0/8⅖ | Do. 7% Cum. Pref. | 1¼—1⅜ | 5 2 0 | .. | .. | .. |
| St. | 4½% | † Do. 4½ 1st Db. Stk. Red. | 103 —106 | 4 5 0 | — | .. | — |
| 5 | 2/6 | †Urban Electric Supply Ord. | 4¼—4¾ | 5 5 0 | — | — | .. |
| 5 | 2/6 | † Do. 5% Cum. Pref. | 4⅞—5⅛ | 4 17 6 | — | .. | .. |
| St. | 4½% | † Do. 4½% 1 Mort. Deb. | 102 —104 | 4 6 6 | .. | .. | .. |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 9½—10½ | 6 4 0 | Mar, Sept | 10 | [illegible] |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⁵⁄₁₆—5⁹⁄₁₆ | 4 10 0 | .. | .. | .. |
| 5 | .. | Do. £1 and 7/6 premium paid | 1¼—1½ | .. | .. | .. | .. |
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| St. | 4% | Baker St. & Waterloo 4% Perp. Db. St. | 100 —102 | 3 18 6 | .. | .. | .. |
| .. | .. | Bath Elec. Trams Pref. Ord. | ¹⁵⁄₁₆—1¹⁄₁₆ | .. | .. | 1 | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | ¹⁵⁄₁₆—1¹⁄₁₆ | 4 12 3 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 103 —105 | 4 5 6 | .. | 103¾ | .. |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 101 —103 | 4 7 9 | .. | 102 | .. |
| 10 | 2½% | Bristol Tramways and Carriage Ord. | 15¼—15¾ | 4 7 6 | Feb, Aug | — | .. |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10 —10¼ | 3 18 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Debs. | 104 —106 | 3 15 6 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 7½—7⅞ | 8 17 6 | — | 7⅝ | 7½ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 9½—10 | 6 0 0 | Feb, Aug | 9¾ | [illegible] |
| St. | 5% | † Do. 5 per Cent. Perpetual Debs | 111½—114½ | 4 7 8 | .. | 117 | 110½ |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 97 —99 | 4 11 0 | .. | .. | .. |
| St. | 4% | Central London Ordinary Stock | 91 —93 | 4 6 0 | June, Dec | 92½ | 91¼ |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 102 —104 | 3 17 0 | .. | 103½ | .. |
| St. | 4% | Do. Deferred Stock | 82 —85 | 4 14 0 | .. | 83¾ | [illegible] |
| 100 | 4% | Do. 4 per Cent. Debs. | 110 —112 | 3 11 3 | .. | 111½ | .. |
| St. | 4% | Charing X, Euston & Hmpstd Per. Db. Stk. | 95 —97 | 4 2 6 | .. | .. | .. |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 5⅛—5⅜ | 4 18 0 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 101 —104 | 3 17 0 | .. | .. | .. |
| St. | 1¾% | City and South London Rly. Con. Ord. | 41 —43 | 4 7 0 | Feb, Aug | 42 | 41 |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 120 —123 | 4 1 4 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 115 —118 | 4 4 8 | .. | .. | .. |
| St. | 5% | Do. (1901) | 113 —116 | 4 6 0 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 106 —109 | 3 13 4 | May, Nov | 106½ | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13¾—14¾ | 4 1 6 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½—15½ | 3 17 8 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 4½—4¾ | 8 8 0 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8 —9 | 4 8 11 | — | .. | .. |
| St. | 4½% | †Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 101 —103 | 4 7 6 | .. | .. | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 15 —16 | 5 12 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 12 —12½ | 4 17 0 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 107 —108 | 4 3 0 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼—2¾ | 9 8 6 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 80 —85 | 4 14 0 | — | .. | .. |
| 10 | 1¾% | Liverpool Overhead Railway Ord | 8¼—8⅝ | 3 18 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾—10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99 —102 | 3 19 8 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9½—10 | 5 0 0 | — | 9⅞ | [illegible] |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 95 —98 | 4 2 6 | — | 97¾ | [illegible] |
| St. | .. | Mersey Con. Ord. Stock | 6 —8 | — | — | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8 —11 | — | — | — | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | ³⁄₁₆—¼ | .. | — | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | ¹⁵⁄₁₆—1¹⁄₁₆ | 4 14 6 | — | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104 —106 | 4 5 0 | — | .. | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum. Pref. | ½—1½ | .. | May .. | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8½—9 | 5 15 0 | .. | .. | .. |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9 —9½ | 5 5 0 | Feb, Aug | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103 —106 | 4 5 0 | — | .. | .. |
| 100 | 5% | Sunderland Dst. Elc. Trms. 5% 1st Mt. Db. | 92 —95 | 5 5 0 | .. | .. | .. |
| — | 5% | Underground Elec. Rys. Co. of London | 98 —100 | 5 0 0 | .. | .. | .. |
| St. | 3½% | Waterloo and City Ord. | 98 —101 | 3 6 0 | June, Dec | 99 | .. |
| St. | 4½% | Yorkshire W.R. El. Trs. Co. 4½% 1st Debs. | 95 —97 | 4 13 0 | .. | [illegible]½ | .. |

| Shre. | Last Dividend | Name. | Price Wed., Mar. 28. | Rate % Yield-ed. £ s. d. | Dividend Due. | Business, Week to Mar. 28. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC MANUFACTURING, &c.** | | | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝—⅞ | 5 6 6 | — | .. | .. |
| 1 | 10½d. | Aron El. Met. 6% Cm. Pf. | ⁷⁄₁₆—⁹⁄₁₆ | .. | .. | .. | .. |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3⅞—4⅛ | 4 17 9 | .. | [illegible] | [illegible] |
| 1 | 7½d. | Do. Pref | 1⁷⁄₁₆—1⁹⁄₁₆ | 3 16 10 | .. | .. | .. |
| [illegible] | 4/0 | British Insulated & Helsby Cables Ord. | 6½—7 | 5 6 0 | July, Feb | .. | .. |
| [illegible] | 3/0 | Do. 6 per Cent. Pref. | 6¾—7¼ | 4 16 0 | Jan, July | [illegible] | [illegible] |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103 —106 | 4 4 11 | .. | .. | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 96 —98 | 4 12 0 | .. | .. | .. |
| [illegible] | .. | British Westinghouse 6% Pref. | 1⅞—[illegible] | .. | .. | [illegible] | [illegible] |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 80 —85 | 4 14 0 | .. | .. | .. |
| 2 | — | Brush Electrical Engineering | ¾—1 | .. | March .. | 1 | [illegible] |
| 2 | 2/4⅘ | Do. 6 per Cent. Pref. Non-Cum. | 1½—2 | 6 0 0 | Mar, Sept | 1¾ | .. |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 97 —99 | 4 11 0 | Mar, Sept | .. | .. |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 82 —84 | 5 7 4 | Jan, July | .. | .. |
| 5 | 5/0 | Callender's Cable Con. Ord. | 10½—11½ | 5 4 0 | Jan, July | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5¾—6 | 4 3 4 | Jan, July | 6 | [illegible] |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 108½—110½ | .. | Nov, May | .. | .. |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1 —1⅛ | 5 6 6 | .. | 1¹⁄₁₆ | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 95 —100 | 4 10 0 | — | .. | .. |
| 1 | 2⅔d. | Chadburn's (Ship) Telegraph Ord. | 1³⁄₁₆—1⁵⁄₁₆ | 7 10 0 | .. | .. | .. |
| 1 | 7½d. | † Do 6% Cum. Pref. | 1¹⁄₁₆—1³⁄₁₆ | 5 8 0 | .. | .. | .. |
| 3 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 2 —2¼ | 3 9 0 | Jan, July | 2⅛ | .. |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | [illegible]%—[illegible]% | 5 2 0 | Jan, July | .. | .. |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8¾—9¼ | 5 8 0 | Sept | .. | .. |
| 5 | 3/0 | † Do. 6% Cum. Pref. | 6 —6½ | 4 14 0 | Sept | 6¹⁄₁₆ | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104 —106 | 4 5 0 | .. | .. | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅝—1⅞ | — | Feb, Aug | 1¾ | .. |
| 5 | 2/6 | Do. (£5 paid) | 2½—3 | — | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 86 —88 | 4 11 0 | June, Dec | 86½ | [illegible] |
| St. | 5% | † Do. 5 per Cent. 2nd Deb. Stock | 90 —95 | 5 5 0 | — | .. | .. |
| 5 | 2/6 | Edmundson's Elec. Corp. Ord. | 4 —4½ | 7 15 6 | H'lf-yearly | .. | .. |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5 —5½ | 5 9 0 | .. | [illegible] | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 104 —106 | 4 5 0 | .. | 104 | .. |
| 2 | 1/7½ | Electric Construction Co. | ½—¾ | 9 6 0 | July | [illegible] | .. |
| 2 | 2/9⅘ | Do. 7 per Cent. Cum. Pref | 2 —2½ | 5 12 0 | July | [illegible] | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 89 —92 | 4 7 0 | Jan, July | .. | .. |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9⅜—9⅞ | 5 3 0 | .. | [illegible] | .. |
| St. | 4% | † Do. 4 per Cent. 1st Mort. Debs. | 92 —96 | 4 3 0 | — | .. | .. |
| 5 | [illegible] | Henley's Telegraph Works Ord. | 12½—13½ | 5 11 0 | Feb, Aug | 12[illegible] | .. |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼—5½ | 4 2 0 | Feb, Aug | .. | .. |
| St. | .. | Do. 4½ per Cent. 1st Mt. Db. St. | 108 —110 | .. | .. | .. | .. |
| St. | .. | Do. Do. Scrip (50% paid) | 57 —59 | .. | .. | .. | .. |
| 10 | 15/0 | India Rubber, Gutta Percha, &c., Wrks. | 17½—18½ | 5 9 0 | Feb, Aug | 17¾ | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Deb (red.) | .. | 3 18 5 | Mar, Sept | .. | .. |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¾—12¼ | 4 1 8 | Mar, Sept | .. | .. |
| 1 | 1/2⅖ | Richardsons, Westgarth & Co., Ltd. Ord. | ²⁹⁄₃₂—³¹⁄₃₂ | 6 4 0 | .. | [illegible] | .. |
| 1 | 7½d. | Do. 6% Cum. Pref. | ⅞—1⅛ | 5 15 0 | .. | [illegible] | 1 |
| St. | 4½% | Do. 4½% Perp. Deb. Stock | 99 —101 | 4 10 0 | .. | .. | .. |
| 12 | 4/0 | Telegraph Construction & Mainten'ce. | 82½—84½ | 5 5 0 | Mar, July | 83 | .. |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 100 —102 | 3 18 6 | Jan, July | .. | .. |
| 1 | 2/0 | †Vickers, Sons & Maxim, Ltd., Ord. | 2½—2⅝ | 4 9 0 | .. | [illegible] | .. |
| 1 | 6d. | † Do. 5% Non-Cum. Preference | 1⅛—1¼ | 4 0 0 | .. | [illegible] | .. |
| St. | 5% | † Do. 5% Non-Cum. Preferred | 120 —123 | 4 2 8 | — | .. | .. |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock Red. | 105 —107 | 3 14 8 | .. | 106½ | [illegible] |
| 100 | 4½% | Do. 4½% 2nd Mort. Debs., Red. | 106 —108 | 4 3 3 | .. | 107 | .. |
| 5 | — | Willans and Robinson Ord. | 1¾—2¼ | — | Apr, Oct | [illegible] | .. |
| 5 | — | Do. 6 per Cent. Cum. Pref. | 3½—4¼ | — | Apr, Oct | .. | .. |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 80 —85 | 4 14 0 | May Nov | .. | .. |
| | | **TELEGRAPHS.** | | | | | |
| 100 | 4% | *African Direct Tel. 4% Mrt. Deb. (red.) | 98½—101½ | 3 18 6 | Jan, July | .. | .. |
| 10 | — | Amazon Telegraph | 3¾—4¼ | .. | Jn, Dec .. | .. | .. |
| 100 | 5% | Do. 5% Debs. (red.) | 83 —88 | 5 18 6 | .. | [illegible] | .. |
| St. | 21/0 | Anglo-American | 66 —67 | 4 17 0 | F, My, Ag, N | .. | .. |
| St. | 32/0 | Do. Preferred | 112½—113½ | 5 6 0 | F, My, Ag, N | 114 | .. |
| St. | 10/0 | Do. Deferred | 19⅜—19⅝ | 2 12 0 | F, My, Ag, N | [illegible] | .. |
| St. | 4% | †Commercial Cable 4 per Cent. Deb. Stk | 96½—97½ | 4 1 0 | Jn, Ap, Jy, O | [illegible] | .. |
| 10 | 5/0 | Cuba Submarine Ord. | 8½—9 | 5 11 0 | Feb, Aug | .. | .. |
| 10 | 10/0 | Do. Preference 10 per Cent | 17 —18 | 5 11 2 | Feb, Aug | .. | .. |
| [illegible] | 2/0 | †Direct Spanish Ord | 3⅜—3⅝ | 5 11 9 | April, Oct | .. | .. |
| 5 | 5/0 | † Do. 10 per Cent. Cum. Pref. | 8½—9 | 5 11 0 | April, Oct | .. | .. |
| [illegible] | 4½% | Do. 4½ per Cent. Deb. | 100%—103% | 4 7 8 | Jan, July | .. | .. |
| [illegible] | 4/0 | †Direct United States Cable | 10¼—11¼ | 4 5 0 | Ja, Ap, Jy, O | [illegible] | .. |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 100 —102 | 4 8 0 | Jn, Dec .. | .. | .. |
| St. | 25/0 | Eastern Ordinary | 146 —149 | 4 14 0 | Ja, Ap, Jy, O | [illegible] | .. |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 90 —92 | 3 16 6 | Ja, Ap, Jy, O | [illegible] | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 107 —109 | 3 13 8 | May, Nov | [illegible] | .. |
| 10 | 2/6 | Eastern Extension | 14¾—15¼ | 4 11 8 | Ja, Ap, Jy, O | [illegible] | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 105 —107 | 3 14 8 | Feb, Aug | [illegible] | .. |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 99 —101 | 3 19 3 | Feb, Aug | .. | .. |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101%—103% | 3 18 8 | May, Nov | .. | .. |
| 10 | 5/0 | G. N. (of Copenhagen) with coupon 66 | [illegible] | 5 13 0 | Jan, July | .. | .. |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 100 —102 | 4 8 0 | June, Dec | .. | .. |
| 25 | 12/6 | Indo-European | 57 —59 | 5 10 0 | May, Nov | .. | .. |
| 100 | $1 | Mackay Companies Common | 61¾ | 3 4 9 | Jan, July | .. | .. |
| 100 | 4% | Do. Preference | 75⅛ | 5 6 6 | Ja, Ap, Jy, O | .. | .. |
| 1 | .. | Marconi's Wireless Teleg. Co. | 1¼—1⅜ | .. | .. | .. | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 99 —102 | 3 18 6 | June, Dec | .. | .. |
| 10 | 4/0 | West African Telegraph Shares | 9¾—10¼ | 4 17 6 | .. | .. | .. |
| [illegible] | — | West Coast of America | ⅝—¾ | .. | Jan, July | .. | .. |
| 100 | 4% | Do. 4 per Cent. Debs. | 100 —102 | 3 18 3 | May, Nov | .. | .. |
| 10 | — | West India and Panama | ⅜—⅝ | .. | May, Nov | .. | .. |
| 10 | 6/0 | Do. 6% 1st Pref. | 8¼—8¾ | 6 6 8 | May, Nov | .. | .. |
| 10 | — | Do. 6 per Cent. 2nd Pref. | 6 —7 | .. | Jan, July | .. | .. |
| 100 | 5% | * Do. 5 per Cent. Debs. | 100 —103 | 4 17 0 | Mr, Jn, O, D | .. | .. |
| 10 | 3/0 | Western Telegraph | 14¼—14¾ | 4 15 0 | June, Dec | .. | .. |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 100 —102 | 4 18 0 | .. | .. | .. |
| St. | 4% | Do. 4% Deb. Stock (red.) | 102 —104 | 3 16 10 | .. | .. | .. |
| | | **TELEPHONES.** | | | | | |
| .. | .. | Amer. Teleph. & Telegh. Coll. Trust $1,000 4% Bonds | 96 —98 | .. | .. | .. | .. |
| St. | 5% | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 101 —103 | 4 17 0 | August | .. | .. |
| [illegible] | 3/0 | Chili Telephone (fully paid) | 8 —8½ | 4 17 0 | — | .. | .. |
| 1 | 0/9⅗ | Monte Video Telephone Ord. | ¹⁵⁄₁₆—1¹⁄₁₆ | 3 15 3 | .. | .. | .. |
| 1 | 1/0 | Do. 5% Pref. | ⅞—1 | 5 0 0 | — | .. | .. |
| St. | 6% | National Co. Pref. Stock | 109 —111 | 5 8 0 | — | .. | .. |
| St. | 6% | Do. Def. Stock | 112 —114 | 4 7 6 | Feb, Aug | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 12 —14 | 4 5 6 | Feb, Aug | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 10½—12½ | 4 16 0 | Feb, Aug | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5¼—5¾ | 4 11 0 | June, Dec | .. | .. |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 99 —101 | 3 9 3 | — | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 103 —105 | 3 16 3 | April, Oct | .. | .. |
| 1 | 0/7½ | Oriental | 1¼—1⅜ | 4 12 0 | — | .. | .. |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1¼—1⅜ | 4 7 0 | .. | .. | .. |
| St. | 24/7⅔ | Do. 4% Red. Deb. Stock | 97 —99 | 4 1 0 | .. | .. | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 103 —106 | 4 4 9 | July .. | .. | .. |
| 5 | 3/0 | United River Plate | 7¼—7½ | 5 6 8 | June, Dec | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5½—5¾ | 4 7 0 | June, Dec | .. | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 110 —112 | 4 9 3 | — | .. | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 4¾—5¼ | 5 14 0 | Ja, Ap, Jy, O | .. | .. |
| 10 | 2/0 | Globe Telegraph and Trust | 11 —11½ | 4 15 6 | Ja, Ap, Jy, O | .. | .. |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14⅝—14⅞ | 4 0 6 | April, Oct | .. | .. |
| 10 | 6% | Submarine Cables Trust (Cert.) | 128 —131 | 4 13 6 | .. | .. | .. |

* In calculating the yields, allowance has been made for accrued interest but not for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote the

# P.P.P. DYNAMOS

STATION COSTS
ARE LOW WHERE
P.P.P. MACHINES
ARE INSTALLED.



Peebles-Belliss 750 kw. Steam Dynamo.

## Bruce Peebles
& Co., Ltd.

**LONDON & EDINBURGH.**

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Telegraphic and Cable Address:
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**BRASS and COPPER TUBES, SHEETS, WIRE RODS, BOTTOMS, PANS, FIRE-BOX PLATES, ALUMINIUM, TIN, LEAD, ZINC, IRON, &c.**

---

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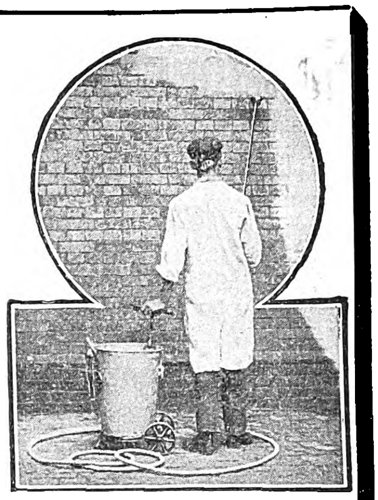
Every Description of **BRASS, COPPER, ZINC, LEAD, BATTERY PLATES, ASHES, BORINGS,** and **REFUSES** containing Metals of any kind, also **OLD CABLES, BOILERS, DYNAMOS,** &c., &c. Also any Description of **PLANT** for **DISMANTLING.**

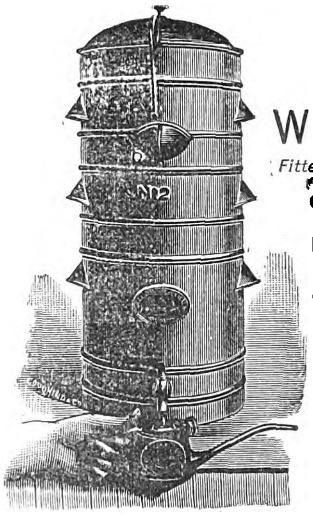
ENQUIRIES SOLICITED.

## WELLS' 'Lightning' Lime & Color Washer

*A Great Saving of Time, Labour and Money. No Outside Power Required. Saves its Cost in a Few Days. Lime, Whiting or Cold Water Paints. Speed 10 to 20 square yards per minute.*

| No. | | |
|---|---|---|
| 6A. | With detachable pail | 115/- |
| 4. | Capacity 6 gallons | 170/- |
| 4A. | On wheels, same capacity as No. 4 | 190/- |
| 5. | Large size, capacity 10 gallons | 210/- |
| 5A. | On wheels, same capacity | 235/- |





## WELLS' "WASTE OIL" FILTERS

*Fitted with PATENT "SIGHT-FEED" SYPHONS.*

**Over 10,000 Sold.**

**Invaluable to ELECTRIC LIGHT INSTALLATIONS and all USERS of MACHINERY.**

*Small Money Savers, as Dirtied Oil, which has hitherto been thrown away, can be Filtered and used again and again.*

**Supplied to the Principal Electric Light Stations & Works in the United Kingdom.**

| No. | *PRICES.* | |
|---|---|---|
| 1. | For Small Users, 17in. by 9in | 35/- |
| 2. | A Useful Size, 22in. by 10in. | 60/- |
| 3. | For where a good quantity of oil requires filtering, 27in. by 12in. | 70/- |
| 4. | Large Filter, 36in. by 16in. | 110/ |
| 5. | 43in. by 26in. | 189/- |
| 6. | Powerful Filter, for cleaning large quantities of oil, 54in. by 30in. | 336/- |

**A. C. WELLS & CO.,**
99, Midland Road, St. Pancras,
**LONDON.**

◆

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## ELECTRICAL ENGINEERS.

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**Dynamos and Motors.**

**ELECTRIC CRANES**
OF ALL KINDS AND SIZES WITH ONE OR THREE MOTORS.

**ELECTRIC WINCHES, CAPSTANS for all Loads and Voltages a Speciality.**

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**ELECTRIC LIGHT and POWER INSTALLATIONS of all kinds.**

**VERTICAL ENCLOSED FORCED LUBRICATION DOUBLE-ACTING HIGH-SPEED ENGINES Of all sizes.**

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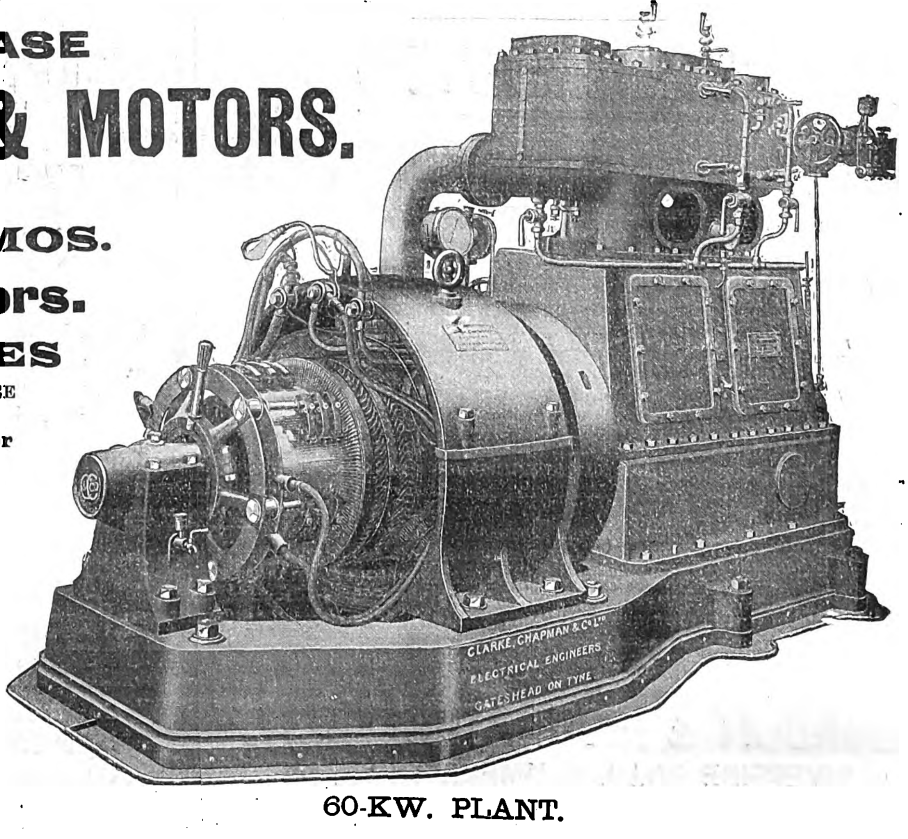

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**NO MORE COLLAPSED FURNACES OR BUCKLED TUBES**

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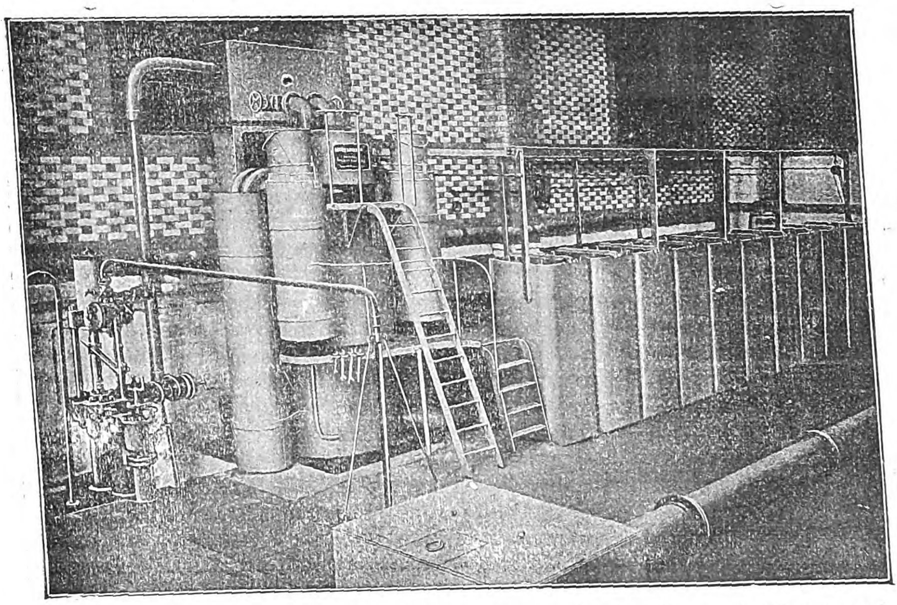
**IF YOU PURIFY THE CONDENSED WATER**

**WITH THE "HARRIS-ANDERSON" PURIFIER.**



" Harris-Anderson " Purifier, Pinkston Power Station, Glasgow Corporation Tramways.
Capacity, 22,000 gallons per hour.

Grease Absolutely Removed.
No Objectionable Matter introduced.
Automatic and Simple Action.
Minimum Waste of Water.
Numerous Plants now at work in Electric Light and Power Stations, &c.

*WRITE for FULL PARTICULARS to the—*

**HARRIS PATENT FEED WATER FILTER, LTD.,**

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◆ ◆ ◆

NO MORE FIRES
From Electric Wires.

Important to Electrical Engineers.

**IMPROVED ELECTRIC WIRING**

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**The only SAFE SYSTEM.**

ABSOLUTELY PREVENTS ALL DANGERS
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***FIRES FROM THIS SYSTEM HAVE NEVER OCCURRED.***

**In use at Car Sheds of British Tramways, Portsmouth Tramways, London United Tramways, Dublin Tramways, and Municipal Buildings at Glasgow, Newport, Cardiff, Brighton, &c.; also at Arundel Castle, British Museum, Eaton Hall, Woburn Abbey, &c.**

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**"EVERIGHT"**
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IS THAT:—

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3. It is unaffected by the capacity of the cables under test.
4. It has no pivots to wear and cannot "stick."
5. It requires no levelling.
6. Its calibration is absolutely permanent.
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WE DO NOT KNOW if it is the CHEAPEST, but you can easily ascertain this for yourself.

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## SALE BY AUCTION.

MESSRS. HORNE & CO., 8, Delahay-street, Storey's Gate, Westminster, S.W., will SELL by PUBLIC AUCTION, at the Royal Arsenal, Woolwich, on TUESDAY, 24th April, 1906, by order of the Secretary of State for War, at Eleven o'clock in the forenoon precisely, the following **OBSOLETE** and **UNSERVICEABLE STORES, &c.**:—2 tons Ashes (Founders'); 497 tons Iron Cast, Wrought and Steel; 83½ tons Brass (C.M.G. Cartridge Cases and Miscellaneous); 10¾ tons Copper; 14 tons Gunmetal; 31 tons Mixed Metals; 18 tons Lead Ingots; Phosphor Bronze; 5½ tons Cupro Nickel; White Metal; Silver; Tin; 27 tons Zinc Cylinders and Linings; Solder; 3 Lathes; 1 Boring Machine; 60 Anchors; 280 Axletrees; 800 Cast Iron Fenders; Drag Shoes; Tinplate; Telegraphic Instruments; Electrical Appliances and Cable; 2,000 Tinplate Canisters; Tools, Stocks and Dies; Rope; Canvas; Silk Cloth and Shalloon Cuttings, &c.; Indiarubber; Sheeting Waterproof; Old Bags; Waste Paper and Books; Leather (Cuttings, Miscellaneous, &c.); Hose Pipes; Clogs; Harness; 450 Horse Neck Collars; 10 Horse Drugs; Shafts; Limber Poles; Boxes; Cases; 17 stacks Powder Barrel Staves and Heads; Wood, &c., &c. The Lots may be viewed at the Royal Arsenal, Woolwich, from 10 to 1 o'clock and from 2 to 4:30 o'clock on the Friday and Monday previous to, and on the morning of the Sale. Catalogues may be obtained at the War Office, Pall Mall; at the Ordnance Office, Tower; and at the Ordnance Office, Royal Arsenal, Woolwich.

## MISCELLANEOUS PLANT, &c., WANTED.

COMPOUND ENGINE and DYNAMO, combined or otherwise, 150 to 200 amps., 500 volts; state price, makers, condition, where seen.—OIL COMPANY, Dalmeny.

WANTED, LAMP TOPS, with Platinum, Scrap Platinum, &c.—EDEY & Co., 29, Ludgate-hill, London, E.C.

## MISCELLANEOUS PLANT, &c., FOR SALE.

WANTED TO SELL, ELECTRIC PLANT in first-class condition, consisting of dynamo, 17½ kilowatts, 110 volts, speed 780: Crossley's gas engine (three tanks) 28 B.H.P., exhaust box and silencer, self-starter, and switchboard complete; 8 new Jandus arc lamps and 20 old type. Only reason changing to higher voltage.—NEW SPA AND GARDENS, LTD., Bridlington.

ELECTRIC MOTORS FOR SALE.—One British Thomson-Houston enclosed ventilated 2 H.P. 110 volts 960 revs., spare armature, starting and regulating switch; price £25. One McClure & Whitfield open type 3 H.P. 1,300 revs., armour-clad, starting and D.P. switches and cutouts; price £20.—Apply ENGINEER, Clement's Printing Works, Portugal-street, London, W.C.

WANTED, offer for 36 H.P. SHUNT-MOTOR, 440 volts, 700 revolutions, 3 bearings, slide rails, and belt pulley; made by Phœnix Dynamo Company, Bradford. Perfectly new; can be seen by appointment.—J. T. & J. TAYLOR, LIMITED, Batley.

THE TELEGRAPHISTS' AND TELEPHONISTS' NOTE BOOK has just been PUBLISHED. Useful to every operator. Full of facts and data. Price 1s. 1d., post free, from RENTELL, 36, Maiden-lane, London, W.C.

Telegrams: Turnstile London.

# STANLEY

**GOLD MEDAL St. Louis, 1904.**

## SURVEYING & DRAWING INSTRUMENTS.

*NOTICE OF REMOVAL OF THE RETAIL DEPARTMENT*
from GREAT TURNSTILE to
**286, HIGH HOLBORN, LONDON, W.C.** Price List post free.

## TENDERS INVITED, &c.

### COUNTY BOROUGH OF WEST HAM.

ELECTRICITY DEPARTMENT.

TENDERS FOR CABLE.

The Council hereby invite TENDERS for the Supply of about 3,500 YARDS L.T. ·75 SQUARE INCH SECTIONAL AREA CONCENTRIC PAPER INSULATED LEAD COVERED CABLE.

Forms of Tender and further particulars may be obtained, on and after the 7th inst., at the Borough Electrical Engineer's Office, Central Electricity Station, Tucker-street, Canning Town.

Tenders to be enclosed in endorsed envelopes supplied with the Forms, and sent to my Office not later than Five o'clock on WEDNESDAY, April 11th, 1906.

The Council do not bind themselves to accept the lowest or any Tender.

The Contractor will be required to enter into a bond with sureties for the due performance of the Contract, and no Goods, Materials, &c., will be ordered under any Contract until such bond has been duly executed.

The Contractor whose Tender is accepted, and with whom a Contract is entered into, will be required to pay to the whole of his workmen such rate of wages, and observe such hours of labour, as are recognised by the workmen's trade unions and in force at the time of signing the Contract. In the event of any breach of such agreement the Council will enforce the penalty clause in its entirety.

By order of the Council,
FRED. E. HILLEARY, Town Clerk.

Town Hall, West Ham,
London, E., April 3rd, 1906.

### COUNTY BOROUGH OF SALFORD.

The Electricity Committee invite TENDERS for the Supply, Delivery and Erection of a

**750 KW. STEAM TURBO-GENERATOR AND CONDENSING PLANT.**

Plans, Specification, and Form of Tender may be obtained from the Borough Electrical Engineer, Electricity Works, Frederick Road, Pendleton, on payment of a deposit of Two Guineas, which will be returned on receipt of a bona fide Tender. All enquiries in connection therewith to be addressed to the Borough Electrical Engineer at the above works.

Sealed Tenders endorsed "Tender for Turbo-Generator" to be delivered at the Office of the undersigned on or before SATURDAY, April 21st, 1906.

The Committee do not bind themselves to accept the lowest or any Tender.

L. C. EVANS, Town Clerk, Salford.

Town Hall, Salford, March 19th, 1906.

### CITY AND COUNTY OF KINGSTON-UPON-HULL.

ELECTRICITY DEPARTMENT.

The Electric Lighting Committee of the Hull Corporation are prepared to receive TENDERS for the following PLANT required at their Sculcoates-lane Generating Station:—

Contract 55. **COAL HANDLING PLANT, &c.,** in connection with Eight Lancashire Boilers.

Contract 56. **CONDENSERS, PUMPS, PIPEWORK, &c.,** in connection with Six Lancashire Boilers and Two High-speed Engines.

Forms of Tender and Specifications for either Contract may be obtained on depositing the sum of One Guinea with the City Treasurer, T. G. Milner, Esq., Town Hall, Hull, for each copy required, such deposits being returnable on receipt of a bona fide Tender.

Tenders in separate sealed envelopes, endorsed respectively "Coal Handling Plant" and "Pipework, &c.," are to be addressed to the Chairman of the Electric Lighting Committee, Town Hall, Hull, before noon on THURSDAY, April 19th, 1906.

The Corporation do not bind themselves to accept the lowest or any Tender.

Any further information can be obtained from the undersigned.

By order,
H. BELL, City Electrical Engineer.

Sculcoates-lane, Hull, April 3rd, 1906.

**TENDERS INVITED continued on next page.**

# DOULTON TROUGHING

AND BRIDGE-INSULATORS

**For SOLID SYSTEM CABLES.**

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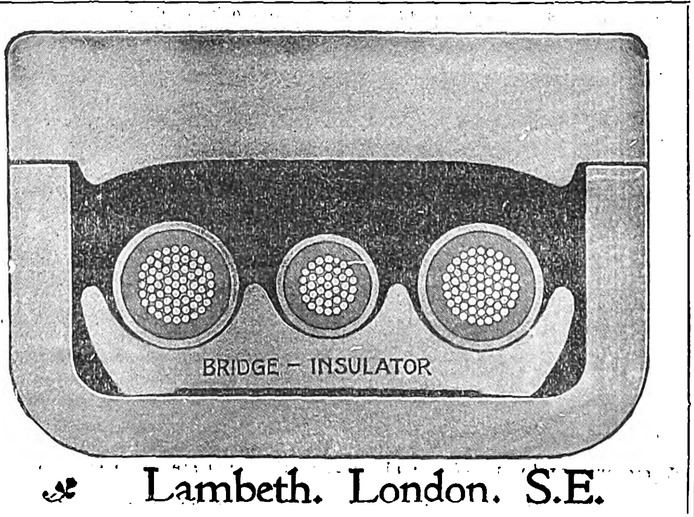

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## TENDERS INVITED—*continued.*

### CITY AND COUNTY OF THE CITY OF EXETER.

**ELECTRIC TRAMWAYS—EXTENSION.**

The Corporation of Exeter invite TENDERS for the following :—

CONTRACT No. 8.

For the **ELECTRICAL OVER-HEAD EQUIPMENT** of about five-eighths of a mile of route length.

Specifications and Forms of Tender can be obtained and plans inspected at the office of Mr. H. D. Munro, City Electrical Engineer, 184, Sidwell-street, Exeter, on and after the 31st March inst., on payment of a deposit of one guinea, which will be returned on receipt of a bona-fide Tender.

The Contractor whose Tender is accepted will be required to pay not less than the minimum standard rate of wages for the time being in force in each branch of the trade.

The Corporation do not bind themselves to accept the lowest or any Tender, and the person whose Tender is accepted will be required to enter into a formal agreement under seal with sufficient sureties for the due performance of the Contract.

Sealed Tenders, endorsed "Tramways, Contract No. 8." must be received at my office, No. 8, Southernhay West, Exeter, on or before WEDNESDAY, the 11th day of April next.

By order,

Exeter, March 28th, 1906. H. LLOYD PARRY, Town Clerk.

### CORPORATION OF GLASGOW.

**ELECTRICITY DEPARTMENT.**

The Corporation invite TENDERS for the Supply of (1) MAIN CABLES; (2) SMALL CABLES and WIRES; (3) ELECTRICITY METERS; and (4) CARBONS for a period of twelve months from 31st prox.

Copies of the Specifications and Forms of Tender may be obtained on application to Mr. W. W. Lackie, Engineer, 75, Waterloo-street, Glasgow, on making a deposit of Two Pounds for each Specification. The amount deposited will be returned on receipt of a bona fide Tender. Sealed Offers, marked "Electricity Department, Tender for........," and addressed to the subscriber, must be lodged with him on or before MONDAY, 23rd instant.

The Corporation do not bind themselves to accept the lowest or any Offer.

A. W. MYLES, Town Clerk.

City Chambers, Glasgow, April 2nd, 1906.

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FACTORY SITES, with dock, rail and road facilities, to be LET, on long Lease, at moderate rates. Areas to suit tenants.—Apply to HARRY HOOPER, Estates Offices, Millwall, London, E.

FACTORY LAND to be LET or SOLD at Ilford, frontage to River Roding. Outside L.C.C. area. Close to G.E. Railway Station. Labour, gas, water, &c., cheap.—LEOPOLD FARMER & SONS, Factory Specialists, 46, Gresham-street, E.C., and Kilburn, N.W., London.

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### SUBMARINE CABLES TRUST.

NOTICE is Hereby Given that on TUESDAY, the 17th April instant, the COUPON due on the 15th instant will be paid by Messrs. GLYN, MILLS & CO., of 67, Lombard-street, E.C., between the hours of 10 a.m. and 2 p.m.

The Coupons should be left with the Bankers not later than Tuesday, 10th instant,

By order of the Trustees,

SIDNEY COLLETT, Secretary.

Electra House, Finsbury Pavement,
London, E.C., April 6th, 1906.

### WEST RIDING COUNTY COUNCIL.

The West Riding County Council offer FOUR TECHNOLOGICAL SCHOLARSHIPS each of the value of £60, open to residents within the Administrative Area of the West Riding of Yorkshire, and available for courses of instruction in connection with the following :—

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These Scholarships are intended for young artisans who already have a suitable amount of mill or workshop experience.

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Application Forms and full particulars may be obtained from the Education Department (Technical Branch), County Hall, Wakefield.

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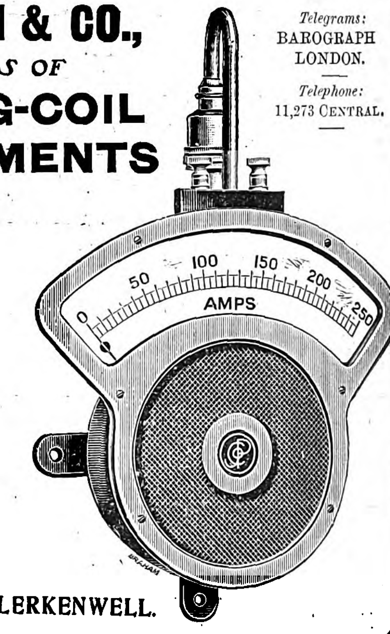

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# THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,455. [No. 25. Vol. LVI.] FRIDAY, APRIL 6, 1906. PRICE SIXPENCE (by post, 6½d.), *Abroad 9d., or 18 cents, or 90c., or 80pf.*

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## NOTES.

◆

IT is to be regretted that the proposals of the Additional Electric Power Supply Co. should have been summarily rejected in the House of Commons on Tuesday, practically at the instance of the Government, for the President of the Board of Trade directly asked the House to vote against the second reading of the measure. Originally, the Bill was for power to supply electrical energy "in bulk" to any customers they could find for this commodity, but, in view of the action which was announced by the Government in the debate on the London County Council Power Bill last week, the promoters indicated that they would be satisfied with powers to supply electric railways and canals—not exclusive powers, but little more than permission to close contracts with railway and canal companies for the supply of electricity. The Company, in fact, had entered into a provisional agreement with the Great Northern Railway to furnish the energy for the working part of this railway system electrically, and there were indications of a similar understanding, perhaps of a more tentative nature, with the London, Brighton & South Coast Railway. Had the Additional Company reduced the provisions of their Bill to apply only to these two lines of railway, it is not improbable that it would have been passed; but even in its present form it is to be regretted that the ordinary course should not have been followed—viz., that of passing the second reading and sending the Bill to a Committee for full consideration. Whatever may be the merits and demerits of the London County Council Power Bill in other respects, there can be general agreement on one point—viz., that the London County Council is not the proper authority for supplying power to the big railway companies.

◆

THE decision of the Government with regard to the formation of the Hybrid Committee of the House of Commons which is to consider the London County Council Electric Power Bill has now been made. We expressed the hope, in our leading article last week, that of the nine members forming the Committee five would be appointed by the Committee of Selection and four by the House, so that the party-political element would be neutralised. Unfortunately, four only of the nine members are to be appointed by the Committee of Selection, and of the five members selected by the Government, four (including one Labour member and one Irish Nationalist) are from the Ministerial side of the House. It is greatly to be regretted that the question of electric power supply in the metropolis is still being treated by the Government as one of party politics, but it is some consolation that none of the members chosen are on the London County Council, although there would have been a precedent for this.

◆

IF barges on canals are to be towed by mechanical means, there is no doubt that an electrical system has the first claim to consideration. Some tests carried out on a new electric system of towing on the Erie canal are reported in another column of this issue, and they go to show that the combined efficiency of the electrical and mechanical portions of an electric tractor may rise well above 80 per cent. It is another question, of course, whether canals can ever hope to compete with railways even if provided with a perfect system of towing. From the table in the article referred to above it will be gathered that the tractive effort per ton of total weight towed ranged from 4·8 lb. to nearly 10 lb. in the various trial runs according to the total weight and the speed. The data given by various authors for the tractive resistance of carriages and waggons on railways per ton of total weight vary greatly, but the average figure is not far from the lowest figure quoted above for the barges. Hence not more, and probably less, power is required to propel a given load on a railway than on a canal. This remark refers to barges or a train of barges whose total weight does not exceed 850 tons (the maximum weight experimented with on the Erie canal) and whose speed is approximately 4 miles an hour. For higher speeds, the railway would show up even better, while for a larger total weight and the same low speed the barges may possibly be cheaper in operation. But the comparison is incomplete if it is only one of the energy expended in the two cases. In wages, depreciation and other costs, canal traction is undoubtedly cheaper, and it is quite conceivable that a fresh lease of life may be granted to our canals by treating the traffic on them as well as their construction and maintenance as an engineering problem. Much will depend, however, on the present condition of the canals themselves, and evidence of this point will, in due course, be placed before the Royal Commission that is now sitting. Up to the present the evidence has been of a general character but when technical evidence is taken it shall be duly reported in our columns.

◆

SINCE the introduction of commutating poles, the question has been frequently ventilated as to how their presence affects the flux distribution of the machine as a whole. The opinions held by different authors are conflicting, however. Some incline to the belief that the main pole flux and the auxiliary flux act as if they were entirely independent of one another, while others aver that the insertion of an auxiliary pole of one or the other polarity between two main poles of opposite polarity must necessarily lead to an asymmetrical distribution of flux. This question would now seem to have been settled in favour of the former opinion by some experiments which are described and discussed by Messrs. T. F. WALL and S. P. SMITH elsewhere in this issue. The experiments were made with an armature at rest, and nothing is said about the distribution when the armature is loaded and running. If we consider the armature-turns in the direction of the brushes as back-turns with regard to the turns on the auxiliary poles, it would appear likely, however, that the flux distribution in the machine on load is not different in principle from that at rest. If this view is correct, the use of a separate magnetic circuit for the auxiliary flux should be unnecessary. It should be pointed out, however, that in the Siemens machine, described also in this issue, a separate auxiliary magnetic circuit is used; so that perhaps there are some other considerations to be taken into account, such as the possibility of laminating the entire auxiliary system to accelerate the response to sudden changes of load.

◆

ON another page will be found a short account of Capt. WILDMAN'S observations of the effects of Alaskan meteorological conditions on wireless signalling. The most noteworthy conclusion reached is that a high wind carrying water particles abstracts energy from the receiving antenna, and that, consequently, the receiving surface should be kept as small as possible. It is very difficult, however, to understand how this loss can happen when the storm-beaten air-wire is well covered with insulating material; and, therefore, we think a more ordinary explanation at present better. It is well known that electric waves passing through a medium crowded with conducting particles suffer great absorption, and no doubt Alaskan storms fill the air pretty closely through many miles with such particles. Errors of observation were certainly posssible as all the recorded measurements of the strength of received signals were made by noting what shunt was necessary across the telephone to leave the signals just audible.

◆

**King's College, London,**—The annual dinner of King's College, London, will be held at the Hotel Cecil on Monday, May 7th. Mr. Justice Grantham will preside.

**Students' Section of the Institution of Electrical Engineers.**—The visit of the Students' Section of the Institution of Electrical Engineers to the works of the Amalgamated Press (Ltd.), arranged for Saturday, April 14th, has been postponed.

**Municipal Ownership of the Chicago Tramways.**—According to a Reuter telegram, dated Wednesday, it has been decided by a majority of 3,837 to municipalise the street railways and tramways of Chicago. 14,488 voters supported the scheme, and 10,651 votes were recorded against it. The issue of certificates for £15,000,000 for the purchase of the existing systems has also, it is rumoured, been approved.

**Royal Institution.**—Last week Prof. Zeeman gave the Friday evening discourse, his subject being that in which he has gained fame—namely, magneto-optics. In excellent English he summarised the main results of the researches of the past ten years, and illustrated by a splendid series of lantern slides his investigations into the minute anatomy of spectrum lines split by magnetic fields.

**Cable Interruptions and Repairs.**

| | Date of Interruption. | Date of Repair. |
|---|---|---|
| Tarifa—Tangier | Jan. 18, 1904 | — |
| Jamaica—Colon | Jan. 10, 1905 | — |
| Cadiz—Teneriffe | July 20, 1905 | — |
| Puerto Plata—Martinique | Dec. 15, 1905 | April 3, 1906 |
| Tangier—Cadiz | Feb. 17, 1906 | — |
| Santa Lucia—St. Vincent | Feb. 19, 1906 | — |
| Porto Rico—St. Croix | Feb. 26, 1906 | — |

**The Fynn Single-phase Motor.**—Mr. Fynn asks us to make the following corrections in his supplementary notes to his Paper published in *The Electrician* of March 30th, p. 966. On p. 966, second column, line 36 from top, read "increase of EX" instead of "decrease of EX"; line 42, read "whereas EW" instead of "whereas EH"; lines 13 and 14 from the bottom of the same column, read "leading TF by about 70 deg." instead of "lagging by about 110 deg. behind TF."

**The "National Telephone Journal."**—We have received a copy of the first number of the "National Telephone Journal," a monthly journal published for the benefit of the staff of the National Telephone Co. It is produced by an editing committee formed of prominent members of the staff, and, although largely devoted to matters of departmental interest, it also contains some interesting articles on general questions of telephone engineeering and organisation. It is difficult to single out any articles for special commendation, but we may particularly mention a contribution by Mr. C. E. Fenton, describing the repairing work at the Nottingham factory of the company, a detailed account by Mr. F. D. Watson of the methods used in restoring the Glasgow "Royal Exchange" test-room after the fire that occurred there last year, and a Paper by Messrs. J. Anderson and J. R. Thyne on "Office Organisation."

**Large Alternators at Messrs. Siemens Bros. Dynamo Works.**—In case it might be inferred from the introduction to the second part of our article on the above (*The Electrician*, March 23, p. 930) that Mr. Rodgers' share in the design of these machines was subsidiary, we are asked to point out that the design of the alternators in question was primarily due to Mr. Rodgers, whilst Dr. Kloss's responsibility for the alternating-current designs of the firm of Messrs. Siemens Bros. only commenced whilst these machines were in course of construction. To Dr. Kloss, however, is due the devising and supervising of the system of testing, as Mr. Rodgers is now chiefly engaged at the London office of the firm.

**Electrically-Operated Ships' Bulkhead Doors.**—A lecture on this subject was given on March 13th at the Massachusetts Institute of Technology by Mr. W. B. Cowles. After dwelling at length on the necessity of a reliable system, he pointed out the advantages of doors electrically operated from the bridge, and described the principal features of what is known as the "Long-Arm" system, in which a central emergency station is provided on the bridge, from which all the doors can be closed quickly in cases of emergency. Indicator lamps show at a glance which doors are open or closed, pointing out in case of local obstruction which door is to be cleared. Each door is also fitted with a "liberty" action, whereby a man on either side of any door can open it at any time during an emergency period for duties or escape, the door immediately closing after such action without further manipulation, either locally or from an emergency station. Each door is fitted with an automatic cut-out, by means of which the circuit is opened when an obstruction meets the door, but the moment the obstruction is removed the circuit is again closed. The main controller is arranged to close the various doors in succession to avoid an excessive current consumption. Auxiliary hand gear is also fitted to each door.

**Royal Commission on Canals and Waterways.**—At the meeting of the Royal Commission on Canals and Waterways on Wednesday, the chief evidence was as to the establishment of local trusts which should have the management and control of all canals and waterways in certain defined areas. The districts were specified as follows: North-West, North-East, South-West, South-East and the Great Midlands or Birmingham. Mr. Arthur Lea, a member of the Bristol Chamber of Commerce and a manufacturer in London and Bristol, advocated this method of dealing with the matter, and also suggested that all canals should be freed from railway control. He considered that the difficulty of raising capital in the past for the improvement of canals was due to the antagonism of railway companies. During the course of the evidence the chairman suggested the following classification of canals: (1) Canals which were so good that no attention was required; (2) canals which would repay capital expenditure; (3) canals upon which it would be doubtful whether or not capital expenditure would be remunerative; (4) canals which were not worth expenditure. Mr. Lea, in further evidence, said that the local bodies suggested should be under some control, and that the cost of maintenance and improvement of canals should be borne by the districts comprised by the respective local bodies. The Commission adjourned until May 9th.

**Electrical Testing.**—A Paper was read on the above subject by Prof. E. W. Marchant before the Liverpool Engineering Society on March 21st, which detailed some of the methods employed in the electrical laboratorities at the University of Liverpool. Commencing with the measurement of resistance, the author spoke of the necessity for care in avoiding temperature errors in the use of the cheaper forms of Wheatstone's bridge. He also described a special apparatus for testing the contact resistance of carbon brushes in which the brushes are pressed against a revolving copper drum which takes the place of the commutator. A modified "loss of charge" method of testing cables was described. Some results of tests of dielectric strength were also given which bore out the law that the break-down voltage is roughly proportional to the square root of the thickness of the plate. Reference was made to Prof. Marchant's recent work on fuses (see *The Electrician*, March 2nd, p. 792). In dealing with magnetic testing, the author alluded briefly to the yoke methods of Hopkinson, Ewing and Crompton, and mentioned the errors likely to arise owing to the length of time taken to reverse the magnetism of the iron yoke as pointed out in 1895 by the late Dr. J. Hopkinson and Prof. E. Wilson (see *The Electrician*, Vol. XXXIV., p. 510). For testing hysteresis, he inclined to the dynamometer method described by Mr. Sewell (*Proc.* Roy. Soc., Vol. CXCVIII., pp. 33-104). A number of tests of meters were given, and a special form of wattmeter was described. Some photometric tests have been carried out in the laboratory, many of which show remarkable differences in the actual candle-powers of similarly rated lamps. Passing on to the testing of machines, a convenient form of Prony brake for small motors is described, and some characteristics and wave-form curves are given for a Heyland self-exciting alternator (see *The Electrician*, Vol. LIII., p. 510). The remainder of the Paper is devoted to a description of the University Laboratory, which was fully described in *The Electrician*, Vol. LV., p. 457.

**Electric Winding Plant at a Shale Mine.**—One of the first electrical winding plants on the Ilgner flywheel motor-generator principle to be installed in the United Kingdom has been put down at the Cobbinshaw pit of the Tarbax Oil Co., the contractors having been Messrs. Bruce Peebles & Co. According to *Engineering*, the pit is 140 yds. deep, and when fully developed will have an output of 640 tons per day of eight hours. Power is supplied by overhead mains at 400 volts three-phase from the power house of the Pumpherston Oil Co. The net load for which the equipment is designed is 25 cwt. per wind, 30 seconds are allowed for decking and the maximum speed is 23 ft. per second with an acceleration of 2 ft. 4 in. per second per second, so that the whole wind is completed in 25 seconds. The ropes are $1\frac{1}{16}$ in. diameter and the drums run at a maximum speed of 90 revs. per min. The rated capacity of the three-phase induction motor driving the flywheel set is 80 B.H.P., the continuous-current generator has a corresponding output, but is enabled by a compensating winding to deal with something like 400 per cent. overload without sparking troubles. The flywheel is made from a special Krupp casting and weighs 6 tons. The synchronous speed of the set it 750 revs. per min., but the speed in practice varies from about 650 to 735 revs. per min. The winding motor is coupled directly to the drums and receives constant excitation from the exciter set, speed variation being effected in the usual way by variation of the field of the flywheel generator. A special arrangement is adopted for automatically inserting resistance into the rotor circuit of the induction motor for keeping the input constant for varying flywheel speeds. This consists of a small three-phase star-connected motor, the windings of which are in series with the stator windings of the main induction motor. The rotor of this motor is not allowed to run, as its torque is opposed by a balance weight. When the current exceeds 60 amperes per phase, the motor is able to lift the balance weight and rotate the brushes of a controller, which inserts an amount of resistance into the rotor circuit corresponding with the stator currents. An additional liquid rheostat is provided for running the flywheel up to speed, which operation takes about 20 minutes. The mechanical portion of the gear was supplied by Messrs. Gibb & Hogg.

**The Corpuscular Theory of Matter.**—Prof. J. J. Thomson in his fifth Saturday lecture at the Royal Institution showed that near his model electric atom there might be, besides the three directions of stable equilibrium for charged particles, definite positions of stable equilibrium for uncharged particles. This may be illustrated by the experiment of bringing an uncharged conducting ball into a variable electric field, or by allowing an iron ball to move freely in a magnetic field. In either case the ball runs to the place where the field is strongest and settles there. Thus, in the case of the electric atoms we may expect to find different modes of chemical combination according as the atom (or molecule) introduced is charged or uncharged; and thus the forces holding the atoms of a molecule together would appear to be of two types. This raises the question: Are the atoms in a molecule charged? The evidence available is very indirect and is chiefly optical, but it all points to the conclusion that in some cases the atoms are charged, in some uncharged. The chief optical evidence arises from the consideration that if the atoms are not charged an atomic additive law should be possible for the refractive indices of chemical compounds. As a fact, series of related organic compounds are found within which an additive law holds, but in different series different values have to be assigned to the atomic refractive indices, which implies that the same atoms may carry different charges in different series of chemical compounds. The phenomena of rotatory polarisation in gases, so far as they go, yield the same conclusion. The lecturer next discussed the question of the actual number of negative corpuscles in an atom. It does not follow that because the hydrogen atom is 1,700 times heavier than the negative corpuscle, there are, therefore, 1,700 corpuscles in the atom; for the mass of the positive electricity in the hydrogen atom may not be negligible. One way of attacking the problem lies along the theory of absorption of electromagnetic waves by a monatomic gas. The best available figures give the surprising result that the mass of the positive electricity in the hydrogen atom must be nearly that of the whole atom, and thus there can only be few negative corpuscles in the hydrogen atom. Again, the intensity of secondary Röntgen radiation from air shows that there are approximately 25 times as many negative corpuscles in the cubic centimetre as atoms. Finally, absorption by solids confirms the conclusion that the number of negative corpuscles in any atom cannot be a large multiple of the atomic weight of the atom.

**Motor Omnibus Services in Relation to Tramways.**—A Paper on this subject was read before the Tramways and Light Railways Association, on March 27, by Mr. Norman D. Macdonald, Mr. W. Worby Beaumont in the Chair:—

The author pointed out that he was not an enemy of electric tramways but that the main object of the Paper was to suggest ways and means whereby the motor omnibus could be utilised most advantageously in conjunction with electric tramway system. At the same time, however, he took up a somewhat unfriendly attitude, in the early part of the Paper, towards electric tramways. For instance, he said that: "When the traffic of the tramway reaches a certain point it defeats itself, because you are compelled to try to work it all (in either direction) on 4 ft. 8½ in. Hence, you get a string of cars checking each other, especially by their constant stops for passengers, and it is sometimes better to get out and walk, as at the bottom of Broadway, New York." Hitherto, he said, tramways had been tolerated, but the paramount necessity for flat, smooth streets would make the public mind more and more grasp the inconvenience and danger of rails with their ruts and grooves, especially for indiarubber tyres and for fast-travelling vehicles. Tramways monopolised the best part of the road, and if they were to be economical they had to be of great size. Having discussed the advantages of a fleet of "cruiser" omnibuses to act as feeders to the tramways, and also considered the advantages of using a coadjutor fleet of motor omnibuses for doing overlap work, having in mind the limitations of tramways as to speed and capacity, he suggested that it would pay the tramway authority to run motor 'buses alongside their own tramcars, starting from points beyond the tramway termini, and giving an express service into the central parts. Coming once more, unconsciously, to the question of motor 'buses *v.* tramways, the author remarked that once there were sufficient omnibuses for the internal parts in big cities such as London, the 'bus companies would invade the surrounding tramway territories. In other towns, where the streets were fairly wide and the traffic not very dense, motor 'buses would be a very serious rival to tramways. The inflexibility of tramways was a cause of loss to them, and the author concluded by remarking once more that the whole burden of his argument was that the mobile motor vehicle would be found a good auxiliary for handmaid work to the fixed tramway. Incidentally he remarked that he was one of those who felt that tramway men hardly realised the very rapid depreciation of all outside electric tramway plant after a certain age, under modern conditions of very heavy cars and high speeds. The author, it may be mentioned, was responsible for the first public service of autocars—viz., in Edinburgh, seven years ago. His new company is now starting with 30 large modern motor 'buses, and within a year it is expected that 80 to 100 will be running. The author is also interested in the London motor 'bus service.

Mr. EMILE GARCKE, who opened the discussion, said that, although he agreed that the motor 'bus could be used for the improvement of tramway services, there was much that the author had said that he could not agree to. Where a tramway system was well designed and served a densely-populated district, competition from the motor omnibus need not be feared. A field was opened to the motor omnibus, however, in many cases by the short-sighted policy of municipal authorities in adopting various gauges, and so preventing the linking up of the tramway systems and through running. Some of the author's criticisms of electric tramways were not well founded. For instance, the extra congestion which he said tramways cause. At Piccadilly, Manchester, the congestion of traffic was extraordinary when the horse tramcars were running, but since the introduction of electric traction this had all been removed. There was an enormous economy in working electric tramways where the energy was generated at one central point as compared with motor 'buses. Again, the working expenses of motor omnibuses were about twice those of an electric tramway, for he had attempted to run a service of motor 'buses in connection with a provincial tramway system. Motor omnibuses had an excellent field where electric tramways were not practicable, but he did not think the author's idea of "overlapping" services by 'buses would be found workable in practice. He claimed to speak impartially, for although, as everyone knew, he was largely interested in electric tramways, yet he was engaged in the erection of a factory here for building motor omnibuses.

Mr. SHRAPNELL SMITH said he did not think Mr. Garcke's service of motor omnibuses could have been properly managed if it cost 1s. per car-mile, which would be about double the ordinary tramway working expenses. The motor 'bus industry was at present suffering from many drawbacks, such as the difficulty of obtaining spare parts, which would soon be eliminated, and the running costs considerably reduced. As to the greater advantage of the centralisation of the motive power of tramways, he said that experiments were now being made with motor 'buses in which the explosive mixture would be derived from a producer plant on the vehicle. When these vehicles were obtainable, the running expenses would be brought down to the same as those of tramways.

Mr. RÜFFER said that motor 'buses might pay very well for five years if no depreciation was allowed, but he was of the opinion that 30 per cent. would not be too much for depreciation. If the 'bus people allowed sufficient for depreciation he did not think the tramway people need fear.

Mr. CONRADI said he had made a calculation that if all the street passenger traffic in the United Kingdom at present caused by tramways and 'buses was to be carried by motor omnibuses it would need 400,000 such vehicles. But he did not think this would ever come about.

The CHAIRMAN (Mr. W. Worby Beaumont) thought 25 per cent. depreciation for motor omnibuses would be sufficient with the present bad state of our roads. With a more scientific treatment of the surfaces of streets higher speeds could be attained with less wear and tear.

Mr. MACDONALD, in reply, on the question of congestion of traffic by tramways, said that this was causing terrible trouble in New York, and the opinion had been expressed that in time all the tramways would be taken up, the roads paved with smooth asphalte, and motor omnibuses substituted. Regarding cost, from the experience they were now having in London, the working expenses of motor 'buses should be about 7d. per car-mile.

## ARRANGEMENTS FOR THE WEEK.

**(To-day) FRIDAY, April 6th.**

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER STUDENTS' SECTION.

*8 p.m.* General Meeting, when Mr. D. L. Sands will read a Paper on "Some Automatic Devices for Electricity Control."

**SATURDAY, April 7th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture VI., by Prof. J. J. Thomson, F.R.S., on "The Corpuscular Theory of Matter."

**MONDAY, April 9th.**

INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' ASSOCIATION.

*8 p.m.* Meeting at Storey's Gate, St. James' Park. Paper to be read: "Tube Railways and their Construction," by P. A. Amy.

**TUESDAY, April 10th.**

INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER LOCAL SECTION.

*7:30 p.m.* Meeting at the University, Manchester, when the following Paper will be read: "Lifts and Hoists," by H. C. Crews. At this meeting the committee and officers for the ensuing session will be elected.

INSTITUTION OF ELECTRICAL ENGINEERS: GLASGOW LOCAL SECTION.

*8 p.m.* Meeting at 207, Bath-street, Glasgow. Paper to be read: "Notes on Booster Development," by A. H. Kelsall.

FARADAY SOCIETY.

*8 p.m.* Meeting at the Institution of Electrical Engineers, 92, Victoria-street, Westminster, London. The following Papers will read. The first three will be communicated by Mr. F. W. Harbord: (1) "Notes on the Rotating Electric Steel Furnace in the Artillery Construction Works, Turin," by Ernesto Stassano. (2) "Electrothermics of Iron and Steel," by C. A. Keller. (3) "Recent Developments in the Gin Electric Steel Furnace," by Gustave Gin. (4) "Note on the Cleaning of Work by Means of the Electric Current," by H. S. Coleman.

**WEDNESDAY, April 11th.**

CRYSTAL PALACE COMPANY'S SCHOOL OF PRACTICAL ENGINEERING.

*12 noon.* Prize and Certificate Distribution by Sir Alexander Binnie.

INSTITUTION OF ELECTRICAL ENGINEERS: STUDENTS' SECTION.

*7:30 p.m.* Meeting at the Northampton Institute, St. John's-street, Clerkenwell. Paper to be read: "Medical Electricity," by L. Lambe. A party will be conducted over the laboratories of the Institute at 6;45 p.m.

ASSOCIATION OF ENGINEERS-IN-CHARGE.

*8 p.m.* Meeting at the St. Bride's Institute, Bride-lane, Fleet-street, London, when a Paper will be read by Sir Charles S. Forbes, Bart., on "The Origin and Progress of Acetylene and its Adaptability to Various Uses."

## APPLICATION OF ELECTRICITY IN MINES.

Mr. C. P. Sparks' Paper, published in our last two issues, was discussed at the Institution of Electrical Engineers on March 22nd, 29th and yesterday, in conjunction with Mr. W. C. Mountain's Paper on Electric Winding read before the Manchester Local Section of the Institution of Electrical Engineers on January 16th. An abstract of Mr. Mountain's polemic appeared in our issue of February 9th, p. 658. Mr. Mountain opened the discussion with some remarks on Mr. Sparks' Paper, and a résumé of the views expressed in his own Paper, and he was followed on the first day by those who supported his contention that electric winding would not be as economical as steam winding for heavy work. On the second day speakers were called upon in support of electric winding, and figures were adduced to prove that Mr. Mountain's estimates were fallacious.

*March 22nd.*

Mr. W. C. MOUNTAIN said he had been over the Aberdare installation and had been struck with the way in which the work had been carried out from the engineering standpoint. Not a penny had been wasted, and he congratulated Mr. Sparks on the result and the company on having Mr. Sparks' advice. He thought, however, that Mr. Sparks would have incurred less expense as regards first cost if he had employed three 1,000 kw. units in the generating installation; then two units would have done the work, and the third would have been a stand-by in case of accident. With the units as at present, if the 2,000 kw. set were fully loaded and broke down, the two 750 kw. sets would hardly carry the load. The design of the switchboard did credit to the Electrical Co. With regard to the cost per unit, which was given at 0·365d., he understood from Mr. Shaw that this was beyond the actual cost to-day now that the plant had been loaded. This was a figure which, from his experience, was actually obtained under colliery conditions, and included ample allowance for interest and depreciation. In this case, also, the cost of coal was taken at 4s. 2d., but many colliery engineers would bear him out that that was far more than the value of the coal which was generally used in a colliery. He knew many instances where the coal was put down at 1s. 6d. per ton, but it was only put at that figure because they must put something down. As a matter of fact, if it were not used under the boilers, it would have to be put on the pit heap, and there, of course, it was liable to spontaneous combustion. He knew a colliery where they made 7½ tons of slack from their daily output. Of this, 3½ tons were used under the boiler and the rest was carried away at 3d. per ton. In the early days he had used lead-covered cables for mining work with continuous currents (with which he admitted the conditions were different from alternating current), but he had hardly ever put in one that had not sooner or later failed. It was a German practice, but from his experience he did not think it a good practice, because of the moisture and electrolytic action. He could endorse Mr. Sparks' action in having slow-speed motors for his hauling gear, because unless the motors for this service were of very moderate speed, the vibrationset up in the gear sooner or later broke down the armatures of continuous-current machines, and with three-phase machines was liable to damage the rotors. There was also the wear and tear on the bearings, and the possibility of the rotors cutting the stators. The total cost per kilowatt given by Mr. Sparks—viz., £17—confirmed the actual cost in a number of contracts which he himself had carried out, and in this particular case was a moderate price for the thoroughly good job that had been put up.

Coming to the question of steam *v.* electric winding, he characterised the German efforts in this direction as "playing at winding," and said that the machines employed so far were very little better than electric hoists. Before he approached this subject he had received a good many inquiries for electric winding installations, and therefore he had gone to Germany and had studied the subject very closely. The result was that he came back convinced that the cost of electric winding and of the gears themselves was so excessive that there was no possibility of adopting it for serious heavy commercial work in this country. From information given him by 12 colliery owners, who were representative of all classes and conditions of collieries in this country, he had then prepared a table showing the actual cost of winding by steam engines, which showed that the total cost of winding 100 tons, with interest and depreciation added, varied from 3s. 11d. (at Mr. H. Rhodes' Colliery, Rotherham) to 19s. 10¾d. at the Hulton Collieries. He maintained that this was the only way of considering the cost of winding. It was no use to take so many pounds of steam per useful horse-power of rope. This conveyed absolutely nothing to the mind of the practical mining engineer. After communicating with Messrs. Siemens Bros. & Co. and the Electrical Co., both of which firms had been very kind in giving information, he thought he would prepare some tables which they could fight about. Consequently he first prepared a table showing the estimated cost of winding per 100 tons with high-class coupled-compound non-condensing engines at 135 lb. steam pressure. He had taken first 1,000 tons of coal raised 500 yds. in 10 hours per day winding; the total cost of winding per 100 tons with interest and depreciation was 6s. 3d. Similar figures were also given for 1,500 tons per day and 2,000 tons per day which were 5s. 1½d. and 6s. 6½d. respectively per 100 tons. He then got from Messrs, Markham & Co., of Chesterfield, some figures which enabled him to compile a third table showing the estimated cost of winding per 100 tons with high-class coupled high-pressure non-condensing engines at 150 lb. steam pressure, because it was a disputed point as to whether compound or high-pressure engines were the most economical. The results on the same basis as the second table were 6s. 8½d., 6s. and 6s. 8½d. respectively. As the latter figures, however, were for eight hours and not ten hours, he had compiled a fourth table from Messrs. Fraser & Chalmers' plant on the 8 hours basis, and the corresponding figures were 6s. 9¾d., 5s. 5d. and 7s. 2½d. The last of the three figures in each set was in all cases for 700 yds. depth, as against 500 yds. in the others. In all cases 10 per cent. was added for interest and depreciation. Having got these results he then set to work to calculate what it would cost to wind electrically. This formed the subject of a fifth table. He had treated this table in precisely the same way as the others, but one or two figures had had to be assumed. One figure which he had assumed, and which he hoped would be questioned, was the steam consumption per kilowatt-hour. He had taken 25 lb., which on a colliery load which was always varying was as low a figure as could safely be estimated upon. It was no use taking fancy figures which were not going to be realised in practice. In Mr. Sparks' Paper 3¾ lb. of coal per kilowatt-hour was given, which meant 7 lb. of water per lb. of coal, and this was a result which he had had over and over again. On colliery boilers it was seldom more, and sometimes was a little less. Therefore Mr. Sparks' 26 lb. of steam per kilowatt-hour could be taken as a good average figure. In this fifth table he had taken the same quantities and depths as in the previous tables—viz., 1,000 tons in eight hours at 500 yds., 1,500 tons in eight hours at 500 yds., and 2,000 tons in eight hours at 700 yds. In estimating the cost of the winding gear he had assumed the use of balancers, because he did not think any system of winding which he had seen so far was of the slightest use unless balancers were adopted. He had seen the Preussen gear, but he did not think it could be regarded as the most economical way of winding, and if we were to wind electrically we must balance our loads in some way, and the balancer which he had seen at Zollern was the only practical way of doing it. The final result of his own estimates was that the cost of electric winding per 100 tons 500 yds. deep and 1,000 tons per day was, without interest and depreciation, 3s. 8½d.; for 1,500 tons per day 500 yds. deep 2s. 11½d. per 100 tons, and for 2,000 tons 700 yds. deep 3s. 0½d. per 100 tons. Adding 10 per cent. for depreciation and interest, this raised the above figures to 13s. 9½d., 11s. 7d., and 12s. 5d. for electric winding, against 6s. 9¾d., 5s. 5d., and 7s. 2½d. for steam winding under exactly the same conditions. He had taken 250 days a year, which he believed was a fair number of days. Therefore, if they were going to compete against steam, it was absolutely necessary to reduce the cost of electric winding plants to something like the cost of the steam plant. Figures for the Grand Hornu mines had been given him by the Electrical Co., and he embodied them in a sixth table. 1,400 tons were wound each day of 24 hours, or only about sixty tons an hour, which he had already characterised as hoisting and not winding. The cost of winding was £13. 14s. 6d. per day of 24 hours, including depreciation and interest, and the cost of winding 100 tons was 19s. 7¾d. against steam winding varying from 3s. 10d. to 6s. or 7s. If, under present conditions, they were to compete with steam winding, the electric supply people would have to supply the energy for nothing, and give something in.

Mr. J. LEGGATT (Cardiff) pointed out that the figures of the cost of electrical winding in Mr. Mountain's Paper, with the preparation of which he had had a good deal to do, were all either estimated or taken from Continental practice. It would be interesting to see whether any results obtained by Messrs. Siemens Bros. & Co. for the large winder which they were putting down in South Wales for the Duffryn Rhondda Co., and which would be a good example of English practice, would modify Mr. Mountain's figures at all. The estimated costs for electric winders given in the Paper were on the assumption that drums were used and not Koepe pulleys. If these pulleys were used the cost of the whole plant would be reduced by about 10 per cent. and the cost of electrical winding accordingly. This Paper, also, only dealt with single winders and the results would be considerably modified in the case of a company having several pits close together fed from one central station, and especially if the power required for purposes other than winding became as great as the power required for main winding. In the majority of cases in this country, however, there would be only one winder, the rest of the plant necessary for driving the surface plant, haulage and pumping, not exceeding half the power necessary for winding. In these cases it would be very difficult to bring the cost of electrical winding out better than, or even as good as, steam winding as regards annual cost. There was one way, however, in which these figures could be completely modified in the case of steam winding. The exhaust steam from the winder might be utilised in a low-pressure turbine by means of the system devised by Prof. Rateau for using the exhaust steam from intermittently running engines. The system was well known and had been described in Papers read by Prof. Rateau and Mr. P. J. Mitchell before the Institution of Mechanical Engineers (see *The Electrician*, Vol. LIII., p. 349 and Vol. LVI., p. 496) and the West of Scotland Iron and Steel Institute. For instance, a winding engine using 450 lb. of steam per wind and winding 60 times per hour and exhausting to atmosphere (allowing 20 per cent. for condensation in the engine, cylinders, pipes, &c.) gave 21,600 lb. of steam available for the low-pressure turbine, and with a consumption per electrical horse-power per hour of 30 lb., a total of 720 E.H.P. would be available for driving motors on the surface and underground. In most cases this was amply sufficient for all purposes about the pit, with the exception, perhaps, of driving the fan. Similar results had been obtained in several collieries on the Continent, and had been guaranteed in the cases of two or three plants being installed in this country, no extra back pressure being put on the winding engines. The heat accumulator, which might consist, as described in the Papers referred to, of an old boiler, could be made large enough to keep the turbine going at full load during the ordinary stops of the winder. With a 500 kw. plant installed at the steel works of the Steel Co. of Scotland, stops for periods as long as six minutes were being successfully negotiated. If the stops were longer than this a special automatic reducing valve came into operation, passing live steam through from the boilers.

Mr. C. P. MARKHAM (Chesterfield) said he did not think it would pay any colliery company to put down electrical plant for winding alone. It was not possible to sink a pit for much under £2,000 in the South Yorkshire district, the depth being usually from 800 yds. to 1,000 yds. To raise 4,000 to 5,000 tons per day was a common performance in South Yorkshire. They had to get the men in and the coal out in eight hours' work, and an engine was wanted that would take an enormous quantity of steam for about two revolutions, get an acceleration up to a very high point, then drop to zero and run out at the pit top. Steam winders were now being used in South Yorkshire with engines having 48 in. cylinders, 7 ft. 6 in. stroke and 120 lb. pressure behind them. At starting they took full steam for the whole of the stroke, cutting off at $\frac{7}{8}$ for the first 2 or $2\frac{1}{2}$ revolutions, and reducing the cut-off to $\frac{1}{10}$ in the next 10 revolutions. By that time they were accelerated sufficiently to run them out at the top, and the balance rope, which was generally used, pulled the engine up quietly. With mines of about 800 yds., from 62 to 68 winds per hour were accomplished. Electrical winding hitherto was child's play compared with this, and he failed to see how electric driving was going to compete. He thought the remarks made by the last speaker indicated the best thing to do—viz., to exhaust the winding engine into a Rateau turbine.

Mr. T. FUTERS (Newcastle) said that managers and owners would be very glad indeed to turn out their old steam engines and adopt electric winding if it were proved that it would be very much more economical than steam. In the main, however, he was bound to agree with what Mr. Mountain had said. The great question was that of cost, and undoubtedly when one considered that the cost of the electric winder alone at present was £10,000 to £15,000, whilst an excellent steam engine might be bought for £5,000, it was evident that any colliery company would regard the extra capital outlay as a very serious item. Another point that had been made very much of in connection with electric winding was the question of automatic safety appliances. Safety appliances were not in favour in this country, and if as electrical engineers they could go to the colliery manager with a plant which worked without any safety appliances whatever, it would be looked on with favour. There was no doubt that the ordinary winding engines, especially in the North of England, were great steam eaters, but this was a very simple question. The engines were controlled by practically two handles—viz., the ordinary steam regulator and the steam reverser, and very good results could be obtained by modifications to the gear. He believed there were at present working in South Wales steam engines which only used 26 lb. of steam per horse-power-hour, and in another case only 15·2 lb. of steam were taken per useful horse-power-hour. The engine was also working without either expansion of condensation, and if these were employed, probably a reduction of 10 or 15 per cent. in steam consumption could be obtained. Although the electrical plant was more efficient, the capital expenditure was greater, which, as Mr. Mountain had pointed out, rendered the working cost rather more than what the saving in coal was to be. It was a very difficult matter to compare the ordinary steam winding engines, when the term "steam consumed per useful horse-power hour" was used. So much depended upon the type of guides, cage, headgear arrangement and so on, which varied very much with the various types of engines at different collieries. He quite believed if it were possible to put down electrical winding plant on to existing drums by simply removing the steam engines and adding a motor, great savings would be effected in steam consumption. That there was a great future before electric winding there could be no doubt.

*Thursday, March 29th.*

Mr. GERALD HOOGHWINKEL read an abstract of the Paper on "Electric Winding considered Practically and Commercially," which he presented at the Newcastle Local Section of the Institution on March 19th (*The Electrician*, March 23rd, p. 925).

Mr. F. HIRD (of Siemens Bros. & Co.), while thanking Mr. Mountain for having accumulated such a mass of information with regard to steam winders, which was very difficult for the ordinary person to obtain, pointed to certain inaccuracies in the figures which threw considerable doubt on the value of the conclusions arrived at. He would like to know why it was necessary for the cages to be a great deal heavier in electric winding than with steam. He had not heard any explanation of this except the facetious one of electrolysis. The heavier rope mentioned in Mr. Mountain's tables might be partly due to the greater acceleration with electric winding, but it was not quite clear why such very high accelerations had been taken, and if these were bigger than necessary it would make the comparison as regards capital outlay unfavourable to electric winding. He would also like to draw attention to a matter which had been suggested by Mr. Hooghwinkel—viz., the very great difference which existed between Mr. Mountain's tabulated results obtained from the actual steam winding and the estimated results upon which Mr. Mountain had based his comparison. It might be urged, of course, that the figures for electric winding, taken for comparison, were also estimated, but there were some reasons for discriminating between the two cases. These reasons he had touched upon in the Paper which he read before the Institution of Mining Engineers in 1903,* and although that was rather a long time ago he saw no reason to change the opinion which he then expressed. The difference between the steam consumption under ordinary working conditions and the steam consumption under test conditions was enormous. This was not a pious opinion, but the result of absolute figures and tests which had been taken in a most careful manner. Under ordinary working conditions the steam consumption was 100 per cent. higher than under the test and guaranteed conditions, and the reason for this was not far to seek. In most, or all, steam winding engines the distribution of steam in the cylinders was left to the control of the man in charge. Unless the man was a past-expert in thermodynamics and pretty nimble with his hands, the result must necessarily be a very great waste of steam. The next reason was that it was possible and very easy to lose a very large percentage of the whole of the energy which was required for the lift during the braking operations, and it was quite easy to do that and know nothing about it when working with steam. With electricity the actual results could easily be investigated by means of recording wattmeter diagrams. With electric plants the braking was done by paying back energy into the motor-generator, and there could be no loss of power in braking except when the emergency brake was used, which was very seldom. There was another source of loss: At the end of a wind it was very common indeed for steam to blow off violently through the safety valve, because the boilers were worked pretty high, and when the lift stopped the steam blew off into the atmosphere. That steam was not included in the guaranteed figures given for the purpose of Mr. Mountain's comparisons. This largely explained the 90 lb. average given by Mr. Mountain from actual tests. He would make one short reference to the only electrical plant that Mr. Mountain had given particulars of—viz., that at the Grand Hornu mine, and he would like to point out that that was a particularly unfavourable result, which might have led Mr. Mountain to his somewhat pessimistic conclusions. The amount of coal raised per hour was very small and the depth was very great—*i.e.*, it was a very small plant, working under unfavourable conditions, and then, beyond this, it was working on practically what was known as the rheostatic system of control, which was extremely wasteful, and the results ought not to be used for making comparisons. It was remarkable that this was not drawn attention to in view of the opinion expressed by Mr. Mountain that the only electric winding plants which were worthy of consideration were those which provided for the storage of power and a balancing arrangement. His own personal opinion was that electric winding was coming, or, in fact, had come, and had come to stay, and he thought they might easily see some very good reasons for this. It was pretty certain that whatever machinery they had about the mines, apart from the winding, it had to be driven electrically, and once this was acted upon by colliery managers and owners they would not be long in perceiving the enormous inconvenience, apart from any question of economy, of having an isolated steam plant to do merely the winding. This was a point of very great importance, and it behoved them as electrical engineers to be prepared for what must inevitably come—viz., a large demand for electrical winding plant. This demand had already arisen here, and it would shortly attain something of the dimensions which it had already attained on the Continent and elsewhere.

Mr. G. L. ADDENBROOKE compared the load of a colliery to a tramway load factor. It was pretty well known that if there was only one car on a service, a 50 kw. generating plant was necessary to run it, but with the increase of the service, 10 kw. per tramcar would do very easily. Similarly, to put up electric winding for one colliery might or might not be worth doing; it was merely a question of finance from the colliery owners' point of view. In his power company's area (the Shropshire, Worcestershire & Staffordshire Electric Power Co.) there were 30 collieries within a radius of 4 miles, and an enormous amount of plant would be saved if all the power were supplied by the power company, because, as in the tramway, the maximum loads would not coincide. The speaker then showed a table of curves which gave the price which could be charged by a power company with stations varying from 3,000 kw. to 60,000 kw., with varying load factors—viz., 0 to 100 per cent. The prices ranged from 0·2d. for 60,000 kw. to 0·4d. for 3,000 kw., both for 100 per cent. load factor. This was taking into account a distributing system radiating up to 8 to 10 miles from the generating station, and the curves were made up on the assumptions that the generating station was erected at once of the size contemplated and not by stages; that coal cost 5s. 6d. per ton, and that an allowance of 10 per cent. of the total capital involved was made to cover interest and depreciation. These figures had been prepared in conjunction with some of the leading manufacturers, and he did not think they were very far out. With Mr. Sparks' load factor of 37 per cent., a station with 40,000 kw. or 60,000 kw. could supply at a much lower figure than in Mr. Sparks' case. In the Powell Duffryn district there was probably within a range of 7 or 8 miles over 100,000 H.P. in collieries, and it would be easy to put up a 60,000 kw. station in that area. He thought there was a better opening for winding electrically than Mr. Mountain imagined.

Dr. R. HERZFELD (the Electrical Co.) said the figures given by Mr. Mountain for steam winding were so favourable that the suspicion must at once arise whether they were right, and as far as he could see they were not correct, and had already done some damage. He should like to know on what authority the statement had been made that the Grand Hornu installation was wasteful and had been discarded by the makers. It was not a wasteful installation, but came out almost as an ideal plant. Mr. Mountain's tables made out that the total cost of winding per 100 tons at Grand Hornu was 19s. 7d. as compared with an average—as he made it—of 9s. 8d. for 12 steam winders. The average depth of these 12 collieries was 435 yds., whilst the depth of Grand Hornu was 767 yds., or nearly double. But this was not the only objection to Mr. Mountain's figures, for there seemed to be a misapprehension on Mr. Mountain's part as to a communication from the makers of this plant. Mr. Mountain mentioned that the total cost of generating energy at Grand Hornu—viz., £13. 14s. 6d. per day for 16,000 units, was solely for winding. But there were various other pieces of machinery which drew on this supply. For instance, there was a 125 H.P. pumping motor, two 200 H.P. ventilating motors, locomotives and other accessories amounting together to more than 1,000 H.P. The figures which actually represented the consumption of the winding engines were as follows: There were at present working at Grand Hornu two winding engines which drew 1,400 tons from a depth of 767 yds., and this represented a total of 3,640 H.P.-hours in mineral raised. From careful investigations with recording wattmeters it was found that one horse-power-hour in mineral raised corresponded to 1·46 units from the generating station. The total consumption of these two winding plants was 5,315 units per day instead of 16,000 mentioned by Mr. Mountain, and the total cost was, therefore, £4. 11s. 3d. instead of £13. 14s. 6d., or 6s. 6d. per 100 tons raised instead of 19s. 7¾d. This latter point was the most important of all. Mr. Mountain had stated that the unfavourable results which he gave—probably they would now be regarded as favourable—were only attained by working 24 hours, but he (Dr. Herzfeld) had information that the winding was done in 7 hours. With regard to boiler plant, he was of the opinion that with an electric plant this was smaller, not only on account of less coal burned, but also on account of the steadier load, because there were excellent means of balancing for a peak on an electrical plant which must be provided for in a steam plant. On the question of acceleration, Mr. Markham had, on the previous evening, said that very difficult problems would have to be solved with electrical plants, because steam winders were ever so much better in this respect. He thought, personally, that the problem of acceleration in winding was not nearly so difficult as acceleration in rolling—reversing rolling—mills; and it might be interesting to Mr. Mountain to hear that quite recently five huge rolling mills had been changed to electrical work which reversed 10 to 12 times per minute, and had an average driving capacity of 10,000 H.P. to 14,000 H.P. To use Mr. Mountain's expression, colliery winders were toys compared to these. Electrical engineers knew well enough that the latest developments of the continuous-current dynamo practically allowed for an unlimited amount of current to be taken out of a dynamo with no volts, so that the acceleration problem did not require any new developments. In fact, he thought the opponents of electric winding must come with heavier guns if they wished to check the progress of electricity.

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* *The Electrician*, Vol. LI., p. 697.

Mr. R. S. CLIFT (Siemens Bros. & Co.) said it was undeniable that the first cost of the steam winder was less than that of the electric winder, but on the other hand the electric winder would be found to be more economical as regards steam consumption. Therefore, if coal cost nothing, winding by steam would be cheaper, but if coal were valuable, electric winding would be cheaper. To show this point he would make use of some of the data from Messrs. Siemens which Mr. Mountain did not make use of. On a 24 hours' test under practical working conditions the steam consumption at Zollern for the main working shaft was 26 lb. per horse-power-hour throughout the whole 24 hours. The average steam consumption per horse-power-hour in the shaft was only 31·3 lb. This was shown in Table A below. The average steam consumption per effective horse-power-hour in the shaft for the 11 collieries mentioned by Mr. Mountain worked out at 90 lb. for steam winding. This was based on 7 lb. of steam per pound of coal, which Mr. Mountain also mentioned as a fair figure to be taken. Mr. Mountain had criticised the use of the term "steam consumption per effective horse-power-hour" as conveying no meaning to the average colliery man, but he must say that this had not been his experience. Colliery managers knew exactly what was meant by this term, and everyone regarded it as a true measure of the efficiency of a common winding engine. Then, again, Mr. Mountain's comparisons had not assumed the same acceleration period for steam and electric winding. The corresponding periods for steam winders had been taken as more than double. Then, again, if they took the figures for the maximum speed of the steam winder, the time for acceleration, a full speed run, and retardation, and worked them out, it would be found that the first steam winder in Mr. Mountain's fourth table, which was there said to be capable of winding from 500 yds., would only wind from 319 yds. The second winder would only wind from 350 yds. instead of 500 yds, and the third would only wind from 400 yds. instead of 700 yds. The time for changing trucks with electric winding was taken as very much longer than with the steam winder, which meant that the plant must be made correspondingly larger, which would run up the cost and make the comparison, in his opinion, unfair. In order to draw up what appeared to him to be a much fairer comparative table than Mr. Mountain's, he had taken Mr. Mountain's third case (700 yds. depth) and reduced the figures to Table C. The figures for the

**Table A.**—*Test of Electric Winding Engine at Zollern No. 2 Pit.*

The test was taken on November 25, 1904, and extended over 24 hours. The engine was winding at about half its full capacity from a depth of 200 yds. 2,423 tons of coal were wound in the two working shifts. At the changes of shifts 1,024 men were taken down and 1,007 men brought up; the weight of the men was averaged at 165 lb.

DISTRIBUTION OF POWER OVER THE SEPARATE SHIFTS.

| — | 6—2 Morning shift. | 2—3 Winding men. | 3—10 Noon shift. | 10—6 Night shift. |
|---|---|---|---|---|
| Total kw.-hours delivered by generating plant | 9,076·33 | 715·82 | 7,506·75 | 4,770·79 |
| Total steam consumption, lbs. | 168,250 | 14,110 | 137,520 | 97,465 |
| Steam consumption per kw.-hour | 18·536 | 19·71 | 18·318 | 20·43 |
| Kw.-hours absorbed by winder | 2,192·07 | 83·96 | 1,577·18 | 552·18 |
| Effective H.P. hours in shaft | 1,562·0 | 13·053 | 990·13 | 92·0 |
| Kw.-hours per effective H.P.-hour in shaft | 1·403 | 6·43 | 1·592 | 6·0 |
| Steam consumption per effective H.P.-hour in shaft in lbs. | 26·01 | 126·77 | 29·178 | 122·62 |

SUMMARY FOR THE 24 HOURS.

| | |
|---|---|
| Total kw.-hours delivered by generating plant | 22,069·69 |
| Total steam consumption | 417,345·0 lb. |
| Total steam consumption per kw.-hour | 18·91 lb. |
| Total kw.-hours absorbed by winder | 4,405·39 |
| Effective H.P.-hours in shaft | 2,657·183 |
| Kw.-hours per effective H.P.-hour in shaft | 1·657 |
| Steam consumption per effective H.P.-hour in shaft | 31·35 lb. |

The steam consumption was ascertained by weighing the water delivered to the boilers during the test.

**Table C.**—*Estimated Cost of Winding per 100 Tons with high-class coupled High-pressure Non-condensing Engines, steam pressure 150 lb., and with Electric Generating Plant and Siemens-Ilgner Winding Engine.*

| | STEAM WINDER—Case 3. | | | | ELECTRIC WINDER—Case 3. | | | |
|---|---|---|---|---|---|---|---|---|
| — | Coal at 3/6 per ton.* | Ditto corrected.* | Coal at 6/- per ton.* | Coal at 8/- per ton.* | Coal at 3/6 per ton.* | Siemens' proposal. | Coal at 6/- per ton.† | Coal at 8/- per ton.† |
| Coal, tons per day (8 hrs.) | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 |
| Depth of shaft ........yds. | 700 | 700 | 700 | 700 | 700 | 700 | 700 | 700 |
| No. of tubs | 6 | 6 | 6 | 6 | 8 | 8 | 8 | 8 |
| Wt. of set of tubs ......cwt. | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| Wt. of coal per wind ..tons | 4·5 | 4·5 | 4·5 | 4·5 | 4·8 | 5·0 | 5·0 | 5·0 |
| Winds per day | 445 | 445 | 445 | 445 | 417 | 400 | 400 | 400 |
| Diam. of cylinders | 35″ & 58″ | 35″ & 58″ | 35″ & 58″ | 35″ & 58″ | .. | .. | .. | .. |
| Stroke | 72″ | 72″ | 72″ | 72″ | .. | .. | .. | .. |
| Diam. of drum | 20 | 20 | 20 | 20 | 22 | 18 | 18 | 18 |
| Revs. per wind | 32·5 | 33·4 | 33·4 | 33·4 | .. | .. | .. | .. |
| Revs. of drum per min. | .. | .. | .. | .. | 49·5 | 53·0 | 53·0 | 53·0 |
| Diam. of winding rope | 1·67″‡ | 1·67″‡ | 1·67″‡ | 1·67″‡ | 2″ | 2″ | 2″ | 2″ |
| Wt. of rope ..........tons | 6 | 6 | 6 | 6 | 5·75§ | 5·75§ | 5·75§ | 5·75§ |
| Wt. of cages and slings..tons | 4·25 | 4·25 | 4·25 | 4·25 | 6·5 | 6·5 | 6·5 | 6·5 |
| Time of wind ........secs | 49·5 | 53·5 | 53·5 | 53·5 | 48 0 | 62·0 | 62·0 | 62·0 |
| Max. velocity....ft. per sec. | 68·0 | 46·39 | 46·39 | 46·39 | 57·0 | 50·0 | 50·0 | 50·0 |
| Period of max. velocity..secs. | 9·4 | 37·02 | 37·02 | 37·02 | 28·0 | 22 0 | 22·0 | 22·0 |
| Acceleration—Rate..ft. secs.² | 5·7 | 3·88 | 3·88 | 3·88 | 6·0 | 2·0 | 2·0 | 2·0 |
| ,, Period ..secs. | 11·96 | 11·96 | 11·96 | 11·96 | 9·5 | 25·0 | 25·0 | 25·0 |
| Retardation—Rate, ft. secs.² | 15·0 | 10·26 | 10·26 | 10·26 | 6·0 | 3·33 | 3·33 | 3 33 |
| ,, Period, secs. | 4·52 | 4·52 | 4·52 | 4·52 | 10 0 | 15·0 | 15·0 | 15·0 |
| Time of changing ....secs. | 11·2 | 11·2 | 11·2 | 11·2 | 20 0 | 10·0 | 10·0 | 10·0 |
| Steam pressure at boilers, lbs. per sq. in. | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 |
| Boilers—No. and size.... | 4 8′6″ × 30′ | 4 8′6″ × 30′ | 4 8′6″ × 30′ | 4 8′6″ × 30′ | 4 8′6″ × 30′ | 2 9′ × 30′ | 2 9′ × 30′ | 2 9′ × 30′ |
| Coal burnt per day ....tons | 13·0 | 20·0 | 20·0 | 20·0 | 10·2 | 8·0 | 8·0 | 8·0 |
| Per cent. burnt to wound | 0·65 | 1·0 | 1·0 | 1·0 | 0·51 | 0·4 | 0·4 | 0·4 |
| Price of coal per ton | 3/6 | 3/6 | 6/0 | 8/0 | 3/6 | 3/6 | 6/0 | 8/0 |
| Cost of coal per 100 tons | 2/3¼ | 3/6 | 6/0 | 8/0 | 1/9½ | 1/4¾ | 2/5 | 3/2½ |
| Wages of men per shift:— | | | | | | | | |
| Winders | 6/0 | 6/0 | 6/0 | 6/0 | 6/0 | 6/0 | 6/0 | 6/0 |
| Stokers and ashman | 12/6 | 12/6 | 12/6 | 12/6 | 8/4 | 8/4 | 8/4 | 8/4 |
| Attendant | .. | .. | .. | .. | 6/0 | 6/0 | 6/0 | 6/0 |
| Wages per 100 tons wound:— | | | | | | | | |
| Winders | 0/3½ | 0/3½ | 0/3½ | 0/3½ | 0/3½ | 0/3½ | 0/3½ | 0/3½ |
| Stokers and ashman | 0/7½ | 0/7½ | 0/7½ | 0/7½ | 0/5 | 0/5 | 0 5 | 0/5 |
| Attendant | .. | .. | .. | .. | 0/3½ | 0/3½ | 0/3½ | 0/3½ |
| Total wages per 100 tons | 0/11 | 0/11 | 0/11 | 0/11 | 1/0 | 1/0 | 1/0 | 1/0 |
| Oil and stores per 100 tons | 0/3 | 0/3 | 0/3 | 0/3 | 0/3 | 0/3 | 0/3 | 0/3 |
| Working days per year | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 |
| Cost of engine, incl. erection £ | 6,500 | 6,500 | 6,500 | 6,500 | .. | .. | .. | .. |
| Price of winding plant....£ | .. | .. | .. | .. | 14,200 | 9,000 | 9,000 | 9,000 |
| ,, generating plant £ | .. | .. | .. | .. | 5,500 | 3,000 | 3,000 | 3,000 |
| ,, boilers, &c.......£ | 3,000 | 3,000 | 3,000 | 3,000 | 3,600 | 2,000 | 2,000 | 2,000 |
| Max. H.P. at drum | .. | .. | .. | .. | 3,324 | 1,700 | 1,700 | 1,700 |
| Steady running H.P. | .. | .. | .. | .. | 1,000 | 910 | 910 | 910 |
| Kw. at generator | .. | .. | .. | .. | 800 | 680 | 680 | 680 |
| Weight of flywheel ....tons | .. | .. | .. | .. | 67 | 28 | 28 | 28 |
| Revs. per min. of flywheel | .. | .. | .. | .. | 300 | 465 | 465 | 465 |
| Interest & depreciation on:— | | | | | | | | |
| Winding plant—Per an. at 10 % ..........£ | 650 | 650 | 650 | 650 | 1,420 | 900 | 900 | 900 |
| Ditto—Per day ........£ | 2/12/0 | 2/12/0 | 2/12/0 | 2/12/0 | 5/13/6 | 3/12/0 | 3/12/0 | 3/12/0 |
| Ditto—Per 100 tons | 2/7¼ | 2/7¼ | 2/7¼ | 2/7¼ | 5/8 | 3/7 | 3/7 | 3/7 |
| Generating plant—Per an. at 10 % ..........£ | .. | .. | .. | .. | 550 | 300 | 300 | 300 |
| Ditto—Per day ........£ | .. | .. | .. | .. | 2/4/0 | 1/4/0 | 1/4/0 | 1/4/0 |
| Ditto—Per 100 tons | .. | .. | .. | .. | 2/3 | 1/2½ | 1/2½ | 1/2½ |
| Boilers—Per an. at 10% £ | 300 | 300 | 300 | 300 | 360 | 200 | 200 | 200 |
| Ditto— Per day ......£ | 1/4/0 | 1/4/0 | 1/4/0 | 1/4/0 | 1/8/10 | 16/0 | 16/0 | 16/0 |
| Ditto— Per 100 tons | 1/2 | 1/2 | 1/2 | 1/2 | 1/5½ | 0/9½ | 0/9½ | 0/9½ |
| Total cost per 100 tons without interest & depreciation | 3/5¼ | 4/8 | 7/2 | 9/2 | 3/0½ | 2/7¾ | 3/8 | 4/5½ |
| Total cost per 100 tons with interest and depreciation | 7/2½ | 8/5¼ | 10/11¼ | 12/11¼ | 12/5 | 8/2¾ | 9/3 | 10/0½ |
| Effective H.P.-hours in shaft per day | 4,752 | .. | .. | .. | 4,752 | .. | .. | .. |

* Mr. Mountain's figures. † Siemens' proposal. ‡ Locked coil. § Balanced

steam winder had been left unchanged, with the exception of the amount of coal burned. Mr. Mountain had given 13 tons, but if they took the same evaporative capacity that Mr. Mountain had assumed for electric winding—viz., 7 lb. of steam per pound of coal, that figure would rise to about 19 or 20 tons. The result of his calculations were a good deal different from Mr. Mountain's, and the results were again set out in the diagrams below. Diagram D showed, by the full line, the cost of winding with steam with different costs of coal. The dotted line showed the corresponding cost of winding with electricity, and the two curves crossed at about 3s. He had worked out diagram E in order to have another check. This represented an electric winder which was of the same capacity as that at the Hulton colliery. He chose this because Mr. Mountain had stated that his figures represented actual tests. It would be seen that the curves crossed at the same point—viz., 3s. The curves were rather interesting, because it was obvious that the deeper the wind the more inclined the curve would be. If a horizontal line were drawn for the intersection of the straight lines with the zero line on the left, the ordinates of that horizontal line would represent the fixed charges and labour, and the ordinates above that line to the diagonal line would represent the cost of coal per 100 tons wound. Obviously, with deep shafts, that cost went up. There was no time for him to go into the many subsidiary reasons which, in most cases, would form additional arguments for electric winding, but he had tried to make the comparison exactly as indicated by Mr. Mountain and to make it as fair as possible. If he had erred, it was in choosing some figures for steam winding which were more favourable than would be the case in actual practice. He might mention that although diagram D was prepared independently, it would be found that Mr. Hooghwinkel's cost of winding at De Wendel (which was a plant corresponding in size) dropped right on the dotted line. It seemed to him that the errors in some of Mr. Mountain's tables did not lead them to place over-much reliance upon the reliability of the remaining figures, but if they studied the Paper carefully in conjunction with the data which he (the speaker) had placed before them, they would find conclusive evidence of the fallacy of Mr. Mountain's deductions.

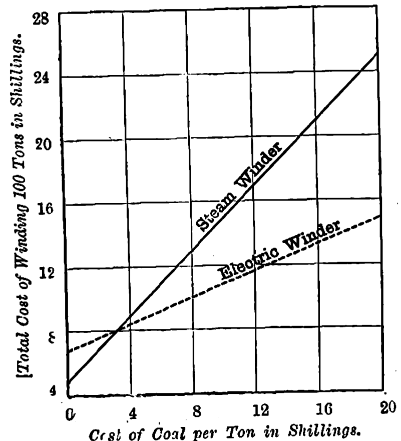

Diagram D.—Engine Winding 2,000 Tons of Coal in 8 Hours from a Depth of 700 yds.

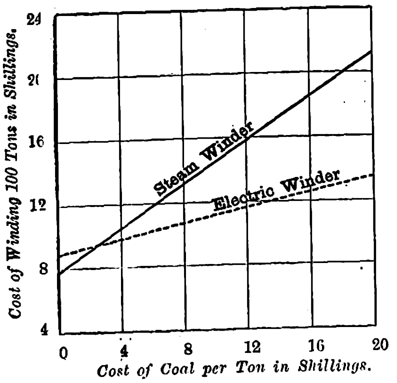

Diagram E.—Engine Winding 567 Tons of Coal in 7½ Hours from a Depth of 312 yds.

Mr. G. S. RAM (Electrical Inspector of Factories) dealt more particularly with Mr. Sparks' Paper from the point of view of safety. Mr. Sparks had drawn special attention to the fact that he had devised his scheme before the Home Office rules were drawn up. In one respect he thought Mr. Sparks had gone one better than the mining rules, at any rate in regard to the earthing and metal work below ground, controller cases, switch covers, motor frames, &c. There was always a difficulty in knowing how this should be done. Mr. Sparks had got over it by running earthed cables right down the shaft and along the roadway. The importance of having cases, &c., earthed was very often overlooked. It was not realised that the conditions in a mine were such that if a man got a shock at all he was likely to get a very bad one, even with low pressure. In a case which he investigated last year a man was killed under conditions which might occur in any mine, by 230 volts continuous current. He was coming out of the mine along one of the main roadways without any clothes on his back. In order to pass some trucks he had to squeeze against the wall, and in doing so pressed his back against an armoured cable. It so happened that the armouring was alive, and the man was killed. The usual excuse was made that the man must have had a weak heart, but the post mortem in this case showed that the man had a very good heart. Mr. Sparks had not told them how he earthed the other end of his earthed cable, and this was a matter upon which very different opinions were held. He was at a colliery a fortnight ago where a sub-station was being built and earth plates were actually being put in whilst he was there. There were three of them, 3 ft. square by ¼ in. thick, of galvanised iron, and the hole was filled in with a mixture of earth and coke. This appeared to be a very good job. On the other hand, at another colliery, he did not like the look of the earth connection, and on giving it a small pull the earth plate, which was only 7½ in. square, buried 6 in. below the ground, in perfectly dry earth, came out. With regard to overhead transmission he gathered from Mr. Sparks' Paper that the cradles which were used were intended to catch a broken wire and to keep it off the ground. In other cases, however, where there was a catcher, he took it that this was intended to earth the wire if it broke; but it was not clear from the illustration how this catcher was earthed. If it was only earthed to the barbed wire on the posts in the ground, the barbs were quite unnecessary. In one of the power schemes which was using steel poles, there was an earthed wire carried from pole to pole, which was a very good plan. With regard to generating stations there was one point which Mr. Sparks had given attention to which was very useful, and that was that if part of the apparatus went wrong, he was able to withdraw a panel out of contact with any live metal and repair it in a safe way. But although this was very good so far as it went, he did not quite see from the drawings how repairs could be made in the 'bus bars in a similar way. If the same idea could also be carried out in the sub-stations, it would be useful, for this point was frequently overlooked in this connection. At one colliery sub-station that he knew of, the switchboard was encased entirely in expanded metal. It was perfectly safe to work in ordinary practice, but as soon as anything went wrong with the expanded screen nothing whatever could be done without shutting the whole place down. Another elementary point had been overlooked in the same installation. They had taken three separate cables at 2,000 volts down the shaft, with the idea of having two spares, but they had spoilt the arrangement by converting all three cables up to the same switch. These were small points in a way, but were extremely important in colliery working.

Mr. A. F. STEVENSON (St. Helens Cable Co.) dealt first of all with the use of high-tension cable in pits, a question which was raised in Mr. Sparks' Paper. He thought this dangerous, as the man in charge might remove the earth connection to make the plant work all right. All that was gained by using earthed high-tension cable was a few hundred pounds on the plant, and against this there was the increased liability to breakdown and the increased risk to life. He had had many experiences himself of recklessness in pits, in spite of the Home Office rules. For instance, sometimes they only used the leakage indicators with the switch on the first stop only, as the needle swung right over with the switch on the second stop. When he had asked what they were doing about it, they had answered "Nothing," and then he would ask if the men got any shocks, and the answer would be "Yes, but it doesn't hurt them!" In another case he had known indicators to be put on the board just for the satisfaction of the inspectors, but they were not connected up. Even when there was a first-class firm doing the work in a colliery with full specifications as to earthing and so on it was very often found that vital points in the connecting up of the cases of the motors and so on were neglected. With regard to the cables used in the Powell-Duffryn pits, as far as the underground work was concerned, he believed that many people who had done cable work in collieries would agree that paper cables were not very suitable, especially where the lead covering was in the neighbourhood of water, which had a very bad effect on the lead covering, and very often in such circumstances would not last 12 months. Although paper cables were used in many cases, he knew of instances in which oil had run down the cable and produced such a hydrostatic head that the lead covering had been ripped open in one case, and in another case the lid of a switch box was broken. He advocated the use of three single cables with metallic covering encased in wood which enabled shafts of 600 yds. to be dealt with without any joints. The latter was a serious cause of trouble, especially where there was water pouring down the shaft all the time.

**The Royal Society.**—Among the Papers read yesterday were the following: "On Retardation of the Discharge of an Electroscope by means of certain Radio-active and other Substances," by Dr. W. S. Lazarus-Barlow. Communicated by Sir William Ramsay, F.R.S.: "On a Mineral, which retards the Rate of Discharge of an Electroscope," by Dr. E. H. Büchner. Communicated by Sir William Ramsay, F.R.S.: "On a New Method of Obtaining Continuous Currents from a Magnetic Detector of the Self-Restoring Type," by L. H. Walter. Communicated by Prof. Ewing, F.R.S.: "On the Distribution of Radium in the Earth's Crust, and on the Earth's Internal Heat," by the Hon. R. J. Strutt, F.R.S.

## FLUX-DISTRIBUTION IN MACHINES WITH COMMUTATING POLES.

BY THOMAS F. WALL AND STANLEY P. SMITH.

The experiments described in this Paper were carried out at the instigation of Prof. E. Arnold at the Technische Hochschule, Karlsruhe. The machine used was of the bi-polar type, provided with two commutating poles, A and B, Fig. 1, and designed for 110 volts at 42 amperes. It was desired to investigate the distribution of flux due to, first, a single commutating pole and, secondly, both commutating poles together, when the main poles were fully excited. The various effects are first theoretically considered, and the experimental results are given in the latter part of the Paper. Taking the case of only one commutating pole, A, on the machine, let us suppose the main poles were unexcited and a current sent through the coil of the commutating pole. The result would be, if the pole were symmetrical with regard to the main poles, that the flux produced would pass through the commutating pole into the armature and divide equally between the two main poles, completing its circuit through the yoke.

Now, suppose the commutating pole were unexcited and the two main poles excited. The flux produced would, again supposing symmetry of the system, pass from the main N-pole through the armature and into the main S-pole, none going through the commutating pole. This can be seen by a moment's consideration. The main N-pole tends to send a flux through the armature, commutating pole and back into itself, but the main S-pole likewise tends to send an equal flux, but in the opposite direction, with the result that no flux passes through the commutating pole.

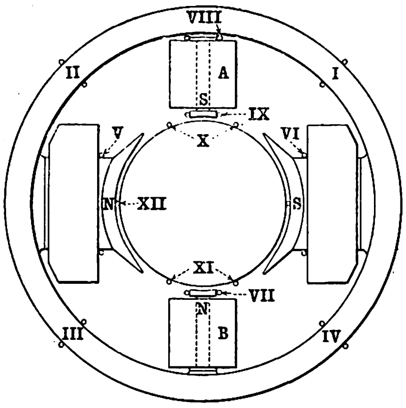

Fig. 1.—Showing the Position of the Search Coils.

Consider, next, what would happen when both the main poles and the commutating pole are excited together. The resultant flux would be obtained by superposing the two individual effects, and hence one would expect a strengthening of one main pole and a weakening of the other.

Passing on now to the case when both commutating poles are used. By the same reasoning as above, if the commutating poles were alone excited the flux would simply pass through the armature yoke, none of it going through the main poles; and in exactly the same way, if the main poles were excited and the commutating poles unexcited no flux whatever would go through the latter. Hence, if both sets of poles were simultaneously excited the result should be a superposition of the two fields—that is, each field would act as if the other were absent.

The flux-distribution was explored by means of a number of search coils wound on the poles, yoke and armature of the machine, as shown in Fig. 1. The obvious method of examining the flux due to the commutating poles would be to keep the main poles excited, and by making or breaking the circuit of the commutating poles to find the throw on a ballistic galvanometer given by the various search coils. This was the method used in the case when both commutating poles were present. When, however, only one commutating pole was used, the method had to be somewhat modified, since the flux due to it threads the main pole coils as well as the search coils. Hence, when the circuit is broken the flux would cut both main pole, field coil and search coil, and the E.M.F. thus induced in the main pole coil would react on the search coil and give a false reading (since the main pole circuit is always closed through its battery). Of course, when both the commutating poles were used this precaution was unnecessary, as none of the commutating pole flux passes through the main poles. The method adopted in this case was as follows: The commutating pole circuit and main pole circuit were connected with two separate batteries, and a switch was used which would break the two circuits simultaneously. The readings of the galvanometer then gave the resultant flux distribution due to both sets of poles. Another experiment was then made by having the commutating pole unexcited and breaking the main pole circuit. The readings thus obtained gave the distribution due to the main poles, and by subtracting the two sets of readings the flux distribution due to the commutating pole was obtained.

The galvanometer used was rather sensitive, and its period of swing was 35 seconds. Some trouble was experienced with earth currents and externally-induced currents, and to get the galvanometer to work satisfactorily it was found necessary to thoroughly insulate it from earth currents and to perform the experiments by night to avoid induced currents.

To test the symmetry of the magnet system with only one commutating pole in action the main pole coils were excited, and it was found that practically no flux went through the commutating pole when it was midway between the two main poles.

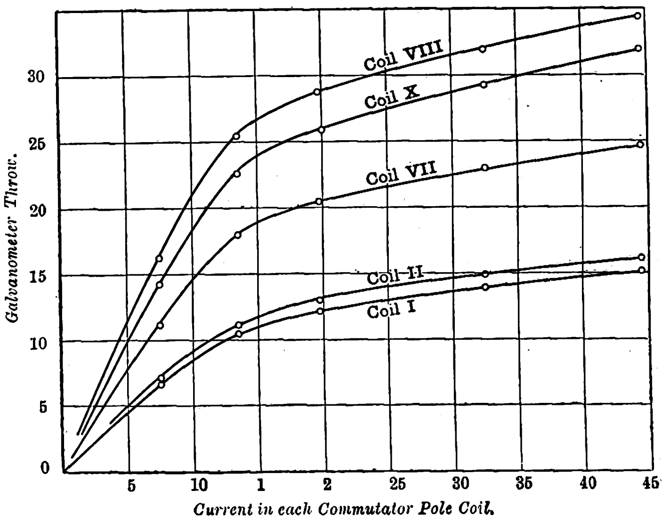

Fig. 2.

Also with two commutating poles in action a current was sent through the main pole coils and no appreciable flux was found to go through either of the commutating poles when they were diametrically opposite and midway between the main poles. A current was then sent through the commutating pole coils and it was found that none of the flux thus produced went through the main poles.

These observations proved conclusively that the whole system was symmetrical.

Coming now to the experiments to determine the flux-distribution, Experiment I. was performed to find the flux-distribution due to one commutating pole, the other being entirely removed. These results are shown in Tables I. and II. It is seen that the flux due to the commutating pole, as given by coil VIII., is greater than that which enters the armature, thus showing considerable leakage between the pole and the yoke. This is accounted for by the fact that the commutating pole was worked at a high saturation. It is, moreover, clearly shown from Table II. that the flux distributes itself uniformly between the two main poles. Thus the flux due to the commutating pole is the same in coil I. and coil II. for both values of the current. There is, moreover, some disturbance of the flux in coils III. and IV., which appears to be due to the fact that some of the flux from the main poles is pressed from the upper half to the lower half of the yoke. That some such complex effect does take place is indicated by the fact that the sum of the commutating pole fluxes which enter the main poles, as given by coils V. and VI., is

**Table I.**

*Experiments* Iᴀ *and* Iʙ.—Commutating Pole A and Main Pole Circuits broken together.

*Experiment* Iᴄ.—Commutating Pole A Circuit open. Main Field Circuit broken.

Commutating Pole B removed throughout.

| Experiment. | Current in commutator, pole coil A. | Coil I. | Coil II. | Coil III. | Coil IV. | Coil V. |
|---|---|---|---|---|---|---|
| Iᴀ | 47 amperes .............. | 14·9 | 17·6 | 16·7 | 16·7 | 33·6 |
| Iʙ | 24·5 amperes.............. | 15·2 | 17·3 | 16·7 | 16·7 | 33·4 |
| Iᴄ | Commutator pole circuit open | 16·4 | 16·1 | 17·2 | 16·4 | 33·0 |

| Experiment. | Current in commutator, pole coil A. | Coil VI. | Coil VIII. | Coil IX. | Coil X. | Coil XII. |
|---|---|---|---|---|---|---|
| Iᴀ | 47 amperes .............. | 31·7 | 3·1 | 2·3 | 2·8 | 2·1 |
| Iʙ | 24·5 amperes.............. | 31·7 | 2·6 | 1·9 | 2·25 | 1·8 |
| Iᴄ | Commutator pole circuit open | 32·6 | 0 | 0 | -0·01 | 0·6 |

**Table II.**—*Showing the Distribution of the Flux due to the Commutating Pole. Derived from Table* I. *by subtracting the Readings of Experiment* Iᴄ *from those of Experiments* Iᴀ *and* Iʙ.

| Current in commutator pole coil. | Coil I. | Coil II. | Coil III. | Coil IV. | Coil V. | Coil VI. | Coil VIII | Coil IX. | Coil X. | Coil XII. |
|---|---|---|---|---|---|---|---|---|---|---|
| 47 amperes .......... | 1·5 | 1·5 | 0·5 | 0·3 | 0·6 | 0·9 | 3·1 | 2·3 | 2·7 | 1·5 |
| 24·5 amperes ........ | 1·2 | 1·2 | 0·5 | 0·3 | 0·4 | 0·9 | 2·6 | 1·9 | 2·15 | 1·2 |

**Table III.**—*Showing the Throw on the Galvanometer given by the various Search Coils when both Commutator Poles are excited.*

| Cur. in each commut'r pole coil. | Coil. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I. | II. | III. | IV. | V. | VI. | VII. | VIII. | IX. | X. | XI. | XII. |
| 7·5 amps | 6·6 | 7·1 | 6·7 | 6·3 | 0·2 | 0·2 | 11·05 | 16·2 | 11·7 | 14·2 | 13·5 | 14·2 |
| 13·5 ,, | 10·45 | 11·15 | 10·7 | 10·25 | 0·2 | 0·2 | 17·8 | 25·45 | 18·25 | 22 5 | 21·6 | 22·7 |
| 19·75 ,, | 12·1 | 12·8 | 12·5 | 11·7 | 0·2 | 0·2 | 20·4 | 28·6 | 20·9 | 25·8 | 24·9 | 26·0 |
| 33·5 ,, | 13·75 | 14·8 | 14·5 | 13·45 | 0·2 | 0·2 | 22·9 | 31·8 | 23·4 | 29·2 | 28·4 | 29·9 |
| 44·5 ,, | 15·05 | 16·1 | 15·6 | 14·5 | 0·1 | 0·2 | 24·6 | 34·3 | 24·8 | 31·8 | 31·25 | 32·9 |

not the same as that which enters the armature as given by coil X. Moreover, coil XII. also gives a considerable throw on the galvanometer.

The results of Experiment II.—*i.e.*, when both commutating poles are used—are shown in Table III. and Fig. 2. These show that the fields due to the commutating poles and main poles exist independently of one another, each being the same as it would be if the other were absent. The curves for the coils X., XI. and XII. practically coincide, as also do the curves for the coils VII. and IX. and for the coils I., II., III. and IV. The difference of the ordinates for the curves VIII. and X. show the amount of leakage into the yoke. The difference of the ordinates for the curves IX. and X. seem to show the leakage from the sides of the commutating pole into the armature.

## RECENT EXTENSIONS AT THE MANCHESTER ELECTRICITY WORKS.

(*Continued from page 958.*)

The latest additions to the generating plant at the Dickinson-street station are two 750 kw. Parsons-Siemens continuous-current turbo-units. Messrs. C. A. Parsons & Co. supplied the steam turbines for these and Messrs. Siemens Bros. & Co. the generators. The latter are four-pole machines with auxiliary "commutating" poles and have a series winding in addition to the shunt winding, so that they may be used on the lighting or traction circuits. As shunt machines they supply 1,870 to 1,670 amperes at 400 to 450 volts, and as compound machines 0 to 1,360 amperes at 500 to 550 volts. The speed is 1,600 revs. per min.

As will be seen from Fig. 6, which shows the machine in end elevation and part section, the armature stampings are mounted directly on the shaft, without any separate core centre. The core is divided into six equal sections by means of five ventilating ducts ¼ in. wide, to which the air is supplied through axial channels formed by holes stamped in the plates, the radial vents being made by spacing the plates by brass distance pieces. The winding is retained in the slots by means of fibre wedges, fitted into notches at the top of the teeth, and no binding wire is employed. Bronze core ends support the bent portions of the coils, which are retained in position by substantial coned shields of manganese bronze, carefully machined all over.

In accordance with the usual practice in turbo-machines, the copper bars are held in against the great centrifugal force by steel rings shrunk on, and insulated from the copper by thick rings of mica. Carbon brushes are used, and the commutation is good. There is, however, a tendency to flash over at the brushes, which Messrs. Siemens are sanguine of overcoming by the use of a new design of brush gear and by the addition of insulating shields.

The magnet yoke is of cast iron, split approximately horizontally to allow of the armature being readily taken out. This departure from the horizontal is necessitated by the position of the auxiliary poles, as seen in the illustration. The main poles, which are laminated, are bolted to the yoke, and the pole shoes consist of iron castings embracing the stampings, and secured to them by rivets.

The auxiliary poles belong to an entirely distinct magnetic system, as shown in the drawing, comprising a separate yoke and four poles. This yoke is made up in two rings, rather less in diameter than the main yoke, and the poles, which have the same length, measured along the axis of the machine, as the main poles, and are, of course, laminated, project into the space between the main poles. They are excited by a winding in series with the armature, so designed as to give a reversing field of correct strength for commutation. The commutation magnetic system is not saturated, and therefore the flux is practically proportional to the load on the machine, and no change in position of brushes is required for varying loads.

The field coils, both on the main and auxiliary poles, are former-wound and heavily insulated with tape. A diverter is provided, by means of which a portion of the main current flowing round the commutation poles can be shunted, so that a certain amount of adjustment can be made of the relative strength of the commutating flux to ensure the best results.

Each of the turbo-units has its own condenser, as have also the two 1,800 Parsons-Parsons sets which have been running since 1903. It will be remembered that there has been considerable trouble at the commutators of these latter machines, and that the consumption of brushes due to sparking was considerable. To one of the machines was therefore added last autumn a compensating winding which removed the trouble entirely, and the other Parsons machine will be treated in a similar manner.

The high-tension switch gear at the Dickinson-street station is, in accordance with modern practice, of the hand-operated remote-controlled type, and has been supplied by the Westinghouse Co. Two feeders come in from the Stuart-street station, and pass through tail boxes in the usual way, whence they are connected by the feeder switches through current transformers to the 'bus bars. There are two sets of 'bus bars, and a selector plug arrangement is provided so that the feeder or motor of the converter can be connected to either set. The tripping coils of the feeder switches are controlled by a reverse-current relay, and of the machine switches by an overload time-limit relay usually set at three seconds. The switches, 'bus bars, instrument transformers and isolating plugs are placed in a locked brick chamber at a corner of the engine-room floor, and the levers controlling the switches, together with the instruments, are on a gallery above. On this gallery are also the main continuous-current lighting and traction 'bus bars, and the continuous-current generator and feeder totalising panels, as well as a panel to which the mains from the adjoining Bloom-street station are brought.

The five-wire network (at 5 × 100 volts) has been retained in the central part of the area, but all the outer area is on the 2 × 200 volt three-wire system. The neutral wire is earthed through the shunt of a recording ammeter and blow-out circuit-breaker, which cuts in a resistance if necessary. At the time of our visit (noon on a bright day) the record of this ammeter was about 15 amperes, and its minimum reading representing the unbalanced leakage from the network, is about 10 amperes. The feeders to the various districts are dealt with at a line of simple panels on the engine-room floor level, and they are connected there to three totalising panels on the new switchboard on the gallery.

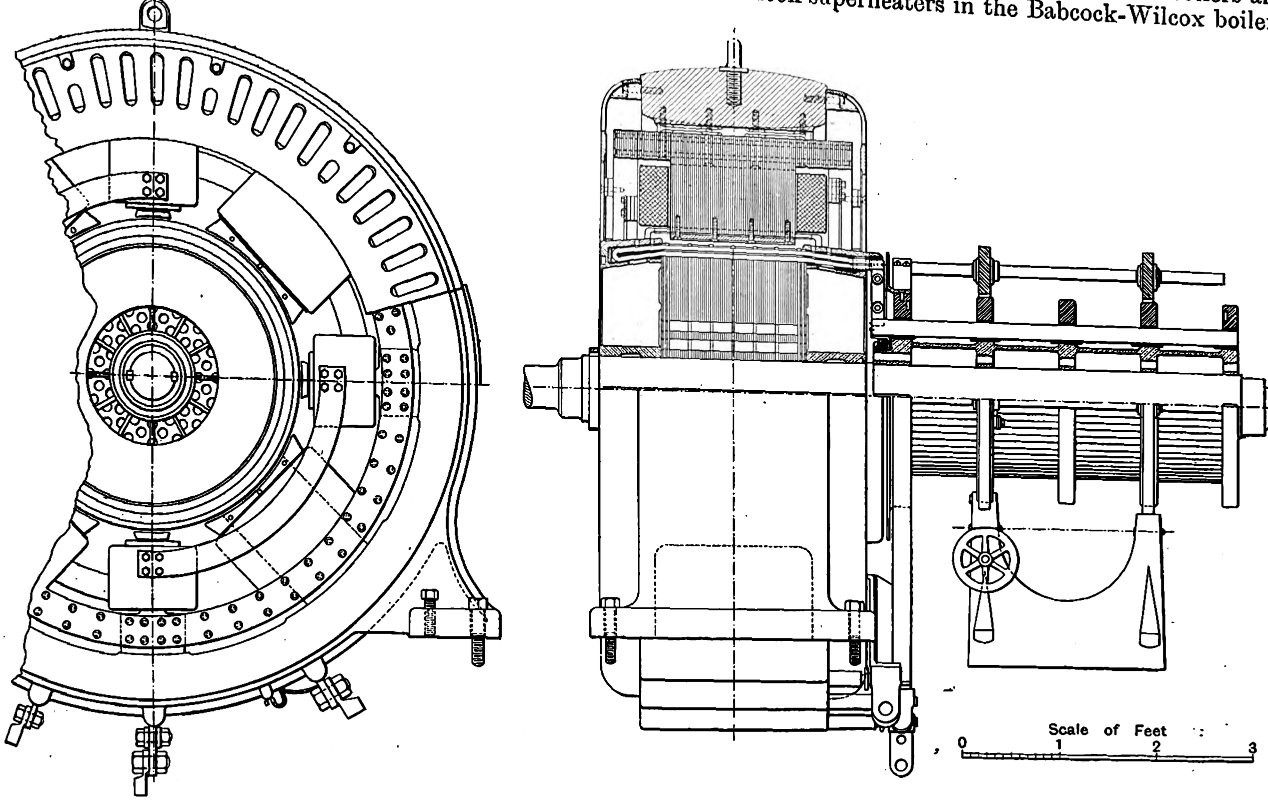

Fig. 6.—750 kw. Siemens Continuous-current Generator for Turbine Drive with Commutating Poles. Speed 1,600 Revs. per Min.

As the new generators all supply current at 400 to 500 volts, balancing transformers are necessary, and those for the five-wire system are doubly wound. Two machines of this nature are in use. One of these, an E.C.C. machine, has been running for some years, and supplies 150 amperes out of balance current, and the second a 250 ampere machine by the General Electric Co. is a recent addition. This machine is also guaranteed to give 500 amperes for a quarter of an hour without overheating. Except for its four commutators, the machine resembles externally an ordinary balancer—that is, there are two machines on the same bedplate, with coupled shafts. The armature of each machine, however, has two windings superposed in the same slots, and each of these is connected to its commutator, and thence to a 100 volt leg of the 5 × 100 volt three-wire system. The two fields are connected in series across the 400 volt outers.

The pipe range and boiler-house has also undergone a general overhaul recently, the chief alteration having been the addition of Galloway superheaters in the Lancashire boilers and Babcock-Wilcox superheaters in the Babcock-Wilcox boilers.

In the Bloom-street station there are four 1,800 kw. sets, but as this station has been described in our columns recently* there is no need to return to it now.

(*To be continued.*)

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* *The Electrician*, Vol. L., pp. 672 and 715.

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## ECONOMIC CONSIDERATIONS IN THE EMPLOYMENT OF STORAGE BATTERIES.*

BY J. R. SALTER.

In the attempts which have been made to prove the advantages which are obtained from its use, it has been usual to compare the cost of the battery with that of steam raising plant. Such a comparison is not, to the author's mind, a valid one, and is to be deprecated. The battery does not *generate* electricity, and is obviously incapable of maintaining a continuous output. It is nothing more than a transforming device, and the comparison of its cost should not be made with steam raising plant, but with other transforming devices, such as static transformers, motor generators, or rotary converters. That this is so is apparent, since in arriving at the cost of the battery a time element is introduced, and this factor is absent in dealing with the cost of the generating plant. It is generally stated that the cost per kilowatt of a battery is equivalent to the cost of steam and electrical plant, based upon the assumption that the battery is discharged at a three hour rate. Why this particular rate of discharge should be chosen it is difficult to understand.

It may, however, be contended that the ability of the battery to store energy, which may be utilised when required, is, at any rate, a sufficient justification for regarding it as generating plant of a capacity equal to the difference between the maximum load which the plant is capable of supplying and the maximum output which the station is called upon to supply, but I venture to think that this claim cannot be substantiated. It depends essentially upon the rated capacity of the generating plant and upon the relative capacity of the units for dealing with the changing loads during the various portions of the day. If it be conceded that the capacity of a generating plant is its capacity at its maximum efficiency, and that such plant can be designed with 100 per cent. overloading capacity for short periods (but, of course, with lower efficiency), then there is no doubt that any reasonable-sized battery, such as one would instal in any particular system, could not be regarded as possessing the modified advantage of part of the generating plant. It is clear, therefore, that the capital cost of the battery cannot even be justified on the ground that it is an addition to the generating plant.

In modern practice there is, as is well known, little or no time in which to shut down a station supplying an electric tramway system; certainly there is not sufficient time to enable the station to be run with a shift less. The tramway load is generally required for 20 hours in the day, and it is practically impossible to run such a station with two shifts. The third shift being essential, there is no reason why it should not be fully utilised, and this remark applies whether the battery is installed in the power station or in the sub-station. It is claimed that the battery is a great source of security in the case of a breakdown in the generating plant, but is this really so? As a matter of fact, to be of any great utility for such a purpose the capacity of the battery would have to be enormous, so great, indeed, that the author thinks there can be no question that the capital cost entailed for a battery to fulfil such conditions would not be justified; and even if the capital cost were not so great, have we not arrived at a stage when generating plant can be considered reliable enough to justify the assumption that nothing short of a catastrophe would involve a breakdown of such a character as to altogether stop the supply? I know of several large power stations operating tramway systems which have never been shut down through defects in the plant, and, with the exception of the Manchester and Bristol stations, I can call to mind no case of a large power supply or tramway generating station which has ceased supply from such a cause. It will, of course, be appreciated that the author's remarks in connection with this section apply to traction and power schemes, and that he does not wish it to be thought that he considers that the battery does not still possess considerable advantage in the direction of auxiliary supply in small lighting stations. The next and probably the most important advantage which is claimed for the battery is the improvement which it gives to the load factor.

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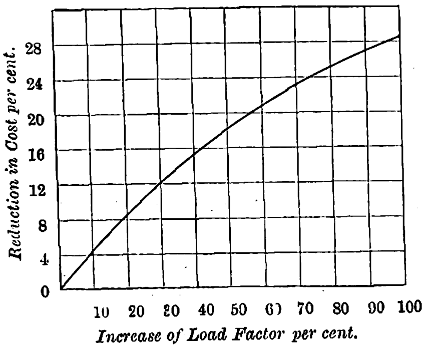
* Abstract of a Paper read before the Manchester Local Section of the Institution of Electrical Engineers, March 13th.

Some improvement in the load factor is due to the fact that with batteries the generating plant in a given time has not only to supply the useful units in a supply, but has also to supply the units which are lost in the battery; and as the total annual steam consumption is made of two terms, the first dependent upon the number of hours the set is run, and the second dependent only upon the number of units generated, the cost of fuel per unit generated is bound to be less, owing to the greater number of units generated, and which are lost in the battery; but it will be apparent that the cost per unit usefully supplied will not be so largely affected. That the loss in batteries is considerable, there will, the author thinks, be no dispute. In a case which recently came under his notice, a battery at the end of three years had only some 55 per cent of its original capacity. If in tramway and power stations the capacity of the steam generators is assumed at its rated capacity, and the overloading capacity is regarded as equivalent to the battery, then the load factor and the annual steam consumption should not exceed the load factor and steam consumption of the sets which the advocates of batteries assume for their purpose to be installed for a given set of conditions. In other words, the author claims that with a properly designed station, the proper method of arriving at the load factor is to take it upon the rated capacity of the set and not upon the maximum load for any given moment.



CURVE SHOWING REDUCTION IN COST PER INCREASE OF LOAD FACTOR.

Let us, however, assume that the load factor *is* improved by the utilisation of storage batteries, and then let us see to what extent the costs of generation are affected. The curve shows the percentage reduction in the costs of generation at various load factors. From this it will be seen that an improvement in the load factor of 33 per cent., that is, from a 10 to a 13·3 per cent. load factor, only reduces the costs by 8 per cent.; to what extent it is claimed that the battery does actually improve the load factor, the author has been unable to ascertain, but in a Paper read before the Institution of Civil Engineers, by Mr. J. F. C. Snell, that gentleman claims by the adoption of storage batteries to have increased his load factor from 45 to 53 per cent. With this improvement, the reduction in the costs are only 3 per cent., and the author suggests that this 3 per cent. improvement in the works costs is largely obtained by the extra units generated and which are lost in the battery.

The third advantage which is generally claimed for the installation of batteries is the saving in feeders, and it is suggested that to obtain this advantage, the battery should be placed in sub-stations at distant points. It is claimed, therefore, that it would be possible to utilise feeders of smaller sectional area, capable only of carrying the average current supply instead of the maximum. In the first place, it should be observed that the installation of batteries at sub-stations or feeding points to effect a saving in the cost of feeders does not affect the load factor at the power station. It should further be borne in mind that the only saving, so far as the feeders are concerned, by the installation of batteries in sub-stations is the saving in copper.

The other main advantage claimed for the battery is the constancy of pressure at the generating station, or the feeding point; but the author contends that there is no special advantage in constancy of pressure at any one part of the system, if the pressure is fluctuating over the other parts of the system.

After, therefore, analysing in a general way the advantages which are claimed for the utilisation of batteries, it would appear that the only real advantage which exists is an improvement in the load factor, and which improvement only slightly affects the cost of production. It should further be remembered that the reduction in the cost is a reduction per unit, and may not necessarily mean an actual reduction in the total costs for giving a definite supply; that is to say, inasmuch as the generator has to supply units which are wasted in the battery, and is more or less evenly loaded, the load factor of the generating set is increased, and the number of units generated greater than if a battery were not installed. The curve shows that the reduction in the cost of generation with a 33 per cent. improvement in the load factor is only 8 per cent., and that as the load factors are increased, the improvement due to the introduction of batteries reckoned as a percentage decreases to a point which becomes almost insignificant. Upon general grounds, therefore, the author is led to the conclusion that in moderate-sized stations the advantages to be obtained from the use of batteries are not justified by the capital charges involved; and it may be well now to give some actual results in connection with two stations in which he is interested.

In the first station, which supplies current to a tramway system operating an average of 28 cars per day, and which in addition supplies approximately 1,000,000 units per annum for power purposes and for street lighting, the plant consists of two 500 kw. two-phase alternators, one 500 kw. direct-current generator, and a battery having a capacity of 265 amperes for six hours. In addition to this, there is installed a motor-generator of a capacity of 250 kw. for converting from alternating to direct current. The generating sets have in each case an overloading capacity of 50 per cent., and the average steam consumption on test was found to be 21·22 lb. per kilowatt hour at full load; 23·423 lb. at three-quarter load; and 25·22 lb. at half load. From time to time tests have been made on the plant running under varying conditions, and the following results have been obtained. The duration of the first test was 31 days: during 26 days the station was run without the battery, the direct-current machine being compounded, and during five days the station was run with the battery, the total output during the whole period being 196,448 units. The second test also covered a period of 31 days, the total output being 195,510 units, and the plant being run for 26 days with the battery and five days without the battery. The costs of operation under these conditions were as follows:—

| | Test (1) without battery. Cost per unit generated. | | Test (2) with battery. Cost per unit generated. |
|---|---|---|---|
| | d. | | d. |
| Coal ................. | 0·187 | ............ | 0·147 |
| Water ................ | 0·032 | ............ | 0 032 |
| Oil.................... | 0·029 | ............ | 0·017 |
| Waste ................ | 0·003 | ............ | 0·003 |
| Stores ................ | 0·009 | ............ | 0·006 |
| Wages ................ | 0·220 | ............ | 0·217 |
| | 0·480 | | 0·422 |

The coal consumptions during these tests were:—

| | Test 1. | | Test 2. |
|---|---|---|---|
| Per unit generated................ | 5·519 lb. | .... | 4·240 lb. |
| Per unit sold .................... | 6·678 lb. | .... | 5·324 lb. |

When running with the battery, the units lost amounted to 39,810, whilst when running without the battery, the units unaccounted for were 36,467. The costs, therefore, per unit sold were 0·592d. without the battery and 0·533d. with the battery, or a difference of 0·059d. in favour of the battery, representing a total annual saving of £578. 4s.

During last month a further test was made for a period of five days, running without the battery, the coal consumed being 4·779 lb. per kilowatt-hour generated, and 5·262 lb. per kilowatt-hour accounted for; whilst the coal consumption for the six months ending December, 1905, and running in the ordinary way with the battery, was 4·257 lb. per kilowatt-hour generated and 5·101 lb. of coal per kilowatt-hour accounted for. These later tests are particularly interesting as showing the difference between the coal consumption per unit generated and sold under the two conditions. When working without the battery the difference is 0·483 lb., whilst when working with the battery the difference is 0·844 lb.; that is to say, without the battery there was practically a 10 per cent. loss and with the battery 20 per cent.; the result being that whilst there is a difference in coal consumption per unit generated of 0·522 lb. per kilowatt-hour in favour of the battery, there is only a difference in the consumption per kilowatt accounted for of 0·161 lb. per kilowatt-hour. The actual reduction in cost, therefore, under these conditions is of the order of £55 per annum in favour of the battery.

As there appeared some likelihood of variation in the quality of the coal, further tests were made with and without the battery for periods of 12 hours each, and the steam consumption measured. The number of units generated when working with the battery was 4,600, and the units accounted for 4,273, the loss being 327 units; whilst the units generated when running without the battery were 4,380 units, the units accounted for 4,247, the loss being only 133 units. When running under these conditions, the steam used per kilowatt-hour generated was as follows :—

| | With battery. | | Without battery. |
|---|---|---|---|
| Units generated | 30·434 lb. | .... | 34·497 lb. |
| Units sold | 32·763 lb. | .... | 35·578 lb. |

This test again indicates the same general result; the useful units supplied in each case are practically identical, whilst 220 extra units were generated when running with the battery. The difference between the steam used per kilowatt-hour generated, whilst being largely in favour of the battery—viz., 4·063 lb. between the steam consumed per unit accounted for, it is decreased to 2·815 lb., showing clearly the extra steam consumption due to the units generated and lost in the battery. Assuming 1 lb. of coal evaporates 7½ lb. of water, and coal at 6s. 6d. per ton, the total annual saving when generating 2,500,000 units amounts to £136. 2s. 8d, which is equivalent to 0·013d. per unit. It should be pointed out that owing to the relation between the size of the units and the load with which they have to cope, the conditions *obtaining* in this station are about as favourable as they possibly could be for the battery. As already explained, when using the battery, one set is practically fully loaded, whilst without the battery, the two sets are loaded only to an *average of from one-third to one-half* their rated capacity.

Let us now ascertain at what cost the reduction in the working coats due to the battery, above enumerated, is obtained. The following is a statement of the capital cost of the battery with its equipment of boosters, &c.

| | |
|---|---|
| Battery | £3,546 |
| 56 kw. positive booster | 729 |
| 40 kw. battery booster with Thury regulator | 1,849 |
| 240 ampere milking booster | 50 |
| Switch gear | 300 |
| Buildings | 750 |
| Connections | 50 |
| Total | £7,274 |

The annual capital charges involved in connection with this equipment are as follows :—

| | | | | | |
|---|---|---|---|---|---|
| Interest on cost of buildings, boosters, &c. | 5 % | on £3,728 | = | £186 | 0 |
| Depreciation on do. | 2½% | do. | = | 93 | 0 |
| Interest and sinking fund on battery | 6 % | on 3,546 | = | 212 | 15 |
| Maintenance (annual amount contracted for in tender) | | | = | 236 | 0 |
| | | | | £727 | 15 |

*representing* a cost per unit of 0·07d., whilst the reduction in cost due to that equipment under the best possible conditions is only 0·059d. per unit, and on the later steam consumption tests only 0·013d. per unit.

In the second case which came under the author's notice, the station is a combined lighting and power station equipped with two 125 kw. sets; two 215 kw. sets and two 330 kw. sets, the total capacity of the station being 1,340 kw. The units generated for the year were 2,397,237, the traction supply taking 1,387,279, the lighting and power supply 659,527 units, the difference between the units sold and the units generated being 303,354. In this station the traction battery has a capacity of 250 kw. for one hour. The supply is given from this station to the tramways under an agreement, by which the tramway authorities pay the actual cost of generation, and, in addition, 10 per cent. on the capital cost of the plant to cover interest and sinking fund charges and depreciation. Now the plant upon which the tramway authority pays these capital charges is taken to be the two 125 kw. sets, one of the 215 kw. sets and the battery. The capital cost of the steam-raising plant is £13,307, and the capital cost of the batteries approximately £3,000. From the tramway authorities' point of view there is little or nothing to take exception to in regard to the capital cost of the plant upon which they are charged. It has been claimed that the installation of the battery and booster system at this station has resulted in a lower capital expenditure on generating plant and in reducing the works costs, and although the tramway authority cannot complain of the amount charged to them in respect to the capital cost of the plant, it is curious to note that, whilst they are only debited with generating plant of a capacity of 465 kw., the lighting and power supply is debited with 875 kw., whereas the maximum load upon the tramway part of the undertaking was 500 kw. and upon the lighting undertaking 400 kw.

It would, therefore, appear that, in order to justify the capital expended on the installation of the batteries, it has become necessary to debit the lighting portion of the undertaking with a much greater proportion of the total plant capacity of the station, although the maximum demand is actually less than the maximum demand upon the tramways. If the tramway authority had been charged on the plant capacity in proportion to the load, they would have been in a position to dispute the cost of the battery installation as not being "reasonably" necessary. There is little doubt that plant capable of dealing with this tramway supply, which has an average of 24 cars running, could be erected for £16,000 excluding buildings, which is practically the amount now charged.

Turning now to the costs of generation, the following is a statement of the actual works costs as charged to the tramways :—

| | |
|---|---|
| Fuel | 0·22d. |
| Oil, waste and water | 0·03d. |
| Repairs | 0·15d. |
| Wages | 0·34d. |

It should be remarked, however, that the wages item is only charged to the tramway supply up to 800,000 units, it being assumed that the wages and management charges are "fixed," and that any additional supply is given at the rate of 0·37d. per unit to cover the cost for fuel, water and repairs, and which items are considered proportional to the output. It is, of course, impossible for the author to say what would have been the result of working if the battery had not been installed, and he can only show what the capital charges involved in connection with the provision of the battery system amount to—viz., £557. 10s. per annum—and which is made up as follows :—

| | | | |
|---|---|---|---|
| 10% on capital cost of batteries—£3,000 | £300 | 0 | 0 |
| Maintenance | 167 | 10 | 0 |
| Interest on capital cost of buildings | 90 | 0 | 0 |
| | £557 | 10 | 0 |

and to point out that these charges are equivalent to 0·096d. per unit. If the battery system had not been installed the working costs could have been increased to 0·466d. per unit and the same result obtained. There is not the slightest reason to suppose that if the battery had not been installed the cost could have been so much higher (over 25 per cent.). The coal consumption per unit generated is now assumed to be 4·73 lb., whilst per unit sold it amounts to approximately 5·3 lb.

These results are almost precisely similar to the results obtained by the author in his own station on the later tests when working without the battery, and if allowance is made for the capital charges involved in the provision of the battery system they are practically equivalent to the results of the first test made under conditions so favourable to the battery.

It would therefore appear that the conclusion, deduced from a general consideration of the matter, that the advantages to be gained by the installation of storage batteries, in tramway and power stations of even moderate size, are not justified by the cost at which they are obtained is well borne out by the actual results obtained under test at the author's own station, and also by the results obtained in actual practice in another station where batteries were specially introduced to obtain these advantages. In such an attractive form have those advantages been proclaimed that batteries of accumulators have been installed without any regard to the cost at which the advantages were obtained, and the author hopes that results of other tests may be forthcoming to assist in the determination as to whether it is not more economical to provide generating plant of such a character as to meet the conditions of electric supply as they now exist, than to instal batteries of accumulators involving capital and maintenance charges out of proportion to the advantages to be derived therefrom.

## DISCUSSION.

Mr. PEARCE said that there had been a tendency to put forward storage batteries as a panacea for all ills, and as applicable in each and every case, whether dealing with lighting, traction, or mixed systems, and he thought good would be done if this Paper of Mr. Salter's induced engineers to think out each case on its own merits, and carefully weigh up the merits and demerits of installing storage batteries in connection with their systems.

Mr. McKINNON did not consider Mr. Salter's station well designed. He begged to say that the accumulator companies ware prepared to keep batteries up to 100 per cent. efficiency at an annual charge of 6 per cent. He considered that Mr. Salter's contention that batteries were not to be compared to the cost of generating machinery to be without any sort of justification, because on that ground, in the case of breakdown with generating plant, one would judge Mr. Salter to be just as well satisfied with a motor generator as with a battery, and one knew very well that such would not be the case. He had studied the figures given in reference to Mr. Salter's works, and considered that the capital cost was greater than necessary. He would like to add in the face of Mr. Salter's statements that they had fitted up 300 battery booster installations in the United States during the past year.

Mr. T. L. MILLER considered that the examples given by Mr. Salter of the South Lancashire undertaking, which had a very small load at present, were not at all final in their conclusions. He could cite an instance in his own experience of a small works where it was necessary to run two 200 kw. sets were it not that they were fitted with a battery booster, which enabled them to run with one 100 kw. set, and afterwards when the load grew to run with two 200 kw. sets, and with the aid of the battery booster to deal with a maximum demand of 380 kw. On that score he contended that it was quite permissible to make comparisons between the cost of batteries and the cost of generating machinery, because the use of batteries will save capital expenditure in generating machinery. Illustrating the benefit batteries were under certain circumstances, he instanced the question of a supply in bulk depending on the maximum demand for the determination of the rate at which the current was to be paid for. It was important that this maximum demand should be kept down. They succeeded in obtaining a rate charged on a maximum for 400 amperes instead of 700 by the use of batteries. He considered Mr. Salter's curve showing the reduction in cost for the increase of load factor per cent. was too flat a characteristic, and thought there must be some mistake. Mr. Salter's contention that load factors should be calculated on the rated capacity of the plant, he considered not at all feasible, because one could make the load factor anything one liked under those conditions. The proper way was to work it out on the maximum demand in the generally accepted fashion.

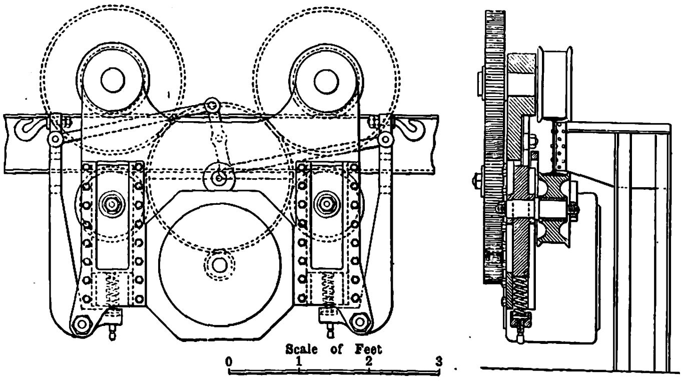
Mr. C. D. TAITE though every case should be considered on its merits. He knew of two cases, one a tramway scheme giving good results for seven years, and another tramway scheme where the engineer, by installing batteries would have to run only one generator instead of two as hitherto. At Salford they were proposing to make further use of batteries in order to relieve a 750 kw. generator from traction work, to be used on the lighting load when most wanted, and they anticipated this would be a financial advantage. He thought the author was quite right in contending that in large places like Liverpool and Manchester batteries would be of little use, but in railway work he thought their use a distinct advantage. He had seen on the Mersey Railway batteries supplying 2,000 amperes one moment and charging the next. He thought the type of engine in use, and the price of coal should be considered in these questions. Mr. Salter seemed to think nothing about balance of pressure, perhaps that was because Mr. Salter had too much plant.

Mr. JACOBS thought Mr. Salter had not proved that accumulators were of no advantage, and the only point that occurred to him was the question of battery capacity and battery efficiency. He thought that there had been a tendency to mix these two terms. A battery efficiency might be 105 per cent. of its original efficiency, and its capacity only 55 per cent. of its original capacity. He thought that it was quite possible to compare the cost of generating plant and the cost of batteries. Mr. Salter complained about the time element being introduced by battery people, but Mr. Salter himself introduced the time element by claiming 100 per cent. overload for short periods on his generating machinery.

Mr. SALTER, in reply, said he had to thank Mr. Jacobs for pointing out the question of battery efficiency and battery capacity, with which he quite agreed. The reason there was such great fluctuations on electric railways was owing to the rapid acceleration insisted upon for the starting of the trains, which he thought not necessary. He wished to disclaim any intention of saying that batteries were of no value, but what he wished to have discussed was whether, in the majority of cases, the saving effected by the use of batteries justified the money spent on them.

## ELECTRICAL TOWING ON CANALS.

We referred in a recent note (*The Electrician*, December 29, p. 446) to the electric system of towing evolved by the joint labours of Messrs. T. Blackwell, St. John Clarke, of New York, and Léon Gerard, of Brussels, and tested on the Erie canal, U.S. This system is a development of Wood's original system as used experimentally on the same canal. A description of the improved system and particulars of tests on it have been published in two pamphlets which have been sent to us.



FIGS. 1 AND 2.—SIDE ELEVATION AND SECTION OF 50 H.P. PROPORTIONAL-ADHESION TRACTOR.

Figs. 1 and 2 show the mechanical construction of the track and of the 50 H.P. proportional-adhesion tractor. The motor used is by the General Electric Co. of America and runs at 500 revs. when supplied with current at 550 volts. It is placed under the track, which consists of a laterally supported I beam (Fig. 1), 10 in. high, laid along the bank of the canal. When running light, the tractor rests on the upper wheels alone, but when load comes on, the small wheels under the girder are pressed upwards in the manner indicated in Fig. 2, and the pull at the hook may even exceed the weight of the tractor (6,480 lb.). The upward pressure can be regulated by adjusting the point at which the hook is attached to the lever. Figs. 3, 4 and 5 are tests carried out by the General Electric Co. last August. The tests were made with square-bow boats, having a mean length of 97 ft., a width at the midship beam of 17·4 ft., a draught of water, light, of 1·33 ft., and a draught, when fully loaded, of 5·8 ft., and a dead weight of 65 tons. The width of the canal where the tests were made was 55·6 ft., at the surface of the water, and the depth of water ranged from 7·86 ft. to 9·2 ft. The following table gives the chief average results of a number of tests.

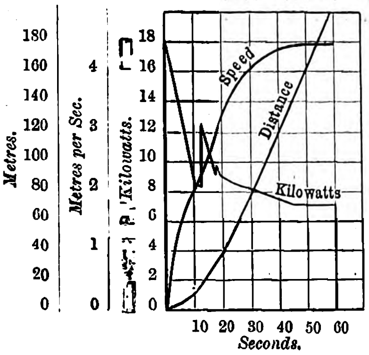


FIG. 3.—DIAGRAM RELATING TO TRACTOR RUNNING LIGHT.

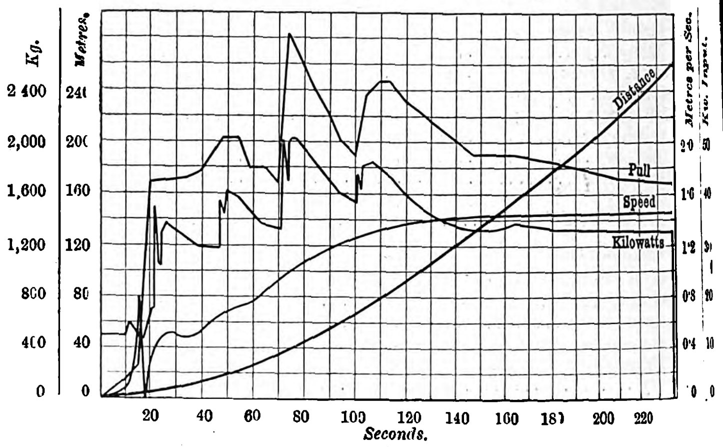


FIG. 4.—DIAGRAM OF START AND TRACTION OF TRAIN OF FOUR LOADED BOATS, WEIGHING 184 TONS, 191 TONS, 127 TONS AND 77 TONS RESPECTIVELY.

This test was made against the current whose velocity was 0·44 ft. per sec.

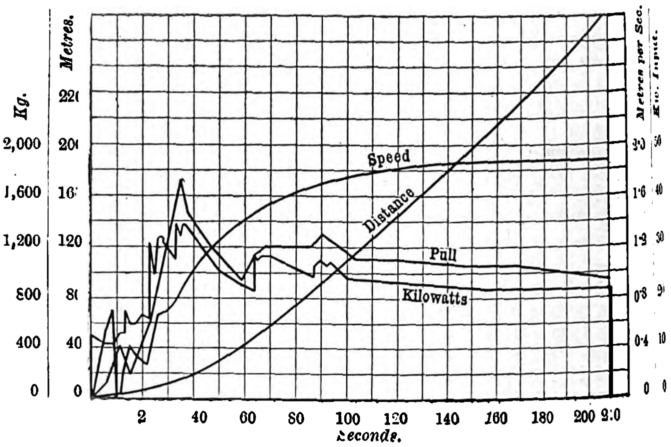


FIG. 5.—DIAGRAM OF START AND TRACTION OF TRAIN OF TWO EMPTY BOATS AND ONE BOAT WITH 77 TONS LOAD.

This test was made against the current whose velocity was 0·44 ft. per sec.

| No. of boats. | Total weight towed. Tons. | Live load. Tons. | Actual speed in ft. per second. | Mean pull. Lb. | Power in kilowatts taken from the line. | Efficiency per cent. |
|---|---|---|---|---|---|---|
| 1 | 248 | 184 | 5·93 | 2,410 | 26·50 | 72·7 |
| 2 | 505 | 375 | 5·54 | 3,290 | 29·48 | 83·5 |
| 3 | 272 | 77 | 6·06 | 2,220 | 21·80 | 83·5 |
| 4 | 839 | 579 | 5·14 | 4,020 | 33·10 | 84·5 |

## EFFECT OF ATMOSPHERIC CONDITIONS ON TRANSMITTING DISTANCE IN WIRELESS TELEGRAPHY.

A number of experimenters have attempted to establish formulæ for the value of the current in a wireless receiver, as, for example, Dr. J. Erskine-Murray's formula given in *The Electrician*, December 15th, p. 358, and the work of Duddell & Taylor. But disturbing elements exist due to atmospheric conditions, the effect of which is not taken into account in these expressions. A series of experimental observations has been made on this subject at St. Michael, Alaska, by Capt. L. D. Wildman, of the United States Signal Corps, who recorded observations of atmospheric conditions over a period of one year, at the same time noticing the variations of the clearness in the received signals. Fig. 1 shows a portion of his results extending over about three months.

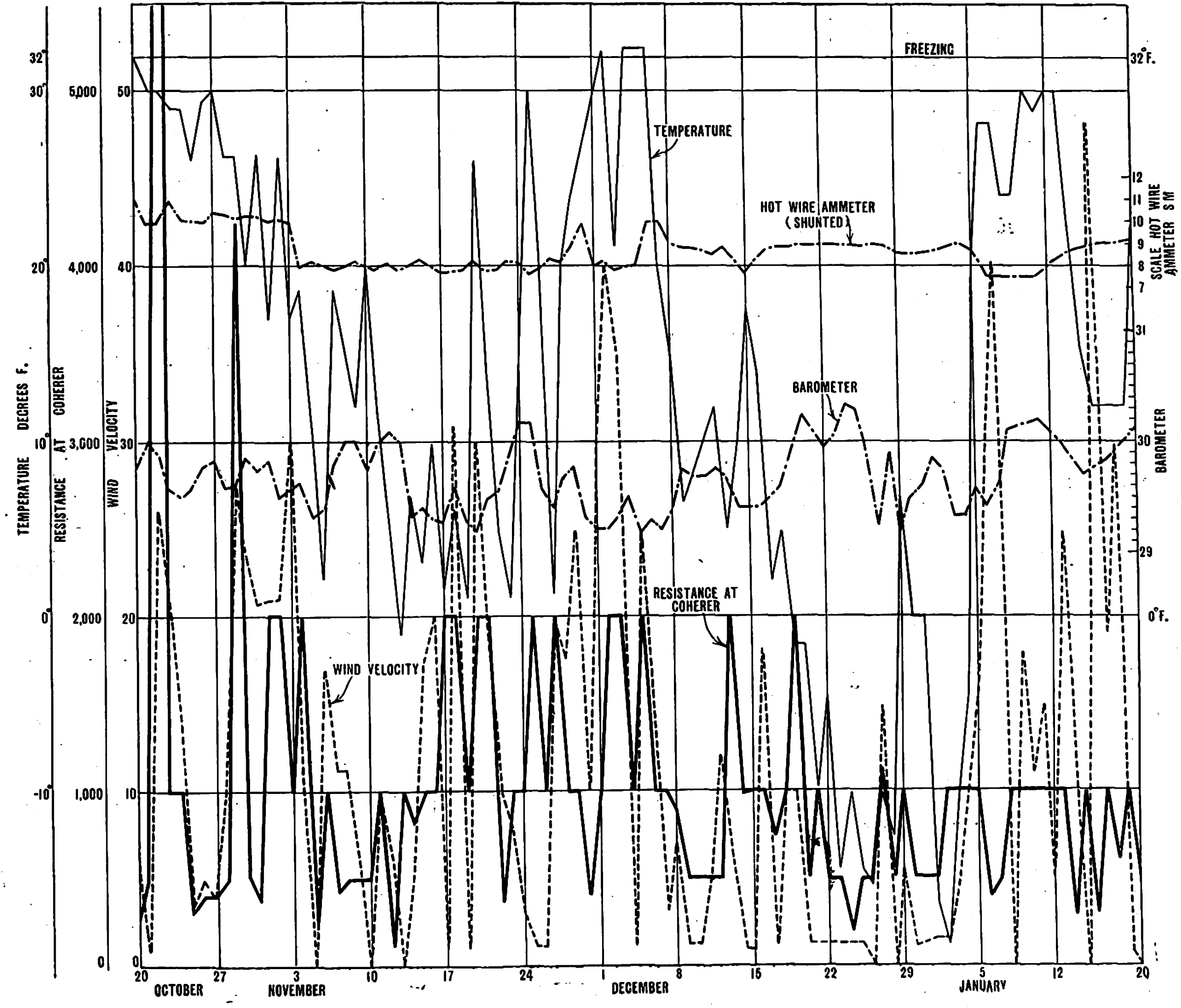


Fig. 1.—Chart of Observations over Three Months.

It will be noticed that the only curves which agree in their rise and fall are those of the wind and the clearness of the signals. The conclusion arrived at is that a high wind carrying moisture with it, or particles of snow and ice, abstracts a certain very definite amount of energy delivered to the antenna, and that, therefore, the strength of signals at the receiving station varies approximately as the wind velocity and the amount of moisture carried with it.

In connection with Capt. Wildman's letter, published in our issue of Jan. 19th, p. 562, we pointed out that it was possible that these difficulties could be prevented by insulating the antenna. Capt. Wildman remarks, however, that in his installation the antenna was insulated, as cable core was used throughout its entire length. Some details of the installation are contained in a letter from Capt. Wildman in our issue of October 20th, p. 34. On the chart the curve of watts in the primary circuit and the hot-wire ammeter readings in the primary antenna itself are not given, for the reason that these curves are practically straight lines. In practice the volt and ampere readings were always brought to the same point every time, and the readings of the hot-wire ammeter in the antenna were always the same when the observations were being made. This element of uncertainty was therefore reduced to a minimum.

The device used for determining the strength of the signals was very simple, but is believed to have been fairly accurate. It consisted of the insertion of a sliding resistance between the cords of the telephone receiver, by which means a proportionate amount of current was shunted from the telephone, depending upon the strength of the incoming signals. By reducing the resistance when signals were being received the strength of these signals could be cut down to a point where they were just intelligible. Fig. 2 gives a diagram of connections. The receiver used was of the standard De Forest type containing a platinum point of minute diameter dipping into an electrolyte. The instruments used in the tests were somewhat crude, as it was not originally intended to carry on the experimental work in Alaska. The moisture had to be judged without instruments, but the anemometer was reliable.

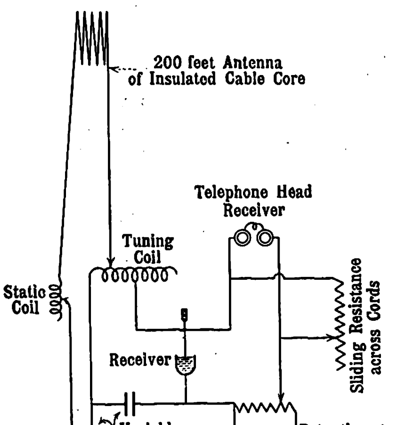


Fig. 2.—Diagram of Connections.

Capt. Wildman hopes that similar experiments will be taken up by other experimenters for the purpose of corroborating or disproving this theory. If true, the facts gained by these experiments would seem to point toward the reduction of surface in the emanating mechanism to the lowest possible amount for emanation, and would seem to argue that a great spread of wires was a particularly bad form of antenna for use in moist, windy climates.

# GAS PRODUCER PLANT FOR ELECTRIC GENERATING STATIONS.*

BY WM. J. U. SOWTER.

Producer gas is generated by passing steam and air through incandescent fuel. The oxygen of the air combines with the carbon contained in the fuel, forming carbon monoxide, and the water splits up to form more of the monoxide and free hydrogen. Further, a certain amount of marsh gas and carbon dioxide are formed, the resulting gas consisting, as regards about half its volume, of nitrogen, together with about 24 per cent. of carbon monoxide, 20 per cent. of hydrogen, and small quantities of carbonic oxide and marsh gas. The calorific value of producer gas is about one-fourth that of ordinary town illuminating gas, consequently four times the volume of gas is required to produce a unit of power as compared with town gas. Producer gas is practically non-luminous, almost odourless, and burns with a pale blue flame.

The ordinary Dowson anthracite pressure plant contains a small vertical boiler used for blowing steam through the incandescent fuel in the producer, a water seal, a coke scrubber, a sawdust scrubber, and the gas holder. This gas holder is so arranged that the rise and fall of the holder acts on a valve regulating automatically the admission of steam to the gas producer. This is a simple and practical contrivance which answers well in practice. The small boiler included in the above-mentioned plant is of course responsible for the consumption of a certain amount of fuel—usually about 15 per cent. of the total amount consumed. In view of this fact, producers have recently been improved so that they generate their own steam from waste heat.

*Bituminous Producers.*—The first apparatus for the conversion into combustible gas of bituminous small coal, and for the recovery of sulphate of ammonia, was put into operation at Messrs. Brunner, Mond & Co.'s works, Northwich. Sulphate of ammonia is a valuable by-product. It is claimed that one ton of ordinary slack will yield from 140,000 cubic ft. to 160,000 cubic ft. of gas, and also furnish the ammonia equivalent to 90 lb. of sulphate of ammonia when manufactured upon a sufficiently large scale. In small plants, however, the quantity of sulphate of ammonia recovered is too small to warrant the capital outlay upon the necessary plant, and it is recommended that this part of the plant is better omitted when the amount of fuel to be gasified daily does not amount to 30 tons; moreover, in order to secure the most efficient and satisfactory results it is desirable that the process should be continuous during the whole 24 hours. A simpler plant has been designed, the distinctive feature of which is that a certain proportion of the exhaust gases from the engine is introduced into the gas producer, together with the air blast. A blower, driven from the small engine used for driving the washers, is used to supply the necessary hot blast to the producer. Owing to the introduction of the exhaust gas the amount of steam required is materially reduced, the carbonic acid in the exhaust gases becoming converted into carbonic oxide upon contact with incandescent fuel.

The plants devised by Messrs. Crossley Bros. are made for use with either anthracite or bituminous fuels. In the bituminous plant the "fixing" of the tars is not attempted, Messrs. Crossley finding it more convenient to pass the gas through a rotary tar-extractor after it has left the saturator and washing apparatus, and before passing it through one or more sawdust scrubbers, where the last traces of tar and water are eliminated. The rotary extractor consists of a fan divided by a central rotary diaphragm. The gas goes in through one set of blades, round the edge of the diaphragm, and back through the second set of blades. In this way globules of tar are beaten out of the gas and the tar passes to a pump, together with the overflow water from the washer tower. The producer itself has a special form of rotary grate, and it is provided with water lutes for removal of the ashes while the plant is at work.

Although this apparatus works on the regenerative system, it is found that not quite sufficient steam can be raised by waste steam, and a small boiler has to be used in conjunction, particularly on first starting up. The Crossley bituminous plant is specially designed to work with either bituminous or anthracite fuel. I am informed that this firm have successfully gasified fuel containing as much as 40 per cent. of ash in its composition; but, of course, using such low-grade fuels the heat available for conversion into work is less according to whatever the calorific value of the fuel happens to be. With this plant no gas holder is required, the gas on leaving the producer being at a suitable pressure for supplying the engines direct.

*Suction Producers.*—Recently a form of producer, known as the suction producer, has been introduced. In this plant the suction in the engine caused by the outstroke of the piston is utilised to draw air and steam through the fire in the generator, the gas being generated in a similar manner to that of other plants. These plants also work on the regenerative system—no external boiler being required. Gas good enough for driving an engine can be made within 10 minutes of starting up the producer from cold. This is an invaluable feature in plants for electricity supply, and the advantage of gas plants in this respect over steam plants is very great. The apparatus is compact and requires little floor space.

A difficulty met with in suction plants is to obtain a uniform quality of gas with varying loads. At small loads, when the engine governor cuts out a number of charges, steam continues to be raised; this fills the steam spaces, and subsequent charges of gas are very inflammable; the fire, too, is cooled by this over-production, and, after this temporary richness has passed off, the gas produced is of lower quality. In the Crossley apparatus one or more cocks are arranged opening from the air space above the water in the saturator into the open air. Through these openings the steam escapes at light loads. With the suction plant very little attention is required, and in most cases the supply of fuel into the producer will only be required at intervals of from four to five hours, and this operation only requires a few minutes each time. So far producers of the suction type have not been made for use with bituminous coals, the difficulties of making clean gas from bituminous fuels being considerable.

It appears to the author that the suction type of plant offers very many advantages in the case of quite small installations. The plant is economical and easily managed. As the apparatus can be located in close proximity to the engines, it is quite possible for one man to run a station with, say, two engines of moderate size running simultaneously. An objection which may possibly appeal to many electrical engineers is that of having coal and ashes within the precincts of the engine room. This, however, is not a very serious difficulty to overcome, and the advantage of having both engines and producers in one room in cases in which it is desirable to economise labour is obvious. There is also no possibility of leakage of gas owing to there being a partial vacuum within the pipes and apparatus, so that, should any defect develop in the producer or pipes, air would be drawn in instead of gas (which is poisonous) escaping.

*Gas Engines.*—The chief points in which the ordinary engine fails are: (1) Bad governing, (2) ignition troubles, (3) difficulty in starting, (4) great floor space necessary.

The ordinary hit-and-miss governor is not very suitable for electric lighting. In running several gas-driven dynamos in parallel, difficulty is often experienced owing to the interchange of current between the machines; this variation is accelerated as the load decreases owing to the number of explosions per minute becoming less. Such a governor would, of course, be quite useless for controlling engines driving alternators in parallel.

Recently another form of governor for gas engines has been introduced working on the throttle system. This governor acts upon the regulator valve which controls the admission of both gas and air to the mixing chamber. As the load on the engine varies the regulating valve moves up or down, increasing or decreasing the quantity or volume of the mixture without altering the quality. The frequency of the impulses is, therefore, the same for all loads, the relative quantities of gas and air remaining constant. Given a suitable engine, governed in this manner, there is no practical difficulty in running direct-coupled alternators in parallel, and the author understands that there are several such plants in successful operation

The chief objection to an engine governing on the throttle is that, owing to the fact that the explosive mixture is never entirely cut off, compression at the lower loads is decreased owing to the reduced volume of gas and air admitted at each charge. This, although it may appear at first sight a serious objection, is really not of great importance. The following figures are the guarantees given by two engine makers for engines of similar size—one throttle governing, the other hit and miss.

*Comparative Consumption of Gas Engines in Cubic Feet per Brake Horse-power. Gas, 150 B.T.U.*

| Load. | Throttle governing. | Hit-and-miss. |
|---|---|---|
| Full. | 66·6 | 66·6 |
| $\frac{3}{4}$ | 77·5 | 73·5 |
| $\frac{1}{2}$ | 88·0 | 86·5 |
| $\frac{1}{4}$ | 110·0 | 100·0 |

The tube system of ignition has been largely superseded by electrical methods. The author is personally acquainted with one supply station in which enormous trouble was experienced owing to pre-ignition. This difficulty was largely overcome by adopting electric ignition, and finally totally eliminated by water-cooling the pistons and exhaust valves. The high-tension system of ignition is exceedingly reliable, and causes little or no trouble.

*Starting.*—The method of starting by means of compressed air seems to be the most satisfactory system in vogue. The air supply is obtained from a small compressor and stored in iron tanks. The method of starting the Westinghouse engine by this means is as follows: A screw is provided, which on being given a few turns renders the admission valve of one cylinder inoperative for the time being. On the back of the crank case is a short lever which on being moved to the right throws out the regular exhaust cam and throws in a supplementary cam which keeps the exhaust valve open during every upstroke, instead of *every other* upstroke of the piston as when the engine is in regular operation. A pipe leads from the air storage tank to the starting valve and thence through a check valve into the cylinder, in which the valve functions have been altered. This valve is actuated by a cam on the lower end of the cam shaft, where it projects through the end of the crank case, and is so timed as to open each time the piston starts on its downward stroke.

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* Abstract of a Paper read before the Dublin Local Section of the Institution of Electrical Engineers on March 8, 1906, Mr. P. S. Sheardown in the chair.

It will be seen that one cylinder is thus converted into a compressed air engine without disturbing the rest of the engine. The engine being set with the corresponding crank a little over the centre, the air and gas supply being properly adjusted, and the stop valve in the air pipe opened, it starts off and continues to run on the air pressure until explosions take place in the other cylinder or cylinders. The air supply is then shut off, the inlet and exhaust valves put back in their normal working positions, and the engine is in full operation.

*Type of Engine.*—The type of engine most suitable for central station work is, in the author's opinion, the vertical, with three or four cylinders, the dynamo or alternator being direct coupled to the shaft. Such a plant takes up little space, as compared with a horizontal engine, and compares generally very favourably with a steam plant. With this type of plant great cyclic regularity is obtained, and an immunity from vibration. The exhaust from an engine with several cylinders, and governed by throttling a constant mixture, is much more silent than that of a single cylinder engine governing on the hit-and-miss principle.

*Economy Compared with Steam Plants*—Numerous tests have been made by eminent authorities upon gas producers in order to ascertain the actual heat efficiency. Mr. Dugald Clerk, in a lecture delivered before the Institution of Civil Engineers* in 1904, gave the results of some tests carried out for him by Mr. M. Atkinson Adam, B.Sc., on two Dowson suction producers, one adapted for a maximum working load of 40 B H.P., generating about 3,000 cubic ft. of gas per hour; the second adapted for a maximum working load of 30 B.H.P., generating about 2,300 cubic ft. per hour. The heat efficiency of the 40 B.H.P. plant was found to be 89 per cent., while the 30 B.H.P. plant showed an efficiency of 86 per cent. The thermal efficiency of the gas engine is very much greater than that of the steam engine, the highest efficiency obtained—so far as the author is aware—being about 33 per cent. on the brake horse-power, while the efficiency of many engines of different sizes and designs varies between 20 and 30 per cent.

*Stand-by Losses.*—Mr. J. Emerson Dowson, in a recent communication to this Institution,† referred to some tests which were taken by independent engineers upon a number of gas generators of his own design, ranging in size from 150 H.P. to 375 H.P. The coal consumption during stand-by hours varies from 1·8 lb. to 3·8 lb. per hour; the mean of four tests in four different towns, each taken by separate engineers, showed a consumption of 3 lb. of anthracite per hour. Mr. Dowson further obtained from engineers in charge of steam plants particulars of the consumption of fuel with various types of boilers standing-by, the size of boilers ranging from 150 H.P. to 500 H.P. The mean of eight tests showed a consumption of 75 lb. of coal per hour, simply to keep steam in the boilers at working pressure, and not including losses by radiation in steam pipes, auxiliaries, &c., which are also appreciable items. The author has also made tests in several stations with which he has been connected, the results showing that in many small stations the amount of fuel consumed without doing beneficial work may be anything up to 40 per cent. of the amount of coal consumed annually.

Concerning the cost of repairs to producers and plant of his own design, Mr. Dowson gives the following figures "as the result of many years' experience, and which may be taken approximately as a fair allowance for repairs and maintenance."

*Repairs and Maintenance.*—For 100 B.H.P. plant, about £4; 200 B.H.P., £6; 300 B.H.P., £9; 400 B.H.P., £12; 500 B.H.P., £15 per annum.

*Gas-driven Stations in Operation and Working Results*—In concluding this Paper it will be interesting to refer to a few stations running successfully, and solely dependent upon gas for motive power.

*Walthamstow.*—This station was erected by the Urban District Council in 1901, to the designs of Mr. J. Enright, B.Sc., consulting engineer to the Council. The capacity of the plant now installed is close upon 3,000 B H.P., and is by far the largest gas-driven station in the British Isles. The plant consists of 13 Westinghouse gas engines direct coupled to continuous-current generators. The first installation consisted of four 115 B.H.P. engines; the first extension, three 250 H.P. sets, while recently six more 250 H.P. sets have been added, three of the latter being in daily use supplying energy to the Council's tramway system.

Gas for operating the station is obtained from Dowson producers, anthracite coal, at 26s. per ton delivered, being the fuel used. Motor-driven three-throw pumps are employed for circulating the water through the jackets, this water being subsequently passed through cooling towers. The water required for make-up and general use is derived from an artesian well 480 ft. deep, in connection with which a motor-driven air compressor plant is provided for raising the water on the air lift principle to a storage tank. Motor generators are employed for energising the ignition circuits of each engine. A common ignition 'bus is run round the length of the station; the various ignition motor generators are made interchangeable, as a safeguard against breakdown in any particular set, and, as a further safeguard, primary batteries are installed as a stand-by.

The arrangements made for starting the engines, by means of compressed air, are also very complete. Air, at a pressure of 200 lb. per square inch, is stored in vertical tanks placed against the engine-room wall. The compressors for filling these tanks are motor-driven. The capital cost of the whole installation (including cable distributing system) works out at £81 per kilowatt installed, which compares favourably with similar steam-driven stations.

The following are particulars of the cost of energy per unit sold for the year ending March 31, 1905:—

*Units sold*, 1,062,446. *Load factor*, 15·45 *per cent.*

| | | |
|---|---|---|
| Coals and other fuel | 0·42d. | |
| Oil, water and engine stores | 0·10 | |
| Wages | 0 33 | |
| Repairs | 0·09 | |
| Works cost | | 0·94 |
| Rent, rates and taxes | 0·02 | |
| Management | 0·22 | |
| | | 0·24 |
| Total cost | | 1·18d. |

No doubt, had the bituminous type of gas plant been further developed at the time the Walthamstow station was started, such a plant would have been installed in preference to the present anthracite plant, and this would probably have had the effect of reducing the coal bill to something like 0·2d. per unit.

*Other Stations.*—A small station, on similar lines to Walthamstow, has been put into operation at Limerick. I understand that it is running very satisfactorily, but unfortunately have been unable to obtain figures as to the cost of production.

*Dolean, N.B.*—Plant consists of two Crossley 27 B.H.P. engines supplied from suction plant by same firm. The result of a 7½-hours' run at full load showed a fuel consumption of 1·293 lb. of coal per kw.-hour. The cost of fuel per unit, generated with anthracite at 25s. per ton, is therefore 0·134d. The works costs for the year 1904 were as follows: Fuel, coal at 18s. per ton, 0·295d.; oil, water, &c., 0·119d.; wages, 0·490d.; works cost 0·904d. per kw.-hour.

*Totnes.*—Plant, two 50 B.H.P. Crossley engines and gas plant. Cost for 1904 as follows: Fuel, coal at 25s. 9d. per ton, 0·352d.; oil, stores, &c., 0·191d.; wages, 0·510d.; works costs, 1·053d. per kw.-hour.

*Milford-on-Sea.*—Plant, two 40 H.P. Crossley engines and suction plant. Coal consumed per unit sold, including distribution and battery losses, amounts to less than 3 lb. per unit sold.

## DISCUSSION.

Mr. W. H. CLEGG referred to a small plant recently installed at Kildare, consisting of two 60 B.H.P. gas engines, supplied with gas on the pressure system, made by Messrs. Whitfield, of Kettering. At Kildare they ran a plant for six months without drawing the fire. On test, the consumption of coal of the plant at half-load (30 H.P.) was 1·6 lb. per brake horse-power hour. In one week the output had been 846 units for 1,650 lb. of anthracite coal, or 1 95 lb. of coal burnt in the generator per unit sold. In addition, 1·23 lb. of slack per unit had been burnt under the boiler. The anthracite cost 24s. 6d. per ton and the slack 15s. 6d., which corresponded to 0·252d. per unit sold for anthracite and 0·099d. for slack, or a total fuel cost of 0·351d. per unit sold. The stand-by losses were 25 lb. from 10:30 p.m. at night to 2 p.m. next day. The staff consisted of two men and one boy, and the engines were of the horizontal type, and gave a steady voltage without battery.

Mr. T. TOMLINSON gave the following empirical formula for the gas consumption of an engine on suction producer plant: Consumption in cubic feet per hour = 10 × maximum brake horse-power of engine + 50 × actual brake horse-hower developed. The figures thus obtained were on the safe side—very much so for engines over 100 B.H.P. The gas consumption in cubic feet per hour divided by 90 gave the pounds of anthracite coal per hour.

Mr. M. RUDDLE expressed the opinion that producer plants and gas engines had a long way to go before they became serious competitors of steam plants. Walthamstow's 0·42d. per unit for coal was not by any means abnormally low. In Dublin the fuel cost was 0·64d. per unit, with an alternate-current supply and a lower load factor.

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* *Proceedings* Institution of Civil Engineers, Vol. CLVIII., Part 4.

† *Journal* Institution of Electrical Engineers, Vol. XXXIII., Part 2.

Mr. P. S. SHEARDOWN did not think there was a distinct economy over steam in small plants. Coal was a most important factor in large stations.

Mr. SOWTER, in reply, said he had got some figures for a few stations showing the actual thermal efficiency over 12 months' working—*i.e.*, taking the number of tons of fuel consumed per annum multiplied by the thermal energy contained in the fuel, as compared with the energy generated in B.O.T. units. The results showed the thermal efficiency to be roughly twice as high for gas-driven stations.

| | | | |
|---|---|---|---|
| *Gas* | —Walthamstow.... | Efficiency of conversion per cent. | 9·0 |
| ,, | Milford-on-Sea .. | ,, ,, ,, | 10·1 |
| ,, | Faversham ...... | ,, ,, ,, | 9·8 |
| *Steam* | —Cheltenham ...... | ,, ,, ,, | 4·2 |
| ,, | Coventry ......... | ,, ,, ,, | 3·5 |

Mr. Ruddle's statement that there was nothing extraordinarily low about a fuel bill of 0·42d. was correct for very large stations, but he (Mr. Sowter) thought the results exceedingly good, and mentioned that the coal consumption at Ealing was over 1d. per unit and at Kingston-on-Thames 0·93d., while there were many others equally high. Regarding the capital cost of gas plants, he had investigated the matter and came to the general conclusion that small stations using sets of about 100 kw. each cost about the same as a steam station with every up-to-date appliance, while probably a very large station would be cheaper with steam than gas plant.

## PHYSICAL SOCIETY.

At a meeting of the Physical Society held in the "Pender Electrical Laboratory," University College, Gower-street, London, on March 23rd, Prof. J. PERRY, F.R.S., President, in the chair,

Prof. F. T. TROUTON read a Paper

### "On Unilateral Electric Conductivity over Damp Surfaces."

Some time since the author noticed a rather perplexing difference in electrical resistance depending on the direction in which the measuring current was passed. The resistance under examination was that of the layer of moisture which adheres to glass when exposed to moist atmospheric conditions. The arrangement in which this resistance measurement was effected was one used for determining the temperature of deposition of dew. For this purpose two parallel wires of platinum were melted on to a glass surface at a small distance apart. The surface could be artificially cooled. A cell and a galvanometer were inserted in series with the two platinum wires. As soon as moisture condensed on the glass the circuit was completed and a current passed, thus permitting the accurate determination of the dew point. When a delicate galvanometer is used a small current can be detected long before the true dew point is reached. It is at this stage that the anomalous behaviour in the resistance is found. On passing a current across the glass surface when exposed to ordinary atmospheric conditions it was found to diminish to a certain minimum value, the amount of which depended on the hygrometric state. On reversal the current assumed its original value and then diminished to a minimum as before, and so on for further reversals. In order more conveniently to study the matter with larger currents, tinfoil grids were prepared by pasting strips of tinfoil on to glass plates. Every second strip was connected to one pole of the battery while the intermediate strips were connected to the other. In this way was obtained a length of surface lying between parallel strips of tinfoil placed at a short distance apart. Grids of various widths were prepared. One set, consisting of eight glass plates with strips 0·2 cm. apart, gave a total length between electrodes of 250,000 cm. When a P.D. of 110 volts was applied, a current of about $9 \times 10^{-4}$ was found to pass, but gradually this diminished to about $1{\cdot}5 \times 10^{-4}$. On reversal, the current was found to be about $3 \times 10^{-4}$, which rapidly rose to about $9 \times 10^{-4}$, and then diminished to about $1{\cdot}5 \times 10^{-4}$, and so on for further reversals. The resistance was measured by a Wheatstone bridge when the grid was in a good conducting phase and when in a badly conducting phase, and found to be about 140,000 ohms and 800,000 ohms respectively. That the effects observed were not due to anything similar to ordinary polarisation was shown by the fact that no back E.M.F. was obtained on short-circuiting through a galvanometer in the usual way, and also by the fact that the ratio of the currents in the two phases was independent of the difference of potential applied. Up to 3,000 volts were applied. This would require a back E.M.F. of 1,500 volts to give a falling-off in current to half value. The theory put forward to account for the phenomenon depended on the transportation of moisture over the surface by the current. In this way the effective thickness of the layer might be much diminished by a banking up of the moisture along the edge of one of the metallic electrodes.

Mr. ROLLO APPLEYARD expressed his interest in the Paper, and pointed out that there were many ways in which electricity could pass between the electrodes. For instance, there was moisture leakage, surface leakage, the electrification effect and the coherer effect. He suggested that experiments should be made so as to localise the separate effects.

Mr. A. CAMPBELL suggested that experiments might be made with electrodes of silver or platinum deposited electrolytically upon the glass, so as to do away with the shellac used to stick down the tinfoil electrodes. He pointed out that moisture had a solvent action upon the glass, and that the film was not one of pure water, but of a solution of salts. He suggested that experiments might be made with films on ebonite or mica.

Mr. W. DUDDELL asked if the effects described might not be due to the formation of a film of insulating oxide along the edge of one of the electrodes. He asked the author what time elapsed between a reversal and the first reading taken after it.

The CHAIRMAN, referring to the author's theory, said that the increase in conductivity on reversal of current was so sudden that he doubted whether the film would have time to spread. Also Mr. Duddell's film would, he thought, not disperse quickly enough.

Prof. TROUTON, referring to the separation of effects, said he had desiccated the glass plates and found them insulators. There was, therefore, no conductivity through the glass. He had used platinum melted on to glass and got the same effects, so that they could not be due to the shellac used in pasting down the tinfoil. Replying to Mr. Duddell, he said that the time elapsing between a reversal and the first subsequent reading was of the order of a tenth of a second.

A Paper on

### "The Construction and Use of Oscillation Valves for Rectifying High Frequency Electric Currents"

was read by Prof. J. A. FLEMING. The author recalled the fact that as far back as 1890, when investigating the Edison effect in glow-lamps, he had shown that the space between the incandescent carbon filament and an insulated metal plate placed in the vacuous bulb possessed a unilateral conductivity, negative electricity being able to pass from the filament to the plate, but not in the opposite direction. This led him to suggest an arrangement of the above kind for separating out or rectifying the oppositely directed currents in an alternating current. This effect was now recognised as due to the copious emission of negative ions or electrons from the incandescent carbon. It was by no means obvious, however, before trial, that any such rectifying arrangement or valve would operate with currents of very high frequency. For example, electrolytic rectifiers such as the aluminium-carbon cell were not available for high frequency currents because a time element entered into the chemical actions involved. In 1904, however, the author discovered that if the carbon filament in an electric glow-lamp was surrounded with a metal cylinder connected to an insulated terminal by a wire sealed through the bulb, and if the filament was made incandescent by an insulated battery, then between the insulated terminal and the negative pole of the battery a unilateral conductivity existed which was operative with currents of any frequency, and the valve so made might be employed to render electrical oscillations measurable by an ordinary sensitive galvanometer. The author exhibited oscillation valves made on this plan, and also showed their uses. If placed in series with a galvanometer, in the circuit of a coil of wire acted upon inductively at a distance by oscillations created in another circuit, the valve gives instructive information as to the damping in the primary circuit. Thus he showed that when using a carbon-point spark-discharger in the primary oscillation circuit, much larger galvanometer deflections were obtained with very short sparks than with long ones. The author explained that the greatly lessened damping in the short spark caused the mean value of the secondary current to be increased, although the charge put into the primary condenser was diminished. The advantages of using multiple spark-gaps in oscillation circuits was also proved by the use of the valve. The author exhibited a multiple spark-gap discharger made with carbon rods, and claimed for it a much greater constancy of action than a discharger made with metal balls. Experiments were also shown illustrating the manner in which the valve is of use in showing the shielding action of thin metal sheets placed between primary and secondary oscillation circuits. Dr. Fleming also exhibited an experiment showing the copious emission of negative ions from the glower of a Nernst lamp at atmospheric pressure. A Nernst oxide glower was placed horizontally near a brass tube filled with water to keep it cool, and on glowing the oxide rod with a continuous current, it was shown that the space between the hot rod and the cool tube possessed a unilateral conductivity and would only pass negative electricity in one direction. The author referred to the employment of carbon-filament oscillation valves such as he had described as wave detectors or cymoscopes in connection with wireless telegraphy. Finally it was pointed out how, by the use of an electrodynamometer and galvanometer in series, the amount of rectification produced by the valve could be measured, and it was shown that it might amount to 89 or 90 per cent.

Dr. R. T. GLAZEBROOK expressed his interest in the Paper, and hoped that Dr. Fleming would be able in a further communication to give numerical data so that the sensitiveness of the arrangement described could be compared with those of other rectifying devices.

A Paper on

### "The Use of the Cymometer for the Determination of Resonance Curves"

was read by Mr. G. B. DYKE. The experiments described in the Paper were made with a view to the adaptation of the direct reading cymometer to the delineation of resonance curves and the determination of the logarithmic decrements of wave trains and the resistance of oscillating sparks. A special form of ammeter was inserted in the cymometer circuit, enabling the current to be observed for any position of the instrument. The ammeter used was of the hot-wire type with a bismuth-iron junction in contact with the hot-wire, the E.M.F. of the junction and hence the current through the fine wire being read off from the deflections of a single pivot galvanometer of low resistance. The results of the work of Bjerknes and Drude on the oscillation transformer are referred to, and the application of their final equations to the determination of logarithmic decrements from the resonance curve discussed. Precautions to be taken in the determination of resonance curves in practice are enumerated, and an example is given of the calculations involved in the determination of the logarithmic decrement and the resistance of an oscillatory spark. The double frequency set up in closely coupled oscillation circuits is shown by means of the resonance curve of a wireless telegraph aerial, the mathematical deductions of Oberbeck being thereby confirmed.

Mr. A. CAMPBELL asked the author if he could give an idea of the sensitivity of the hot-wire ammeter. He pointed out that if the instrument was used in a vacuum, the sensitivity was much increased.

Mr. W. DUDDELL said he had tried thermo-junctions in a vacuum and found their sensitivity increased five or ten times. He suggested that the author should replace the bismuth in the junction by constantan.

Mr. DYKE, in reply to Mr. Campbell, said that a current with a maximum value of 0·17 ampere gave a deflection of 80 divisions.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. FOURNIER D'ALBE.]

*The Positive Column.*—P. Villard discusses the deflection of the positive light in a vacuum tube, with a view to elucidating its mechanism. In the classical experiment concerning its deflection by a magnet, it is found that the beam is bent out towards the region between the poles of the electromagnet somewhat like an elastic band. It behaves like a filament carrying a current. In this phenomenon the walls play a prominent part unless the tube is very wide. In a wide tube the positive particles no longer behave like a conducting filament. Their paths twine round the lines of force of the magnetic field in such a manner that they diminish the field. A conducting filament, on the other hand, rolls itself up in such a manner as to increase the magnetic field. When the field is increased the spirals described by a projected particle diminish in diameter, whereas those of a conducting filament increase. If the positive column consists of particles at rest, or in very slow motion, it may be regarded as a conducting filament. Its positive charge is evidenced by its attraction by a negative pole, and its repulsion by the walls. Its length is increased by increasing the current strength or narrowing the tube.

[P. VILLARD, *Comptes Rendus*, March 19, 1906.]

*Distillation of Metals.*—H. Moissan has found that all metals may be liquefied and distilled. The iron family require very heavy currents in the electric furnace, but even tungsten and molybdenum may be regularly distilled. Boron and carbon, on the other hand, pass direct from the solid to the gaseous state. Brought to the temperature at which carbon evaporates, titanium is liquefied. The author has distilled 17 grammes of titanium in six minutes. A difficulty lies in the avidity with which titanium combines with nitrogen. The author draws some conclusions with regard to the temperature of the sun, which is known to contain titanium. On account of the large amount of heat radiated by the sun, it appears probable that it contains some solid matter as well as gaseous matter. At atmospheric pressure, no solid matter can exist at temperatures superior to that of the electric arc—*i.e.*, 3,500 deg. Under the pressures available within the body of the sun, there will be much solidification, so that bodies can remain solid at temperatures higher than that of the arc. It follows that the temperature may be higher, and that at the surface of the sun it may amount to the 6,590 deg. given by Wilson.

[H. MOISSAN, *Comptes Rendus*, March 19, 1906.]

*E.M.F. between Metals and Liquids.*—When a sensitive electrometer is connected with an insulated metallic vessel having a glass orifice from which a conducting liquid, say, a solution of magnesium sulphate, escapes drop by drop, the electrometer shows a small deflection which attains a steady value after several minutes, and continues as long as the liquid drops. The deflection varies with the metal and the liquid, and, according to C. Nordmann, constitutes a simple expedient for determining the contact E.M.F. between a metal and a liquid. The limiting value of the electrometer deflection is independent of the capacity of the system and of the rate of flow. It depends, however, upon the temperature and upon the state of the surfaces. This variation must be taken into account in the author's "ionograph," employed for registering the ionisation of the atmosphere. The author has succeeded in circumventing it by letting the droplets fall into a smaller vessel having a similar orifice. Whatever charge the smaller vessel receives owing to the contact potential it gives up again automatically, since drops of the same number and radius enter it and leave it. The smaller vessel is connected with an electrometer, and the readings of the latter are thus given a very stable zero, and they directly indicate the ionisation of the atmosphere.

[C. NORDMANN, *Comptes Rendus*, March 12, 1906.]

*Measurement of Resistance.*—W. Jaeger discusses the four chief methods of meauring resistances with the needle galvanometer, and points out the cases in which they can be used to the greatest advantage. In Thomson's method, the resistance to be measured A, should be nearly equal to the standard B. The ratio of the bridge resistance $a$ to A should be very small. The galvanometer resistance $g$ should be A/2. The sensitiveness is then $E/2\sqrt{2}$. In Wheatstone's bridge arrangement, the most favourable conditions are given by $a = A$, $B/A =$ infinite, $g = 2A$. The sensitiveness is then the same as in Thomsons's method. The differential method is the most sensitive when the conditions are favourable. These conditions are $b = A$, $aB/A^2 = 1$, $a/A = 0$, $B/A =$ infinite, and $g = A$. The sensitiveness is then $\frac{1}{2}E$. The compensation method is the least sensitive under the most favourable conditions, which prescribe $b = a = A$, $a/A = B/A = 1$, and $g = A$. The sensitiveness is $\frac{1}{4}E$, E being the E.M.F. used. The differential method can only be employed with large resistances. If the resistance A and $b$ can be changed simultaneously by the same amount, a sensitiveness $= E$ may be attained. With a movable coil galvanometer of half the sensitiveness of a needle galvanometer, the same delicacy of measurement of resistances can be attained.

[W. JAEGER, *Zeitschrift für Instrumentenkunde*, March, 1906.]

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Electric Machine Design," being a revised and enlarged edition of "Electric Generators." By H. F. Parshall and H. M. Hobart. (London: "Engineering.") £2 2s.

"Plant Response as a Means of Physiological Investigation." By Jagadis Chunder Bose. (London: Longmans, Green & Co.) 21s.

"Proceedings of the Royal Society." Series A. Vol. LXXVII. No. A517. Mathematical and Physical Sciences. (London: Harrison & Sons.) 3s.

"Proceedings of the Royal Society." Series B, Vol LXXVII. No. B518, Biological Sciences. (London: Harrison & Sons.) 4s.

"The Chemistry of the Materials of Engineering." By A. Humboldt Sexton. 2nd edition. (Manchester: The Technical Publishing Co.) 5s. net.

"Journal of the Institution of Electrical Engineers." Edited by G. C. Lloyd. February, 1906, No. 176, Vol. 36. (London: E. & F. N. Spon.) 5s.

"Wireless Telegraphy." By William J. White. (London: T. C. & E. C. Jack.) 1s. net.

"The A. B. C. of Parliamentary Procedure." By W. M. Freeman and J. C. Abbott. (London: Butterworth & Co.)

"Tabelle der Prozentualen Spannungsverluste bei Gleich-, Ein- und Dreiphasenwechselstrom für die Querschnitte 1·5—150 qmm." Compiled by Fritz Jesinghaus. (Berlin: Julius Springer.) 50 pf.

"Proceedings of the American Institute of Electrical Engineers." No. 2. Vol. XXV. February, 1906. (New York: The Institute.) 5Cc.

"Jahrbuch der Elektrochemie." 1904. Edited by Dr. Heinrich Danneel. (Halle-a-S.: Wilhelm Knapp.) 28 m.

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**Editorial, Publishing and Printing Offices,**
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*Telephone:* 949 Holborn. *Telegrams:* ELECTRICIAN NEWSPAPER LONDON

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## NOTICE.—GOOD FRIDAY WEEK.

**"THE ELECTRICIAN" will be published on THURSDAY in Good Friday week instead of on Friday. Communications intended for this issue must reach the Offices not later than WEDNESDAY MORNING'S POST.**

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## STORAGE BATTERIES IN CENTRAL STATIONS.

The enormous advantages conferred on systems of distribution of power by a ready means of storing energy are evident to every engineer. The electrical engineer possesses such a means, but he labours under the disadvantage that electrical energy has to be converted into chemical energy before it can be stored, while with systems using such media as water, gas or compressed air, no such a change in the form of energy is necessary. So far, the only electrical storage system successful on a commercial scale is the old lead accumulator developed out of the early experiments of PLANTÉ and FAURE, notwithstanding the wealth of research lavished on the subject in other directions. The nickel-iron cell of EDISON showed some promise, but has not in any way fulfilled expectations, and it is now announced that the same indefatigable inventor is experimenting with cobalt. The load battery, as turned out by the best manufacturers of to-day, is a very different thing from the comparatively unreliable storage battery of ten or fifteen years ago, which earned for accumulators in general such an evil reputation. The secondary cell has to be understood to be appreciated; like some highly strung but powerful animal, it has to be exercised regularly, fed regularly, and watched with unceasing care. The slightest sympton of disease requires to be attended to at once. In careful hands, however, the lead cell is a reliable servant, but only too often is the whole race of storage batteries condemned for the faults of its attendants. Batteries have their inherent defects and have their advantages, it is impossible to generalise as to their universal applicability or the contrary; each case must be judged on its own merits.

The subject is dealt with in a Paper, abstracted elsewhere in this issue, which was read before the Manchester Section of the Institution of Electrical Engineers by Mr. J. R. SALTER, wherein detailed figures are gone into relating to the saving effected by batteries in two moderate-sized stations which came under the author's consideration. The cases selected gave results which could not be described as favourable, but, as pointed out in the discussion, they can hardly be regarded as typical. Many other examples might have been chosen to tell a very different tale. If Mr. SALTER's object was to show that each case should be decided on its merits, it was scarcely an impartial way of dealing with the question to include only examples which showed such a doubtful economy.

The employment of batteries for railway work has increased of late, and much use is made of the automatic boosting systems of HIGHFIELD and others. Nevertheless, the adoption of these two auxiliaries in traction stations cannot be said to be by any means universal. More modern designs have so much improved the capabilities of generating plant as regards overloads, that several engineers of repute think batteries unnecessary when the peaks, although large, are of short duration. This diversity of opinion is well shown by taking the electric railways in operation and in progress in this country. The two oldest, the City & South London and the Liverpool Overhead railways, started originally without batteries but added them at a later stage, and the same may be said of the Liverpool-Southport line of the Lancashire & Yorkshire Railway, where batteries were added during last year in four of its sub-stations of sufficient capacity to run the whole line for one hour with the generating station shut down. The Mersey Railway has also a set of cells in its power house. It is interesting to note, moreover, that in one of the schemes in progress, the electrification of the London local lines of the Great Western Railway, sub-station batteries and automatic boosters will form an important feature. The whole of the remainder, however, including the Central London, Waterloo & City, the Great Northern & City, and the Metropolitan railways, the group of lines fed from the Lot's-road station of the Underground Railways Co. of London, the North-Eastern Railway, and, of course, the projected single-phase portion of the London, Brighton & South Coast Railway, are entirely without batteries. In the United States, although railway batteries are by no means the rule, they are still being put down in some thoroughly up-to-date undertakings; for example, a group with an aggregate capacity of no less than 22,000 ampere-hours is being installed in the sub-stations of the electrified portion of the New York Central & Hudson River Railroad.

The same difference of opinion exists in tramway practice. Of those stations which supply tramways only, and not lighting, quite three-quarters manage without batteries either as buffers or for running the early and late cars. In the case of stations which supply both lighting and power, on the other hand, the proportion employing batteries is much higher, being very nearly 80 per cent., while in supply stations where there is no tramway load the number of cases where batteries are used forms over 80 per cent. of the total. It must be realised that a considerable number of old stations are included in these figures, which were established in the days when conditions of load factor were not so favourable as now, and, if they had been designed later, might have dispensed with their battery room. Looking at these figures, and taking account of the fact that in some cases the battery simply serves as a reserve source of supply to station lighting and excitation and to the pump motors and other auxiliaries, it is difficult not to believe that the saving effected in the majority of cases by the use of batteries in lighting stations is not greater than Mr. SALTER would have us believe, and that for some time to come the smaller undertakings, at any rate, will continue to be good customers to the battery manufacturer. In the case of heavy traction, however, we doubt that, even with the assistance of the automatic reversible booster, the economies furnished by batteries will be able to place a powerful enough weapon in the hands of the continuous-current system to enable it finally to vanquish its single-phase rival.

## REVIEWS.

**(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign book.**

◆

**The Management of Accumulators.** By Sir DAVID SALOMONS. 9th edition. Being a new and revised edition of Vol. I. of "Electric Light Installations and the Management of Accumulators." (London: Whittaker & Co.) 6s. net.

In the Preface to this book the author explains that, owing to the increasing size of his work on "Electric Light Installations and the Management of Accumulators," he has found it necessary to issue the first volume as a separate book, and he has given it the title which appears above. No fault can be found with this proceeding, as the subject is one that undoubtedly warrants very full and careful treatment; but we are surprised that the author's revision did not eliminate much superfluous matter and include some other matter conspicuous by its absence. While there is a good deal that is of value in the book, there is so much to which we must take exception that we hesitate to recommend it to the amateur or the unskilled battery attendant, and the book is apparently chiefly dedicated to these two classes of readers. A few instances will suffice.

Sir David Salomons is of the opinion that the manufacturer, "as a rule, knows comparatively little of the properties of batteries, for his knowledge is confined to laboratory tests, and it is not to his interest to publish all the shortcomings of his wares." Referring to the first part only of this remarkable statement, we would point out that the author is under a grievous delusion. He cannot be aware that all the principal battery companies are responsible for numerous batteries, under maintenance contracts, and that each employs a staff of trained experts who are quite familiar with the properties of batteries. We trust that Sir David is also in error when he taxes manufacturers of dry cells with recommending their wares for practical electric lighting. On p. 52 he asserts that in the case of large cells the plates rest on the edges of the lead-lined boxes, and it is to be hoped that no country-house electrician will follow his advice in this respect. A similar remark applies to the instructions for lead burning on p. 65. Nor can we agree with the author in recommending the addition of alkalies to the electrolyte. Dilute sulphuric acid, pure and simple, is the only thing required, and "doctoring" the electrolyte is to be deprecated.

In addition to the points which we have already mentioned there are several others which indicate a lack of care in the process of revision. Certain statements are repeated so often as to become positively monotonous. For instance, the purple tinge of the electrolyte due to $KMnO_4$ is referred to and duly explained no fewer than three times, and yet the author fails to emphasise the absolute necessity of using nothing but distilled water for "topping up." Tap water is responsible for more ruined plates than most people suspect. As an instance of the typographical errors we may give the following: "All currents may be regarded as more or less dangerous to the person after 250 volts, but the pressures of 60 to 100 volts, which are harmless under ordinary circumstances, may prove dangerous under peculiar conditions."

There is a good deal of information in the later chapters which will prove useful to battery attendants and prospective owners of small batteries, but one or two dimensioned line drawings of battery rooms are desirable.

**Electricity as Applied to Mining.** By ARNOLD LUPTON, G. D. ASPINALL PARR, and HERBERT PERKIN. 2nd edition. (London: Crosby, Lockwood & Son.) 1905. 12s.

In reviewing the first edition we pointed out the difficulty of doing justice to both the electrical and the mechanical sides of the subject, and stated that the joint authorship was, in our opinion, a step in the right direction. The fact that a second edition has been called for in less than three years is certainly a proof of the success of this venture. The original scheme appears to have been closely followed, even to the numbering and headings of the chapters; and the subject matter has been enlarged so that the pages are increased in number from 280 to 320. But although the text has been revised to some extent with undoubted profit, there is still much room for the judicious correction of loose statements and the omission of scrappy details which are likely to prove misleading to the mining engineer for whom the book is primarily intended. Perhaps the most interesting chapter is No. VIII., in which are discussed central electric plants for the transmission of power, with numerical illustrations of costs of plant and power. The appendix, containing the Home Office Special Rules for the Installation and Use of Electricity in Mines, with notes by the authors, should form a valuable addition.

**Modern Turbine Practice.** By JOHN WOLF THURSO. (London: A. Constable & Co.) 1906. 16s.

A readable practical book describing modern water turbine installations by the aid of good illustrations. Amongst others will be found descriptions and illustrations of the 5,500 H.P. turbine for power house No. 2 of the Niagara Falls Power Co.; of the 3,000 H.P. turbine for the electric works on the River Glommen, Norway; of the 2,500 H.P. turbine for the Isawerk, near Munich, Germany; of the 3,000 H.P. turbine for the Cataract Power Co., Hamilton, Ontaria; of the 6,000 H.P. turbine for the Shawinigan Water & Power Co., Shawinigan Falls, Quebec, besides many descriptions and illustrations of details of governors and turbine accessories.

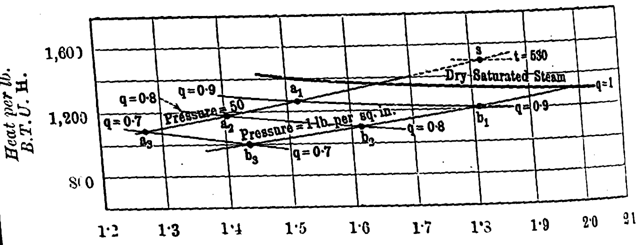
The author expresses his high appreciation for European practice and does not disguise his disapprobation of current American practice, which he considers considerably behind the practice by the best European firms. One chapter of the eleven which form the book is devoted to steam turbines. The whole subject is disposed of in 16 pages, so that little more than mere general descriptions of a few types is attempted.

**Steam Turbines.** By W. GENTSCH. (London: Longmans, Green & Co.) 1906. 21s.

We reviewed this important work on the appearance of the original German edition (*The Electrician*, Vol. LIV., p. 510). The English translation will be welcomed by all who are interested professionally in the steam turbine. It is not a work suitable for students who are approaching the subject for the first time, but given an elementary knowledge of the principles of the subject this book will be found invaluable for more complete study of the different types of steam turbine and their mechanical details. The plan of the work is to take each detail of construction, and each point of principle in turn, and to study them exhaustively. An idea of this arrangement may be obtained from the consideration of one or two chapter headings. Thus, Chapter VIII. is devoted entirely to Condensation, Chapter XII. to Governing Appliances, Chapter XVIII. to Bearings, Chapter XVI. to Clearance Space Packings. The book is profusely illustrated, there being no less than 637 illustrations besides some folding plates. After a short historical introduction, the subject proper is introduced by a chapter on pressure turbines, and here the reader will find described and illustrated a large number of forms which have been proposed and made, including, of course, the types which have persisted. Velocity turbines are then considered in the same complete way in Chapter II., a large number of forms being described. The book is mainly descriptive, and a general reader will find much of interest. This is the most important reference book on the subject which has yet appeared.

**Die Dampfturbine.** WILHELM H. EYERMANN. (Munich and Berlin: R. Oldenbourg.) 1906. 9 marks.

This is a practical book on the subject of the first rank. The plan of the book is good, and the difficulties of the subject are approached gradually. It is first explained by means of the pressure-volume diagram that the available energy when unit weight of steam expands from the boiler pressure to the condenser pressure may all be changed into energy of motion by passing it through a properly formed nozzle, but that the velocity of the turbine wheel which is necessary to utilise this energy of motion properly, and to convert it into mechanical energy, is too great to be practicable. Methods are then described of utilising the available energy with a reduced wheel velocity, and this leads naturally to a classification of turbine types; a diagram shows very clearly the various arrangements which have been suggested or tried. The principles of the thermodynamics required for turbine problems are then briefly and clearly elaborated in the next chapter, and an explanation is given of the uses and the relations between the pressure-volume diagram, the entropy temperature diagram and the Mollier diagram, a diagram obtained by plotting the total heat of steam vertically against the entropy. A vertical line on the Mollier diagram represents an adiabatic change, as on the entropy temperature diagram, but the horizontal line represents a change where the heat contents of the steam is constant. As this is probably a new form of diagram to many readers, a brief description of a way to plot it may be found of interest. Take two rectangular axes, Fig. 1, and choosing suitable scales of entropy and heat, plot the curve representing the total heat of a pound of dry saturated steam against the corresponding entropy, taking the quantities from a steam table, obtaining thus the line marked $q=1$ in the figure. Any point on this line represents a state of dry saturation. The object now is to draw lines of constant pressure, *i.e.*, of constant temperature for saturated steam, crossed by lines of constant dryness below the line $q=1$, and by lines of constant temperature above the line of saturation where the steam will be superheated. Points may be calculated in the following way. If H is the heat contents of steam, $h$ the water or sensible heat, and L the latent heat



MOLLIER'S H,φ DIAGRAM.

$$H = h + qL. \quad \ldots\ldots \quad (1)$$

Again, if T is the absolute temperature of the steam, and $\phi$ the entropy of the steam, $\phi_w$ being the entropy of the water,

$$\phi = \phi_w + \frac{qL}{T}. \quad \ldots\ldots \quad (2)$$

A pressure, and therefore T, may be fixed, and then $q$ may be chosen, and hence corresponding values of H and $\phi$ may be calculated from equations (1) and (2). The point thus determined lies at the intersection of the pressure curve corresponding to $p$, and on the dryness curve corresponding to $q$. By selecting a value of $p$, and giving a series of values to $q$, a curve of constant pressure, $p$, may be drawn on the diagram on which lie a series of points corresponding to the values of $q$ chosen. Again, selecting another value of $p$, and assigning to $q$ the values used in the previous calculation, a second constant-pressure curve is found on which are a series of points corresponding to the values of $q$ chosen.

In this way a family of constant-pressure curves may be drawn, and by joining the points of equal dryness on them a second family of curves are determined crossing them, which give constant dryness. Thus the region below the curve $q=1$ may be mapped out by two families of curves—one of constant pressure, the other of constant dryness.

A few points may be plotted as an example. Let it be required to draw the pressure curve corresponding to $p=50$ lb. per square inch. From the steam tables it will be found that

$$h = 250,\ L = 917,\ T = 742 \text{ and } \phi_w = 0{\cdot}41,$$

so that the pair of equations become

$$H=250+q917,$$

$$\phi=0{\cdot}41+\frac{q917}{742}.$$

Solving these for values of $q$, 0·9, 0·8, 0·7, the corresponding values of H and $\phi$ are

| $q$ | H | $\phi$ |
|---|---|---|
| 0·9 | 1,075 | 1·52 |
| 0·8 | 984 | 1·40 |
| 0·7 | 892 | 1·27 |

The points are represented by the points $a_1$, $a_2$, $a_3$ in Fig 1, and a portion of the constant-pressure curve, $p=50$, is drawn.

Again, take $p=1$ lb. per square inch. From the steam tables

$$h=70,\ L=1{,}043,\ T=563 \text{ and } \phi=0\ 136.$$

Solving the equations for values of $q$, 0·9, 0·8 and 0·7

| $q$ | H | $\phi$ |
|---|---|---|
| 0·9 | 1,010 | 1·806 |
| 0·8 | 905 | 1·61 |
| 0·7 | 800 | 1·44 |

These points are represented by $b_1$, $b_2$ and $b_3$ in Fig. 1. The curve through them is part of the constant-pressure curve $p=1$. And joining $a_1b_1$, $a_2b_2$ and $a_3b_3$ portions of the curves of constant dryness

$$q=0{\cdot}9,\ q=0{\cdot}8 \text{ and } q=0{\cdot}7 \text{ are found.}$$

This example sufficiently illustrates how the lower part of the diagram may be plotted. Above the curve $q=1$ the dryness curves become constant-temperature curves of superheat and points may be found on them in a similar manner from the simultaneous equations

$$H_1=H+(t_1-t)\ 0{\cdot}48$$

$$\phi=\phi_{\text{steam}}+(\log_e t_1-\log_e t)\ 0{\cdot}48.$$

In this case, a pressure is to be selected and then a series of values are to be assigned to $t_1$ the temperature of superheat, $t$ being the temperature of evaporation corresponding to the pressure chosen. One point, $s$, is shown in Fig. 1 corresponding to p=50 and a superheat temperature of 530 deg.

In the above equations the specific heat of superheated steam is taken constant and equal to 0·48. In the treatise under review other ways of drawing the curves are indicated. A large Mollier chart is included with the volume. It may be mentioned that a Mollier chart in English units is to be found in the English translation of Prof. Stodola's book on "Steam Turbines." This chart is extremely useful with regard to calculations in connection with the thermodynamics of steam turbines. In particular, it enables the effect of friction in the nozzles to be exhibited.

Chapter III. is devoted to the design of nozzles, to the design and construction of the several details of the turbine, and some useful practical diagrams are given, by means of which the computations are facilitated. This chapter is full of practical information and is well illustrated. The remainder of the book contains a chapter on steam consumption, on the considerations affecting the choice of a type, and a chapter in which several well-known types are illustrated and described. This is a well-printed, well-illustrated and well-written book on the subject of steam turbines, and will repay careful study.

W. E. DALBY.

**Les Quantités Elementaires d'Electricité: Ions, Electrons, Corpuscles.** Mémoires réunis et publiés par HENRI ABRAHAM et PAUL LANGEVIN. Published under the auspices of the Société Française de Physique. Two volumes. (Paris: Gauthiers-Villars.) 36f.

The title of this work conveys the impression that various elementary quantities of electricity exist, called ions, electrons and corpuscles respectively. But an ion may, according to modern usage, be any small particle endowed with an electric charge, while a corpuscle has always been understood to be a small particle of ponderable or imponderable matter. The word electron has a specialised and almost universally accepted meaning. It signifies the elementary quantity of electricity such as is found to exist in every domain of electric phenomena. Its charge is understood to be "negative" unless otherwise stated. Positive electrons may exist and may possibly be discovered in future, but so far they are unknown, and even unsuspected except in connection with the Hall effect. The word corpuscle is used in the sense of electron by Thomson and Poincaré only, and the word electrion by Lord Kelvin. Is it too much to ask them to fall into line with the rest of the world of physics, and save their weaker brethren from unnecessary confusion? The fine work before us shows that such a unification of terminology would be eminently desirable. Here we have a collection of 97 Papers on ionisation produced by various agents, on the mobility, diffusion and recombination of ions, on the various bodies which emit electrons, on metallic conduction and cosmic phenomena explained through their agency, and on the dynamical, optical and electromagnetic phenomena in which electrons play a part. The authors are alphabetically arranged, and their Papers are in order of time. This prevents the charge of favouritism, but also interferes with the clearness of the historical development of the electron theory, more especially as in many cases no dates are given. The selection of Papers, though judicious on the whole, is open to some criticism. Why, for instance, are Aitken, Coulier and Edison quoted, and Bucherer and Zeeman ignored? Surely there is no comparison between the former and the latter in the matter of the electron theory. No less than 11 Papers are deservedly quoted from J. J. Thomson, and 10 from J. Townsend, while Kaufmann, Lorentz, Rutherford, Stark and the Wilsons hold the lion's share of the remainder. The work is bound to be of great use to the builders of the new theory of electricity and magnetism.

E.E.F.

## THE EFFICIENCY OF LAMP GLOBES.*

BY F. C. PRENTICE AND J. S. WESTERDALE.

The first portion of the Paper contains an account of previous work which has been done on the subject of the efficiency of globes. Dr. Sumpner in a Paper entitled "The Diffusion of Light" (*Phil. Mag.*, February, 1893) (see also *The Electrician*, Vol. XXX., pp. 381, 411 and 439), tested three globes which absorbed 15, 42 and 39 per cent. of the light respectively. Experiments of Messrs. Guthrie and Reidhead are given by Mr. G. D. Shepherdson in a Paper on "The Loss of Light from the Use of Globes with Arc Lamps" (the *Electrical World*, 1894). Mean spherical and mean hemispherical candle powers were measured and the efficiencies of clear, ground glass and opal globes are given as 73·8, 50·2 and 45·2 per cent. for mean spherical and 72·4, 47·8 and 30·7 per cent. for mean hemispherical candle-power respectively. The authors, however, point out some possible causes of error. A Paper by Stort (*Elektrotechnische Zeitschrift*, 1895), however, gives the loss of light with a clear glass globe as 6 per cent. and that with an opal globe as 11 per cent. Experiments by Williamson and Klink, published in the *Journal* of the Franklin Institute (Vol. CXLIX., 1900), dealing mainly with the distribution of light by "holophane" and other globes are next referred to, and after mentioning the article by Mr. M. Solomon on "Some Tests on Lamp Globes" which was published in *The Electrician*, November 3, 1905, p. 91, the first portion of the Paper concludes with a reference to a series of articles by Cravath and Lansingh on "Reflectors, Shades and Globes," which recently appeared in the *Electrical World*. In few of these investigations, however, were polar curves of light distribution made on arc lamps surrounded by globes, so it was with this idea that the authors' experiments were carried out, at the instigation of Prof. J. A. Fleming, in the "Pender" laboratories at University College.

Arrangements were made so that the beam to which the arc lamp was attached could be rotated to any angle about a centre which carried a plane mirror situated in the axis of the optical bench. The arc was inverted to facilitate removal of the globes, and care was taken to keep the P.D. constant at 50 volts and the current constant at 6 amperes. Each observation given in an average of several readings, and the coefficient of reflection of the mirror, were accurately determined and allowed for. As secondary standards, a series of ordinary incandescent lamps were used and these were calibrated against a Fleming large bulb incandescent lamp having a known candle-power at a known current. A fixed Lummer-Brodhun prism photometer was used, the secondary standard being moved to obtain a balance. Figs. 1 to 4 give a set of polar diagrams for four of the cases investigated. The "Rousseau" curves were deduced from these in the usual way. The mean spherical and mean hemispherical candle-powers obtained from these diagrams are given in the following table:—

---

* Abstract of Paper read before the Students' Section of the Institution of Electrical Engineers, March 14, 1906.

| Globe. | Mean spherical c.p. |  | Mean spherical ratio. Per cent. | Mean hemi-spherical c.p. |  | Mean hemi-spherical ratio. Per cent. |
|---|---|---|---|---|---|---|
|  | Arc only. | Arc in globe. |  | Arc only. | Arc in globe. |  |
| 13 in. alabaster.. | 346 | 339 | 98·0 | 592 | 473 | 79·9 |
| 13 in. clear...... | 346 | 308 | 89·0 | 592 | 520 | 87·9 |
| 13 in. opalescent.. | 342 | 343 | 100·0 | 288 | 238 | 82·8 |
| 12 in. prism .... | 342 | 306 | 89·5 | 288 | 250 | 86·9 |

Referring to the polar curves, it is seen that in the case of the uncovered arcs the candle-power drops very rapidly after about 70 deg., owing to the effect of the negative carbon cutting off light from the crater of the positive carbon. But in the case of the alabaster and opalescent globes, the globe itself becomes to a certain extent the source of light, owing to dispersion, so that when the globe is on we get a measurable candle-power right up to 180 deg. There is another important reason why the candle-power in directions above 90 deg. is greater with the globe on than with the arc alone. Light from the crater falls on to the lower parts of the globe and is partly reflected back. This reflected light is partly emitted through the upper part of the globe, thus increasing the candle-power in these directions. The opalescent and alabaster globes cut off a large percentage of the light. This, however, is not all lost, but, being partly dispersed and partly reflected back, increases the candle-power in the directions where for the arc alone it would be either nothing or very small. This accounts for the high values of the mean spherical ratio obtained. From the curves we see that in the directions where the candle-power of the arc is greatest the opalescent globe cuts off more light than the alabaster, even though it is not so dense. This is due to its power of selective dispersion. The yellow rays pass through the globe, but a great part of the blue rays are reflected back and help to increase the candle-powers in the top part of the curve. For street lighting, all light above the horizontal is useless, so that globes that disperse the light well through the 180 deg. are unsuitable, although the mean spherical ratio may be great. The mean hemispherical ratio is the more important in this connection. The clear glass and prism globes have the highest mean hemispherical ratios, so that for street lighting these globes would be more suitable. In conclusion, the authors tender their thanks to Messrs. Hattersley & Davidson, Messrs. Johnson & Phillips, the Electrical Co. and the Brockie Pell Arc Lamp Co., who kindly lent them globes.

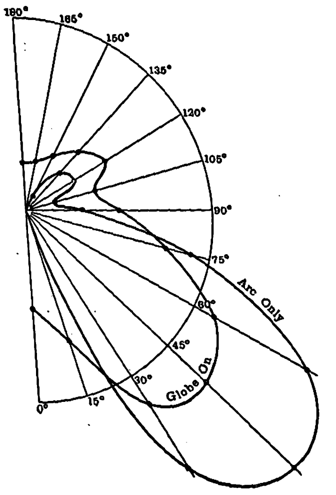


FIG. 1.—PHOTOMETRIC CURVES FOR 13 IN. ALABASTER GLOBE.

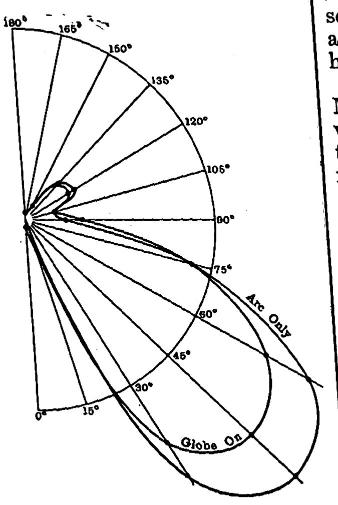


FIG. 2.—PHOTOMETRIC CURVES FOR 13 IN. CLEAR GLASS GLOBE.

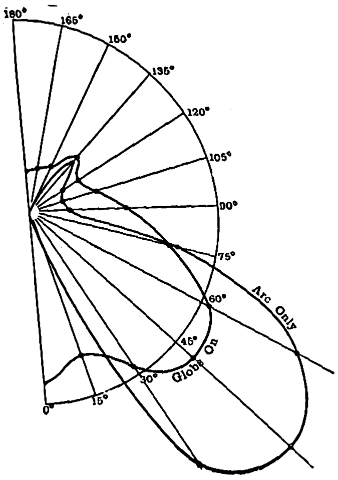


FIG. 3.—PHOTOMETRIC CURVES FOR 13 IN. OPAL GLOBE.

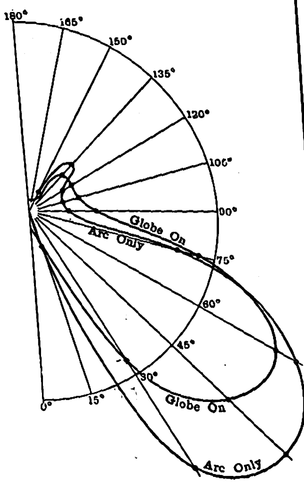


FIG. 4.—PHOTOMETRIC CURVES FOR 12 IN. PRISM GLOBE.

## THE AUSTRALIAN TELEPHONE AND TELEGRAPH SERVICE.

Our Adelaide correspondent writes us as follows: The newly-created position of Chief Electrical Engineer to the Commonwealth Post and Telegraph Department has been conferred on Mr. John Hesketh, the chief electrical officer of the Queensland branch of the service, as was generally expected. Mr. Hesketh, who will receive a salary of £750 per annum in his new position, will in future have his headquarters in Melbourne.

A commencement has been made upon the construction of the Melbourne to Sydney telephone line, gangs of men being now at work upon the existing telegraph route, affixing the brackets for the telephone wires, and lengthening or staying the posts wherever necessary. Specifications have been issued for the conductors and other materials, and it is hoped that the line will be completed and in service by the end of the year. A double line will, of course, be erected, and each wire will weigh 600 lb. per mile, so that as the distance between the cities is 500 miles, over 250 tons of copper will be required. The principal towns en route, some eight or ten in number, will be connected to the circuit, and if the present venture is financially successful, an extension to Brisbane may be looked for in the near future. The tariff has been tentatively fixed at 6s. per conversation of three minutes, which is estimated to return 8 or 10 per cent. upon the capital cost, without, however, any allowance being made for the loss of telegraphic traffic which may be expected by the department when their telephone line enters into competition. The Postmaster-General states that he hopes to be able to reduce this figure, since he believes previous estimates of receipts from trunk lines to have been considerably too low.

The Postmaster-General, Mr. Austin Chapman, who departed for the International Postal Congress at Rome by the P. and O. ss "Moldavia" on February 22nd, announced prior to sailing that throughout the whole telephone service of the Commonwealth the toll system of charging will be introduced on July 1st. Old subscribers will have the option of continuing at the present flat rates (£9 for business premises and £5 for private houses in the principal cities), but no additional subscribers will be taken on except under the new tariff. The complete schedule of charges is as follows:—

| Population of town. | Separate line. | Two-party line. | Four-party line. |
|---|---|---|---|
| Under 10,000...... | £4 0 0 .... | £3 0 0 .... | £2 10 0 |
| 10,000 to 100,000 .. | 5 0 0 .... | 3 15 0 .... | 3 0 0 |
| 100,000 to 250,000 .. | 5 10 0 .... | 4 0 0 .... | 3 0 0 |
| 250,000 upwards .. | 6 0 0 .... | 4 5 0 .... | 3 5 0 |

In all cases 760 free calls will be allowed, and ½d. per call charged for all excess.

Tenders for new switchboards upon the common battery principle are to be called for Melbourne as soon as specifications can be got out, and a commencement made on the thorough reorganisation of this service, though as this is estimated to cost £200,000 to £250,000, the work will be spread over the next five years. The Sydney service will also shortly undergo much improvement, and, though it will not be possible to have the new boards installed by July, it is hoped that they may be ready soon after.

## AN IMPROVED ARC LAMP LOWERING GEAR.

An ingenious form of suspension for arc lamps, which breaks contact when the lamp is lowered, is shown in section in the accompanying figure. The arrangement is certain in action, and engages or disengages as required simply by winding up the lamp as far as it will go and starting to lower it. Current is conveyed by the cables to the two substantial hinged pieces $C_1$ and $C_2$, which act at the same time as contacts and suspending hooks for the lamp. These suspenders are insulated with mica and have their hooked ends tipped with phosphor bronze springs, which form the contacts. Each is provided with a releasing shutter, R, which when pushed up enables the hook to engage in the annular socket on the under side of the lamp insulator, but when down closes the hook so that the descending insulator passes by and pushes the suspender arm aside. The suspenders in the figure are shown in these two positions but they will, of course, in reality both be always in the same position. Thus when the lamp is going into engagement the releasing shutters rise up and allow the suspenders to engage when the lamp is lowered after touching the stop. For disengaging, the lamp is raised high enough to free the shutters and cause them to fall, and prevent the hooks engaging. Thus the whole action depends on raising the lamp higher for disengaging than for engaging. This is done automatically by a stop, S, which contains a triangular piece, which is partly rotated by the act of lowering, so that it projects and prevents the stop passing into a slot when the lamp is next raised for engagement. The lamp spindle has a self-centring and self-locating device, consisting of a stud and a slot, which ensures the right contact being made. The lamp contacts are well protected, as they are on the underside of the insulator. The apparatus is made by the North-Western Electrical Appliance Co., of Glasgow, and can also be arranged for three contacts instead of two. We understand that a number of these couplings are being supplied to the Corporation of Bristol.

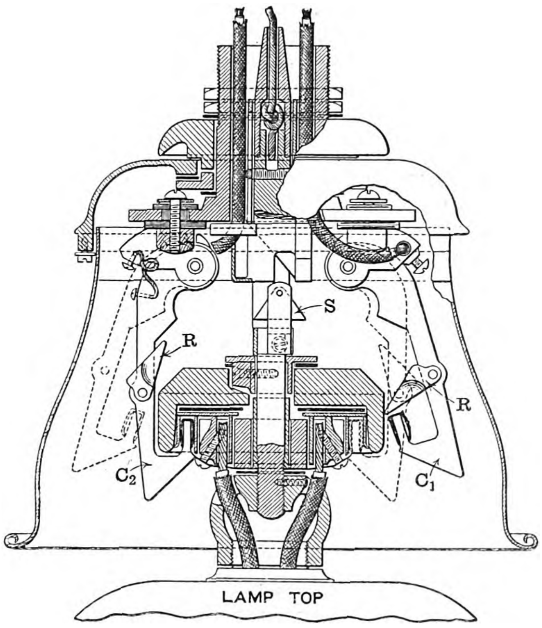


Fig. 1.—Section of Two-contact Lowering Gear.

## SOUTH SHIELDS ELECTRIC TRAMWAYS.

Although the Corporation of South Shields obtained a provisional order for the construction of electric tramways in 1903, it was not until last June that a commencement was made with the work. At the present time there is a route mileage of 2½ miles completed for traffic, and in the course of a few months a further 4 miles will be available. The routes are principally double track, constructed on the overhead trolley principle, the steepest gradient being 1 in 16, which only occurs for a short distance.

Messrs. H. Underwood & Co. were the contractors for the permanent way work, which, together with the car depot, was carried out to the specifications and under the supervision of the borough surveyor, Mr. S. E. Burgess. All the special work is from Hadfield Steel Foundry Co., and is of manganese steel. In the electrical equipment of the track, 12 in. protected bonds of the Forest City Electrical Co.'s manufacture have been used, two at each joint, with cross bonds of 4/0 B. & S. gauge inserted at 160 ft. intervals and inter-track bonds of the same size placed about every 240 ft., bridging bonds being used at all points and crossings. The overhead construction for which Messrs. Dick, Kerr & Co. were contractors, is principally of the side-bracket pole construction, two grades of poles being used except at one or two very heavy curves, where an extra heavy pole is used to take the severe strain of the pull-offs. These tubes are butt-welded and measure 31 ft. long overall, exclusive of the finials, and the depth which they are sunk into the ground is 6 ft. Grooved trolley wire of hard-drawn copper 3/0 B. & S. wire gauge is used throughout and is clamped up by the ears, no solder being used. The ears used on straight runs are 18 in. long and on curves 24 in.

The car depot is capable of housing 40 cars, and was built by Messrs. Arnold, of Doncaster. Eight tracks are provided inside, and each has an inspection pit running almost the entire length. Kinnear revolving steel shutters are fitted and the workshops and offices adjoin the main building.

The 10 cars now running are of the double-deck type, constructed by Messrs. Hurst, Nelson & Co. (Ltd.). They measure 29 ft. overall length by 7 ft. overall width and have open staircases and garden-type seats inside and outside. The seating capacity is 24 inside and 34 outside. The trucks are of the Brill type with four 30 in. wheels and 6 ft. 6 in. wheel base. Each truck is fitted with two 30 H.P. motors, which, with controllers, were supplied by the British Westinghouse Co. Hand and electric brakes are provided.

Energy for the operation of the system is supplied from the Corporation's electricity works, which has been extended to provide for the necessary plant required.

In the boiler house one marine boiler 14 ft. 6 in. external diameter by 10 ft. 6 in. long, with a heating surface of about 2,000 sq. ft. has been added to the five existing ones. The generating plant consists of two 550 kw., 10 pole Dick Kerr generators, direct-coupled to triple expansion marine engines by Messrs. J. and H. McLaren, running at 150 revs per min.

These sets have an output of 1,000 amperes at 550 volts and are over-compounded to give a range of 50 volts between no load and full load. They are capable of standing an overload of 25 per cent. for two hours and 40 per cent. for short periods. The surface condensers are fixed behind each engine and have each a cooling surface of 1,690 sq. ft. The air pumps are of the Edwards type worked by levers from the M.P. crosshead.

Two additional Worthington pumps have been installed for the circulating water, which is pumped from the Tyne into three storage tanks placed on the roof, but can also be pumped direct to the condensers if required. All the extensions and alterations to the pipe work have been carried out by Messrs. J. Abbot & Co. (Ltd.), Gateshead.

The traction switchboard was constructed by the British Thomson-Houston Co., and is of enamelled slate mounted in an iron frame. There are three generator panels, one of which is a spare, and four feeder panels for two feeders each, also the usual Board of Trade panel in the centre.

The generator panels are each equipped with two machine switches, a B.T.-H. circuit-breaker, an ammeter, an equalising switch, and a multiple contact-shunt resistance switch. The feeder panels have two feeder switches, two circuit breakers, two ammeters, two lightning arresters and choking coils, and two integrating wattmaters. Two illuminated dial 'bus-bar voltmeters are provided on a swinging bracket at the end of the board. With the exception of the integrating wattmeters, the instruments are by Messrs. Elliott Bros.

At present five feeder cables are laid, two of these being 0·3 sq. in. section and the others 0·15 sq. in. These are laid in earthenware conduits with draw-in boxes where necessary. Three negative return cables are also laid, each of these being 0·4 sq in. section and laid in earthenware troughing filled solid with bitumen and covered with tiles. All feeder cables are lead covered and juted over all.

A complete telephone installation has been provided in conjunction with the feeder and section pillars, these giving communication between these points and the power station.

The whole of the work, with the exception of the permanent way and car depot, has been carried out to the specifications and instructions of, and under the supervision of the borough electrical engineer, Mr. J. H. Cawthra.

The line was formally opened for traffic last Friday, the first car being driven by Councillor Wylie, chairman of the Tramways committee, and the second by Councillor Henderson, the vice-chairman. Luncheon was served at the Royal Hotel after the ceremony, under the presidency of the Mayor, Councillor Robertson.

## CORRESPONDENCE.

### GRADING LAMP VOLTAGES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The recent correspondence in your columns on the above subject is not only of considerable interest, but of great and intrinsic importance to the whole electric lighting industry, and I am glad that the question has been brought forward, and is being ventilated by this discussion. The time, I think, could scarcely be more opportune whilst the question of a standard specification for this country is under consideration by the Engineering Standards Committee and the Municipal Electrical Association, and it would be well if both these bodies took the matter up seriously.

It is not a question of how much cheaper lamps can be made under such a system, but rather how much more efficient such lamps can be obtained and worked by adopting the principle of grading, and this, I think, is evidenced by the reference in your correspondence to the various metallic filament lamps, which are so much more costly than the present carbon glow-lamp, and it will be agreed further that the latter is very much nearer perfection than the former.

The one object in view, both for lamp manufacturers and supply stations, is to extend the use of electricity for lighting purposes, and one of the main factors in this direction is the lamp, and it is universally admitted that its efficiency in all respects would be very materially increased if run at its proper voltage. This would also minimise, if not altogether eliminate, trouble to the consumer, and the consequent prejudice against electric lighting.

There are, no doubt, difficulties in systematic grading of voltages in our towns, but I do not think that they are altogether insurmountable, and a scheme based on the lines proposed by Mr. Fedden in his letter might be considered by the authorities. It seems to me that it is not a question altogether of reducing or increasing the pressure of supply, but of using the actual conditions as they stand to-day, and I am glad to hear that one, at any rate, of the largest supply companies is seriously considering the question of using lamps of varied voltages, and grading the voltage of the lamps to the different districts, and in accordance with the varied pressures on their network.

Let the supply companies determine the areas for certain voltages, and then issue a circular to the consumers in these particular districts informing them of the voltage at which their lamps should be purchased to give the best results.

This plan, I feel sure, would work to everybody's advantage, and although as a lamp-maker I am not going to prophesy wholesale reductions in the price of the lamps, as we are aiming at efficiency rather than cheapness, yet I am certain that greater satisfaction would be given to those who have to pay for the current, prejudices caused by the present conditions would be removed and benefit would accrue to all concerned. I hope, therefore, that the question will not be shelved until serious consideration has been given to it by all the authorities, and some attempt made to meet and overcome the difficulties.—Yours, &c., T. J. Grainger.

The Sunbeam Lamp Co. (Ltd.), Gateshead, April 4.

## PHASE MEASUREMENT.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your issues of March 16th and 30th, Mr. J. W Waghorn describes how the power factor of the current in any one branch of a polyphase system may be arrived at by shifting the volt leads of the wattmeter. We have made much use of this method for some time, and have dealt with it in our Paper on the "Testing of Transformers and Transformer Iron," which is to be read before the Birmingham Local Section of the Institution of Electrical Engineers on the 25th inst. The method, which we refer to as the *three-point wattmeter method*, is properly applicable whenever single-phase testing is done from a three-phase supply, and we have found it to be the best way available for measuring, not only power factor, but current. The volt-ampere value, which the three-point method leads to, serves in conjunction with the voltmeter as a more perfect ammeter than is commonly attainable, and cases arise in which it is more important to obtain an accurate measure of the current than of the power factor. A simple graphical method of determining both current and phase angle is given in the Paper referred to, and one which is true when the voltages and phase angles of the supply are unsymmetrical.—Yours, &c.,

D. K. Morris,
The University, Birmingham, April 2. G. A. Lister.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Mr. Waghorn, in a letter printed in your last issue, implies that I have misunderstood his method of finding power factor, but the method is too well known to me for this to be the case. In his letter of March 16th he says, "There is also the advantage that the efficiency and power factor of a synchronous or induction motor can be obtained by the use of a single electrical instrument, the wattmeter." I took this statement to imply that Mr. Waghorn was using his method to estimate the average power factor of a multiphase circuit, in which case the criticism I made would apply, as, indeed, Mr. Waghorn admits. But it now appears that the method is only advocated for determining the power factor of *one* of the currents in a multiphase circuit. Under these conditions the method is undeniably accurate if the two voltages to which the pressure coil of the wattmeter is successively connected are of known relative magnitude and phase.

But the method is certainly not new. It is claimed by M'Allister (see *Science Abstracts*, No. 83 of 1902), and an almost identical method is claimed by Frankenfield (No. 92 of 1903). There are no doubt other claimants, and personally I am inclined to think the method is as old as the wattmeter itself. The modern phasemeter, which is merely a multiple wattmeter, consists in one of its most common forms of a single fixed current coil, together with a moving system comprising two pressure coils, connected to two of the voltages of a multiphase set of mains. Such an instrument performs in one operation what the method described by Mr. Waghorn accomplishes in two stages.—Yours, &c.,

W. E. Sumpner.

Technical School, Birmingham, April 2.

## A CONDUCTING GLASS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In commenting last week upon my letter, you referred to certain flint glasses as capable of conducting electricity to a degree comparable with that of the glass to which I drew attention.

May I suggest that you have overlooked the fact of the great increase in resistivity produced in glass by adding even small quantities of lead to the mixture before fusing.

Flint (*i.e.*, lead) glasses are especially remarkable for their extremely—in many cases immeasurably—small conductivity.

Shooters Hill, April 2. Charles E. S. Phillips.

[Mr. Phillips is quite right. We took our figures hastily from Landolt and Börnstein's tables. On now looking at Prof. A. Gray's measurements we find that flint glass is credited with a greater resistance than common glass.—Ed. *E.*]

## SINGLE-PHASE COMMUTATOR MOTORS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: On pages 794 and 795 of his new book on alternating-current machinery, Prof. S. P. Thompson gives a very simple explanation of the A.C. series motor. On p. 794, however, occurs the following statement:—

"At any moment the torque will be proportional to the product of the current and the flux, which it is at that moment producing in the magnet system, *and the average torque will be, cæteris paribus, the product of the average current and the average flux it produces.*" This is surely a mistake, for it can easily be shown that the mean product is not the same, even approximately, as the product of the means. Assuming sine curves and proportionality between current and flux, the torque at any moment is proportional to $C^2$, the mean torque will then be proportional to $C^2_{\text{max.}}/2$, while the product of the means will be proportional to $(2/\pi)^2C^2_{\text{max.}}$, which is about 0·8 of the mean torque. This factor being a constant for sine waves, it may be said that the torque *is proportional to* the mean current multiplied by the mean flux, but it is necessary to use R.M.S. values of current and flux, if equality be substituted for proportionality.—Yours, &c., G. W. O. Howe.

Central Technical College, London, S.W., April 4.

## THE OSCILLOSCOPE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your issue of March 16, 1906, pp. 868 and 881, there is called attention to "Ruhmer's ingenious oscilloscope," described by Dr. Lewis Jones. I beg to remark that it was *not* Mr. Ruhmer who invented this oscilloscope, generally called "glow-light oscillograph." In 1904, April 29, I held a lecture before the German Physical Society and demonstrated the first apparatus of this kind. My first description of it is published in *Verbandlungen der Deutschen Physikalichen Gesellschaft*, Vol. VI., p. 176, 1904. The form of this instrument does not much differ from that announced by Mr. Ruhmer in the *Elektrotechnische Zeitschrift*, Vol. XXVI., p. 143, 1905. But I have invented the characteristic part of this later one, too—that is to say, the mica disc between the two electrodes. If this fact is not known to the writer of the articles in *The*

*Electrician* (*loc. cit.*), it is because of Mr. Ruhmer's not mentioning my authorship in the invention of the mica disc too. I have given a short rectification of Mr. Ruhmer's Paper in the *Zeitschrift für Instrumentenkunde*, Vol. XXV., p. 278 (note 3), 1905.

On this occasion I may remark that the first form of the oscillograph, also described in the *Zeitschrift für Instrumentenkunde*, Vol. XXV., p. 33, 1905, as well as the form with the mica disc between the two nickel wires, has now been superseded by a new construction of mine, published in the *Zeitschrift für Instrumentenkunde*, Vol. XXV., p. 278, 1905. This new glow-light oscillograph is characterised by electrodes consisting of plates instead of wires and gives much more intensive images; therefore, I was able to photograph with this instrument fast alternating currents of 4,000 ~ per second and more. A short abstract of this work has been given in *The Electrician*, Vol. LV., p. 981.—Yours, &c.,

Charlottenburg, March 31. Dr. E. GEHRCKE.

## DAMPING ARRANGEMENTS FOR ELECTRICAL INSTRUMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to a Note in the current issue of *The Electrician* regarding "A New Damping Arrangement for Instruments," the device mentioned is hardly new to English instrument makers. Some three years ago, at the suggestion of Mr. W. A. Price, the writer made a damping device of this kind, and it was used on some of the measuring instruments made by Messrs. Crompton & Co. The damping effect was excellent, and could be varied widely by varying the damping fluid, alcohol, paraffin and machine oil giving a series of increasing damping effects.

The device was disused for most work eventually owing to the very slow zeroing of the pointer due to the gradual manner in which the liquid left the wetted surface of the cylinder. It was found that the damping was best varied by using the most mobile liquid—paraffin or alcohol in all cases, and fitting a radial perforated baffle plate in the cylinder—the coarseness of the perforations in this baffle determining the extent of the damping. I believe the method described in *The Electrician* has been used by instrument makers in England for some considerable time.—Yours, &c.,

Arc Works, Chelmsford, April 4. CHARLES H. WRIGHT.

## THE COST OF ELECTRICITY PER UNIT FROM PRIVATE ELECTRICAL PLANTS.*

BY WILSON HARTNELL.

This Paper does not consider the purpose for which electricity is required, whether it be for power, for lighting, for electro-chemical, or for any other purpose; nor are the advantages or disadvantages of electricity, as compared with other means of obtaining the desired result, here considered. Nor is any comparison intended to be made when the cost of electricity is supplied by a public company. By the "total cost of supply" is here meant all the expenditure incurred (or to be incurred), which might have been (or might be) avoided had electricity been supplied from without. The cost thus defined excludes all the expenses which must be incurred if the same quantity of electricity has been purchased from a public company and used in the same way. Therefore, "cost per unit" excludes the cost of the main distributing switchboard and all beyond it, such as mains, sub-mains, wiring, motors, lamps, &c.

The cost as thus defined may be divided into three main divisions: (1) The capital outlay; (2) capital charges, interest, depreciation and sinking-fund charges, rent, &c.; (3) operating charges, maintenance, material, labour, rates and taxes, &c.

Each of these may have many sub-divisions, some of which are as follow:—

CAPITAL OUTLAY.

| | |
|---|---|
| Land .... | Purchase.<br>Rental.<br>Or taken from existing premises. |
| Buildings | Machinery house, boiler house, store rooms, coal stores, chimney foundations, drains, pipes, cooling ponds.<br>If water power—water supply, dams, channels and supply pipes. |
| Machinery | Boilers and boiler brickwork, tanks, pumps, pipes and valves.<br>Conveying machinery, stoking machinery, coal bunks, cooling towers.<br>Steam engines and belongings, or steam turbines and ditto.<br>Sundry tools, &c.<br>If water power—turbines and their belongings.<br>If gas engines—gas-producer plant, gas engines complete, water supply, &c. |

The items of cost thus enumerated do not pretend to be exhaustive, and most of them include many smaller items of cost. The cost per unit is found by dividing the cost thus obtained by the electrical units produced, after first deducting the units exclusively used over the power plant itself. The unit of quantity here used is a "kilowatt hour." The "cost per unit" is, it will be seen, made up of so many variable quantities that it is impossible to treat this subject generally in this short address. All that can be done is to analyse a limited number of typical examples. In this there is another difficulty: in but few instances are all the limits of cost obtainable, and in but few instances have the kilowatt-hours been recorded.

In regard to maintenance and depreciation. Maintenance means the repairs that can be made to keep the plant in the best working order. Depreciation is the amount which must be written off or carried to some reserve fund. It should be sufficient to cover the capital sunk on the plant at the end of the period when it ceases to be valuable, either from its being worn out or superseded, or from any other cause, less, however, by the value of the discarded plant. In private plants there may be another charge to add to depreciation—viz., a sum to cover an estimated loss from the withdrawal and fixing of capital that might otherwise have been actively employed or withdrawn. 10 per cent. has been estimated here to be the value of interest and depreciation on the gross cost of machinery and buildings, &c. In many cases more might, with prudence, have been allowed.

Electricity can be produced at the least cost per unit in flour mills. In these, the engines are usually high-class compound condensing, often with triple expansions. They usually run day and night (excepting Sundays) and with but few stoppages, say 130 to 140 hours per week, and the dynamo usually runs the whole of that time. In the older mills the dynamo is used for lighting only, but in the more recent mills there are electric motors. One dynamo is easily driven from the main engine. The dynamo requires but a small fraction of the power of the mill engine.

### EXAMPLES.

1. *Flour Mill, medium size.*—Dynamo in basement 12 kw., driven from shafting. Capital outlay to include dynamo, foundation, countershaft and belongings.

*Capital charges*, £120. Depreciation, £12; *Operating charges*—Maintenance, £1; coal, estimated, 60 tons at 7s., £21; oil and sundries; £2, total, £36.

Estimated output per annum, 35,000 kw.-hours; cost, 0·25d. (or ¼d.) per unit per hour.

Here, as in most flour mills, putting in the electric plant involves no outlay for land, buildings or engines, nor any extra charge for labour. In this mill, as, in fact, in all flour mills, the extra coal burned is said to be undiscoverable in the coal bills (although it must be there), so that the electric light is said to cost millers nothing. In the present case it is considered to have saved the expense of £110 per annum for gas for 14 years past.

2. *Flour Mill.*—20 kw. dynamo. Dynamo coupled direct to Willans engine, non-condensing, also an 18 kw. driven by belt from the main engine. 28 kw. runs all night. 18 kw. all day and part of the night.

*Capital outlay*, £650. Capital charges, depreciation and interest, £65; *Operating charges*—Maintenance, £5; coal, estimated, £82; oil and sundries, £8; total, £160.

Estimated output per annum, 107,000 kw.-hours; cost per unit, 0·36d. per unit.

3. *Flour Mill.*—Two 52 kw. dynamos, belt-driven. One vertical engine, non-condensing, shafting and belts. One dynamo is driven from the main engine. The other dynamo can be driven from either engine.

*Capital outlay*, £850. Capital charges, interest and depreciation, £85; *Operating charges*—Maintenance, £6; coal, estimated, £100; oil and sundries, £5; total, £196.

Estimated output per annum, 163,200 kw.-hours; cost per unit, 0·29d. per hour.

4. *Woollen Mill.*—18 kw. dynamo, horizontal engine, non-condensing. Dynamo driven by countershaft from the factory engine. For lighting only.

*Capital outlay*, £200. Capital charges, interest and depreciation, £20; *Operating charges*—Maintenance, £2; coal, £8; oil and sundries, £2; total, £32.

Estimated output per annum, 12,600 kw.-hours; cost per unit, 0·61d. per hour.

Here, although no charges are incurred for building and attendance, the factory hours are short and the output small. When the mill is running overtime the cost per unit is about 0·41d. per hour.

5. *Woollen Mill.*—30 kw. dynamo. Dynamo driven by special arrangement from the factory engine. For lighting only.

*Capital outlay*, £250. Capital charges, interest and depreciation, £25; *Operating charges*—Maintenance, £3; coal, £19; oil and sundries, £3; total, £50.

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* Paper read before the Leeds Section of the Institution of Electrical Engineers February 15, 1906. (Abstract.)

Estimated output per annum, 30,000 kw.-hours; cost per unit, 0·4d per hour.

6. *Woollen Mill.*—Loom shedding. 66 kw. dynamo. Dynamo driven by special shafting from the mill engine. For lighting only.

*Capital outlay*, £550. Capital charges, interest and depreciation, £55; *Operating charges*—Maintenance, £3; coal, £28; oil and sundries, £4; total, £90.

Estimated output per annum, 46,200 kw.-hours; cost per unit, 0·47d. per hour.

7. *Woollen Mill.*—Three 42 kw. dynamos. Dynamos driven by special countershaft from mill engine or water turbine. Also pilot dynamo which can be driven from either of two special non-condensing engines. For lighting only.

*Capital outlay*, £1,300. Capital charges, interest and depreciation, £130; *Operating charges*—Maintenance, £6; coal, £64; oil and sundries, £5; total, £205.

Estimated output per annum, 93,100 kw.-hours; cost per unit, 0·53d. per hour.

8. *Clothing Factory.*—One 21 kw. dynamo. Dynamo coupled direct to gas engine. For lighting only.

*Capital outlay*, £450. Capital charges, interest and depreciation, £45; *Operating charges*—Maintenance, £4; gas, £76; oil and sundries, £2; total, £127.

Estimated outlay per annum, 19,000 kw.-hours; cost per unit, 1·6d. per hour.

9. *Clothing Factory.*—Two 30 kw. dynamos. Dynamos belt-driven from two gas engines. For both lighting and power.

*Capital outlay*, £850. Capital charges, interest and depreciation, £85; *Operating charges*—Maintenance, £5; gas, £205; oil and sundries, £5; attendance, £80; total, £380.

Estimated output per annum, 62,000 kw.-hours; cost per unit, 1·5d. per hour.

10. *Iron Works.*—Mond gas plant in duplicate. Two dynamos, 150 kw. Each direct coupled to the gas engine. Gas also used for other purposes. For power and lighting.

*Capital outlay*, £7,600. Capital charge, proportion of cost of depreciation, charge to electrical plant, £500; *Operating charges*—Maintenance, £40; coal, £156; oil and sundries, £18; attendance, £140; rates, takes, &c., £50; total, £904.

Estimated output per annum, 350,000 kw.-hours; cost per unit, 0·62d. per hour.

11. *Iron Works.*—Four dynamos 150 kw. Two dynamos direct coupled to two gas engines, Two dynamos driven by ropes from two gas engines. Mond gas plants. Gas engines of the positive scavenging type.

Record from accurate measurement extending over nine weeks.

*Capital outlay*, £14,000. Capital charges, interest and depreciation (for nine weeks), £242; *Operating charges*—Maintenance and superintendence, £235; coal, £219; stores and sundries, £21; rates, &c., assumed, £25; total, £733.

Time of running, 4,240 hours. Output, measured by instruments, 328,837 kw.-hours; cost per unit, 0·54d. per hour.

12. *Engineering Works.*—Two 500 kw. dynamos, one 250 kw. dynamo. Dynamos direct coupled to vertical high-speed compound condensing engines. Engine house and boiler house, cooling tower, &c. For power only.

*Capital outlay*, £15,200. Capital charge, interest and depreciation, £1,520; *Operating charges*—Maintenance, £40; coal, £1,120; attendance, oil and sundries, £350; rates, assumed, and allowance for rent, £220; total, £3,250.

Estimated output per annum, 2,000,000 kw.-hours; cost per unit, 4d. per hour.

The cost per unit is highest in private electrical plants with storage cells.

*Private House Dynamo Cells and Gas Engine.*—*Capital outlay*, £350. Interest and depreciation, £44; *Operating charges*—Maintenance, £3; gas at 4s., £32; attendance (period of man's time), £30; oil and sundries, £2; total, £111.

Estimated output per annum, 4,500 kw.-hours; cost per unit, 6d. per hour.

The first seven may be considered as incomplete plants. The capital outlay per kilowatt is therefore a minimum. In 1, 5, 6 and 8 there is no reserve plant. Judging from many years' experience, there seems to be but little risk from its absence, provided there be a spare armature. In 2, 3 and 7, when there are two dynamos and the alternative means of driving them, there is, in effect, some reserve plant. The equivalent dynamo-hours give a rough idea of the extent to which the plant is used. With the same outlay per kilowatt, the cost per unit may be more than halved by using electricity for long hours per annum. 8 and 9 are complete plants, but in 8 no extra attendant is needed. The cost per unit in these examples rises from 1·6 to 2·2. 10, 11 and 12 are complete plants for large engineering and iron works. In 10 there is a large Mond gas plant which supplies gas for other purposes. There is practically a complete reserve plant, and the equivalent dynamo-hours could be doubled if needed. These engines require 2·25 lb. of fuel per kilowatt-hour, and one man attends the two sets. 11 is also a Mond gas plant. The gas plant being suitable for 1,000 H.P. to allow for estimate of plant. The capital charges are high per kilowatt, but so are the equivalent dynamo hours. 12 is a steam plant with boilers and accessories suitable for 1,000 H.P. only. Not more than two dynamos are required for the maximum load. In 10 the gas producers are rated at 2,000 H.P., and interest and depreciation on two-thirds of their value are debited to the electrical plant. In 11 the gas producers are rated at 1,000 H.P., and interest and depreciation on their value are debited to the electrical plant. Although 10 per cent. has been allowed for interest and depreciation, it has already been pointed out that this is dependent upon several circumstances. Apart from these, the value of capital to the manufacturer will depend upon the profit that he can make by utilising it in his business, or whether he is short of capital, or whether he contemplates its early withdrawal. If, therefore, he have the option of purchasing electricity at a higher price than he could produce it, he reckoning 10 per cent. or even 15 per cent. for interest and depreciation, it may yet be good policy to purchase it. On the other hand, where electricity may be extensively used and capital is abundant, electrical plant may be considered as a good and safe investment. The increase in cost per unit, in the above examples, by taking interest and depreciation at 15 per cent (instead of 10 per cent.), may be seen from the following table, which shows both the actual cost and the per cent. increase in cost.

**Table B.**—*Interest and Depreciation 15 per Cent.*

| Example .... | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cost per unit.. | 0·29 | 0·42 | 0·37 | 0·84 | 0·50 | 0·61 | 0·70 | 1·9 | 1·62 | 0·78 | 0·64 | 0·48 |
| Increase per cnt | 17 | 18 | 22 | 31 | 20 | 31 | 31 | 19 | 11 | 28 | 19 | 23 |

The increase of cost averages 23 per cent. for the seven half plants, and 26 per cent. for the complete plants.

The increase in the cost per unit due to an increase in the cost of fuel may be seen from the next table (C). Fuel is assumed to be 33⅓ per cent. dearer, and also 50 per cent. dearer. The per cent. increase in cost per unit is given for both suppositions.

**Table C.**—*Fuel Raised in Price 33⅓ and 50 per cent.*

| Example ........ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Per cent. increase.. | 20 | 18 | 18 | 9 | 12 | 10 | 11 | 18 | 18 | 6 | 10 | 12 |
| Per cent. increase.. | 28 | 28 | 25 | 13 | 19 | 15 | 16 | 30 | 28 | 9 | 15 | 18 |

The average increase for the half plants is 14 per cent. and for the whole plants 16 per cent. in the first case, and 23 per cent. and 25 per cent. respectively in the second place.

From the averages of tables B and C, it appears that in these instances an increase of 5 per cent. on interest and depreciation adds as much to the cost per unit as 50 per cent. in the price of fuel. This cannot be taken as a general conclusion, but it points to the advisability of keeping down capital charges. Apart from capital and depreciation charges the cost of fuel per brake horse-power is least in large gas engines. With a gas plant rated at 1,000 H.P. and two 250 B.H.P. engines (but with one producer only used for the tests) with 77 kw. the fuel gasified was 1·82 lb. per kilowatt, and with 150 kw. on one engine, or 298 kw. on the two—in each case the fuel is given as 1·29 lb. per kilowatt. With fuel at 8s. per ton this would give 18 kw. for 1d. Here fuel is but a small item of cost.

In a large works where there is a gas-producer plant, rated at 12,000 H.P., with an ammonia recovery plant, but where the direct-coupled dynamos are at present only about 1,000 kw.—the gas being used chiefly for heating—I am informed by the partners that they expect to run their plant at 0·2d. per unit. This does not include any depreciation, or rates and taxes, or establishment charges, but it does include repairs and maintenance. The total cost, if debited from a plant suitable to the total kilowatt plant, should be not more than 0·3d.

In a private plant the load is usually fairly steady, and the maximum kilowatt required not much above the average. There is no need to provide for exceptional peak loads, nor for spare plant, beyond, say, one-fourth to one-third of the usual load; some risk can be run as to possible failure. Experience has shown that the risk is almost negligible. The simplest arrangements are not only permissible, but advantageous. Hence the capital outlay per kilowatt may be reduced to a minimum, for the plant decided to be most advantageous, taking all the particular circumstances of cost (as stated at the beginning of this Paper) into consideration.

In general the plant that requires the least cost to operate it at a given maximum load requires the greatest capital outlay. Although when such a plant is fairly loaded the cost per unit may be lowest, yet in a light load it might be greater than with an inferior engine on account of the greater fixed charge. In conclusion, in the restricted use of the word "cost," as here described, half plants have been running for years at a cost of ¼d. to ½d. per unit for lighting, complete plants in factories at from 1¾d. to 2½d. per unit for lighting, and large plants for power and lighting, or power only, are now running at from ⅜d. to ¾d. per unit and under, all charges included.

In two other examples of private house lighting, with a capital outlay, in each case, for oil engine, dynamo and storage cells, of £350, but where no special attendant is required the cost per unit, so far as can be ascertained, is about 6d.

From the facts stated in the examples above given, the following table has been made showing the capital outlay per kilowatt and the equivalent "dynamo-hours." This latter expression means the hours in which the dynamo could have produced the kilowatt-hours if it had run continuously.

Table D.

| Example. | Capital per kilowatt. | Equivalent dynamo-hours. | Cost per unit. | — |
|---|---|---|---|---|
| 1 | £10 0 0 | 2,900 | 0·25 | Lighting only. |
| 2 | 13 1 0 | 2,300 | 0·36 | |
| 3 | 8 2 0 | 1,600 | 0·29 | |
| 4 | 11 1 0 | 700 | 0·61 | |
| 5 | 8 3 0 | 1,000 | 0·40 | |
| 6 | 8 3 0 | 700 | 0·47 | |
| 7 | 13 6 0 | 980 | 0·53 | |
| 8 | 21 5 0 | 910 | 1·62 | Lighting and power. |
| 9 | 14 2 0 | 1,040 | 1·50 | |
| 10 | 16 6 0 | 1,180 | 0·62 | |
| 11 | 23 3 0 | 3,030 | 0·54 | Power only. |
| 12 | 12 2 0 | 1,600 | 0·29 | |

# PARLIAMENTARY INTELLIGENCE.

## THE LONDON POWER BILLS.

In the House of Commons on Monday, on the motion of Mr. Lloyd-George, President of the Board of Trade, the London County Council (Electric Supply) Bill was referred to a Committee of nine members, five to be nominated by the House, and four by the Committee of Selection. It was ordered that all petitions against the bill be referred to the Committee, that the Committee have power to send for persons, papers and records, and that it be an instruction to the Committee to consider, with special reference to the proposals of the bill, the best means for providing for the supply of electrical energy in bulk and for power and motive purposes, and to report thereon.

The following members have been selected by the Government to serve on the Hybrid Committee which will deal with the London County Council (Electric Supply) Bill: Mr. Chance (Liberal), Mr. Joseph Nolan (Irish Nationalist), Mr. James Parker (Labour), Mr. Watson Rutherford (Unionist) and Mr. Luke White (Liberal). This still leaves four members to be nominated by the Committee of Selection.

The second reading of the following bills has been deferred until Monday, April 30: Administrative County of London & District Electric Power; Charing Cross, West End & City Electricity Supply; City of London Electric Lighting; West London Electric Undertakers' Association; Hackney Electricity; Shoreditch & Stepney Electricity; London Electric Supply Corpn.

The Additional Electric Power Supply Bill came up for second reading in the House of Commons on Tuesday. The rejection of the measure was moved by

Mr. E. H. PICKERSGILL (Bethnal Green). The general points in his argument against the bill were the great loss in transmission which must necessarily result through the generating station being at St. Neots, 50 miles from London; the absence of a purchase clause and of any defined area of supply; the authority sought to compete with existing undertakings unhampered by the legislative conditions attaching to these. If the bill passed the second reading it would gain an unfair advantage over the other electric power bills promoted this session, and must inevitably result in the establishment of a great monopoly. Even the suggestion made by the promoters that they should confine their bill to supplying only railways and canals, except with the consent of the London County Council, did not reassure him.

Mr. SUMMERBELL (Sunderland), who seconded the motion for rejection, contended that the £3,000,000 capital proposed was insufficient. Existing municipalities with electric lighting undertakings were saddled with all sorts of conditions, and he hoped that no further monopolies would be granted to private companies, as these would hamper still further municipal operations in the domain of electric supply.

Mr. C. HOBHOUSE, on behalf of the promoters, supported the bill and stated that although he had, in the past, supported the various municipal duties and burdens undertaken by the London County Council, he considered the supplying of electricity to railways beyond their scope, and he appealed to the London County Council to allow the second reading to be taken. He would then move that it be an instruction to the Committee to which the bill was sent to insert a clause that, with the exception of supplying energy to railways and canals, no supply should be given without the consent of the London County Council.

Mr. BELL (Derby), Mr. BERTRAM (Hitchin) and Mr. BARNARD (Kidderminster) supported the bill, with the amendment proposed by Mr. Hobhouse. They also were of opinion that the greatest possible assistance should be given to railway companies to convert their lines to electric traction in order to enable them to compete more effectively with municipal tramways.

Mr. HOWELL DAVIES (Bristol) opposed the second reading.

Mr. LLOYD-GEORGE said he was sorry that the promoters of this bill had forced the House to come to a decision on its merits. It would have been better had they accepted the proposal of the Government to take a locus standi against the London County Council (Electric Supply) Bill before the Hybrid Committee which was about to be appointed. Other opponents, with greater responsibility in this matter, had accepted this position, and he could not help regarding the attitude of the promoters of this bill as an attempt to secure the advantage of a year over the other proposals. It would be a breach of faith if the Government refrained from opposing the bill now and he hoped the House would teach the promoters a lesson. In his opinion the object of the bill was to secure the cream of the business in the matter of electric supply in London.

On a division the bill was rejected by a majority of 197.

## MUNICIPAL WIRING.

### LONDON COUNTY COUNCIL (GENERAL POWERS) BILL.

This bill, which included powers to enable the London Borough Councils to undertake the wiring of consumers' premises, &c., was considered by the Police and Sanitary Committee of the House of Commons this week. The London Electrical Contractors' Association lodged a petition too late, and an application for a locus to appear against the bill was refused. A number of London electric supply companies were granted a locus against this portion of the bill, but they did not appear on their petitions. There was, therefore, no opposition, and after consultation the Committee inserted the following clause in the bill:—

"It shall be lawful for the council of any metropolitan borough being authorised to supply and supplying electrical energy to expend money upon the wiring and supplying with wires and fittings, motors and apparatus the premises of their consumers or prospective consumers, and to enter into and to carry into effect agreements and arrangements with respect thereto, and to make such charges therefore as they may think fit.

"Provided that nothing in this section shall be deemed to authorise the council of any metropolitan borough to manufacture any such fittings or apparatus.

"Provided also that every such council shall so adjust the charges to be made by them aforesaid as to meet any expenditure by them under the powers of this section (including interest upon any moneys borrowed under and for the purpose of this part of this act and payment of sinking fund in respect of such moneys).

"Every sum charged by any such council to a consumer in respect of the wiring and fitting of the premises of such consumer and the supplying of wires, fittings, motors and apparatus shall be clearly stated on every demand note by such council for payment for electrical energy supplied to such consumer distinct from the charge for such energy.

"The total sum received and expended by such council under this part of this act in each year (including the amount required for interest and repayment of sinking fund in respect of all moneys borrowed) shall be separately shown in the public accounts of the electric lighting undertaking of such council for such year.

"Any such council of a metropolitan borough may borrow, in the same manner and subject to the same conditions as though such expenditure were for the purposes of the Electric Lighting Acts of 1882 and 1888, as amended by the London Government Act of 1889, such sums of money as may be required by such council for the purpose of this part of this act."

The bill, with this clause inserted, was subsequently ordered to be reported for third reading.

## TRAMWAYS ON THE THAMES EMBANKMENT AND OVER THE BRIDGES.

The London County Council (Tramways and Improvements) Bill came up for second reading on Friday last week.

Mr. BURDETT-COUTTS said, unlike former occasions, he was now prepared to support the bill, as the recent report of the London Traffic Commission had shown that the problem of tramway communication in London should be dealt with as a whole. The case for the extension of tramways across bridges had, moreover, been strengthened by the fact that the County Council had acquired the tramways in the north and that there was now something to be connected up on both sides of the river.

Mr. ALLEN BAKER compared the working costs of electric tramways and motor omnibuses. The cost of an electric tramway was about 6d. or 7d. a car-mile against 11d. or 1s. a car-mile for the motor omnibus. He had also been informed by his chief officer that the tramways were not being seriously affected by the motor omnibus competition; in fact, the tramway receipts were steadily increasing.

The bill was then read a second time.

## MISCELLANEOUS.

**Breakdowns on the District Railway.**—In the House of Commons, on Wednesday, Mr. T. Davies drew the attention of the President of the Board of Trade to the recent accidents on the District Railway, caused by the breaking of axles, and asked whether similar experiences had occurred on other electric railways. Mr. Lloyd-George, in reply, said he had appointed an inspecting officer of railways to inquire into two of the breakages referred to, and had also urged the Metropolitan District Railway Co. to take measures to prevent such accidents in future. He understood that the axles that had broken had been those of the trailing bogies of the motor carriages, and that no time was being lost by the company in order to replace these with others of a stronger type. More than one-third had been replaced already, and six weeks was the time estimated to complete this work. The axles in question were made by Krupp at Essen. Since the beginning of 1904 there had been seven breakdowns on electric railways other than the District Railway due to broken axles.

The London County Council (Tramways and Improvements) Bill and the Middlesex County Council Tramways Bill were read a second time in the House of Commons on Wednesday last week.

The Folkestone & District Electricity Supply Bill was read a second time in the House of Lords on Thursday last week.

The North & South Shields Electric Railway Bill was read a second time in the House of Commons on Friday last week.

The North-East London Railway Bill was read a second time in the House of Commons on Monday.

The Twickenham & Teddington Electric Supply Bill was read a second time in the House of Commons on Wednesday.

The South Lancashire Tramways Bill was passed by the Unopposed Committee of the House of Lords on Tuesday. The bill seeks an extension of time for the construction of certain lines authorised in 1900, 1901 and 1903.

The Preston, Chorley & Horwich Tramways Bill was before the Unopposed Committee of the House of Lords on Tuesday. This bill gives an extension of time for the tramways authorised in 1903, the authorisation of certain new lines and the abandonment of others. Five years for the completion of the new works is specified, and the acquisition of certain lines by the Wigan Corporation is also provided for.

The Macclesfield Tramways Bill was passed by the Unopposed Committee of the House of Commons on Tuesday. The objects of this bill were given in our issue for March 23.

Mr. H. C. Lea will move the rejection of the Metropolitan Electric Supply Co.'s Bill when it comes up for second reading on April 30.

The second reading of the Lancashire Electric Power Bill has been postponed until Tuesday, April 24.

A Committee of the House of Lords has been formed to deal with the following bills: West Yorkshire Tramways, Cumberland Electricity & Power Gas, County of Durham Electric Power Supply, Newcastle-on-Tyne Electric Supply and West Cumberland Electric Tramways. The Commiteee, which will meet for the first time on May 1, is constituted as follows: Earl Lauderdale, Earl Cathcart, Viscount Ridley, Lord Rossmore and Lord Estcourt.

## LEGAL INTELLIGENCE.

### Swansea Corporation v. the National Telephone Co.

On Wednesday the Court of Appeal (Lords Justices Vaughan Williams, Stirling and Cozens-Hardy) considered the report of Major Cardew, R.E., who was appointed by the Court to ascertain the requirements for intercommunication between the Corporation's and the company's telephone systems at Swansea.

Mr. BUCKMASTER, K.C., stated that the Corporation found themselves in some difficulty in dealing with the report, unless they could ask Major Cardew a series of questions arising out of the answers given. He was not entitled to interfere in any way with the report and he made that statement in order that the Court might not think the Corporation passed it without comment. The question was as to what were the proper facilities for intercommunication. The first question the Court asked Major Cardew was: "Whether, in order to afford all proper facilities for the transmission of telephone messages between persons using the system of the telephone company in the Swansea exchange area and persons using the system of the Corporation in the same area, and between persons using the latter system and persons using the former system junction wires in sufficient numbers should be laid between all or some, and which of the company's exchanges, and all or some and which of the Corporation's exchanges, and whether such junction wires should be one-way wires—that is to say, one set to be used for calls from the company's subscribers to the Corporation's subscribers and a corresponding set to be used for calls from the latter subscribers to the former, and whether such junctions should be enclosed in cables in sets or how otherwise." Major Cardew had *answered* on this point: "As it is now common practice that all telephonic circuits should consist of a line and a return wire, in place of using, as was formerly customary, a single line wire and completing the current by means of the earth, I have in my answers used the term junction circuit, which must be understood to include two wires properly erected and connected. (The particular junctions required are then set out). These junction circuits should be all one-way junctions to be for calls from the Corporation subscribers. They may be either enclosed in cables in sets or erected overhead, or partly in one way and partly in the other." Mr. Buckmaster submitted that it was quite clear the language in the answer wanted considerable modification in order that it might be understood. The second question was: "Whether the laying down of sufficient junction wires between the several exchanges of the Corporation and company respectively at (1) Swansea, (2) Mumbles, and (3) Morriston, will afford all such proper facilities as aforesaid." The *answer* to this question was: "No further facilities will be required to provide for what may reasonably be expected as regards intercommunication." Question 3 ran: "Whether, in order that all such proper facilities as aforesaid should be afforded, it is necessary that there should be provided junction circuits to directly connect the Corporation's principal exchange in Swansea with each of the following exchanges of the company: Swansea, Blackpile, Forestfach, Pontardulais, Pontardawe, Sketty, Killay, Gorseinon, Clydach and Lansamlet, or any and which of such places." The *answer* was: At present junction circuits should be provided to directly connect the Corporation's principal exchange in Swansea with each of the following exchanges of the company: Sketty and Gorseinon. Additional junction circuits to other exchanges may be required later when the traffic has sufficiently increased." Mr. Buckmaster said he attached great importance to that answer because the judgment appealed from involved the very question—as to coming back to the Court, when the traffic had sufficiently increased, to require further communications such as those the learned judge directed. The fourth question was: "Whether any and what additional or other steps ought to be taken by the Corporation and company respectively in order that each of the parties concerned should afford all such proper facilities as aforesaid." *Answer*: "(*a*) The Corporation should make such arrangements at Morriston as will best provide for calls from their subscribers to Clydach and Pontardawe by the junction circuits to be provided and their existing junction circuits to Morriston. (*b*) The junction circuits to be provided may pass through the company's exchanges at Swansea and Morriston respectively, but should not be brought to the switchboard in those exchanges for operating purposes. (*c*) Besides the junction circuits specified above, which should be laid at once, additional junction circuits should be provided as and when required by the traffic as follows: When the number of calls in any one hour from subscribers on the Corporation's system to an exchange on the company's system not at present to be connected directly with the Corporation system has exceeded five on three or more occasions in one month, a direct junction circuit should be provided from one Corporation exchange to the company's exchange, and by this circuit the calls should be transmitted from the Corporation's system to the company's exchange. (*d*) Similarly, when the number of calls in any one hour from subscribers on the company's system to an exchange on the Corporation's system has exceeded the same limit a direct junction circuit should be provided from the company's exchange to the Corporation's exchange, and by this circuit the calls should be transmitted from the company's system to the exchange of the Corporation. (*e*) From and after the time when one or more junction circuits have been provided for the purpose of transmitting calls from the Corporation's system to any exchange on the company's system, or from the company's system to any exchange on the Corporation's system, all such calls should be so transmitted, and these junction circuits should be added to as may be required to provide adequately for this service. Mr. Buckmaster said the question was as to whether what the company demanded was right and reasonable. The company demanded that the Corporation should lay wires from the central exchange to all the company's sub-exchanges with which intercommunication was necessary. The answer to that was: "No. Our system has been constructed so that when intercommunication takes place our system is efficient and will take the whole of the extra traffic without further wires having to be laid down." But the company must make their system efficient for transmitting the Corporation's messages, as the Corporation's system was efficient for transmitting the company's messages.

Lord Justice VAUGHAN WILLIAMS: Having regard to the state of things arrived at, which resulted in these questions being put to Major Cardew, and his report in answer, our duty is to determine what, as a matter of fact, ought to be done. Your observations, Mr. Buckmaster, do not deal with that, but deal with who was right or who was wrong at the time the action was brought.

Mr. ASTBURY, K.C., for the company, said they took an entirely different view of the report. He submitted that their contention had been completely affirmed by Major Cardew's report.

Lord Justice VAUGHAN WILLIAMS: I think we understand your arguments. We are anxious to deliver judgment this sittings.

### Margerison & Co. v. Bradford Corporation.

At West Riding Assizes on Saturday, before Mr. Justice Bigham, plaintiffs sought to recover from Bradford Corporation £156. 14s. damages for alleged neglect in laying electric cables, and also for nuisance.

Mr. NEWELL, for plaintiffs, said Bradford Corporation supplied electrical energy for public and private purposes, and they supplied electricity for working and driving machinery used by plaintiffs in their business of wool merchants. On Dec. 8, 1904, by reason of the defective condition of defendants' apparatus, or by defendants' negligence in the control thereof, an explosion occurred. Owing to that explosion plaintiffs had to suspend their business for 3½ days, thereby incurring serious loss. He contended that the Corporation ought to have been aware that the sheaths of some of the cables were in a defective and dangerous condition, but no adequate steps were taken to remedy them. The cables were also faulty and corroded. Leakages in the supply had been undetected, or if detected had not been removed. Insufficient fuses had been provided, and no adequate arrangements had been made for preventing an extensive stoppage of supply.

The defendant Corporation admitted that on the days mentioned they made default in supplying electricity to plaintiffs. If any damage was suffered by plaintiffs, which was denied, it was caused by the explosion cutting off the supply of electricity, and no damage was caused in any way by electricity for which the Corporation was liable. They further contended that their liabilities were defined by Act of Parliament, for when they as electricity undertakers made default in supply they should be liable to a penalty of 40s. for each default.

His LORDSHIP, in giving judgment, said the duties and liabilities of defendants were defined by Act of Parliament. The imposition of a fine of 40s. for each default was a punishment for failure to supply the electricity; which they had undertaken to supply, and that penalty was incurred whether the Corporation was negligent or not. The mere fact that it had made default was sufficient. It must be remembered that defendants supplied innumerable people, and if by any cause whatever they interfered with the business of the people whom they supplied they would be liable to damages should that action succeed. If such was the case it would be impossible to estimate the damages for which they might be responsible. The explosion might have interfered with the supply of electricity to thousands of people, and if he found for plaintiffs all those people might also be entitled to recover. That would be a terrible liability to place upon defendants, and one which he did not think was intended to be imposed. It might have been a nuisance, but he did not think it caused any special damage to plaintiffs within the meaning of the act. Therefore they had no ground on which to recover in respect of a nuisance. In his opinion, the action with regard to damages also failed. If it did not, he did not know where the liabilities of a Corporation in the position of Bradford Corporation would cease. Their liabilities would be so great, and the difficulties in dealing with the claims would be of such a nature, that it would be almost impossible for them to carry on their business. He gave judgment for defendants, with costs.

### J. Stone & Co. v. General Electric Co.

On Friday, before Mr. Justice Swinfen Eady, Mr. Austin Cartwell moved on behalf of plaintiffs for an injunction to restrain defendants from selling electric lamps with the name of Stone or Stone's patent upon them, they not having been made under the authority of plaintiffs.

Mr. MAGHAN, for defendants, asked that the motion might stand over.

Mr. CARTWELL said he thought it was a case in which an undertaking should be given not to continue the sale of these lamps until the matter was heard.

Mr. MAGHAN said his clients were not in court, and he was unable to give an undertaking, though he would on his own responsibility offer to keep an account.

His LORDSHIP thought defendants must be restrained for a week on the usual undertaking as to damages.

The motion was then directed to stand over for a week.

### Tramways Assessment.

At Dewsbury police-court last week the Yorkshire (Woollen District) Electric Tramways (Ltd.) asked the justices to state a case for appeal with regard to claims against the company by Liversedge Council for £55. 16s., Heckmondwike Council for £29. 15s. 10d., and Thornhill Council for £42. 12s., in respect of district rates.

Mr. WALKER (for applicants) contended that the company should be treated as a railway and be charged only one-fourth of the district rate.

The application was refused.

### Oliver Clark & Co. v. J. E. Hutton (Ltd.)

At Marylebone (London) County Court on Wednesday plaintiffs sued for £12 odd, balance of account for an electric lighting installation at the recent Olympia Motor Show. About the middle of October last plaintiffs entered into a contract to supply a number of arc and other lamps for lighting defendants' exhibit, and the installation was to be complete before the show opened on Nov. 17. Shortly before that time defendants were not satisfied with the amount of light on their exhibit, and ordered additional arc lamps from plaintiffs, who had then almost finished their work. Owing to the alterations it was impossible to comply with the conditions of the original contract, but when the account was presented defendants deducted a certain amount for damages, which, they alleged, they had suffered through the lamps not being ready in time, and it was in respect of that amount that the present claim was made. After hearing the evidence, his Honour (Sir Wm. Selfe) gave judgment for £10 odd and costs.

**In re Llanrwst Electric Supply Co. (Ltd.)**—Mr. Justice Swinfen Eady last week appointed a receiver of this company, and gave leave to apply in chambers for the appointment of a manager.

## THE ELECTRO-HARMONIC SOCIETY.

The closing concert of the 20th season of the Electro-Harmonic Society on Friday evening last may be considered as the most conspicuously successful of a very long series of pleasant gatherings. Sir William Preece, K.C.B., was to have presided, but was compelled, under doctor's instructions, to forego the pleasure which the occasion offered. Sir William's place was ably taken by Col. R. E. Crompton, C.B.

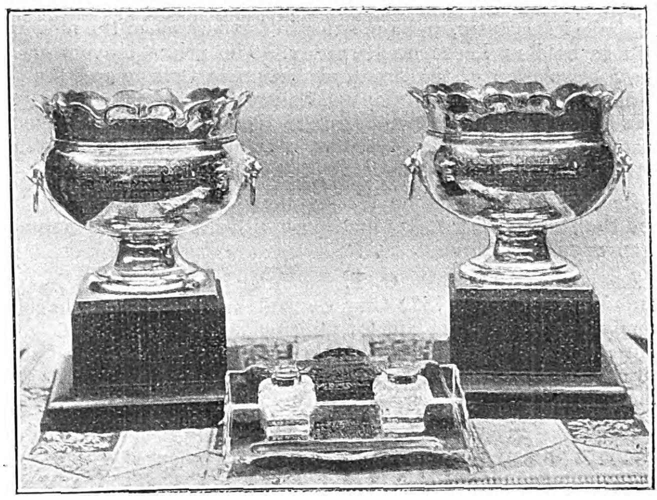
At the close of the first half of a very excellent programme, which seemed to give a crowded audience even more than the usual measure of satisfaction, Col. CROMPTON rose to notify that a large number of the members of the Society had subscribed to a testimonial presentation to the able musical directors of the Society, Mr. T. E. Gatehouse and Mr. A. E. Izard; and to Mr. H. Alabaster, who for the greater portion of the period the Society had been in existence had acted as honorary secretary. Col. Crompton referred in felicitous terms to the excellent services rendered to the Society by Mr. Alabaster, who had kept the society's funds straight and left it in a healthy financial condition. He dwelt also upon the very large amount of gratuitous work performed by their honorary musical director, Mr. T. E. Gatehouse, who throughout the entire 20 years of the Society's existence had ministered to their pleasure by his regular contributions to the excellent programmes provided at the Electro-Harmonic Society's concerts. Col. Crompton alluded also in appreciative terms to the good work of Mr. Izard, who, as their professional musical director, had worked hard in the interests of the Society and had contributed largely to its success.

Col. Crompton then presented Mr. Alabaster and Mr. Gatehouse each with a handsome silver bowl on plinth, suitably inscribed, and to Mr. Izard a handsome silver inkstand, also suitably inscribed.

Mr. ALABASTER, in response to a warm call, gave an account of the initiation of the Electro-Harmonic Society and of the warmth with which the proposal was taken up by a number of the leaders of the electrical profession in the early days, including Sir William Preece, whose absence from illness they regretted that evening. He thanked the subscribers to the testimonial for their gift, which he should treasure as long as he lived.

Mr. T. E. GATEHOUSE, who was enthusiastically received, also referred to the early days when the Electro-Harmonic Society was formed, and to the ready response received from many of those whom he was glad to say were still amongst them and as enthusiastic in the interests of the Society as ever. Sir William Preece, he said, was one of these, as was Mr. R. Kaye Gray, to whom he owed much and to whom he tendered his thanks for his share in organising the testimonial which had been presented to him. He also thanked the other members of the committee for their kindly offices in this connection. He had always been a musical enthusiast, and for more than a quarter of a century had worked hard and gratuitously in the interests of good music. He had given his services to many societies, but in all this long time he had never before been the recipient of a testimonial of any kind. The feeling, therefore, which this testimonial demonstrated was particularly pleasing to him, and he assured them of his gratitude. The kindliness shown towards him he felt most keenly, and it would urge him to continued efforts to please them. He recognised that these efforts in the past had always been received in a most encouraging manner, and he hoped to be able in the future to render equally good service.

Mr. A. E. IZARD expressed his thanks to the members for their handsome present, and assured them that his efforts for the Electro-Harmonic Society had always given him the greatest pleasure. He had received the utmost courtesy on all hands, and his work with Mr. Gatehouse had always been of a completely harmonious character. There had been no difference of opinion between them during all the years of their close association.



PRESENTATION SILVER BOWLS (ON PLINTHS) AND SILVER INKSTAND.

We give above a photographic reproduction of the two silver bowls and inkstand, which were much admired, and are certainly excellent examples of the silversmith's art.

A list of the subscribers to the testimonial was circulated at the concert, and a copy of this list will be sent post free on request to Mr. G. Tucker, hon. sec. to the Fund, 1, 2 and 3, Salisbury-court, Fleet-street, London, E.C.

## MUNICIPAL, FOREIGN & GENERAL NOTES.

### APPOINTMENTS VACANT AND FILLED.

Two additional assistants are required in the electrical engineering department of the Central Technical College, Exhibition-road, London, S.W. Salaries £300 and £150 per annum respectively. Applications to Prof. W. E. Ayrton. See also advertisement.

An electrician is required for service on the Lagos Government Railway. Salary £300, with free first-class passage out and home and free single furnished quarters. Applications to Messrs. Baker & Shelford, consulting engineers, 35A, Great George-street, London, S.W. See an advertisement.

On the recommendation of the Fire Brigade committee London County Council appointed on Tuesday Mr. L. Richards Lee as electrical and mechanical engineer to assist the chief officer with the inspection of electric lighting, heating and other arrangements at places of public entertainment at £400 a year; and Mr. Victor Ambrose Cornelius was appointed assistant electrical engineer at £200 a year.

Mr. F. E. Wilkinson, late of York electricity works, has been appointed resident engineer for Messrs. Crompton & Co. at Falmouth, commencing April 9.

Mr. H. Brownscombe has been appointed junior shift engineer at Dover electricity works.

In connection with the taking over of the Croydon tramways by the Corporation, the following appointments have been made:—

Mr. H. B. Harris, mechanical engineer, at £208 per annum; Mr. C. G. Foster, outdoor superintendent, at £182 per annum; and Mr. F. J. Reavey, chief clerk in the tramways office, at £143 per annum.

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**A Decade Hence.**—According to the "Daily Mail" Mr. Marconi has announced that within 10 years it will be possible to send wireless telegrams to Mars. It ought to be added, however, that the "New York American" is responsible for the publication of the original statement credited to Mr. Marconi.

**Argentina.**—"The Review of the River Plate" states that Buenos Ayres municipality propose to extend their public electric lighting, and the Cia Alemana Transatlantica de Electricidad offer to substitute 984 arc lamps for the existing 4,000 gas and oil lamps at $21 a month for 10 ampere and $19·50 for 8 ampere arcs. The company offer to pay the initial cost in return for an eight years' contract and exoneration from taxation on their revenue from lighting the district. It is proposed to use overhead mains.

La Plata Government have authorised the United River Plate Telephone Co. to construct 250 km. of new lines at a cost of $200 per kilometre.

**Association of Teachers in Technical Institutes.**—It is proposed to establish a West Yorkshire Association of Teachers in Technical Institutes, and a meeting in furtherance of the movement will be held at Leeds on Saturday. The prime movers are the Staff Association of the Bradford Technical College and the West Riding Association of Teachers of Science, Art and Technology, the idea being to practically amalgamate these two bodies, and to ultimately unite all technical teachers in an association working in the interests of technical education.

**Aston.**—The Council on Wednesday appointed Aldermen Evans and Smith to settle matters in dispute with the City of Birmingham Tramways Co.

**Australasia.**—Mr. W. G. T. Goodman (Noyes Bros.) has submitted to Auckland (N.Z.) City Council an estimate of the cost of supplying and erecting plant for utilising the heat from the Council's refuse destructor in generating electric current. The first cost is put at £20,000 and the annual profit, after the first year, at £360. The Streets committee are considering the matter.

**Bexhill.**—The Council have decided to give consumers, in addition to the present maximum demand system of charging, the option of a flat rate of 5½d. per unit.

**Bexley.**—The Council have received sanction to a loan of £4,710 for electric tramway purposes.

**Birmingham.**—The reconstruction of the Saltley and Nechells–King's Heath, Moseley-road, and Stratford-road tramway routes has been completed by Dick, Kerr & Co. £3,086 has been paid to the City of Birmingham Tramways Co. for loss of traffic during the reconstruction of these lines. Four sites have been obtained for tramcar depots and contracts let for the buildings. Special track work for the depots has been supplied by Hadfield's Steel Foundry Co. at £3,999. The work of constructing the new tramways is being proceeded with as rapidly as possible, contracts for the work having been let to Wm. Griffiths & Co. at £14,289, John Aird & Co. £43,698 (with a supplementary contract at schedule rates stated in principal tender), and Dick, Kerr & Co. £6,235. These prices do not include cost of rails and paving material.

Representations have been made to the Tramways committee requesting that the lines may be laid in wood blocks, but the committee, finding that wood paving, being less durable, exceeds the cost of granite sett paving by from £200 to £250 per mile of single line per annum, have decided to adopt granite sett paving. The committee have adopted the span wire system with side poles, except in parts of the Balsall Heath and Neckells routes, where bracket arms have been found advisable, and rosettes on the buildings have been substituted for side poles in Corporation-street, Martineau-street, and Old-square. A contract for overhead work on about 44 miles (single track) of new and reconstructed lines has been let to Dick, Kerr & Co. at £27,231.

The National Telephone Co. have agreed to place their wires underground upon payment by the Corporation of half the total cost, estimated at £4,390.

The Tramways committee have directed that 150 of the new cars be fitted with top-deck covers, have substituted radial for rigid wheel trucks, and have directed that the whole of the cars shall be fitted with magnetic brakes. These and other improvements will increase the cost by about £23,500.

**Bradford.**—The receipts of the tramways department for the year ended March 31 were £224,147. 18s. 6d. or £1,375. 3s. 6d. less than in 1904-5. The car-miles run were 5,034,154, against 5,040,452, and the average takings per mile were 10·68d. compared with 10·88d. for the previous 12 months. The income of the parcels department was £3,927, or more than double that for 1904-5.

**Brighton.**—The President of the L.G. Board (Mr. John Burns, M.P.) has promised to perform the ceremony of opening the Corporation's electric power station at Southwick.

**Caerphilly.**—The L.G. Board have sanctioned a loan for the Council's electricity supply scheme.

**Chili.**—The electrification of the Central Railway between Santiago and Talcar has been officially authorised and the work is to be proceeded with. The generating station will be near the town of Rancagua and for power for the works the waters of the river Cachapoal is to be utilised.

**Christiania (Norway).**—Proposals have been submitted to the Municipal Council by the Glommen Fosse Kompani for the utilisation of the Halfredsfos and Solberg waterfalls for the generation and supply of electricity for lighting and power in Christiania. The Felten & Guilleaume-Lahmeyerwerke A.G. will undertake the construction and equipment of the works. It is estimated that at least 20,000 H.P. is available at the Glommen fall.

**Customs Changes.**—Under the new customs tariff of Ecuador, telephonic and telegraphic apparatus are subject to an import duty of 25 centavos per kilog.

**Dangers of Gas.**—The danger of fire from the employment of gas as a lighting agent is forcibly illustrated in the annual report of the Fire Brigade committee of London County Council. During 1905 no less than 168 fires were caused in the Metropolitan area by escapes of gas, 83 fires were due to curtains or window blinds, nine to decorations, one to films, six to goods, and three to linen coming in contact with gas lights, and 15 to clothes, curtains, &c., coming in contact with stoves. 33 other fires were ascribed to the use of swinging gas brackets and 46 to various causes beyond those already mentioned in connection with the overheating, &c., of gas stoves. 12 fires were caused by overheat produced by gas light, 12 to accidents while gas fitters were at work and three to gas explosions. Altogether, during the 12 months, 407 fires were directly caused in the Metropolitan area alone from the use of gas. In comparison with the foregoing the fires caused by or attributed to electricity are only 73. 70 of these were alleged to be due to defective electric circuits, one to a gaspipe coming in contact with an electric conducting rail, one to a workman's tool falling on an electric conducting rail and one to "overheat from an electric light."

**Darwen.**—The Electricity committee have reduced the charge for electric current for power from 3d. to 2d. per unit. At present motors of an aggregate of about 300 H.P. are connected.

**Dublin.**—The Lighting committee, having worked out the average prices paid by various classes of consumers on the maximum demand system, recommend the Council to adopt a series of flat rates varying from 2½d. to 5½d.

The committee state that at the start of the new system in 1903 there were 322 consumers, with the equivalent of 33,000 8 c.p. lamps, compared with 1,086 consumers at present and 108,634 lamps.

In regard to the recent expression of disapproval by the L.G. Board auditor (Mr. Drury) of the payment by the Corporation of a higher price for certain work than the amount of the accepted tender, the Cleansing committee state this was in regard to a contract for switchboards at Pigeon House, Fleet-street and various sub-stations. On the occasion in question the committee accepted an offer from Ferranti Limited at £609. 15s. over the tenders sent in by other firms, on a total sum of nearly £14,000. The committee state that they accepted Ferranti's offer in order to comply strictly with the regulations of the Board of Trade. With regard to Mr. Drury's recommendation that the plant depreciation fund should be increased because the Fleet-street plant had to be disposed of for a small price, it should be borne in mind that the abolition of Fleet-street station and the generation of all the current required at Pigeon House had led to more economical working. The committee therefore consider it would be unfair to throw upon them the provision of a depreciation fund for the benefit of futurity.

The Corporation have received sanction to a loan of £28,000 for the extensions of the electric lighting mains to Clontarf.

**Dudley.**—An inquiry was held on Friday into an application for sanction to borrow £22,000 for the electricity supply undertaking. £11,677 was required to meet excess expenditure on previous work, £9,322 for additional plant and £2,000 for cables.

The consulting engineer (Mr. R. P. Wilson) explained how the excess arose. The Corporation were required, subject to a penalty, to be ready to supply current by March 1 of 1899, though as a matter of fact the tramway company were not ready to take current till July. The Council found it impossible to procure, in the time specified, the engines they desired, and the result was that they had afterwards to put down larger engines and extend the building, and then excess expenditure was also incurred.

After discussion this part of the inquiry was adjourned till to-day (Friday) for the production of the accepted tenders. Mr. Wilson then gave particulars of the expenditure in connection with the extensions, and said the present plant had a capacity of 1,600 kw., and the maximum load during the recent winter months for lighting and traction was 1,410 kw.

The Tramway committee recommend that the town clerk be authorised to take up the award of the arbitrator (Mr. H. Graham Harris) as to the price to be paid by the Corporation to the Birmingham & Midland Tramways and the Dudley, Stourbridge & District Electric Traction Companies for portions of their lines in the borough, and arrangements are to be made for a temporary loan for a period not exceeding 12 months to provide the purchase money.

**Edinburgh.**—The Electric Lighting committee decided on Tuesday to recommend that, as from May 15, the charge for public arc lamps be reduced from £10. 15s. to £9 per lamp per annum; that the charge for current for private lighting be reduced from $3\frac{1}{4}$d to 3d. per unit; and for motive power from $1\frac{1}{4}$d to $1\frac{1}{8}$d, and that the rate to consumers who agree not to use current during the heavy-load period in the winter months be reduced from $1\frac{1}{10}$d to 1d per unit

**Erdington.**—After protracted negotiations, the agreement between the Council and the City of Birmingham Tramways Co. has been rescinded, and the offer of Birmingham Corporation has been accepted to work the tramways in the district under the following conditions:—

Erdington to maintain track and supply current; Birmingham to maintain overhead equipment; receipts, apportioned on a stage mileage basis, to belong to the respective local authorities in proportion to the length of each stage in their respective districts; Birmingham to be paid working expenses, calculated on basis of car-mileage of whole system worked by Birmingham; the actual cost of maintaining the overhead system in Erdington to be paid by Erdington to Birmingham.

**Exhibitions.**—On Thursday last the 12th annual trades' exhibition was opened at Bingley Hall, Birmingham. Apparatus for electric lighting, electric cooking, electric engraving, &c., is shown, in addition to suction-gas plant and steam, gas and oil engines.

Maidstone Corporation's electrical exhibition was opened on Monday by the mayor (Councillor W. Day). The exhibits include dynamos and motors, electric lighting, cooking and heating apparatus, telephone instruments, &c. Electric cookery demonstrations are being given.

**Exhibition Lighting.**—The Union Electric Co. inform us that, as in the case of the Olympia Electrical Exhibition, the "Excello" arc lamp has been selected for lighting the whole of the street approaching the North-Eastern Counties Electrical Exhibition, Newcastle-on-Tyne. In this case the lamps are placed 30 ft. above the ground level. Both exterior and interior lighting is effected by these lamps.

**Gloucester.**—The City Council have introduced an optional flat rate of 4d. per unit, and the charge for street lighting has been reduced to 2d. per unit.

**Hammersmith (London).**—The estimated net profit on the electricity undertaking for the year ended March is £519.

**India.**—It is reported that the Mysore Government contemplate carrying out a further extension of the Cauvery Falls electric power scheme, which supplies power to the mines of the Kolar goldfield. At the end of last year the Mysore Gold Mining Co. took 1,635 H.P. from Cauvery Falls, and has since applied for an additional 850 H.P.

**Islington (London)**—An additional high-tension feeder is to be laid at a cost of £1,820, and other main extensions are to be carried out at a cost of £515.

On Friday the Council decided to abolish the maximum demand system of charging for electric current, and to introduce a uniform charge of $3\frac{1}{2}$d. per unit for private lighting, with 3d. for places of worship, hospitals, public institutions, &c. The charge for power and domestic purposes will be 1d. per unit up to 50,000 units per quarter, and 0·8d. per unit for all over 50,000 units, on a three years' agreement. Meter rentals have been abolished, and no further customers are to be supplied at the special daylight charge of 2d. per unit.

The borough treasurer estimated that, with a uniform rate of $3\frac{1}{2}$d. per unit for lighting, 1d. for power, and a special rate of 3d. for public institutions, there would be a demand for 2,530,398 units for private supply (1,560,398 at $3\frac{1}{2}$d., 278,826 at 3d., and 691,732 at 1d.), yielding a revenue of £29,123, and 1,683,121 units for public lighting, yielding £15,734, a total of £44,857. The estimated expenses would be £45,793, or a loss of £936.

The chairman of the Lighting committee (Mr. H. B. Vorley), in support of the recommendation, said it was highly necessary that a reduction of price should be made. Promises had to be given to many customers that the price would be reduced in order to retain their custom. Both the Lighting and Finance committees had concluded that the time had arrived for a reduction. The proposal to reduce the rate from 5d. to $3\frac{1}{2}$d. per unit was a very drastic one, but they felt that the time had come when, with the competition of incandescent gas, coupled with bad trade and hard times, they must make a thoroughly drastic alteration, so that electric current might be within the reach of all.

**Leeds.**—The receipts of the tramways department for the year ended March 31 were £309,000, compared with £294,324 in 1904-5. There were, however, six more working days in the financial year just ended. 69 million passengers were carried, or about $8\frac{1}{4}$ millions more that in 1904-5; the car-miles run numbered over 7,000,000, an increase of about 100,000.

**King's Norton.**—On Wednesday the Council authorised the Tramways committee to take steps for reconstructing the Moseley and King's Heath tramways for electric traction, and to obtain tenders for carrying out the necessary works.

**Leyland.**—The Council have applied for a further extension of their electric lighting order, 1902.

**Light Railways.**—Llandudno District Council have arranged terms with Messrs. Bruce Peebles & Co. in regard to the construction of the Llandudno-Colwyn Bay light railway.

**Lincoln.**—An inquiry was held on Wednesday into the Council's application for sanction to borrow £13,000 for extensions of the electricity undertaking.

The deputy town clerk (Mr. W. T. Page) and the borough electrical engineer (Mr. Stanley Clegg) gave evidence.

**Llanelly.**—An inquiry was held on Tuesday into the application of the Council for permission to borrow £6,000 for electricity supply.

The electrical engineer (Mr. J. C. Howell) said an agreement had been entered into with the South Wales Electrical Power Distribution Co. for supply of electricity in bulk. A firm had promised to supply feeders free, provided they were allowed to advertise on them. The cost would be well within £6,000. Seventy persons had promised to take current, and he estimated the receipts at £1,050 per annum. He was certain the Council would lose nothing.

**London County Council.**—At Tuesday's meeting it was agreed to loan £4,000 to Hackney for electric lighting.

*Tramways.*—The Council passed the estimates for the year, which included £1,925,000 for tramways.

*Northern Tramways.*—The Highways committee recommended the expenditure of £46,500 in respect of the reconstruction for the underground conduit system of the proposed extension of the Aldwych to Islington tramways from the "Angel" to Highbury:—Postponed.

*Southern Tramways*—The same committee recommended expenditure of £39,500 for the construction of conduit tramways between High-street, Lewisham and Lee Green.—Postponed.

*Stoneware Ducts.*—The offer of Mr. H. R. Mansfield and of Hosea, Tugby & Co. to supply 300,000 stoneware cable ducts at the rate of £14 per 1,000 was accepted. Contracts for these ducts were entered into with G. Skey & Co. and Stanley Bros., each for the supply of 750,000 stoneware cable ducts at £11. 19s.6d. and £13 per 1,000 respectively, rates of delivery 5,000 and 10,000 ducts a week respectively. Arrangements have been made for Reid Bros. to undertake the work of laying the ducts for the first section of the northern lines, and special arrangements are necessary for expediting the supply of the ducts. The above contracts have been entered into for the guaranteed delivery of 40,000 ducts a week.

**London County Council Tramways.**—At midnight on Saturday last the tramways north of the Thames, hitherto worked by the North Metropolitan Tramways Co., passed into the hands of London County Council, in accordance with an agreement under which the company surrendered the undertaking to the Council four years before the latter could have taken them over compulsorily. The amount of the valuation of rolling stock, horses, buildings, &c., was £355,000, and the Council have to pay this sum, in addition to £80,000 for goodwill. The company's employés have all been taken temporarily into the Council's service. The conversion to electric traction of the first 22 miles of single track is already in hand and the conversion of the whole system is expected to be completed by 1910.

**Loughborough.**—On Wednesday the Council decided, on the recommendation of the Gas and Electricity committee, not to accept the proposals recently made by the Brush Co. for the purchase of the Corporation's electricity undertaking by a new company to be formed.

**Manchester.**—The Electricity committee were authorised by the Corporation on Wednesday to arrange for the borrowing of £63,000 for extensions of the electricity undertaking.

**Manchester Association of Engineers.**—On Saturday last the 50th annual meeting of this association took place, when a testimonial was presented to Mr. Robert Mathews (president) to celebrate the association's 50th year of existence. Mr. W. H. Hunter was elected president for the ensuing year.

**Milan International Exhibition.**—The King of Italy will open this Exhibition on 21st inst,, when His Majesty will visit several of the British courts.

**New Malden.**—On Tuesday the Council appointed Messrs. Talbot & Stevenson consulting engineers, at a fee of 30 guineas, to prepare a report upon the best means of carrying out the Council's electric lighting order.

**Paraguay.**—Assuncion Municipality will shortly invite tenders for the electric lighting of the city.

**Presentations.**—On Friday evening Mr. S. Edgar Fedden, manager of the Sheffield Corporation electric light department (who is about to be married to Miss Margaret Warwick, of Bedford) was presented with a cabinet of Prince's cutlery and a "round robin," designed by the head draughtsman of the department (Mr. J. Taylor) bearing the names of the subscribers—the staff and workmen employed by the department, numbering some 200.

Mr. Fedden entertained the subscribers to supper and subsequently the evening was spent in social enjoyment. Mr. H. S. R. Parton, secretary of the presentation fund, presided, and was supported by Mr. Fedden, Mr. J. W. Beauchamp (deputy chief of the electric supply department, who made the presentation), Mr. A. Cuthill (stations superintendent), Mr. W. Howard (mains department), and Mr. J. W. Barnes (wiring and trading department). There were 140 present.

Mr. J. W. Beauchamp said they thought the occasion was a proper one for showing their appreciation of Mr. Fedden as a chief during the six years he had been in Sheffield. On behalf of the staff and employés generally, he heartily wished Mr. Fedden and his future wife every success in life.

Mr. Fedden expressed his appreciation of the esteem that had prompted the presentation and which he regarded as a token of the respect of every one of those associated with the work of the Sheffield electric supply department. It was the proudest day of his life, because, while keeping proper control over them, if he had been able to gain their goodwill it demonstrated that his endeavours to treat them justly had not been in vain. The success of the electricity department was entirely owing to the hearty co-operation of every member of the staff down to the humblest employé, and he thanked them for their loyalty and support. Regarding the hope expressed that his life's work might be in Sheffield, Mr. Fedden said he had worked in the United States and Canada, in Scotland, and other parts of this country, but after six years' sojourn in Sheffield he confessed to liking Sheffield more than anywhere.

A gold watch and chain have been presented by the employés of Willans & Robinson to Mr. H. T. Gear, who is leaving to take up a London appointment.

The Folkestone staff of the National Telephone Co. have presented an umbrella and walking stick to Mr. Bacon, chief district inspector, who is leaving for Leatherhead.

Last week the Ramsgate staff of the National Telephone Co. presented Mr. G. H. Rogers, manager of the Ramsgate district for the past 2½ years, with a gold signet ring on his departure to take up an appointment in the telephone service in Montreal, Canada.

**Rochdale.**—The receipts for the year ended March 31 exceeded £42,000. After paying working expenses it is estimated that there will be a balance of £18,000 to meet interest ahd sinking fund.

**St. Pancras (London).**—Ald. F. Purchese has resigned the chairmanship of the Electricity and Public Lighting committee owing to ill-health.

**Shipley.**—The salary of the electrical engineer (Mr. S. D. Schofield) has been increased from £250 to £275 per annum, with a further advance of £25 on April 1, 1907.

**Southampton.**—An unopposed inquiry was held here last week into the application of the Council for permission to borrow £7,000 for extensions of the electricity undertaking.

The borough electrical engineer (Mr. H. F. Street) explained that he anticipated a greater demand for electric current, owing to recent reductions in the tariff. There were also many thoroughfares with good-class properties where there were no mains, and it was the intention of the Corporation to lay mains and supply electricity in those districts. Of the £2,000 for new works, £1,600 was for additional batteries and £400 for switch gear.

**Southwark (London).**—The London Electric Supply Corpn. offer to supply electric current for public lighting at 1½d. per unit. From the accounts of the electricity department to March 31 last it appears that the prosent charge is 2·52d. per unit, and the company's offer has been referred to the General Purposes, Law and Parliamentary committee.

A new feeder is to be laid at a cost of £2,000.

**Switzerland.**—The Langenthal-Jura Railway Co., of Langenthal, have been granted a concession for the construction and working of an electric railway between Langenthal and Ensingen.

**Victoria (Australia).**—The estimates of Melbourne City Council for 1906 provide £26,045 for street lighting, of which £23,470 is for electric illumination.

The contract held by the gas company for the street illumination of Collingwood expires on March 15. Tenders are to be called alternatively for gas and electric lighting.

Hamilton Town Council, at the invitation of the engineer to the local electric lighting company, are considering the question of electrically lighting the principal streets and town hall.

**Village Lighting.**—Gowerton Parish Council have decided to adopt electric lighting and to enter into an agreement with Baldwins & Co. for supply of current.

**Wath-upon-Dearne (Yorks.)**—The Council are applying for an extension of 12 months of their electric lighting order, 1899.

**Wembley.**—The adjourned inquiry into the applications of the Council and the North Metropolitan Electrical Power Distribution Co. for a provisional order has resulted in a compromise. The Board of Trade have decided to grant an order to the Council, with a clause by which the undertaking will be run by the company upon agreed terms. The Council retain the right to purchase at 14, 21, 28, or 35 years.

**West Yorkshire Tramways.**—Brighouse Council have now withdrawn their opposition to the West Yorkshire Tramways Co.'s proposal to construct tramways in the borough to form part of the Halifax-Huddersfield route.

**Wigan.**—The Council decided on Tuesday to apply for sanction to borrow £48,000 for extensions of the electricity works and mains. £13,500 further is to be borrowed for the construstion of the Abram tramways.

**Wimbledon.**—An agreement has been come to between the Council and the London United Tramways (Ltd.) with regard to the construction of tramways in the borough The company agree to pay £4,614 for relief from responsibility with regard to manholes and sewers

Johnson & Phillips have been allowed, in consequence of the recent fire at their works, to sub-let their contract for telephone and pilot cables to Siemens Bros. & Co.

**Wolverhampton.**—Arrangements have been made with the British Electric Traction Co. to run cars to Bilston, on the Willenhall route. The company have also agreed to hand over the whole of the running to the Corporation, who take all revenue collected in the borough, the company taking the receipts outside. Three single-deck cars are to be purchased for intercommunication between Wolverhampton and Willenhall, and 10 cars are to be equipped for running between Dudley and Wolverhampton.

**Woolwich.**—The Council have authorised the Works committee to have all side street gas lamps on the route of the existing mains converted to electric lighting.

**Worcester.**—A special meeting of the City Council will be held on 24th inst. to discuss a recommendation of the borough electrical engineer (Mr. C. M. Shaw) to remove the steam plant from Powick to Hylton-road station, and also a proposal to modify the charges for electric current.

**Dinner.**—The annual dinner of the Brighton Section of the National Telephone Co. took place on Friday last, Mr. F. W. Taylor (district manager) presiding.

Among those present were Mr. H. Julius Maclure (contract manager), Mr. Armstrong (local manager, Hastings), Mr. Legge (engineer, Brighton), Mr. Pharo (traffic manager, Portsmouth) and Mr. J. H. Watkins (assistant engineer, Brighton), the last-named acting as hon. secretary of the Dinner committee. A smoking concert followed the dinner, and subsequently Mr. Taylor was presented with a service of plate and an illuminated address bearing the names of over 260 subscribers.

In acknowledging the presentation, Mr. Taylor said he felt most deeply the kindness shown to him by the staff, and highly prized their handsome gift. He had his doubts in coming to Brighton, but he had been with them nearly two years and his hopes had been more than fulfilled. He had around him one of the best staffs any district could have, and they pulled together wonderfully well. The Brighton staff was fourth largest in the provinces.

## TRADE NOTES AND NOTICES.

### NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1906 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is even more complete and accurate than in previous issues, and has been revised up to day of publication. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Traders purposes. The valuable large sheet Tables, &c., have been very carefully revised and extended, making the 1906 Edition of this indispensable work the most complete book of the kind ever published.

A full Digest of Contents will be sent post free on request.

### TENDERS INVITED.

*Salford* Electricity committee invite tenders for supply and erection of 750 kw. steam turbo-generator and condensing plant. Plans, specification, &c., from the borough electrical engineer, Pendleton. Tenders by April 21 to the town clerk, Mr. L. C. Evans, Town Hall, Salford. See also an advertisement.

*Exeter* Corporation invite tenders for the electrical overhead equipment of about ⅝ mile of route length of tramway. Specifications from the city electrical engineer (Mr. H. D. Munro), 184, Sidwell-street, Exeter. Tenders to the town clerk (Mr. H. Lloyd Parry), 8, Southernhay West, Exeter, by April 11. See also an advertisement.

*Exeter* Corporation also want tenders by April 11 for construction and bonding of about $\frac{5}{8}$ mile single track electric tramway and erection of two additional bays at car depot.

*Glasgow* Corporation invite tenders for supply of (1) main cables, (2) small cables and wires, (3) electricity meters, and (4) carbons for 12 months from the 31st prox. Specifications from the chief engineer (Mr. W. W. Lackie), 75, Waterloo-street, Glasgow. Tenders to the Town Clerk (Mr. A. W. Myles) before 23rd inst. See also an advertisement.

*Glasgow* Corporation also want tenders by 23rd inst. for cast-iron joint boxes and for 12 months' supply of other stores and materials to their electricity department.

*Glasgow* Parish Council and Lunacy District Board require tenders by 10 a.m. of 20th inst. for 12 months' supply of electric lamps and fittings, ironmongery, &c , to their poorhouse, hospitals and asylums. Forms of tender from Mr. J. R. Motion, 266, George-street, Glasgow,

*West Ham* Corporation invite tenders for supply of 3,500 yds L.T. 0·75 sq. in. sectional area concentric paper-insulated lead-covered cable. Specifications, &c , from the borough electrical engineer, (Mr. A. Hugh Seabrook), central electricity station, Tucker-street, Canning Town Tenders to the town clerk (Dr. Fred. E. Hilleary) by 5 p.m. April 11. See also an advertisement.

*Hull* Electric Lighting committee invite tenders for the following plant for their Sculcoates-lane electricity generating station: Coal-handling plant, &c , in connection with eight Lancashire boilers; condensers, pumps, pipe work, &c., in connection with six Lancashire boilers; and two high-speed engines. Specifications, &c , from the city treasurer, Mr. T. G. Milner. Tenders to the chairman of the committee, Town Hall, Hull, before noon April 19. See also an advertisement

*Belfast* Tramways and Electricity committee invite tenders for supply and erection of coal and ash conveying plant, bunkers and chain grate mechanical stokers. Tenders by 11 a.m. April 16 to Sir Samuel Black, Town Hall, Belfast.

*Islington* (London) Lighting committee invite tenders for 12 months' supply of lead-covered paper h. and l.t. cable; also for transformer, cast-iron goods, &c. Tenders to the Town Hall, Upper-street, London, N., by 5 p m. April 11.

*Wallasey* District Council want tenders by 10 a.m. May 7 for stores for their steamers and ferries, including electric globes and carbons, lamps, tubing, metals, oils, packing, &c. Forms of tender from manager's office, Seacombe Ferry.

*Edinburgh* District Lunacy Board want tenders by 10 a.m. 9th inst. for electric lighting of hospital, nurses' home, &c , at Bangour village. Specification from Mr. H. J. Blanc, 25, Rutland square, Edinburgh.

*Chorlton* Guardians want tenders by 9 a.m. 18th inst. for electric lighting of workhouse and hospitals at Withington. Specifications from Mr. G. R. Peers, 16, John Dalton-street, Manchester.

*South Shields* Corporation want tenders by noon 18th inst. for 10 open staircase double-deck motor tramcars, with option of adding five cars.

*Maidenhead* Corporation want tenders by April 18 for electrical stores, engine-room stores and coal.

The *Cape of Good Hope* Government is inviting tenders for the supply of flat twin leading-in 20/10 covered wire for the six months to June 30, 1907, the annual estimated requirements being 12,000 yds. Forms of tender, &c., from the controller of stores, G.P.O., Cape Town. Tenders to chairman of tender board, Control and Audit Office, Parliament-street, Cape Town, by May 9.

The Commercial Intelligence Branch of the Board of Trade have received from the Acting British Consul-General at Christiania particulars of a call for tenders by the *Norwegian State Telegraph Department* for the supply of 2,013 metres of 506-pair cable. Tenders by noon of April 18. Specifications, &c., from the Board of Telegraphs, Hasselgaarden, Christiania, and of the inspectors of telegraphs, Trondhjem, Bergen, Stavanger and Arendal, and Copies (in Norwegian) of specification may be seen at the offices of the Board, 73, Basinghall-street, London, E.C. Apart from usual Customs duties, a preference of from 10 to 15 per cent. is given to Norwegian manufacturers, and in all cases of Norwegian Government contracts it is obligatory that a resident agent should act for tenderers not residing in Norway.

Tenders will be opened on April 28, at the Secretaria de Gobernacion, Havana, Cuba, for the construction and working of a telephone system extending over a radius of 10 kilometres in *Caimanera*. The Havana "Gaceta" of March 10 contains particulars.

## TENDERS RECEIVED AND ACCEPTED.

Messrs. Ed. Bennis & Co., Little Hulton, Bolton, and 28, Victoria-street, London, S.W., have recently received the following orders:—

Ten stokers and compressed-air furnaces (repeat order) for the British Cotton & Wool Dyers' Association, Bradford; coal elevating plant, with six stokers and compressed-air furnaces for the Ocean Coal Co., Ton Pentre, South Wales; complete coal elevating plant, with eight stokers and compressed-air furnaces for the Glamorgan Coal Co., Llwynypia, South Wales; four stokers and compressed-air furnaces (repeat) for the Patent Shaft & Axletree Co., Wednesbury; four stokers and compressed-air furnaces (repeat) and complete coal-handling plant for the Cardiff Steam Coal Collieries Co., Llanbradach, Cardiff; four stokers and compressed-air furnaces (repeat) for the Plas Power Colliery Co., Plas Power Colliery, near Wrexham; two stokers and compressed-air furnaces (repeat) for the African Oil Mills Co., Liverpool; two stokers and compressed-air furnaces (repeat) for the Australian Alum Co., Runcorn; two stokers and compressed-air furnaces for Darlington Corpn. Electricity Works; two stokers and compressed-air furnaces (repeat) for Storthes Hall Asylum, Kirkburton (per Ashwell & Nesbit); two stokers and compressed-air furnaces for Worcester Corpn. Electricity Works; two stokers and compressed-air stokers (repeat) for Spencer & Co., Melksham, Wilts; two stokers and compressed-air furnaces for the Chilworth Gunpowder Co., Chilworth; one "Bennis" patent 10 ton revolving truck tippler (similar to that supplied to the Metropolitan Electric Supply Co. at Willesden), supplied to Mr. J. M. V. Money-Kent (for Cape Copper Co.); and two stokers and compressed-air furnaces for the Soc. Siderurgica di Savona, Savona, Italy.

For 11 induction motor-generators for Limehouse, Shoreditch and Mildmay Park sub-stations of London County Council's northern tramways the following tenders were received:—

| | | | | | |
|---|---|---|---|---|---|
| Siemens Bros. & Co. (*ac.*) | **£19,242** | **10** | Elec. Construction Co. | £20,729 | 19 |
| Vickers, Sons & Maxim | 24,888 | 0 | Brush Co. ............ | 20,472 | 1 |
| B.T.-H. Co. .......... | 22,075 | 0 | General Electric Co. .. | 20,102 | 5 |
| Mather & Platt ...... | 21,965 | 0 | Brit. Westinghouse Co. | 19,416 | 10 |
| Dick, Kerr & Co....... | 21,053 | 14 | | | |

The successful tenderers are permitted to sub-let to E. F. Moy (or such other person or firm as may be approved by the engineer under the contract) the manufacture of the small regulating resistances in connection with the motor-generators.

For high and low-tension switch gear for Limehouse, Shoreditch and Mildmay Park sub-stations the following tenders were received:

| | | | | | |
|---|---|---|---|---|---|
| Ferranti Limited (*ac.*) | **£8,304** | **17** | Evered & Co. ........ | £10,020 | 18 |
| Elliott Bros.......... | 12,092 | 0 | Dick, Kerr & Co....... | 9,624 | 6 |
| Elec. Construction Co. | 10,373 | 10 | J. E. Spagnoletti & Co.. | 9,070 | 0 |
| Siemens Bros. & Co. .. | 10,350 | 0 | General Electric Co. .. | 8,556 | 4 |
| Brit. Westinghouse Co. | 10,322 | 15 | | | |

The successful tenderers may sub-let to Barrett & Power the building of the brickwork cells for the switch gear.

For low-tension switchboards for sub-stations the following offers were received:—

| | | | | | |
|---|---|---|---|---|---|
| Eckstein, Heap & Co. (*ac.*) | **£2,413** | **17** | John Fowler & Co. .... | £3,244 | 0 |
| Elliott Bros. .......... | 4,161 | 8 | Siemens Bros. & Co..... | 3,172 | 0 |
| Cox-Walkers .......... | 4,127 | 0 | Bertram Thomas ...... | 3,126 | 0 |
| Dick, Kerr & Co. ...... | 3,665 | 0 | Elec. Construction Co... | 2,928 | 0 |
| Brit. Westinghouse Co. . | 3,365 | 4 | Evered & Co........... | 2,927 | 18 |
| Edison & Swan Co. .... | 3,245 | 0 | Ferranti Limited ...... | 2,832 | 3 |

The contractors may sub-let to Elliott Bros. the manufacture of the measuring instruments, and to Bertram Thomas the manufacture of circuit-breakers.

Wimbledon Council have accepted the following tenders for annual supplies for the electricity department:—

British Westinghouse Co., transformers; Ferranti Limited, meters; British Thomson-Houston Co., prepayment meters; A. Duckham & Co. and Anglo-Russian Oil Co., oils; R. Woods & Co., electric lamps; Geipel & Lange, carbons; Pryke & Palmer, Jas. Gibb & Co., George Hatch (Ltd.), Dicks' Asbestos Co., F. Bird & Co., Jas. Harvey and Brunner, Mond & Co., engine-room stores; Callender's Co., high-tension and private lighting cables; St. Helens Cable Co., public lighting cables; Albion Clay Co., conduits; Doulton & Co., British Insulated & Helsby Cables, W. Lucy & Co., Rumney & Rumney, Callender's Co. and W. T. Henley's Co., joint boxes and joint materials; Davis Electric lamp Co., General Electric Co. and G. Straus & Co., accessories; Shaw & Co., arc lamp globes; Jas. Gibb & Co., castings; Hall & Co. (Croydon), Ltd., fire bricks and fire clay; J. Halden & Co., drawing materials.

Briton Ferry Council received the following tenders for supply, delivery, erection and laying of sub-station switchboard, non-rubber feeder and distributor cables, feeder pillars, joint boxes, arc standards, arc lamps, &c.:—

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Callender's Co. (*accepted*) | **£1,576** | **14** | **2** | Johnson & Phillips.. | £1,655 | 11 | 0 |
| Ellis & Ward ...... | 1,859 | 0 | 0 | W. T. Henley's Co.. | 1,649 | 5 | 4 |
| Improved Electric Supplies (Ltd.) .. | 1,815 | 10 | 0 | W. T. Glover & Co. | 1,646 | 19 | 2 |
| Western Electric Co. | 1,733 | 10 | 6 | British Insulated & Helsby Cables .. | 1,634 | 17 | 0 |
| | | | | Siemens Bros. & Co.. | 1,633 | 10 | 10 |

London County Council have accepted the tender of J. O. Grant & Taylor for wiring the Brixton fire station at £151. 9s. There were 11 tenders, varying in amount from that of the accepted to £257. 5s. For wiring the Herne Hill sub-station tenders were received from the same 11 firms, but in this case the lowest tender (£120) was submitted by J. Defries & Sons and was accepted The highest tender amounted to £202. 10s.

Bermondsey Council have accepted the following tenders for annual supplies for the electricity undertaking:—

Geipel & Lange, arc lamp carbons (estimated quantity required, 25,000 pairs), at £2. 19s. 1d. per 1,000 (20 tenders received); Doulton & Co., conduits (six tenders); British Insulated & Helsby Cables, 100 meter boards (15 tenders); Silvertown Oil Storage Co., dynamo oil, 1s., and crank-chamber oil, 2s. 2d.; C. C. Wakefield & Co., cylinder oil, 2s. 4d., forced lubrication chamber oil, 1s. 5d. (20 tenders); Reason Mfg. Co., meters (up to 15 amps.), indicators and fuses; Chamberlain & Hookham, meters above 15 amps.; Reason Mfg. Co., demand indicators, cut-outs, sealing troughs and standard fuses (23 tenders); Johnson & Phillips, Ltd., boxes, &c. (10 tenders).

Greenock Corporation received tenders from the following firms for supply of two 750 kw. steam generating sets and one 750 kw. d.c. motor generator. No tender has yet been accepted.

Brush Co., Bruce Peebles & Co., British Westinghouse Co., British Electric Plant Co., Browett, Lindley & Co., Crompton & Co., Dick, Kerr & Co, Electric Construction Co., Electrical Co., John Fowler & Co. (Leeds), General Electric Co., J. Howden & Co., Johnson & Phillips, Mather & Platt, Mavor & Coulson, Thomas Parker (Ltd.), Phœnix Dynamo Mfg. Co., C. A. Parsons & Co., John A. Rudd, Siemens Bros. & Co. and Vickers, Sons & Maxim.

The following firms recently submitted tenders for supply and delivery to Willesden (London) Council of 66 flame arc lamps for street lighting. The figures are, however, not available, and up to the present no tender has been accepted:—G. Braulik, General Electric Co., Brockie-Pell Arc Lamp (Ltd.), Armorduct Mfg. Co., Union Electric Co., Electrical Co., Oliver & Co., Crompton & Co., Johnson & Phillips, G. Straus & Co., Gilbert Arc Lamp Co. and D. Santoni & Co.

London County Council have accepted the tender of Holloway & Greenwood at £27,999 for the erection of a car shed at Stamford Hill in connection with the Council's northern tramway system. There were 10 tenders, varying in amount from that of the accepted to £34,493.

Ilford Council have accepted the following tenders at schedule prices for annual supply for the electricity department:—

British Thomson-Houston Co. & Reason Mfg. Co., electricity meters and demand indicators; W. T. Henley's Co., cables; British Thomson-Houston Co., incandescent lamps; Geipel & Lange, arc lamp carbons; Reason Mfg. Co., house service fuse boxes.

Shoreditch (London) Council have accepted the following tenders for annual supplies for the electric lighting undertaking: Johnson & Phillips, W. T. Glover & Co., W. T. Henley's Co. and G. Braulik, for cables and sundries; A. Howard & Co, Middleton Bros. and Jas. Gibb & Co., for engineers' stores.

London County Council have accepted the tender of Wm. Cory & Son, at £38,854. 3s. 4d., with demurrage of 2d. a ton of coal a day, for the supply and delivery of coal for the Greenwich electricity generating station up to June 30, 1907.

Sydney Electric Lighting committee recommend for acceptance the tender of J. Stewart & Son at £12,397 for extension of Pyrmont generating station. Seven higher tenders were received, varying from £12,500 to £14,495.

Shanghai Municipal Council have placed an order with C. A. Parsons & Co. for supply and delivery (c.i.f. Shanghai) of one 800 kw. horizontal steam turbo-alternator (single-phase), with condensing plant, at £7,475. The alternator is to be by Bruce Peebles & Co.

For the third year in succession, Adams Mfg. Co., 147, Queen Victoria-street, E.C., have secured the contract for the supply to Salford Corporation of Sturtevant "Igranic" motor-starting rheostats for motors of from 5 B.H.P. to 30 B.H.P. Blackburn have also placed an order with the company for rheostats for the ensuing year.

The Australian Postmaster-General's Department (Victoria) has accepted the tender of W. T. Henley's Telegraph Works Co. for 10 miles of 26-pair lead-covered paper-insulated telephone cable at £1,980.

Islington Lighting committee have accepted the tenders of the Union Electric Co. for 250 "Excello" flame arc lamps at £1,705, and that of Rowland Carr & Co. for 250 lamp columns, complete with bases, shafts, crutches, &c., at £2,125.

Erdington District Council have accepted the tenders of Geo. Law for the construction of tramways from Salford Bridge to Sutton boundary at £35,210 and for laying margins in the main road on the same route with wood blocks at £16,927.

Torquay Town Council have accepted the tender of the Main Colliery Co. for 1,500 to 2,500 tons of smokeless thro' steam coal at 15s. 2d. per ton, delivered Torquay Harbour.

The Lancashire Dynamo & Motor Co., Trafford Park, Manchester, have received an order from Salford Corporation for 12 months' supply of motors (7 H.P. to 30 H.P.) for the fourth year in succession.

Halifax Guardians have accepted the tender of Joseph Hamer for supplying electrical fittings to the workhouse.

Paddington (London) Council have accepted the tender of the General Electric Co. for the annual supply of electric lamps and shades.

Lancaster Council have accepted the tender of E. Green & Son for the renewal of one section of the economiser at £150, and that of Callender's Co. for lighting cables.

**Reason Co.'s "New Solution" Electrolytic Meter.**—The following have recently placed contracts for meters with the Reason Mfg. Co.: General Post Office, Falkirk, Leith and Stoke-on-Trent Corporations, and Ilford District Council.

## BUSINESS NOTICES.

The Cape Asbestos Co. (Ltd.) have removed to more commodious offices at Guildhall Annexe, 23, King-street, Cheapside, E.C. The company's telephone number will be 1,298 London Wall, the telegraphic address ("Incorrupt London") remaining as hitherto.

Owing to the increase of business D. Santoni & Co. (Ltd.) have removed to more commodious premises at Alba Works, 15-17, Beauchamp-street, Holborn, London, W.C., where they have erected up-to-date works and testing laboratories. With a well-trained and technical staff the company will be able to give the closest attention to thorough workmanship and reliability of the "Santoni" intense flame arc lamp. The firm will also undertake the manufacture of all kinds of indicating apparatus and accessories, spare parts, &c., for electric tramways and railways, &c., and the repair of armature and other windings.

Mr W. Pollard Digby has removed to 82, Victoria-street, London, S.W.

After 7th inst. the offices of the Tramways Department of the London County Council will be 62, Finsbury-pavement, E.C.

Harold S. Martin and Geo. V. Stavert, electrical engineers, 13, Cumberland street and 22, Sir Thomas-street, Liverpool, have dissolved partnership. Debts by Mr. Martin, who continues.

## BANKRUPTCIES, LIQUIDATIONS, &c.

Jas. Marshall Vaughan, electrical engineer, 27, Harrowdene-road, Knowle, and Three Queen's-lane, Bristol, has been adjudicated bankrupt. First meeting of creditors on 11th inst. at 26, Baldwin-street, and the public examination on 27th inst. at the Guildhall, Bristol.

The adjourned examination of Thos. King, electrical engineer, Maidstone, took place last week.

Gross liabilities, £573. 3s. 2d., unsecured, £563. 19s., assets (including £980 book debts), £984. 7s. Debtor alleged that £624 was due to him as commission on the sale of certain electric light works. When he failed in 1898 he paid a dividend of 1s. 3½d., on £2,261. 17s. Examination adjourned till April 25 for debtor to file a cash account for past year, and, if necessary, a dificiency account.

The first meeting of creditors of Shadrach Ferris, electrical engineer, Swindon, took place last week. Liabilities £175. 17s. 5d., of which £170. 3s. 10d. was due to 53 unsecured creditors. Total assets £4. 18s. 3d. Bankrupt, who is blind, first commenced business in December, 1904, with borrowed capital of £21.

The discharge of Robt. Pries (trading as Durtnall & Pries), electrical sundriesman, 75, City-road, London, E.C., has been supended for two years.

The trustee in the bankruptcy of Wm. Peter Durtnall, consulting engineer, Caversham-road, Reading, and 85, Finsbury-pavement, London, E.C., has been released.

Claims against the Clift Mfg. Co. (Ltd.) by May 14 to Mr. F. C. Harper, 27, Chancery-lane, London, W.C.

The liquidator in the winding up of the Garcin-Renault Electric Cars & Accumulators (Ltd.) has been released.

The Automatic Electrical Advertising Synd. (Ltd.) is being wound up voluntarily. Mr. W. A. Allerton, 26, Victoria-street, London, S.W., is liquidator.

The British Electric Separating Co. (Ltd.) is being wound up voluntarily. Mr. J. F. Harvey, 3-5, Goat-street, Swansea, is liquidator.

A meeting will be held on May 4 at 37, Essex-street, London, W.C., to receive an account of the winding up of the Rhyl & Prestatyn Light Railway Co. (Ltd.).

**Sale by Auction.**—Messrs. Horne & Co., 8, Delahay-street, Westminster, S.W., will sell by auction at the Royal Arsenal, Woolwich, on Tuesday, April 24 (by order of the Secretary of State for War), at 11 a.m., obsolete and unserviceable stores, including a quantity of copper, gunmetal, lead, phosphor-bronze and other metals, lathes and tools, telegraphic instruments, electrical appliances, cable, &c. Further particulars are given in an advertisement, and catalogues may be obtained at the War Office, Pall Mall, the Ordnance Office, Tower, and the Ordnance Office, Royal Arsenal, Woolwich.

**Premises to Let.**—Mr. Alfred Kirkland, 113, Cottenham-road, Upper Holloway, London, N., advertises an extensive new factory to let.

Light workshops and offices are advertised to let at 219, Goswell-road, London, E.C.

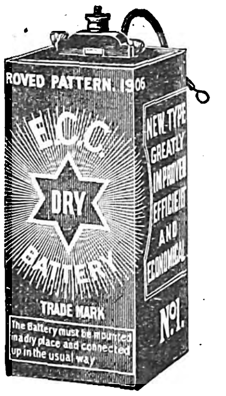
A factory at Holloway, London, N , is advertised to let.

**Electric Drilling Machines.**—Kramos Limited, Bath, have sent us their latest sheet of illustrations of electrical drilling machines of up-to-date design. This sheet, which is folded within neat covers of pocket size, allows the design, weight, and the performances of the 16 specialities shown to be seen at a glance. These specialities include portable electric drills of various designs and capacities, a drilling equipment on wheels, an electrically-driven grinding equipment on wheels, breast drills for attachment to flexible or telescopic shafts, a track drill press, and so on. All parts are interchangeable, so that spares can be obtained from stock.

**Buyers' Guide to Pleasure Cars and Commercial Vehicles of 1906.**—This is a useful list of motor cars, ranged according to price, constructional details and mechanical features. The statistics, which have been reprinted from "The Automotor Journal," should prove very useful to motorists and intending buyers of cars. The guide is published by F. King & Co. (Ltd.), 44, St. Martin's lane, London, W.C., and the price is 1s. net.

**Catalogues, &c.**—Elliott Bros., of Lewisham, S.E., have ready a new list relating to Young's patent speed indicator (tachometer), and a portable form of this instrument, half size, is illustrated on the sheet. It is claimed to be invaluable for the laboratory, the engine house and the factory, and shows at a glance speeds of from 100 to 2,000 revs. per min.

The General Electric Co. are placing on the market a new pattern E.C.C. dry cell, of which an illustration accompanies this note. The E.C.C. dry cell has been on the market for some 14 years, and has earned for itself the highest reputation for uniformity of output. Important improvements have been added to the 1906 pattern, and in the circular list now published diagrams of output are given, as well as illustrations of different sizes and patterns of the cell.


ROVED PATTERN. 1906
E.C.C.
DRY
BATTERY
TRADE MARK
NEW TYPE GREATLY IMPROVED EFFICIENT AND ECONOMICAL
No. 1.
The Battery must be mounted in a dry place and connected up in the usual way

New Pattern of E.C.C Cell.

We have received from Hooper's Telegraph & India Rubber Works (Ltd.) a price sheet relating to their vulcanised indiarubber cables and jointing material, and two charts showing graphically the diameters and radial thicknesses of the various parts of each size of cable: copper, pure rubber, separator, jacket, tape and external braiding. At the side of these charts are tables of the sizes, sectional areas, weights and resistances of the various cables referred to, which range from 1/20 to 37/14. We note that some of these figures differ from those of the Engineering Standards committee.

A sheet list of new designs in iron case dust and weatherproof bells for mines, collieries, factories and exposed positions is issued by the Sun Electrical Co., 118 & 120, Charing Cross-road, London, W.C. The list also dsecribes and illustrates some new designs in buzzers, which are also dust and insect proof.

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from March 28 to April 3, with the ports of destination :—

*Africa*—Alexandria, £15 ; Capetown, £92 (telegraph material) ; Delagoa Bay, £68 ; Durban, £2,473 (including £1,621 telegraph material) ; Port Elizabeth, £138 ; Suez, £85 (telegraph material). *Argentina*—Buenos Ayres, £360 (telegraph material) ; Rosario, £370 (telegraph material). *Australasia*—Adelaide, £232 ; Auckland, £51 ; Brisbane, £386 (including £47 telegraph material) ; Lyttelton, £11 ; Melbourne, £2,220 (including £1,986 telegraph material) ; Napier, £31 ; Perth, £31 ; Sydney, £2,009 ; Wanganui, £9 ; Wellington, £966 (including £67 telegraph material). *Austria*—Fiume, £189 ; Trieste, £476 (including £295 telegraph material) *Belgium*—Ostend, £40. *British Guiana*—Demerara, £18. *Burma*—Rangoon, £80. *Ceylon*—Colombo, £14. *China*—Shanghai, £27 ; Tientsin, £630. *France*—Paris, £159. *Germany*—Bremen, £20 : Hamburg, £41 ; Gibraltar, £44 (telegraph material). *Holland*—Amsterdam, £175 (including £135 telegraph material). *Hong Kong*, £156. *India*—Bombay, £584 ; Calcutta, £323 ; Karachi, £22 ; Madras, £69. *Japan*—Kobe, £59 ; Nagasaki, £59 ; Tokyo, £1,275 (including £251 telegraph material) ; Yokohama, £817. *Malta*, £462. *Mauritius*, £78. *Spain*—Bilbao, £22. *Straits Settlements*—Penang, £31 ; Singapore, £58 (including £50 telegraph material). *Turkey*—Piræus, £10 (telegraph material). *U.S.A.*—New York, £208 (including £200 telegraph material). *Zanzibar*, £101 (telegraph material). Total, £15,794, against £23,824 in the corresponding week last year (March 28 to April 4).

# PATENT RECORD.

## APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are no open to public inspection until after acceptance of Complete Specification. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

February 7, 1906.

2,928 Davies. Construction of alternate or change-over tumbler switch.*
2,936 Electric Ignition Co. & Hall. Magneto machines for ignition systems of electrically fired internal combustion engines.
2,944 Aitken. Electric indicators or annunciators.
2,956 Thomson. Electric flash or pocket lamps.
2,960 Böhm. Manufacture of ozone.
2,963 Doddrell. Electric table game.
2,989 Lafontaine. Electrolytic process for extracting metals from their ores and recovery of pure copper from copper waste.*
2,993 Sutton. Separation of particles of different dielectric capacities.*
3,000 Hunter. Switches.*
3,004 Société Electro-Metallurgique Francaise. Electric mixing furnace for mixing steel. (Date applied for, Feb. 11, 1905.)*†
3,012 Finzi. Repulsion motors. (Date applied for, Feb. 8, 1905.)*†
3,026 Isaac. Electrical apparatus for transmitting angular movements or reproducing same at a distance, applicable to telautograph apparatus. (Date applied for, Feb. 8, 1905.)*†

February 8, 1906.

3,096 Lycett & Conaty. Electric tramcars.
3,119 Guénée. Electric stamp hammers.*
3,127 Marconi & Marconi's Wireless Telegraph Co. Apparatus for electric wave telegraphy.
3,133 Wilton. Electrical insulators.
3,136 B.T.-H. Co. (G.E. Co., U.S.) Signalling systems.
3,137 Warwick Machinery Co. (G.E. Co., U.S.) Machines for cutting slots in turbine and like wheels.

February 9, 1906.

3,164 Kennedy-McGregor. Electrical switches.
3,170 Flint. Sealing the ends of electric cables.
3,172 Montgomery. Ship's or analogous electric telegraphic apparatus.
3,185 Torda. Dynamo-electric machines.
3,199 Thompson. Primary batteries.
3,212 Howorth. (Phönix Electrotechnische G.m.b.H., Germany). Regulating devices for arc lamps.*
3,213 and 3,225 Just, Hanaman, Landesberger, Salzmann & Vereinigte Elektricitäts A.G. Incandescing bodies for electric lamps.
3,224 Ljungman, Berglund & Hjorth. Combined telephone receivers and microphones.*
3,243 B.T.-H. Co. (G.E. Co., U.S.) Prepayment mechanism for electricity meters.

February 10, 1906.

3,249 Kirwan, Quanby, Tierney & Malone. Automatic signalling apparatus for electric tramways or railways,
3,250 Rothwell. Clocks for connection with electric call alarms.
3,258 Bevis & Coates. Electrical ignition for internal combustion engines.
3,261 Campbell. Tramway rails.
3,268 Hall. Operating electric controllers and imparting motion to electrical and mechanical appliances.
3,289 Rhodes & Romapac Tramway Construction Co. Appliances for fixing and cutting off the wearing portions of compound tramway rails.
3,340 Brockie. Arc lamps.*

February 12, 1906.

3,361 Evans-Day. Electric lampholder with shade carrier, spring collar and terminals.
3,376 Montgomery. Ships' or analogous telegraphic apparatus.
3,402 Sharpe. Sparking plugs for electric ignition.
3,415 Hatherly & Hatherly. Adjusters for electric light cords.*
3,430 Hammond. Electrical muscular exercising machines. (Date applied for, May 23, 1905.)*†
3,455 B.T.-H. Co. (G.E. Co., U.S.) Magnetic material for electrical purposes and producing the same.
3,456 B.T.-H. Co. (G.E. Co., U.S.) Filaments for incandescent lamps and manufacturing same.
3,457 B.T.-H. Co. (G.E. Co., U.S.) Arc lamps.

February 13, 1906.

3,509 Iseki. Filament for incandescent lamps.*
3,540 Venner & Griesbach. Electrical time-switches.
3,541 Siemens Bros. & Co. (Siemens Schuckerwerke G.m.b.H., Germany.) Safety appliances for electric circuits.*
5,572 Platte. Suspension of current conductors for railways. (Date applied for, Sept. 28, 1905.)*†
3,574 Sauvanet, Teurtroy, Chaligne & Capitaine. Arc lamps.
3,577 Allgemeine Elektricitats-Ges. Switch apparatus for advertising devices. (Date applied for May 4, 1905.)*†
3,581 Ward. Electric machines for the production or expenditure of electricity.
3,583 Moscicki. Producing nitric oxides by electricity.*
3,590 B.T.-H. Co. (G.E. Co., U.S.) Alternating-current motors.

February 14, 1906.

17,957A/05 Birnbaum & White. Step-by-step switches. (Date applied for, Dec. 13, 1905.)
3,604 Davis. Electric exploding apparatus.

3,613 Williams. Mechanical continuity and earthing device in electric cable conduits.
3,620 Hollyer. Contacts for electric warning signals for railways.
3,630 Field. Multiplex telegraphy.*
3,657 Lamme. Dynamo-electric machines. (Date applied for, Feb. 21, 1905.)*†
3,658 Mitchell. Switches for closed circuit fire alarm systems.
3,663 Martin & Shepherd. Magnetic clutches.
3,677 Siemens Bros. & Co. (Siemens Schuckertwerke G.m.b.H., Germany.) Reducing the fluctuations of load in alternating-current generators.*
3,684 Just, Hanaman, Landesberger, Salzmann & Vereinigte Elektricitats A.-G. Incandescing bodies for electric lamps.

February 15, 1906.

3,712 Eckford. Prevention of robbery of prepayment slot meters.
3,713 Bowie & Phelps. Vacuum tube for the production of violet or ultra-violet, X- or other rays, or combination of rays.
3,714 Jones & Jandus Arc Lamp & Electric Co. Arc lamps.
3,715 and 3,716 Drake, Jones & Jandus Arc Lamp & Electric Co. Arc lamps.
3,760 Simpson, Strickland & Co. & Jay. Sparking plugs for internal combustion motors.
3,769 Kidd. Trolley wheel collector for electric traction.
3.780 Schulz. Labyrinth packing for rotary machines.
3,781 B.T.-H. Co. (G.E. Co., U.S.) Electro-magnetically operated switches.
3,783 and 3,784 Peard. Electric fuses.

February 16, 1906.

3,840 Bulfin. Joints and fishplates for tramways and light railways.
3,865 Dixon & Turner. Automatic signals for electric tramways and railways.
3,890 Lake. (Parker Clark Electric Co.) Incandescent lamps.*
3,902 Robinson. Electrical igniters or sparking plugs.
3,904 B.T.-H. Co. & Holden. Electric measuring apparatus.
3,907 and 3,908 Ekstrom. Telephone intercommunication systems.

February 17, 1906.

3,937 Halcomb, Macgregor & Bennett. Electrically heating materials to be rolled or drawn.
3,948 Turner & Wright. Air brake apparatus. (Date applied for, Feb. 17, 1905.)*†
3,951 Henry. Devices for cleaning outside of pipes, tubes, &c., in steam generators, superheaters, water heaters and the like.
3,988 Schade. Incandescent lamps.*
3,990 McCarty. Decomposing water by electrolysis.
4,007 Wilson. Fixing of steam turbine blades.

## SPECIFICATIONS PUBLISHED.

1905 Specifications.

778 Bloxam (Pulzeniusz). Accumulator plates.
934 Nicholson. Apparatus for producing high potential electric discharges.
3,560 Morrison & Bulkley. Secondary battery electrodes.
3,616 Moy & Bastie. Fuses for electrical circuits.
4,102 Connett. Electric tramways with conduit current supply.
4,979 Lake. (Wirt Electric Co.) Resistance units for rheostats and the like.
5,893 Burnaby. Electric vehicles and permanent way therefor.
6,790a Potthoff. Electroplating. (Date applied for, March, 30, 1905).
7,606 B.T.-H. Co. (G.E. Co., U.S.) Electromagnetic cutouts.
8,026 B.T.-H. Co. (G.E. Co., U.S.) Starting devices for alternating-current dynamos.
8,443 Halstead, Johnson & Winn. Trolleys for electric tramcars.
9,431 B.T.-H. Co. (G.E. Co., U.S.) Vapour-electric apparatus.
10,202 Kallmann. Measuring, switching, signalling and regulating electric current.
10,910 Isherwood. Switches.
11,440 Elektrizitäts A.G. vorm W. Lahmeyer & Co. Single-phase alternate-current motors with communicators. (Date applied for, July 11, 1904).
11,494 Hamilton & Ferranti Limited. Mercury or other liquid retaining devices for electricity meters.
11,535 B.T.-H. Co. (G.E. Co., U.S.) Regulators for dynamo electric machines.
11,931 Soc. Anon. Westinghouse & Leblanc. Suppressing harmonics in alternating-current dynamo-electric machines. (Date applied for June 10, 1904.)
11,949 Just, Hanaman & Vereinigte Electricitäts, A.G. Filaments for incandescent lamps.
11,971 B.T.-H. Co. (G.E .Co., U.S.) Vapour electric apparatus.
12,947 Fox. Storage of electrically transmitted energy.
13,252 De La Valette. Magneto-electric ignition for internal-combustion engines.
13,427 Kitsee. Secondary batteries.
13,689 Gardner. (Thoresen & Tharaldsen.) Deviating or drawing out electric discharges for the chemical decomposition and combination of gases.
13,909 Lawson. Electric purifier for purifying flour, grain, rice, &c.
14,324 Bullock & Bullock. Electrical ignition device.
14,471 Job. Switching devices for electric-flash advertising.
15,067 Allgemeine Elektricitäts-Ges. Regulation of alternating-currant dynamos. (Date applied for, July 22, 1904.)
15,222 and 26,434 Render. Fuse heads for electric blasting.
15,462 Küzel. Metallic connection between light-emitting bodies and supply conductors of glow lamps.
16,057 Gawron. Magneto-ignition for internal-combustion engines. (Date applied for, Aug. 6, 1904.)
16,905 Lapeyrade. Alternating-current machines. (Date applied for, Aug. 23, 1904).
17,645 Gabet. Operating mechanism from a distance by electrical waves (Date applied for, Oct. 26, 1904.)
17,930 Martinetto. Alternating current motors.
18,403 Siemens & Halske A.G. Incandescence bodies of tantalum wire for glow lamps. (Date applied for, Oct. 13, 1904).
19,092 Wagner. Reciprocating electric engines. (Date applied for, Sept. 22, 1904).
20,068 Poulsen. Receiving systems for wireless transmission of signals. (Date applied for, Oct. 8, 1904.)
20,217 Vareille. Apparatus for the electrolysis of water.
20,496 Boult. (Egan.) Telephones and telephone systems.
20,593 Peterson. Annunciators for telephones.
21,181 Varley. Electrical measuring instruments.
21,444 Kaeferle. Electromagnetically operated heat supply valve for heating and ventilation. (Date applied for, July 17, 1905).
22,113 Reichenbach. Igniting the charges of internal-combustion engines.
22,724 Kriéger & Cie. Parisienne des Voitures Electriques. (Procédés Kriéger.) Regulating the speed of electric motor cars. (Date applied for, Dec. 3, 1904.)
22,741 Harrison & Frazer. Indicators for ships' electric signal lamps.
23.132 Simms & Bosch. Magneto-electric ignition apparatus.
23,172 Pieper. Electro-mechanical propulsion of automobiles. (Date applied for, Sept. 29, 1905.)
23,722 Deutsche Telephonwerke R. Stock & Co. (G.m.b.H.) Connections for telephone offices with separated plug-service, and for signalling whether an operator is engaged. (Date applied for, Nov. 17, 1904).
23,863 Esser. Advertising device for electrical station indicators.
24,867 Justice (Industrial Development Co.) Ignition device for internal combustion apparatus.
25,169 Kriéger & Cie. Parisienne des Voitures Electriques. (Procédés Kriéger.) Operating the controlling switch of electric vehicles. (Date applied for, March 9, 1905.)
25,392 von der Lippe. Illuminating photographic studios with electric lamps.
25,702 Holmes. Resistances.
25,768 Coridori. Insulating electric wires or cables.
26,144 Richards. Fuses for electrical circuits.
27,198 Allgemeine Elektricitäts-Ges. Dynamo electric machines. (Date applied for, Jan. 20, 1905).

1906 Specifications.

222 Thomas. Vapour electric converters. (Date applied for, 13/1/'05.)

## COMPANIES' MEETINGS AND REPORTS.

**AMERICAN TELEPHONE & TELEGRAPH CO.**—In the report of the president (Mr. F. P. Fish) it is stated that since January, 1900, the number of telephones in the hands of the subsidiary companies has increased from 1,580,101 to 5,698,258, the total number of stations using Bell telephones from 675,761 to 2,528,715, the miles of wire in toll and exchange use from 1,518,609 to 6,043,518, the number of officers and employés from 29,599 to 87,213, and the number of yearly conversations from 1,708,800,000 to 4,479,500,000. The American Bell system of the United States, it is stated, now exceeds in number of subscribers, mileage of wire and extent of traffic the telephone systems of Great Britain and all Continental Europe combined. The net output of telephones during 1905 was 1,217,694, the greatest increase in any one year in the history of the company.

**ANGLO-ARGENTINE TRAMWAYS CO. (LTD.)**—The working of the combined systems (Anglo-Argentine and City of Buenos Ayres Tramway Cos.) for 1905 resulted in gross receipts of £720,488. 10s. 8d., working expenses (including £50,000 carried to depreciation) were £464,872. 13s. 5d., and with £5,922. 3s. 6d. from 1904 the available balance is £261,538. 0s. 9d. Deducting interest, preference and interim ordinary dividends and £20,000 carried to reserve, the balance is £52,714. 2s. 3d. The directors recommend a final dividend of 5s. per share (tax free) on the ordinary shares (making 8s. per share or 8 per cent. for the year), leaving £10,214. 2s. 3d. to be carried forward. The conversion to electric traction of the lines of the "City" system having been only partially completed during the year, the number of passengers carried during 1905 was 82,442,410. Owing to the large increase in the number of passengers it has been necessary during the year to augment the service on nearly all the electric routes. What has greatly facilitated the traffic working in 1905 has been the increased number of trailers placed in service. In July and August two new electric routes were opened, with good results. 138 new motor cars have been put in service, and 34 closed trailers and 35 open trailers—horse cars converted—have also been put in service. The total number of cars at Dec. 31 was 902.

**BRUSH ELECTRICAL ENGINEERING CO. (LTD.)**—Lord Vaux of Harrowden, who presided at the meeting on Tuesday, said the directors' report somewhat justified the hopeful expectations he indulged in at the last meeting. The output for the year was the largest in the company's history, and that, coupled with the recommendation that the company should resume payment of dividends on the ordinary shares, would show that the business was in a more prosperous condition than for some years past. While they had derived a substantial advantage from their interests in the Bombay Electric Supply & Tramways undertaking, they had applied an exceptional amount to writing down various items in the account, so that the larger profits for division were fairly representative of normal growth in earning power. In previous years it had been intimated that they were going through a preparatory period in several departments, and that expenditure was being incurred out of revenue, which would bear fruit hereafter. In 1905 they felt that they were beginning to reap the harvest of the patient study and close application of the staff during the past few years. In its rolling stock department the company was now admitted to be in the front rank of railway vehicle constructors, and in certain lines, notably the building of steel cars, their reputation would bear comparison with that of any other firm. The only orders placed in this country for any considerable quantity of steel railway coaches, namely, those for the Great Northern & City and Metropolitan District Railways, had gone to their works. The facilities with which they were now provided for turning out the varied types of rolling stock required for home, colonial and foreign undertakings were somewhat exceptional, and they had a complete plant for rendering non-flammable the timber used in tube coaches, motor 'bus bodies, &c. Mr. W. L. Magden, managing director, seconded the motion for the adoption of the report, which was carried unanimously.

**CALCUTTA TRAMWAYS CO. (LTD.)**—The gross traffic receipts for 1905 were £145,263, working expenditure £75,631, leaving £69,838. The directors propose to allocate £10,000 to depreciation, and to pay a final dividend of 4s. 6d. per share, making 8 per cent. for year. Heavy expenditure has continued on capital account with the object not only of making more effective the existing system, but also in preparation for the demands which will be made upon the plant and machinery by further extensions in sight.

**CLYDE VALLEY ELECTRIC POWER CO.**—Sir David Richmond at the meeting on Thursday last week, said that both the Motherwell and Yoker generating stations were now in operation. The demand for current through the area of supply had been very encouraging, especially at Motherwell, where it had been found necessary to proceed at once with the construction and equipment of additional plant. The output of current for the half-year amounted to 154,873 units. The subscribed capital still stood at £600,000. Cables had been laid across the river Clyde at Renfrew.

**W. T. GLOVER & CO. (LTD.)**—At the annual meeting on Thursday last Mr. A. L. Ormrod explained the various items in the report given in our last issue. Mr. Ormrod having signified his intention to retire from the board, the following were re-elected directors: Mr. Henry Edmunds, Mr. G. B. Samuelson, Mr. E. A. Claremont, Mr. C. Cooper, and Mr. Ll. B. Atkinson.

**GUILDFORD ELECTRICITY SUPPLY CO. (LTD.)**—At the meeting last week Dr. F. R. Russell moved the adoption of the directors' report, which stated that the gross receipts for the past year were £5,374. 9s. 6d., compared with £4,859. 15s. 11d. for 1904. The balance was £1,682. 10s. 3d., after writing off £500 for depreciation, &c. After making provision for preference dividend and interest, &c., the balance was £58. 5s. During 1905 a new boiler, a steam dynamo and other plant had been laid down to meet the needs of the company's increasing business and considerable improvements had been made in the buildings. They regretted to pass the ordinary dividend on this occasion. The year's revenue had increased from £4,859 in 1904 to £5,374, but the increase was swallowed up largely in the payment of preference interest and the great increase in the coal bill. The latter was due to the breaking down of their accumulators, the result being that they had to work their boilers night and day to ensure a constant supply of current. One of their mechanical stokers also broke down, and they had to buy Welsh coal and stoke by hand for a considerable period. There had been a considerable increase in the capital expenditure during the year to enable to give a constant supply for the future. They spent £3,781 during the year on machinery, &c., including an oil separator, which would prove of great advantage. They had put in extra feed pumps, and an extra main steam pipe. Upon mains £1,792 had been expended, and the total capital outlay during the year was £6,217. They had sold 243,000 units, against 211,000 in 1904.

**HARROW ELECTRIC LIGHT & POWER CO. (LTD.)**—At the meeting on Thursday last J. N. Stuart said there had been an increase in the output of 25,724 units. The receipts were £7,788. 14s. 5d., against £7,599. 10s. 8d., and the working expenses showed a decrease. The available balance was £2,315. 6s. 4d., and a 5 per cent. dividend on the ordinary shares was recommended. The works costs had been reduced from 2·61d. to 2·48d. per unit, and the cost of generation showed a reduction of ¼d. per unit. Owing to the new condenser and superheater, they had spent £73 less on coal and had sold 25,000 more units.

**KIDDERMINSTER & DISTRICT ELECTRIC LIGHTING & TRACTION CO. (LTD.)**—The report for 1905 states that the total capital expenditure to Dec. 31 amounted to £44,700. Receipts, including dividends, amounted to £6,979. Deducting expenses, &c., the balance is £1,645. The directors propose, after paying the cumulative preference dividend for 1905, to carry forward the balance (£143).

**METROPOLITAN ELECTRIC TRAMWAYS (LTD.)**—The total revenue for 1905 amounted to £171,797. 10s. 5d., including interest on investments and on advances made to the North Metropolitan Electric Power Supply Co. The gross traffic receipts (£140,040. 9s. 8d.) show an increase of £58,197 over the previous year, the advance being mainly the result of the electrification of the remaining portions of the company's tramways and the opening for traffic of some of the light railways. Deducting all expenses chargeable to revenue, including interest and providing for rent payable to Middlesex County Council in respect of light railways, there remains £42,050. 10s. 8d., making with £3,854. 13s. 11d. from previous account, a total of £45,905. 4s. 7d. Preference dividend absorbs £25,000, £20,905. 4s. 7d. £6,600 is placed to reconstruction and renewals fund, and a dividend of 3 per cent. is declared on the ordinary shares, leaving £4,701. 11s. 11d. to be carried forward. Since the end of the year the purchase price to be paid by the company for the tramways undertaking of the Harrow Road and Paddington Tramways Co., and for the horses, cars and loose plant used in connection therewith, has been agreed at £44,810, subject to repayment to the company of the costs incurred in the promotion of the Harrow Road and Paddington Tramways Act, 1903. The reconstruction of these tramways has been commenced in anticipation of the completion of the purchase. During the year the reconstruction of the remaining portions of the company's tramways has been completed, and further light railways have been constructed and opened for public traffic. London County Council has leased to the company for three years a short length of tramway connecting the horse tramways of the Council in Holloway-road with the light railway in Archway-road, Highgate. At Dec. 31 over 22 miles of tramway and light railway were operated by the company. Since the close of the year a short section of line between Cricklewood and Willesden Green station has been opened for public traffic. Considerable progress is being made with new works, the light railway from Wood Green to Alexandra Palace (1 mile in length) will, it is expected, be opened before Easter. Another line (1½ miles), forming an extension of the Harrow Road and Paddington tramways, will be completed at an early date. The County Councils of Middlesex and Hertfordshire are now constructing their respective portions of the light railway (2 miles) running from Barnet to the existing terminus in the Great North-road at North Finchley, and it is anticipated that, before the end of the summer, the company's cars will be running from Highgate to Barnet town, a through journey of 7 miles. Another extension from the terminus of the company's tramways at Wood Green to Southgate is also under construction. The company's investment in the North Metropolitan Electric Power Supply Co., including loans, amounts to £321,623. 1s. The North Metropolitan Electric Power Supply Act, 1905, authorises the Power Supply Company to acquire electric lighting orders from local authorities and other bodies and extends the area of supply. Agreements have been made under the provisions of the act with the Urban Councils of Edmonton and Kingsbury for the transfer of their electric lighting orders. A contract has also been secured by the Power Supply Company for the supply until 1946 of all electrical energy required for working the County of Hertford light railways to be leased to the Metropolitan Electric Tramways. In June a sub-station was opened at Finchley for supplying current for working the Great North-road light railway. On May 14, 1905, the Power Supply Company commenced supplying Electricity to the North Metropolitan Electrical Power Distribution Co. at Barnet, and an agreement has been made by which electrical energy required by the Distribution Co. for all other undertakings will be purchased from the Power Supply Company. A supply under this agreement will be given this year for lighting Enfield. Negotiations are in progress with local authorities for supply of power in bulk or for the transfer of their lighting orders to the Power Supply Company. The North Metropolitan Electrical Power Distribution Co. (Ltd.), the whole of the shares in which are held by the Power Supply Company, is already supplying electricity at Barnet and Hertford, and has obtained a lighting order for Ware and an amendment order in respect of Barnet, and is now commencing work in connection with the order authorising the distribution of electricity in Enfield. Applications have been made for lighting orders for Cheshunt, East Barnet Valley, Wealdstone and Wembley. The electric lighting order of St. Albans has been acquired from the Corporation, and an order has also been obtained authorising the distribution of electricity in the district outside the town.

**NATIONAL ELECTRIC CONSTRUCTION CO. (LTD.)**—Mr. L. B. Schlesinger, at the meeting on Wednesday, said that having regard to the time it took to develop an electric lighting undertaking, they might congratulate themselves upon the result of their operations. They had recently secured the contract for constructing and equipping the tramways on the Rhondda Valley, the contract price being about £227,000.

**OLDHAM, ASHTON & HYDE ELECTRIC TRAMWAYS (LTD.)**—Mr. Emile Garcke, presiding at the meeting on Friday last, said the net profit last year was £6,285, or £186 less than in 1904. Owing to municipal tramway competition they had lost about 72,000 3d. passengers, but they had carried more 1d. and 2d. passengers. Their average profit per car-mile had been reduced. Expenses had been reduced, but there had been an increase in rates and taxes. The local authorities, instead of allowing the company to make the moderate extensions they had contemplated, had promoted tramways of their own which had not proved remunerative and were a burden on the rates. The slight advantage to the travelling community of having tramways run by the municipalities at a loss would not outweigh the serious consequences of largely increasing the local rates and of doing an injustice to the pioneers of industry. The prospects of the current year were good, as agreements had been made with Stockport and Ashton Corporations.

**ROTHESAY TRAMWAYS CO. (LTD.)**—At the meeting on Friday Viscount Emlyn moved the adoption of the directors' report for the year 1905. The total capital expenditure, including £24,820. 16s. on extension to Ettrick Bay, was £136,527. 9s. The revenue was £10,397. 2s. 10d., expenditure £8,820. 5s. 2d., leaving £1,576. 17s. 8d. The extension to Ettrick Bay was opened for traffic on July 14, and the results during the 5½ months' working had been so satisfactory that the directors consider they have in this extension a valuable asset in perpetuity.

**SLOUGH & DATCHET ELECTRIC SUPPLY CO. (LTD.)**—The directors' report stated that the capital expended during the year was £1,595. 10s. 7d., bringing the total to £40,577. 18s. 2d. The equivalent of 8,605 8 c.p. in lamps and motors is connected, an increase of 2,997 on the year. The total revenue was £3,231. 0s. 7d., against £3,011. 7s. 1d. The total net profit available for distribution, after adding balance from previous year, was £2,005. 2s. 7d., and the directors recommended a dividend at rate of 3 per cent. per annum (less tax), that £250 be transferred to depreciation and that the balance be carried forward. The directors are applying for a provisional order for Burnham, Farnham Royal, Horton, Langley Marish and Stoke Poges.

**SWANSEA IMPROVEMENTS & TRAMWAYS CO. (LTD.)**—For the half-year ended Dec. 31, the gross receipts of the tramways undertaking were £23,178, an increase of £7,816 over the corresponding period of 1904, and the expenses to £18,429, an increase of £7,830. The profit on the half-year's working is £4,749. A dividend on the ordinary shares of $2\frac{1}{2}$ per cent. for the year is recommended.

**THAMES IRON WORKS SHIPBUILDING & ENGINEERING CO. (LTD.)**—In the report for 1905 it is stated that the electrical engineering department has been mainly occupied during the year with the electrical equipment of H.M.S. "Black Prince," and as practically the whole of the auxiliary machinery is electrically driven, this has involved a very large amount of work. The department has also completed a considerable amount of the electrical work on the sister vessels, and it has also carried out the electrical equipment of a model testing tank in Paris for the French Admiralty. After payment of interest and preference dividend, the ordinary dividend is 5 per cent. (less tax) for the year.

**UNDERGROUND ELECTRIC RAILWAYS CO. OF LONDON (LTD.)**—At an extraordinary meeting on Monday a resolution was passed authorising the directors to raise or borrow any sum or sums of money for the purposes of the company not exceeding £5,000,000, in addition to the amounts which they are at present authorised to borrow.

**WATERLOO & CITY RAILWAY CO.**—At an extraordinary meeting yesterday the bill of the L. & S. W. Railway Co., which authorises the latter company to acquire the undertaking of the Waterloo & City Railway, was approved.

**WILLANS & ROBINSON (LTD.)**—The directors' report and accounts for the half-year ended Dec. 31 last show a loss of £1,201. 17s. 11d. for Rugby and £11,873. 2s. 1d. for Queen's Ferry, or £13,075 in all, which compare with losses of £8,616. 17s. 3d. and £14,285. 14s. 9d. at the two places respectively, or £22,902. 12s. in all, in the preceding half-year. These figures show a distinct improvement, and as the total amount reserved for depreciation is £15,873. 14s. 8d. it will be seen that the result of the half-year's trading has involved nothing beyond a book loss. The conditions of trade are still highly unfavourable as regards prices, and the work of supplementing by new branches of manufacture the old-established but now less profitable speciality of the company is still in an early stage. In the most important of these new branches, the manufacture of steam turbines, much success has been achieved, and the directors confidently hope that, so far as Rugby is concerned, the era of unprofitable working is nearly at an end. As regards Queen's Ferry, the directors think it is better to keep the works going, with a view either to developing a successful business, or to disposing of the works as a going concern, rather than to close them and face the very serious loss which would then be inevitable. The cost of production of boilers has been materially lessened by arrangements with the patentees in France, and it does not appear unreasonable to hope that better prices may again prevail. It is to be remarked that the comparison between the results of last half-year's working at Queen's Ferry and those of the preceding half-year is in reality more favourable than is shown by the reduction of the loss upon the half-year's working from £14,285 to £11,873. In the preceding half-year the loss at Queen's Ferry was reduced by the receipt of royalties to the extent of £2,025 upon boilers made by sub-licencees, which did not arise in any way from trading operations at Queen's Ferry. In the last half-year there is no such source of revenue. The company's steel is becoming widely and favourably known. The accounts show that, upon the whole, the company makes fair progress towards recovery. Great attention has been given to the financial position, which is now satisfactory.

**WINCHESTER ELECTRIC LIGHT & POWER CO. (LTD.)**—At the recent meeting it was reported that the equivalent of 5,676 8 c.p. lamps had been added during the past year, making the total connections 47,363 8 c.p. lamps. Including £480 from last year, the net profit was £6,027. A dividend at the rate of 7 per cent. has been declared for the half-year (making $5\frac{1}{2}$ per cent. for the year).

**WINDSOR ELECTRICAL INSTALLATION CO. (LTD.)**—It was reported at the recent meeting that the number of lamps and motors installed on Dec. 31, 1904, was equivalent to 31,025 8 c.p. During the year, 3,296 were added, bringing the total to 34,321, of which 2,784 represented motor power. The capital expenditure amounted to £77,447. 1s. 2d., an increase during 1905 of £9,066. 1s. 9d. More than half the additional capital expenditure was for the buildings, machinery and mains to supply Old Windsor, and the remainder consisted principally of expenditure on new mains in Windsor and Eton. The year's revenue from the lighting department was £11,510. 0s. 3d., and the profit on the department was £4,600, against £4,500. The installation department has not worked satisfactorily, and the result was a loss on the year's trading of £654. 9s. 8d. The balance available for distribution, after providing for interest, loss on installation department, depreciation and directors' fees was £2,814. 12s. 10d. A further dividend of $2\frac{1}{2}$ per cent. was recommended (making 5 per cent. for the year).

**WOKING ELECTRIC SUPPLY CO. (LTD.)**—The revenue for 1905 was £11,486. 4s. 6d. and the expenses £6,769. 11s. 4d., £676. 5s. 7d. from previous year makes £5,392. 18s. 9d. After paying interest, preference dividend, and a dividend of 5 per cent. on the ordinary shares, placing to depreciation £1,000, the balance was £497. 19s. 11d., which has been carried forward. There are 870 consumers, representing an equivalent of 33,735 8 c.p. connected, against 783 and 29,566 8 c.p. at end of the previous year. Capital expenditure is now £85,893. 1s. 8d. and during 1905 $3\frac{1}{4}$ miles of cable were laid, a new boiler and a second 400 kw. steam alternator were put down.

**WYCOMBE (BOROUGH) ELECTRIC LIGHT & POWER CO. (LTD.)**—The report for 1905 states that the lamp connections have risen from 37,383 to 40,983 8 c.p. The profit is £4,437. 6s. 5d., and after paying expenses amounting to £2,517. 18s. 10d., the balance is £1,919. 7s. 7d. The directors recommend a dividend of 4 per cent. for year.

## NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES, LIENS, &c,

### NEW COMPANIES.

**CAPILLIFORM TELEGRAPH INSTRUMENT CO. (LTD.)** (88,153.)—Reg. March 27, capital of £25,000 in £1 shares, to acquire any inventions relating to electrical, telegraph and telephone apparatus and appliances, in particular to acquire the benefit of provisional protection No. 19,425 of 1905, granted to E. Oldenbourg, relating to electro-capillary apparatus, and to carry on the business of electrical and mechanical engineers, manufacturers of electrical, telegraphic, telephonic and other apparatus and appliances, &c. Reg. office, 4, Trafalgar-square, London, S.W.

**CARNARVONSHIRE ELECTRIC TRACTION SYND. (LTD.)** (88,230)—Reg. March 31, capital £1,000 in £1 shares, to carry on the business of contractors for public works, tramway, railway, omnibus and van proprietors, carriers of passengers and goods, suppliers of electricity, accumulator and dynamo manufacturers, &c.

**WOLFRAM LAMPEN AKTIENGESELLSCHAFT, AUGSBURG.**—This company has been formed for the purpose of acquiring and exploiting certain patents relating to the use of tungsten or molybdenum in the manufacture of incandescent lamp filaments, &c. The capital is 850,000 m. (£42,500). The founders of the company include Herr Ign. Salzmann, of Vienna; Dr. Alex. Just, of Budapest; and Herren A. and F. Martini, of Augsburg. Dr. Just and Herr Franz Hanaman are the vendors of the patents.

### STATUTORY RETURNS.

**BRITISH WESTINGHOUSE ELECTRIC & MFG. CO. (LTD.)**—In return to Jan. 1 capital is £3,250,000 in 500,000 preference shares of £5 each and 75,000 ordinary shares of £10 each, all of which have been taken up. £5 per share has been called up on the preference and £2,500,000 has been received. £750,000 is considered as paid on the ordinary. Mortgages and charges, £1,016,353.

**HART ACCUMULATOR CO. (LTD.)**—The capital in the return to March 14 is £60,000 in 40,000 ordinary and 20,000 preference shares of £1 each, of which 40,000 ordinary and 6,729 preference have been taken up. £1 per share has been called up on 17,500 ordinary and 6,729 preference. £24,229 paid. 22,500 ordinary considered as fully paid. Mortgages and charges, nil.

**KENSINGTON & KNIGHTSBRIDGE ELECTRIC LIGHTING CO. (LTD.)**—Return to March 15 gives capital as £350,000 in 50,000 ordinary, 10,000 first preference and 10,000 second preference shares of £5 each, of which 21,000 ordinary, 10,000 first preference and 10,000 second preference have been taken up. £5 per share has been called up on 15,968 ordinary, 10,000 first preference and 10,000 second preference shares of £5 each and £179,840 has been received. £25,160 is considered as paid on 5,032 ordinary. Mortgages and charges, £90,000. Debenture stock issued by company in conjunction with Notting Hill Electric Lighting Co., £152,500.

### MORTGAGES AND CHARGES.

**CONDUITS AND FITTINGS (LTD.)**—£1,500 6 per cent. debentures, created Jan. 30 and dated March 26, 1906, charged on the company's undertaking and property, present and future, including uncalled capital, have been registered. No trustees.

## CITY NOTES.

**MEMORANDA** (April 5).—**Bank rate $3\frac{1}{2}$ per cent.** (April 5, 1906). Price of silver $29\frac{5}{8}$d. per oz. Consols $90\frac{13}{16}$—$90\frac{15}{16}$ for money, 91—$91\frac{1}{8}$ for account; $2\frac{1}{2}$ per cent. annuities $89\frac{3}{8}$—$89\frac{5}{8}$. Consols Pay Day, April 4. Stocks and Shares Continuation Days, April 9 and 24; Ticket Days, April 10 and 25; Pay Days, April 11 and 26; Mining Share Carry-over Day, April 16.

**BABCOCK & WILCOX (LTD.)**—The directors recommend a final dividend for 1905 of 8 per cent., with a bonus of 4 per cent., equal to 2s. $4\frac{4}{5}$d. (tax free). With the interim dividend in October, this makes the dividend for the year 16 per cent. and a bonus of 4 per cent., the same as last year.

**BERGMANN ELECTRICITATS WERKE AKT. GES., BERLIN.**—The net profit for 1905 was 3,123,510 m. (about £156,175), against 2,773,449 m. (about £138,672) in the previous year. Dividends are recommended of 18 per cent. on the old shares (as last year) and 9 per cent. on the new shares.

**CLAYTON & SHUTTLEWORTH (LTD.)**—The profit for the past year, including £5,607 brought forward, was £113,017. £11,601 is written off for depreciation, £5,000 is placed to reserve and £20,000 to reserve for capital expenditure. It is proposed to pay a dividend of 6 per cent. on the ordinary shares, carrying forward £6,759.

### ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. No. of weeks. | Aggregate. Amount. | Aggregate. Inc. or Dec. (a) |
|---|---|---|---|---|---|---|
| | | £ | £ | | £ | £ |
| **Aberdeen Corporation** | March 31 | 1,161 | + 8 | 44 | 58,975 | – 7 6 |
| **Airdrie** | ,, 23 | 2[illegible]4 | + 80 | 12 | 2,542 | + 245 |
| Anglo-Argentine | April 1 | 15,311 | + 1,599 | 13 | 193,5[illegible]0 | + 20,135 |
| Ashton-under-Lyne Corpn. | March 31 | 273 | + 12 | 1 | 273 | + 12 |
| Baker St. & Waterloo Ry. | ,, 31 | 1,518 | ... | 8 | 4,899 | ... |
| **Barnsley** | ,, 23 | 165 | + 4 | 12 | 1,799 | + 11 |
| **Barrow** | ,, 23 | 212 | – 5 | 12 | 2,868 | + 186 |
| **Bath Electric Trams, Ltd.** | ,, 23 | 578 | + 4 | 13 | 8,198 | + 1,117 |
| Birkenhead Corporation | April 1 | [illegible]96 | – 28 | 13 | 13,0[illegible]5 | + 23 |
| **Birmingham Corporation** | March 31 | 416 | + 46 | 52 | 19,597 | + 2,463 |
| ***Birmingham & Mid.** | ,, 23 | 1,489 | – 415 | 12 | 16,008 | – 4,139 |
| Blackburn Corporation | ... | ... | ... | ... | ... | ... |
| **Blackpool Corporation** | ,, 29 | 888 | – 77 | 13 | 4,282 | + 210 |
| **Blackpool and Fleetwood** | ,, 31 | 229 | – 41 | 13 | 2,470 | – 75 |
| **Bolton Corporation** | April 1 | 1,918 | + 56 | 1 | 1,918 | + 56 |
| **Bournemouth Corporation** | March 31 | 1,887 | + 577 | †52 | 78,064 | + 17,411 |
| **Bradford Corporation** | ,, 31 | 4,052 | + 451 | 52 | 221,148 | – 1,375 |
| **Brighton Corporation** | April 1 | 729 | – 120 | 1 | 729 | – 120 |
| **Bristol Trams & Carriage** | March 30 | 4,474 | – 50 | 7 | 32,699 | + 1,597 |
| **Buenos Ayres & Belgrano** | April 1 | 3,597 | + 328 | 13 | 45,953 | + 4,029 |
| Buenos Ayres Elec. Trms | ,, 8 | 1,544 | + 425 | 9 | 12,785 | + 8 103 |
| **Burnley Corporation** | March 31 | 1,032 | – 67 | 52 | 66,905 | + 3,591 |
| **Burton Corporation** | ,, 31 | 252 | – 53 | §52 | 15,680 | – 1,835 |
| Bury Corporation | ,, 25 | 815 | ... | §51 | 39,120 | ... |
| **Calcutta Tramways Co.** | ,, 31 | R42,170 | + R3,376 | 13 | R578,786 | + R[illegible]6,3[illegible]6 |
| **Camborne-Redruth** | ,, 31 | 100 | – 1 | 22 | 2,845 | + 53 |
| Cardiff | ,, 31 | 1,757 | + 288 | 52 | 104,724 | + 514 |
| **Carlisle Tramways Co.** | ... | ... | ... | ... | ... | ... |
| Cavehill | ,, 23 | 63 | + 13 | 12 | 523 | + 78 |
| **Central London Railway** | ,, 31 | 6,905 | – 149 | 13 | 90,546 | – 2,661 |
| **Chatham & Dist. Lt. Rys.** | ,, 29 | 538 | – 62 | †13 | 7,285 | – 190 |
| ***City of Birm'gh'm Tram Co.** | ,, 28 | 5,808 | – 685 | 12 | 60,881 | – 2,155 |
| **City & South London Rly.** | April 1 | 8,059 | + 362 | 13 | 88,939 | + 562 |
| **Colchester Corporation** | March 29 | 147 | + 74 | 33 | 6,262 | – 1,635 |
| **Cork Electric Trams Co.** | ,, 29 | 373 | – 45 | 13 | 5,206 | – 27 |
| Derby Corporation | ,, 31 | 636 | + 3 | 52 | 37,964 | + 10,299 |
| **Devonport & Dist. Trams** | ,, 23 | 400 | – 66 | 12 | 4,732 | – 289 |
| **Dover Corporation** | ,, 31 | 172 | + 3 | ‡52 | 11,328 | + 116 |
| **Dublin & Lucan Railway** | ,, 30 | 92 | + 9 | §13 | 1,150 | – 83 |
| **Dublin United** | ,, 30 | 4,120 | – 257 | ‡13 | 57,683 | + 1,313 |
| **Dudley—Stourbridge** | ,, 23 | 767 | – 52 | 12 | 8,765 | + 297 |
| **Dundee Corporation** | ,, 28 | 921 | + 125 | §45 | 42,864 | + 4,000 |
| **East Ham Council** | ,, 31 | 786 | + 41 | 52 | 42,816 | + 5,915 |
| **Gateshead & Dist. Trams** | ,, 23 | 911 | + 14 | 12 | 10,734 | + 5[illegible]8 |
| **Glasgow Corporation** | ,, 31 | 15,617 | + 965 | 44 | 669,594 | + 43,196 |
| Glossop | ,, 31 | 115 | – 11 | 13 | 1,586 | + 175 |
| Gloucester Corporation | ,, 23 | 207 | – 87 | 52 | 14,558 | + 1,100 |
| **Gravesend—Northfleet** | ,, 23 | 199 | – 11 | 12 | 2,237 | + 95 |
| **Gt. Northern & City Rly.** | ,, 31 | 1,831 | + 109 | 13 | 23,690 | + 840 |
| **Greenock & Port Glasgow** | ,, 28 | 546 | + 14 | 12 | 6,589 | + 495 |
| **Halifax Corporation** | ,, 23 | 1,238 | – 41 | 52 | 79,747 | + 5,968 |
| **Hartlepool Tramways** | ,, 23 | 257 | – 2 | 12 | 2,958 | + 123 |
| Hastings Elec. Trams Co. | ,, 30 | 848 | ... | 13 | 4,692 | ... |
| **Huddersfield** | ... | ... | ... | ... | ... | ... |
| **Hull Corporation** | ,, 31 | 2,068 | – 143 | 52 | 115,538 | + 2,610 |
| Ilford Dist. Coun. | ,, 31 | 402 | + 26 | 52 | 28,906 | + 1,128 |
| **Ipswich Corporation** | ,, 31 | 804 | + 6 | 52 | 21,852 | – 1,984 |
| **Isle of Thanet Co.** | ,, 31 | 287 | – 79 | 25 | 6,645 | – 647 |
| **Kidderminster & District** | ,, 23 | 95 | – 9 | 12 | 1,060 | – 5 |
| Kilmarnock Corporation | ,, 31 | 138 | ... | 46 | 7,081 | ... |
| **Kirkcaldy Corporation** | ,, [illegible]8 | 192 | + 7 | 4 | 780 | – 3 |
| **Lanarkshire Trams Co.** | ,, 29 | 794 | + 186 | †13 | 10,623 | + 2,373 |
| Leamington | ,, 23 | 127 | + 56 | 12 | 1,581 | + 519 |
| **Leeds Corporation** | ,, 31 | 5,510 | + 39 | 52 | 309,133 | + 9,598 |
| **Leicester Corporation** | ,, 31 | 1,984 | + 20 | 13 | 25,9[illegible]3 | + 2,957 |
| Leith Corporation | ... | ... | ... | ... | ... | ... |
| **Liverpool Overhead Rly.** | April 1 | 1,352 | – 137 | 13 | 17,972 | – 1,180 |
| Liverpool Corporation | March 24 | 10,415 | + 115 | 12 | 121,795 | + 4,564 |
| ***London County Council** | ,, 24 | 13,745 | – 167 | 51 | 3,338,736 | + 96,412 |
| **Lowestoft** | ,, 31 | 116 | – 14 | 27 | 3,458 | – 37 |
| **Maidstone Corporation** | ,, 29 | 79 | – 21 | 52 | 6,019 | ... |
| **Manchester Corporation** | ,, 31 | 12,174 | + 251 | 52 | 665,834 | + 83,603 |
| Mersey Railway | ,, 31 | 1,762 | + 190 | 13 | 22,089 | + 1,149 |
| **Merthyr** | ,, 23 | 189 | – 10 | 12 | 2,056 | – 21 |
| Metropolitan Dist. Railway | April 1 | 7,889 | + 413 | 13 | 105,850 | + 5,754 |
| ***Metropolitan Elec. Trams.** | March 23 | 2,890 | + 640 | 12 | 32,567 | + 10,183 |
| **Middleton** | ,, 23 | 812 | – 24 | 12 | 3,295 | + 211 |
| **Nelson Corporation** | ... | ... | ... | ... | ... | ... |
| **Newcastle-on-Tyne Corp.** | ,, 31 | 3,608 | – 28 | 52 | 197,167 | + 4,566 |
| **Newport (Mon.)** | ,, 31 | 525 | – 16 | 26 | 14,162 | + 989 |
| Northampton Corporation | ... | ... | ... | ... | ... | ... |
| **Oldham, Ashton & Hyde** | ,, 23 | 541 | – 11 | 12 | 5,971 | + 248 |
| **Oldham Corporation** | April 1 | 1,739 | – 364 | 1 | 1,789 | – 364 |
| Perth (N.B.) Corporation | ... | ... | ... | ... | ... | ... |
| **Perth (W. A.) Elec. Trams** | March 30 | 1,504 | + 118 | ‡13 | 19,914 | + 1,0[illegible]2 |
| **Peterborough** | ,, 23 | 104 | – 20 | 12 | 1,184 | – 67 |
| Pontypridd District Coun. | ,, 31 | 165 | ... | 52 | 8,196 | ... |
| Portsmouth Corporation | ,, 31 | 1,391 | – 235 | 52 | 97,229 | + 1 5 9 |
| **Potteries** | ,, 23 | 1,785 | + 135 | 12 | 20,397 | + 1,337 |
| Preston Corporation | ,, 18 | 622 | + 56 | ... | ... | ... |
| **Reading Corporation** | ,, 19 | 531 | – 32 | ... | ... | ... |
| **Rotherham Corporation** | ,, 29 | 393 | – 3 | 52 | 23,498 | + 23 |
| **Rothesay** | ,, 23 | 55 | + 6 | 12 | 571 | + 43 |
| **Salford Corporation** | ,, 31‡ | 3,095 | + 970 | 52 | 222,878 | + 13,459 |
| **Sheerness** | ,, 21 | 49 | – 15 | 12 | 544 | – 93 |
| **Sheffield Corporation** | April 1 | 4,868 | + 185 | 1 | 4,868 | ... |
| **Southampton Corporation** | March 28 | 756 | – 87 | 25 | 21,832 | + 46 |
| **Southend Corporation** | ,, 28 | 224 | – 33 | 52 | 18,891 | + 1,063 |
| **Southport Tramways** | ,, 23 | 252 | – 11 | 12 | 2,719 | + 17 |
| **S. Staffordshire Trams.** | ,, 23 | 782 | + 64 | 12 | 9,007 | + 1,427 |
| **Stockport Corporation** | ,, 30 | 746 | + 259 | 52 | 39,645 | + 11,850 |
| Sunderland Corpn. | ,, 31 | 1,081 | + 339 | 52 | 67,795 | + 8,528 |
| **Swansea Trams** | ,, 28 | 725 | + 226 | 12 | 8,319 | + 2,900 |
| Swindon Corporation | ... | ... | ... | ... | ... | ... |
| Taunton | ,, 23 | 41 | – 2 | 12 | 485 | + 13 |
| **Tynemouth and District** | ,, 23 | 163 | – 3 | 12 | 1,876 | – 187 |
| Tyneside Trams Co. | ,, 21 | 867 | – 19 | 12 | 3,994 | + 96 |
| **Wallasey District Council.** | ,, 31 | 697 | – 19 | 52 | 13,691 | + 1,630 |
| **Warrington Corporation** | ,, 2[illegible] | 3[illegible] | + 16 | 52 | 17,804 | + 1,247 |
| **West Ham Corporation** | ,, 29 | 1,816 | + 618 | 52 | 96,008 | + 41,144 |
| **Weston-super-Mare** | ,, 21 | 62 | + 8 | 12 | 850 | – 4 |
| Wolverhampton Corpn. | ,, 28 | 6[illegible]4 | ... | ... | ... | ... |
| * **Wolverhampton District** | ,, 23 | 397 | + 26 | 12 | 4,393 | + 892 |
| * **Worcester** | ,, 23 | 285 | – 60 | 12 | 2,737 | – 242 |
| **Wrexham** | ,, 23 | 108 | + 5 | 12 | 1,069 | – 82 |
| Yorkshire W.R. Trams | April 1 | 762 | + 171 | 13 | 8,832 | + 3,033 |
| Yorkshire Woollen District | March 23 | 869 | + 195 | 12 | 9,547 | + 3,182 |

(a) These comparisons are with the corresponding period last year. † Minus 8 days. ‡ Minus 2 days. § Plus 2 days. ¶ Plus 3 days. * Partly electrical.

**CUBA SUBMARINE TELEGRAPH CO. (LTD.)**—The directors recommend a dividend on the ordinary shares at the rate of 5 per cent. per annum, tax free.

**EASTERN EXTENSION, AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.)**—Subject to confirmation by the shareholders, the directors have declared a dividend for the quarter ended Dec. 31 of 2s. 6d. per share, together with a bonus of 4s. per share, or 2 per cent., making a total distribution of 7 per cent. for the year 1905. The dividend and bonus will be paid on 10th prox. The share register will be closed from May 2 to 9 inclusive.

**MANX ELECTRIC RAILWAY CO. (LTD.)**—Subscriptions are invited for £200,000 4½ per cent. irredeemable first mortgage debenture stock and £114,500 in £5 5½ per cent. cumulative preference shares at par.

**ORIENTAL TELEPHONE & ELECTRIC CO. (LTD.)**—The directors recommend, subject to final audit, payment of the dividend on the preference shares and a final dividend of 4 per cent. on the ordinary shares (tax free), making 7 per cent. for the year.

**RAND CENTRAL ELECTRIC WORKS (LTD.)**—The result of working for March was 964,000 units generated, yielding a gross revenue of £8,900, against 861,000 units and £8,050 for the corresponding period of last year.

**STOCK EXCHANGE NOTICES.**—The Stock Exchange committee have granted quotations to a further issue of 3,000 £10 fully-paid ordinary shares of the *Bournemouth & Poole Electricity Supply Co. (Ltd.)*, and a further issue of £1,500 £5 fully-paid ordinary shares of the *Oxford Electric Co. (Ltd.)*

**SUBMARINE CABLES TRUST**—Coupons due 15th inst. will be paid by Messrs. Glyn, Mills & Co., 67, Lombard-street, London, E.C.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Wed., April 4. | Rate per cent. yielded. | Dividend Due. | Business, Week to April 4. Highest. | Business, Week to April 4. Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | £ s. d. | | | |
| 5 | 8/0 | **Anglo-Argentine Ord. Shares** | 9 —9¼ | 4 6 6 | Ap, Oct | 9 3/16 | 9 1/16 |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞—6⅛ | 4 10 0 | — | 6 3/32 | 6 1/16 |
| St. | 6% | Do. Permanent 6% Deb. Stock | 141 —144 | 4 3 3 | — | .. | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 104 —106 | 4 14 3 | — | .. | .. |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | ⅞—1⅛ | .. | .. | 1 1/16 | 1 1/32 |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | [illegible]⅞—4⅛ | 6 1 4 | — | 4 1/16 | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | [illegible]3 —[illegible]6 | 4 [illegible]3 9 | — | .. | .. |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 120 —1[illegible]3 | 4 17 6 | — | .. | .. |
| St. | 5% | Do. Pref. Ord. Stk | 110 —113 | 4 8 4 | — | 11[illegible]¾ | 110 |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock | 107 —1[illegible]0 | 4 11 0 | — | 10[illegible] | — |
| 4[illegible] | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%—105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 102 —105 | 4 5 0 | — | 106 | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | [illegible] | 5 10 0 | — | 3[illegible] | .. |
| 5 | 3/0 | Do. 6 per Cent. "A" Cm. Pref. | 5⅞ - 6⅛ | 4 13 0 | — | .. | .. |
| 5 | 3/0 | Do. "B" | 5¼—5¾ | 5 4 0 | — | .. | .. |
| St. | 5% | Do. 5 per Cent. Debs. | 106 —108 | 4 12 6 | — | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102 —105 | 4 15 0 | — | .. | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 100 —102 | 4 19 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 102 —106 | 5 4 3 | .. | .. | — |
| 100 | 6% | † Do. 6% 1st Deb. Bonds | 101 —105 | 5 14 0 | .. | .. | .. |
| 5 | 8/6 | Calcutta Tramways (Nos. 1 to 105) | [illegible]⅜ - 9⅝ | 4 8 0 | — | 9[illegible] | 9[illegible] |
| 5 | 2/6 | Do. Nos. 105,001 to 137,610 | 9 —9½ | .. | — | .. | .. |
| 10 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 106 —108 | 4 3 8 | — | .. | .. |
| 1 | 0/6 | Cape Electric Tram Shares | ⅝ - ⅞ | 5 14 0 | — | .. | .. |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 102 —104 | 4 16 0 | — | .. | — |
| .. | 5% | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 96 —98% | 5 2 0 | .. | .. | .. |
| St. | .. | Kalgoorlie Elec. Trams 5% "A" Deb. Stock | 91 —93 | .. | .. | 91½ | 94 |
| St. | .. | Do. 6% "B" Ditto | 83 — 88 | .. | .. | 8[illegible]⅜ | 84½ |
| 1 | .. | Lisbon Elec. Trams Ord. | [illegible]½—1⅝ | .. | .. | 1[illegible] | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅛—1⅜ | 4 7 4 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 100 —103 | 4 17 0 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 103 — 106 | 4 14 8 | Ja, Jul | .. | .. |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101 —103 | 4 17 0 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102 —104 | [illegible] 6 6 | — | 10[illegible]¾ | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 105 —108 | 4 12 6 | .. | — | .. |
| .. | $2 | †Sao Paulo Tramway, Light and Power Co. $100 Stock | 145 – 14[illegible] | 5 7 3 | .. | .. | .. |
| .. | 5% | Do. 5% 1st Mt. $500 Dbs. | [illegible]8%—10[illegible]% | 4 19 0 | .. | .. | .. |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | 3/ | Adelaide Elec. S'ply Co. 6% Cu. Pr. | 4¾—[illegible]¼ | 5 14 6 | .. | | .. |
| 5 | 8/8 | Calcutta Elec (1–50,000) | 9 - 9½ | 4 6 6 | — | 9½ | — |
| 10 | [illegible]% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbr. | 5[illegible] —[illegible]2 | 4 16 0 | .. | .. | .. |
| .. | 5% | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 94 —96 | 5 4 0 | .. | .. | .. |
| [illegible] | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½— 3 | .. | .. | .. | — |
| St. | 5% | Do. 5% Debs. | 88 —92 | 5 9 4 | — | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | 7¾ — 8¾ | — | — | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92 —94 | 5 6 8 | .. | .. | .. |
| St. | 26/2 | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. | 111 —114 | 5 5 0 | .. | 113½ | .. |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞ –1 | 6 0 0 | — | [illegible] | .. |
| 1 | 1/0 | Rand Electric | 1 3/16 - 1 5/16 | — | — | .. | .. |
| 1 | .. | River Plate Electricity Co. Ord. | [illegible] | — | .. | 1 | .. |
| 1 | 1/2⅜ | Do. 6% Non. Cum. Pref. | [illegible] | .. | .. | .. | .. |
| St. | 5% | Do. 5% Deb. Stock | 101 —103 | 4 17 0 | .. | .. | .. |
| 5 | 8/0 | †Rosario Elec. Co. 6% Pref. (1-12,000) | 5 —5½ | 5 0 0 | .. | 5[illegible] | [illegible]⅜ |
| 5 | [illegible]/6 | † Do. (12,001-20,000) | [illegible]¼—[illegible]¾ | 3 5 0 | .. | .. | .. |
| 100 | 4½% | *†Royal Elec., Montreal 4½% 1st Mort. Deb | 99 —102 | 4 8 0 | Ap, Oct | — | ... |
| .. | 5% | Shawinigan Water and Power 5% Bds., Scrip | 101 —103 | 4 17 0 | .. | 101 | .. |

* In calculating the yield, allowance has been made for accrued interest; but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Shre. | Last Dividend | Name. | Price Wed., April 4. | Rate % Yielded. £ s. d. | Dividend Due. | Business, Week to April 4. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 10 | 14/0 | †Bournemouth & Poole Elec. Sup. Ord. | 11½–12 | 5 16 6 | .. | .. | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10–10½ | 4 5 9 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11–12 | 5 0 0 | .. | 11⅛ | – |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 106–108 | 4 8 3 | .. | .. | .. |
| 1 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5½–5¾ | 4 15 8 | .. | .. | .. |
| St. | 4½% | Do. Do. 1st Debs | 103–105 | 4 5 0 | – | .. | .. |
| 5 | 5/6 | Brompton & Kensington Elec. Sup. Ord. | 8½–9½ | 5 8 6 | – | 8¾ | .. |
| 5 | 8/6 | Do. 7 per Cent. Pref. | 8½–9½ | 3 15 6 | Mar, Sept | .. | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 102–105 | 3 16 3 | – | .. | .. |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 4½–5½ | 4 15 0 | Feb, Aug | 4⅜ | .. |
| 5 | 2/8 | Do. 4½ per Cent. Pref. | 4½–5 | 4 10 0 | Feb, Aug | 4 11/16 | 4⅝ |
| St. | 4% | Do. 4% Deb. Stock (red.) | 101–103 | 3 17 6 | – | .. | .. |
| 5 | 2/8 | Do. City Undertaking 4½% Cm. Pref. | 4–4½ | 5 0 0 | – | 4½ | .. |
| 5 | 2/8 | Do. Do. (1908) | 4–4½ | 5 0 0 | .. | – | .. |
| 5 | 8/9 | Chelsea Electric Supply Ord. | 5½–5¾ | 5 6 0 | March | 5 5/16 | .. |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 107–109 | 4 2 6 | Jn, Dec | 108¼ | 108 |
| 10 | 7/0 | †City of London Electric Lighting Ord. | 10½–11½ | 5 4 4 | Feb, Aug | 10 15/16 | 10⅝ |
| 10 | 6/0 | † Do. 6 per Cent. Cum. Pref. | 13–14 | 4 5 6 | Jan, July | 13 5/16 | . |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 123–126 | 3 19 4 | Jn, Dec | .. | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 101–103 | 4 8 0 | .. | 102 | .. |
| 5 | 4% | †County of Durham Elec. P. D. Ord. £2 pd. | 2 31/32–3 1/32 | 4 0 0 | April, Oct | .. | .. |
| 5 | 5% | † Do. Do. 5% non cum. pref. | 5¼–5⅝ | 4 5 3 | April, Oct | .. | .. |
| 10 | 6/0 | †County of London Elec. Supply Ord. | 8–9 | 5 11 0 | – | 8½ | .. |
| 10 | 6/0 | † Do. 6 per Cent. Cum. Pref. | 11½–12½ | 4 16 0 | Mar, Sept | 11⅝ | 11¾ |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 109–112 | 4 0 4 | .. | 110¾ | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 101–103 | 4 7 6 | .. | 103 | 102¾ |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼–5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | † Do. 5 per Cent. Cum. Pref. | 5–5½ | 4 11 9 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101–104 | 4 6 6 | – | .. | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8½–9 | 4 14 0 | – | .. | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100–103 | 4 7 5 | – | .. | – |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 9½–10¼ | 4 18 0 | .. | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½–7 | 4 5 9 | Jan, July | – | – |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98–101 | 3 19 2 | .. | .. | .. |
| St | 4% | †Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101–103 | 3 17 6 | – | .. | .. |
| 8 | 2/4½ | London Electric Supply Ord. | 2–2½ | 6 15 0 | – | 2 3/16 | .. |
| 5 | 8/0 | Do. 6 per Cent. Pref. | 5–5½ | 5 7 0 | – | .. | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 98–101 | 3 19 2 | Mr, Jn, S, D | .. | .. |
| 5 | 10% | †Metropolitan Electric Sup. Ord. | 8½–9½ | 5 5 0 | April, Oct | 9 | 8¾ |
| 5 | 2/3 | Do. 4½ per Cent. Cum. Pref. | 5⅝–5⅞ | 4 0 0 | Jan. July | 5½ | 5 11/16 |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 110–114 | 3 19 0 | Jn, Dec | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 95–97 | 3 12 3 | – | .. | .. |
| 100 | 4½% | Midland Elec. Corp. for P. D. 1st Mort. Db. | 101–103% | 4 7 4 | – | 103 | [illegible] |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 11⅛–11⅜ | 6 0 0 | Feb, Aug | 11⅜ | .. |
| 100 | 4½% | Do. 4½% Deb. | 101½–102½ | 4 6 6 | Jan, July | . | .. |
| 5 | 8% | Newcastle Elec. Supply Ord. | 7½–7¾ | 5 4 11 | Feb, Aug | 7 11/16 | 7⅝ |
| 5 | 5% | † Do. 5 per Cent. Non. Cum. Pref. | 5¾–6 | 4 5 1 | Feb, Aug | 5⅞ | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99–100 | 3 19 7 | Jan, July | 100 | .. |
| 1 | 8% | †Northern Counties Elec. Sup. | ⅞–31/32 | 3 6 8 | Mar, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 101–102 | 4 7 6 | Jan, July | – | – |
| 10 | 9/0 | Notting Hill Electric Ord. | 13–14 | 6 8 0 | March | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mt. Debs. | 97–99 | 4 1 0 | .. | .. | .. |
| 5 | 4/6 | Oxford Electric Ord. | 6½–7 | 4 16 0 | March | .. | .. |
| St. | 4% | Do. 4% Deb. Stock | 99–101 | 3 19 0 | – | .. | .. |
| 5 | 7/6 | St. James' & Pall Mall Elec. Ord. | 9–10 | 6 5 0 | Feb, Aug | 9⅝ | 9⅜ |
| 5 | 8/6 | Do. 7 per Cent. Pref. | 7–8 | 4 7 0 | Feb, Aug | 7½ | 7¼ |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 96–98 | 3 12 0 | – | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 5¼–5¾ | 8 4 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76–80 | 5 0 0 | – | .. | .. |
| 5 | 4/0 | †South London Electric Supply Ord | 8–8½ | 5 14 0 | .. | .. | .. |
| 1 | 0/3 | South Metrop'n Elec. Lt. & Power Ord. | ¾–⅞ | .. | .. | .. | – |
| 1 | 0/8¾ | Do. 7% Cum. Pref. | 1¼–1⅜ | 5 2 0 | .. | .. | .. |
| St. | 4½% | † Do. 4½ 1st Db. Stk. Red. | 103–106 | 4 5 0 | – | .. | – |
| 5 | 2/6 | †Urban Electric Supply Ord. | 4¼–4¾ | 5 5 0 | – | – | .. |
| 5 | 2/8 | † Do. 5% Cum. Pref. | 4⅞–5⅛ | 4 17 6 | – | 5 1/16 | .. |
| St. | 4½% | † Do. 4½% 1 Mort. Deb. | 102–104 | 4 6 6 | .. | .. | .. |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 9½–10½ | 6 4 0 | Mar, Sept | 10 | 9¾ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5 5/16–5 9/16 | 4 10 0 | .. | .. | .. |
| 5 | .. | Do. Issued at 7/6 premium all paid | 5 1/16–5 9/16 | .. | .. | 5⅝ | .. |
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| St. | 4% | Baker St. & Waterloo 4% Perp. Db. St. | 100–102 | 3 18 0 | .. | .. | .. |
| 1 | – | Bath Elec. Trams Pref. Ord. | 15/16–1 1/16 | .. | .. | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16–1 1/16 | 4 12 3 | .. | .. | .. |
| St. | 4½% | Do. 4½ 1st Mort. Deb. Stock (red.) | 101–103 | 4 7 3 | – | 102¾ | .. |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 101–103 | 4 7 9 | .. | 10[illegible]⅜ | .. |
| 10 | [illegible]½% | Bristol Tramways and Carriage Ord. | 15½–15¾ | 4 7 6 | Feb, Aug | .. | .. |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10–10¼ | 3 18 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Debs. | 103–105 | 3 16 0 | Feb, Aug | .. | . |
| 10 | 6/0 | British Electric Traction Ord. | 6–7 | 4 5 8 | – | 7 3/32 | 6⅞ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 9–9½ | 6 6 0 | Feb, Aug | 9½ | 9¼ |
| St. | 5% | † Do. 5 per Cent. Perpetual Debs | 111½–114½ | 4 7 8 | .. | 114 | 112 |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 97–99 | 4 11 0 | .. | 98 | .. |
| St. | 4% | Central London Ordinary Stock | 91–93 | 4 6 0 | June, Dec | 92½ | .. |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 101–103 | 3 17 6 | .. | .. | .. |
| St. | 4% | Do. Deferred Stock | 82–85 | 4 14 0 | .. | 83⅛ | 82 |
| 100 | 4% | Do. 4 per Cent. Debs. | 110–112 | 3 11 3 | .. | 111¾ | 111½ |
| St. | 4% | Charing X, Euston & Hmpstd Per. Db. Stk. | 95–97 | 4 2 6 | .. | 96¾ | .. |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 5⅛–5⅜ | 4 13 0 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 101–104 | 3 17 0 | .. | .. | .. |
| St. | 1¾% | City and South London Rly. Con. Ord. | 41–43 | 4 7 0 | Feb, Aug | 42⅞ | 41½ |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 120–123 | 4 1 4 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 115–118 | 4 4 8 | .. | .. | .. |
| St. | 5% | Do. (1901) | 113–116 | 4 6 0 | – | .. | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 106–109 | 3 13 4 | May, Nov | .. | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13¾–14¼ | 4 1 6 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½–15½ | 3 17 8 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 4¼–4¾ | 8 8 0 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8–9 | 4 8 11 | – | .. | .. |
| St. | 4½% | †Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 101–103 | 4 7 6 | .. | .. | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 15–16 | 5 12 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 12–12½ | 4 17 0 | Mar, Sept | – | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 107–108 | 4 3 0 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2½–2¾ | 9 8 6 | – | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 80–85 | 4 14 0 | – | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8 11/16–8 13/16 | 8 13 0 | Feb, Aug | .. | .. |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾–10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99–102 | 3 19 3 | Jan, July | .. | . |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9½–10 | 5 0 0 | – | 10 | 9 21/32 |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 95–98 | 4 2 6 | – | 97½ | 96½ |
| St. | .. | Mersey Con. Ord. Stock | 4–5 | – | – | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8–11 | – | – | – | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | 3/16–½ | .. | – | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | 15/16–1 1/16 | 4 14 0 | – | .. | .. |
| St. | 4½% | Do. 4½% Deb. Stock | 104–106 | 4 5 0 | – | .. | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum Pref. | ½–1½ | .. | May | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8–9 | 5 15 0 | .. | – | .. |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9–9½ | 5 5 0 | Feb, Aug | – | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103–106 | 4 5 0 | – | .. | .. |
| 100 | 5% | Sunderland Dst. Elc. Trms. 5% 1st Mt. Db. | 92–95 | 5 5 0 | .. | 92½ | .. |
| – | 5% | Underground Elec. Rys. Co. of London | 98–100 | 5 0 0 | .. | .. | .. |
| St. | 3½% | Waterloo and City Ord. | 101–104 | 3 2 6 | June, Dec | 101½ | .. |
| St. | 4½% | Yorkshire W.R. El. Trs. Co. 4½% 1st Debs. | 95–97 | 4 13 0 | .. | .. | .. |

| Shre. | Last Dividend | Name. | Price Wed., April 4. | Rate % Yielded. £ s. d. | Dividend Due. |
|---|---|---|---|---|---|
| | | **ELECTRIC MANUFACTURING, &c.** | | | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝–⅞ | 5 6 6 | – |
| 1 | 10½d. | Aron El. Met. 6% Cm. Pf. | ⅞–1⅛ | .. | – |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3⅞–4⅛ | 4 17 9 | .. |
| 1 | 7½d. | Do. Pref | 1 7/16–1 9/16 | 3 16 10 | .. |
| 5 | 4/0 | †British Insulated & Helsby Cables Ord | 6½–7 | 5 6 0 | July, Feb |
| 5 | 3/0 | Do. 6 per Cent. Pref. | 5¾–6¼ | 4 16 0 | Jan, July |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 103–106 | 4 4 11 | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 96–98 | 4 12 0 | .. |
| 1 | .. | British Westinghouse 6% Pref. | 1⅛–1⅝ | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 80–85 | 4 14 0 | .. |
| 5 | .. | Brush Electrical Engineering | ¾–1 | .. | March |
| 5 | 2/4½ | Do. 6 per Cent. Pref. Non-Cum. | 1½–2 | 6 0 0 | Mar, Sept |
| St. | 4½% | Do. 4½ per Cent. Perp. 1st Deb. Stock | 97–99 | 4 11 0 | Mar, Sept |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 82–84 | 5 7 4 | Jan, July |
| 5 | 5/0 | Callender's Cable Con. Ord. | 10½–11½ | 5 4 0 | Jan, July |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5¾–6 | 4 3 4 | Jan, July |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 108½–110½ | .. | Nov, May |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1–1⅛ | 5 6 6 | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 95–100 | 4 10 0 | – |
| 1 | 9⅝d. | Chadburn's (Ship) Telegraph Ord. | 1 3/16–1 5/16 | 7 10 0 | .. |
| 1 | 7½d. | † Do 6% Cum. Pref. | 1 1/16–1 3/16 | 5 8 0 | .. |
| 8 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 2–2¼ | 3 9 0 | Jan, July |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 96%–98% | 5 2 0 | Jan, July |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | 8¾–9¼ | 5 8 0 | Sept |
| 5 | 3/0 | † Do. 6% Cum. Pref. | 6–6½ | 4 14 0 | Sept |
| St. | 4½% | Do. 4½% Deb. Stock | 104–106 | 4 5 0 | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅝–1⅞ | – | Feb, Aug |
| 5 | 2/6 | Do. (£5 paid) | 2½–3 | .. | Feb, Aug |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 86–88 | 4 11 0 | June, Dec |
| St. | 5% | † Do. 5 per Cent. 2nd Deb. Stock | 90–95 | 5 5 0 | – |
| 5 | 2/6 | Edmundson's Elec. Corp. Ord. | 3¾–4¼ | 8 4 6 | H'lf-yearly |
| 5 | 3/0 | Do. 6 per Cent. Cum. Pref. | 5–5½ | 5 9 0 | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 103–106 | 4 5 0 | – |
| 2 | 1/7½ | Electric Construction Co. | 1 9/16–1 13/16 | 9 6 0 | July |
| 2 | 2/9⅝ | Do. 7 per Cent. Cum. Pref | 2–2½ | 5 12 0 | July |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 89–92 | 4 7 0 | Jan, July |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9⅜–9⅞ | 5 3 0 | .. |
| St. | 4% | † Do. 4 per Cent. 1st Mort. Debs. | 92–96 | 4 8 0 | – |
| 5 | 10/0 | Henley's Telegraph Works Ord. | 12½–13½ | 5 11 0 | Feb, Aug |
| 5 | 2/3 | Do. 4½ per Cent. Pref. | 5¼–5¾ | 4 2 0 | Feb, Aug |
| St. | .. | Do. 4½ per Cent. 1st Mt. Db. St. | 108–110 | .. | .. |
| St. | .. | Do. Do. Scrip (50% paid) | 57–59 | .. | .. |
| 10 | 15/0 | India Rubber, Gutta Percha, &c., Wrks. | 17½–18½ | 5 9 0 | Feb, Aug |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¾–12¼ | 4 1 8 | Mar, Sept |
| 1 | 1/2⅜ | Richardsons, Westgarth & Co., Ltd. Ord. | 29/32–31/32 | 6 4 0 | .. |
| 1 | 7½d. | Do. 6% Cum. Pref. | 15/16–1 1/16 | 5 16 0 | .. |
| St. | 4½% | Do. 4½% Perp. Deb. Stock | 98–101 | 4 10 0 | .. |
| 12 | 4/0 | Telegraph Construction & Mainten'ce. | 83–85 | 5 2 6 | Mar, July |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 100–102 | 3 18 6 | Jan, July |
| 1 | 5/0 | †Vickers, Sons & Maxim, Ltd., Ord. | 2 7/16–2 9/16 | 5 13 0 | .. |
| 1 | 6d. | † Do. 5% Non-Cum. Preference | 1⅛–1¼ | 4 0 0 | .. |
| St. | 5% | † Do. 5% Non-Cum. Preferred | 120–123 | 4 2 8 | – |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock Red. | 105–107 | 3 14 8 | .. |
| 100 | 4½% | Do. 4½% 2nd Mort. Debs., Red | 106–108 | 4 3 8 | .. |
| 5 | – | Willans and Robinson Ord. | 1¾–2¼ | – | Apr, Oct |
| 5 | – | Do. 6 per Cent. Cum. Pref. | 3¾–4¼ | – | Apr, Oct |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 80–86 | 4 14 0 | May Nov |
| | | **TELEGRAPHS.** | | | |
| 100 | 4% | *African Direct Tel. 4% Mrt. Deb. (red.) | 98½–101½ | 3 18 6 | Jan, July |
| 10 | – | Amazon Telegraph | 3¾–4¼ | .. | Jn, Dec |
| 100 | 5% | Do. 5% Debs. (red.) | 83–88 | 5 18 6 | .. |
| St. | 21/0 | Anglo-American | 65–67 | 4 17 0 | F, My, Ag, N |
| St. | 32/0 | Do. Preferred | 111½–113½ | 5 6 0 | F, My, Ag, N |
| St. | 10/0 | Do. Deferred | 19⅞–20⅛ | 2 12 0 | F, My, Ag, N |
| St. | 4% | †Commercial Cable 4 per Cent. Deb. Stk | [illegible] | 4 1 0 | Jn, Ap, Jy, O |
| 10 | 6/0 | Cuba Submarine Ord. | 8½–9 | 5 11 0 | Feb, Aug |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17–18 | 5 11 2 | Feb, Aug |
| 5 | 2/0 | †Direct Spanish Ord | 8⅜–8⅝ | 5 11 9 | April, Oct |
| 5 | 5/0 | † Do. 10 per Cent. Cum. Pref. | 8½–9 | 5 11 0 | April, Oct |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 100%–103% | 4 7 8 | Jan, July |
| 20 | 4/0 | †Direct United States Cable. | 11¼–11¾ | 4 5 0 | Ja, Ap, Jy, O |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 100–102 | 4 8 0 | Jn, Dec |
| St. | [illegible] | Eastern Ordinary | 146–149 | 4 14 0 | Ja, Ap, Jy, O |
| St. | 7/6 | Do. 3½ per Cent. Pref. Stock | 90–92 | 3 16 6 | Ja, Ap, Jy, O |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 107–109 | 3 13 8 | May, Nov |
| 10 | 2/6 | Eastern Extension | 14¾–15¼ | 4 11 8 | Ja, Ap, Jy, O |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 105–107 | 3 14 8 | Feb, Aug |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb, 1909 | 99–101 | 3 19 3 | Feb, Aug |
| [illegible] | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101%–103% | 3 18 3 | May, Nov |
| 10 | 5/0 | G. N. (of Copenhagen) with coupon 66 | 39½–41½ | 5 16 0 | Jan, July |
| 100 | 4½% | Halifax & Bermudas 4½% 1st Mt. Db. (red.) | 100–102 | 4 8 0 | June, Dec |
| 25 | 12/6 | Indo-European | 57–59 | 5 10 0 | May, Nov |
| 100 | $1 | Mackay Companies Common | 61¾ | 3 4 0 | Jan, July |
| 100 | 4% | Do. Preference | 75⅛ | 5 6 6 | Ja, Ap, Jy, O |
| 1 | .. | Marconi's Wireless Teleg. Co. | 1⅛–1⅜ | .. | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 99–102 | 3 18 6 | June, Dec |
| 10 | 4/0 | West African Telegraph Shares | 9¾–10¼ | 4 17 6 | .. |
| [illegible] | – | West Coast of America | ⅝–¾ | .. | – |
| 100 | 4% | Do. 4 per Cent. Debs. | 100–102 | 3 18 3 | Jan, July |
| 10 | – | West India and Panama | ⅜–⅝ | .. | May, Nov |
| 10 | 6/0 | Do. 6% 1st Pref. | 5¼–5¾ | 6 6 8 | May, Nov |
| 10 | – | Do. 6 per Cent. 2nd Pref. | 6–7 | .. | May, Nov |
| 100 | 5% | * Do. 5 per Cent. Debs. | 101–104 | 4 16 0 | Jan, July |
| 10 | 8/0 | Western Telegraph | 14¼–14¾ | 4 16 0 | Mr, Jn, O, D |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 100–102 | 4 18 0 | June, Dec |
| St. | 4% | Do. 4% Deb. Stock (red.) | 102–104 | 3 16 10 | .. |
| | | **TELEPHONES** | | | |
| – | .. | Amer. Telephn. & Telegh. Coll. Trust $1,000 4% Bonds | 96–98 | .. | .. |
| St. | 5% | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 101–103 | 4 17 0 | August |
| 5 | 3/0 | Chili Telephone (fully paid) | 8–8¼ | 4 17 0 | – |
| 1 | 0/9⅜ | Monte Video Telephone Ord. | 15/16–1 1/16 | 3 15 3 | .. |
| 1 | 1/0 | Do. 5% Pref. | ⅞–1 | 5 0 0 | – |
| St. | 6% | National Co. Pref. Stock | 109–111 | 5 8 0 | – |
| St. | 5% | Do. Def. Stock | 111–113 | 4 8 6 | Feb, Aug |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 12–14 | 4 5 6 | Feb, Aug |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 11½–12½ | 4 16 0 | Feb, Aug |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5¼–5½ | 4 11 0 | June, Dec |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 99–101 | 3 9 3 | – |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 103–105 | 3 16 8 | April, Oct |
| 1 | 0/7½ | Oriental | 1½–1⅝ | 4 12 0 | – |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1¼–1⅜ | 4 7 0 | .. |
| St. | 24/7⅜ | Do. 4% Red. Deb. Stock | 98–100 | 4 0 0 | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 103–106 | 4 4 9 | July |
| 5 | 8/0 | United River Plate | 7–7½ | 5 6 8 | June, Dec |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5½–5¾ | 4 7 0 | June, Dec |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 110–112 | 4 9 8 | .. |
| | | **FINANCIAL, INVESTMENT, &c.** | | | |
| 5 | 3/0 | Elec. & Gen. Investment 6% Cum. Pref. | 4¾–5¼ | 5 14 0 | Ja, Ap, Jy, O |
| 10 | 2/0 | Globe Telegraph and Trust | 10⅞–11⅛ | 4 16 6 | Ja, Ap, Jy, O |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14⅝–14⅞ | 4 0 6 | April, Oct |
| 10 | 6% | Submarine Cables Trust (Cert.) | 128–131 | 4 13 6 | – |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote

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WANTED, LAMP TOPS, with Platinum, Scrap Platinum, &c.—EDEY & Co., 29, Ludgate-hill, London, E.C.

## MISCELLANEOUS PLANT, &c., FOR SALE.

ELECTRIC LIGHT INSTALLATION.—Dynamo, Chamberlain & Hookham (semi-enclosed), 40 amperes, 100 volts; Accumulators, 33 cells, by Ashmore Co. (Stockton); Engine, 5 horse-power National (gas); Switchboard, &c., complete. Nearly new. Seen working. Perfect order.—FRAZIER, Trinity-road, Birchfield, Birmingham.

"WESTON" AMMETER, with Shunt, and VOLTMETER for SALE; also INSULATION TESTER. All in first-class condition. —Address BROWN HOISTING MACHINERY Co., 39, Victoria-street, London, S.W.

ELECTRIC LIGHTING PLANT, complete with boiler, for 250 lights, first-class condition, suitable for house or works, FOR SALE, cheap.—Address, M. 1,144, Birchall's Advertising Offices, Liverpool.

DYNAMO, 100 volts; CROSSLEY GAS ENGINE, 8½ H.P., double flywheels; seen working; both splendid condition; cheap, FOR SALE.—MULHOLLAND, 11, Moore-street, Glasgow.

THE TELEGRAPHISTS' AND TELEPHONISTS' NOTE BOOK has just been PUBLISHED. Useful to every operator. Full of facts and data. Price 1s. 1d., post free, from RENTELL, 36, Maiden-lane, London, W.C.

## MOSELEY'S FAMOUS

NOTE THE FINISH.

**RUBBER GLOVES.**

**OUR OWN MAKE.**

Perfectly Soft Finish. Never Harden.
Stand any Climate. Guaranteed absolutely

**PURE FINE PARA RUBBER.**

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Telegrams: Turnstile London.

## STANLEY

GOLD MEDAL St. Louis, 1904.

**SURVEYING & DRAWING INSTRUMENTS.**

*NOTICE OF REMOVAL OF THE RETAIL DEPARTMENT*
from GREAT TURNSTILE to
**286, HIGH HOLBORN, LONDON, W.C.** Price List post free.

## PATENTS, DESIGNS AND TRADE MARKS ACTS,

1883 TO 1902.

NOTICE is Hereby Given that HERBERT ARNAUD TAYLOR, SIDNEY GEORGE BROWN, and JOSEPH ARTHUR LOVEL DEARLOVE, all of 4, Great Winchester-street, in the County of London, Electrical Engineers, seek leave to AMEND the SPECIFICATION of Letters Patent No. 1,434 of 1899, granted to the said SIDNEY GEORGE BROWN for "Improvements in Electric Telegraph Apparatus."

Particulars of the proposed amendment were set forth in the *Illustrated Official Journal* (Patents), issued on the 4th April, 1906.

Any person, or persons, may give Notice of Opposition to the Amendment (on Form G), at the Patent Office, 25, Southampton-buildings, London, W.C., within one calendar month from the date of the said Journal.

C. N. DALTON, Comptroller-General.

## TENDERS INVITED, &c.

### CITY AND COUNTY OF KINGSTON-UPON-HULL.

ELECTRICITY DEPARTMENT.

The Electric Lighting Committee of the Hull Corporation are prepared to receive TENDERS for the following PLANT required at their Sculcoates-lane Generating Station:—

Contract 55. **COAL HANDLING PLANT, &c.,** in connection with Eight Lancashire Boilers.

Contract 56. **CONDENSERS, PUMPS, PIPEWORK, &c.,** in connection with Six Lancashire Boilers and Two High-speed Engines.

Forms of Tender and Specifications for either Contract may be obtained on depositing the sum of One Guinea with the City Treasurer, T. G. Milner, Esq., Town Hall, Hull, for each copy required, such deposits being returnable on receipt of a bona fide Tender.

Tenders in separate sealed envelopes, endorsed respectively "Coal Handling Plant" and "Pipework, &c.," are to be addressed to the Chairman of the Electric Lighting Committee, Town Hall, Hull, before noon on THURSDAY, April 19th, 1906.

The Corporation do not bind themselves to accept the lowest or any Tender.

Any further information can be obtained from the undersigned.

By order,
H. BELL, City Electrical Engineer.

Sculcoates-lane, Hull, April 3rd, 1906.

### COUNTY BOROUGH OF SOUTHAMPTON.

**TO CONTRACTORS AND OTHERS.**

The Corporation invite TENDERS for RECONSTRUCTING their TRAMWAYS in the Avenue. Specification, conditions, and form of Tender can be obtained upon application to the General Manager and Engineer, Mr. H. F. Street, at the Tramway Office, Above Bar-street, after the 10th instant.

Sealed Tenders, endorsed "Tender. Tramways, Avenue," must be delivered at the Town Clerk's Office before 2 p.m. on the 23rd instant.

No pledge is given to accept the lowest or any Tender.

R. R. LINTHORNE, Town Clerk.

Town Clerk's Office, Municipal Offices,
Southampton, 6th April, 1906.

### THE ST. PANCRAS BOROUGH COUNCIL invite

TENDERS for the Supply of **ARC LAMP CARBONS** for Twelve Months. Delivery to be made as required.

Copies of the Specification, Conditions of Contract, and Form of Tender can be obtained upon application at the Electricity Department Offices, No. 57, Pratt-street, Camden Town, N.W., on payment of a deposit of £2, which will be refunded only on the Specification being returned accompanied by a bona fide Tender,

Tenders to be sent to the undersigned, endorsed "Tender for Arc Lamp Carbons," by 12 o'clock noon, on MONDAY, 30th April, 1906.

The Council do not bind themselves to accept the lowest or any Tender.

C. H. F. BARRETT, Town Clerk.

Town Hall, Pancras-road, London, N.W.,
April 10th, 1906.

---

## Royal Doulton Potteries.

# INSULATORS

AND ALL KINDS OF

**POTTERY FOR ELECTRICAL PURPOSES.**

## DOULTON & CO.,

*LIMITED.*

**Lambeth, LONDON, S.E.**

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# EVERSHED & VIGNOLES, LIMITED.

Our New List of AMMETERS and VOLTMETERS will be forwarded post free on application.

*Makers of all kinds of ELECTRICAL INSTRUMENTS,*
**Acton Lane Works, CHISWICK, LONDON, W.**

◆◆◆

## FACTORIES & WAREHOUSES TO LET & WANTED.

FACTORY TO BE LET at once; a large new factory, 50 ft. long by 31 ft. wide, and 31 ft. high; another floor could be put in if necessary. Rent £100.—Apply ALFRED KIRKLAND, 113, Cottenham-rd., Upper Holloway London, N.

FACTORY TO LET (Two Floors); moderate rent; situated near "Nag's Head," Holloway.—Apply W. H. C., 4, Pembroke-street, Copenhagen-street, Islington, London, N.

IPSWICH.—SPACIOUS MODEL FACTORY TO LET; specially constructed with lift; near dock, rail and trams.—Apply R. D. & J. B. FRASER, LIMITED, Princes-street, Ipswich.

TO BE LET, near City, good light WORKSHOPS and OFFICES.—219, Goswell-road, London, E.C.

FACTORY to be LET, or would be SOLD, close to London Fields Station, about 123 ft. by 23 ft.; one floor, rent £95; two floors, each about 123 ft. by 23 ft., rent £180. Convenient and light.—Apply MAYGROVE, 51, Aldersgate-street, London, E.C.

COLCHESTER.—Extensive FACTORY, suitable for manufacturers of motors and other manufacturers, to be LET, or the FREEHOLD to be SOLD, as a whole or in three lots. Spacious and modern manufacturing premises, with manager's residence and foreman's house. The property has a ground area of about 18,600 sq. ft., is well lighted, and very conveniently arranged.—Apply to Messrs. JONES, LANG & CO., Surveyors, 3, King-street, Cheapside, London, E.C.

FACTORY, commanding position, facing station, near centre of Leeds, with unrivalled business advertising possibilities, at junction of six great railways (650 passenger trains daily, 320 stopping at the junction). Main building 90 ft. by 60 ft., four floors, lofty, well-lighted rooms, in splendid condition; sheds 90 by 19, and 40 by 16; office, stable, boiler house, &c. Frontage to railway siding, tram route, and electric power main. To LET July.—Apply B. RAMSDEN, Crescent, Roundhay, Leeds.

FACTORY LAND to be LET or SOLD at Ilford, frontage to River Roding. Outside L.C.C. area. Close to G.E. Railway Station. Labour, gas, water, &c., cheap.—LEOPOLD FARMER & SONS, Factory Specialists, 46, Gresham-street, E.C., and Kilburn, N.W., London.

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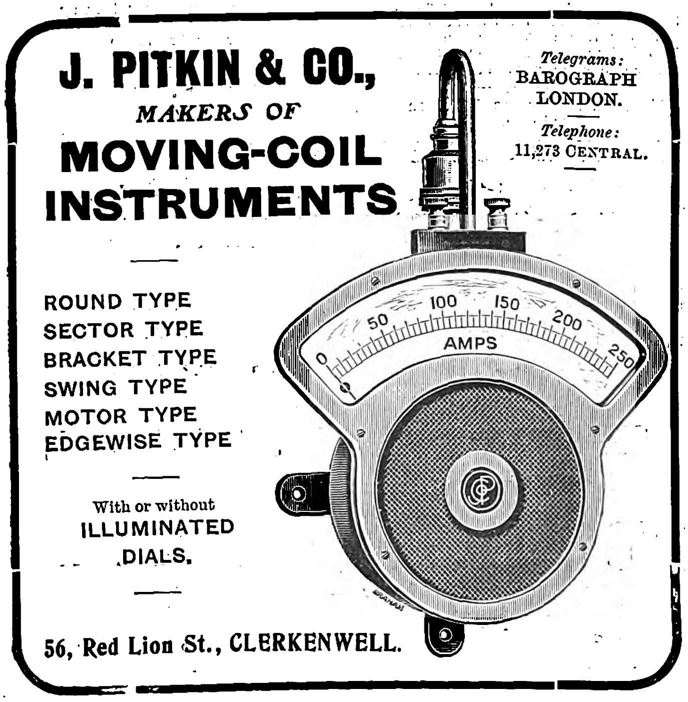
*Three Lines and under (Minimum)* ... ... ... 1s. 6d.
*Per Line after* ... ... ... ... ... ... 6d.

Ten Words to the Line.

Where answers to any of the above Advertisements are to be sent to the Publishing Offices to be forwarded, the sum of 3d. must be sent with the order to pay for postage of these replies. Six Words must be allowed for the address of the Publishing Offices.



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*MAKERS OF*
**MOVING-COIL INSTRUMENTS**

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ROUND TYPE
SECTOR TYPE
BRACKET TYPE
SWING TYPE
MOTOR TYPE
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With or without
ILLUMINATED
DIALS.

56, Red Lion St., CLERKENWELL.

THE COUNTY OF LONDON ELECTRIC SUPPLY COMPANY, LIMITED.

NOTICE is Hereby Given that the TRANSFER BOOKS and REGISTER of HOLDERS of SECOND DEBENTURE STOCK of the Company will be CLOSED from the 18th to the 30th inst., both days inclusive, preparatory to the payment of the interest due on May 1, 1906.

By order,
H. B. RENWICK, Secretary.

Moorgate-court, Moorgate-place,
London, E.C., April 10th, 1906.

## PARTNERSHIPS, AGENCIES, &c.

FOR THE **SALE** OF
**CONTINUOUS-CURRENT MOTORS, DYNAMOS, VENTILATING FANS**
to Wholesale Dealers, Machinery Manufacturers, and Factors we **REQUIRE** trustworthy ***AGENTS.***
**ROLAND-WERKE Electric. G.m b.H., BERLIN-WEISSENSEE, Germany.**

~~FERBECK CHIMNEY CONSTRUCTION CO.—CHIMNEY SHAFTS in any part of the World (Economical Patent System), CHIMNEY TANKS, LIGHT TOWERS, WATER TOWERS (Intze System), ELECTRIC and all other FURNACES, SOOT KILNS, ARC and DYNAMO CARBON PLANTS, &c.—FINSBURY PAVEMENT HOUSE, LONDON, E.C.~~

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### SITUATIONS VACANT

*Three Lines and under (Minimum)* ... — — 1s. 6d.
*Per Line after* — — — — — — 6d.

Ten Words to the Line.

### SITUATIONS WANTED.

*Sixpence per Line of Ten Words, minimum One Shilling.*

Where answers to any of the above Advertisements are to be sent to the Publishing Offices to be forwarded, the sum of 3d. must be sent with the order to pay for postage of these replies. Six Words must be allowed for the address of the Publishing Offices.

## SITUATIONS, &c., VACANT.

REQUIRED, by a Technical Institute, the services of a TECHNICAL MAN for spare time work. Good remuneration will be paid, and the work will not interfere with present occupation.—Write all details, &c., to EDUCATION Box 522, Smith's Advertising Agency, 100, Fleet-street, London, E.C.

ENGINEER, with first-class qualifications and long experience in manufacture of electrical machinery, required as WORKS MANAGER, thorough knowledge in construction of turbo generators and large units, together with good organising qualities, essential.—6,083, *Electrician* Office, Salisbury-court, Fleet-street, London.

ARC LAMPS.—MANAGER WANTED by an old established company with a large output of all types; only first-class men, thoroughly experienced in both the business and practical sides of this department of electrical engineering need apply, in confidence, stating age, salary required, &c., to "C. W. M.," *Electrician*, Salisbury-court, Fleet-street, London.

WANTED.—ENGINEER, in London District, having first-class experience in the preparation of estimates for heavy electric power plant and machinery. Replies, giving particulars of training, experience, and remuneration required, will be treated as confidential.—6,091, *Electrician* Offices, Salisbury-court, Fleet-street, London.

WANTED IMMEDIATELY, thoroughly experienced and first-class ELECTRICAL ENGINEER, to take complete control of Electrical Department. Must have thorough knowledge of estimating, and be competent to propose and carry out schemes for electrical power installations for works and collieries. Apply, stating age, experience, and salary required, to MILLS, ENGLISH & CO., LIMITED, Mechanical and Electrical Engineers, Swansea.

WANTED, by Chartered Patent Agent, an ASSISTANT capable of drawing patent specifications for electrical inventions.—Age, salary and references to X., 6,093, *Electrician* Offices, Salisbury-court, Fleet-street, London.

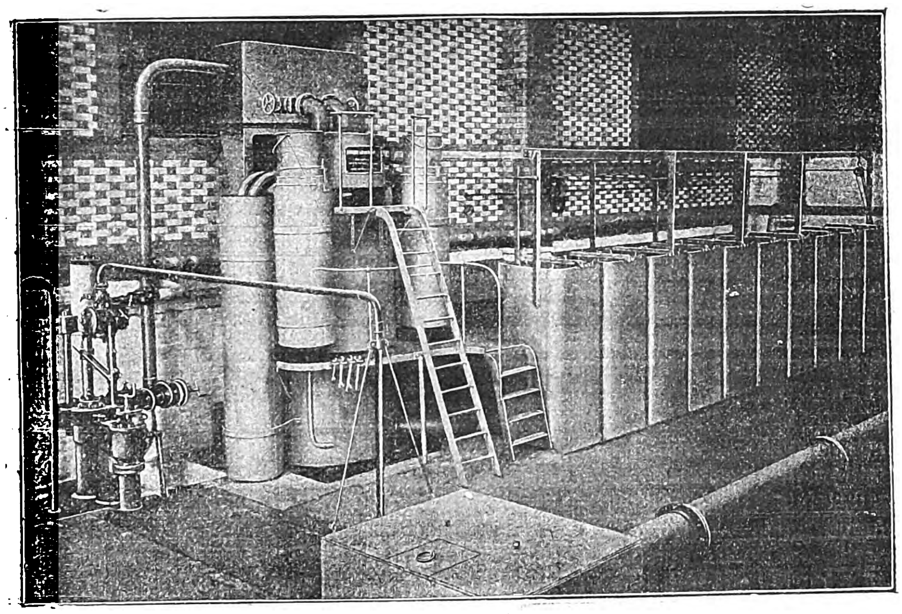
**SITUATIONS VACANT, &c., continued on page xiv.**

**NO MORE COLLAPSED FURNACES OR BUCKLED TUBES**

**THROUGH GREASE**

**IF YOU PURIFY THE CONDENSED WATER**

**WITH THE "HARRIS-ANDERSON" PURIFIER**



"Harris-Anderson" Purifier, Pinkston Power Station, Glasgow Corporation Tramways.
Capacity, 22,000 gallons per hour.

Grease Absolutely Removed.
No Objectionable Matter introduced.
Automatic and Simple Action.
Minimum Waste of Water.
Numerous Plants now at work in Electric Light and Power Stations, &c.

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MAKERS OF
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COMPLETE EQUIPMENTS
FOR
ELECTRIC DRIVING
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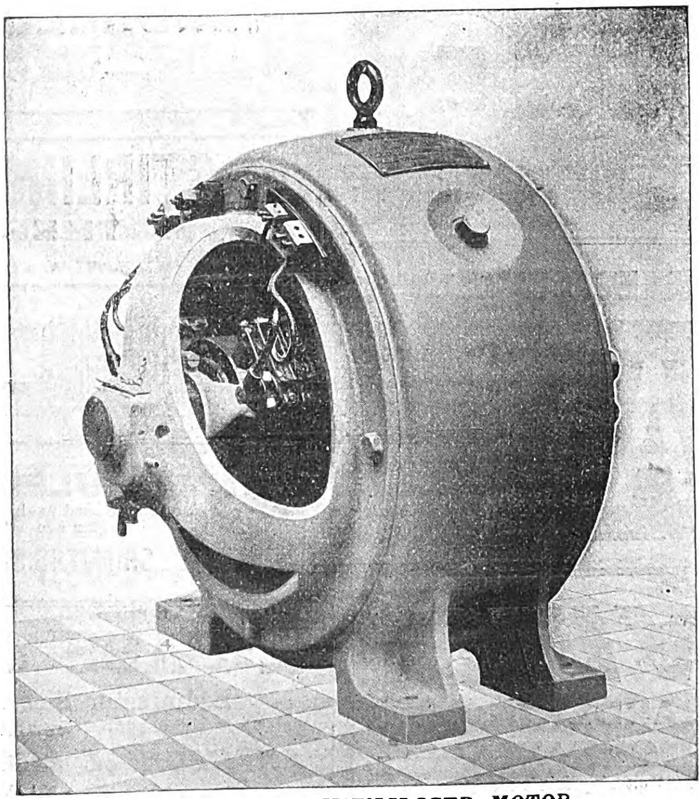
FACTORIES.



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DRAUGHTSMAN REQUIRED for electrical engineer's office in large steel works. Must have had some experience with switchboard designs, &c.—Apply, stating experience, age and salary required, to W. C. P., *Electrician* Offices, Salisbury-court, Fleet-street, London.

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DRAUGHTSMAN WANTED, accustomed to high-tension switch gear work. Only first-class men need apply.—Apply, stating full experience, age, and salary required, to FERRANTI LIMITED, Hollinwood, Lancs.

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**MICA**

**MICA SEGMENTS** FOR **COMMUTATORS.**

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Contractors to H.M. Government.

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BEST RESULTS OBTAINABLE.

*FREE SAMPLE sent on Application.*

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**John E. Raworth,**

*Queen Anne's Chambers,*
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**Patent Agent.**

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CATALOGUE ON APPLICATION.

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**MOTHERWELL, N.B.**

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**"ANTI-SULPHURIC" ENAMEL**

Should be used in all **ACCUMULATOR ROOMS** for Protection from Acid Fumes.

Sole Makers: **GRIFFITHS BROS. & CO.,** Mack's-rd Bermondsey, LONDON, S.E.

**C. PASS & SON, LTD.,**

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**GASKELL & GROCOTT,**
Whitehall Works, Longport, Stoke-on-Trent.
**J. MACINTYRE & CO., LTD.,**
Washington Works, Burslem.

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## INSTRUMENTS AND PLANT TESTED.

## THE ELECTRICAL STANDARDIZING, TESTING AND TRAINING INSTITUTION.

(Proprietors: The Syndicate of Electrical Engineers, Ltd.)

**(Established 1889.)**

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Telephone No. 9999 Central. Telegraphic Address: "Standardising London."

Standardizes and Tests Electrical Instruments.
Inspects and Certifies every kind of Electrical Plant and Materials.
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Lets Private Experimenting Rooms, and offers every facility, with skilled assistance when desired, to Experimenters in Electrical Science.

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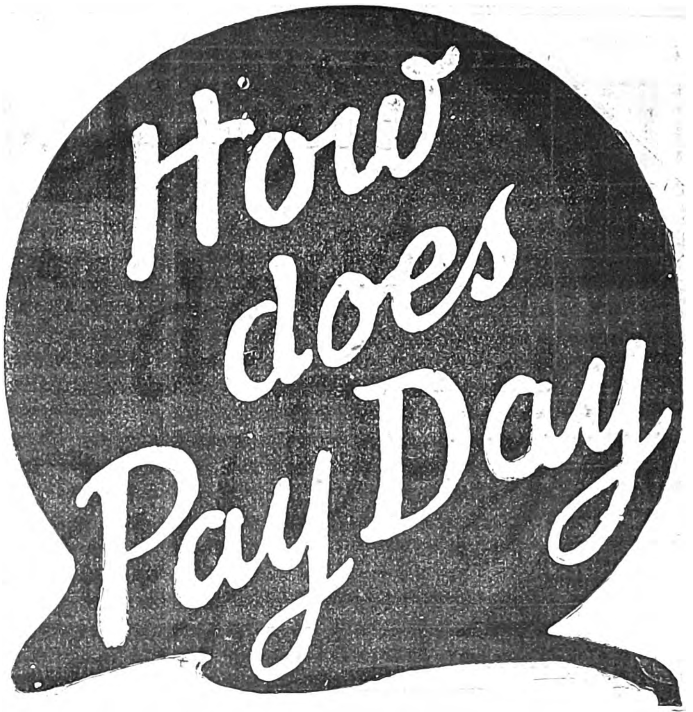

affect you? If you are not drawing as much salary on pay day as you would like to do, then we can alter this for you. We train you by post, direct to the home, under our proved successful system, for a good position, with good pay, as an Electrical or Mechanical Engineer. We have done this for thousands, and can do the same for you.

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WE RECOMMEND OUR WELL-KNOWN

**ACID-PROOF PAINTS.**

Which are in General Use by LEADING ELECTRICAL FIRMS, and are recognised as EXCELLENT MATERIALS by prominent Technical Experts.

**INSULATING VARNISHES.**

For Machinery and Apparatus using either HEAVY or WEAK CURRENTS. Tested by the Physik. Techn. Reichs Versuchsanstalt, and their merits demonstrated at the Paris Universal Exhibition in connection with a 3,000 H.P. machine.

**NEW "ELECTRO" ENAMEL.** Allows 25 to 30 per cent. Excess Current in Conductors.

**Best Guarantee against Short-Circuiting and for Preventing Theatre Fires and Stoppages on Electric Tramways and High-Speed Railways.**

Breakdown Voltage, **13,200!**

A. F. AMMON, *Sole Agent*, 5, Cross Street, MANCHESTER.

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## THEIR CONSTRUCTION AND MANAGEMENT.

Price 9s. Nett.
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A THOROUGHLY PRACTICAL MANUAL FOR CENTRAL STATION ENGINEERS, DISTRIBUTING ENGINEERS, AND STUDENTS.

By
**C. H. W. GERHARDI.**

This valuable Practical Manual on the Management of Electricity Meters, which will form a volume in "THE ELECTRICIAN" Series, wil be ready next week. The Author has had many years' exceptional experience with Electricity Meters in connection with the Meter Department of the largest electricity supply undertaking in the Kingdom. Mr. Gerhardi's intimate acquaintance with the working of all existing meters on the market, and with the details of their construction and management, is a guarantee that the book will meet the requirements of those engaged in work in which the Electricity Meter forms an essential part. In the division of the book devoted to "Testing" Mr. Gerhardi's unique experience will prove of the greatest service to supply station engineers and managers.

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For **POWER TRANSMISSION** and all **OVERHEAD WORK.**

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HULL AND WEST HARTLEPOOL.

NO MORE FIRES
From Electric Wires.

Important to Electrical Engineers.

**IMPROVED**
**ELECTRIC WIRING**

STEEL ARMOURED
INSULATING CONDUIT

**The only SAFE SYSTEM.**

ABSOLUTELY PREVENTS ALL DANGERS
Arising from the Fusing of Wires.

*FIRES FROM THIS SYSTEM HAVE NEVER OCCURRED.*

**In use at Car Sheds of British Tramways, Portsmouth Tramways, London United Tramways, Dublin Tramways, and Municipal Buildings at Glasgow, Newport, Cardiff, Brighton, &c.; also at Arundel Castle, British Museum, Eaton Hall, Woburn Abbey, &c.**

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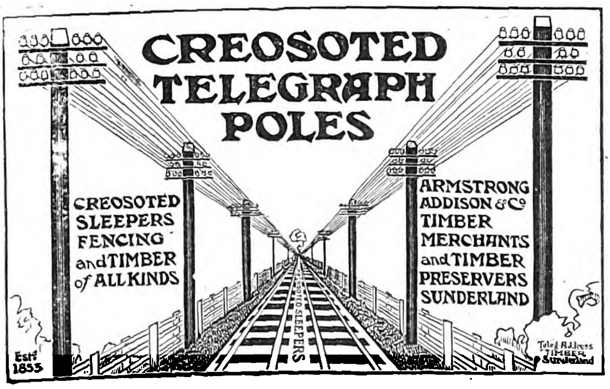
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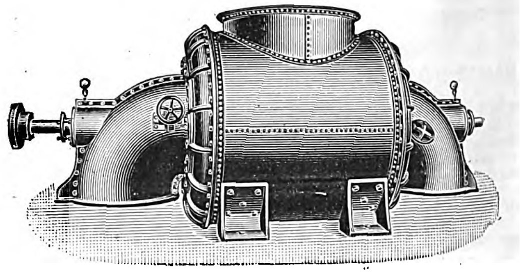

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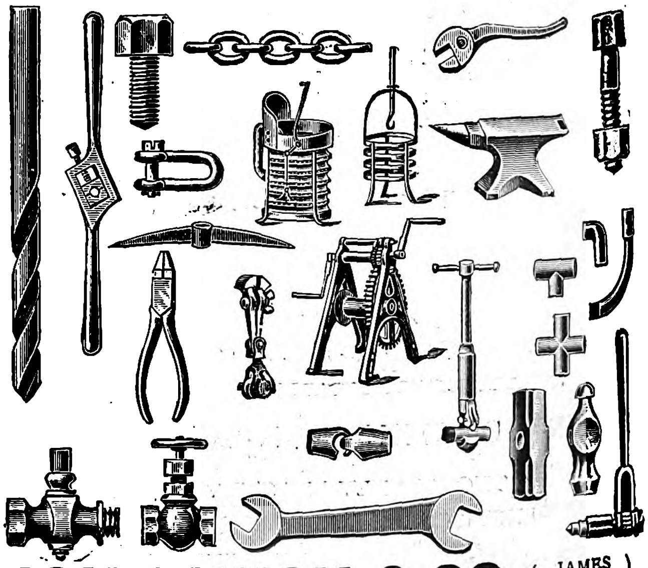

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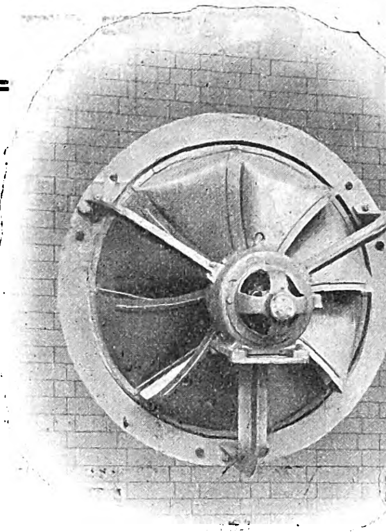

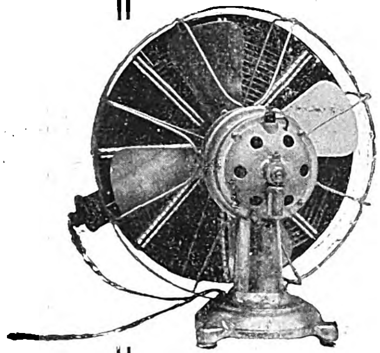

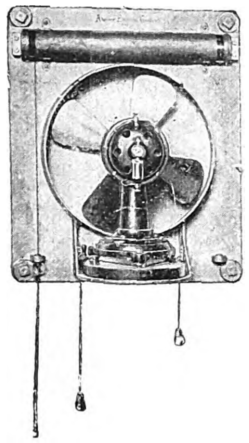

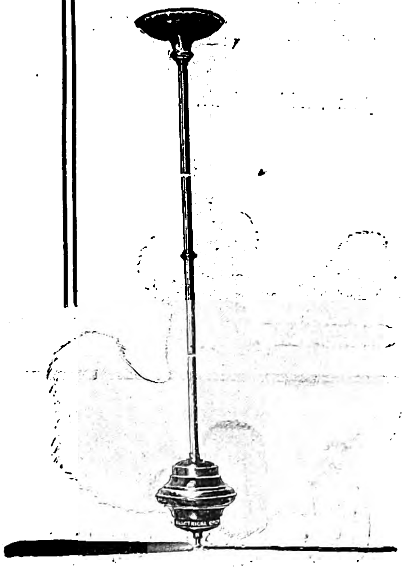

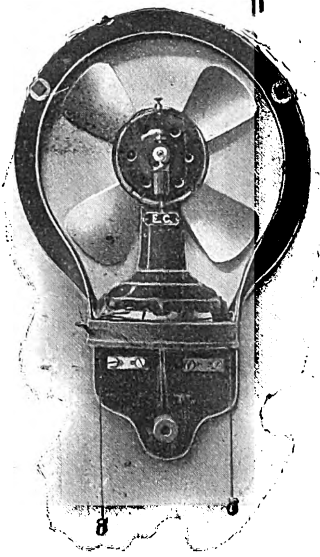

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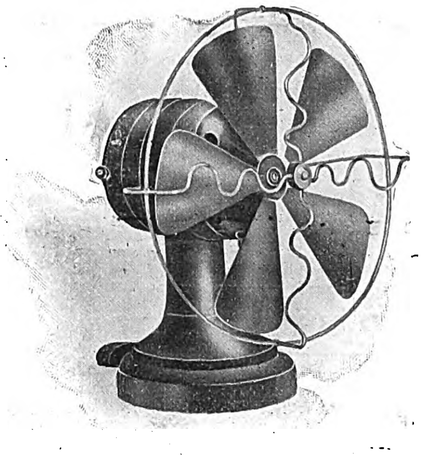

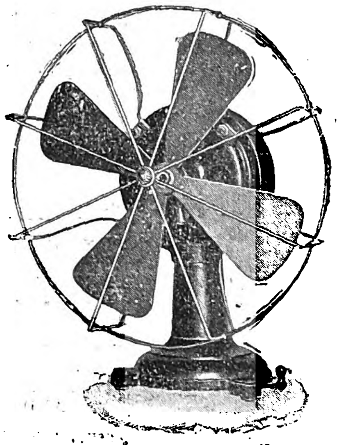

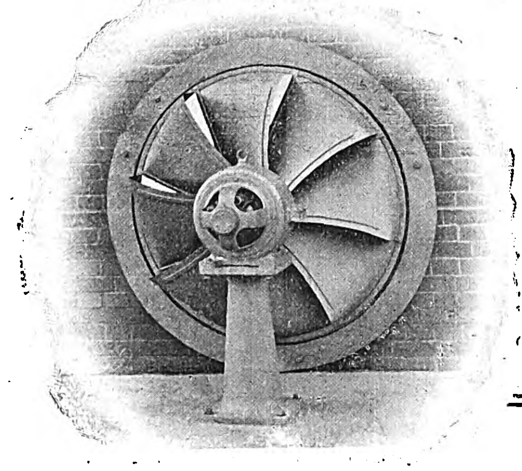

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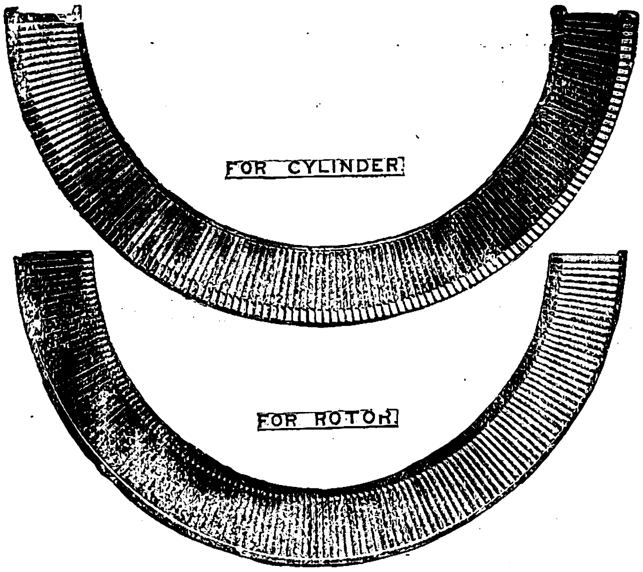
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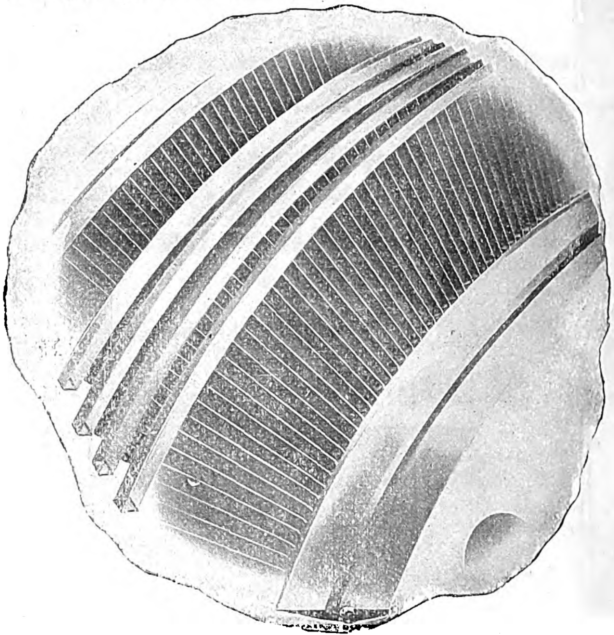

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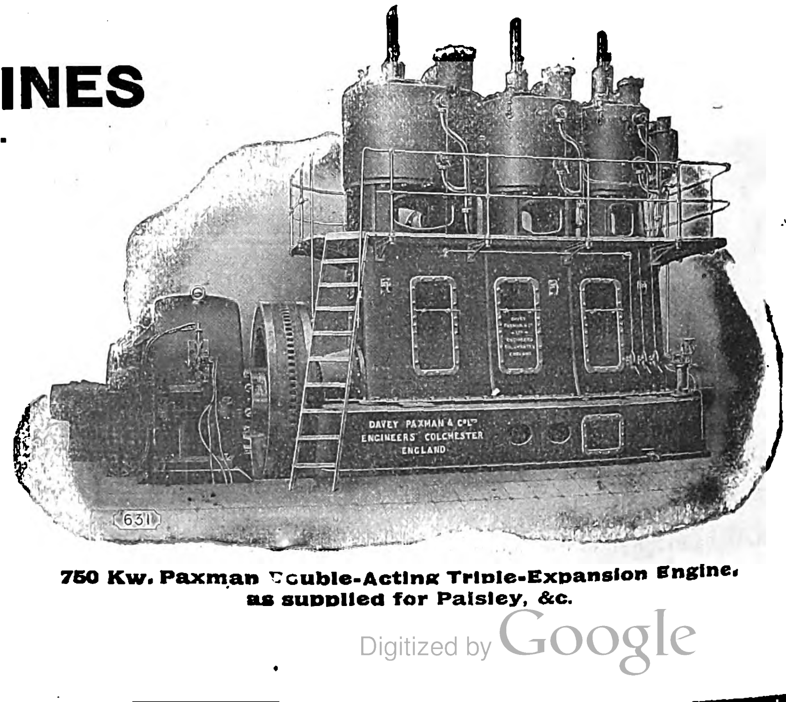
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THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

No. 1,456. [No. 26. Vol. LVI.] FRIDAY, APRIL 13, 1906. PRICE SIXPENCE (by post, 6½d.), Abroad 9d., or 18 cents, or 90c., or 80pf.

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## NOTES.

THE race for the production of a really good and marketable metallic filament incandescent lamp suitable for ordinary supply pressures still continues. The osmium and tantalum lamps, which are the only ones on sale at present, are being threatened with several rivals, and the last of these is the "Wolfram" lamp. This lamp, as its name implies, is to have a tungsten filament, and the method of making this is certainly ingenious. From the particulars published in another column it is seen that the metal is first deposited on a carbon filament, and it appears that on heating the filament to incandescence the carbon is absorbed, and a carbide of the metal is formed. The next process is the removal of the carbon by oxidation, for which three alternative methods are described. This is, doubtless, the critical part of the process, for it is essential that the filament in its final form shall be hard, firm and thoroughly homogeneous.

◆

DR. ULBRICHT'S spherical photometer, of which a description appears elsewhere in this issue, deserves attention for various reasons. It is a practical and promising photometric apparatus for determining the mean spherical or mean hemispherical candle-power of a portable source of light by a single reading. It is not the first attempt in this direction, however. Perhaps the best-known previous photometer of this description is the "integrating photometer," which was described by Mr. C. P. MATTHEWS in a Paper before the American Institute of Electrical Engineers in 1902. In this design, the light from the lamp tested is reflected by a number of mirrors—arranged in a semi-circle around the lamp—on to the screen of a Lummer-Brodhun photometer, and the constant of the instrument is obtained by direct comparison with a standard lamp. The Ulbricht design is an extension and at the same time a simplification of this principle, inasmuch as the reflecting surface is the whitened interior of a hollow sphere. This leads to greater accuracy, and, probably, to a saving in cost. One of the chief advantages of the new photometer is that it can be used for irregular sources of light, as is proved mathematically and experimentally by Mr. BLOCH. This valuable property was only obtained in Mr. MATTHEWS' design by rotating the mirrors.

◆

THE ordinary methods of photometry by comparison with a standard lamp, excellent as they may be in skilled hands for laboratory work, are scarcely suitable for everyday testing of incandescent lamps by consumers or their wiring contractors. It is to meet the want of a simple instrument by which the candle-power of an incandescent lamp can be quickly measured with a fair degree of accuracy that the portable selenium photometer of Dr. TORDA has been devised. The apparatus, which we describe this week also reduces photometry to the pressing of a button, while the selenium "does the rest," and it can be used by unskilled observers. The precautions which are taken to limit the time of exposure of the selenium cell and to ensure a sufficient period of darkness between the successive observations should enable the calibration to remain fairly constant. The tests given show good results in this respect, but we are inclined to think that if the instrument is manufactured in large numbers it will be difficult to avoid variations in the lasting qualities of the selenium cells, as their preparation is a rather delicate matter. The range of the instrument is somewhat limited, and it has the disadvantage of requiring a different calibration for lamps giving light of different colours. It should, however, prove useful for rough tests of carbon filament lamps of ordinary candle-powers, and for ascertaining whether lamps come up to a certain standard or are to be rejected.

AT a recent meeting of the Société Française de Physique on March 16th, M. TURPAIN described the results of a year's experiments undertaken to prove the existence or non-existence of N-rays. In those cases in which the experimenter knew whether the N-rays acted on the sulphur or not, the observed effects agreed in about 80 cases out of 100 with the expected results, but when the investigator had to rely solely on his observations, not knowing whether the N-rays were acting or not, the correct and incorrect guesses were approximately equally divided. The obvious conclusion is that they *were* guesses. On the other hand, Mr. GUTTON recently published some photographs showing the effect of N-rays on the sparks from a Hertzian oscillator. The N-ray remains a mystery.

◆

A new automatic telephone system, the Lorimer, is being developed on a principle differing from other automatic telephone exchanges that have been put on the market. In the Strowger system and developments from it, a step-by-step mechanism is needed for every subscriber's line, but in the Lorimer system the step-by-step device is associated with what corresponds to the operators' cords in an ordinary exchange. In this way the amount of complicated mechanism is lessened. At the exchange end of each line a device is necessary for the selection of a "cord," but this, we believe, is comparatively simple compared with the step-by-step mechanism itself. In the event of all the cords being engaged, the call is stored up, not at the exchange end, but at the subscriber's instrument, until the connection can be effected. The idea is ingenious, but, as in all such systems, it appears that there will be considerable complication in the case of large exchanges, and that junction work will hardly be feasible. The extra cost of the subscriber's instrument must also be taken into account, and probably the cost of the exchange equipment will also be greater than that of a manual switchboard. The cost of operating exchanges of a couple of hundred subscribers is not great, so that it is doubtful whether there will be a wide field of utility for the invention. As we understand that an experimental exchange may be put down in this country, however, we await its advent with interest.

◆

**Technical College Finsbury Old Students' Association.**—A meeting of old students of the Finsbury Technical College, at which Sir Owen Roberts, M.A., D.C.L., J.P., has kindly consented to preside, will be held at the Technical College, Finsbury, on May 8th at 8 p.m. Any old student who has not received a notice of this meeting is invited to attend.

| **Cable Interruptions.** | Date of Interruption. |
|---|---|
| Tarifa—Tangier | Jan. 18, 1904 |
| Jamaica—Colon | Jan. 10, 1905 |
| Cadiz—Teneriffe | July 20, 1905 |
| Tangier—Cadiz | Feb. 17, 1906 |
| Santa Lucia—St. Vincent | Feb. 19, 1906 |
| Porto Rico—St. Croix | Feb. 26, 1906 |
| Trinidad—Demerara | April 10, 1906 |

**Manchester Section of the Institution of Electrical Engineers.**—The report of the committee of the Manchester Section of the Institution for 1905-6 states that the number of members at the close of the session, including students, was 769, as compared with 764 last year. The Students' Section has had a very successful session, the membership having increased from 306 to 324, and the average attendance at the meetings being 82.

**Metropolitan District Railway.**—The Metropolitan District Railway have announced their intention of permanently discontinuing the use of the middle doors on their electric railway carriages, in consequence of several minor accidents having taken place through passengers being crushed between them. It is intended to use the space thus available for seats. It will have been noticed that since Monday last the middle doors have been out of use, but the additional seats have not yet been fitted.

**Golden Wedding of Sir William Crookes.**—Sir William and Lady Crookes celebrated the fiftieth anniversary of their wedding on Wednesday. A very large number of congratulatory telegrams and messages were received, not only from friends in different parts of England, but also from Europe, America and Africa. In the evening a reception was given at the Empress Rooms, Kensington, when about 400 guests were present, including nearly all the leading men of science of the country. Sir William Crookes reaches the age of 74 this year.

**Boiler Explosions.**—The annual report for the year ended June 30, 1905, of the Secretary of the Board of Trade upon the working of the Boiler Explosion Acts of 1882 and 1890 has just been published as a Parliamentary Paper. During the 12 months 14 persons were killed and 40 injured by boiler explosions, and this is a considerable reduction over the figures for previous years, for during the past 22 years the averages are 28 and 60 respectively. The report ascribes the reduction in the number of serious explosions to the decrease in the use of steam as a motive power and to the successful operation of the Boiler Explosions Acts and those provisions of the Factory and Workshops Act of 1901 which render compulsory the periodical inspection of all boilers used in factories and workshops. The paper contains, as an appendix, a summary of the reports of those cases in which formal investigations were made, but none of these are of extreme interest, the greater proportion of them referring to small boilers for miscellaneous purposes in which, for the most part, the explosions were due to extreme age of the boiler or improper treatment.

**Patent Law Amendment.**—The President of the Board of Trade (Mr. Lloyd-George) received on Monday a deputation relating to an amendment of the existing patent law. Sir William Holland, M.P., who headed the deputation, said that their object was to urge the necessity for legislation by which all British patents which were not worked within the United Kingdom after the lapse of three years from the date of application should be forfeited. Several speakers followed, and gave instances to illustrate how industries had been handicapped in this country by the absence of a compulsory working clause, which, it was stated, is insisted upon by Germany, France, and other countries. Sir Joseph Lawrence said he would be satisfied with the German law, but suggested another deputation to discuss details. Mr. Lloyd-George in reply stated that, although he was very much afraid that no action could be taken this year, he agreed that something should be done, although for the moment he thought there was no substantial difference between our law and the German law. In the Act of 1902 there was compulsory working in principle, and he would like to know where this Act had broken down. He accepted the principle which the deputation had in its mind; but, in putting that principle into operation, care must be taken not to punish the British inventor while they were trying to get at the foreign monopolist.

**Iron and Steel Institute.**—Arrangements have been made to hold a joint meeting of members of the American Institute of Mining Engineers and of the Iron and Steel Institute in London during the week commencing July 23, 1906. The Lord Mayor of London has kindly consented to act as chairman of the London Reception Committee, and a varied programme of entertainments, visits and excursions will be provided. Meetings for the reading and discussion of Papers will be held on the mornings of July 24th, 25th and 26th, with visits to works in the afternoons. The Lord Mayor will give an evening reception at the Mansion House on July 24th. On July 25th there will be an entertainment in the evening at the Earl's Court Exhibition, and on July 26th at the Crystal Palace. On July 26th the annual dinner of the Institute, to which the American visitors are invited, will be held, by kind permission of the City Corporation, at the Guildhall. On July 28th a visit will be arranged to the blast furnaces of Messrs. Butlin & Co., at Wellingborough. Detailed particulars will be issued later. After the meeting in London, a tour will be arranged for the American visitors to York, Middlesbrough, Newcastle-on-Tyne, Glasgow and Edinburgh. As an alternative excursion a number of the American visitors have been invited by the local reception committee for the summer meeting of the Institution of Mechanical Engineers to take part in the Cardiff meeting of that society.

**Borough Polytechnic (London).**—Last Saturday visitors were invited to inspect the annual exhibition of work done by students of the Borough Polytechnic Institute. The number of students has been continuously growing, and at present more than 2,000, mostly evening-class students, are receiving instruction. Steady progress is being made in the electrical laboratories, under the direction of J. Henderson, D.Sc., and the equipment is now being extended to include heavy electrical machinery. Electric testing in all its branches will still remain the prominent feature of the electrical department, however, and the testing equipment is quite complete and up to date. A photometer room is also provided. Both continuous and alternating currents are available, and continuous current at any voltage is distributed to a number of wall plugs in the main testing laboratory by means of a large set of accumulators in conjunction with a suitable switchboard. A recent addition to the mechanical engineering department is a complete motor car. Some samples of steel made in the Héroult electric furnace were on view in the chemical laboratory. A metallurgical department is to be set up in the near future. During the last year some £1,600 from the London County Council were spent in enriching the equipment of the Institute, which does good work technically, physically and morally, in the neighbourhood.

**Portrait of Mr. R. Kaye Gray.**—At the last meeting of the Institution of Electrical Engineers a portrait in oils of Mr. R. Kaye Gray was presented to him as a mark of esteem on the part of the members. Sir Joseph Swan, as chairman of the committee which organised the presentation, in a few remarks, referred to the several exceptional features which marked the tenure of Mr. Gray's presidency. In the first place his term of office was exceptionally long and necessitated an unusual amount of work owing to the International Telegraph Conference being held, and this work was added to by the very much lamented death of the secretary, Mr. W. G. McMillan. In regard to the International Telegraph Conference, not only did the onus of entertainment of the visitors and the ladies who accompanied them fall largely upon Mr. Gray, but much of the expense was also borne by him. Thus arose the desire to commemorate Mr. Gray's presidency, and the result was that they wished to present him with his portrait, which had been painted by Miss Beatrice Bright, daughter of the late Sir Charles Bright, a name famous in the telegraph industry. Therefore, on behalf of the subscribers and the Institution generally Sir Joseph asked Mr. Gray to be good enough to accept the portrait and to allow a duplicate to be placed in the Institution. Mr. J. Gavey, the President, said that a large number of members were unavoidably absent that evening, and he had received letters from Sir A. B. W. Kennedy, Messrs. S. Z. de Ferranti, Mark Robinson, J. F. C. Snell, C. H. Wordingham and others. Mr. Gray, in thanking the Institution, said he hardly knew what to say for this very great kindness towards him, in fact it was impossible for him to express himself in any words. He would only like to say that it was a very nice feeling that had prompted the committee to entrust the work to Miss Beatrice Bright, who was the daughter of his very old friend and master, Sir Charles Bright. He had had the pleasure of serving under Sir Charles Bright for a considerable time, and there was no kinder man than he. The President then proposed a formal vote of thanks to the committee and especially to Sir Joseph Swan, the chairman, and Mr. W. H. Patchell, honorary secretary. The vote of thanks was carried unanimously, and Sir Joseph Swan and Mr. W. H. Patchell thanked the members. Miss Bright is the painter of two of the portraits in the lecture room of the Institution of Civil Engineers—viz., those of Sir William Preece and Sir Guilford Molesworth. She also recently painted a portrait of Dr. Alexander Muirhead.

**Corpuscular Theory of Matter.**—At the Royal Institution on Saturday, in the closing lecture of the series, Prof. J. J. Thomson referred to the conclusion reached in the last lecture, that the number of corpuscles in an atom could not be a very large multiple of the atomic weight, and remarked that this result seemed to be strongly negatived by the existence in many spectra of an enormous number of lines. Each spectrum line is supposed to be due to a charged particle in orbital motion, and on this supposition Lorentz showed mathematically that the effect of a strong magnetic field should be to introduce into the radiation two new frequencies, one less and the other greater than the original. The lecturer illustrated this by experiments on a gyroscopic pendulum. This effect is that discovered by Zeeman, who has found that practically every line of, for example, the iron spectrum shows these multiple periods under magnetic force. Thus, to maintain the view arrived at last week regarding the small number of corpuscles in the atom we must inquire if all spectrum lines are really due each to single corpuscles. Prof. Thomson expressed himself as inclined to the belief that under the great E.M.F.s of the electric spark used in producing the spectra, combinations of corpuscles are formed which behave as units in the Zeeman experiment. Absorption spectra appear to support this view. Thus, the number of corpuscles in an atom cannot be calculated from the number of spectrum lines. That the groups here occurring are electrically charged can be shown be introducing a little lithium chloride at one pole of the spark of an induction coil. The colouration spreads along the spark or is confined strictly to one pole according to the sign of the discharge—*i.e.*, the radiating groups are carried decidedly in a definite direction. Prof. Thomson next sketched briefly some of the speculations arising out of, or explanations made possible by, the corpuscular theory of matter. The most important point touched upon was the remarkable discovery that if the secondary radiation emitted by elements under the influence of Röntgen rays be measured by the ionisation it produces within a millimeter of the surface of the substance, numbers are obtained that rise steadily with the atomic weight. If the ionisation be plotted on an atomic weight base a curve of such definiteness is obtained as may prove useful in the future in fixing doubtful atomic weights. The application of the corpuscular theory to the explanation of the electrical conductivity of metals has shown that we must admit that a kind of corpuscular dissociation is continually taking place in a conductor, so that there are always numbers of free corpuscles ready to move under any E.M.F. applied. Further, if the free corpuscles be regarded as capable of carrying heat, then the ratio for different conductors of thermal to electrical conductivity can be calculated. It is remarkable that the calculations on this basis agree very closely with the experimental results.

## ARRANGEMENTS FOR THE WEEK.

**WEDNESDAY, April 18th.**

ROYAL METEOROLOGICAL SOCIETY.

*7:30 p.m.* Meeting at the Institution of Civil Engineers, 25, Great George-street, Westminster, when the following Paper will be read: "Some so-called Vagaries of Lightning reproduced Experimentally," by A. Hands.

**THURSDAY, April 19th.**

INSTITUTION OF ELECTRICAL ENGINEERS: LEEDS LOCAL SECTION.

*7:30 p.m.* Meeting at the University, Leeds. The Election of Officers for next Session will take place, and the adjourned Discussion on the following Paper will be taken: "The Cost of Electricity per Unit from Private Electrical Plants," by Wilson Hartnell.

**FRIDAY, April 20th.**

JUNIOR INSTITUTION OF ENGINEERS.

*8 p.m.* Meeting at the Westminster Palace Hotel. Paper to be read: "Recent Developments in the Construction of Suction Producer Gas Plants," by W. A. Tookey.

**SATURDAY, April 21st.**

BIRMINGHAM AND DISTRICT ELECTRIC CLUB.

*7:30 p.m.* Meeting at the Colonnade Hotel, New-street, Birmingham, when a Paper on "Submarine Cables" will be read by W. Smith.

## RECENT EXTENSIONS AT THE MANCHESTER ELECTRICITY WORKS.

(*Concluded from page 1005.*)

The Stuart-street station, with its capacity of 16,500 kw., takes the greater part of the load at Manchester, and the load factor is so good that the works costs are very low indeed. During January last they averaged 0·248d. per unit generated. In these works, just as in those at Dickinson-street, extensions and modifications are constantly being carried out to keep up to date with modern practice. Even before the works as originally designed were running, large extensions had been commenced, almost doubling the capacity of the station. These are now complete, but modifications of the switch gear are already in hand. Figs. 7 and 8 show the works in sectional elevation and plan. The boiler house on the left of these figures and the left-hand half of the engine room represent the first part of the station, designed by Sir A. B. W. Kennedy in 1901, and rapidly pushed through to completion for opening in the following year, for the existing works were fully loaded. In the meantime extensions were entrusted to Mr. G. F. Metzger, who was then chief engineer, and Boiler House No. 2 was built, and the two 3,750 kw. sets on the right-hand side of the engine room were put in hand. The plan of the works is an interesting example of the alternative methods of design, as in the one case the boiler house is at right angles to the engine room, and in the second case parallel to it.

The boilers in both boiler houses are of the B. & W. water-tube types, and coal for both is brought from the Park Station of the Lancashire & Yorkshire Railway on a line across Clayton Vale $\frac{5}{8}$ mile long. This line is built largely on an embankment and, together with the coal depot and bunkers, cost some £85,000. Outside each boiler house are two hoppers holding 400 tons each, but this 800 tons is but a fraction of the entire coal storage capacity as over 6,000 tons can be stored in the bunkers over the boiler houses. These are filled by chain coal-conveying plant.

All the generators have been supplied by the Electrical Co. The older part of the engine room contains six 1,500 kw. three-phase 6,500 volt machines driven by vertical cross compound Yates and Thom engines, and three auxiliary 200 kw. continuous-current sets driven by Willans engines, while in the newer part are the two 3,750 kw. machines already mentioned, which are driven by Wallsend Slipway & Engineering Co.'s engines. These latter engines are of the marine vertical triple expansion four-crank type, with two L.P. cylinders. The dimensions are as follows: H.P. cylinder 39 in., M.P. cylinder 68 in., L.P. cylinders 72 in., stroke 60 in., speed 75 revs. per min. Willans barometric condensers are used for the older sets and Mather & Platt surface condensers for the large new ones, each engine having its own condenser. Part of the condensing water is obtained from the Ashton-under-Lyne canal, but this is not sufficient for the purpose, and a number of cooling towers have been erected (four Klein, three Wheeler, and three Balcke). The three-phase generators are all of the well-known A.E.G. tangentially stayed pattern. In the large sets the magnet wheel, which acts as flywheel, is in four sections. The periphery of the flywheel is surrounded with a collar of lamination and the poles, which are also laminated, are attached to this by a dovetail and key in such a manner that they can be withdrawn in a direction parallel to the shaft without shifting the stator. The stator is built in three sections, forming a circular ring of iron clamped between two iron-end plates, to which the tangential stays are fixed, the outside of the core being exposed to the air. In addition to this, the usual ventilating ducts are provided. There are six slots per pole per phase, and the windings are placed in micanite tubes. A 7·5 mm. air-gap has been adopted. The weight of the stator is 64 tons, the magnet wheel weighs 117 tons, and the total weight of the generator, including shaft and bearings, is 235 tons. The machines are star connected.

In addition to the main machines in the station and the auxiliary D.C. machines already referred to, there are two 125 kw. and two 220 kw. motor-generators, which can be used in place of these for excitation purposes, pump motors, station lighting, &c.; and four 300 kw. motor-generators and a balancer in the engine room forming the local sub-station for lighting the district near the station and supplying power to the immediate tramway routes.

The switchboard of the older part of the station was put in by the Electrical Co. The H.T. switches are of the hand-operated flare type, and the board has the disadvantage of fuses, a practice which is practically obsolete now for main H.T. switchboards. As this plant was only completed in 1902, it shows how rapidly practice changes. The same applies to the Ferranti fuses and switches on the Ferranti board, which was put in for the local sub-station. These fuses have been taken out and bridged over, and Witting-Eborall oil switches with time element relays and tripping coils have been put in. B.T.-H. motor-operated switches were installed for the generator panels of the two large machines, but it is found that the relatively slow action of these compared with other switches in the station has resulted in bad synchronising on many occasions, and they are being supplemented with hand-operated Ferranti switches of the new pattern for synchronising purposes. Westinghouse switches are used for the H.T. feeder panels.

The chief sub-station is known as the "Polygon" sub-station, not on account of the shape of the building, but owing to some historical associations connected with its site. It contains six synchronous motor-generator sets, each rated at 220 kw., and one 100 kw. balancer supplied by the Electrical Co. and two 300 kw. sets made by the General Electric Co. Of the six Electrical Co. sets, four are for traction and two for lighting, while the other two machines have been wound so that they may be used for either service. In addition to these a 500 kw. La Cour motor converter, similar to those at Dickinson-street, is to be installed. Current is supplied to the motors at 6,500 volts. The traction sets are each fitted with an exciter on an extension of the shaft, The fields of the motors can, however, also be excited from the lighting 'bus bars, as is done in the case of the lighting sets. The combined sets are excited from their own continuous-current terminals. Both high and low-tension switch gear was supplied by the Electrical Co.

There are ten sub-stations in Manchester from 320 kw. capacity upwards, on similar lines to the Polygon sub-station, and ten from 400 kw. to 1,600 kw. capacity, built slightly differently. The largest of these is in Oldham-road, and contains four 300 kw. and two 150 kw. synchronous motor-generators (by the General Electric Co. and the Electrical Co. respectively), which can be used either for lighting or traction, and a 100 kw. balancer. In this case, also, as at the Stuart-street and Polygon sub-stations, La Cour motor-converters are to be put in for extensions. The switch gear is of the old Ferranti type, and is being modified as at Stuart-street, and the original low-tension switch gear is also undergoing alterations.

The Polygon sub-station is the headquarters of the mains department, and also of the motor-hiring business and the meter-testing and instrument-standardising laboratory. The motor business is an important part of the work of the electricity department, for over 10,000 H.P. is connected to the mains, of which about 3,000 H.P. is supplied by hired motors. This includes both continuous-current and three-phase consumers. Among the latter are the works of Messrs. Beyer, Peacock & Co., whose consumption is about $1\frac{1}{4}$ million units per annum, and whose maximum load is 500 H.P. The sheet-wire and rolling mills of Messrs. Johnson & Nephew are also extending the use of electric driving in their works, and it is expected that their annual consumption of energy will be between two and three million units. Another large consumer is the chemical works of Peter Spence (Ltd.), at which about half a million units are consumed, with a maximum load of 250 H.P. The department has also concluded negotiations for a large power supply to the works of Messrs. Mather & Platt, Hans Renold (Ltd.), Sir W. G. Armstrong, Whitworth, & Co., and many other large works.

The testing and motor department is, for the convenience of control and better organisation of the work, divided into three sections known as "meter," "motor," and "mains." Each section is managed by a senior assistant, acting under the direct control of the head of the department, who is himself directly responsible to the chief engineer for all the work done. The junior assistants stick at one job, and consequently become expert at it, but they are given the opportunity, when the occasions arise, of changing to another section, and thus becoming conversant with the whole range of the work. This, of course, is only fair, since the salaries are not high, and some return in the way of education is due to them.

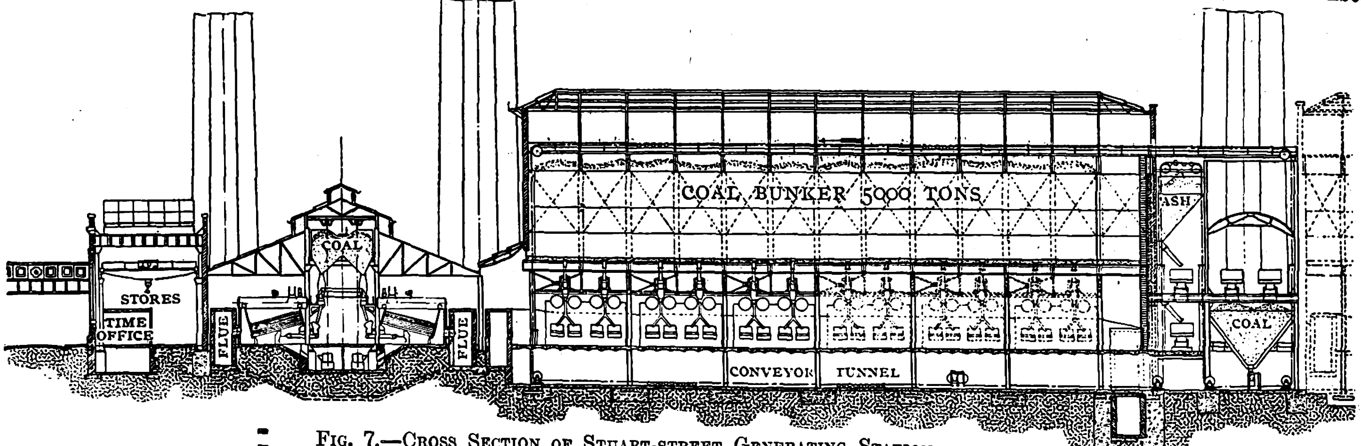
STORES
TIME OFFICE
COAL
FLUE
FLUE
COAL BUNKER 5000 TONS
CONVEYOR TUNNEL
ASH
COAL

Fig. 7.—Cross Section of Stuart-street Generating Station.

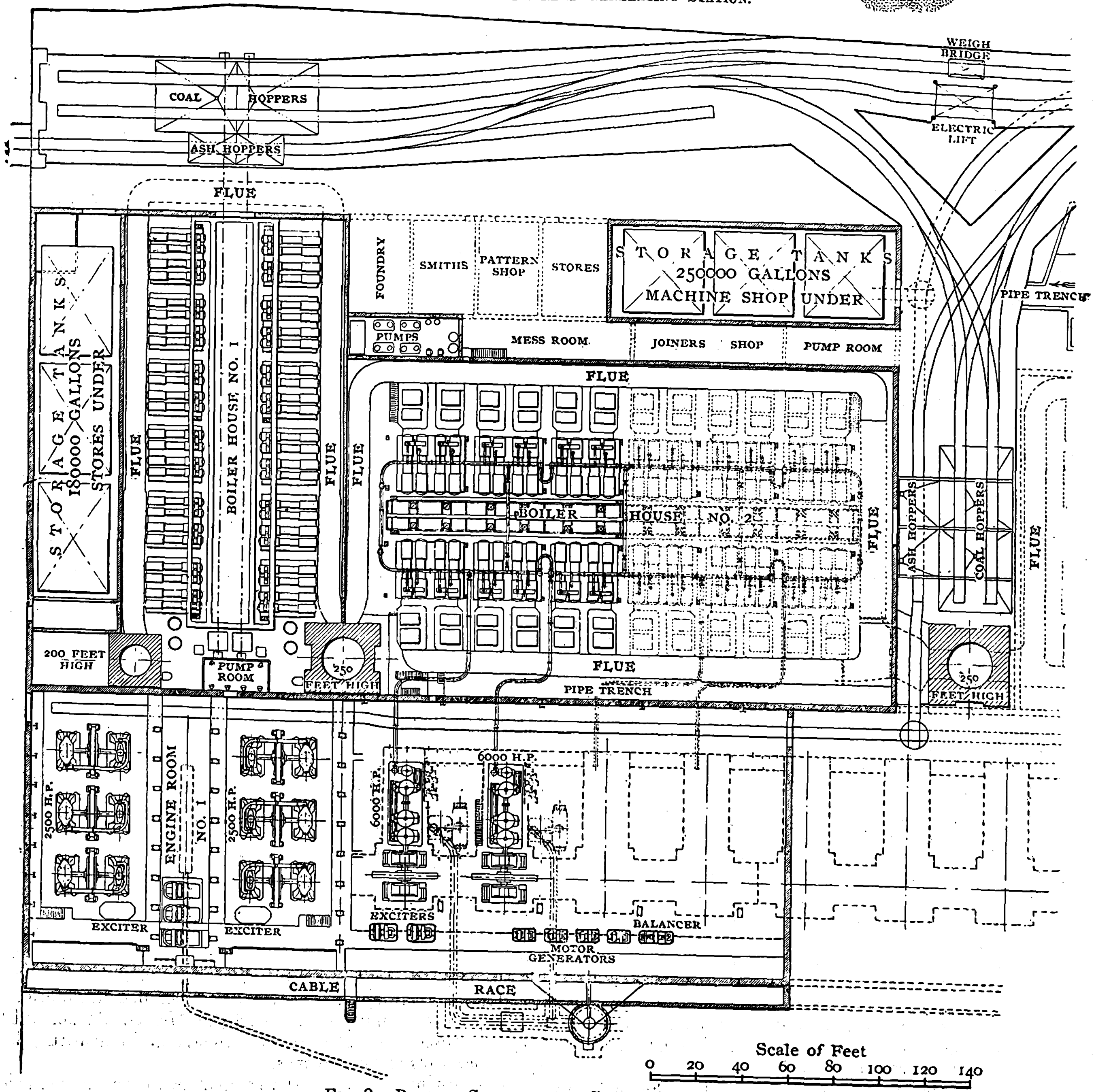
WEIGH BRIDGE
COAL HOPPERS
ASH HOPPERS
ELECTRIC LIFT
FLUE
STORAGE TANKS 150000 GALLONS STORES UNDER
FLUE
BOILER HOUSE NO. 1
FLUE
FLUE
FOUNDRY
SMITHS
PATTERN SHOP
STORES
STORAGE TANKS 250000 GALLONS MACHINE SHOP UNDER
PIPE TRENCH
PUMPS
MESS ROOM
JOINERS SHOP
PUMP ROOM
FLUE
BOILER HOUSE NO. 2
FLUE
ASH HOPPERS
COAL HOPPERS
FLUE
200 FEET HIGH
PUMP ROOM
250 FEET HIGH
FLUE
PIPE TRENCH
250 FEET HIGH
2500 H.P.
ENGINE ROOM NO. 1
2500 H.P.
6000 H.P.
6000 H.P.
EXCITER
EXCITER
EXCITERS
BALANCER
MOTOR GENERATORS
CABLE RACE
Scale of Feet
0 20 40 60 80 100 120 140

Fig. 8.—Plan of Stuart-street Generating Station.

The work of the department is extremely varied, and includes the following principal features :—

*Meter Section.*—Testing, calibrating and repairing of all house service meters. Testing, calibrating and repairing various types of switchboard and other instruments used in the different generating and sub-stations and in the department itself. Construction of various apparatus for testing and other similar purposes.

*Motor Section.*—Testing of motors and starting switches used for hiring-out purposes. Fixing of motors and starters on consumers premises. Repairing of motors and starters on consumers' premises. Repairing in department workshops motors, &c., damaged on circuit, including the re-winding of armatures.

*Mains Section.*—Insulation tests on all new cables laid. High-tension pressure tests when necessary. Periodic insulation tests on all lighting and traction feeders, both high and low-tension. Localisation of faults on high and low-tension feeders and distributors. Miscellaneous tests for electrolysis, conductivity, &c., when necessary. Photometric tests.

The department is one of the best equipped of its kind as far as central stations are concerned, and the general arrangement is such as to admit of the work being carried out on a scale of considerable proportions, but, at the same time, accurately and commercially. One of the principal features of the equipment is the centring of all control at specially-designed switchboards, thus doing away with straggling leads, and eliminating the possibility of accidents to instruments, &c.

The equipment of the "Meter Section" comprises the necessary tables and racks on which the meters are fixed for testing, all being provided with terminals and 'bus bars connected to the various batteries, and from which current for main circuits and pressure for shunt circuits can be obtained as required. Current for these purposes is distributed from a large central switchboard built up of four panels. Three of these panels control chloride batteries, each consisting of 10 cells; two of the batteries are of 600 ampere-hour capacity with a maximum discharge of 350 amperes and the third of 720 ampere-hour capacity with a maximum discharge of 420 amperes. For large currents, the three panels can be paralleled and the united discharge of the three batteries obtained. The current is regulated by controllers operating resistances in parallel, the resistances consisting of approximately 1, 10 and 100 ampere units, a gradual regulation below 1 ampere being obtained by means of Lord Kelvin's patent drum rheostats. Practically any steady direct current may be obtained from $\frac{1}{1000}$ ampere up to 1,000 amperes. These batteries are charged by means of a motor-generator, consisting of a 400 volt motor driving a dynamo having an output of 120 amperes at a range of from 15 to 35 volts, For heavy currents this generator can also be thrown in parallel with the batteries when required.

The fourth panel controls the circuits from 280 small "Tudor" cells, having a maximum discharge of 5 amperes and a control giving any voltage from $\frac{1}{5}$ volt to 500 volts, by $\frac{1}{5}$ volt steps. These circuits are used for lamp-testing, voltmeter-testing and the shunt circuits of watt-hour meters, &c.

Each of the current panels is fitted with Weston ammeters of three different ranges, which are used as sub-standards for the ordinary meter testing, these standards being instantly checked, if necessary, by being thrown into series with one of the three Kelvin balances or the various shunts connected to the potentiometer. The balances have ranges of 10, 100 and 600 amperes. The potentiometer is provided with 1·5, 15, 150 and 1,500 ampere shunts. The large shunts are fixed in the meter test room near the main switchboard, and potential leads only are carried into the laboratory. Various Evershed and Weston voltmeters are used as sub-standards of pressure.

All motor meters are carefully tested at full, three-quarter, half, quarter, one-tenth and one twentieth loads by quick timing methods, the gearing in addition being tested by long dial tests; tests are also made for starting current, insulation resistance, &c., and the meters are carefully overhauled mechanically. The calibration of meters containing permanent magnets is extended over periods of not less than six weeks, in order to eliminate errors which might possibly arise through changes in the magnets. All meters which have been on circuit for any length of time and which show any signs of deterioration, are taken to pieces, thoroughly overhauled and repaired, and re-calibrated; and we are informed that the results obtained on testing repaired meters are actually superior to those obtained on the new ones received from the makers.

The laboratory is furnished with a Crompton potentiometer with volt-box reading to 750 volts, various mirror galvanometers, resistance boxes, standard megohm, standard condensers, millivoltmeters, ammeters, and the usual switches, keys and adjuncts for these; also standard H.T. electrostatic voltmeters covering a range from 800 to 50,000 volts, a standard H.T. wattmeter, a photometric dark room, containing a 150 in. photometer bar fitted with "Bunsen disc," flicker photometer, and a 2 c.p. Pentane standard lamp.

The motor test room is fitted with racks on which the various motor starters are placed for test, and test beds on which the motors can be run under working conditions. The motors are belt-driven on to dynamos, enabling them to be run at any desired load and at either 200 or 400 volts.

The whole of this work is controlled from a switchboard, and the output of the dynamos is fed back on to the supply 'bus bars. Various pulleys are provided for the dynamos to accommodate the different motors on test. The load is varied by controlling the excitation of the dynamos, and the latter are excited off the 'bus bars. The usual tests consist of six-hour runs, readings being taken to enable speed and temperature curves, &c., to be obtained. Brake tests can also be taken, if necessary. A simple band brake is used, the pulleys of the motors being cooled by an electrically-driven Sturtevant blower.

Starting switches are tested under working conditions on the various size motors which they are intended to work. The line resistances are also measured, and the action of the overload and no-load voltage magnet coils are also checked. Benches are also provided in the test room for the repairing of rheostat coils, starting switches, &c., and for armature winding. The heavier motor repairs and the cleaning and overhauling of motors are being carried out in a separate workshop provided for the purpose.

The equipment of the mains section comprises portable test trucks containing mirror galvanometers, standard resistances and condensers, &c., and a portable high-pressure testing apparatus contained in a van, which can be drawn by two horses. This consists of a 10 kw. alternator driven by a D.C. 400 volt motor, three 3 kw. oil-cooled static transformers and an 8 kw. Cowan regulating transformer, and the necessary switching and controlling gear. By means of this apparatus any voltage can be obtained from a few volts to 30,000 volts at various frequencies. In addition to pressure tests on the mains, this set is also used for testing insulators and insulating material, and for the testing and calibration of alternating-current instruments in the meter room. Various portable instruments are also used, comprising Kelvin testing sets, slide-wire bridges, ammeters, voltmeters, &c. Experience has shown that the simpler the apparatus for fault localisation the better, and we are informed that the department has obtained good results with the use of ammeters and voltmeters only.

For many details in connection with the above description of the testing and motor department we are indebted to Mr. Ratcliffe, who acts as superintendent of the department, under Mr. S. L. Pearce, engineer-in-chief, and, as we have already stated, without Mr. Pearce's assistance and that of the various contractors, it would not have been possible for us to prepare this article.

## A PORTABLE SELENIUM PHOTOMETER FOR INCANDESCENT LAMPS.

BY DR. THEO. TORDA.

A large amount of money is spent annually on incandescent lighting, but, as has frequently been pointed out, a considerable portion of the expenditure is practically wasted by the employment of cheap lamps of inferior quality, by which the market is flooded. These, if applied to work on high efficiency, are far too short-lived, and cause continual complaint on the part of the consumer, or if they are used at a low efficiency, which is most frequently the case, then they create dissatisfaction on account of the high electricity bill. A great saving can be effected, especially by large consumers, by testing the quality of lamps before purchasing them, and by checking their intensity in use, with the view of a timely renewal. The public once educated to the proper economic use of the electric incandescent lamp, would soon appreciate its advantages. Thus a great field of usefulness exists for a simple and reliable method of photometry, by means of which dealers or consumers can easily make tests of lamps for themselves. Nor is the want of a simple system of testing by any means diminished by the introduction of new type lamps, such as those with tantalum, osmium, zirconium, and other metallic filaments, which, though having remarkable qualities, are as yet far from perfection.

Such a photometer should be suitable for use by any unskilled man and in any place, without regard to the surroundings and external light effect. For ordinary commercial use it is of the greatest importance that the instrument shall be portable and absolutely direct measuring, but for sake of easy manipulation, extreme exactness and independence from colour effect can be to some extent dispensed with. For practical purposes it is sufficient to have a photometer calibrated for the colour of the carbon incandescent lamp only, when burning at a temperature corresponding to an efficiency of 1/3·5 to 1/4 candle per watt, or if greater accuracy is desired, it could be supplied with two scales for the colours of carbon and tantalum lamps respectively.

A practical photometer must enable anyone to take his candle-power readings just as easily as he can read the pressure on a voltmeter. This problem can be solved only by the application of the light to produce either physical or chemical action. The reason that physical or chemical photometers have not hitherto come into general use is due to the view that nothing can be substituted for the human eye in testing the value of light for visual purposes, and that, therefore, the lighting intensity must be measured by the eye and compared with that of a standard unit. Instruments of comparative photometry are numerous, such as the Bunsen and Lummer-Brodhun photometers. These appliances, however, do not eliminate the difficulties caused by the difference in the colours of the standard light source and of the lamp to be tested. To make measurements independent of the colour effect, the flicker type, of which the Simmance-Abady instrument is an example has been designed. Comparative photometry demands from the operator a certain knowledge and skill, and is far from exact in the hands of an untrained man in everyday practice. For the design of a direct-measuring photometer, on which the reading is independent of the operator's judgment, the action of the light rays upon the electric resistance of selenium, or upon the radiometer, may be utilised, or their action on chlorine by producing expansion or effecting chemical combination with hydrogen. Such physical photometers are commonly condemned on the ground that they are influenced by the light in quite a different way from the eye, that they act differently for light rays of different colours, and, further, that they are not only influenced by light, but also by heat rays. In other words, they do not record the physiological effect of the light.

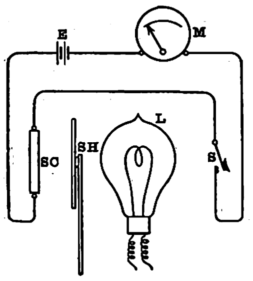

Fig. 1.—Diagram of Connections.

These objections are got over by calibrating a photometer of this kind for a certain class or classes of lamps only by means of careful comparative measurements, executed by an experienced tester on a good standard photometer.

In view of the above considerations the author has developed an apparatus which is based upon the action of the light on selenium, which alters its electric resistance with variations of the intensity of light in accordance with a certain physical rule. The principal parts of such a selenium photometer, suitable for testing incandescent lamps, are: A light-tight box containing a selenium cell, a constant E.M.F. produced by dry cells, a milliamperemeter, a push-button contact, a lampholder with flexible leads and an automatic shutter, which covers the hole of the partition placed between the selenium cell and the lamp. The lamp, fixed in the holder, is properly centred to the hole at a certain distance and faces the selenium cell. Fig. 1 illustrates the arrangement diagrammatically and shows the connections of the photometer. SC represents the selenium cell and E the dry cells. In closing the small switch S an electric current will flow through the circuit, corresponding to the dark resistance of the selenium cell, and produce a deflection on the milliamperemetre M. If the lever of the shutter is depressed, it will be opened, and the light rays passing through the hole of the partition will cause a decrease of the resistance of the selenium to take place, whereby the deflection shown by M increases. This reading, which is a measure of the light intensity, is taken, and the screen closes automatically after a definite period, and owing to the action of the clockwork remains locked for a time, in order that a certain period of rest in darkness shall be given to the selenium cell. Under normal conditions the time of exposure is about two seconds, enabling a reading to be taken easily on the dead-beat ammeter, while the period in darkness before a new reading can be taken is 40 seconds.

The application of this automatic clock arrangement overcomes several practical difficulties which would impede the commercial employment of selenium. These difficulties arise through the following properties of the material.

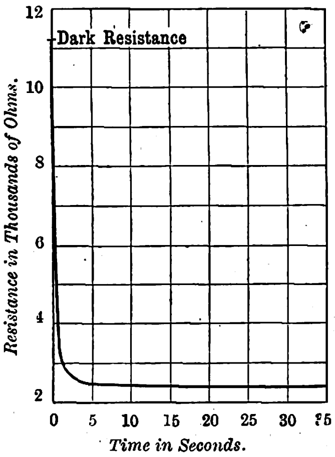

Fig. 2.—Resistance Variation of Selenium Cell with the Duration of Exposure.

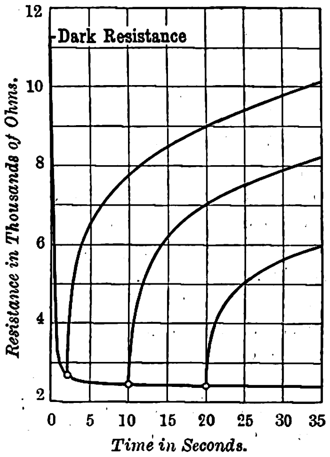

Fig. 3.—Variation of Resistance in Darkness after Exposures of Different Duration.

When exposed from darkness to light selenium does not take up its final resistance corresponding to the particular light intensity quite instantaneously at the beginning of the exposure; the resistance attains almost its final value, but a further exposure causes a slight degree of further alteration. This characteristic effect is shown in Fig. 2. Another property of selenium is that, once exposed to light for a certain length of time, it requires a period in darkness several times as long as the exposure to regain its normal resistance. The necessary time of recuperation increases quickly with the strength of the light and length of the exposure, as illustrated in Fig. 3.

By means of the automatic shutter the time of exposure is adjusted for a certain duration which depends on the permissible molecular stress in the selenium, on the suitable period of recuperation and on the necessary time of taking a reading. The fixed length of exposure eliminates the time element in the action of this photometer and the automatic locking of the shutter prevents a new exposure taking place prematurely before the molecules have regained their normal state. Experiments have proved that with an ordinary selenium cell of a sensitiveness of 1 : 20—viz., the resistance being 20 times greater in darkness than in close proximity of a 16 candle lamp, an exposure of 2 seconds and a rest of 40 seconds form good practical conditions. A standard photometer for measuring intensities from 1 to 50 or 100 candles can cope with 800 to 1,000 lamps in 10 hours as the whole operation of measurement takes 45 seconds at the utmost.

It will be of interest to give some details of such an apparatus: A flat selenium cell having a resistance of approximately 10,000 ohms in darkness and 500 ohms in close proximity to a 16 candle lamp is placed at a distance of about

7 in. from the centre of the source of light, and two dry cells are included in the circuit. The measuring instrument is a milliamperemeter reading up to 1·5 milliamperes and having a scale divided into 120 equal divisions. The length of a division being about $\frac{1}{32}$ in., a reading within half a division can easily be made, and, therefore, the degree of exactness obtainable for the various part of the range will be as follows: $\frac{1}{8}$ of a candle for an intensity of 5 candles, $\frac{1}{6}$ for 8 candles $\frac{1}{4}$ for 16 candles and $\frac{1}{3}$ for 30 candles.

The calibration curve of such an instrument is shown in Fig. 4, from which it can be seen that the range of the apparatus is from 1 c.p. to 31 c.p. If the same photometer is required to read up to 100 c.p. this can be provided for either by inserting a light-absorbing medium between the lamp and the selenium cell, or by increasing the distance of the selenium from the source of light. A second scale, which is obtained on the same photometer, is represented in Fig. 5, and reads up to 70 candles, and the limits of accuracy within which measurements can be taken are as follows: $\frac{1}{12}$ of a candle for an intensity of 5 candles, $\frac{1}{9}$ for 8 candles, $\frac{1}{6}$ for 16 candles, $\frac{1}{4}$ for 32 candles, and $\frac{1}{3}$ for 50 candles.

The calibration of the scale is a simple matter, and consists only in the noting of the deflections on the dead-beat instrument when the selenium is exposed to the effect of a series of different lamps which have been previously tested on a standard photometer. Slightly different curves will be obtained if carbon and tantalum filament lamps are used as sub-standards, as has been already pointed out. The calibration of the selenium photometer is as permanent as that of any other similar apparatus, the parts which can be affected by use being the selenium cell, the dry cells and the milliamperemeter.

Selenium cells can be made and obtained which under the actual working conditions remain practically constant for years. They are not used for higher currents than 5 milliamperes, and precautions are taken that the selenium shall not be exposed to a temperature exceeding 150° F. The dry cells, which have to give a constant voltage, can be used for months, as the discharge current is extremely small, and variations of internal resistance are of no importance, because the resistance is only a very small portion of that of the whole circuit. It is advisable to check or recalibrate the photometer's scale about every three months, and the dry cells should be renewed every six or nine months, while the selenium cell may be used one or two years or more, according to the quality. To illustrate the constancy of the selenium cells employed, it will be of interest to give an extract of a record kept for a photometer in everyday use for about two hours. This series of tests was carried out by means of two 200 volt incandescent lamps used only as standards for the checking of the constancy of the instrument:—

**Table I.**—*Tests of Constancy of Calibration.*

| Date. | Deflections. | | Date. | Deflections. | |
|---|---|---|---|---|---|
| | $7\frac{1}{2}$ c.p. lamp. | $17\frac{1}{4}$ c.p. lamp. | | $7\frac{1}{2}$ c.p. lamp. | $17\frac{1}{4}$ c.p. lamp. |
| Dec. 15, 1905 .. | 75·4 | 99·2 | Feb. 1, 1906.. | 76·1 | 98·3 |
| Jan. 2, 1906 .. | 75·7 | 98·5 | Feb. 15, 1906.. | 77·3 | 99·2 |
| Jan. 15, 1906 .. | 75·5 | 98·6 | Feb. 28, 1906.. | 74·8 | 99·2 |

The values of the deflection, given in the table, are the mean values of several measurements.

It is hardly necessary to point out that as the circuit of the selenium cell is independent of the lamp circuit, the photometer can be used for continuous as well as for alternating current lamps of any voltage. Should the supply voltage be variable, then it is necessary to apply a voltmeter and to make corresponding corrections in the candle-power readings. In the following table a series of measurements are given, taken on a 220 volt 8 nominal candle-power lamp, and it is interesting to note how consistently the candle-power readings follow the rise and fall of the supply voltage.

**Table II.**—*Series of Measurements on a 220 volt 8 c.p. lamp, taking 0·2 ampere.*

| Time. p.m. | Voltage. | Deflection. | Candles. | Time. p.m. | Voltage. | Deflection. | Candles. |
|---|---|---|---|---|---|---|---|
| 8:30 | 222 | $81\frac{1}{2}$ | 9·75 | 8:46 | 220 | 80 | 9·25 |
| 8:32 | 221 | 81 | 9·5 | 8:48 | 222 | 81 | 9·5 |
| 8:34 | 219 | $79\frac{1}{2}$ | 9·0 | 8:50 | 220 | 80 | 9·25 |
| 8:36 | 220·5 | $80\frac{1}{2}$ | 9·25 | 8:52 | 224 | 84 | 10·5 |
| 8:38 | 222 | $81\frac{1}{2}$ | 9·75 | 8;54 | 223·5 | 84 | 10·5 |
| 8:40 | 224 | 83 | 10·25 | 8:56 | 222 | 81 | 9·5 |
| 8:42 | 220·5 | $80\frac{1}{2}$ | 9·25 | 8:58 | 223 | $82\frac{1}{2}$ | 10·0 |
| 8:44 | 221 | 81 | 9·5 | 9:0 | 222 | $81\frac{1}{2}$ | 9·75 |

A comparison between the types of photometer, in which the standard light unit is compared by eye at each measurement with the lamp to be tested, and the above apparatus clearly shows that both classes of photometers possess certain advantages and disadvantages, and that in practice each type has its own particular field of application. Comparative photometry is the only method which permits of the direct measurements of the physiological effect of light, though its results are only reliable in the hands of careful and experienced operators. With the comparative photometer different observers often obtain different values of intensity with the same lamp, while with the physical photometer this uncertainty is eliminated. Another disadvantage of physiological photometry, from the practical standpoint, is that it is very tiring, so that an increasing personal error comes into play the longer the testing lasts. The use of the comparative or physiological photometer is irksome and demands some skill, while in the case of the selenium photometer the observation is simply reduced to the reading of a measuring instrument, and no special knowledge is required. Also the variations of the standard of light do not cause repeated errors, as in the case of the selenium photometer the standard lamp is only used when the scale of the instrument is first calibrated by means of a very careful comparative test. In the case of the physical photometer error may, however, enter in the series of measurements through the variation of the selenium cell and the dry cells, but the liability to error is by no means greater than in the former case.

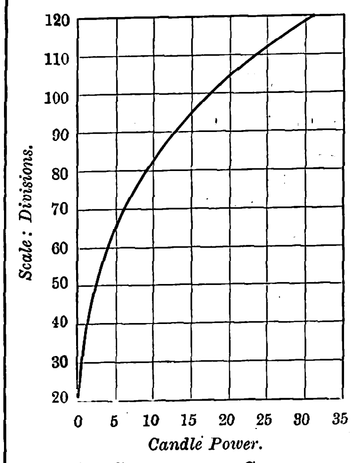

Fig. 4.—Calibration Curve of a Selenium Photometer.

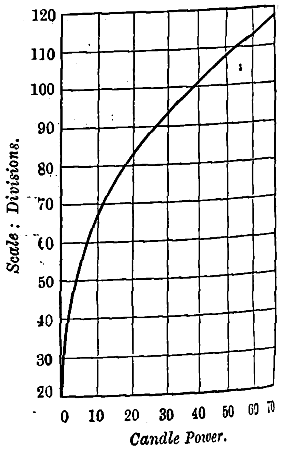

Fig. 5.—Calibration Curve of a Selenium Photometer with Light-Absorbing Medium before the Selenium Cell.

It is well to recall here the serious difficulties connected with the continuous use of either the primary or secondary light standards. Primary flame standards are not suitable for everyday use on account of the variation of the atmospheric conditions, and also they are apt to cause difficulties when applied for testing lamps of a colour and intensity greatly differing from that of the standard.

The use, however, of a secondary standard of the same type as the lamp to be tested in the photometry of electric incandescent lamps introduces some new difficulties, such as electric contact troubles and sensitiveness of the screen to the variation of the angle at which the plan of filament is placed. Such secondary standard lamps must have large bulbs, must be aged and must be used at such a high specific consumption as 4·5 to 5 watts per candle, otherwise, they quickly change their intensity in use. From the latter condition it follows that a secondary standard at 4·5 to 5 watts per candle cannot give strictly exact results, when compared with a lamp working with the practical specific consumption of 3·5 watts per candle, because not only do the colours differ, but their sensitiveness for voltage variations of the supply is also different.

The selenium photometer, when calibrated, will be exposed to the light effect of exact secondary standards of the usual filament form, with a temperature corresponding to 3·5 specific consumption. Such an apparatus is, in practical use, superior to the comparative photometer and gives reliable results in measuring the intensity of carbon lamps with a specific consumption of 3 to 4 watts per candle. A photometer of the type described is illustrated in Fig. 6. It is arranged for testing the maximum and mean horizontal intensities of electric incandescent lamps, but for practical purposes it is sufficient to take the maximum horizontal candle-power, as this gives, with close approximation, the mean spherical intensity too, by multiplying it with a certain empirical constant.

The first operation is the adjustment of the lamp in the holder at the proper centre height opposite the selenium cell, the small press button contact at the right is then closed with one hand, and the key releasing the clockwork actuating the shutter is depressed with the other hand in order to take a candle-power reading.

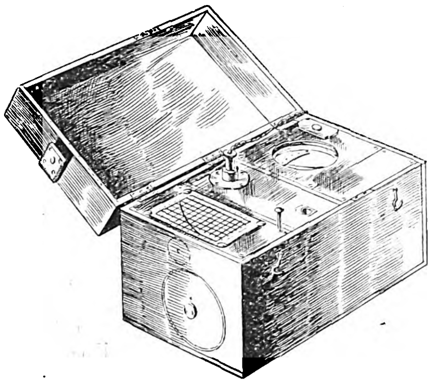

Fig. 6.—Photometer Outfit Complete.

In conclusion it may be pointed out that photometers like those of the Lummer-Brodhun or Simmance-Abady type are suitable for carrying out a series of exact tests in laboratories or occasional measurements in the practice, when great exactness is required, whereas the form of photometer described in this article, is particularly intended for everyday commercial use. Considering that this apparatus is calibrated for one or two classes of lamps by means of the secondary light standards of comparative photometry, the same could advantageously be designated a *secondary photometer*, being in its existence dependent on comparative measurements.

## APPLICATION OF ELECTRICITY IN MINES.

The discussion on Messrs. Sparks and Mountain's Paper on "Electricity in Mines" was concluded at the Institution of Electrical Engineers on Thursday last week. A report of the discussion on March 22nd and 29th was published in our last issue. Mr. Sparks' Paper was given in our issues for March 23rd and 30th, and an abstract of Mr. Mountain's Paper appeared on page 658 of our issue of February 9th.

Mr. **W. H. PATCHELL** pointed to some further inaccurate figures in Mr. Mountain's first table, which purported to show what steam winding engines would do, and he complained that the corrections which had been sent by the manager of one of the collieries to the *Iron and Coal Trades Journal* had not been incorporated. From these corrections it appeared that the total coal wound was 2,600 tons and not 3,600 as stated by Mr. Mountain.

Mr. **MOUNTAIN**: You will find that the calculations are on the basis of 2,600 tons. It is a clerical error.

Mr. **PATCHELL**, continuing, said there were other corrections. The cost per 100 tons should be, so the manager said, 3s. $1\frac{3}{4}$d. and not 4s. $8\frac{1}{4}$d., and whereas the manager stated that the former figure included interest and depreciation, Mr. Mountain said his figure did not. Further, on the particular test, it was stated that $17\frac{1}{2}$ hours were worked per shift, but he could not imagine that that was continuous. After pointing to other mistakes and discrepancies in Mr. Mountain's first table, Mr. Patchell passed on to his fifth table, in which the costs of electric winding were estimated. If, in this, the total lift was calculated from the data given as to the acceleration and retardation, he found that in the first case taken, the travel worked out to 320 yds. and not 500 yds., in the second case 346 yds. instead of 500 yds., and in the third case 400 yds. and not 700 yds. It was, therefore, evident that these discrepancies discredited the other figures. They would all be very indebted to anyone who would give true figures as to what either steam or electric winding would do. It was stated that electric winding was out of the question for heavy work, because they did not accelerate quickly enough. But on this point they had only to refer to a railway motor, where the acceleration was greater than was ever accomplished with steam locomotives, and the same could be accomplished in connection with a mine. At the end of a journey, after having had an enormous acceleration when using steam, it was often the case that the steam was turned against the steam engine or the brake was put on. With electric winding, on the other hand, using the Ilgner system, the energy was put back into the flywheel, so that it was possible to run at the higher speed nearer to the bank. The stand-by question was an important one, for it was here that money was lost. The difference came in in the standing hours, and those of them that had plants which worked a few hours a day, and were standing ready to work for probably 16 or 18 hours a day, knew well what that meant. The winding engine had to be kept with steam on it and the boilers under full steam, and the radiation losses were enormous. He did not think it would be a bit too high to put them at 25 per cent. of the useful work. There were some interesting points in connection with this matter in a Paper by M. R. A. Henry in the *Revue Universelle des Mines*, of Liège, of July, 1904. According to this, 50 per cent. of the total steam used during the 24 hours was actually wasted—viz., it did no useful work. Other interesting figures were also quoted in that Paper. With regard to Mr. Sparks' Paper, he would like to know the scale of Fig. 2, because he could not see how a man, even though the panel was pulled out, could get at the ends of his feeder mains and 'bus bars, which were at the back, and which did not, he took it, come forward with the panel on the little waggon. It also struck him that the overhead cables were rather close together, and he would like to know if any storms had yet had to be weathered, and, if so, what was the effect. The wires were hung together nearer than he personally would have dared to do. He did not agree with the view that had been expressed that high tension should not be taken down pits. As a rule it was treated with more respect by the workmen, and when he served on the Home Office Committee which dealt with the question of electricity in mines he put this opinion very strongly before his brother committeemen. He considered low tension was the more dangerous, and of this there had been unfortunate evidence recently. But this was not the only point. The higher the tension the less the current, and the less the damage when there was a burn out. He had had burn outs at from 100 volts to 10,000 volts, and the smallest area of burn out was with 10,000 volts. Mr. Sparks' haulage data was just what was wanted, for many accounts had been published of haulage sets which were absolute physical impossibilities. He had checked some of them, and found that the motor, even at treble its nominal rated load, would not move the "journey"—*i.e.*, the train of trucks. Electric haulage would not only save the colliery owner money, but it showed him at once, if there were instruments, whether his road was bad. With steam or horses this was not the case, but with electricity the ammeter indicated what part of the road was bad, and money was saved by attending to it, instead of waiting for the road to get so bad that the trucks ran off it. In Mr. Sparks' final figures he was not sure whether his output was at the rate of, or the actual output, for 12 months.

Mr. **SPARKS**: It is at the rate of 12 months. We only started in May last.

Mr. **A. BLOEMENDAL** (Alliance Electrical Co.) said he would like to have heard some figures, from those gentlemen who advocated electric winders, as to the actual cost of upkeep and repairs. He believed that this was what the colliery man wanted to know more than anything else at the present moment. There was no doubt that it would be higher than with the ordinary steam winder. For instance, in the Ilgner system they had four electric machines to keep up. Referring to Mr. Sparks' Paper, he said that according to this the large haulage gears only had one motor. He had always found it useful practice with haulage gears over 150 H.P. or 200 H.P. to use two motors, and with the continuous-current systems this had several advantages. One was that two commutators allowed of very simple speed regulation, and in one installation they had two commutators on each motor. From a miner's point of view there was another advantage. These motors had to run at a very low speed, which meant that they assumed a very large diameter and so required a great deal of head room, and the head room was reduced with a two-motor equipment, as the motors were smaller. The last advantage which could be claimed for two-motor equipments was the question of stand-by. In case of breakdown, if there were two motors one motor could be used as a stand-by and the gear worked with a smaller output. He disagreed with Mr. Sparks that there was no need for speed regulation with fans. He had found in most cases the colliery man required speed regulation in order to alter the amount of fresh air brought into the mine according to his fresh air ways and the length of room. He had tried to do this with the three-phase system, but with resistance regulation there was a very great drop in efficiency. He had also tried to vary the number of poles in the machine, but that also was not very successful. If Mr. Sparks had any figures on this they would be very welcome. Mr. Sparks had not given any figures as to the actual coal consumption for the different years, but probably the plant had not been long enough in operation for any data to be available. Perhaps, therefore, he might be permitted to give some data on this point which he had collected about a week ago. It was very interesting, as it afforded a comparison of steam and electric pumping. In a mine recently equipped there was a 150 kw. continuous-current generator driven by a Davy-Paxman horizontal engine, which had it own boiler adjoining. This generator supplied current for a number of pumps, haulage gears and fans. One pump was left in the pit, however, to be driven by steam. On a week-end test of 36 hours the steam pump pumped 15,000 gallons per hour, and the actual consumption was, per horse-power-hour in water delivered, 3·8 lb. The next week-end they used the generating plant for supplying current to the motor driving another 15,000 gallon pump, and the actual consumption was worked out to be 3·1 lb. per horse-power-hour of water delivered. These figures compared very favourably for the electric pump, and the more so because the generating plant was, of course, only working at a very small load in comparison with the total output. On the question of systems of haulage, the speaker mentioned the fact that in this country there were very few electric locomotives in mines, and in this respect both American and Continental practice was ahead of the English. Recently, however, he had been supplying some locomotives to an English mine, and the following figures would be of interest: With horse traction the cost per ton-mile of coal hauled was 1·67d., and with electric traction this had been brought down to 0·9d. This latter figure took into consideration the interest and depreciation on the plant, whereas the 1·67d. for horse traction did not.

The PRESIDENT (Mr. J. Gavey, C.B.) then called upon Mr. Sparks.

Mr. C. P. SPARKS first made a few remarks on Mr. Mountain's Paper. In his own opinion electric winding was the most difficult of all the problems that had to be faced in connection with colliery work, and it should be left to the last, because there were so many other applications of electricity in mines by which immensely greater savings could be made. On the other hand, he did not regard the position with regard to winding as hopeless as Mr. Mountain had suggested. Continental colliery owners had gone in very largely for electric winding, and he dissented from the view that the gears on the Continent were in the nature of toys. The winding installations on the Continent were quite serious and were carried out on a large scale. Why should the English colliery proprietor not do the same? In his opinion it was the extra capital charges for electric winding that had been the drawback, although there was the solid advantage of lower fuel and running costs. At the present moment the capital charges so outweighed the other advantages that electric winding had not yet been adopted to any great extent. The first reason for adopting it abroad was the longer hours of winding, for these naturally reduced the importance of heavy charges. The usual hours of winding in Great Britain were 7¾-8, whereas abroad they were nearly double. Another reason was that fuel was dearer abroad than in this country. Next, the Koepe wheel was generally adopted to minimise the mass requiring acceleration, and not conical drums as in this country. Next, there was the combination of electric winding in connection with the general use of electric power for all purposes. Mr. Mountain had debited the winder with the entire cost of a large unit as well as the boilers, as if nothing else were supplied. Of course, this was an extreme condition, and he thought they were all agreed that to put down electrical machinery for winding only was not, at present, a commercial possibility. During the past three or four years he had had two opportunities of employing electric winders from 250 H.P. to 1,000 H.P. In one case there would have been a transmission of 2½ miles and in the other 1 mile from the generating station. In the first case it was proposed to drive the winder direct from the generator and in the second case to use the Ilgner system. In both cases, however, the saving in running charges would have been more than counterbalanced by the extra interest and depreciation charges. The simplest method of reducing the capital costs was to have direct supply, but this was only practicable if the power-house had very large units and a very large output, so that the peaks were relatively unimportant. This happened on the plant of the Powell Duffryn Co., where there were motors taking peaks of 300 kw. or 400 kw., which were relatively unimportant. When working with the big units, they did not influence the load factor sufficiently to spoil the running costs. As soon as the capital charges of electric winding plant could be reduced, the running charges, in his opinion, would show an economy of 40 or 50 per cent. and this would more than counterbalance the interest charges. Electric winding would then progress even in coal mines. In other classes of mines where the fuel had to be bought, it would be advantageous, even under present conditions, to apply electric winding. The output of the Grand Hornu mines had been put at 16,000 units per day, and the cost, including interest and depreciation, was put at 0·2d. per unit. Although he had not time to check these figures fully, in his opinion, such a cost, including interest and depreciation on that output, was too low. With the output increased to 24,000 units at the same mine the cost was put at 0·16d. The interest and depreciation appeared to be worked out on a 5 per cent. basis, but he thought that the figures in his own Paper of 0·36d. per unit falling with increased output to something under 0·3d., with coal at 4s. 2d., was nearer the right figure.

Replying to the discussion on his own Paper, Mr. SPARKS first dealt with Mr. Mountain's criticism of the division of the units. The station when completed would have two 1,500 kw. units and two 750 kw. units. If the entire equipment had been installed in the first place, he might have put in three 1,500 kw. sets, but he thought, in view of the period of the year when they would be running on a comparatively light load, the sub-division of 1 unit into two halves was a convenient arrangement. On the question of lead-covered cables in mines, he admitted there was a risk of the lead being eaten away and the cable depreciating, but this was a risk which should be borne by the colliery company, because the question of safety to life came in. With any other form of cable there might be partial leakage, which, although not sufficient to operate the automatic cut-out, might result in danger to life. The suggestion had been made that there should be three separate insulated conductors down the shaft, but in his opinion there was nothing more deadly. A partial leakage from such a system, although not sufficient to prevent working, might kill several of the employés of the pit. On the general question of safety, he said the Powell Duffryn Co. had never stinted any expense if it would add to the safety of the employés. Electricity was considered a dangerous agent, but when the enormous risks which were ordinarily run by the mines were considered, he believed that electricity was going to give added safety. The Powell Duffryn Co. had 12,000 employés, and the yearly loss of life was a very serious matter, and from the limited experience of the electric installation, the management were of the opinion that this was a safer system than before. He entirely disagreed with the view that low pressure should be used below ground. With the large powers required it would be quite impossible to work induction motors satisfactorily. The essence of success was to have a steady and even pressure when starting the motors, and the use of high pressure and cables of fair section helped to keep up the pressure at the motor terminals at starting; an impossibility with low pressure. Further, he also pointed out that it would always be found that street box explosions in an ordinary electric lighting network were always on the low-tension part of the system. With regard to the scale of Fig. 2, he said he would have this put on, but the 'bus bars and 'bus bar contacts could be got at if necessary; there was not frequent necessity for this, however. On the question of the overhead lines, raised by Mr. Patchell, he said that there were over 400 poles and some severe storms had been experienced, but they had not caused any trouble. There was one exceptional gale, accompanied by sleet, however, which caused him to put up extra poles at one point in order to shorten the span. None of the lines had yet been brought down. Mr. Bloemendal had referred to two-motor equipments for haulage gears. Undoubtedly this had considerable advantage from the point of view of stand-by, but the capital cost, in his opinion, more than outweighed it. The speed regulation of fans was a very difficult question. They had considered this at an early stage, and found that in cases where the fan was not working up to its full capacity it was cheaper, where a district was just opened up, to put in a small motor at the start and eventually to put in a larger one, transferring the smaller motor to some other duty. In the case of fans approaching their full duty the pulleys were arranged so that they could, by altering them, speed up the fan to the full duty. In most cases, however, he had dealt with fans that were working at their full duty, and therefore the question of speed variation had not been touched. He had no figures as to the coal consumption for different haulage gears other than those he had given in the Paper, and he failed to see how he could get them, because once he had started the power station, he could not disconnect and make a special test on any part of the system. He had not sufficient mining experience in England to speak as to the application of electric locomotives, but in South Wales he should hardly say there was any possibility of applying them. The question of the contact alone put them out of the question. If there was a trolley—assuming there was sufficient height to allow of this—then there would be sparking, and the first question was safety.

Mr. W. C. MOUNTAIN, in reply, said he would deal with Mr. Patchell first. He said he was not aware of the corrections referred to by Mr. Patchell, or he would certainly have included them. He agreed that the number of winds done were not quite equal to the quantity of coal, as pointed out by Mr. Patchell, and he had already corrected most of these figures at the Manchester meeting, but they had not been reported. Mr. Hooghwinkel had criticised his figures, but had made some errors in his table of comparison between the winding cost at Zollern and his (Mr. Mountain's) figures. It should be borne in mind that the Zollern electric winder was designed for an output of 1,350 tons from 330 yds. in eight hours, but he understood that the plant was capable of dealing with about this quantity of coal up to a depth of about 550 yds., so that Zollern might be taken as very nearly representing his example of an electric winding gear to wind 1,500 tons from a depth of 500 yds. The errors which Mr. Hooghwinkel had made were as follows: In his (Mr. Mountain's) Paper it was stated that the weight of coal per wind was 3·6 tons, Mr. Hooghwinkel gave it as 3. The number of winds per shaft of eight hours was given as 417; for two shifts it should be 834 and not 1,000 as Mr. Hooghwinkel said. The weight of cages was stated as 5·5 tons. Mr. Hooghwinkel gave 3 tons. The time of winding was stated as 49 seconds. Mr. Hooghwinkel gave it as 57 seconds. The consumption of coal on two shifts of eight hours should be 11·5 tons, not 8·5 as stated by Mr. Hooghwinkel. The cost of coal was given by him (Mr. Mountain) as 3s. 6d. per ton. Mr. Hooghwinkel based his estimate upon 2s. 6d., so that to wind 200 tons the cost of coal should be 11½d., not 1s. 4d. The result of adjusting these figures was that the total cost of winding per 100 tons without interest and depreciation should be 2s. 7d. His own figures were all based on the assumption that the plant only ran for eight hours per day, but if the interest and depreciation had to be spread over two shifts, then the cost per 100 tons after adjusting the figures would be as follows:—

| | | s. | d. |
|---|---|---|---|
| Zollern II. | per 100 tons eight hours shift, per Mr. Hooghwinkel | 10 | 9¾ |
| | Mr. Mountain's example, per 100 tons ........... | 11 | 3 |
| Zollern II. | two shifts (actual) per Mr. Hooghwinkel .......... | 6 | 1¾ |
| | Mr. Mountain's example ........................ | 6 | 11¾ |

It would be noted from the table which he gave that the real point between Mr. Hooghwinkel and himself was in making up the very slight difference which existed in the amount allowed for labour. He considered Mr. Hooghwinkel's allowance was far too small, but in Germany they appeared to pay their men 3d. per hour. He also considered that Mr. Hooghwinkel's coal consumption was too low to be safe. He had based his consumption throughout on 25 lb. per kilowatt, which meant about 15 lb. of steam per indicated horse-power of the engines, and this, in his opinion, was low enough, considering that steam had to be provided for the feed pumps and also something for the condensation in the steam pipes.

and other losses. Where Mr. Hooghwinkel had gone wrong in his comparative estimates was that instead of adding his depreciation on the plant on 8 or 16 hour shifts, he had simply taken the depreciation over a year of 365 days, adding the proportion due to the short time that the winding engine was working. This, of course, was an incorrect method, but it had the effect of making the amount for depreciation very much smaller than the amount which he had provided, and which he thought would be agreed was correct. Mr. Hooghwinkel then gave another example of the electric winding at the De Wendel colliery, this colliery being equipped with electric winding plant to deal with 1,400 tons in eight hours 770 yds. deep. When Mr. Hooghwinkel's Paper was discussed in Newcastle he had assumed that the figure representing the cost of the electrical plant included a proportion of the cost of the generating plant, but in his reply Mr. Hooghwinkel stated that the sum of £15,000 which he quoted was the cost of the electric winder only, together with the balancer. If they would compare this figure with his (Mr. Mountain's) estimated figure of the cost of winding 2,000 tons per day of eight hours from a depth of 700 yds.—namely, £14,200, it would be seen that instead of the prices being high, they were, as a matter of fact, much lower than the costs quoted against him by Mr. Hooghwinkel. At the De Wendel colliery it appeared that the coal used for fuel under the boilers was very cheap—namely, 1s. 6d. per ton, but notwithstanding this fact the Paper stated that the cost was 6s. per 100 tons. The cost represented, he understood, the cost of electrical energy from the power station, but to this must be added the wages of winders, including oil, &c., amounting to 6d., making the total cost 6s. 6d. Mr. Hooghwinkel had apparently omitted interest and depreciation in his cost of 6s. 6d. per 100 tons, and then only proposed to add interest and depreciation on £5,500—namely, the difference between his estimated cost of steam-winding and electric-winding plant, but this, of course, was an incorrect method of calculating, because the interest and depreciation must be added on the full value of the electric winding gear. At 10 per cent. per annum the interest and depreciation on £15,000 was £1,500 per annum, or on 250 days' winding per annum £6 per day, or 8s. 8d. per 100 tons. Adding this to the original cost of 6s. 6d. brought the total cost of winding at De Wendel to 15s. 2d. per 100 tons. Mr. Hooghwinkel had produced a list of about 40 collieries equipped with electric winding plant, but the bulk of them were for very small outputs, and it was conceivable that under these circumstances electric winding could be economically adopted, but it would have been much more interesting to the Institution if in each case the actual cost of these plants had been stated, and the cost per 100 tons wound worked out on the same basis as he had done in his Paper. Mr. Hooghwinkel gave the figure of 50 lb. of steam per useful horse-power as the best result to be obtained from high-class steam-winding engines. This figure, however, was much in excess of what Messrs. Fraser & Chalmers and other makers of high-class steam engines would be prepared to guarantee, and such figures had been obtained in practice. To his mind, the term "useful horse-power" conveyed very little of value to the mining engineer, because it did not take into account the actual horse-power which was required to accelerate, and what would appeal to the mining engineer was the cost of winding from his shaft per 100 tons. He thought Mr. Clift's comparison had been rather unfair, because, for instance, the figures for the weights of cages, ropes, &c., in Mr. Markham's table corresponded exactly with those he had taken for the electric winder. The fact that Messrs. Fraser and Chalmers' figures did not arrive until late accounted for the difference in the case of this table and in the other few instances. In view of all this, he had prepared further tables, and the corrected figures were now: Steam winder, 7s. 2½d. for winding 100 tons, 8 hours, with interest and depreciation; ditto 7½ hours, 6s. 9¾d.; with coal at 6s. per ton the figure would be 8s. 5¼d., and with coal at 8s. per ton it would be 9s. 9d. Against this he compared the following respective figures given by Mr. Clift for electric winding—viz., 12s. 5d., 8s. 2¾d., 9s. 3d. and 10s. 0½d. He also considered Mr. Clift's costs too low. Mr Clift had complained that he (Mr. Mountain) had not made use of some of the information supplied by Messrs. Siemens Bros., but as a matter of fact this information had not been what was asked for, although he had told the firm the basis upon which he wished to make the calculations. In a large colliery, where the energy used for winding was probably three or four times everything else, he could not see how it was possible to put down electric plant which would compete with high-class steam plants as these existed to-day. If they had the Ilgner system or the motor-generator system there was the dynamo, cables, switchboard, motor, heavy flywheel, bearings, generator and two more motors in between the source of power and the winding engine, all of which were liable to go wrong, and the losses would be probably 45 per cent. The steam winding engine of modern practice was not the bad thing described by some people. With a compound engine, the engine worked at 150 lb. per square inch, and between the cylinders was a receiver, which was superheated so that the temperature was kept up. The engine started with full pressure on the low-pressure piston, and it was as economical and cheap an engine as could be built. The principal loss was in the time that it had to stand. Mr. Patchell had mentioned the standing time, but it was not so serious, for the engine, as a matter of fact, did not stand idle very much during the night, it being then required continuously for various purposes. The general conclusions which he now drew as regards electric winding were as follows: (1) For small collieries there was a future for electric winding if the coal used under the boilers was of any considerable value; (2) In large collieries there was a future for electric winding if the fuel or coal used under the boilers exceeded 8s. to 10s. per ton; (3) the electric winding could not be economically applied in collieries for very large outputs where the horse-power required for winding was greatly in excess of the horse-power required for driving the other machinery, both on the surface and underground; (4) that in collieries generally, particularly those in which electric winding was adopted, colliery owners would be well advised to take the supply from a power company, assuming that they could purchase the current at a reasonable price, and even assuming that this price was slightly in excess of what they could make the current for themselves. The amount of capital required for the generating plant, being so heavy could usually, be applied to much greater advantage in increasing the electrification or improving other machinery about the collieries.

## THE "WOLFRAM" LAMP.

A lamp, apparently destined to be called the Wolfram lamp, in which a filament of "wolfram" or tungsten is employed, is (according to our Continental contemporaries) shortly to be brought on the market. This lamp is distinct from the one which is being developed by Dr. Kuzel, references to which have recently appeared in our columns, although tungsten is one of the metals which are mentioned in Kuzel's patent. It is the subject of a patent by Dr. Alexander Just and Franz Hanaman of the Vereinigte Elektricitäts-Werke (Budapest), and the German rights have been acquired by the Wolfram Lampen Aktiengesellschaft (Augsburg).

We give the following particulars of the process of manufacture from the British Patent No. 11,949 of 1905.

Experiments, it is said, have demonstrated that when carbon filaments, which are provided with coats of wolfram (tungsten) or molybdenum of sufficient thickness, are submitted in highly rarefied gases or *in vacuo*, in order to prevent oxidation of the metal under the action of the electric current, to an adequate temperature, the carbon combines with the metal surrounding it with the formation of a carbide. The carbon becomes completely dissolved in the metal in such a manner that a filament formed in accordance with this process is entirely homogeneous, so that, according to the patent specification, under the microscope no carbon core can be distinguished at the point of fracture. This process, which may be termed "dissolving" the carbon, occupies but a few minutes, and takes place the more speedily the greater the excess of metal above the carbon.

Carbon filaments of the greatest possible fineness (of a diameter of, say, from 0·02 mm. to 0·06 mm.) are submitted to the action of an electric current in an atmosphere of chlorides of wolfram or molybdenum (preferably $WCl_6$ = wolfram hexachloride, or molybdenum pentachloride = $MoCl_5$) in the presence of hydrogen or of some other gas exercising a reducing action, whereby the wolfram or the molybdenum is metallically deposited upon the surface of the carbon. When the metallic coating is of sufficient thickness, which may be ascertained by the current indicated by an ammeter (say 1 ampere when carbons of 0·04 mm. diameter are employed), the filaments are brought to incandescence by an electric current in an atmosphere of very highly rarefied inert gases, such for example as hydrogen gas at a pressure of 20 mm. The solvent process referred to above then takes place in a very brief period, a few minutes being usually sufficient. The filaments so obtained, which contain the carbon in a bound form (mostly as carbide) present a glittering white metallic appearance.

The incandescing filament is once more raised to a high temperature by an electric current in a mixture of steam with reducing gases, and the carbon is oxidised by a similar action to that which takes place in the manufacture of water gas. An alternative method given for the elimination of the carbon is to raise the incandescing filament to a high temperature *in vacuo* by the electric current for a long time (say 24 hours) in such a manner that the carbon volatilises. Another method of decarbonising described is as follows: The metal filaments containing carbide are embedded in a refractory crucible, which is then carefully luted, in very finely pulverised low oxides of these metals, such for example as $WO_2$ or $MoO_2$, which is then submitted to the heat of a blast furnace (about 1,600°C are required) for several hours. By this process the carbon is oxidised as indicated in the following equations: (1) $WO_2 + 2C = 2CO + W$; (2) $MoO_2 + 2C = 2CO + Mo$. The reduced wolfram or molybdenum does not become deposited upon the filament, but remains comprised in the oxide mass, because the wolfram or molybdenum upon reduction at this temperature surrounds the filament as an amorphous powder, without being deposited upon the same. As soon as this oxidation process is completed (in, say, from 10 to 12 hours) cooling is allowed to take place, and the crucible is opened.

The metallic filaments obtained by one of these processes may then, it is stated, be fused into the glass bulbs and employed for incandescent lamps without further treatment.

**Continuous Current at 100,000 Volts.**—According to the *Elektrotechnischer Anzeiger*, the Compagnie de L'Industrie Electrique in Geneva has pushed its experiments with high-tension continuous current to a voltage of 100,000 volts between line and earth; this corresponds to 200,000 volts between the wires.

# NEW YORK, NEW HAVEN AND HARTFORD SINGLE-PHASE RAILWAY.*

The locomotives for this system are required to operate on D.C. over the New York Central part of the New Haven system, and on A.C. on its own part of the line. For this reason there is necessarily some duplication of parts on the locomotive, such as the collecting devices, certain details of the controllers, wiring, &c.

The main power house of the system is at Riverside, about 3 miles from Stamford, and contains Westinghouse-Parsons turbo-alternators, having a single-phase rating of 3,750 kw., or about 5,500 kw. when supplying three-phase current. The generators, which supply at 11,000 volts, have two poles, and run at 1,500 revs. per min., so that the frequency is 25 ~ per second. As an illustration of the unusual conditions met with in the design of such machines it may be mentioned that a single complete armature coil weighs about 600 lb. However, as the machines have only two poles, the total number of amature coils is comparatively small. As a machine in such service is liable to have short circuits at times, the armature end windings are extremely well braced. The terminal of each machine is always grounded when in service.

The trolley system is to be suspended from steel bridges which span from four to six tracks normally, and even a greater number at special points. These bridges are placed at intervals of about 300 ft., and at points about 2 miles apart heavier structures, called anchor bridges, are placed. The steel cables which support the trolley wire proper are supported by massive insulators on the bridges. Two cables are used for each wire, and form a double catenary suspension carrying the trolley wire by means of triangular supports, placed about 10 ft. apart. The steel cables have a total sag of about 6 ft., while the trolley wire itself is maintained in a practically horizontal position. At points about 2 miles apart each trolley wire is broken by section insulators, and is connected to the other trolley wires and to two feeder wires through automatic circuit-breakers. The two feeder wires are carried the whole length of the alternating system. Current is collected from the trolley wire, which is at a nominal height of 22 ft. above the track, by the pantagraph type of trolley, which has an effective range of about 8½ ft. The stresses in the supporting cables with a load of ice ½ in. thick on the cables, hangers, &c., will be about one-sixth of the breaking strain. As 11,000 volts is used on the trolley system, no transforming stations are necessary on the part which is now to be installed. The high voltage trolley system will extend about 19 miles in one direction from the power house and about 3 miles in the opposite direction to Stamford.

The mechanical construction of the locomotive presents many novel and interesting features which deserve special consideration. The running gear consists of two trucks, each mounted on four 62 in. driving wheels, the length of wheel base being 8 ft. To the side frames of forged steel are bolted and riveted the pressed steel bolster carrying the centre plate. The weight on the journal boxes is carried by semi-elliptic springs with auxiliary coiled springs under the ends of the equaliser bars, to assist in restoring equilibrium. The bolsters are 30 in. wide at the centre plate and are widened, when bolted to the side frames, to nearly double this amount, thus giving a very strong construction without excessive weight. The centre plate, which transmits the tractive effort to the frame, is 18 in. in diameter, and will be lubricated to permit a perfectly free motion in curving. Truck centres are 14 ft. 6 in. apart. Owing to the fact that the entire space between the wheels is occupied by the motors, it was impossible to transmit the drawbar pull through the centre line of the locomotive in the usual way. Instead of this, strong plate girders, heavily cross-braced, are carried outside of the wheels, and the entire strain of the drawbar is carried to these through strong box girders having top and bottom plates 42 in. wide. Directly underneath the girder at each end is a Westinghouse friction draft gear to which the drawbar is attached. The cab is built up of sheet steel on a framework of "Z" bars, and the apparatus inside is arranged on a framework of structural steel which is built into the cab and firmly anchored to floor and ceiling. A large trap door permits easy access to motor bearings, brushes, &c.

There are four motors, each of 250 H.P. nominal capacity, and over 200 H.P. continuous capacity. They are of the gearless type and are wound for a normal full-load speed of about 225 revs. per min. They are connected permanently in pairs and require about 450 volts alternating and 550 to 600 volts continuous. Instead of being placed directly on a shaft, the armature is built up on a quill through which the car axle passes with about ⅝ in. clearance all around. Bearings to carry the field frame are at each side of the quill. At each end of the quill is a flange from which project seven round pins, parallel to the shaft, into corresponding pockets in the hub of the wheel. Around each pin is placed a coiled spring wound with the turns progressively eccentric. These springs are contained between two steel bushings, the smaller of which slips over the pin, and the larger fits in the pocket in the wheel. These springs are amply strong to carry the entire weight of the motor, but are normally required to transmit only the torque of the motor and to keep the motor axis parallel to the axle. They allow a total vertical movement of about ¾ in. The end play of the motor, instead of coming directly on the wheels, is taken by strong coiled springs inside of the driving pins, which press against covers in the outer ends of the spring pockets in the wheel. The torque on the motor frame is taken by heavy parallel rods which anchor the frame to the truck above and below the axle. These rods permit vertical or side motion of the motor, but prevent excessive bumping strains from coming on the motor-driving springs. The entire weight of the motor is normally carried on springs supported from a steel frame surrounding the motor and resting on the journal boxes.

On account of the relatively low speed of the motors, the maximum commutator speed is very low, being less than 3,000 ft. per minute when the locomotive is running at 60 miles per hour. One interesting feature in these motors is the method of cooling. As a blower is used in the locomotive for cooling the lower transformers, it was decided to extend this method of cooling to the motors also. In the floor of the cab is an air conduit of considerable size from which air is piped to each motor, which can also be kept very clean in this manner, as the inside of the motor is under partial pressure at all times. The air furnished to the motor, being taken from the inside of the cab, can be kept relatively clean and dry.

On the D.C. part of the line, current is taken from the third-rail system, except in the case of some short sections at cross-overs fed from an overhead trolley on D.C. On A.C. the motors are not operated in series parallel as on D.C., but are connected permanently in a given manner, and the supply voltage is varied. This gives an equivalent of the series parallel, except that the number of efficient operating steps is much greater. On A.C. operation no resistance is used in regular running, but a slight amount is used in passing from one working step to the next, this being in the nature of a preventive device to diminish the short circuiting effect when passing from one transformer tap to another. There are six operative voltages or running points on the A.C., corresponding to six taps on the lowering transformer, while there are a small number of intermediate steps, which are used only in passing from one working point to another. Experience has shown that the number of steps on A.C. required to give a smooth acceleration is considerably smaller than required on D.C. In consequence, the controller is so arranged that on A.C. about half as many steps are used as on D.C. The type of motor used is one which permits an almost indefinite shunting of the field without affecting the commutation or operation otherwise, and advantage is taken of this to obtain several higher speeds by shunting the fields before passing into multiple.

There are two step-down transformers, one on each side of the cab, in order to balance the weight. It must be borne in mind that these transformers are the heaviest single pieces in the cab, and there would be considerable difficulty in placing a single transformer to advantage. A further reason for two transformers is that an injury to one would not entirely disable the locomotive. The transformers are connected in parallel across the high voltage, but on the low voltage side each transformer feeds one pair of motors, through a separate control unit.

The main controllers are of the well-known Westinghouse electro-pneumatic unit switch type. In design, however, they differ somewhat from the D.C. type, due to the fact that switches, blow-outs, &c., must operate on both A.C. and D.C., as many parts of the controller are common to both. It may be mentioned, also, that the reversing switches are of the unit switch type. The main controllers are operated from master controllers at each end of the cab. The controller system is arranged for multiple unit operation, so that two or more locomotives may be coupled to the same load.

In addition to the controlling and transforming apparatus there is a number of auxiliary parts, such as two air compressors driven by motors, which can be operated on either A.C. or D.C.; two blowers driven by similar motors, for furnishing air to the transformer and motors, and to the D.C rheostat. It may be mentioned that the air which passes through the transformers is also sent through the rheostats. In addition to the above auxiliary apparatus there are H.T. oil circuit-breakers, switches for throwing from A.C. to D.C. and so on. There is also a steam generator in the cab for the purpose of generating sufficient steam for heating the coaches in cold weather.

The locomotive is equipped with devices for collecting both A.C. and D.C. For the latter there are eight collecting shoes, four on each side of the locomotive, arranged in pairs of two each, and with a pantagraph low tension overhead D.C. trolley to conform with certain New York Central requirements. For collecting A.C., the locomotive is equipped with two pantagraph-type high-tension bow trolleys.

Each of these locomotives is to be able to handle a 200 ton train in local service on a schedule of 26 miles per hour, with stops about 2 miles apart. In order to make this average speed, the maximum speed will be about 45 miles per hour. One locomotive will also be able to handle a 250 ton train on through service. For heavier trains than this it is intended to couple two locomotives together and operate them in multiple.

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* Abstract from a Paper by Mr. B. G. Lamme before the New York Railway Club on March 16th.

The weight of the locomotive is 85 tons, and its average acceleration is 0·45 miles per hour per second. The motors are ventilated through ducts tapped through the motor frame near the commutator end of the machine, and screened to prevent the entrance of dust. The switches for connections are operated pneumatically. The grid resistances are carried on one side of the centre aisle of the locomotive body and the transformers on the other side. The master controller is not arranged with a revolving handle, as with most controllers, but with a lever similar to the throttle handle on a steam locomotive and moving through an arc of 96 deg. The reversing handle is a shorter lever directly below the operating handle.

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# AN INVESTIGATION INTO THE PERIODIC VARIATIONS IN THE MAGNETIC FIELD OF A THREE-PHASE GENERATOR BY MEANS OF THE OSCILLOGRAPH.[*]

BY G. W. WORRALL AND T. F. WALL.

The periodic variations in the magnetic field of a generator have frequently been the subject of mathematical and speculative investigation, but no actual experiments appear to have been made to ascertain their nature and magnitude. The object of the present investigations was to obtain experimental records of the variations referred to under various conditions of load. The generator employed was three-phase, star-wound, rotating armature, ten poles, one tooth per pole per phase, semi-closed slots; it was run at a speed of 837 revs. per min., and was excited to give 209 volts on open circuit between the neutral and one-phase. The full-load current was 11 amperes. The excitation was maintained constant throughout the experiments. For the purpose of the investigation these periodic variations were observed by means of the E.M.F.s induced in certain search coils attached to the pole-pieces. These will be referred to as "stationary coils." The E.M.F. induced in the armature conductors was also observed by means of other search coils attached to the armature. These will be referred to as "moving coils." The periodic variations in the E.M.F.s induced were recorded by one pair of strips of a Duddell high frequency double oscillograph and revolving film camera.

The position of the armature relative to the pole-pieces corresponding to any instant in the E.M.F. wave was ascertained by means of a contact maker attached to the armature which closed the circuit of the second pair of strips of the oscillograph through a Leclanché cell once in every period of the machine. The maximum time of contact was about 1-5000th second Thus, in the photographic records, there was a small peak on the zero line once in every period, which corresponded to a predetermined position of the armature. A stationary coil of six turns was attached to the two leading tips of adjacent poles, a similar coil to the two trailing tips and a third to the centres of the two faces. Three moving coils, each of one turn, were laid in the armature slots similar in their circuit to a loop of the armature winding and respectively at the top, the bottom, and the centre.

The machine was run respectively on open circuit; non-inductive load, consisting of liquid resistances; inductive load, consisting of choking coils of very small resistance; and capacity loads, consisting of mica condensers.

It was found that the curves from all the three coils in the slots were identical with each other in shape, and only varied in magnitude within the limits of accurate copying.

In the stationary coil curves six waves were found to occupy the same time as one period of the machine. Therefore, as the frequency of the machine was 70 per second, that of the variations in the field was 420 per second, and, as there were three teeth to each pole, the passage of each tooth through any part of the field was marked by the occurrence of one of the periodic variations under investigation. The movements which go to make up one of these variations may be described as a "flash" and a "drag." The flash occurs across the slot in the opposite direction to that in which the armature moves, while the drag occurs in the same direction as the motion of the armature, and is caused by hysteresis effects in the teeth. These flash and drag movements of the flux are apparent in all the stationary coil curves and are distinct from each other, but the distinction is most apparent in the curves taken in open circuit. The E.M.F.s due to the drag are measured to the left of the zero line and those due to the flash to right.

In Table I. are given the maximum values of the E.M.F.s induced in a single conductor of each stationary coil under the various conditions of load, and these values correspond with those induced in a pole-piece and available for the production of eddy currents. The ratios of the same E.M.F.s to those induced on open circuit are also given.

**Table I.**

| — | Max. E.M.F. in volts induced in the pole pieces. | Ratio of max. E.M.F. in pole piece and armature loop. | Ratio of max. E.M.F. in pole piece on load and on open circuit. |
|---|---|---|---|
| 1. *Open Circuit.* | | | |
| Leading pole tip ........ | 0·15 | 0·14 | .. |
| Trailing pole tip ........ | 0·18 | 0·16 | .. |
| Centre of pole face ...... | 0·25 | 0·22 | .. |
| 2. *Non-Inductive Half Load.* | | | |
| Leading pole tip ........ | 0·15 | 0·13 | 0 99 |
| Trailing pole tip ........ | 0·27 | 0·23 | 1·50 |
| Centre of pole face ...... | 0·24 | 0·20 | 0·96 |
| 3. *Non-Inductive Full Load.* | | | |
| Leading pole tip ........ | 0·16 | 0·13 | 1·03 |
| Trailing pole tip ........ | 0·33 | 0·27 | 1·83 |
| Centre of pole face ...... | 0·25 | 0·21 | 1·00 |
| 4. *Inductive Half Load.* | | | |
| Leading pole tip ........ | 0·13 | 0·13 | 0·84 |
| Trailing pole tip ........ | 0·17 | 0·18 | 0·94 |
| Centre of pole face ...... | 0·15 | 0·16 | 0·62 |
| 5. *Inductive Full Load.* | | | |
| Leading pole tip ........ | 0·06 | 0·07 | 0·39 |
| Trailing pole tip ........ | 0·12 | 0·14 | 0·66 |
| Centre of pole face ...... | 0·07 | 0·08 | 0·28 |
| 6. *Capacity Half Load.* | | | |
| Leading pole tip ........ | 0·28 | 0·16 | 1·77 |
| Trailing pole tip ........ | 0·33 | 0·20 | 1·83 |
| Centre of pole face ...... | 0·45 | 0·27 | 1·80 |

The flash and drag taken together were periodic and their frequency constant under all loads, while, taken individually, their times were found to be unequal and to vary in relation to each other under different loads. The time of the flash was longer on load than on open circuit. The area of the curve of the flash was in all cases equal to that of the drag—a result which might be expected in the absence of any continuous forward or backward movement of the flux.

It was found that, although the actual values of the fluxes varied through a wide range, yet in all cases, except the inductive loads, the sum of the fluxes moving under the two tips are equal to the flux moving in the centre of the pole face. The ratios of these fluxes to the total flux are given in Table II. The actual flux threading the moving coil at the top of a slot when placed symmetrically about a pole-piece was determined by the ballistic method.

**Table II.**—*Giving the Ratios of the Fluxes moving under the Pole Tips and the Centre of Pole Face to the Total Flux.*

| — | Leading tip. | Trailing tip. | Centre of face. |
|---|---|---|---|
| Open circuit ............... | 0·0054 | 0·0054 | 0·0112 |
| Non-inductive, half load.... | 0·0094 | 0·0168 | 0 0261 |
| Non-inductive, full load .... | 0·0078 | 0·0300 | 0·0377 |
| Inductive, half load........ | 0·0054 | 0·0078 | 0·0054 |
| Inductive, full load........ | 0·0060 | 0·0084 | 0·0054 |
| Capacity, half load ......... | 0·0269 | 0·0180 | 0·0450 |

As the flash and the drag approached equality in time the E.M.F.s induced by them approached equality in magnitude. All the stationary coil curves have two principal features—*i.e.*, the correspondence in period of six of their waves with one period of the machine and the formation of each wave by one flash and one drag movement of the flux. These features distinguish them from the moving coil curves, which have next to be considered. In these the continuity of the flash due to the movement of the coil across the pole face destroys the division into periods, and the drag being caused by the movement of the teeth does not influence the form of the wave. By the continuous flashing in the opposite direction to the motion of the armature, however, the height of the wave is increased; but as the flashing varies from point to point of the pole face and with various loads the increase in height due to this cause is neither constant nor proportional to the flux. The moving coil curves generally exhibit the well-known effects of armature reaction, but these effects are not apparent in the case of the peaks formed under the trailing pole tip in non-inductive and capacity loads, the height of these being the same as on open circuit, whereas they would be expected to be greater.

From Table I. it will be seen that even on open circuit the E.M.F. induced in the pole face may be as much as 22 per cent. of the E.M.F. induced in an armature conductor, and on non-inductive full load this value rises to 27 per cent. It will also be noted that, although the E.M.F.s induced have their largest values in the capacity load, their ratios to those generated in an armature conductor are approximately the same as on non-inductive full load. It occurred to the authors that the periodic variations in the field might possibly penetrate beyond the air-gap into the main magnetic circuit, but, as on connecting with the oscillograph two coils each of six turns wound respectively round a limb and yoke of the magnets, and running machine under capacity load, no variations were recorded, it was concluded that such is not the case to any appreciable degree.

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[*] Abstract of a Paper read before the Manchester Section of the Institution of Electrical Engineers, March 27th.

## BOUCHEROT'S SQUIRREL-CAGE MOTOR WITH LARGE STARTING TORQUE.

In a recent issue of *L'Industrie Electrique*, M. E. J. Brunswick gives some interesting particulars of a 130 H.P. Boucherot squirrel-cage motor with large starting torque constructed for pump work by the Breguet Co. As is well known, M. Boucherot's method of obtaining a large torque consists in embodying resistances in the squirrel-cage rotor, and causing, by purely electrical means, the rotor current to flow through these resistances during the starting-up period, but to pass them by when the rotor has gained speed. This is accomplished as follows: The rotor is long, and its copper bars are continuous the whole length of the armature, being electrically inter-connected at either side by bronze rings in the usual manner. The middle point of each copper bar is connected to the middle points of the neighbouring bars through German silver resistances, which thus form a circle around the armature half way between the ends. Instead of having one stator, as in the customary design, there are two stators, each of which is provided with an ordinary three-phase winding. One stator encloses one end of the rotor and the other encloses the other end, while a short length in the middle of the rotor—where the resistances are—is not embraced by either stator. When running, the currents induced in the copper bars by the two stators are in phase, and the currents flow in the squirrel-cage rotor as if there were only one common stator, and no current flows through the resistances. At starting, however, the currents induced at either end of the rotor by the respective stator are caused to be out of phase, the result being that each end forms more or less a squirrel-cage rotor by itself and completes its circuit through the German silver resistances. This displacement in phase can be achieved either by rotating one stator to a certain extent at starting by mechanical means, or else by connecting up the two stators differently. The latter means seems to be more generally favoured. A simple switch is employed for changing the connections. In the starting position of the switch, the three phases of each stator are connected in such a manner that the two stators oppose one another. When the switch is moved to its second position, one stator alone is active, the other being short-circuited upon itself. Less current now flows through the rotor resistances. In the third, and running, position finally, the stator windings are connected in parallel, and both stators act as one single stator would. The three phases of each stator are always connected in star.

The figures below refer to a two-pole 130 H.P. motor of this type, fed from a 1,000 volt 46·5 ∿ supply and running light at 2,790 revs. per min. and at normal load at 2,750 revs. per min.

| | |
|---|---|
| Efficiency and power factor at full load | 0·90 |
| *Stator*—Outside diameter of stampings | 50·0 cm. |
| Inside diameter of stampings | 25·3 cm. |
| Total axial length of each stator | 23·0 cm. |
| Number and width of ventilating ducts | 2·0 × 1·5 cm. |
| Number of slots | 24 |
| Dimensions of slots | 4·2 × 1·8 cm. |
| Number of conductors per slot | 22 |
| *Rotor*—Outside diameter | 24·9 cm. |
| Slots | 26 slots, each 1·35 × 2·4 cm. |
| Dimensions of bar | 2·2 × 1·15 cm. |
| Dimensions of bronze end rings | 8·0 × 1·0 cm. |
| Number of resistances | two groups of 26 each. |
| *Resistances*—Section | 5·2 × 2·5 cm. |
| Length, when opened out | 11·1 cm. |

In the motor in question, the resistances were of such a value that the starting torque was half the normal torque with a current of about 30 amperes. The centrifugal pump was of the Rateau type, being designed for raising 115 cubic metres per hour to a height of 200 metres. It is stated that the efficiency of the set as a whole was 65 per cent.

## BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Analyse des Metaux par Electrolyse." By A. Hollard and L. Bertiaux. (Paris: H. Dunod & E. Pinat.) 6f.

"Properties of Matter." By C. J. L. Wagstaff. (London: W. B. Clive.) 3s. 6d.

## "ELECTRIFICATION" OF SUBURBAN RAILWAYS.

In view of the recent decline in the market values of the old London "Underground Railway" securities since the adoption of electric traction, *The Times Financial and Commercial Supplement* publishes an article discussing generally the subject of conversion of local lines from steam to electric working which by no means reflects the forebodings sometimes heard in this connection, and treats the question in a very rational way. Dealing first with the Metropolitan Railway Co., whose stockr have especially suffered, it is pointed out that as yet electric traction has not been given a fair trial. There are four distinct steam services still running on the northern half of the Circle, so that there are at present about two steam trains to every electric train. It is hoped, however, that the last steam train on any part of the Circle will disappear by July, as the electrical equipment of the Great Western suburban lines is expected to be completed by that time. Not till then will it be possible to take full advantage of the increased capabilities for acceleration afforded by electric traction, so it is unfair to pronounce the result of the conversion either success or failure until these conditions have been attained. After speaking of the advantages to be gained by this increased acceleration, especially at crowded terminal stations, where it is essential that at certain times of the day trains should follow one another in quick succession, it is further pointed out that an electric train can be driven from either end, and can, therefore, be dealt with as a unit as distinguished from a train of ordinary coaches drawn by a separate steam engine. This permits of very considerable economies being effected, both in time and space, at terminal stations, and reduces the number of switching and signalling operations. It will readily be seen that these are most important points, because at crowded traffic centres it is often impossible to extend station and siding accommodation, and where it is possible it can only be done at great cost, owing to the high value of the land and property in the neighbourhood.

A full discussion of comparative cost per train-mile is, of course, not entered into. The circumstances can so rarely be parallel that reliable figures are practically unattainable. The assumption is made—probably, in the present state of affairs, rightly—that, mile for mile, for exactly equal conditions, the line run by steam would be operated at less cost than the line run by electricity. The point is, however, that the conditions do not remain the same, and, as our contemporary remarks, a statement of this kind is of no real value inasmuch as such a set of circumstances is not conceivable in this country or, indeed, in any other in modern times. The real proposition before railway directors and shareholders is whether capital spent in converting an existing line from steam to electric traction is advantageously laid out and will yield a good return. In solving this problem the actual cost of electric energy as compared with steam is only one of several factors to be taken into account.

In the case of the underground lines of London it may be said that self-preservation was one of the principal incentives that led to the making of the change. Public opinion demanded that something should be done to improve the distinctly disagreeable conditions that prevailed in the London tunnels. Another public demand which the underground companies felt it was essential they should meet was for a more frequent service of trains. This they could not provide under the old conditions and so another determining factor was created in favour of electric traction, under which greater acceleration is possible and trains can follow one another more quickly over the same pair of rails. Several of the foregoing considerations operated also in the case of the Mersey Tunnel Railway, upon which electricity was introduced in place of steam in 1903. The number of trains run on this railway has been greatly increased, and the conditions of travel have been vastly improved, with the result that there has been a satisfactory expansion of business.

Another example is taken from the electrification of the Liverpool and Southport section of the Lancashire & Yorkshire Railway, where electric traction was adopted to meet a demand for a greatly increased train service as an alternative to incurring a large capital expenditure in providing relief lines and in enlarging its terminal accommodation. It has been officially stated that on this line the actual cost of operation is slightly greater than it was under steam traction; but the increased service of trains and the greater despatch, rendered possible by electrical working and now given, have induced such an increase in traffic as to justify fully the change from every point of view.

Another case mentioned is the conversion of the Manhattan section of the New York Elevated Railway, which took place in 1901. By running as many trains as possible during their last year under steam conditions the company succeeded in carrying 190,045,741 passengers. In the first complete year under electric traction the number of passengers carried was no fewer than 286,634,195, an increase of about 50 per cent. In the first-named period (under steam traction) the cost of working was equal to

55·79 per cent. of the gross receipts, while in the latter period (under electricity) the cost of working was only 41·20 per cent. of the gross receipts. Here we have a direct and substantial saving due, not to the cost of electricity *per se* being less than the cost of steam, but to the fact that with electric traction it is possible to do a much greater amount of remunerative work in the same time and over the same rails.

In conclusion, the opinion is expressed that even if it should be demonstrated eventually that, after taking everything into account, electricity is a more costly motive power to produce than steam, there may, and probably will, be other considerations, as in the instances cited above, which render its adoption on a local railway not only desirable but also economical.

## CONTEMPORARY ELECTRICAL SCIENCE.

[Compiled by E. E. Fournier d'Albe.]

*Colloidal Solutions.*—E. F. Burton has determined the size and charge of the particles of colloidal solutions of metals produced by sparking between metallic electrodes under the surface of pure water. He determined the size of the particles by an ultra-microscopic method, and found it to lie between $2 \times 10^{-5}$ cm. and $6 \times 10^{-5}$ cm., thus corroborating the estimate of Bredig based upon theoretical considerations. He found that the electro-negative, non-oxidisable metals, gold, silver and platinum give solutions in water and ethyl malonate, in which the particles are negatively charged. The electro-positive, oxidisable metals gave solutions in water, methyl alcohol, and ethyl alcohol, in which the particles are always positively charged. In the former case there is incomplete combination with the liquid. Several platinum atoms, for instance, combine with one positive atom of hydrogen, and it doing so deprive the HO ion of its electron. The platinum-hydrogen aggregate dissociates slightly so as to form an atmosphere of positively-charged hydrogen ions about the negatively-charged colloidal particle. With the other metals in water and the alcohols we have a corresponding formation of the hydroxides, lead combining with OH and leaving neutral hydrogen free. By a slight dissociation of the $Pb_nOH$ a positively-charged colloidal particle is obtained, surrounded by a layer of negative OH ions in the liquid.

[E. F. Burton, *Philosophical Magazine*, April, 1906.]

*Absorption of α Particles.*—E. Rutherford has succeeded in obtaining photographic effects with α particles having a velocity less than half their velocity of projection. The particles traversed a layer of aluminium having an absorbing power equal to that of 7 cm. of air, that being the maximum range of ionisation of an α particle from radium C. The scattering of the particles increases as their speed is reduced. The ratio $e/m$ remains, however, the same, and after passing through 5·5 cm. of air the particles have the same charge and mass as they have when issuing from a bare wire coated with radium C.

[E. Rutherford, *Philosophical Magazine*, April, 1906.]

*Alternate-current Conductivity of Flames.*—H. A. Wilson and E. Gold have measured the electric conductivity of flames containing salt vapours for alternating currents, and furnish an explanation of their results on the ionisation theory. The relative conductivity of salts of the alkali metals in non-luminous flames varies in nearly the same manner in steady currents and in alternating currents. For rapidly oscillating currents of the Tesla kind a flame containing an alkali-salt vapour behaves like an insulating medium having a high specific inductive capacity. Since the mass of the positive carriers is large, and their mobility small, they will be practically stationary in comparison with the negative carriers, which oscillate with each alternation. All regions within the amplitude of this oscillation from the electrodes will be deprived of negative ions, while having the usual density of positive ions. There is, therefore, a neutral layer in the middle between the electrodes, surrounded by two positive layers. The apparent capacity per unit area should vary as the square root of the number of ions per cubic centimetre, and inversely as the square root of the maximum P.D. applied, but should be independent of the distance between the electrodes. The experimental results fully support these conclusions. Not more than one molecule in 30 salt molecules is ionised at any instant in the flame, but each molecule is probably ionised and recombined several million times per second.

[Wilson and Gold, *Philosophical Magazine*, April, 1906.]

*Conductivity of Nernst Filaments.*—F. Horton describes some experiments which go to show that the conductivity of metallic oxides is mainly metallic and not electrolytic, as Nernst supposed. On heating a slab of cupric oxide from 12°C. to 385°C. its conductivity increases 5,000 times, and on heating lime from 763°C. to 1,466°C. its conductivity increases to nearly a million times its value at the lower temperature. Since the material remains solid, it is not likely that the mobility of the ions has increased. And since in concentrated electrolytes the degree of dissociation decreases on heating, the number of ions is not increased if the oxides conduct electrolytically. The alternative thus indicated is that the conduction is metallic—*i.e.*, that it is due to free electrons. Wehnelt has already shown that hot metallic oxides emit electrons very freely. The author shows that the conductivity of oxides increases in the same proportion as the rate of emission of electrons from their surfaces. The fact that mixtures of certain oxides conduct better than either of their constituents is capable of explanation on the electron theory of metallic conduction. One of the constituents may have a large percentage of free electrons but a small free path. The other may have but few electrons but a large free path. In the mixture the number of electrons will be greater than before, while the free path is not much less.

[F. Horton, *Philosophical Magazine*, April, 1906].

*Magnetisation of Iron Powder.*—W. Trenkle has studied the magnetism of powdered iron by means of a modified yoke method, which gives more complete results than that of Börnstein. He finds that with a given field the magnetisation and the susceptibility of pure iron powder is always greater than that of a mixture of iron powder and some non-magnetic substance. Hence the saturation point of pure iron powder is always higher than that of the dilute powder. The saturation value of the magnetic intensity is about one-fifth of that of solid iron. Generally speaking, therefore, the saturation value of the magnetisation is the smaller the less the density of the iron. Thus cast iron, which has a smaller average density than steel or wrought iron, has a relatively small intensity of maximum magnetisation. The field required for saturation is greater in the case of diluted iron powder than in the case of the pure powder, but this rule cannot be extended to solid iron. The effect of the change of density is entirely independent of the effect of a change in length, and must not be taken as amounting to the same. The relation between the changes produced by altering the various dimensions is very complicated.

[W. Trenkle, *Wiedemann's Annalen*, No. 4, 1906.]

*Thomson Effect.*—E. Lecher has examined the variation of the Thomson effect with the temperature in the case of iron, copper, silver and constantan. He used an electric furnace through which two wires of the metal to be investigated were drawn. Their ends projected from the oven, and were joined across through three different thermocouples. Currents in opposite directions were sent through the two wires. The Joule effect in the two wires compensates itself, but the two Thomson effects are added up, and their fourfold value may be obtained by reversing the current. To obtain a small gradient of potential, the wires are wound with asbestos. The Thomson effect is probably proportional to the gradient for small gradients. In iron, the Thomson effect at 52 deg. is $27{\cdot}8 \times 10^{-7}$ gramme-calories per coulomb. The author corroborates Tait's observation that in iron the Thomson effect possesses a point of inversion. In copper the temperature coefficient of the Thomson effect is $+3{\cdot}01 \times 10^{-7}$ gramme-calories per coulomb, in silver $+7{\cdot}36 \times 10^{-7}$ and in constantan $-4{\cdot}73 \times 10^{-6}$. In iron and constantan the temperature effect follows a curve of the second degree, while in copper and silver it describes a straight line.

[E. Lecher, *Wiedemann's Annalen*, No. 4, 1906.]

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## ELECTRIC WINDING.

The three evenings' debate on applications of electricity in mines at the Institution of Electrical Engineers was chiefly devoted to discussing the relative merits of steam and electric winding. A Paper, read by Mr. W. C. MOUNTAIN before the Manchester Local Section of the Institution of Electrical Engineers last January, was brought up to London for trial, and it must be admitted that the correction administered was well deserved. Mr. MOUNTAIN, although he is an electrical engineer himself, and although a large part of his business is the application of electricity in mines, had deliberately set himself the task of proving that electric winding was not, and never could be, so economical as direct steam winding. He had prepared a number of tables to prove this proposition, but speaker after speaker rose to point out discrepancies and inaccuracies in these tables, and serious omissions in the estimates. Mr. MOUNTAIN has, of course, "explained" a number of these, and, in reply to the discussion, he produced a fresh set of revised tables, but he has not done sufficient to explain the peculiar position he has adopted. It is bad enough for an electrical engineer to set out with the definite object of disparaging a particular application of electricity to those who may be customers for it, but matters are still worse when the figures and data he uses for this purpose will not bear the test of critical analysis. To suggest that the reason of the inaccuracies is that the figures were prepared hastily is hardly sufficient excuse, for there was no need for haste to damn a branch of electrical engineering which is still in its incipient stages of development. In any event the two months which elapsed between the presentation of the Paper in Manchester and its discussion in London afforded ample time for the correction and verification of his figures had Mr. MOUNTAIN desired to correct and verify them on his own account. We must, however, call the attention of mining engineers to the fact that the conclusions expressed by Mr. MOUNTAIN at the end of the discussion are already considerable modifications of the views he originally expressed, and by the time the patents that control the most serviceable methods of electric winding have expired, it is possible that he may be as enthusiastic for it as he is now energetic in condeming it.

Leaving aside the case in which the only application of electricity in the mine would be winding on one or two main shafts, and in which, at any rate, the winding at these shafts represents the great bulk of the electrical energy used, everything depends on the value of coal. At some pits mentioned, small coal that can be burned in the local boilers has actually a negative value, so that if it is not burned money has to be paid for carting it away; then within certain limits the more inefficient the winding engine the more economical will be the final result, and in such circumstances also no elaborate tables are needed to prove that electric winding should not be adopted. There must be, however, a large number of instances in which the electrical equipment of the mine may be extended economically to the winding engine. One mechanical engineer, who rose to speak apparently under the impression that electrical engineers understood nothing of steam engine building, described with pride the existing steam-winding engines, which did a large part of their total work on each wind with steam admitted at full pressure to the cylinder for practically the whole of the stroke. Now, electrical engineers find it more economical to use steam expansively in their engines. Then again, there are enormous stand-by losses on the steam-winding engine plant, which has to be ready for working at any time in the 24 hours, a large quantity of steam is lost in "blowing-off," and, lastly, much work is wasted in using the engine for braking. The conditions are, in fact, such that independent steam winding plants are run almost under the most uneconomical conditions that a steam plant can be subjected to. This is why the estimated costs of steam winding differ so much from the actual observed costs, and also why the results of tests vary so much, for the subsidiary losses which do not occur in the engine itself are not always taken into account in the tests. Thus the question is the same one that governs many applications of electricity to power purposes on a large scale. The capital cost of applying the new methods is greater, but there is a saving in working costs. As we have already said, this particular application of electricity is new; consequently the capital costs are at present high. By encouraging the utilisation of electric winding in every instance where it may be adopted with advantage, the first cost will soon be lowered, and the cases in which the electric motor may be profitably employed for winding will eventually be numerous.

## REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign book.)

**Practical Electro-Chemistry.** By BERTRAM BLOUNT. (London: Archibald Constable & Co.) 2nd edition. 15s. net.

The second edition of Mr. Blount's well-known book on Electro-chemistry has been fully revised and brought up to date since the edition which we reviewed in 1903 (*The Electrician,* Vol. LII., p. 94). The progress of the electro chemical industry has been rapid of late, and the essential points of the many new processes which have been devised and the improvements of old methods which have been introduced are embodied in the present volume. Not the least in importance of these additions is the new section of the book devoted to the electro-metallurgical production and treatment of iron and steel. As the author points out, a great change has occurred during the last few years in this portion of the subject. The earlier period of experimental struggle, which seemed all but hopeless, has given place to an epoch of moderately fruitful toil, and there is good cause to believe this will merge into an era of industrial activity. A reason suggested why success has been won slowly in this subject is that the ambition of the pioneers was chiefly limited to smelting iron electrically from its ores. This of course can be and has been accomplished, but it is less easy and less immediately useful than the production of steel and alloys of iron by electrical means, using as raw material the ordinary products of the blast furnace. Mr. Blount sums up the situation by saying that, as the blast furnace is a fairly efficient thermal device, and as it uses fuel direct instead of in a roundabout electrical manner, it is difficult to displace it except where fuel is extravagantly dear, whereas in the conversion of cheap pig iron into high-priced steel, or special iron alloys, the cost of energy necessary for the process is not so large a part of the total cost as to make electrical methods impracticable. After referring to the advantages of plentiful water possessed by Canada, where the Government is giving great encouragement to the development of this industry, the author reminds ironmasters in this country of the huge horse-power obtainable from the gases from their blast furnaces, which is eminently suitably for running electrical steel plants, using the products of their blast furnaces as a raw material. The Keller process of iron smelting is described in this section, together with Héroult, Kjellin and Gin furnaces for steel manufacture. Other sections of the book have been enlarged, including that devoted to alkali, chlorine and their products, where the conditions which experience has proved necessary for successful operation on a large scale are given, and all the leading systems described. A number of new illustrations have been added and the work, which is certainly a standard work on the subject, and bears every evidence of careful and thorough revision.

**Valves and Valve Gear Mechanisms.** By W. E. DALBY, M.A., B.Sc. (London: Edward Arnold). 1906. 21s. net.

Prof. Dalby has the great advantage of being not only theoretically, but practically, fully acquainted with the subject on which he writes. The result is a book of exceptional merit, useful not only to the student, for whom it is primarily intended, but also to others who are practically engaged in the matter. Special features of the book are the excellence of the illustrations and the numerous detailed numerical examples. It is stated in the Preface that the scope of the book is limited to an examination of types of gears in which there is one, and only one, position of the valve for a given position of the crank. A few gears are, however, described in which a governor is included in the mechanism operating the valve. In this case there is more than one position of the valve for a given position of the crank.

The subject is treated both graphically and analytically, but the two methods are separated, so that all technical information can be obtained without reading the analytical portion. It is hardly necessary to point out that the graphical method is usually the most practical. The first three chapters deal principally with general questions, explaining what the duties of the valves are and giving descriptions of many well-known valves and valve gears. In Chapter IV. is given a method of determining the valve displacement relatively to that of the piston, a method originally described by Prof. Osborne Reynolds; this method is used throughout the book, and although more lengthy than Zeuner's, Reuleaux's (which are also fully described) it presents the matter in a very clear manner, and is far the most helpful method from the student's point of view. The simple eccentric gear is considered in this chapter, and in Chapter V. independent cut-off gears are dealt with.

In Chapter VI. the valve gears considered in the preceding chapters are dealt with analytically, and several numerical examples are given, such, for instance, as a Meyer gear. Reversing gears are dealt with in Chapter VII. in a very full manner, which begins with an interesting example of the hand-reversing gear of the ss. "Puritan," belonging to the Fall River line. This is probably the largest engine in the world in the point of size and weight, and develops 7,500 H.P.; the low-pressure cylinder is 110 in. diameter and has a 14 in. stroke, and yet the reversing is done by hand. The reversing gears of locomotives constitute a large portion of this chapter, and a very fully worked out example is given of the valve displacement curves (for various points of cut off) for a Great Eastern locomotive. The chapter concludes with a description of several of the mechanisms used for actuating reverse gears. Chapter VIII. deals with radial gears, principally of the Walschaert type, but Joy's gear and Marshall's gear are also described, and valve displacement diagrams are given for each. Chapter IX. consists of statical and dynamical problems in connection with the design of the valve gear to determine the acceleration of the parts of the gear, and the method used is that published by Prof. R. H. Smith in 1885. The standard Joy gear of an L. & Y. Railway Co. locomotive engine has been chosen for detailed examination, and this example has special value, as every link of the gear was made the subject of an experiment at the Horwich Locomotive Works. The book concludes with an important chapter on the representation of a valve displacement curve by a trigonometric series. A brief discussion of the principles of the Fourier method is given which will be assistance to engineers in many other directions.

H. R. S.

**The Application of Electric Motors to Machine Driving.** By ANDREW STEWART. 3rd edition. (London: S. Rentell & Co.) 2s.

After an opening chapter on the general character of the shunt series-compound single-phase and polyphase motors, indicating the class of work for which each is suitable, and a description of typical forms of starting gear, there follows a discussion of the points in which electrical driving conduces to greater economy than other methods, particular attention being drawn to the smaller falling off in efficiency with electric motors than small gas engines. The remaining chapters are principally devoted to the way in which electric driving is applied in various industries, one of the most interesting being that dealing with printing machinery, where the very wide variation of speed renders special methods necessary. A large number of illustrations are provided of electrically-driven machines, and useful figures of the power required by various classes of machinery are given.

**Practical Pattern Making.** By HERBERT AUGHTIE. Second edition. (Manchester: The Scientific Publishing Co.) 4s.

Mr. Aughtie's book is a thoroughly practical treatise on pattern making and includes a short chapter on pattern-shop machinery. After describing, in the first chapter, the moulding of simple patterns in green sand, the author discusses successively patterns with loose parts, circular patterns, skeleton patterns, loam patterns and loam moulds, and finishes up by a detailed description of a number of more elaborate patterns, such as are required for steam cylinders, toothed wheels, &c. The book is well illustrated from cover to cover, but considerable space might have been saved by reducing some of the drawings, which are quite unnecessarily large.

**Engineering Tables and Data.** By W. W. F. PULLEN. Second edition. (Manchester: The Scientific Publishing Co.) 2s. 6d.

Although this book has been compiled with special reference to the requirements of the steam engineer, many of its tables—especially those relating to general mathematics, geometry, mensuration, the metric system, &c.—will be useful to the electrical engineer and student. In glancing through the book we came across one or two misprints in the letterpress, and can only hope that the author has been more careful in checking the tables and data given.

**Electric Power: What it is and what it can do.** By ALFRED W. MARSHALL. (London: Percival Marshall & Co.) 3d. net.

This little work is intended to open the minds of that section of the public who do not realise that electricity is capable of serving any other useful purpose than lighting. The style in which it is written is eminently intelligible, as may be gathered from the following extract: "Do you find it difficult to get through your work on a hot summer's day? You can have an electric fan and switch on the current when you feel inclined for a cooling breeze. . . . . But do not leave the fan running when you want to get rid of a caller; he will not leave it if he can help it." The descriptive portion concludes with the excellent piece of advice: "It is advisable to avoid interrupting an electric circuit except by means of a proper switch." The best feature of the work is the glossary of electrical terms at the end.

**L'Année Electrique, Electrothérapique et Radiographique.** By DR. FOVEAU DE COURMELLES. (Paris: Ch. Béranger.) 3 fr. 50 c.

The sixth issue of this annual commences with a collection of short notes on miscellaneous new electrical discoveries and inventions made during the past year, followed by similar brief chapters on recent advances in electro-chemistry, electric lighting, heating and traction, telegraphy with and without wires and other applications of electricity. Next we have a chapter on electrical hygiene and safety appliances, which, with somewhat grim irony, contains a paragraph on "Electrocution of Criminals." The greater part of the book, however, is devoted to medical applications of electricity, including chapters on radiography, the curative applications of Röntgen rays and light and a chapter on radium and radio-active bodies. The book concludes with a few notes on "Electrical Jurisprudence" and some obituary notices. The usefulness of the volume would be greatly enhanced by an alphabetical index.

## COAL TESTING.*

BY JOHN HOLLIDAY.

The calorific value of any fuel is the number of heat units evolved by the complete combustion of a unit weight of it. Whilst admitting a preference for metrical equivalents, with the calorie or gramme-degree C. as the unit, popular practice in these countries demands the use of the British thermal unit or pound degree F., which will be employed throughout this Paper. There are three different methods by which the calorific value of a fuel may be determined: (1) by calculation from the chemical analysis of the fuel; (2) by combustion on a small scale (a few grains) in some form of calorimeter; (3) by combustion on a large scale (a few tons) under a well-arranged steam boiler used as a test boiler.

In order to calculate the heating value of a fuel from its chemical analysis, a reliable analysis is required, and this, when not already available, is necessarily tedious and expensive to obtain. Moreover, the leading authorities are not agreed upon the values to be assigned to the various combustible elements, nor upon the allowances to be made for possible changes of state during combustion. The following are the calorific values of the combustible elements generally found in all fuels: carbon 14,544, hydrogen 62,032, and sulphur 4,032 B.Th.U. per pound.

In Dulong's method, which is commonly employed, it is assumed that all the oxygen present is combined with some of the hydrogen in the form of water, so that only the remaining hydrogen is available for combustion. Another formula used by M. Ser gives the calorific value in thermal units of any coal as $= 3{,}184\left(\frac{\text{carbon}}{3} + 8 \text{ hydrogen}\right)$.

In 1887-88 the late M. Scheurer-Kestner made an elaborate study of a sample of South Wales coal supplied to him by the late Mr. Bryan Donkin. It was, in fact, a sample of the special lot of Nixon's navigation coal used by Mr. Donkin and Prof. (now Sir) A. B. W. Kennedy, F.R.S., in their elaborate set of trials of various steam boilers with the same coal, the results of which were published in *Engineering* in 1888. In M. Scheurer-Kestner's Paper, entitled "The Study of an English Coal," which appears in the *Bulletin de la Société de Mulhouse* (1888), Vol. LVIII., he compares the value of this coal as calculated by various formulæ with his own experimental result as determined by calorimeter thus:—

| | B.Th.U. |
|---|---|
| Calculation by the formula of Dulong ............ | 15,214 |
| Calculation by the formula of Scheurer-Kestner and Meunier Dolfus .................... | 15,455 |
| Calculation by the formula of Corrét ............... | 15,613 |
| Calculation by the formula of Ser ................. | 16,682 |
| Experimental result by Scheurer-Kestner ........... | 15,955 |

In the above figures the calorific value is given as that of pure coal, which is in accordance with the practice of Continental authorities when dealing with coal on a scientific rather than on a commercial basis, and this accounts for the high values. Nor in these figures is there any correction made for the heat which would in practice be carried away as latent heat in the steam, which is the product of the combustion of the hydrogen, but which is retained and measured in a calorimeter.

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* Abstract of a Paper read before the Dublin Local Section of the Institution of Electrical Engineers on April 5, 1906.

In 1900 Dr. Bünte published the results of a series of laboratory experiments on the chemical composition of almost every kind of coal used in Germany with the calculated calorific power of each according to the formula,

$$81\,C+290\left(H-\frac{O}{8}\right)+25S-6W,$$

where C=percentage of carbon; H=percentage of hydrogen; O=percentage of oxygen; S=percentage of sulphur; W=percentage of moisture; and he found that the calculated values approximated very closely indeed to the values of the same fuels as determined by calorimetric experiments. The committee of the American Society of Mechanical Engineers on the standard method of conducting steam boiler trials, dated 1889, adopted Dr. Bünte's formula.

It is generally agreed that the calorimetric determination of the calorific value of a coal is more satisfactory than any value ascertained by calculation, for the ultimate constituents of two coals may be approximately the same in their proportions and yet be very differently developed in the intermediate stage of distillation.

The determination of the exact amount of heat developed in chemical combinations of the subjects under examination with air or pure oxygen is a subject which has received considerable attention from a number of experimenters, most of whom devised special apparatus to test the substances they were studying, but none of them produced a simple instrument by which the calorific value of a complex material like coal could be fairly accurately determined without the assistance of highly-skilled experts. In a Paper written by the author in conjunction with the late Mr. Bryan Donkin, and published in Vol. CII. of the *Proceedings* of the Institution of Civil Engineers, a description is given of various early forms of calorimeters—viz., Rumford's, Ure's, Swackhöfer, Fischer, Lewis Thompson, William Thompson, Berthelôt's, and Favre and Silbermann's. The principle of all these instruments is the same—viz., the heat evolved by the complete combustion of a known quantity of the combustible is transferred to a weighed quantity of water, and from the increase in the temperature of the water the calorific value of the fuel is obtained by calculation.

In Rumford's and Ure's instruments comparatively large quantities of combustible were used, combustion being accelerated by bellows. These instruments are of little more than historical interest. The instruments of Fischer, Favre and Silbermann and Swacköfer are essentially of the laboratory class, and, consequently, of less present interest than the commercial instruments of Lewis Thompson, William Thompson and the Mähler bomb calorimeter.

The Lewis Thompson instrument is of great interest on account of the ingenious method of supplying to the fuel the oxygen necessary for combustion. This instrument achieved a considerable amount of popularity, and is still the recognised instrument for testing coal used in some of our technical schools, though in accuracy it is far surpassed by the William Thompson and bomb calorimeters. The instrument consists of a glass vessel which holds, when filled to a mark about one-third the distance from the top, 2,000 grammes of water. The furnace is a copper cylinder, closed at one end, which contains the charge of 2 grammes of finely-powered coal intimately mixed with the oxygen mixture, composed of three parts by weight of potasssic chlorate and one part of potassic nitrate. A cotton fusee, prepared by dipping it in a solution of potassic nitrate and drying it, about ½ in. in length is fixed in the centre to the extent of half its length. The temperature of the water having been accurately taken, the fuse is ignited, the diving bell is fixed over the furnace on to the cover, and the whole lowered rapidly into the water, the stop-cock being closed. The combustion takes about two minutes and the gases escape through holes in the bottom of the diving bell and in the base, and give up their heat to the water as they rise to the surface. The temperature of the water is raised about 10°F. with a fair sample of coal. The heat capacity of the glass vessel, the copper cylinder, and diving bell, and the thermometer must be allowed for. Then an allowance must be made for imperfect combustion, cooling losses. The cooling losses can be determined experimentally, but the other losses cannot, and they will vary with different classes of coal, so that it is better to find a constant for each instrument by burning in it a sample of coal of known heating capacity, and determinnig the value in thermal degrees of the thermometer. The rule of the inventor was to add 10 per cent. to the result of the experiment to cover all loses, but this is generally found to be insufficient. Several points have to be observed in working with this instrument. The author of the present Paper has found that with coals rich in hydro-carbons better results are obtained by increasing the proportion of oxygen mixture. Anthracite coals and coke are only burned with difficulty, and generally leave behind appreciable quantities of unburned carbon. The copper furnaces oxidise rapidly and require frequent renewal. Dr. F. Stohmann and Herr C. von. Richenberg have developed the idea of the Lewis Thompson calorimeter, and have evolved a reliable instrument, which, however, is so elaborated as to become a laboratory rather than a commercial instrument.

A better instrument for the purposes of the steam user than any of those already mentioned is that designed by Prof. William Thompson (*Journal* of the Society of Chemical Industry, 1886, Vol. V., p. 581). The diving-bell arrangement of the Lewis Thompson is retained, but instead of deriving the oxygen necessary for combustion from solid salts mixed with the fuel, it is forced into the diving bell in the gaseous state and made to impinge on the glowing fuel. In W. Thompson's original instrument 1 gramme of the fuel to be tested was placed in a small platinum crucible supported on a clay stand affixed to the metal base. The diving bell, of glass, is attached to the metal base by springs. Oxygen is supplied from an outside source to the copper tube, which fits loosely in the elongated stem of the diving bell. The products of combustion and excess oxygen escape through the holes in the metal base, and the bubbles of gas as they rise through the water are broken up by wire screens, and the heat they contain is thoroughly transmitted to the water. The water is contained in a glass vessel, which is protected from draughts by a metal casing.

The author has made several modifications of Prof. Thompson's instrument, with a view to rendering it more self-contained and reliable in working. The outer metal case is replaced by a glass cylinder, which allows the progress of combustion to be watched, and the whole is mounted on a stand provided with levelling screws and a support for the calorimeter thermometer, and a second thermometer to show the air temperature. A stirrup is affixed to the base, which allows the whole apparatus to be used as an agitator, and a bayonet joint is used to secure the bell to the base instead of springs. A stirrer fixed on the end of the oxygen pipe allows the fuel to be raked, so that none of it escapes contact with the stream of oxygen. Using 2 grammes of fuel the combustion lasts about 10 minutes, and in this time losses by radiation would be serious, being at the rate of about 0·02°C. per minute, but these losses are practically eliminated by having the temperature of water some 3°C. below at the beginning of the experiment, and finishing with it about the same amount above the temperature of the room, and even with this precaution some allowance for losses must be made. A rather crude form of this instrument is on the market as the Houston calorimeter.

An instrument which has recently found much favour is the bomb calorimeter, originally invented by M. Berthelôt, and improved by M. Mähler. In this a new principle is employed. The fuel to be tested is carried on a platinum dish and enclosed in a steel bomb, into which is introduced at a high pressure sufficient oxygen gas for combustion. The bomb is inserted in water in the calorimeter, and fired by an electric spark. The products of combustion are allowed to escape through a coiled tube closed by a tap, and it can be arranged to collect them for analysis. The apparatus gives good results in working, but requires delicate manipulation, and is necessarily expensive.

In view of the extensive and extending use of gas engines and producer gas, mention must be made of the gas calorimeter, prescribed by Metropolitan gas referee for the calorific test of gas supplied in London. This apparatus, devised by Prof. C. V. Boys, was described by him in a Paper read before the Royal Society on December 7, 1905. The gas, measured by a test meter and regulated by a pendulum governor, is delivered to the pair of burners which are fixed in the base of the instrument. The burners are surrounded by a chimney which is encircled by a series of Clarkson tubes, these again by a ring of non-conducting material encircled by a second ring of Clarkson tubes, and the whole enclosed in a light metal casing which is an easy fit in the outer case; in the cover of the case, are the water inlets to the exit from the Clarkson tubes through which the cooling water circulates. The air supply is through holes in the base; the products of combustion pass through the chimney into the lower part of the water outlet casting and over the Clarkson tubes to the gas outlet. The water supply is maintained at constant pressure, and the quantity used is measured, as is also the quantity of water condensed, for which the necessary correction is made in calculating the results. Other gas calorimeters are the Simmance-Abady and Junker calorimeters.

The selection and preparation of a sample of coal for test or analysis is a matter of the first importance. In dealing with a small sample, the following course is recommended: The sample is spread out on a clean metal plate, and all the larger lumps reduced to the size of peas. The whole is then well mixed and spread out over the plate and divided by cross lines into four equal portions. Two alternate sections of these are retained and two rejected. The retained portions are then put into a sieve of about eight meshes to the linear inch, and all the lumps that will not pass through the sieve are broken down to do so. The process of mixing and halving continues till a sample of about 1 oz. is left. This is reduced by grinding in a mortar till it all passes through a sieve of 30 meshes to the linear inch. If the fuel is an anthracite coal or coke, it is necessary to pass it through a still finer sieve of, say, 60 meshes to the inch before burning it in the calorimeter. The sample of about 10 grammes is then put into a drying bottle, weighed and dried at a temperature not exceeding 220°F., the process being continued till no further alteration in weight is found. The weight lost will give the moisture in the fuel as received. A portion of the sample, 1 to 2 grammes, is then weighed in a porcelain crucible and burned to destruction in a muffle furnace, and the remaining weight gives the ash or incombustible in the coal. The calorimeter samples are then taken from the drying bottle, which should be kept well stoppered to prevent oxidation of the coal. There is another method of testing coal which will appeal to every steam user—viz., the actual test in the boiler. It would be superfluous here to enter into all the details of a boiler test, and reference is made to the report of the committee on steam engine and boiler trials which appears in Vol. CL., 1901-2, of the *Proceedings* of the Institution of Civil Engineers, which deals very fully with the subject.

Let us now consider in what respects other than its calorific power the value of coal varies. First, as regards size, it is well known that the slack or dust from any coal commands but a small price compared with that of the large coal produced with it. The variation in calorific power may be very slight, but it is generally found that at the pit's mouth, large coal, which will pass over a screen of 2 in. mesh, will command nearly double the price of the coal that passes through the screen, and in some cases the difference is much greater. This difference is mainly due to the fact that small coal does not burn well in ordinary furnaces with fixed bars. The small particles of coal soon close up the airways between the bars, and a fair rate of combustion cannot be maintained. With the blocking of the airways the bars soon miss the cooling effect of the air passing over them, and get overheated and sometimes melted down. The difficulty is met by the use of mechanical stokers, rocking bars, &c., of which the number and variety is legion. They depend for their commercial success largely on their ability to evolve the heat contained in the small coal or slack as efficiently as the heat would be evolved in a plain hand-fired furnace with the large coal from which the slack might have been produced. Small coal is also successfully burned in fixed grates of special construction, in which the bars are artificially cooled by water, as in Pinèt's furnace, or by the use of a steam jet with special bars, as in Meldrum's furnace. Small coals are generally of a much higher calorific value as compared with large coal than the respective prices would lead one to expect, and it is to the advantage of the steam user to make use of such fuels whenever he can do so. The character of the clinker formed, the comparative smokelessness, are amongst the features to be considered when comparing one coal with another, and the testing of different coals in a standard boiler under standard conditions is, perhaps, the only reliable method of arriving at a decision on such points.

There is a further property of coal which materially affects its value for the purpose of steam raising—that is, the speed at which it can be burned, or the rate at which it can be made to yield the energy stored in it. Where boiler power is inadequate it is possible that the adoption of a quicker burning fuel may prevent or postpone the expenditure of capital on additional boilers, or in a large installation may, by reducing the number of boilers to be kept in work, either increase the margin of space or reduce the size of the installation, and thus keep down capital expenditure. A due appreciation of this feature will possible justify the steam user in being satisfied with something less than the highest economy as represented by the amount of steam produced per pound of fuel.

In conclusion, the following general rules may be enunciated as applicable to coal testing: (1) be satisfied that the sample examined absolutely represents the bulk; (2) be as sure of the results of the examination as if you had made all the determinations yourself; (3) in comparing results, leave a fair margin for variations, personal equation and other variables.

The following clause for insertion in a specification or tender form may be of use: "The coal shall be delivered in a reasonably dry state, free from stones, dirt and fine slack, and shall contain on delivery — per cent of large, which shall be that retained on a metal screen of — meshes to the linear foot, and shall develop when tested in a —— calorimeter not less than — thermal units per pound of the dry coal, and shall leave not more than — per cent. of incombustible matter when completely burned in a muffle furnace."

## DISCUSSION.

Mr. T. TOMLINSON considered that calorimeter tests, even with apparatus much cruder than the apparatus of Prof. Wm. Thompson or than the more elaborate "Bomb" calorimeter, were capable of giving thoroughly reliable results provided they were standardised by actual calorimetric estimations of a fuel of which the calorimetric value was known. The actual test under a boiler was, however, the most reliable, provided arrangements were made for such changes, as regards fire bars, grate area and air admission, as would be necessary in practice in dealing with the particular class of fuel dealt with.

Mr. W. J. U. SOWTER saw a difficulty in the boiler test in ensuring that the boiler should always be in the same condition as to scale—a very small thickness made a big difference in evaporation. As to the economy of burning very small coal in special furnaces, he had known of a case where the cost of steam raising had been reduced by one-half by this means.

Mr. R. B. FOSTER wished to know whether, if your chemical analysis showed elements in combination, such as combined carbon and combined sulphur, you could get fairly reliable results.

Mr. W. TATLOW said that there was great need of a suitable substance with which to standardise the calorimeter, and suggested the use of crystallised sugar.

Mr. P. S. SHEARDOWN remarked that the Paper was scarcely open to discussion, and was the work of an expert. In his experience the behaviour of the coal varied from cargo to cargo, and even in one cargo, and the practical difficulty was that these varying cargoes required different treatment for best economy; and that, when burning coal on a large scale, you had only got into the best manner of utilising a given cargo in the most economical manner when a new cargo, possibly requiring quite different treatment, was delivered. This was a practical point with which no calorimetric estimation could deal.

Mr. HOLLIDAY (in reply) explained that he used his standard boiler for the comparison, on a commercial scale, of coals of about the same quality, and that he varied air and grate area as required. He agreed with Mr. Tomlinson that excellent comparative results could be got with the L. Thompson calorimeter, but he would not rely on it for accurate quantitative results. In reply to Mr. Tatlow, he had tried charcoal as a standard, but found it defective, as it occluded hydrogren, and that in varying quantities. In practice he had used a sample of Welsh steam coal powdered and kept in an air-tight flask.

## EXTERIOR LIGHTING BY MERCURY VAPOUR LAMPS.

The first installation of Cooper Hewitt mercury vapour lamps for exterior lighting in this country is now to be seen outside the *Tribune* offices in Bouverie-street, E.C. The general appearance of the lamps is shown in Fig. 1. The six lamps installed are each of 800 c.p., enclosed in a specially designed weatherproof lantern, shown in Fig. 2. They give a brilliant light of a mauve colour, which distinctly illuminates the large building, and arouses considerable interest among the passers-by. The lamps themselves do not differ from the ordinary form for indoor lighting. They are 45 in. long by 1 in. in diameter, and work on a 200 volt direct-current circuit. It will be remembered that they are started by tilting the tube so that the mercury flows from one electrode to the other in a small stream. The metallic mercury momentarily connects the two electrodes, and as the stream breaks, an arc is formed which increases the vapour pressure. The vapour then becomes luminous. The lanterns, accordingly, had to be constructed in such a manner as to make the tilting of the lamps possible. They are suspended on trunnions by which the lantern and lamp are tilted together by hand.

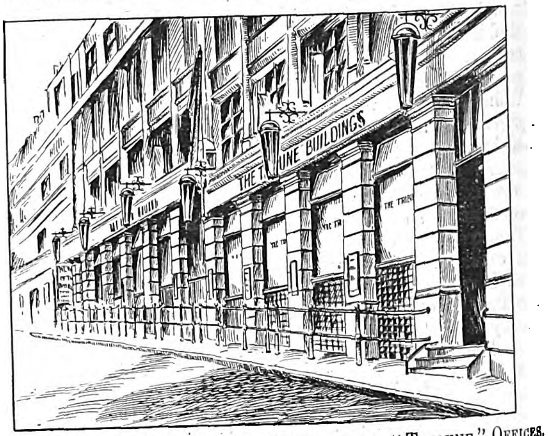

Fig. 1.—Mercury Vapour Lamps outside the "Tribune" Offices.

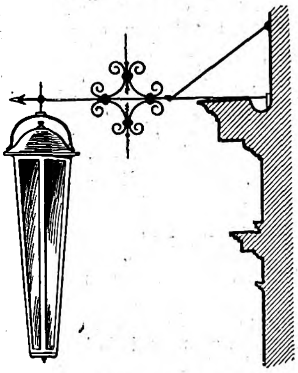

Fig. 2.—Special Lantern for Mercury Vapour Lamp.

An advantage possessed by the mercury vapour lamp over the arc lamp is that it requires no trimming nor attention. Its efficiency also is higher, the energy consumption being under half a watt per candle-power. On the other hand, although the makers claim that the colour of its light causes the least amount of eye fatigue, the entire absence of red rays and the peculiar and weird effects this produces are undoubtedly a drawback. The greater steadiness of the mercury vapour lamp in comparison with the arc is some compensation for this, and the diffusion is certainly good. The weatherproof lanterns outside the *Tribune* offices were designed by the British Westinghouse Co., who hold the patent rights of the Cooper-Hewitt lamp for the United Kingdom.

## NOTES ON THE CLEANING OF WORK BY MEANS OF THE ELECTRIC CURRENT.*

BY H. S. COLEMAN.

Under certain conditions, work, consisting of iron and brass articles to be nickel-plated, may be cleaned by means of the electric current. Having large quantities to deal with, I could not get sufficient scoured by hand to keep the plating vats fully loaded. After increasing the staff of operators and getting little better results, I was advised to try cleaning by means of the electric current. Cables were carried to the iron tank containing a boiling solution of potassium hydrate (brown Montreal potashes), sp. gr. 12°T. A series of experiments were performed, chief of which are given below.

*Experiment* 1.—Using the iron tank as the cathode, and the work to be cleaned as the anode. Current flowing for five minutes. P.D. 1·75 volts.

*Result.*—Part of the grease appeared to be removed, but the surface of the work (cathode) was covered with a brown-stained deposit, which could not be removed by acid or cyanide dip.

*Experiment* 2.—Using the iron tank as the anode, and the work the cathode. Current flowing for five minutes. P.D. 1·5 volts.

*Result.*—The work was free from grease and dirt, but the surface was covered with a lead-coloured stain or deposit, which could not be removed by acid dips, and only very slowly by a cyanide dip.

At this stage it was decided to try the effect of reversing the current, in order to remove this "stain," or "deposit," if possible. Repeating experiment 2, I waited until the "stain" appeared, and then reversed the current. The result was very satisfactory; the "stain" disappeared, and the surface of the work became clear and bright.

A final experiment was performed to determine the current density required for successful working. This was as follows: Approximate area of work, 8½ sq. ft.; current, 68 amperes; working C.D., 8 amperes per sq. ft.; P.D., 2½ volts.

In experiment 1 the cathode (iron tank) did not show any signs of electrolytic action having taken place. In experiment 2, however, the anode (iron tank) was attacked, the surface being covered with a thin layer of oxide. This I anticipated from the fact that, during the time the work is the *cathode* the whole of the grease and dirt is removed, the reversal to *anode* being only necessary for the removal of the stain. That the cleaning is due to an electrolytic, and not merely a chemical, change, I feel convinced, for unlike ordinary chemical potash cleaning, the same result is obtained by using a *cold* bath. The cleaning, however, is very much slower than with the hot bath. Electrolysis takes place, and minute quantities of metallic sodium (using sodium hydrate solution only) appear around the cathodes (work), and occasionally take fire. In actual working it is much better to use the hot solution. By this process the grease, which consists chiefly of tallow, is saponified and remains in solution. The lighter dirt is thrown upon the surface of the bath and may be skimmed off, the remainder, consisting of very fine emery, falling to the bottom of the tank.

A working plant capable of cleaning a considerable quantity of work per day consists of the following, the necessary current being supplied from the plating dynamo: There is a wrough-iron tank containing the cleaning solution. Over each end is erected a wooden structure, clear of the tank, to support the rods on which the work hangs. Along the top of each support is a flat copper strip, which is connected to the cable by means of a stud. The rods are made of H.C. hard-drawn copper. These make surface contact only, owing to the variety of articles to be cleaned. There is a resistance board and change-over switch in the circuit.

In the first stage of the process the iron tank is used as the anode, and the work the cathode. A voltmeter is connected across the terminals of the bath for recording the difference of pressure, the current being recorded on the ammeter placed in the main circuit from the dynamo. The cleaning bath is made up of equal quantities of brown Montreal potash and sodium hydrate dissolved in water and kept boiling, sp. gr. 18°T. The work, after wiring up in the usual way, is distributed along the copper rods in small bunches. The current is now switched on and adjusted until a difference of pressure of 2½ volts is recorded on the voltmeter. Immediately the surface of the work begins to change colour, which takes from 5 to 10 minutes; the current is then reversed for a short time, usually 30 to 40 seconds, until the surface is clear and bright. It is then switched off, and if the work is still dirty the operation is repeated. It is then thoroughly swilled in clean, cold water, passed through suitable dipping solutions, electro coppered, passed through clean cold water again and transferred to the plating bath.

The advantages of this process are: (1) The work is cleaned in one-third of the time occupied by the older method of scouring by hand; (2) it is all wired up ready for plating, and the surface is not touched again by the hand until it is unwired after plating. This not only prevents a certain amount of stripping, but also saves the considerable time which would be occupied in wiring up again, after scouring by hand; (3) the work is rendered *chemically* clean, due to the action of the current working out all grease and dirt from parts where it is impossible to scour with a brush; (4) time is saved in filling the vats, thus giving an increased output; (5) saving of labour and materials.

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* Paper read before the Faraday Society last Tuesday.

## A SPHERICAL PHOTOMETER.

Herr L. Bloch contributed recently a very valuable article on a spherical photometer to the *Elektrotechnische Zeitschrift*. The spherical photometer, invented by Prof. Ulbricht some five years ago, enables the mean spherical or the mean hemispherical illuminating power of a portable source of light to be determined by a single measurement. It consists essentially of a hollow sphere whose inside is painted dull white. Herr Bloch proves mathematically that any point on the inner surface of the sphere, if screened from direct rays of the lamp tested, receives by reflection an amount of light which is proportional to the mean spherical candle-power if the source of light be suspended in the centre of the sphere, and is proportional to the mean hemispherical candle-power if the source of light be on the inner surface of the sphere. In the former case it does not matter how irregularly the light is distributed from the source, but in the second case the assumption is made that the flux of light emitted is symmetrical with respect to the radius of the sphere through the source of light. This condition is frequently very closely approximated to in practice. It is not necessary for the lamp tested to be exactly in the centre of the sphere, for the author proves that the illumination at any point on the interior surface of the sphere remains practically constant unless the lamp be shifted to a considerable distance out of the centre. The error, for example, remains less than 1½ per cent. as long as the light is between the centre and a point midway between the centre and the inner surface of the sphere.

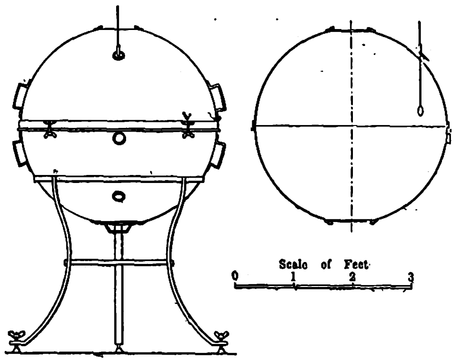

FIG. 1.—ELEVATION AND SECTION OF SPHERICAL PHOTOMETER.

Fig. 1 represents the "sphere" photometer as used for the tests described below. As it was intended to use the apparatus chiefly for testing powerful arc lamps, the internal diameter of the sphere was fixed at 1 metre (3 ft. 3⅓ in.). The hemispheres are of 2 mm. (0·079 in.) zinc plate, the upper half being removable. There is an opening of 200 mm. (7·86 in.) diameter at the top for introducing the lamps, and another opening of 250 mm. (9·84 in.) diameter is provided at the bottom which can be used for the insertion of specially large lamps and for removing any deposit. There are also three small peep-holes 50 mm. (1·97 in.) in diameter and fitted with lids arranged as indicated in Fig. 1. A disc of white opaque cardboard, 55 mm. (2·16 in.) in diameter, serves to screen that peep-hole used for photometric purposes from the direct rays. It is attached to the end of an adjustable rod, which protrudes through the upper peep-hole. The sphere as well as all the lids are painted on the inside with "Lithopone" (barium sulphate) to a recipe by Prof. W. Wedding. It is said that this paint withstands the intense illumination of powerful arc lamps for a long time without turning yellow.

Fig. 2 is a simplified section through the photometer used to determine the degree of illumination at one of the peep-holes. It is of the design first suggested by Prof. Brodhun. The light of the lamp to be tested is compared, with the aid of the Lummer-Brodhun prism W, with a 1·5 c.p. osmium lamp O fed from a 3 volt storage battery. To carry out measurements, the flux of light from the osmium lamp is rendered intermittent, the duration of the light flashes being altered until adjustment has been attained. According to Talbot's law, the light from a source which is periodically covered and uncovered, appears to the eye to be steady, provided the frequency of the flashes be high, the ratio of the apparent illumination to the actual illumination being the same as the ratio of the time during which the light is uncovered to a complete period. An image of the small disc *d* of frosted glass in front of the osmium lamp is produced at W by means of the lenses and the two prisms *pp*. These two prisms are set in rapid rotation by the small electric motor M, so that the rays of light passing through *pp* on their way from *d* to W are also given a rotary motion. This rotating beam passes through a shutter with a fixed and a movable sector (shown on a larger scale on the left-hand side of Fig. 2), the aperture of which may be varied from 0 deg. to 110 deg. by means of the small handle *t*. The position of this handle *t* can be read off very accurately by means of a vernier, and forms an indication of the apparent illumination from the osmium lamp. The light from the lamp under test falls through the peep-hole and the tube T on to a plate S of plaster of paris, by which it is diffused. Those rays which fall on the prism *k* are reflected in the direction of the axis of the apparatus, and an image of the illuminated disc is formed at W by means of lenses, and is finally focussed by the eye-piece *l*. The tube T can be rotated about the axis of the apparatus, and its position may be read off at *h*. The photometer can be calibrated by direct comparison with a light of known illuminating power. For measuring lamps of extra high candle-power, the light is partly absorbed by one or more frosted or smoked glasses inserted in the tube T. An image of the illuminated frosted glass is then thrown by a suitable combination of lenses on to a small mirror (which takes the place of the plaster of paris plate), from which the light is reflected as before. In the former arrangement the distance is measured from the plaster of paris plate, while in the latter case the distance is measured from the frosted glass plate to the source of light.

A series of experiments were made to verify the theoretical conclusions mentioned above. A number of sources of light, having a very unequal distribution of light, were placed successively in the centre of the sphere, photometric tests being carried out at various points. It was thus shown that all points on the inner surface were practically equally brilliant, however irregular the distribution of the light from the lamp. The illumination of the inner surface depends to a certain extent on the size of the lamp fittings, and if these are large compared with the diameter of the sphere, the readings will not be strictly correct. In order to investigate this point, the author experimented with three lamps, the distribution of light from which differed in each case and whose fittings increased in bulk in the order of enumeration: (1) A 110 volt carbon filament lamp; (2) a 6 ampere continuous-current arc lamp with vertical carbons and without globe; and (3) a 15 ampere continuous-current flame arc lamp with vertical carbons and without globe. The mean spherical candle-power of these lamps, determined carefully by the point-to-point method, will be found in the first vertical column of Table I., while the second column contains the corresponding relative figures, the spherical candle-power of the carbon filament lamp being taken as unity. Measurements were taken at the peep-hole in the horizontal plane, the source of light being placed in the centre in one series of tests and about 10 cm. (4 in.) from the top of the sphere in the other series. The corresponding readings of the photometer are arranged in columns 3 and 5, and columns 4 and 6 contain the relative values. It will be observed, first of all, that the readings are invariably greater when the lamp is near the inner surface of the sphere than when the lamp is in the centre. The reason is that the fittings shield the peep-hole from the reflected rays more or less when the lamp is in the centre. It may also be gathered that the errors due to the screening effect of the fittings outweigh considerably the errors due to the shifting of the lamp out of the centre. In order to obtain good results, it is therefore advisable to place the larger parts of the lamp fittings outside the sphere as far as possible. A number of tests were next undertaken to determine whether it was necessary to have the lamp always at exactly the same distance from the inner surface of the sphere, and it was found that the measurements remained the same as long as the distance was not less than 8 cm. and not more than 15 cm.

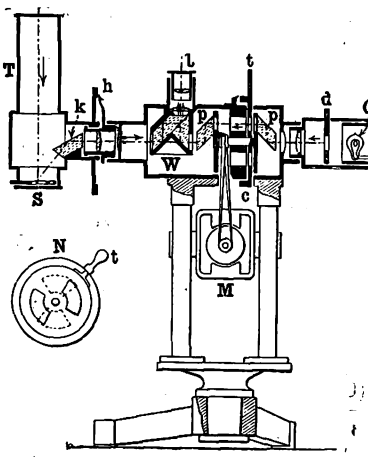

Fig. 2.—Section of Photometer.

The constant of the photometer was determined by means of a 110 volt carbon filament lamp, whose mean spherical candle-power was carefully determined and found to be 21·1 c.p. A number of different lamps were then suspended 10 cm. (4 in.) from the top and tested. These lamps included a 2 ampere continuous-current arc lamp (81½ c.p.) with vertical carbons and globe, a 10 ampere continuous-current arc lamp with inclined carbons without a globe (750 c.p.) and a 20 ampere flame arc lamp without globe (2,350 c.p.). Although the distribution and intensity of the light differed greatly from case to case, and was very irregular in each particular case also, the agreement in the figures for the spherical candle-power, obtained by the ordinary point-to-point method and by means of a single measurement with the sphere photometer agreed very well, the largest difference amounting to only 3·1 per cent.

A number of precautions must be observed when taking measurements. The peep-hole must be carefully screened from the direct rays, the photometer must be fixed exactly in front of the peep-hole and the interior coat of paint must be uniform and well preserved. It is also advisable to check the photometer constant at frequent intervals.

### Table I.

| Type of lamp under test. | Mean spherical candle-power. | Ratio. | Photometer reading. | | | |
|---|---|---|---|---|---|---|
| | | | Lamp in centre. | | Lamp 4 in. from the top. | |
| | | | Scale read'g | Ratio. | Scale read'g | Ratio. |
| Carbon filament lamp...... | 21·1 | 1 | 43 | 1 | 44·5 | 1 |
| 6 ampere continuous-current arc lamp .............. | 255 | 12·1 | 473 | 11·0 | 550 | 12·3 |
| 15 ampere continuous-current flame arc lamp .... | 1,000 | 47·3 | 1,800 | 41·8 | 2,060 | 46·3 |

If the source of light is very large, the cardboard shield used for screening the peep-hole from the direct rays assumes considerable proportions and screens the peep-hole, also, from a considerable portion of the reflected rays. For this reason tests on large lamps and lamps with large reflectors or globes are liable to error. It is stated, however, that measurements of sufficient accuracy for practical purposes can be made with a photometer of 1 metre diameter, provided the source of light is not more than about 12 cm. in diameter.

In order to prove experimentally that the photometer measures the hemispherical candle-power when the source of light is on the inner surface of the sphere, Herr Bloch carried out a series of tests with different types of lamps, of which the results are given in the table below:—

### Table II.

| Type of lamp. | Hemispherical candle-power. | | Error in per cent. |
|---|---|---|---|
| | Determined by the point-to-point method. | Measured in the photometer. | |
| Carbon filament .. | 21·5 | 21·5 | .. |
| 2 ampere arc ...... | 116 | 117 | +0·9 |
| 6 ampere arc ...... | 458 | 450 | −1·8 |
| 15 ampere flame arc | 1,960 | 1,980 | +1·0 |
| 10 ampere arc, with slanting carbons.. | 1,390 | 1,360 | −2·2 |

The author does not recommend this method of measuring the mean hemispherical candle-power for practical use, because the accuracy of the result depends to a very great extent on the exactness with which the position of the source of light is adjusted.

**A Method of Supporting Osmium Filaments.**—Owing to the flexibility of osmium filaments when incandescent and their liability to breakage during transport, it is advisable to provide these filaments with suitable supports within the lamp globe to prevent excessive pressure or vibration. In a patent granted to C. A. von Welsbach it is stated that a satisfactory material for the support of osmium filaments is found in an intimate mixture of about 10 parts, by weight, of pure thorium oxide and about one part of magnesia. These oxides are mixed in a powdered form and used with a viscous binding material consisting of a solution of sugar. This paste is shaped into rods which are dried and subsequently burned in free air until all organic matter is consumed. The support thus formed is non-adherent to incandescent osmium and is chemically indifferent thereto.

# CORRESPONDENCE.

## ELECTRIC IGNITION FOR MOTOR CARS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention was drawn to a Paper on "Electric Ignition for Motor Cars," read by Mr. Frank Little before the Newcastle Local Section of the Institution of Electrical Engineers on February 5, 1906. In the course of this Paper I found a number of paragraphs which seemed to me to have a singularly familiar sound. I have extracted some of these paragraphs and have placed them side by side with some paragraphs from a book entitled "O'Gorman's Motor Pocket Book," of which I happen to have a copy. Before sending you these parallel extracts, I wrote to the secretary of the Newcastle Section and asked him whether any acknowledgment of the origin of these paragraphs had been made, and he very promptly sent me a copy of the original Paper, in which I looked in vain for such acknowledgment.—Yours, &c.,

MERVYN O'GORMAN.

82, Victoria-street, Westminster, S.W., April 7.

| EXTRACTS FROM MR. FRANK LITTLE'S PAPER ON "ELECTRIC IGNITION FOR MOTOR CARS." | EXTRACTS FROM "O'GORMAN'S MOTOR POCKET BOOK." |
|---|---|
| To get the best output from an explosion engine you must ignite at the best moment. . . . The finding of the happy medium is left to the activity and skill of the driver in most cars. | *Page 170:* To get the best output from an explosion engine we must ignite at the best moment. . . . The finding of the happy medium is left to the activity and skill of the driver in almost all motor-cars, and he can only use the method of trial and error. |
| When obliged by a hill climb to change his gear ratio, the driver (who has only two hands and two feet, but many levers to manage) is very often compelled to use his engine inefficiently, firing the best of his pressure into the exhaust, and getting a diminished torque at the very moment when he wants all his output . . . increased speed of the engine requires earlier ignition . . . upon the spark occurring the explosion is instantaneous. The complete ignition of a cylinder full of gas takes an appreciable time. One reason for moving the ignition spark to an earlier moment when running faster is owing to the lost "time in" due to the inertia of the trembler becoming relatively important at the high engine speeds. | When obliged by a hill climb to change his gear ratio, the driver (who has only two hands and two feet, but many levers to manage) is very often compelled to use his engine inefficiently, firing the best of his pressure into the exhaust, and getting a diminished torque at the very moment when he wants all his output. . . . The greater speed calls for an earlier ignition. . . . It is sometimes thought that upon a spark occurring the explosion is instantaneous. This is wrong. One reason for moving the ignition spark to an earlier moment when running faster is based upon the fact that the complete ignition of a cylinder full of gas takes an appreciable time. The other reason is the "lost time" due to the inertia of the trembler becoming relatively important at high engine speeds. |

# CRYSTAL PALACE SCHOOL OF ENGINEERING.

The 100th presentation of certificates to the students of the Crystal Palace Company's School of Practical Engineering took place on Wednesday, when Sir Alexander R. Binnie, President of the Institution of Civil Engineers, distributed the awards to the students of the last term.

In his address to the students, parents and other well-wishers, who were present in large numbers, Sir Alexander recalled the old days when technical education was practically unknown and when the engineering pioneers made their way by sheer force of brain, character and hard work. Nowadays, with the greater facilities for obtaining technical education, there was a danger of turning out as engineers many men who lacked that love for their profession and that self-reliance which characterised the early engineers. Only those could possibly succeed who made their profession their life's work, sacrificing, if necessary, athletic recreations to some extent. It was also necessary to avoid narrow specialisation, and every engineer ought to have a thorough grasp of Nature's laws, especially those of electricity and chemistry. Engineers, to be successful, ought also to cultivate the sense of tact, which was invaluable in connection with the control of men.

Mr. J. W. WILSON, the principal, spoke on the continued prosperity of the school and the striking success attained by many of the former students, who numbered altogether some 900 during the last 33 years.

In the engineering and electrical workshops and laboratories, which were open to inspection before and after the distribution of certificates, were exhibited examples of work done by the students during the past term. The exhibits included drawings of mechanical and electrical machinery, small electric motors, complete vertical steam engines, patterns, castings, a variety of finished machine parts and so on. All the work shown appeared to be neat and accurately made, and this must be largely attributed to the personal attention which is given to each individual student by the instructors. This personal supervision and care is, indeed, the keynote of this school. Practical and theoretical training is intermixed in a perfect manner, a feature which was humorously referred to in one of the speeches—after luncheon—as the plum-cake system in contradistinction to the sandwich system.

# PARLIAMENTARY INTELLIGENCE.

## SCOTTISH TRAMWAY PROVISIONAL ORDERS.

An inquiry has been held during the week at Edinburgh by a Commission appointed under the Private Legislation Procedure (Scotland) Act into a number of Scotch tramway schemes. The Commissioners were Lord Killanin, chairman, Lord Sinclair, Viscount Dalrymple, M.P., and Mr. Alexander Findlay, M.P.

**Falkirk and District Extensions.**—The object of this order was to extend the mileage already owned by the Falkirk & District Tramways Co. by about 2 miles, in order to link up the districts of Laurieston and Grangemouth. The chief opponents to the proposal were the Caledonian Railway Co., the North British Railway Co. and the Scottish Central Electric Power Co. The first two opposed on the ground of competition, and the Power Co., it was stated, sought the insertion of a clause practically forcing the tramway company to be their customer, whereas the promoters wished to be free to bargain with any supply authority. Mr. Stephen Sellon, who gave evidence in favour of the proposed routes, estimated the capital expenditure at £57,000 and the total revenue at over £10,000. The Commissioners found the preamble proved, but struck out a clause dealing with the carriage of goods, &c.

**Dunfermline Tramways.**—This was a proposal to construct a new system of tramways, having its centre in Dunfermline and radiating in various directions to a total length of 18 miles. Great stress was laid upon the present want of adequate railway facilities, and it was stated that the local authorities favoured the scheme. Mr Stephen Sellon, on behalf of the promoters, said there were no engineering difficulties with regard to the line, and Mr. Peebles, of Messrs. Bruce Peebles & Co., spoke as to the interest of his firm in the bill and their intention to carry out the works. The preamble of the order was eventually passed, with the exception of one branch of the proposed lines.

## THE LONDON POWER BILLS.

The following have been nominated by the Committee of Selection of the House of Commons to serve on the Hybrid Committee which will consider the London County Council (Electric Supply) Bill: Sir Francis Lowe (Unionist), Mr. Henry Norman (Liberal), Mr. Richard Bell (Labour), Mr. J. H. Duncan (Liberal). The other members of the Committee which we announced last week are as follows: Mr. Chance (Liberal), Mr. Joseph Nolan (Irish Nationalist), Mr. James Parker (Labour), Mr. Watson Rutherford (Unionist) and Mr. Luke White (Liberal).

## MISCELLANEOUS.

**Workmen's Compensation Bill.**—The Workmen's Compensation Bill was further discussed in the House of Commons on Tuesday. The main provisions of the bill were given in issue of March 30. It was read a second time, and was then referred to the Standing Committee on Law.

**Reduction of Telephone Rates.**—In reply to a question by Mr. Henniker Heaton in the House of Commons on Tuesday, the Postmaster-General said that he had read a speech delivered by the Australian Commonwealth Postmaster-General, in which his conviction was expressed that he would be able to give every man a telephone in his own house for a shilling per week. He understood, however, that this speech was delivered at the annual picnic of the Electric Telegraph and Telephone Construction Branch Union at Sydney, and that the nature of the cheap telephone service referred to was not explained. From other sources, however, he gathered that it was intended to be the minimum charge in small towns for a limited number of calls made on a four party line. Additional calls beyond the minimum number would have to be paid for. Although he was looking into the present charges in this country, he saw no possibility of giving an efficient service at the rate mentioned.

The Watford & Edgware Railway Bill is now unopposed.

The Wireless Telegraphy Bill, 1906, was read a second time in the House of Lords on Friday.

The Todmorden Corporation Bill was read a third time in the House of Commons on Tuesday.

**Proposed Power Station for Sydney University.**—In a Paper read before the Sydney University Engineering Society, Prof. E. Kilburn Scott discusses the advisability of establishing a separate power station to supply the various buildings within the university area, and where practical station experience could be given to students. The greater part of the Paper is devoted to a detailed consideration of the plant and equipment which the author would propose for the purpose and the general organisation of the undertaking, together with estimates of costs of installation and working.

# LEGAL INTELLIGENCE.

## Wakefield & District Lights Railway Co. v. Wakefield Corporation.

On Tuesday Justices Ridley, Darling and A. T. Lawrence heard an appeal from a decision of the Wakefield Justices, who had decided against appellants' contention that their railway should be rated at one-fourth of the net annual value. It appeared that a complaint was preferred before the Justices against the plaintiff company for that they, being a company duly rated and assessed on a general rate and on a water rate, and payment of such rates having been lawfully demanded, they had not paid same. It was proved or admitted before the Justices that the rates in question were duly made and that the company was duly rated for rails laid in certain roads. The net annual value was estimated at £237 and the rates made on the full net annual value. Appellants tendered a sum calculated on the fourth of the net annual value, but this was refused. It was also proved that the lines comprised railways which were laid entirely within certain streets in Wakefield City, which streets were highways repairable by the inhabitants at large, and were vested in the Corporation of Wakefield as the urban authority. Appellants contended that the lines of railway (which were worked on the overhead electric system) and the land occupied thereby were used only as a railway constituted under certain acts for the public convenience within the meaning of sec. 2 (*b*) of the Public Health Act, 1875, because they were used and constructed under the Wakefield and District Light Railway Orders, 1901 and 1902, and therefore were only assessable on one-fourth of their net annual value. Respondents maintained that the land on which the rails were laid was not land used only as a railway, and that the railway was not a railway constructed for public convenience, and therefore it was liable to be assessed on the full net annual value.

Mr. Danckwerts, K.C., and Mr. Ryde appeared for appellants and Mr. Clavell Salter, K.C., and Mr. Wm. Mackenzie for respondents.

Mr. RYDE said the company had to keep to a fixed permanent way and it was only because they had an exclusive right that they were rateable at all.

Mr. Justice DARLING said the public had a right to use the land on which the lines were laid and it seemed a curious result that because the company had not got the land all to itself they should be higher rated.

Mr. RYDE submitted that appellants came within sec. 211 of the Public Health Act and were entitled to the partial exemption therein provided for.

Mr. SALTER said no doubt the origin of a light railway and that of a tramway were different, but it was also different from that of a railway. The exemption of a railway from paying full rates was conferred because, in proportion to their holding, they enjoyed very few of the advantages of the good lighting, paving, &c., paid for by the rates. But a tramway was not exempt because it did enjoy most of these advantages, and this light railway was practically in the position of a tramway. He submitted that the railway was not constructed under the powers of an Act of Parliament. He agreed that if sec. 211 was a general enactment relating to railways he was wrong.

Mr. Justice RIDLEY, in giving judgment, said the Justices had decided that the land question was not used only as a railway and was not constructed under the powers of an Act of Parliament. He thought the land was used only as a railway, but on the second point he felt less difficulty. The railway was made under the order of 1901 and not directly under an Act of Parliament, but on looking at sec. 12 they got over that difficulty. He thought the section said that light railways were to be treated as if made under a special act and that the order made under the act was to be called a special act and, therefore, that this railway was constructed under the powers of an act of Parliament. He also thought sec. 211 was a general enactment relating to railways. Enactment was not the same thing as act. The latter meant the whole act, the former the act or part of the act. He came to the conclusion that the appeal should be allowed.

Justices DARLING and LAWRENCE concurred and the appeal was accordingly allowed.

Leave to appeal was applied for and granted.

## Yorkshire (Woollen District) Electric Tramways Co. v. Justices of West Riding (Dewsbury).

In the High Court on Wednesday, before Justices Ridley, Darling and A. T. Lawrence, Mr. LLEWELLYN DAVIES moved on behalf of the Yorkshire (Woollen District) Electric Tramways Co. for a rule nisi calling upon the Justices of the West Riding to show cause why a mandamus should not issue commanding them to state a case for the opinion of the High Court, the question at issue being whether the company, whose lines were constructed under the powers and orders of the Light Railways Act, 1896, were bound to pay rates on the full net annual valuation or were entitled to partial exemption under sec. 211 of the Public Health Act, 1875. The company, said counsel, had arranged with some of the local authorities to pay the whole amount, the authorities undertaking to refund if the decision was in favour of the company. But three authorities had declined to do this—Liversedge, Heckmondwike and Mannhill—and took proceedings. The case came before the Justices, who made an order for payment in full, refusing to hear the company's solicitor and making an order for a distress warrant to issue in case of non-payment. This was a similar action, counsel considered, to the Wakefield case (reported above).

Mr. Justice RIDLEY: You may take a rule.

Mr. DAVIES asked for three separate rules against the three authorities and the court consented.

## Swansea Corporaton v. National Telephone Co.

In the Court of Appeal, on Wednesday, Lords Justices Vaughan Williams, Stirling and Cozens-Hardy delivered their reserved judgment in this appeal by defendants from a judgment of Mr. Justice Buckley.

Lord Justice STIRLING, in delivering judgment, said that at the close of the arguments they were disposed to think that Mr. Justice Buckley had taken a view which was unduly favourable to plaintiffs, but as the action related to matters which called for some local and scientific information they were desirous of obtaining a report from a scientific referee on certain questions. An order was made to that effect in January, and the referee's report was dated Feb. 28. They had considered that report, and found themselves confirmed in the opinion they had previously formed. They therefore propose to make the following order: That the appeal be allowed, and that the judgment and order of Mr. Justice Buckley, dated May 28, 1905, be discharged, except so much thereof as did order that the operation of the said judgment (except as therein mentioned) should be stayed pending the hearing of the appeal and instead thereof order as follows :—

That, under sec. 3 (5) of the Telegraph Act, 1899, and the Telegraph Intercommunication Order, 1899, and in the events which have happened the plaintiffs are entitled to be afforded by defendants all proper facilities for restricted intercommunication within the meaning of the said order of Mr. Justice Buckley between persons using the telephone system of the defendants and the telephone system of the plaintiffs in the pleadings referred to.

That, in order to afford such proper facilties, junction circuits within the meaning of Major Cardew's report, answers 1 and 3, ought now to be provided to directly connect plaintiffs' principal exchange in Swansea and each of defendants' exchanges at Sketty and Gorseinon in manner following—that is to say, to connect plaintiffs' principal exchange at Swansea and the exchange of defendants at Sketty one junction circuit, and to connect plaintiffs' principal exchange at Swansea and exchange of defendants at Gorseinon two junction circuits.

That the several junction circuits so to be provided as aforesaid would be all one-way junctions—that is to say, one set to be used for calls from defendants' subscribers to plaintiffs' subscribers, and the corresponding set to be used for calls from plaintiffs' subscribers to defendants' subscribers, and that such junction circuits may be either enclosed in cables in sets or erected overhead, or partly in one way and partly in the other.

That the junctions so to be provided may pass through the company's said principal exchange at Swansea, but should not be brought to the switchboard in that exchange for operating purposes.

Liberty for either party to apply as to relief consequent on the aforesaid declarations, and as to costs of making the junctions and as to further facilities and generally. The costs of the appeal to be taxed and paid by respondents to appellants. Each party to bear his own costs down to and including the trial before Mr. Justice Buckley.

Mr. DANCKWERTS (for the Company): As to the cost of laying these junctions?

Lord Justice STIRLING: That will be matter for application if you think the question arises.

Mr. PARKER (for the Corporation): Should not there be a limit as to the costs of carrying out the works?

Mr. Justice STIRLING: If you so desire it there may be.

## J. Stone & Co. (Ltd) v. General Electric Co. (1900) (Ltd.)

On Friday before Mr. Justice Swinfen Eady, K.C., Mr. EVE said he had a motion on behalf of plaintiffs to restrain defendants from selling electric lamps with the name of Stone or Stones' patent upon them, they not having been made under the authority of plaintiffs.

Mr. MAUGHAM, for defendants, said he offered a perpetual undertaking in the terms of the notice of the motion, also an account of profits and costs of the action. The only question was, whether there should be an undertaking or an injunction.

His LORDSHIP made an order in the form offered by defendants.

## Tramway Bye-Laws.

At Hanley Police Court on Thursday last, John Henry Stone, a conductor in the service of the Potteries Electric Traction Co., was charged with a breach of one of the company's bye-laws. The complainant was a local solicitor, who was recently fined for refusing to pay his fare on the tramway owing to the overcrowded state of the car.

Mr. ASHMALL, for the prosecution, said the complainant brought the matter forward in order to show the company that they could not make regulations and set them aside at their own pleasure. Bye-law 23 provided that the conductor in each car should enforce or prevent any breach of the bye-laws to the best of his ability; and Bye-law 15 provided that no person should hold on or hang on by or to any part of any carriage, or travel there otherwise than on a seat provided for passengers. It was common knowledge that overcrowding of the tramcars had gone on to an excessive extent.

Evidence having been tendered, Mr. KENT (for defendant) submitted that the conductor had carried out the bye-laws to the best of his ability. He also contended that a member of the public had no power to take proceedings against the company to compel the enforcement of bye-laws made by the company for its own protection. The remedy was for the local authorities to make bye-laws for the regulation of traffic and prevention of overcrowding, under another section of the act, and that was what the local authorities were doing.

The magistrates held that there had been a breach of the bye-laws, and fined defendant 2s. 6d. and costs.

Mr, KENT notified that the company would appeal.

**Driscoll v. Hintze.**—On Wednesday, Mr. Justice Warrington heard a motion for the appointment of a receiver of this firm. Counsel for the plaintiff said the action was really one for dissolution of partnership and winding up, but there was a dispute between the parties as to whether a partnership actually existed. Plaintiff had advanced moneys to carry on the concern amounting to about £500, but although he had applied for his share of the profits he had never received any return for his advances. He had paid all the wages and outgoings. For defendant it was stated that plaintiff had not fulfilled conditions precedent to the partnership. Eventually his lordship appointed a receiver, defendant to be employed as manager, plaintiff agreeing to pay two weeks' wages.

# MUNICIPAL, FOREIGN & GENERAL NOTES.

## APPOINTMENTS VACANT AND FILLED.

Messrs. Mills, English & Co., Swansea, require a thoroughly experienced electrical engineer, to take complete control of electrical department. See an advertisement.

There is a vacancy for a premium pupil at the Canterbury electricity works. See an advertisement.

Two additional assistants are required in the electrical engineering department of the Central Technical College, Exhibition-road, London, S.W. Salaries £300 and £150 per annum respectively. Applications to Prof. W. E. Ayrton.

Mr. G. R. Spurr, of Ilford, has been appointed by Walthamstow District Council as electrical engineer at £350 per annum, rising by annual increments of £25 to £450, in place of Mr. J. H. Fooks-Bale, resigned. Mr. W. Murray, of Ipswich, has been appointed traffic manager of the tramways at £200 per annum, rising by annual increments of £20 to £300.

The London County Council have appointed Mr. T. L. Horn resident electrical superintendent of the Northern tramways. The three selected candidates were Messrs. T. L. Horn (L.C.C. tramways), W. A. Tester (Lancaster) and F. H. Corson (Blackburn). Mr. W. Crauford has been appointed assistant permanent way engineer and Mr. J. Terry district traffic superintendent, while Messrs. J. P. Dudin, O. A Pilcher and J. R. Walker have been selected to be charge engineers at Greenwich power station.

Mr. A. McAdam, of Erith, has been appointed shift engineer at Gillingham.

Oldham Council have appointed Mr. Mann canvasser of the electric light department.

## EDUCATIONAL NOTICES.

**Electrical Standardizing, Testing & Training Institution** — As the result of the recent examination for entrance scholarships held at Faraday House on April 4, 5 and 6, the following awards have been recommended by the examiners:—

Maxwell scholarship of 50 guineas, tenable for two years, to H. T. Warren, Haberdashers' (Aske's) Hampstead School; exhibitions of 30 guineas, tenable for two years, to C. S. Bell, Dungannon School, and to G. H. N. Reay, Lancing College; special prizes of 20 guineas each have been awarded to L. C. Martin, Bishop's Stortford School, and to L. W. Johnson, Dulwich College.

**York Railway Institute.**—Lord Wenlock distributed the prizes on Thursday evening last, when Mr. A. Kaye Butterworth, general manager of the N.E.R. Co., presided over a large gathering, including Mr. A. Watson (general superintendent), Mr. J. B. Harper (divisional superintendent), Mr. W. Robinson (chief goods manager), Mr. C. H. Ellison (chief telegraph superintendent), and other principal officials of the company.

Lord Wenlock said, in the course of his address, that the man who could by scientific investigation increase the life of a steel rail was doing his part in economising methods of mechanical traction, as was also the man who discovered how to obtain a greater amount of steam from a ton of coal than it would at present generate. He believed that with cheaper methods of carrying on the work of the railway, they would be able to create a still greater number of industries in North Eastern England, and go a long way towards solving the great difficulties of unemployment which existed.

**Northampton Institute.**—The fourth annual dinner of the day students took place on the 5th inst at the Holborn Restaurant. Mr. T. Y. Porter presided, and among those present were Dr. R. Mullineux Walmsley, Mr. M. Holroyd Smith and Mr. S. Field.

**Arbitration Proceedings.**—At the Royal Courts of Justice, London, on the 2nd and 9th inst., Mr. W. H. Patchell, the arbitrator appointed upon the claim of Messrs. D. Firth & Son, electrical engineers and contractors, Manchester, against Cardiff Corporation, for £1,602 for work done, &c., sat to hear evidence. It was explained by Messrs. Firth & Sons' counsel that the firm's tender was accepted by Cardiff Corporation for the electric lighting at Whitchurch Asylum, and on Nov. 28, 1905, the Corporation electrical engineer (Mr. Arthur Ellis) reported that very little progress had been made with the work. As a result of the ensuing dispute, the contractors knocked off work, and now sued for the amount done, which they valued at £1,402, with £200 in addition for profit. The Corporation had since sub-let the contract to another contractor for a larger sum. The proceedings were adjourned until April 25, plaintiffs' case being not yet concluded.

**Arbroath (N.B.)**—The Council resolved on Monday to support Mr. Geo. Balfour's electric lighting scheme, and to assent to an application for a provisional order.

**Argentina.**—The Anglo-Argentine Tramways Co. (Buenos Ayres) have opened the Venezuela-Cuyo electric tramway route.

It is stated that $100,000 has been subscribed towards the capital of a second electricity supply company for Pergamino.

**Assessments.**—The assessment of the generating station of the Altrincham Electric Supply (Ltd.) has been reduced, on appeal, from £1,765 to £1,260.

The assessment of the Middleton Electric Traction Co.'s undertaking has been reduced, on appeal, from £1,250 to £820.

**Australia.**—A number of the leading Australian electrical contractors recently sent a letter of protest to the Midland (W.A.) Corporation as to the manner in which the specifications for the extension of the Corporation's electrical plant had been prepared. The letter stated:—

> Having in view the unsatisfactory method which has obtained in the past by municipal and other bodies in asking for tenders for electrical and other machinery, we suggest that an independent advisory engineer be appointed by the councils and other bodies to prepare the necessary plans and specifications and to advise on the tenders; that complete specifications, with details of requirements, be submitted by municipalities and other bodies; that plans be furnished setting forth details of existing machinery and structural work, with outline of proposed alterations or additions; that a summary of tenders received be made public; and unless the foregoing conditions are adhered to by your Council we shall reluctantly be compelled to refrain from submitting our tenders.

The Council have taken no action in the matter.

At the last annual meeting of the Empire Electric Light Co. (Sydney) a 6 per cent. dividend was declared. The chairman (Mr. R. Imray) said that in spite of the competition of Sydney Corporation the company's progress had been satisfactory, and additions to their plant would shortly be necessary.

The "Australian Mining Standard" says the Premier of South Australia (the Hon. T. Price) has informed the tramway companies in Adelaide district that the Government have decided to offer a price for the whole of the lines.

Sydney Corporation will shortly invite tenders for additional electric plant.

The acting city electrical engineer reported to the Sydney Electric Light committee recently that, owing to numerous demands for electric motors on hire, the stock was exhausted. Specifications for a further supply are to be prepared.

It had been agreed that Sydney Corpn. would lay mains in Camperdown on condition that the mains should be exempt from taxation, but, as the Camperdown local authority is insolvent, it is now doubtful whether this work can be carried out under such an arrangement.

The Victorian chief inspector of mines (Mr. E. R. Meekison) recommends the installation of telephones in mines. At the annual conference of the A.M.A. of Victoria and Tasmania recently, it was resolved that the conference support the introduction of the telephone into all mines, and it was mentioned that in mines where telephones are used it is found that medical help can be obtained more promptly in cases of accident than where no such instruments are available.

The act to further amend the Mines Act, passed in the Victorian Legislature in 1904, does not make it compulsory for mines to adopt telephones, but it is provided that there "shall be some proper means of communicating distinct and definite signals from the bottom of the shaft, levels, &c., to the engine room . . . and no verbal signals or communications shall be made up or down a shaft . . . except through speaking tubes or telephones in the pump or ladder compartment of such shaft.

Mr. T. A. Coghlan, Agent-General for New South Wales, has been appointed to represent Australia on the Pacific Cable Board.

Brunswick (Victoria) Council have decided to ask for terms for the public lighting of the district by Melbourne Corporation electricity department. It is proposed to substitute incandescent electric lamps for the present gas and kerosine lamps, with 500 c.p. arcs in positions where Welsbach triple burner lamps are at present in use. The North Melbourne Electric Light Co. have signified their willingness to carry out the contract.

**Battersea (London).**—The charges for electric current have been reduced to 3½d. net per unit for private and 2½d. for outside arc lighting.

The commencing salary for the vacant position of electrical engineer has been fixed at £500 per annum.

**Bedford**—The Council have decided to spend £1,121 in additional arc and incandescent lamps for street lighting. The charge for current for power has been reduced from 1½d. to 1d. per unit.

**Berlin.**—The Berlin Elevated & Underground Railway Co. have entered into an agreement with the Municipal Council which will enable the railway to be extended a further 4½ miles.

**Birmingham.**—The Board of Trade inspection of the new section of the Corporation tramways between Lodge-road and Newhall-hill took place on Monday. The line will be opened for traffic this week.

**Bishop Auckland.**—The Rural Council have approved the Dene Beck Scheme of main outfall sewerage and sewage disposal works, which comprises a large portion of their district, including South Church, Auckland Park Colliery, Grange Hill, Cockton Hill, Eldon and Eldon-lane.

The sewage will be conveyed by main outfall sewers to a pumping station to be erected at South Church, where there will be high and low-level storage tanks, from which the sewage will be pumped by means of pumps driven by electric motors to the site of disposal works, distant about 800 yds., through a cast-iron pumping main. The consulting engineers are Messrs. D. Balfour & Son, of Newcastle-on-Tyne and London.

**Blackrock (Dublin).**—The Board of Trade have notified the Council that they have no authority to transfer their powers, &c., under their Provisional Electric Lighting Order, 1901. It is probable that a fresh order will be applied for to authorise the transfer to Messrs. Mills & Tomlinson. The matter will be further considered at a special meeting in July.

**Boston.**—The Council have formally assented to the application of the National Provincial Electricity Corpn. for a provisional electric lighting order.

**Bradford.**—At the Corporation meeting on Wednesday the chairman of the Tramways committee (Ald. E. Priestley) in moving the adoption of the minutes of his committee, stated that a sub-committee had examined plans submitted by the general manager (Mr. F. Spencer) showing a device for enabling cars to run upon either the Bradford or Leeds gauge by means of extensible axles, and had decided to recommend that the general manager be authorised to make application for securing immediate protection of the arrangement by provisional patent, and also that a car truck be fitted with the apparatus for trial. The provisional patent would be taken out in the name of Mr. Spencer and Mr. Dawson, carshed superintendent. The minutes were confirmed.

**Brierley Hill.**—The Council's provisional electric lighting order (1900) has been extended for 12 months.

**Burton-on-Trent.**—For the year ended March 31 the increased receipts of the tramways department amounted to £1,452. The total receipts were £16,139, against £17,591 for the previous year. The total number of passengers carried was 3,501,214, against 3,878,269. The mileage run was reduced by 4½ per cent.

**Cannock.**—The Council have sealed the transfer of their electric lighting order to the Shropshire, Staffordshire & Worcestershire Electric Power Co.

**Carnarvon.**—There are now 141 consumers, representing the equivalent of 4,059 8 c.p. connected.

**Edinburgh.**—The Corporation are recommended by the Cleansing and Lighting committee to erect 120 additional arc lamps in thoroughfares to be selected

**Electrical Engineers Volunteers.**—The Tees Royal Engineers Volunteers (Submarine Miners) have been converted into Electrical Engineers Volunteers.

**Electrical Machinery Exports.**—The principal exports from the United States to Japan in 1905 included electrical machinery, the value amounting to $1,239,878, compared with only $102,944 in 1900 and $129,777 in 1902. The value of exports of electrical machinery from the United Kingdom to Japan in 1905 are not yet available, but the value in 1904 was £58,751.

**Electricity in Mining.**—At the meeting of the Monmouthshire Colliery Officials' Association on Saturday evening, the president (Mr. A. S. Tallis) in his inaugural address dealt with the application of electricity to mining.

Some five years ago (he said) electricity was hardly known in South Wales collieries except for lighting and underground signalling, and it was not before 1901, when the Tredegar Iron & Coal Co. put down their first installation, that electricity was used to its best advantage as an agent for distribution of power for general underground purposes, such as hauling, pumping and coal-cutting. At that time to introduce electricity in any form at more than a very low voltage into the so-called fiery mines of South Wales was in the nature of an experiment fraught with a good deal of risk, and was looked upon by some people as bordering on madness. It was decided to adopt the polyphase system in preference to direct current, because of the greater mechanical strength and simplicity of the motors and their lesser liability to sparking, and because of its adaptability for long-distance transmission. The company had never regretted their decision in that respect.

**Electrotyping.**—In a lecture on "Rapid Methods for Producing Electrotypes," given by Mr. Sherard Cowper-Coles at the L.C.C. School of Photo-Engraving and Lithography, Bolt-court, Fleet-street, E.C., on Thursday last, the lecturer described in detail the improvements that had taken place in electrotyping, which has finally resulted in electrotypes being produced in from five to ten minutes, against eight to twelve hours by the older process.

**Exhibitions.**—The powerful support accorded to the Imperial-Royal Austrian Exhibition, which opens at Earl's Court in less than a month, has resulted in an extensive and thoroughly representative collection of exhibits being brought to London. The exhibition buildings and grounds have been entirely transformed, some of the former rebuilt, but the whole scheme of alteration has been carried out completely in conformity with Austrian architecture and colour.

At the Trades' exhibition at Bingley Hall, Birmingham, which, as we briefly announced in our last issue, was opened on 29th ult., the exhibits include electric lighting plant (suction gas plant, gas engine and dynamo) shown by the Industrial Engineering Co.; lift gears, flame arc lamps, switchboards, electrical instruments, &c., by the Walsall Electrical Co.; electric fans, &c., by Jas. Stott & Co.; gas engines and suction gas plant by Tangyes (Ltd.), Kynoch Engine Works (Ltd.), T. H. & J. Daniels, Crossley Bros., and the National Gas Engine Co.; electromagnetic separators and scrap testers by the Rapid Magnetting Machine Co.; machine tools by the Timbrell & Wright Machine Tool & Engineering Co., W. Ward & Co., Aucott & French and Chas. Taylor; stampings for electrical engineers by J. Rhodes & Sons; wood-working machinery by J. Sagar & Co., R. Becker and Co. and Kirchner & Co.; and oils, &c., by Snowdon, Sons & Co., Joseph Gilman & Son and Thos. Howse. The exhibition remains open until June 9.

**French West Africa.**—It is reported that the system of land telegraphs in French West Africa is very complete, every post of any importance throughout the whole of these vast territories being in telegraphic communication with the capital city of Dakar and thence with Europe. The West African telegraph system is about to be connected with that of Algeria across the desert north of Timbuctu, £4,000 having been set aside for this purpose for 1906. In this region wireless telegraphy is being experimented with by the French telegraph authorities.

**Fulham (London).**—The system of requiring deposits from residents in flats requiring supply of electric current has been abandoned.

**German Electrical Industry.**—In an instructive report upon the trade of Germany for 1905, Mr. Consul-General Schwabach has presented a mass of statistical and general information regarding German trading operations during last year. With regard to the electrical industry Mr. Schwabach writes:—

The electrical industry experienced a year of exceptional activity, orders being plentiful both for home and export, particularly for all kinds of electrical apparatus, machines and implements used in the German mining and iron industries and farming. Dynamo, electric motor and accumulator works were exceedingly well employed and frequently worked overtime, the industry also deriving much benefit from the rapidly growing use of motor cars and traction vehicles. Large orders were booked and executed in the telephone and the telegraph branches, and from September onwards the business in electric lighting articles and accessories became very active. Good orders were received from abroad for electric street cars and the erection of electric and car plant. The great labour dispute in the Berlin electrical industry in September threatened to seriously hamper the promising development of the important part of the industry centralised in Berlin, but the difficulties were speedily overcome. The scheme now under discussion of erecting central electric power generating stations in the Rhenish-Westphalian industrial district, with the object of supplying mines and factories throughout that district with cheap electric light and power would, if realised, provide the electrical industry with an abundance of lucrative work for some time to come. This scheme—in connection with which the names of two prominent and influential German firms are mentioned—is intended to be carried out by the Rhenish-Westphalian Electric Works, a joint stock company established in 1900 with a share capital of £187,500, which was raised to £500,000 in 1903. The electrical power supplied by this concern rose from 2,777,000 kw.-hours in 1900-01 to 8,200,973 kw.-hours in 1904-05, when the price of electric current for lighting purposes was, approximately, 32 pf. (about 3d.) per kilowatt-hour.

The value of exported electric cables increased to £1,680,000 in 1905, compared with £1,362,600 in 1904 and £1,068,000 in 1903. There were exported in 1905 2,916 tons of electro-technical articles made up of fine copper and 791 tons of articles of brass and other copper alloys for electro-technical uses. The total exports of telegraphic appliances, telephones and microphones were valued at £392,350, compared with £382,000 in 1904 and £195,100 in 1903. Electrical machinery exported in 1905 is put down at the value (in £1,000's) of 1,141·8.

On the subject of the dispute in the electrical trade in Berlin during 1905 Mr. Schwabach writes:—

The struggle in the Berlin electrical industry ended in the defeat of the men, as the large works answered the demands of the latter with a general lock-out. In this case public opinion, which in the miners' strike sided with the men, was avowedly against them. The movement began at the works of Siemens & Halske and the Allgemeine Elektrizitäts Gesellschaft—the two largest concerns in the German electrical industry—a comparatively small number of workmen demanding an increase of wages from 30 pf. to 33 pf. per hour and slightly increased piece rates, the men basing these demands on the increased cost of living. The works were willing to meet the men, but, contrary to the advice of their trade unions, two groups of men—450 in all—struck work on Sept. 19, whereupon the two firms in question, adopting a common plan of action, closed part of their works—viz., the cable works of the General Electric Co. and the dynamo works of Siemens & Halske, locking out some 10,000 hands. As the strikers refused to submit, the two firms on Sept. 30 closed most of their other works, whereby another 20,000 electrical workers became idle. Unofficial negotiations, conducted at the request of the men by the chairman of the trade tribunal, proved abortive, as the masters declined to make further concessions. Later on the operatives at the Berlin Elektricitäts Werke and those still working at the works of the said two concerns attached themselves to the locked-out men, bringing up the total number (on Oct. 2) to close on 40,000. The works succeeded in keeping their power stations in operation and supplying electric power for lighting and other domestic purposes, with the aid of a large number of their engineers, technical staff, foremen and the municipal fire brigade which the civic authorities ordered to assist. The employers' organisations of the Berlin metal industry decided to refuse employment to any workmen locked out by the Berlin electrical trusts, and the Association of Berlin Metal Works, of which the electrical firms are members, threatened to lock out 20,000 more men in their employ. On the strong recommendation of the strike committee the strikers consented to resume work on the terms conceded by the works, and the dispute terminated on Oct. 13. The firms agreed to take back all the men.

**Glasgow.**—An extension of the Corporation tramways from Parkhead Cross to Dalmarnock-road, a little over a mile in length, was opened for traffic on Sunday.

**Govan.**—The salary of the burgh electrical engineer (Mr. Theodore C. Parsons) has been increased by £50 per annum. Several members of the Council testified to the good work done by Mr. Parsons in making the electricity undertaking a success. The income of the department had been doubled, while the output was now more than three times that prevailing when he first came to the town.

**Hackney (London).**—The Council are extending the mains at a cost of £350 to give a supply of electricity for lighting and power to the Motor 'Bus Co. at the old militia barracks.

**Hastings-Bexhill Tramways.**—A service of electric tramways between Bexhill and St. Leonards was inaugurated on Monday. The system is to be completed by extending to Cooden on the one side and Hastings on the other—a distance of about 7 miles along the sea front.

**Ilford.**—The salary of the tramways manager (Mr. G. R. Spurr) has been increased from £250 to £300, with yearly increments of £50 until £400 is reached. On another column it will be seen that Mr. Spurr has just been appointed electrical engineer at Walthamstow.

**Japanese Telegraphs and Telephones.**—An important branch of Japanese administration is that of the Department of Communications, presided over by Minister Isaburo Yamagata with Mr. Ren Nakakōji as vice-minister. This department is under the superintendence of Director-General Kenjiro Komatsu, with Dr. S. Oi as chief engineer, Dr. O. Asano as chief electrician, and with 18 district superintending engineers whose administrative departments are stationed at Tokyo, Osaka, Kyoto, Kumamoto, Aomori, Nagasaki, Utsunomiya, Nagoya, Yokohama, Supporo, Niigata, Takamatsu, Nagano, Kobe, Hiroshima, Sendai, Kanazawa and Kagoshima. The submarine section of this important department comprises the well-known cable steamer, the "Okinawa Maru" (built in England and described in *The Electrician*, Vol. XXXIII., p. 816), and a new cable ship now being built in Japan, for which the cable machinery, the bow and stern sheaves, dynamometers, bell mouths and tank fittings were obtained from Messrs. Johnson & Phillips (through Messrs. A. R. Brown, McFarlane & Co., of Glasgow). This steamer was described in *The Electrician* for March 23, 1906. There were, at the end of March, 1905, 144 submarine cables of a total length of 2,228·395 nautical miles, with 2,962·331 miles of conductors. The telegraph land lines at the same date totalled 16,471 miles, with 85,414 miles of conductors. 9 miles of lines were underground, the number of conductors in this section being 737.

The telephone branch of the Department of Communications (owned and worked by the Imperial Japanese Government) at March 30, 1905, had 2,837 miles of bare wire, 223·5 miles of aerial cable, 174 miles of underground and 3·68 nautical miles of subaqueous telephone cable. The systems of switchboard adopted includes the magneto standard, magneto series, magneto bridging and common battery bridging. The method of charging for local telegrams in Japan is peculiar to that country. For a Japanese telegram containing not more than 15 characters, handed in for delivery within the same city, town or village, a charge of 10 sen (2½d.) is made with 3 sen additional for every five characters or less. For a message in European characters of not more than five words, 15 sen is charged, with 3 sen for every additional word. The address in a Japanese telegram is not counted. The local distance telegrams are sent on a different scale. For a Japanese telegram containing not more than 15 characters, dispatched to any part of a province, the charge is 20 sen, for every additional five or less characters 5 sen. For a message in European characters of not more than five words, 25 sen is charged, with 5 sen for every additional word. At the present time, with silver about 30d. per ounce, a sen is worth ¼d., making a yen (100 sen) worth 2s. 1d. Telephone charges are made up as follows: In the principal towns a sum of 15 yen (about 31s.) has to be lodged, and the annual subscription is then 66 yen, or under £7. This applies to Tokyo and Osaka. The subscription for Yokohama, Kobe, Kyoto and Nagoya is a payment of 10 yen (21s.), and 54 yen annual subscription, about £5. 12s. 6d. At smaller towns the fee is 5 yen and 48 yen as annual subscription. Call office fees are made at 5 sen (1¼d.) for a five minutes' conversation with intertown subscribers and 5 sen for every additional five minutes. For conversations with outside subscribers the charge is 10 sen for a five minutes' conversation and 10 sen extra for additional five minutes. Interurban telephonic communication is subject to a charge of about 5d. per five minutes' conversation up to a distance of 12½ miles, 25 sen up to 62½ miles, with 1 sen extra per five minutes' conversation extra for each 2½ miles beyond 62.

**Kennel Lighting.**—The new Quorn kennels at Pawdy Cross-roads, Leicestershire, are lighted electrically.

**King's Norton.**—The amount finally fixed as the price to be paid by the Council for the tramways of the City of Birmingham Tramways Co. in the Council's area is £26,000.

**Light Railways.**—The Light Railway Commissioners have decided to grant the application of the Empire Electric Lighting & Power Co. for the transfer of powers obtained by Hales Owen District Council for the construction of light railways in the district, subject to conditions as to road widenings, &c.

**Littleborough.**—The Council are negotiating with Rochdale Corporation for a supply of electricity in bulk.

**London County Council.**—At Tuesday's meeting it was agreed to lend £4,345 to Bermondsey and £48,545 to Marylebone for electric lighting.

*New Tramways.*—On the report of the Highways committee, which proposed the expenditure of £46,500 for the reconstruction of the tramways from the "Angel," Islington, to Highbury Station, and of £39,500 and £2,700 for the construction of tramways between High-street, Lewisham and Lee Green,

Mr. P. H. Harris complained that the expenditure now proposed was not in the estimates which the Council passed only a week ago.

The recommendations were both adopted.

*Speed of Tramcars.*—The Highways committee reported that arrangements had been approved for the fitting of special brakes to a certain number of cars to enable them to be run at increased speeds. Difficulties had arisen in this connection and with regard to other matters, and the committee recommend that the Home Secretary be asked to receive a deputation to place the Council's views before him.—Agreed.

*Staff.*—In reference to the reorganisation of the staff, the Highways committee recommended that Mr. T. Leopold Horn (at present electrical assistant in the tramway department) be appointed resident electrical superintendent at £300 per annum, rising to £350; that Mr. W. Craufurd (now with Messrs. J. G. White & Co.) be appointed assistant permanent way engineer at £250 a year; and that Mr. J. P. Dudin (in the Council's service), Mr. O. A. Pilcher (of the Underground Electric Railways Co.), and Mr. J. R. Walker (in Council's service) be appointed charge engineers at the Greenwich generating station at £250 a year each.—Agreed.

*Alleged Defective Cables.*—The Main Drainage committee reported that certain electric cables at Crossness outfall had been found defective. The contractors were unable to admit liability, and suggested that the matter go to arbitration. It was decided to appoint Major Cardew sole arbitrator.—Agreed.

**L.C.C. Tramways.**—The traffic receipts for the year ended March 31 were £614,779 from lines worked by electric traction, and £145,000 from horse cars; total £759,779. For 1904-5 the figures were £535,220 and £127,987 respectively; total £663,207.

**Longton.**—Sanction to a loan of £3,000 for mains extensions has been applied for by the Council.

**Macclesfield.**—The Council's provisional order, 1901, is to be transferred to the local tramways company, who pay the Council £600 to defray expenses.

**Maidstone.**—Considerable discussion has arisen on the recommendations of the Electricity and Light Railways committee that Mr. O. Jones be appointed part-time canvasser for the electricity department; that a commission be paid to any contractor introducing customers, at the rate of 6d. per lamp for ordinary consumers and 3d. per lamp for those who wish to avail themselves of the free-wiring system; that premises be hired for showrooms, &c.; and that duplicate condenser plant, at an estimated capital cost of £1,200, be provided forthwith. The recommendation as to the condenser was adopted, the remainder of the report being referred back.

**Municipal Wiring.**—Brighton Corporation have resolved to request the Municipal Electrical Association to consider the advisability of asking the Board of Trade to introduce a bill into Parliament authorising all Municipal Corporations carrying on electrical undertakings to wire consumers' premises, &c.

**Newcastle-on-Tyne.**—The new extension of the Corporation tramways from the old toll-bar in Scotswood-road to Scotswood station was formally opened on Friday.

**Patent Amendment.**—Messrs. Herbert Arnaud Taylor, Sidney George Brown and Joseph Arthur Lovel Dearlove, electrical engineers, 4, Gt. Winchester-street, London, E.C., seek leave to amend the specification of Letters Patent No. 1,434 of 1899, granted to Mr. S. G. Brown for "Improvements in Electric Telegraph Apparatus." Particulars of proposed amendment are set out in the "Illustrated Official Journal (Patents)" of April 4, and notice of opposition must be given within one calendar month from that date.

**Pontypridd.**—The Electrical committee on Tuesday considered a communication from Mr. R. P. Wilson, consulting engineer to the Rhondda Tramways Co., asking whether the committee were prepared to supply the company with 1,750,000 units of electric current per annum at ¾d. per unit. The committee would have to put down additional plant to meet this demand, and it was decided to renew the offer to supply electrical energy at Porth at 1⅛d. per unit.

**Presentation.**—Last week the Southampton staff of the National Telephone Co. presented the district manager (Mr. W. Howe) with a silver mounted tantalus, and silver spoons for Mrs. Howe, as a token of their esteem and to mark the completion of his 25 years' service with the company.

**Radcliffe.**—In future the maximum charge for electric current will be 4d. per unit for private and 2d. for public lighting.

**Rathmines (Dublin).**—The Council are applying for sanction to a further loan for electric lighting extensions.

**Ravensthorpe.**—The Council have decided to take current in bulk from the Yorkshire Electric Power Co., and to borrow £2,650 for the laying of distribution mains, &c.

**Russia.**—Although little or nothing has been done towards the introduction of electric traction for tramways in Warsaw, it is announced that if no further strikes or disturbances take place electric tramcars will commence running in October next. The complete programme for electric tramway construction includes an extension of the present service from 19 miles to 24 miles. Electric lighting for Warsaw is also promised this year, the public lighting being effected in the thoroughfares through which the electric tramways are to run. Owing to the disturbed state of the country the demand in 1905 for machinery was very small with the exception of electric motors, which were imported in anticipation of the higher import duty under the new tariff.

**Sheffield.**—Mr. Albert Davidson, electrical and mechanical engineer, and secretary of the Sheffield branch of the Electrical Contractors' Association, has obtained the fiat of the Attorney-General to and has commenced an action against Sheffield Corporation for a declaration that the Corporation have no power to carry on the business of wiring consumers' premises, or of supplying or fixing electric fittings, or of selling motors outside the city of Sheffield, and have no power to expend in such trades or businesses any capital moneys borrowed for the purposes of their electric lighting undertaking, or the receipts of such undertaking. The Corporation have decided to defend the action.

**South Africa.**—The "British and South African Export Gazette" states that the Electric Construction Co. have supplied two 300 kw. three-phase generators and the British Westinghouse Co. the transformers for Penhalonga Proprietary Mines, Umtali.

The South African General Electric Co. have imported electric motors of an aggregate of 2,175 H.P. to meet demands for agricultural purposes.

East London Municipality are about to place orders for a street fire-alarm.

A company called the Somerset Strand Electric Lighting & Tramway Co. has been formed to operate at Somerset West, Cape Colony.

**Southport.**—The Electricity committee proposes that £2,750 out of the past year's profits be voted to relief of rates.

**Stalybridge.**—The Joint Tramways & Electricity Board have increased the salary of Mr. Ambler, station superintendent, to £175 per annum, rising to £200.

**Stirling.**—The Town Council, the Bridge of Allan Council and the local tramway company have been approached on behalf of Newcastle-on-Tyne and London syndicates with proposals for the purchase of the tramways, the extension of the system and the adoption of electric traction.

**Stockton-on-Tees.**—Permission to supply electric current to works in the borough has been granted by the Council to the Cleveland & Durham County Electric Power Co., the Council to receive 1¼ per cent. of the revenue during the first five years, and 1 per cent. during second five years.

**Swinton and Pendlebury.**—The Council have appointed a committee to treat with the Lancashire Electric Power Co. for a supply of electricity in bulk.

**Telephones in Police Stations.**—The Commissioner of the Metropolitan Police has assented to the installation of telephones, connected with public call offices, at several police stations in the division on the outer circle of the metropolitan police area.

**Torquay.**—The Council have received sanction to borrow £3,815 for main extensions, and £500 for meters. The first-named loan is for 15 and the latter for five years.

**Tramway & Vehicle Workers' Association.**—The annual report of the secretary (Councillor G. T. Jackson) states that the membership is now 11,059, against 10,757 at the commencement of 1905. The number of branches is 73. The capital is £21,606 against £18,760.

**Truck Acts Inquiry.**—The Home Secretary (Mr. H. Gladstone, M.P.) has appointed a committee to inquire into the working of the Truck Acts. The members are:—

Right Hon. T. Shaw, M.P. (Chirman); Messrs. E. A. Brotherton and F. Cawley (M.P.s), M. Delevingue (Home Office), J. Ramsay Macdonald, M.P., F. Maddison, M.P., and A. F. Yarrow and Mrs. H. J. Tennant. The terms of reference are: "To inquire into the operation of the Truck Acts, and to consider and report what amendments, or extensions, of those acts or changes in their administration are desirable; particularly whether fines and deductions from wages should be prohibited; and, further, to consider and report whether the practice of shop assistants and certain classes of workpeople being lodged and boarded by their employers gives rise to abuses needing remedy by an extension of the Truck Acts, or by any other action of the State." The secretary is Mr. T. E. Bettany, Home Office, Whitehall, S.W.

**Water-power Schemes in British India.**—It was announced by Reuter from Lahore, under date April 7, that a company had been formed with a capital of £2,000,000 to construct a hydro-electric power installation in Kashmir by harnessing the Jhelum river. The power (the report states) will be utilised to supply current for an electric railway, 200 miles in length, to connect Abbotabad with Srinagar, to propel a large fleet of powerful electric dredgers, which will be employed in safeguarding Kashmir against disastrous floods and in reclaiming valuable rice-producing tracts of land from the marshes, to supply the motive power for numerous proposed factories and thus serve to convert Kashmir into the Lancashire of India, and to impart new energy to the great silk industry of the province. The price of electric power is to be less than half that of steam power, and the scheme, when carried out, is to be the biggest of its kind in the world. (We refer to the Government Kashmir project below.)

We have referred from time to time in *The Electrician* to the Cauvery Falls power scheme in the Mysore State of Southern India. As our readers are aware, work on this scheme was started in 1900, the initial installation being completed in June, 1902. Early in 1905 the plant was brought up to a total capacity of 7,920kw., making it the largest hydro-electric installation now operating in Asia.

The success of this scheme has led the Indian Government to take in hand a project for the utilisation of the waters of Jhelum River, Kashmir, in North-West India. The power plant in this case will be installed near Rampur, about 50 miles below Srinagar, where a 6 mile conduit will provide a head of water of about 400 ft. At first plant of about 20,000 H.P. will be installed.

It is proposed to use the power for operating the Kashmir section of the Jhelum Valley railway electrically along its entire length of 180 miles. A single-phase system of traction will be employed. The most important immediate use to which the power will be put will be in operating dredgers for deepening the Jhelum river in the Kashmir Valley, and thus minimising the floods, which periodically devastate the entire country. The contemplated plant will also allow of the reclamation of a very large tract of land, and permit of the storage of water in Wular Lake above the power plant for sale to the Punjab Irrigation Department. Another important use of the power will be for operating the large silk factory at Srinagar and also for supplying with current the electric water heaters in the silk mill. The power will also be utilised for other industrial purposes and for the lighting of Srinagar and Abbottabad, Murree and Rawalpindi, all prosperous towns in the province of Hazara, to the west of Kashmir.

After successfully completing the preliminary arrangements the consulting engineer (Major A. J. de Lotbiniere, R.E.) was instructed in May last, by the Jammu and Kashmir State Council (acting for the Maharajah of Jammu and Kashmir), to proceed to Europe and America in order to interview the leading electrical and hydraulic plant manufacturers, and to request those selected to submit tenders.

Major de Lotbiniere, we are informed, recommended his Government that the contracts for the entire hydraulic and electrical equipment should be placed in the United States, and as part of this subject we are now informed that the Abner Doble Co., of San Francisco, has been awarded the contract for the hydraulic equipment, comprising the hydraulic plant complete from the forebay to the tailrace, including the intake, valves, pressure pipes, pressure-pipe thrust blocks, interior piping, water-wheels and nozzles, hydraulic governors, &c., the whole to be delivered at Karachi, India. The gravity conduit line for the power plant will be approximately 34,000 ft. in length, and for the upper 8,500 ft. will consist of an excavated ditch lined with masonry. The remaining portion of the water channel will consist of a rectangular flume, which is to have a capacity of over 500 cubic ft. per second. The forebay at the end of the gravity line and at the head of the pressure pipes will be constructed of masonry and will be provided with special head-gates. The sliding elements of the intake gates will be of timber, all iron and metal parts necessary for the construction of the gates being furnished by the hydraulic contractors. The pressure lines will consist of riveted steel pipes designed with a factor of safety of 5, each supplying one of the hydro-electric units. For each pipe line a standpipe and two special vacuum valves will be provided to protect the pipe against injury in case the water should be drawn out suddenly. At the lower end of each pressure line the last length of pipe will terminate in a flange, which will be bolted to a massive cast-iron thrust block that will rest on a heavy cast-iron sole-plate or base. The latter will be mounted on a substantial masonry foundation and be held in position by anchor bolts. This fitting will be designed to take the entire hydraulic thrust of the pipe, an ample factor of safety being allowed. Each pressure line will consist of a riveted steel pipe varying in diameter from 30 in. to 36 in. and a 54 in. to 36 in. taper pipe, 10 ft. long at the upper end. The pipes will be 790 ft. in length, and will deliver the water under an effective head of 400 ft.

The interior piping of the power house will consist of welded pipe with welded flanges, all piping and fittings beyond the thrust block being designed with a factor of safety of 10 and be subjected to a test pressure of $1\frac{1}{2}$ times the working pressure for five hours. 12 main units and three exciter units will constitute the equipment of the power house. Each main unit will consist of a Doble tangential water-wheel with automatic oil-pressure governor delivering 1,765 B.H.P. to the shaft, under an effective head of 400 ft. Each wheel will be direct connected to a 1,000 kw. alternator, the speed of the unit being 500 revs. per min. The exciter units will each consist of a Doble tangential water-wheel delivering 285 B.H.P. to the shaft under an effective head of 400 ft. The speed of the exciters will also be 500 revs. per min. The hydro-electric units will be of Doble standard two-bearing type, the wheel runner being fastened on the end of the shaft. For each of the main units the Doble Co. will furnish a high-carbon open-hearth steel forged shaft and two bearings of a special ring-oiling type provided with revolvable bearing shells. The exciter water-wheel runners will be mounted on the extended ends of the exciter generator shafts. The water-wheels will be equipped with ellipsoidal buckets, needle-regulating nozzles and centrifugal water guards. The regulation of the main units will be effected by hydraulic governors operating jet deflectors. For the exciter units hand regulation will be provided by means of the needle nozzles The gate valves for each wheel will be of special construction with outside screw and yoke, bronze mounted, with by-pass.

The power house will be provided with a double-steel roof and two travelling cranes will be erected. The transformers will be installed in a bay of the main building or in a separate structure. The specifications for the electrical and hydraulic equipment stipulated that no single piece of machinery should weigh more than 4 tons when packed, as there is 200 miles of road transportation, including a lift over a range of mountains 8,000 ft. high. A total of 5 tons, including trolley, is the maximum weight that can be hauled over the mountains. Portland cement is about 31s. per barrel delivered on the site of the works, making its use prohibitive for heavy concrete work. There is, however, a plentiful supply of natural rock in the vicinity, and masonry construction will be used for the walls of the power house, for the foundations of machines, intake, forebay, &c.

The entire hydro-electric installation will be constructed, erected, tested and placed in operation under the supervision of Major A. J. de Lotbiniere, R.E. Major D. Fraser, R.E., and Capt. Thomson, R.E., will act as his engineering representatives in London. Mr. A. C. Jewett, formerly of General Electric Co. (U.S.A.), will act as installing engineer for the Government. Mr. Jewett was connected with the installation of the Cauvery Falls plant.

**Wednesbury.**—The Council have decided to expend £5,150 upon additional plant at the electricity works, extensions to mains, &c.

**West Ham.**—The borough electrical engineer (Mr. A. Hugh Seabrook) reports that he considers there will be no difficulty in reaching the additional 1,000,000 units for power estimated for the current year. Strenuous efforts will be made to reach the 900,000 extra units estimated for lighting.

An additional cable is to be laid at a cost of £3,900 to Stratford for tramway purposes.

Wanstead Council refuse to allow a tramway to be constructed across Wanstead Flats.

Arrangements have been made for joining up the East and West Ham municipal tramways at Plashet-lane.

**West Hartlepool.**—The Corporation are seeking authority to borrow £1,170 for another feeder.

**Wolverhampton.**—The Council approved on Monday the arrangements referred to in our last issue for tramway intercommunication between Wolverhampton, Willenhall and Dudley.

# TRADE NOTES AND NOTICES.

## TENDERS INVITED.

*Hull* Electric Lighting committee invite tenders for the following plant for their Sculcoates-lane electricity generating station: Coal-handling plant, &c.; in connection with eight Lancashire boilers; condensers, pumps, pipe work, &c., in connection with six Lancashire boilers; and two high-speed engines. Specifications, &c, from the city treasurer, Mr. T. G. Milner. Tenders to the chairman of the committee, Town Hall, Hull, before noon April 19. See also an advertisement.

**NOW READY.**

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1906 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is even more complete and accurate than in previous issues, and has been revised up to day of publication. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Traders purposes. The valuable large sheet Tables, &c., have been very carefully revised and extended, making the 1906 Edition of this indispensable work the most complete book of the kind ever published.

A full Digest of Contents will be sent post free on request.

*Southampton* Corporation invite tenders for reconstructing their tramways in the Avenue. Specifications, &c., from the general manager and engineer (Mr. H. F. Street), Tramway Offices, Above Bar-street. Tenders to the town clerk (Mr. R. R. Linthorne), Municipal Offices, Southampton, before 2 p.m. 23rd inst. See also an advertisement.

*St. Pancras* (London) Borough Council invite tenders for the supply of arc lamp carbons for 12 months. Specifications, &c, from the Electricity Department Offices, 57, Pratt-street, Camden Town, N.W. Tenders to the town clerk (Mr. C. H. F. Barrett) Town Hall, Pancras-road, N.W., by noon of Monday, April 30 See advertisement.

*Salford* Electricity committee invite tenders for supply and erection of 750 kw. steam turbo-generator and condensing plant. Plans, specification, &c., from the borough electrical engineer, Pendleton. Tenders by April 21 to the town clerk, Mr. L. C. Evans, Town Hall, Salford.

*Glasgow* Corporation invite tenders for supply of (1) main cables, (2) small cables and wires, (3) electricity meters, and (4) carbons for 12 months from the 31st prox; also for cast-iron joint boxes and other stores and materials. Tenders to the town clerk (Mr. A. W. Myles) before 23rd inst.

*Glasgow* Parish Council and Lunacy District Board require tenders by 10 a.m. of 20th inst. for 12 months' supply of electric lamps and fittings, ironmongery, &c , to their poorhouse, hospitals and asylums. Forms of tender from Mr. J. R. Motion, 266, George-street, Glasgow,

*Belfast* Tramways and Electricity committee invite tenders for supply and erection of coal and ash conveying plant, bunkers and chain grate mechanical stokers. Tenders by 11 a.m. April 16 to Sir Samuel Black, Town Hall, Belfast.

*Darlington* Electricity committee want tenders by 30th inst. for supply and erection of jet condensing plant, with piping and cooling tower.

*Birkenhead* Corporation require tenders by 9 a m. May 1 for washed slack or small coal for their electricity stations.

## TENDERS RECEIVED AND ACCEPTED.

Salford Council have accepted the following tenders for annual supplies to the tramway and electricity departments :—

General Electric Co., Angold enclosed arc lamps, cut-outs, casing and capping ; Sperryn & Co., tumbler and link switches ; Berry, Skinner & Co., patent push-and-pull switches ; Royce Limited, Berry, Skinner & Co., and Adams Mfg. Co., motor starters ; United Asbestos Co., dagger packing 1s. 6d. lb., pure asbestos twine 10d., do. tape 1s. 3d., do. millboard 3d., do. cloth 1s. 3d., rubber insertion 11d., brass joint rings $\frac{2}{3}$d. per inch, boiler gauge glasses £1. 16s. gross ; Cresswell's Asbestos Co., asbestos gland packing 1s. 2d. lb.; Baxendale & Co., Brockie-Pell arc lamp globes 5s. each : J. Hill & Co., R. W. Blackwell & Co. and S. Dixon & Sons, overhead insulating materials ; J. Hill & Co., frogs, pull-offs, &c.; British Westinghouse Co., special car accessories; W.T. Henley's Telegraph Works Co., L. Andrew & Co., J. Barrett, British Insulated & Helsby Cables, cable; Ferranti Limited, meters; British Insulated & Helsby Cables, and Reason Mfg. Co., house fuse boxes ; General Electric Co., steel insulated screwed tubing; Electromotors Limited, $\frac{1}{2}$ H.P. to 5 H.P. motors; Royce Limited and Lancashire Dynamo & Motor Co., 5 H.P. to 30 H.P. motors ; Baxendale & Co., double-pole main switches ; S. Dixon & Sons, Tandem Smelting Synd., W. Boydell & Sons, Malleable Seeel Castings Co., J. W.

Rowlands & Co., Estler Bros., J. Cookson (Ltd.), Brecknell. Munro & Rogers, R. W. Blackwell & Co., Mattok Metals Co., and J. Hall, car accessories (mechanical); L. Andrew & Co., A. G. Brown, British Thomson-Houston Co., Edison & Swan Co., General Electric Co., J. Hall, Liverpool Electric Cable Co., Malleable Steel Castings Co., W. McGeoch & Co., F. Riddaway & Co., W. T. Henley's Co., and Veritys Limited, car accessories (electrical); Rowland Carr & Co., bitumen; Simplified Underground Conductor Co., asphalt concrete, £2. 1s. 9d. ton; Howard Troughing Co., asphalt troughing.

The following tenders have been received by the London County Council for seven tramcar traversers:—

| | With two countershafts. | With one countershaft. |
|---|---|---|
| Jessop & Appleby Bros. (*accepted*) | £5,390 | £5,075 0 |
| Dick, Kerr & Co. | 6,300 | 5,670 0 |
| Cowans, Sheldon & Co. | 5,740 | 5,715 10 |
| Hurst, Nelson & Co. | 5,565 | 5,250 0 |
| J. Buchanan & Co. | 5,390 | 5,292 0 |
| Heenan & Froude | 5,250 | 5,218 10 |
| John Hitchen & Son | 4,340 | 4,270 0 |

West Ham Corporation have accepted the following tenders:—

General Electric Co., motor generator (£1,150) and for annual supply of transformers; British Insulated & Helsby Cables, annual supply of cables; British Electric Transformer Co., transformers; British Westinghouse Co., meters; Universal Electric Mfg. Co., house cut-out boxes.

Fulham (London) Council have accepted the following tenders for annual supplies for the electricity department: H. Edmonds & Co., packings, jointings, &c.; J. Gibb & Co., street lighting goods; Municipal Supplies Co., fuse wire, &c.; Geipel & Lange, carbons; British Insulated & Helsby Cables, house cutouts, &c.

The Postmaster-General's department, Brisbane, has accepted the following local tenders:—

G. Wills & Co., cast-iron brackets and pole roofs; Jas. Wilson, wrought-iron brackets; Webster & Co., stay wire and g.i. wire; Paul & Gray, cup-head bolts and nuts and insulator carriers; Smellie & Co., g.i. staples and lead-head nails; Zwicker, Tod & Co. (Melbourne), coach screws; and the Federal Nut & Bolt Co. (Sydney), stay-rods and stay-bars.

The tender of R. B. Hungerford has been accepted for supply of 700 telephone wall sets and 100 table sets in connection with the common battery telephone equipment for Hobart (Tasmania) at £3,988. 5s. 11d.

The Postmaster-General's department, Sydney, has accepted the tenders of J. & R. Horn, for wood insulator pins and wood cross arms; the Federal Nut & Bolt Works, for bolts and nuts, &c.; and the Vacuum Oil Co., for Morse instrument oil.

London County Council have accepted the tender of Munday & Son (London) at £5,916 for building the Mildmay Park sub-station for the working of the first electrified portion of the Northern tramways.

Brighton Corporation have accepted the tender of Millars' Karri & Jarrah Co. for 6,000 Jarrah paving blocks for the tramways department.

Sixteen tenders, varying from £526 to £1,555, were received by London County Council for three 10 ton travelling hand cranes for the tramway sub-station, and that of John Smith (Keighley) (Ltd.) at £660 was accepted. The tender of the Dewsbury Electric Mfg. Co., which was the lowest, was not in accordance with the specification.

Colchester Corporation have accepted the tender of W. H. Allen, Son & Co. at £750 for alterations and additions to condensing plant at the electricity works.

West Bromwich Corporation have accepted the tender of C. A. Parsons & Co. for a 400 kw. turbo-generator and exhaust piping, and that of Babcock & Wilcox for a water-tube boiler, steam piping, &c.

J. E. Spagnoletti & Co. have received an order for 43 H.T. three-phase and 43 L.T. panels, and 40 transformers for Bloemfontein municipal sub-stations.

London County Council have accepted the offer of Bolckow, Vaughan & Co., who are supplying track rails for the first section of the northern tramlines, to also supply 220 tons of sole plates at £7. 10s. per ton.

Messrs. Mordey & Dawbarn are ordering 500 Hookham d.-c. and 600 Ferranti a.-c. meters for Johannesburg Municipal electricity department.

Finchley Council have accepted the tender of Gwynnes Limited for supplying and fixing centrifugal pumping installation for £334, with certain spare parts, at an estimated cost of £15.

London County Council have extended the contract of Reid Bros. to include laying ducts for the Lewisham to Lee Green tramways at £1,000.

Whitby Council have entered into an agreement with the Tudor Accumulator Co. for the maintenance and upkeep of the storage battery at the electricity works for six years, at an annual cost of £156.

Islington (London) Guardians have accepted the tender of Pryke & Palmer for electrical fittings and sundries.

Southend Council have accepted the tender of the Brush Co. for fitting Brill trucks, equipments and controllers to three tramcars.

Battersea (London) Council have accepted the tender at £788. 2s. 6d. of Oliver & Co. for 70 arc lamps with raising and lowering gear.

Luton Council have accepted the tender of W. T. Garnett's Cable Co. for supplying distributing cable.

The tender of Besana Hermanos has been accepted for supplying and erecting 13 Otis electric elevators in Buenos Ayres Congress Hall at $47,060 gold

## BUSINESS NOTICES.

The Glasgow office of Mather & Platt has been removed to the Edinburgh Life Assurance Co.'s Building, 124, St. Vincent-street.

The telephone number of the Electrical Standardizing, Testing and Training Institution, Faraday House, 62-70, Southampton-row, W.C., is 9999 Central for all departments.

Dr. W. A. Caspari has resigned his position as head chemist to the National Physical Laboratory, and has established himself in consulting practice at 7, Idol lane, London, E.C.

## BANKRUPTCIES, LIQUIDATIONS, &c.

Last week the first meeting of creditors was held of A. H. Sparkes, formerly engineer. of 31, Kirby-street, Hatton Garden, London. In May, 1903, debtor began business in partnership at Kirby-street with another as electrical engineers. In Sept., 1903, the business was formed into a company, which eventually went into liquidation. Liabilities £194. 9s. 10d., assets nil.

The discharge of Edward Mann, electrical engineer, has been suspended for two years.

In May, 1899, bankrupt formed the Compass Trading Co. to take over the business of an electrical engineer, which he had carried on in Bridge-street, Westminster, and he attributed his insolvency to liability under guarantees given on behalf of the company and to ill-health. Liabilities estimated at £9,794; nothing had been realised in respect to the estate.

A first and final dividend of 9¾d. is payable at 14, Chapel-street, Preston, in the bankruptcy of Jas. W. Smith (trading as Smith & Co.), electrical engineer, Bolton-road, Darwen.

The trustee in the bankruptcy of W. & E. Sumner, electrical and mechanical engineers, formerly trading at 65, Victoria-street, and 108, St. Mary's-road, Garston, Liverpool, and 9, Grange-road, West Kirby, has been released.

A meeting will be held on May 15 at 65, Old Broad-street, London, E.C., to receive an account of the winding up of the Mexican Electric Works (Ltd.)

A meeting will be held on May 7 at Prudential-buildings, Queen-street, Nottingham, to receive an account of the winding up of the Electrical Bleaching Co. (Ltd.)

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**Instruments for Sale.**—The Brown Hoisting Machinery Co., 39, Victoria street, London, S.W., advertise for sale a Weston ammeter with shunt, and voltmeter; also insulation tester.

**Premises to Let.**—Mr. Alfred Kirkland, 113, Cottenham-road Upper Holloway, London, N., advertises an extensive new factory to let.

Light workshops and offices are advertised to let at 219, Goswell-road, London, E.C.

Messrs. R. D. & J. B. Fraser, Princes-street, Ipswich, advertise a spacious factory to let.

A factory at Holloway, London, N, is advertised to let.

**Motor Starters.**—We have received from Messrs. Reyrolle & Co., of Hebburn-on-Tyne, the following letter on the subject of "Motor Starters":—

TO THE EDITOR.

SIR: It has come to our knowledge that a rumour is current to the effect that we are having a certain number of our motor starters made by outside firms, as we are unable at the present time to deal with the quantity of orders in hand. It is true that we are called upon to supply a very large and rapidly-increasing demand for our motor starter and are very busy in consequence, and have considerable extensions to our works in progress, but there is no truth in the rumour that we are putting some of our motor starter work in the hands of outside firms, and we would esteem it a favour if you would contradict this part of the rumour by a short notice in your columns, as the erroneous rumour may be injurious to our business if not immediately contradicted.—Yours, &c.,

H. W. CLOTHIER,
For A. REYROLLE & Co. (LTD.)

**Wood Fibre.**—Not long ago it would have been difficult to associate the use of wood fibre, or wood wool, as a packing material for the electrical industry. What was formerly understood by the term "wood wool" was a coarse, hard, stringy material which it would have been considered desirable to keep away from instruments and apparatus and other articles of a delicate nature. But this has been considerably changed of late by the successful operations of the City of London Wood Wool Co., who have established extensive works premises, known as Plover Works, London, N.E., where the manipulation of a special class of timber results in the production of what is known as "wood fibre," of a class specially suitable for safely and effectively packing delicate goods for transit.

We understand that amongst the earliest trades to recognise the value of this specially prepared material were certain sections of the electrical industry, whose earlier experience of wood wool, however, was not of a wholly satisfactory character. This was recognised by the City of London Wood Wool Co., whose first business it was to provide a satisfactory raw material. It was found that the timber usually employed for manipulation into wood wool was unsuitable where a soft and springy packing was essential. It was ultimately found that an excellent white pulp wood was obtainable from the Tinman Mountains, in north Russia, and a well-equipped engineering department having been established, and new patterns of machinery designed and manufactured for cutting the fibre so that it retained the elastic properties of the timber, secured for the company the desirable article which is now sold in large quantities under the trade-mark name of "Elastene." It is claimed for "Elastene" that it is of extreme lightness, is cleanly cut, of great length, and free from dust and waste chips, free from objectionable smell or dampness, and that its elastic resistance is high, which enables it to retain its "springiness" for a long time under normal packing conditions. This material having been satisfactorily placed upon the market, it was found that different trades required a different cut of the fibre, and the company have, to meet this need, designed machinery of a character that meets all present demands. Many of our readers will be surprised to learn that, besides ordinary packing, wood fibre is employed for softening boiler feed water, and is, we are informed, used in a number of well-known types of water softeners. "Elastene" wood fibre ropes are also employed in foundry work in preference to the old hay-bands or straw ropes. Coring ropes made of wood fibre are also largely used for roping round poles, conduit tubes, lamp standards, columns, trolley poles, &c.

The company's Plover Works, at Hackney Wick, where this material is manufactured, cover about three-quarters of an acre, and the turn-out of the machinery there installed gives excellent proof of the demand and of the skill which has been brought to bear upon what appears at the outset to be a somewhat unlikely industry.

**Tantalum Lamps.**—Siemens & Halske A.-G., Berlin, announce that, owing to the cheapening of the cost of manufacture, the price of the tantalum lamp has been reduced from 4 to 2·50 marks.

**City of London Directory.**—The 1906 edition of this valuable directory and handbook to the City of London reaches us from the publishers, Messrs. W. H. & L. Collingridge, the "City Press" offices, Aldersgate-street, London, E.C. The publication of this directory is delayed, as in the case of other books of the kind whose publishers desire to be up-to-date, by the fact that much of the information is not obtainable in complete form until some time after the turn of the year. This makes the work more rather than less valuable, from the fact that the very numerous changes which take place in the early months of the year are recorded, and in this way the book is not out of date before it reaches the public. This is the 36th annual edition of a very useful work, which is indispensable to all who have business in the City of London, or who have commercial transactions with the Livery Companies, with the City authorities, the London County Council, or any other of the numerous official and semi-official bodies whose location is in the City and County of London. The information provided regarding all these special features is very complete. There is an excellent map of the City, and a biographical section which gives interesting information concerning its leading men. The price of this Directory, which consists of about 1,200 large pages, is 12s. 6d.

"**Telefunken**," **System of Wireless Telegraphy.**—We have received from the Foreign Department of the Electrical Co., 125, Charing Cross-road, London, W.C., a well got-up and elaborately illustrated description of the "Telefunken" system of wireless telegraphy. Readers of *The Electrician* are familiar with the majority of the illustrations and also with the textual descriptions given in the publication to hand, but there remains beyond these sufficient matter to make the pamphlet interesting reading.

**Catalogues, &c.**—A new ignition battery list has been issued by Portable Accumulators, Ltd., of Coventry. The list includes several novelties, one of these, a battery specially for motor cycles, introducing the company's patent wood separators, which, it is claimed, absolutely avoid any possibility of short-circuiting.

The British Aluminium Co. have ready sheets Nos. 29 to 32, giving prices, &c. of pure aluminium and light aluminium alloys, including aluminium wire (in coils), tubes, rolled rods and bars, &c.

In connection with the North-Eastern Counties Electrical Exhibition now being held at Newcastle-on-Tyne, J. H. Holmes & Co., of Newcastle-on-Tyne, have had a catalogue of specialities prepared, and copies can be obtained on application.

A new list of series-wound and three-phase motors for intermittent service has been published by the foreign department of the Electrical Co., 125, Charing Cross-road, London, W.C. The list, which extends to 44 pages of closely printed text, illustrations and comparative tables, deals very fully with the construction, working and management of these machines, which are now supplied in large numbers for all purposes where intermittent service from the motor is required.

Tvermoes & Abrahamson, of Copenhagen, have ready a new catalogue of electric light art fittings, and we are asked to state that any trading firm interested in this matter can obtain a copy of the catalogue and price list on application to 43, Raadmandsgade Copenhagen. The list contains a large variety of both plain and ornamental fittings, a number of the designs being very artistic. The list extends to 100 large quarto pages, a number of illustrations being shown on nearly every page.

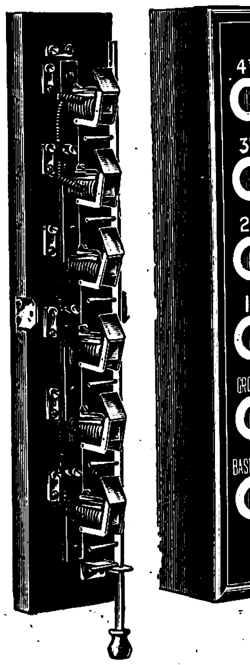

FIG. 1.—G.E.C. ELECTRIC LIFT INDICATOR.

The accompanying illustration (Fig. 1) shows a pattern of electric lift indicator supplied by the General Electric Co. It is fitted with a new patent locking and restoring movement constructed on approved scientific and electrical principles, and so constructed mechanically that no amount of jolting or oscillation can cause the disc to fall. Stock cases for the apparatus are in polished Spanish mahogany, but can be supplied in any wood or style to suit interior decoration of lift cab.

The General Electric Co.'s "Progress Sheet" for March shows an excellent type of adjustable standard lamp, suitable for writing desks, pianos, and, in fact, any position where a flexible method of lighting is a necessity. There is also illustrated a new pattern plug adapter, suitable for bayonet holders. There has recently been a reduction in price of this accessory, as well as in other items of electrical sundries illustrated and described on this sheet.

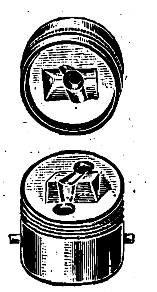

FIG. 2.—G.E.C. PLUG ADAPTER.

**Imports.**—The following are official values of imports of electrical machinery, material and apparatus imported into this country during March, 1906:—

Electrical machinery, £47,473 (a decrease of £701); telegraph and telephone cables, £16,425; telegraph and telephone apparatus, £32,943; other electric wires and cables (rubber insulated) £8,996; (with other insulations), £1,637; other electrical goods and apparatus £39,716. Total of electrical goods and apparatus (other than machinery and telegraph and telephone wire), £99,717 (increase, £11,078).

**Exports of Electrical Apparatus and Material.**—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from to April 4 to 10, with the ports of destination:—

*Aden*, £75 (telegraph material). *Africa*—Alexandria, £1,148 (including £942 telegraph material); Capetown, £62; Delagoa Bay, £784; Durban, £5,059 (including £1,249 telegraph material); East London, £66; Mombasa, £18; Port Elizabeth, £31; Suez, £560; Taltal, £102. *Argentina*—Buenos Ayres, £1,648 (including £723 telegraph material); Rosario, £139. *Australasia*—Adelaide, £121; Brisbane, £66; Fremantle, £65; Melbourne, £88; Perth, £167; Sydney, £1,993. *Austria*—Fiume, £20. *Belgium*—Antwerp, £50; Ghent, £60; Ostend, £45. *Brazil*—Rio Janeiro, £225 (including £135 telegraph material). *Burma*—Rangoon, £16 (telegraph material). *Canada*—Halifax (N.S.), £1,450 (telegraph material). *Ceylon*—Colombo, £244 (including £102 telegraph material). *Cochin China*—Saigon, £49. *Cuba*—£1,390. *France*—Boulogne, £51. *Germany*—Bremen, £30 (telegraph material); Hamburg, £353. *Gibraltar*, £160 (telegraph material). *Holland*—Amsterdam, £100; Rotterdam, £270. *Hong Kong*, £813. *India*—Bombay, £402; Calcutta, £3,103 (including £18 telegraph material); Madras, £640. *Japan*—Kobe, £14; Yokohama, £3,765; Yokosuka, £666. *Malta*, £178. *Mauritius*, £210 (telegraph material). *Portugal*—Oporto, £23 (telegraph material). *Russia*—Kurch, £1,105; Reval, £180. *Spain*—Barcelona, £115; Bilbao, £65. *Straits Settlements*—Penang, £10; Singapore, £219 (including £153 telegraph material). *Turkey*—Constantinople, £55 (telegraph material). *Sweden*—Stockholm, £108. *U.S.A.*—New Plymouth, £43. Total, £27,258, against £20,781 in the corresponding week last year (April 5 to 11).

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

Note.—*The undermentioned Applications (except those marked †) are no open to public inspection until after acceptance of Complete Specification. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

February 19, 1906.

13,954a/05 Harrison. (Electric Railway Improvement Co., U.S.) Adjustable electrical resistances. (Date applied for, July 6, 1905.)*†
4,019 Lewis & Hughes. Lighting by arc lamps.
4,032 Hintze. Portable electric apparatus for signalling at a distance.
4,033 Smith. Ships' telegraphs.
4,040 Brocksopp. Conductors for electric vehicles.
4,071 de Leeuw. Electromagnetic switch operating mechanism.
4,076 Fauvin, Amiot & Cheneaux. Dashpot for electricity meters.*
4,081 Just, Landesberger, Salzmann & Vereinigte Elektricitäts A.-G. Incandescing bodies for electric lamps.
4,100 B.T.-H. Co. (G.E. Co., U.S.) Current-collecting devices for electric vehicles.
4,102 Mecke. Measuring, indicating and registering speed by a dynamo in combination with a solenoid with a core.

February 20, 1906

4,151 Welsh. Pulleys for trolleys of electric railways and tramways.
4,161 Stebbins. Regulation of alternating-current systems by a storage battery in connection with converters.
4,163 Pieper. Regulating arrangements for electro-mechanically propelled automobiles. (Date applied for, Feb. 28, 1905.)*†
4,190 Thorogood. Switches.
4,198 Hill. Electric cauterizing apparatus and resistances therefor.
4,220 Massie. Condensers for wireless telegraphy and other uses.*
4,221 Massie. Oscillaphones or wave-responsive devices.*
4,229 Bein. Electrical measuring, indicating or relay apparatus.*

February 21, 1906.

4,236 Aldigier. Sparking plugs.
4,252 Bristowe & Henman. Battery coil and sparking plug testing machine.*
4,272 Hill. Electrical safety lock.
4,279 Pycroft & Hacking. Arc lamps.
4,292 Morris. Incandescent electric lamps.
4,294 Stirk. Electrically driven boring and turning mills, slotting, shaping, planing, punching and shearing machines, &c.
4,308 Vickers, Sons & Maxim & Sumpner. Improvements relating to electrical apparatus for training and elevating heavy guns.
4,318 Clarke, Chapman & Co., Walker & Money. Driving and controlling electric capstans, hoists, &c.*
4,322 B.T.-H. Co. (G.E. Co., U.S.) Electric controllers.

February 22, 1906.

4,331 Taylor. Mechanism to complete an electric circuit at any or every hour and minute.*
4,335 Bingham. Regulating the voltage in electric furnaces.
4,336 Bingham. Electric furnaces.
4,343 Carbone. Arc lamp. (Date applied for, Feb. 27, 1905.)*†
4,350 Smith. Electrical governors for gas engines used for generation of electricity.
4,355 Roy. Accumulator grid.
4,369 Müller. Cable for power transmission.*
4,383 Ridings. Arc lamps.
4,405 Weill. Apparatus for electroplating.

February 23, 1906.

4,422 Barr & Stroud. Electro-mechanical devices for producing corresponding positions in transmitting and receiving apparatus.
4,459 Raworth. Regenerative control of electric vehicles.
4,488 Cook. Improvements in connection with railway or tramway cars or trucks.
4,489 Ralston. Dynamo-electric machines. (Date applied for, March 1, 1905.)*†
4,493 Phœnix Dynamo Mfg. Co. & Pohl. Armature windings for commutating electric machines especially for high-speed machines.
4,510 Blanchon. Dies for forming accumulator plates. (Date applied for, Feb. 24, 1905.)*†
4,513 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control systems specially for operating bulkhead doors.
4,514 B.T.-H. Co. (G.E. Co., U.S.) Systems of motor control.

February 24, 1906.

4,518 Opsahl. Electrically operating points of electric railways and tramways.
4,519 Dolphin. Electrolytic deposition of copper.
4,528 Vyner. Electrical igniters for internal combustion engines.
4,530 Veritys Limited & Walker. Electric motors for working cranes, lifts and like.
4,535 Walter. Apparatus for detecting electrical oscillations.
4,538 Torda & Stanger. Shade holders for electric lamps.
4,543 Longford. Terminals for insulated wires conducting electricity.
4,565 Fairbrother. Mercury vapour electric lamps.
4,585 Wesselius. Wireless telephony.*
4,606 Chadburn's (Ship) Telegraph Co. & Grant. Ships' telegraphs.

February 26, 1906.

4,619 Turner & Dixon. Current-collecting devices of electric tramways and railways.
4,649 Tourtel & Johns. Coin-freed electric supply apparatus.
4,653 Smith & Bausche. Electromagnetic door-opening apparatus.*
4,657 Ganz & Co. Eisengiesserei und Maschinen Fabriks A.-G. Regulating pressure of alternating-current generators. (Date applied for, May 24, 1905.)*†
4,677 Blondel. Arc lamps.
4,683 Sanders. Manufacture of wire, bars, &c., by electrodeposition.
4,691 Collins. Wireless telephony or telegraphy.
4,692 Gratz. Processes for obtaining pure caoutchouc gutta-percha and the like. (Date applied for, Feb. 1, 1906.)*†
4,694 Ferranti. Turbine blades.
4,700 Lake. (Rhode Island Electromobile Co., U.S.) Secondary batteries.*
4,702 Fiedler. Automatic regulator for seondary batteries.
4,709 B.T.-H. Co. (G.E. Co., U.S.) Lightning arresters.
4,710 Potter. Equipment of electric vehicles or trains. (Date applied for, Feb. 27, 1905.)*†
4,711 and 4,720 Pevear. Control of switches and operating mechanism therefor. (Date applied for, Feb. 27, 1905.)*†
4,716 McDonald. Electrolytic apparatus.*
4,717 Wirt. Telephonic transmitters.

February 27, 1906.

4,724 Tatlock & Dennison. Apparatus for recording electrical measurements.
4,773 A. Holmes, J. H. Holmes, L. W. Holmes, E. Holmes & Ralph. Controllers for electric motors.*
4,795 La Société Anon Westinghouse & Brun. Direct-current motors. (Date applied for, March 1, 1905.)*†
4,808 Brooks & White. Holders for incandescent lamps.*
4,813 Siemens & Halske A.G. Temporarily producing alternating currents in a circuit at optional points and the application thereof to working printing telegraph apparatus. (Date applied for, 3/21/05.)*†
4,815 Dawson & Buckham. Transmitting and receiving signals.
4,827 Offroy & Offroy. Contact device for weaving-looms for shuttle-changing or stop-motion mechanism.
4,838 Lake. (Smith, U.S.) Electric motors.*

February 28, 1906.

4,862 Phillips & Smith. Electrical measuring instruments.
4,871 Bruce Peebles & Co. & La Cour. Compounding synchronous alternating-current dynamos.*
4,874 Shaw & France. Trolley pulleys or like collectors.
4,891 Neumann & Kepes. Multiple supply of continuous current from an alternating-current conductor.
4,917 Nussbaum. Microphones.
4,925 B.T.-H. Co. (G.E. Co., U.S.) Insulation of metal for electrical apparatus.
4,926 B.T.-H. Co. (G.E. Co., U.S.) Electric motor-control systems.
4,929 Ogilvy & Davson. Rheostats.
4,930 Ogilvy & Davson. Speed regulating and steering apparatus for electric vehicles.
4,931 Chalas, Réquillart & Contal. Electric horn. (Date applied for, March 3, 1905.)*†
4,936 Hobart. Electric motors.
4,939 Lake. (Lentz, Germany.) Fenders for tramway and like vehicles.
4,951 Paulet. Electricity meters. (Date applied for, March 1, 1905.)*†

March 1, 1906.

4,961 Lea. Measuring and recording mechanical and electrical forces.
4,965 Hettinger. Selective or multiplex wireless signalling.
4,970 Bould. Joint boxes for telegraphic and other cables.
4,975 Bailey. Tramway and like rails.
4,987 Clark & Kelvin & James White. Mariner's compass.
5,003 Otis Elevator Co. (Otis Elevator Co., U.S.) Controlling devices for electric lift motors.*
5,013 Blathy. Electricity meters.*
5,028 Guyon. Binding posts for electrical connections.
5,037 Howorth. (Maschinenfabrik Oerlikon, Switzerland.) Synchronous alternating-current generators.*
5,047 Kroeger. Electro-therapeutic treatment.*
9,181a/05 Hirst & Collings. Electric light candle fittings. (Date applied for, Nov. 1, 1905.)*†

March 2, 1906.

5,082 Horsnaill. Magnetic clutches for conveying rotary motion.
5,088 Pringle. Supports for conductors for electric railways.
5,089 Pringle. Trolley wheels and similar collecting devices for electric railways.
5,092 Holmes. Electric lamp heating apparatus.*
5,093 Shaw-Browne & Williams. Telephonic and similar instruments.*
5,111 Barron & Barron. Electric lamps.
5,129 Kuzel. Manufacturing light-emitting bodies for glow lamps and connecting them to the supply conductors.*
5,136 Creedy. Improvements in single-phase dynamo-electric machines.
5,148 Bowen. Switches.
5,153 Elektrizitäts A.G. vorm. W. Lahmeyer & Co. Regulating asynchronous electric motors. (Date applied for, March 18, 1905.)*†
5,154 Elektrizitäts A.G. vorm. W. Lahmeyer & Co. Magnets for alternating currents. (Date applied for, May 31, 1905.)*†
5,160 Schwartz. Electrical generators. (Date applied for, March 7, 1905.)*†
5,166 Morgan Crucible Co. & Speirs. Holders for commutator brushes.
5,167 Morgan Crucible Co. & Speirs. Pneumatic holders for commutator brushes.
5,168 Leitner. Systems of electric lighting.
5,170 & 5,171 Peard. Electric fusible cut-outs.

March 3, 1906.

5,176 Kingscote. Absorbing the vibrations in steam, gas or electric engines and motors.
5,202 Eatwell. Electrical time signalling apparatus.
5,221 Sperryn & Wood. Tumbler switches.
5,250 Allgemeine Elektricitäts-Ges. Operating rotary flywheel converters. (Date applied for, May 24, 1905.)*†
5,258 de Forest. Wireless telegraphy.*
5,261 B.T.-H. Co. & Hopps. Dynamo-electric machines.
5,262 B.T.-H. Co. & Hopps. Suspension of the motors in electric vehicles.
5,263 B.T.-H. Co. & Hopps. Control of electric vehicles.
5,268 Koreck & Pikal. Insulating device for underground conductors.

## SPECIFICATIONS PUBLISHED.

1904.

25,620 Taylor. Controlling and supplying current for power and light on consumers' premises during certain periods.

1905.

1,528 Tayler. Controlling or supplying current for power and light on consumers' premises during certain periods.
2,039 B.T.-H. Co. & Holden. Electricity meters.
3,855 Moore & Bennitt. Apparatus for automatically accelerating electric motors.
4,595 Charlton & Tarver. Stopping and starting electrically-driven hydraulic pumps.
4,753 Skwirsky. Mercury or other conducting vapour lamps.
5,771 Barclay. Printing telegraphs.
5,977 Elektrizitats A.G. vorm. W. Lahmeyer & Co. Regulating the speed of alternate-current machines with commutators. (Date applied for, April 15, 1904.)
6,257 Parlett & Coxon. Automatic safety switches for compound-wound dynamos.
7,068 Andrews & Andrews, jun. Shade carrier for electric lamps.
7,903 Fennell & Perry. Accumulators or secondary electrolytic cells.
8,780 Adamson & Duckitt. Electric controllers and starting switches.
9,405 Kitt. Electromagnetic mechanism for actuating points of electric railways.
10,400a Birnbaum & Bell. Combined fire alarm and telephone systems. (Date applied for, Oct. 20, 1905.)
10,554 B.T.-H. Co. (G.E. Co., U.S.) Electric motor-driven pumps.
10,728 Wunderlich & Hughes. Suspension devices for arc lamps.
10,895 and 10,896 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control.
11,120 Read. Wiring for electric lighting and power installations.
11,881 Drake & Gorham. Arc lamps.
13,093b Boult. (Duntley.) Switches for electric drills. (Date applied for, June 24, 1905.)
14,467 Nelson & Murray. Electrotype plates.
14,566 B.T.-H. Co. & Wedmore. Electric circuit interrupting devices.
15,059 Warner. Radial railway and tramway trucks.
16,221 Soc. Anon. des Manufacture des Glaces et Produits Chimiques de Saint-Gobain, Chauny . et Cirey. Mounting of electricity conducting rails. (Date applied for Oct. 7, 1904.)
19,525 Lean. (Maschinenbau Anstalt Humboldt.) Magnetic ore separators.
20,950 Otis Elevator Co. Controlling devices for electric motors of lifts.
21,070 Elektrizitäts A.-G. vorm. W. Lahmeyer & Co. Polyphase alternate-current commutator machines. (Date applied for, 17/10/1904.)
21,202 Veritys Limited & Thorpe. Electric light fittings.
23,035 Hess. Arc lamps.
23,211 Thompson. (Ges. für drahtlose Telegraphie m.b.H.) Producing electric vibrations of different phase.
25,749 Von Recklinghausen. Automatic starters for vapour electric apparatus. (Date applied for, Dec. 13, 1904.)
25,759 De Kando. Protective devices for the stators of rotary electric machines.
26,355 Hein. Electrically-driven vacuum cleaning apparatus. (Date applied for, March 17, 1905.)

# COMPANIES' MEETINGS AND REPORTS.

## Willans & Robinson (Ltd.)

The ordinary general meeting was held on Wednesday, under the presidency of Mr. Mark Robinson.

The Secretary (Mr. C. S. ESSEX) having read the notice calling the meeting,

The CHAIRMAN said: I do not think it is necessary to say very much as to the position of the company. The improvement is obvious, and, though it is far short of what we need, it is certainly progressive and gives every hope for the future. With regard to Queen's Ferry, the board has no intention to keep the works open for an indefinite period for results such as are now shown, even though the loss should continue to diminish as at present. But the reasons given in the report are, we think, conclusive against closing the works without a longer attempt either to make them remunerative or at least to keep them in a going and improving condition, while we continue to look out for other use for them. The success achieved with the company's steel made at Queen's Ferry is remarkable. There is already a profit from it, which promises to become considerable, though, unfortunately, the volume of business possible to be done with the present steel-making appliances is comparatively small. In the steam turbine branch of its business the company is doing well. During the past half-year we have received a fair proportion of the orders which have been placed in this country for land-service turbines of large size, and its patented system of blading (Capt. Saukey's patent), which is one of the special features of our turbines, has been adopted for the turbines of the two great Cunard steamers now building under special arrangement with the Government. In the high-speed engine trade competition is carried so far that the manufacture of the long-famous Willans engine is no longer profitable to us, though there is a good demand for it. Other branches of new business which we are essaying have already yielded profit, and give ground for much hope for the future. As, upon the whole, we have had to reckon with such unfavourable conditions, the progress made by the company up to the present time may claim to be relatively satisfactory; indeed I do not think it falls short of anything we have led you to expect during the past two years. I do not think the details of the accounts need much explanation. They are clear enough and speak for themselves. Incidentally they will show you that we have been able to effect some substantial reductions in the expenses. I now move the adoption of the report and accounts.

Mr. A. W. COUSINS (a shareholder) seconded the motion, which after a short discussion was carried *nem. con.*

The retiring directors having been re-elected and the retiring auditors re-appointed, a vote of thanks to the chairman, directors and staff brought the meeting to a close.

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**ANGLO-ARGENTINA TRAMWAYS CO. (LTD.)**—At the meeting on Tuesday, Mr. J. B. Concanon said they might without exaggeration congratulate themselves upon the results of last year's working. The combined receipts were £720,488, and the expenditure (including £38,000 set aside for maintenance and £12,000 for depreciation renewals) was £464,872, leaving a net profit of £255,616. Interest charges, preference dividend, interim ordinary dividend, sinking fund and £20,000 carried to reserve absorbed £208,823, leaving £52,714, which admitted of a balance ordinary dividend of 5s. per share, making 8s. per share (or 8 per cent.). The completion of the electrification of the City lines was now only a matter of four to six weeks. When 90 per cent. of the work was finished and ready for working, under their contract with the contractors they were bound to issue 80,000 shares.

**BABCOCK & WILCOX (LTD.)**—The net profit for 1905, after deducting depreciation, &c., amounts to £291,022. 0s. 9d. Adding balance from last account (£28,519. 13s. 10d.), and deducting amount voted to directors as bonus at last meeting (£1,575), the balance is £317,966. 14s. 7d. Deducting interim dividends to June 30 of 3 per cent. on the preference and 8 per cent. on the ordinary shares (£67,000), the balance is £250,966. 14s. 7d. The directors recommend dividends for half-year ended Dec. 31 of 3 per cent. on the preference (less tax) and 8 per cent. on the ordinary shares (tax free), together with a bonus of 4 per cent. on the ordinary shares (also tax free). £100,000 is placed to reserve, and £20,000 to dividend equalisation fund, leaving a balance forward of £31,966. 14s. 7d.

**BATH ELECTRIC TRAMWAYS (LTD.)**—During 1905 the construction of the tramway extension to Newton-St.-Leo has been completed and opened for traffic, and work on the Midland Bridge route has been continued. In November the Light Railway Commissioners authorised the construction of a further line to Saltford (about 1 mile 4 furlongs 7 chains). Capital expenditure to Dec. 31, 1905, is £335,051. 9s. 1d. Traffic receipts for 1905 amounted to £35,756. 6s. 2d., an increase of £2,595. 0s. 7d. over previous year. Operating expenses were £19,433. 1s. 9d., compared with £19,759. 10s., although in 1905 there was an increase in the car-mileage of 67,387 miles and of 98,230 in the number of passengers carried. Out of the balance of £7,793. 4s. 6d., the directors recommend payment of the preference dividend absorbing £3,780. 6s. £2,000 is placed to reserve.

**CALCUTTA TRAMWAYS CO. (LTD.)**—At the meeting on Tuesday Mr. E. C. Morgan said that £117,000 had been expended on additions to plant and machinery during the past year. Permanent way and equipment accounted for £26,653 of this. The heaviest amount (£52,358) had been spent on the extensions to power and sub-station plant and buildings, which included additional engines, boilers and generators, as well as a new chimney at the generating station, all the buildings and machinery at two sub-stations, and a new shop and smithy. It was largely due to that outlay that they had been able to handle so effectively the very greatly increased traffic, and to run an additional 500,000 miles during the year. Expenditure on cars and electrical equipment also appeared to be a very heavy amount (£34,322). In addition to the cars in use there were a large number in course of construction, bringing the total number up to 400 cars, of which 200 were motors. They hoped the Howrah and Alipore extensions might be in such a forward position as to enable them to work portions of the lines by the end of the year.

**CUBA SUBMARINE TELEGRAPH CO. (LTD.)**—The report of the directors for the half-year ended Dec. 31 last states that the total receipts of the six months were £14,647. 19s. and expenses were £6,257. 9s. 7d., leaving £8,390. 9s. 5d., to which is added £6,031. 14s. 10d. brought forward, making £14,422. 4s. 3d. £1,818. 4s. 4d. has been added to reserve, which now stands at £87,000. The preference dividend absorbs £3,000, leaving £9,603. 19s. 11d., and the directors recommend payment of a dividend at the rate of 5 per cent. per annum on the ordinary shares (tax free), the balance, £5,603. 19s. 11d., being carried forward. The company's cables continue in good working order. The claim against the United States Government for payment of the cost of repairing the damage done to the cables during the Spanish-American war is still unsettled.

**INDO-EUROPEAN TELEGRAPH CO. (LTD.)**—The report of the directors for the year ended Dec. 31 last states that the Russian section of the company's line passed into the possession of the Imperial Russian Government on Jan. 31, 1905, under the terms of the company's extended concession from that Government. This section, which stood in the last balance-sheet at £313,285. 5s. 5d., has been written off out of reserve, which now stands, with accrued interest, at £138,628. 15s. 9d. The investments, representing £313,285. 5s. 5d. written off as above, remain in the balance-sheet, together with other items, under the heading "Unappropriated Investments." The lines of the company continue to work efficiently, and the direct Wheatsone working in use on all sections enables the heavy traffic to be dealt with satisfactorily. The company's revenue from all sources amounted to £129,761. 18s. 11d., compared with £141,400. 17s. 2d. for 1904, a decrease of £11,638. 18s. 3d. Expenses were, on commercial and general account £45,123. 9s. 7d., and on maintenance account £25,669. 0s. 10d., total £70,792. 10s. 5d., against £71,930. 1s. 10d. for 1904, decrease £1,137. 11s. 5d. The revenue, therefore, shows a balance of £58,969. 8s. 6d., which is carried to profit and loss account, 1905. Bringing forward the balance profit for 1904 of £19,391. 13s. 7d., and deducting income tax paid (£4,162. 5s. 6d.) and the interim dividend (£10,625), there is an available balance of £63,573. 16s. 7d. The company has during the year received £3,838. 5s. 10d. in respect of traffic receipts outstanding for some time past. As this sum is not attributable to the earnings of the year the directors propose to keep it as an open balance against future contingencies. The directors now propose a dividend for the six months ended Dec. 31, 1905, of 17s. 6d. a share (making, with interim dividend already paid, 6 per cent. for the year) and a bonus of 20s. per share (both tax free). They also propose to add £10,000 to equalisation of dividends funds and to hand over a further £5,000 to the trustees of the retirement trust fund, carrying forward £16,698. 16s. 7d. to credit of 1906. The directors do not consider it necessary to reinvest the interest accrued during 1905 upon the unappropriated investments and upon the deposit of Russian Government rente, and therefore propose making a special distribution to the shareholders from these sources of £12,750, equivalent to 15s. per share. This distribution will also be free of tax.

**LONDON & GENERAL POWER SUPPLY CO. (LTD.)**—Mr. Stanley Boulter, at the meeting on Tuesday, said the principal electric supply bills to come before Parliament had been the London County Council Bill, the Administrative Supply Company of London Bill and the Additional Electrical Supply Bill. The chief feature of the latter measure was its identification with the great railway interests of London—a feature peculiar to that bill alone. Its object was to assist in solving the pressing question of the electrification of the suburban traffic of London. A few weeks ago they were given to understand that the London County Council intended, if possible, to push their own bill through Parliament and to get the other bills rejected. To disarm the opposition of the Council, it was arranged to omit from the "Additional" Bill the clauses which would have enabled the company to supply in bulk such of the large electrical companies and borough councils as desired to take energy from the Additional Co., and to restrict the powers to railways and canals alone. This was giving up not only what was likely to be a profitable source of business, but what might have proved of great service to the local companies and borough councils. If the "Additional" Bill had been read a second time, like that of the County Council, and sent to the Committee for consideration, he and his colleagues would naturally have been prepared to go the great expense and trouble of attending that Committee and producing evidence which, he thought, would have satisfied them that the scheme was a proper one for Parliament to sanction. But to be told that a second reading was not to be given to the bill, and that they were at liberty to attend the Committee where the County Council Bill was being discussed, in order that they might point out any defects in that measure, was a proposal they could not entertain. They had asked for no monopoly. The persons who sought a monopoly were the London County Council, and with the assistance of the Government they seemed likely to get it. During the previous week the general managers of two of the large London railways had called at the Board of Trade to express their anxiety to see the "Additional" Bill passed, as it would, in their opinion, do much to hasten the electrification of their suburban systems; and the general manager of another large London railway, who could not attend, wrote to say that he was in full sympathy with the object of the visit of the other general managers. Some indication might have been expected from the Government of a desire to assist in a matter so vitally affecting the comfort of many thousands of workers, but the influence of London County Council was so strong that all such considerations were ignored. To supply the railways of London it would not have been necessary for them to break up any of the London streets, as the wires for carrying the electric current could have been taken along the railways themselves. The way in which the President of the Board of Trade had approached the subject, and the manner in which he had declined to give even a fair consideration to a question of such vital importance to the working classes of London, was, he thought, most unfortunate.

**MADRAS ELECTRIC TRAMWAYS (1904) (LTD.)**—The report for 1905 states that the net profit, after providing for maintenance, interest, &c., and placing £1,500 to depreciation and renewal fund, is £1,119. The extensions of the tramways, for which an order was secured last year, are under construction, and the lines, it is expected, will be in operation before the end of July.

**METROPOLITAN ELECTRIC TRAMWAYS (LTD.)**—At the meeting on Wednesday the chairman (Mr. Emile Garcke) after explaining the various items in the report (given in our last issue) said that as they held a large part of the shares of the North Metropolitan Tramways Co. they would be receiving a considerable amount from the sale of that company's undertaking to London County Council, and they expected this would realise £4. 10s. to £4. 15s. per share. The company had arranged to buy the Harrow-road and Paddington Tramways for £44,800. The new electric lines opened during the year 1905 were doing well, one route (from Finsbury Park to Wood Green) returning £15,000 per route mile. The average receipts on the whole of their tramways, other than light railways, amounted to nearly £12,000 per route mile. In the course of the summer they hoped the company's cars would be running from the Holloway-road to Barnet Town, a distance of 7 miles. In regard to the supply of electric power, they last year supplied $5\frac{1}{2}$ million units, of which 4 millions were required for their tramways. As the L.C.C.'s Electricity Bill was an invasion of their area they would oppose that bill. They had made an arrangement with Stoke Newington Council to supply them with electricity in bulk, and they looked to a large business in that direction in the future. He considered they had nothing to fear from the competition of motor omnibuses.

**TYNEMOUTH & DISTRICT ELECTRIC TRACTION CO. (LTD.)**—The capital expended during 1905 was £5,705, the total capital outlay on electrical construction and equipment of the lines being £91,918. The revenue was £13,686, and expenditure £9,982, leaving £3,703. A dividend of $3\frac{1}{2}$ per cent. on the ordinary shares is declared.

**WORCESTER ELECTRIC TRACTION (LTD.)**—The capital expenditure to Dec. 31 was £115,086. The total revenue for the year was £15,979. After deducting expenses (including repairs, maintenance and interest) there remains £5,884, and the directors recommend that £1,241 be placed to depreciation and reserve, and a dividend on the ordinary shares of 5 per cent. It has been decided to construct about 200 yds. of light railway along the Malvern-road.

## NEW COMPANIES, STATUTORY RETURNS.

### NEW COMPANIES.

**ELECTRICAL MANUFACTURERS' & WHOLESALE TRADERS' PROTECTION ASSOCIATION (LTD.)** (88,267).—Reg. April 3 with 250 members, each liable for 5s. in the event of winding up, with objects as indicated by the title. The subscribers are, J. W. Rook, E. H. F. Reeves, H. R. Pattrick, E. Sheppard, A. Baxter, H. H. Thompson, and H. E. Davis. The management is vested in a committee.

**LAWRENCE E. ALLEN & CO. (LTD.)** (88,320.)—Reg. April 6, capital £1,000 in £1 shares, to acquire and carry on the business carried on at 56 and 57, Aldermanbury, E.C., as the Rose Electric Lamp Co., and to carry on the business of electric lamp manufacturers, electricians, mechanical, gas, electric and telegraph engineers, producers and suppliers of electricity, &c. L. E. Allen is the first sole director. Reg. office, 56 and 57, Aldermanbury, London, E.C.

**SIMPLEX CONDUITS (LTD.)** (88,290).—Reg. April 4, capital £100,000 in 10,000 6 per cent. cumulative preference shares of £5 each and 50,000 ordinary shares of £1 each, to acquire and carry on all or part of the business of electrical and mechanical engineers and manufacturers of electric fittings and apparatus now or recently carried on by the Simplex Steel Conduit Co. (Ltd.), in Birmingham, London and elsewhere. The subscribers are, L. M. Waterhouse, engineer; H. & F. Huggins, manufacturers; H. C. Pinsent, H. R. Hodgkinson, G. J. Withington and H. G. Silk. First directors H. Huggins, F. Huggins and L. M. Waterhouse, with power to appoint others prior to statutory meeting.

### STATUTORY RETURNS.

**W. T. HENLEY'S TELEGRAPH WORKS CO. (LTD.)**—Return to March 15 gives capital as £400,000 in 40,000 ordinary and 40,000 preference shares of £5 each, all of which have been taken up. £5 per share has been called up on 32,616 ordinary and 39,880 preference, and £362,480 has been received. £37,520 considered as paid on 7,384 ordinary and 120 preference. Mortgages and charges, £150,000.

**NOTTING HILL ELECTRIC LIGHTING CO. (LTD.)**—According to return to March 13 capital is £200,000 in 16,452 ordinary, 2,998 "ordinary preference" and 550 founders' shares of £10 each, of which 10,852 ordinary, 2,998 "ordinary preference" and 550 founders' have been taken up. £10 per share has been called up, and £144,000 has been received. Mortgages and charges, £64,000. Mortgages and charges guaranteed jointly by company and Kensington & Knightsbridge Electric Lighting Co.: £152,500.

**TELEGRAPH CONSTRUCTION & MAINTENANCE CO. (LTD.)**—In return to March 13 capital is £448,200 in 37,350 shares of £12 each, all of which have been taken up and paid for in full. Mortgages and charges, nil.

## CITY NOTES.

**MEMORANDA** (April 11).—Bank rate $3\frac{1}{2}$ per cent. (since April 5, 1906). Price of silver $29\frac{3}{4}$d. per oz. Consols $90\frac{11}{16}$—$90\frac{13}{16}$ for money, $90\frac{13}{16}$—$90\frac{15}{16}$ for account; $2\frac{1}{2}$ per cent. annuities $89\frac{5}{8}$—$89\frac{7}{8}$. Consols Pay Day, May 4. Stocks and Shares Continuation Day, April 24; Ticket Day, April 25; Pay Day, April 26; Mining Share Carry-over Day, April 23.

**ANGLO-AMERICAN TELEGRAPH CO. (LTD.)**—The directors have resolved to declare an interim dividend for the quarter ended March 31 of 15s. per cent. on the ordinary and £1. 10s. per cent. on the preferred, less tax, payable May 1.

**CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)**—The directors have decided, subject to audit, to recommend a dividend for the half-year ended Dec. 31, on the paid-up share capital, at the rate of $10\frac{1}{2}$ per cent. per annum, making, with interim dividend, $8\frac{1}{2}$ per cent. for the year.

**COUNTY OF LONDON ELECTRIC SUPPLY CO. (LTD.)**—The transfer books and register of holders of second debenture stock will be closed from 18th to 30th inst. inclusive, preparatory to payment of interest due May 1.

## ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

| Line. | Week ended | Amount. | Inc. or Dec. (a) | Aggregate. No. of weeks. | Aggregate. Amount. | Aggregate. Inc. or Dec. (a) |
|---|---|---|---|---|---|---|
| | | £ | £ | | £ | £ |
| **Aberdeen Corporation** | April 7 | 1,247 | + 90 | 45 | 60,222 | − 686 |
| **Airdrie** | March 30 | 213 | + 84 | 18 | 2,756 | + 279 |
| Anglo-Argentine | April 8 | 15,381 | + 1,519 | 14 | 208,961 | + 21,654 |
| Ashton-under-Lyne Corpn. | ... | ... | ... | ... | ... | ... |
| Ayr Corporation | March 31 | 190 | − 3 | 45 | 12,907 | − 83 |
| Baker St. & Waterloo Ry. | April 7 | 1,429 | ... | 4 | 6,328 | ... |
| **Barnsley** | March 30 | 155 | − 8 | 18 | 1,954 | + 3 |
| **Barrow** | „ 30 | 217 | + 11 | 13 | 2,585 | + 198 |
| **Bath Electric Trams, Ltd.** | April 4 | 717 | + 104 | 14 | 8,915 | + 1,220 |
| Birkenhead Corporation | „ 8 | 1,005 | ... | 14 | 14,010 | + 23 |
| **Birmingham Corporation** | „ 7 | 395 | + 88 | 1 | 395 | + 83 |
| ***Birmingham & Mid.** | March 30 | 1,372 | − 450 | 18 | 17,880 | − 4,589 |
| Blackburn Corporation | April 4 | 943 | + 69 | ¶1 | 1,249 | + 58 |
| **Blackpool Corporation** | ... | ... | ... | ... | ... | ... |
| **Blackpool and Fleetwood** | „ 7 | 296 | + 52 | 14 | 2,766 | − 28 |
| **Bolton Corporation** | „ 8 | 1,985 | + 165 | 1 | 1,985 | + 165 |
| **Bournemouth Corporation** | „ 4† | 706 | + 27 | †1 | 706 | + 27 |
| **Bradford Corporation** | „ 7 | 4,254 | + 321 | 1 | 4,254 | + 321 |
| **Brighton Corporation** | „ 8 | 838 | + 28 | 1 | 838 | + 28 |
| **Bristol Trams & Carriage** | „ 6 | 4,957 | + 861 | 8 | 87,656 | + 1,658 |
| **Buenos Ayres & Belgrano** | „ 8 | 3,466 | − 63 | 14 | 49,419 | + 4,086 |
| **Buenos Ayres Elec. Trms** | March 10 | 1,487 | + 831 | 10 | 14,225 | + 8,434 |
| **Burnley Corporation** | April 7 | 1,288 | + 156 | 1 | 1,283 | + 156 |
| **Burton Corporation** | „ 8 | 279 | − 22 | §1 | 802 | − 97 |
| Bury Corporation | March 31 | 682 | ... | §52 | 39,802 | ... |
| **Calcutta Tramways Co.** | April 7 | R45,142 | + R4,768 | 14 | R618,928 | + R61,094 |
| **Camborne-Redruth** | „ 7 | 109 | − 2 | 23 | 2,454 | + 51 |
| Cardiff | ... | ... | ... | ... | ... | ... |
| **Carlisle Tramways Co.** | ... | ... | ... | ... | ... | ... |
| Cavehill | March 30 | 58 | + 9 | 13 | 575 | + 87 |
| **Central London Railway** | April 7 | 6,785 | − 428 | 14 | 97,281 | − 8,084 |
| **Chatham & Dist. Lt. Rys.** | „ 5 | 637 | − 26 | †14 | 7,872 | − 217 |
| ***City of Birm'gh'm Tram Co.** | March 30 | 4,975 | − 765 | 13 | 65,856 | − 2,920 |
| **City & South London Rly.** | April 8 | 2,678 | − 126 | 14 | 41,617 | + 486 |
| **‡Colchester Corporation** | „ 5 | 171 | + 2 | 84 | 6,433 | − 1,519 |
| **Cork Electric Trams Co.** | „ 5 | 447 | + 14 | 14 | 5,654 | − 42 |
| Derby Corporation | ... | ... | ... | ... | ... | ... |
| **‡Devonport & Dist. Trams** | March 30 | 371 | − 57 | 13 | 5,103 | − 845 |
| **Dover Corporation** | April 7 | 208 | + 27 | ‡1 | 208 | + 27 |
| **Dublin & Lucan Railway** | „ 6 | 97 | − 7 | §14 | 1,247 | − 20 |
| **Dublin United** | „ 6 | 4,692 | − 26 | ‡14 | 62,180 | + 1,338 |
| **Dudley—Stourbridge** | March 30 | 747 | − 74 | 13 | 9,512 | + 223 |
| **Dundee Corporation** | April 4 | 994 | + 168 | §46 | 43,858 | + 4,169 |
| **East Ham Council** | „ 7 | 884 | + 134 | 1 | 884 | + 134 |
| **Gateshead & Dist. Trams** | March 30 | 883 | + 21 | 13 | 11,617 | + 559 |
| **Glasgow Corporation** | April 7 | 17,012 | + 1,858 | 45 | 626,686 | + 45,854 |
| Glossop | ... | ... | ... | ... | ... | ... |
| ¶Gloucester Corporation | March 31 | 317 | − 53 | 52 | 14,668 | + 1,150 |
| **‡Gravesend—Northfleet** | „ 30 | 190 | − 12 | 18 | 2,487 | + 83 |
| **Gt. Northern & City Rly.** | April 7 | 1,813 | + 97 | 14 | 25,503 | + 937 |
| **Greenock & Port Glasgow** | March 30 | 654 | + 39 | 13 | 7,243 | + 534 |
| **Halifax Corporation** | ... | ... | ... | ... | ... | ... |
| **Hartlepool Tramways** | „ 30 | 242 | − 11 | 13 | 3,200 | + 112 |
| Hastings Elec. Trams Co. | April 5 | 421 | ... | 14 | 5,018 | ... |
| **Huddersfield** | „ 7 | 1,891 | + 168 | 1 | 1,891 | + 168 |
| **Hull Corporation** | „ 7 | 2,166 | + 72 | 1 | 2,166 | + 72 |
| **Ilford Dist. Coun.** | „ 7 | 468 | + 60 | 1 | 468 | + 60 |
| **Ipswich Corporation** | „ 7 | 873 | + 88 | 1 | 873 | + 20 |
| **Isle of Thanet Co.** | „ 7 | 298 | − 18 | 26 | 6,948 | − 660 |
| **Kidderminster & District** | March 30 | 85 | − 10 | 18 | 1,146 | − 16 |
| Kilmarnock Corporation | April 7 | 153 | − 7 | 47 | 7,284 | ... |
| **Kirkcaldy Corporation** | „ 4 | 220 | − 20 | 5 | 1,000 | − 23 |
| **Lanarkshire Trams Co.** | „ 5 | 869 | + 236 | †14 | 11,392 | + 2,589 |
| **Leamington** | March 30 | 122 | + 71 | 15 | 1,653 | + 511 |
| **Leeds Corporation** | ... | ... | ... | ... | ... | ... |
| **Leicester Corporation** | April 7 | 2,103 | + 148 | 14 | 28,026 | + 3,064 |
| Leith Corporation | March 31 | 421 | + 208 | 45 | 16,928 | + 12,005 |
| **‡Liverpool Overhead Rly.** | April 8 | 1,409 | − 90 | 14 | 19,381 | − 1,570 |
| Liverpool Corporation | March 31 | 10,724 | − 231 | 13 | 132,519 | + 4,838 |
| ***London County Council** | „ 31 | 14,004 | + 217 | 52 | 760,629 | + 97,422 |
| London United | April 6 | 5,810 | + 466 | †14 | 66,889 | + 1,340 |
| **Lowestoft** | „ 7 | 112 | − 7 | ‡8 | 8,571 | − 120 |
| **Maidstone Corporation** | „ 5 | 97 | − 11 | 1 | 97 | − 11 |
| **Manchester Corporation** | „ 7 | 12,971 | + 992 | 1 | 12,971 | + 992 |
| Mersey Railway | „ 7 | 1,789 | + 164 | 14 | 23,878 | + 1,313 |
| **Merthyr** | March 30 | 171 | − 4 | 18 | 2,228 | − 25 |
| Metropolitan Dist. Railway | April 8 | 7,808 | + 572 | 14 | 118,156 | + 6,326 |
| ***Metropolitan Elec. Trams.** | March 30 | 2,609 | + 379 | 18 | 85,176 | + 10,662 |
| **Middleton** | „ 30 | 273 | − 13 | 13 | 8,568 | + 199 |
| **Newcastle-on-Tyne Corp.** | April 7 | 3,801 | + 121 | 1 | 3,801 | + 124 |
| **Newport (Mon.)** | „ 7 | 593 | + 69 | 1 | 593 | + 69 |
| Northampton Corporation | ... | ... | ... | ... | ... | ... |
| **Oldham, Ashton & Hyde** | March 30 | 499 | − 17 | 13 | 6,470 | + 226 |
| **Oldham Corporation** | April 8 | 1,089 | + 137 | 2 | 3,428 | + 127 |
| Perth (N.B.) Corporation | ... | ... | ... | ... | ... | ... |
| **Perth (W. A.) Elec Trams** | „ 6 | 1,528 | + 160 | ‡14 | 21,442 | + 1,152 |
| **Peterborough** | March 30 | 92 | − 31 | 13 | 1,226 | − 98 |
| Pontypridd District Coun. | April 7 | 178 | + 22 | 1 | 178 | + 22 |
| Portsmouth Corporation | „ 7 | 1,675 | + 69 | 1 | 1,675 | + 69 |
| **Potteries** | March 30 | 1,657 | − 131 | 13 | 22,084 | + 1,206 |
| Preston Corporation | April 4 | 688 | + 66 | 1 | 638 | + 66 |
| **Reading Corporation** | „ 5 | 570 | + 8 | 1 | 570 | + 8 |
| **Rotherham Corporation** | ... | ... | ... | ... | ... | ... |
| **Rothesay** | March 30 | 57 | + 8 | 13 | 628 | + 46 |
| **Salford Corporation** | ... | ... | ... | ... | ... | ... |
| **Sheerness** | „ 23 | 48 | − 14 | 13 | 592 | − 107 |
| **Sheffield Corporation** | April 8 | 5,108 | + 476 | 2 | 9,976 | + 280 |
| **Southampton Corporation.** | „ 4 | 864 | − 6 | 26 | 22,242 | + 880 |
| **Southend Corporation** | ... | ... | ... | ... | ... | ... |
| **Southport Tramways** | March 30 | 243 | − 43 | 13 | 2,942 | − 26 |
| **S. Staffordshire Trams.** | „ 30 | 741 | + 59 | 18 | 9,748 | + 1,486 |
| **Stockport Corporation** | ... | ... | ... | ... | ... | ... |
| Sunderland Corpn. | April 8 | 1,892 | − 83 | 1 | 1,392 | − 88 |
| **Swansea Trams** | March 30 | 725 | + 248 | 13 | 9,074 | + 3,147 |
| Swindon Corporation | March 28<br>April 4 | 161<br>188 | − 12<br>− 8 | 52 | 10,005 | ... |
| **Taunton** | March 30 | 38 | − 9 | 13 | 521 | + 4 |
| **Tynemouth and District** | „ 30 | 163 | − 25 | 13 | 2,039 | − 152 |
| Tyneside Trams Co. | „ 28 | 851 | ... | 13 | 4,348 | + 96 |
| **Wallasey District Council.** | April 7 | 700 | + 20 | 1 | 700 | + 29 |
| **Warrington Corporation** | ... | ... | ... | ... | ... | ... |
| **West Ham Corporation** | „ 5 | 2,133 | + 946 | 1 | 2,183 | + 946 |
| **Weston-super-Mare** | March 28 | 81 | − 9 | 18 | 880 | − 13 |
| Wolverhampton Corpn. | April 4 | 741 | ... | 1 | 741 | ... |
| ***Wolverhampton District** | March 30 | 858 | − 4 | 18 | 4,736 | + 888 |
| ***Worcester** | „ 30 | 217 | − 59 | 18 | 2,954 | − 302 |
| **Wrexham** | „ 30 | 82 | − 14 | 13 | 1,151 | − 46 |
| **Yorkshire W.R. Trams** | April 8 | 760 | + 128 | 14 | 9,642 | + 8,161 |
| **Yorkshire Woollen District** | March 30 | 771 | + 162 | 13 | 10,838 | + 8,294 |

(a) These comparisons are with the corresponding period last year. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days. ¶ Plus 3 days. * Partly electrical.

**CANADIAN GENERAL ELECTRIC CO.**—The profit for 1905 was $608,206, out of which four quarterly dividends at the rate of 10 per cent. per annum have been paid on the common stock, and two half-yearly dividends at the rate of 6 per cent. per annum on the preferred stock.

**DEUTSCH-NIEDERLANDISCHE TELEGRAPHEN GESELLSCHAFT A.-G. (COLN).**—A dividend of 6 per cent. has just been declared.

**HARTMANN & BRAUN A.-G. (FRANKFORT-ON-MAIN).**—A dividend of 10 per cent. (against 9 per cent. in 1904) is to be paid for 1905.

**OSTEUROPAISCHE TELEGRAPHENGESELLSCHAFT (COLOGNE).**—This company has declared a dividend of 3½ per cent.

**PRIMITIVA GAS & ELECTRIC LIGHTING CO. OF BUENOS AYRES (LTD.)**—The directors recommend a dividend of 7 per cent. on the ordinary shares for the past year.

**STOCK EXCHANGE NOTICE.**—The Stock Exchange committee have appointed April 25 a special settling day in a further issue of £185,000 cumulative perpetual preference stock of the *British Columbia Electric Railway Co. (Ltd.)*, and have ordered same to be quoted.

**TOKYO ELECTRIC LIGHT CO.**—A provisional agreement has, it is announced, been concluded between representatives of a London syndicate and this company for an issue of £500,000 5 per cent. debentures at 92. The issue, which is to provide capital for a turbine-driven power station, will be redeemable in 15 years.

**TORONTO ELECTRIC LIGHT CO.**—The income for 1905 was $775,948, and the expenses (including interest) $471,318, leaving $304,629, out of which have been paid four quarterly dividends at the rate of 7 per cent., amounting to $208,936, leaving $95,693 to be carried forward. A new sub-station for the reception and distribution of Niagara power, is nearing completion.

## COLONIAL AND FOREIGN INVESTMENTS.

| Share. | Last Dividend | Name. | Price Tues., April 10. | Rate per Cent. Yielded.* £ s. d. | Dividend Due. | Business, 6 Days to April 10. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| 5 | 8/0 | Anglo-Argentine Ord. Shares | 9 —9¼ | 4 6 6 | Ap, Oct | 9⅛ | 9 1/16 |
| 5 | 2/9 | Do. 5½% Cum. Pref. | 5⅞—6⅛ | 4 10 0 | — | 6 1/16 | 6 1/32 |
| St. | 6% | Do. Permanent 6% Deb. Stock | 141 —144 | 4 3 3 | — | 144 | .. |
| St. | 5% | Auckland Elec. Trams 5% Deb. (red.) | 104 —106 | 4 14 3 | — | 106 | .. |
| 5 | .. | Brisbane Electric Trams. Invest. Ord. | ⅞—1⅛ | .. | .. | .. | .. |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 3⅞—4⅛ | 6 1 4 | — | 4 1/16 | .. |
| St. | 4½% | Do. 4½ per Cent. Db. Prov. Cts. | 113 —116 | 4 13 9 | — | 95½ | .. |
| St. | 6% | British Columbia Elec. Rlwy. Def. Ord. | 120 —123 | 4 17 6 | — | — | .. |
| St. | 5% | Do. Pref. Ord. Stk | 110 —113 | 4 8 4 | — | .. | .. |
| 10 | 5% | Do. 5% Cum. Perp. Pref. Stock | 107 —110 | 4 11 0 | — | 103 | — |
| 40 | 4½% | Do. 4½ per Cent. 1st Mort. Dbs. | 103%—105% | 4 5 9 | — | .. | — |
| 100 | 4½% | Do. Vancouver Power Debs. | 102 —105 | 4 5 0 | — | .. | .. |
| 5 | 2/6 | Buenos Ayres and Belgrano Ord. | 3½—3¾ | 5 6 8 | — | 3 9/16 | 3 17/32 |
| 5 | 8/0 | Do. 6 per Cent. "A" Cm. Pref. | 5⅞—6⅛ | 4 18 0 | — | .. | .. |
| 5 | 8/0 | Do. "B" | 5¼—5¾ | 5 4 0 | — | 5⅝ | .. |
| St. | 5% | Do. 5 per Cent. Debs. | 106 —108 | 4 12 6 | — | .. | .. |
| St. | 5% | Do. 5% 2nd Deb. (red.) | 102 —105 | 4 15 0 | — | .. | .. |
| St. | 5% | Buenos Ayres Elec. Trams (1901) Ltd. | 101 —103 | 4 17 0 | .. | .. | .. |
| 100 | 5½% | Buenos Ayres Grand National 5½% Pref. Debs. | 102 —106 | 5 4 3 | .. | .. | — |
| 100 | 6% | † Do. 6% 1st Deb. Bonds | 100 —105 | 5 14 0 | .. | .. | .. |
| 5 | 8/6 | Calcutta Tramways (Nos. 1 to 105) | 9 7/16—9 11/16 | 4 8 0 | — | 9 19/32 | 9⅝ |
| 5 | 2/6 | Do. Nos. 105,001 to 137,610 | 9 —9½ | .. | .. | 9 | .. |
| 10 | 4½% | Do. 4½% 1st Deb. Stock (red.) | 106 —108 | 4 3 8 | — | 107¼ | 07¼ |
| 1 | 0/6 | Cape Electric Tram Shares | ⅝ - ⅞ | 5 14 0 | — | .. | .. |
| St. | 5% | Colombo Trams & Ltg. 5% 1st Mt. Deb. (red) | 102 —104 | 4 16 0 | — | 103¾ | 103 |
| .. | 5% | Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds. | 96 —98% | 5 2 0 | .. | 97 | 96½ |
| St. | .. | Kalgoorlie Elec. Trams 5% "A" Deb. Stock | 91 —98 | .. | .. | .. | — |
| St. | .. | Do. 6% "B" Ditto | 83 – 88 | .. | .. | 85¼ | .. |
| 1 | .. | Lisbon Elec. Trams Ord. | 1½—1⅝ | .. | .. | .. | .. |
| 1 | 0/7½ | Do. 6% Cum. Pref. | 1⅜—1⅝ | 4 7 4 | .. | .. | .. |
| 100 | 5% | Do. 5% Reg. Mort. Debs. | 100 —103 | 4 17 0 | .. | .. | .. |
| St. | 5% | Madras Elec. Trams 5% Deb. Stk. | 103 - 106 | 4 14 8 | Ja, Jul | 105 | 104 |
| 100 | 5% | Montreal St. Ry. St'g 5% Mort. Debs. (1908) | 101 —103 | 4 17 0 | — | .. | .. |
| 100 | 4½% | Do. Sterling 4½% Debs. (1922) | 102 —104 | 4 6 6 | — | .. | .. |
| St. | 5% | Perth (W.A.) Elec. Trams. 1st Mt. Deb. Stk. | 105 —108 | 4 12 6 | .. | .. | .. |
| .. | $2 | †Sao Paulo Tramway, Light and Power Co. $100 Stock | 147 – 149 | .. | .. | .. | .. |
| .. | 5% | Do. 5% 1st Mt. $500 Dbs. | 99%—101% | 4 19 0 | .. | 99½ | 99 |
| | | **ELECTRICITY SUPPLY.** | | | | | |
| 5 | 3/ | Adelaide Elec. S'ply Co. 6% Cu.Pf. | 4¾—5¼ | 5 14 6 | .. | .. | .. |
| 5 | 3/8 | Calcutta Elec. (1-60,000) | 9⅛—9⅜ | 4 5 4 | — | .. | — |
| 10 | 5% | City of Wellington Elec. Lt. and Power 5% Reg. 1st Dbs. | 50 —52 | 4 16 0 | .. | .. | .. |
| .. | 5% | Cordoba Lt. and Power Co. 1st Mt. Stk. £100,000 5% Bds. | 94 —96 | 5 4 0 | .. | .. | .. |
| 1 | .. | Elec. Ltg. & Trac. Co. of Aust. 6% Cum. Pref. | 2½—3 | .. | .. | .. | — |
| St. | 5% | Do. 5% Debs. | 88 —92 | 5 9 4 | — | .. | .. |
| 10 | .. | Havana Electricity Co. Shares | 7¾—8¾ | — | — | .. | .. |
| 100 | 5% | Do. 5% Dbs. iss. at 95, Scrip, all pd. | 92 —94 | 5 6 8 | .. | .. | .. |
| St. | 26/2 | Indian Elec. Sup. and Trac. Co. Db. St. Rd. Prov. Certs. | 111 —114 | 5 5 0 | .. | 114 | .. |
| 1 | 5·38d | Kalgoorlie Elec. Power & Ltg. 6% Cum. Pref. | ⅞—1 | 6 0 0 | — | .. | .. |
| 1 | 1/0 | Rand Electric | 1 5/16—1 7/16 | — | — | .. | .. |
| 1 | .. | River Plate Electricity Co. Ord. | 9/16—11/16 | — | .. | .. | .. |
| 1 | 1/2⅔ | Do. 6% Non. Cum. Pref. | 15/16—1 1/16 | .. | .. | .. | .. |
| St. | 5% | Do. 5% Deb. Stock | 101 —103 | 4 17 0 | .. | .. | .. |
| 5 | 8/0 | †Rosario Elec. Co. 6% Pref. (1-12,000) | 5¼—5⅝ | 5 8 6 | .. | .. | .. |
| 5 | 2/6 | † Do. (12,001-20,000) | 5⅛—5⅜ | 3 6 6 | .. | .. | .. |
| 100 | 4½% | *†Royal Elec., Montreal 4½% 1st Mort. Deb | 99 —102 | 4 8 0 | Ap, Oct | .. | ... |
| .. | 5% | Shawinigan Water and Power 5% Bds., Scrip | 101 —103 | 4 17 0 | .. | 101¼ | 100⅞ |

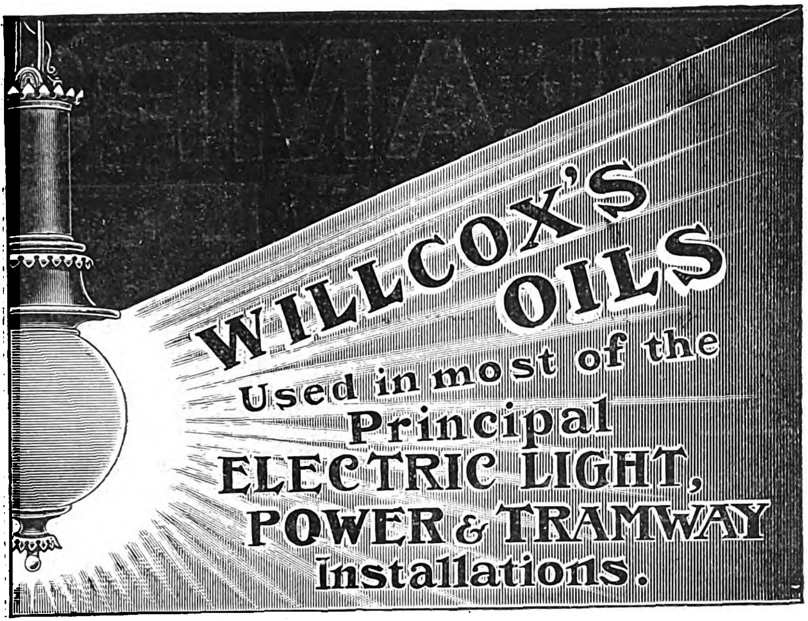
* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

# ELECTRICAL COMPANIES' SHARE LIST.

| Shre. | Last Divi-dend | Name. | Price Tues., April 10. | Rate % Yield-ed. | Dividend Due. | Business, 6 Days to April 10. Highest | Lowest |
|---|---|---|---|---|---|---|---|
| | | **ELECTRICITY SUPPLY.** | | £ s. d | | | |
| 10 | 14/0 | †Bournemouth & Poole Elec. Sup. Ord. | 11 –12 | 5 16 6 | .. | .. | .. |
| 10 | 4/6 | Do. 4½ per Cent. Cum. Pref | 10⅛–10⅝ | 4 5 3 | .. | .. | .. |
| 10 | 6/0 | Do. 6% Cum. Second Pref. | 11 –12 | 5 0 0 | .. | .. | – |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock (red.) | 106 –108 | 4 8 3 | .. | .. | .. |
| 5 | 2/0 | Bromley (Kent) El. Lt. & Power Shares | 5½–5¾ | 4 15 8 | .. | 5⁹⁄₁₆ | .. |
| St. | 4½% | Do. Do. 1st Debs | 103 –105 | 4 5 0 | – | .. | .. |
| 5 | 5/6 | Brompton & Kensington Elec. Sup. Ord. | 8¾–9¼ | 5 8 6 | – | .. | .. |
| 5 | 8/6 | Do. 7 per Cent. Pref. | 8¾–9¼ | 3 15 6 | Mar, Sept | .. | .. |
| St. | 4% | Central Elec. Sup. Co. 4% Guar. Db. Stock | 102 –105 | 3 16 8 | – | 104 | 102 |
| 5 | 2/6 | Charing Cross (W. End & City) El. Sup. Co. | 4 – 5 | 5 0 0 | Feb, Aug | 4⅜ | 4¼ |
| 5 | 2/8 | Do. 4½ per Cent. Pref. | 4⅜–4⅞ | 4 12 6 | Feb, Aug | 4⅜ | 4⁷⁄₁₆ |
| St. | 4% | Do. 4% Deb. Stock (red.) | 101 –103 | 3 17 6 | – | 102 | .. |
| 5 | 2/8 | Do. City Undertaking 4½% Cm. Pref. | 4 – 4½ | 5 0 0 | – | .. | .. |
| 5 | 2/8 | Do. Do. (1908) | 4 – 4½ | 5 0 0 | – | – | .. |
| 5 | 3/9 | Chelsea Electric Supply Ord. | 5½–5¾ | 5 6 0 | March .. | 5¹⁹⁄₃₂ | 5⅜ |
| St. | 4½% | * Do. 4½ per Cent. Deb. Stock (red.) | 107 –109 | 4 2 6 | Jn, Dec .. | 109 | .. |
| 10 | 7/0 | †City of London Electric Lighting Ord. | 10½–11 | 5 9 0 | Feb, Aug | 10¹³⁄₁₆ | 10⅝ |
| 10 | 6/0 | † Do. 6 per Cent. Cum. Pref. | 13 –14 | 4 5 6 | Jan, July | .. | .. |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 123 –126 | 3 19 4 | Jn, Dec .. | .. | .. |
| St. | 4½% | Do. 4½% 2nd Deb. Stock (red.) | 101 –103 | 4 8 0 | .. | .. | .. |
| 5 | 0/11½ | †County of Durham Elec. P. D. Ord. £2 pd. | 1⅞–2⅛ | 4 0 0 | April, Oct | .. | .. |
| 5 | 5% | † Do. Do. 5% non cum. pref. | 5 –5½ | 4 11 0 | April, Oct | 5⁵⁄₁₆ | .. |
| 10 | 6/0 | †County of London Elec. Supply Ord. | 8 –9 | 5 11 0 | – | 8⁹⁄₁₆ | .. |
| 10 | 6/0 | † Do. 6 per Cent. Cum. Pref. | 11½–12¼ | 4 18 0 | Mar, Sept | 11¾ | .. |
| St. | 4½% | Do. 4½% Deb. Stock (all paid) (red.) | 109 –112 | 4 0 4 | .. | 110½ | .. |
| St. | 4½% | Do. Second Deb. Stock Prov. Certs. | 101 –103 | 4 7 6 | .. | .. | .. |
| 5 | 2/0 | Folkestone Electricity Supply Co. Ord. | 5¼–5¾ | 4 15 8 | .. | .. | .. |
| 5 | 2/6 | † Do. 5 per Cent. Cum. Pref. | 5 –5½ | 4 11 9 | .. | – | .. |
| St. | 4½% | Do. 4½ 1st Deb. Stock (red.) | 101 –104 | 4 6 6 | – | – | .. |
| 5 | 4/0 | Hove Electric Lighting Ord. | 8½–9 | 5 0 0 | .. | – | .. |
| St. | 4½% | I. of W. Elec. Lt. & Power 4½% Db. St. (red.) | 100 –103 | 4 7 5 | – | .. | – |
| 5 | 5/0 | Kensingtn. & Kngtsbdg. Ord | 9¾–10¼ | 4 18 0 | – | .. | .. |
| 5 | 6% | Do. 6 per Cent. 1st Pref. | 6½–7 | 4 5 9 | Jan, July | – | – |
| St | 4% | Do. 4 per Cent. Deb. Stock (red.) | 98 –101 | 3 19 2 | .. | .. | .. |
| St | 4% | †Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stck. (red.) | 101 –103 | 3 17 6 | – | .. | .. |
| 8 | 2/4½ | London Electric Supply Ord. | 2 –2½ | 4 0 0 | – | .. | .. |
| 5 | 8/0 | Do. 6 per Cent. Pref. | 5 –5½ | 5 7 0 | – | 5¹⁄₁₆ | .. |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. | 98 –101 | 3 19 2 | Mr, Jn, S, D | .. | .. |
| 5 | 10% | †Metropolitan Electric Sup. Ord. | 8½–9½ | 5 5 0 | April, Oct | 8¾ | 8½ |
| 5 | 2/8 | Do. 4½ per Cent. Cum. Pref. | 5⅜–5⅝ | 4 0 0 | Jan. July | .. | .. |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock 1st Mort. | 110 –114 | 3 19 0 | Jn, Dec .. | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Mrt. Db. Stock (red.) | 95 –97 | 3 12 8 | – | .. | .. |
| 100 | 4½% | Midland Elec. Corp. for P. D. 1st Mort. Db. | 101 –103% | 4 7 4 | – | .. | .. |
| 10 | 7½% | Newcastle & Dist. Elec. Ltg. Ord. £9 paid | 11½–12¼ | 5 6 0 | Feb, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 102 –104 | 4 6 6 | Jan, July | .. | .. |
| 5 | 8% | †Newcastle Elec. Supply Ord. | 7¾–8¼ | 5 0 0 | Feb, Aug | .. | .. |
| 5 | 5% | † Do. 5 per Cent. Non. Cum. Pref. | 6 –6½ | 4 0 0 | Feb, Aug | .. | .. |
| 100 | 4% | Do. 4% Mort. Deb. red. 1907 | 99 –100 | 3 19 7 | Jan, July | .. | .. |
| 1 | 8% | †Northern Counties Elec. Sup. | ⅞–⅞ | 3 6 8 | Mar, Aug | .. | .. |
| 100 | 4½% | Do. 4½% Deb. | 101 –102 | 4 7 6 | Jan, July | – | – |
| 10 | 9/0 | Notting Hill Electric Ord. | 13 –14 | 6 8 0 | March .. | .. | .. |
| 100 | 4% | † Do. 4 per Cent. 1st Mt. Debs. | 97 –99 | 4 1 0 | .. | .. | .. |
| 5 | 4/6 | Oxford Electric Ord. | 6½–7 | 4 16 0 | March .. | .. | .. |
| St. | 4% | Do. 4% Deb. Stock | 99 –101 | 3 19 0 | – | .. | .. |
| 5 | 7/6 | St. James' & Pall Mall Elec. Ord. | 9 –10 | 6 5 0 | Feb, Aug | 9¾ | 9½ |
| 5 | 8/6 | Do. 7 per Cent. Pref. | 7 –8 | 4 7 0 | Feb, Aug | .. | .. |
| St. | 3½% | Do. 3½ per Cent. Deb. Stock (red.) | 86 –88 | 3 12 0 | – | .. | .. |
| 5 | 4/0 | Smithfield Markets Electric Sup. Ord. | 2¼–2¾ | 8 4 0 | .. | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 76 –80 | 5 0 0 | – | .. | .. |
| 5 | 4/0 | †South London Electric Supply Ord | 3 – 3½ | 5 14 0 | .. | .. | .. |
| 1 | 0/8 | South Metrop'n Elec. Lt. & Power Ord. | ¾–⅞ | – | .. | .. | – |
| 1 | 0/8¾ | Do. 7% Cum. Pref. | 1¼–1⅜ | 5 2 0 | .. | 1⁹⁄₃₂ | .. |
| St. | 4½% | † Do. 4½ 1st Db. Stk. Red. | 103 –106 | 4 5 0 | – | .. | – |
| 5 | 2/6 | †Urban Electric Supply Ord. | 4¼– 4¾ | 5 5 0 | – | – | – |
| 5 | 2/6 | † Do. 5% Cum. Pref. | 4¹⁵⁄₁₆–5¹⁄₁₆ | 4 14 0 | – | .. | .. |
| St. | 4½% | † Do. 4½% 1 Mort. Deb. | 102 –104 | 4 6 6 | .. | 102½ | .. |
| 5 | 6/6 | Westminster Elec. Sup. Ord. | 9½–10½ | 6 4 0 | Mar, Sept | 10 | 9¹¹⁄₁₆ |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5⁷⁄₁₆–5⁹⁄₁₆ | 4 10 0 | .. | 5¹⁵⁄₃₂ | .. |
| 5 | .. | Do. Issued at 7/6 premium all paid | 5⁷⁄₁₆–5⁹⁄₁₆ | .. | .. | 5¹⁵⁄₃₂ | 5⁵⁄₁₆ |
| | | **ELECTRIC RAILWAYS, TRAMWAYS, &c.** | | | | | |
| St. | 4% | Baker St. & Waterloo 4% Perp. Db. St. | 100 –102 | 3 18 6 | .. | .. | .. |
| 1 | – | Bath Elec. Trams Pref. Ord. | ⅞–1⅛ | .. | .. | .. | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | ⅞–1⅛ | 4 12 3 | .. | .. | .. |
| St. | 4½% | † Do. 4½ 1st Mort. Deb. Stock (red.) | 101 –103 | 4 7 3 | – | .. | .. |
| St. | 4½% | B'ham & Midland Trams 4½ 1st Db. Stk. | 101 –103 | 4 7 9 | .. | 102¾ | .. |
| 10 | 9½% | Bristol Tramways and Carriage Ord. | 15½–15¾ | 5 15 2 | Feb, Aug | – | – |
| 10 | 4% | Do. Cum. Pref. (fully paid) | 10 –10½ | 3 18 0 | .. | – | – |
| St. | 4% | Do. 4 per Cent. Debs. | 103 –105 | 3 16 0 | Feb, Aug | .. | .. |
| 10 | 6/0 | British Electric Traction Ord. | 6 –7 | 4 5 8 | – | 6²³⁄₃₂ | 6½ |
| 10 | 6/0 | Do. 6 per Cent. Cum. Pref. | 9 –9½ | 6 6 0 | Feb, Aug | 9⅜ | 9⁷⁄₃₂ |
| St. | 5% | † Do. 5 per Cent. Perpetual Debs | 111 –114 | 4 8 11 | .. | 112¾ | 111½ |
| St. | 4½% | Do. 4½ per Cent. 2nd Deb. Stock | 96½–98½ | 4 11 10 | .. | 98½ | 96¼ |
| St. | 4% | Central London Ordinary Stock | 91 –93 | 4 6 0 | June, Dec | 91½ | .. |
| St. | 4% | Do. 4 per Cent. Pref. Stock | 100 –102 | 3 18 6 | .. | .. | .. |
| St. | 4% | Do. Deferred Stock | 82 –85 | 4 14 0 | .. | 83½ | 83½ |
| 100 | 4% | Do. 4 per Cent. Debs. | 110 –112 | 3 11 3 | .. | 112 | .. |
| St. | 4% | Charing X, Euston & Hmpstd Per. Db. Stk. | 95 –97 | 4 2 6 | .. | .. | .. |
| 5 | 2/6 | City of Birmingham Trams. 5% Cm. Prf. | 5⅛–5⅜ | 4 18 0 | .. | .. | .. |
| 100 | 4% | Do. 4 per Cent. 1st Mort. Debs. | 101 –104 | 3 17 0 | .. | .. | .. |
| St. | 1¾% | City and South London Rly. Con. Ord. | 41 –43 | 4 7 0 | Feb, Aug | 43 | 42¼ |
| St. | 5% | Do. 5 per Cent. Perp. Pref. (1891) | 120 –123 | 4 1 4 | Feb, Aug | .. | .. |
| St. | 5% | Do. (1896) | 115 –118 | 4 4 8 | .. | .. | .. |
| St. | 5% | Do. (1901) | 113 –116 | 4 6 0 | – | .. | .. |
| St. | 4% | Do. 4 per Cent. Perpetual Debs | 106 –109 | 3 13 4 | May, Nov | .. | .. |
| 10 | 6/0 | Dublin United Trams. (1896) Ltd., Ord. | 13¾–14¾ | 4 1 6 | .. | .. | .. |
| 10 | 6/0 | Do. 6 per Cent. Pref. | 14½–15½ | 3 17 8 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern & City Rly. Prf. Ord. (4%) | 4 –4½ | 9 8 2 | .. | .. | .. |
| 10 | 4/0 | Gt. Northern, Piccadilly & Brompton Ord., Speyer Bros. Scrip Certs. | 8 –9 | 4 8 11 | – | .. | .. |
| St. | 4½% | †Hastings & Dist. Elec. Trams. Co. 4½ Db. St. | 101 –103 | 4 7 6 | .. | .. | .. |
| 10 | 9% | ‡ Imperial Tramways Ord | 15 –16 | 5 12 0 | Mar, Sept | .. | .. |
| 10 | 6% | ‡ Do. 6 per Cent. Pref. | 12 –12½ | 4 17 0 | Mar, Sept | .. | .. |
| St. | 4½% | ‡ Do. 4½ per Cent. Debs. | 107 –108 | 4 8 0 | Jan, July | .. | .. |
| 5 | 2/6 | Isle of Thanet Elec. Trams & Lt. 5% Pf. | 2¼–2¾ | 9 8 6 | – | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 80 –85 | 4 14 0 | – | .. | .. |
| 10 | 1½% | Liverpool Overhead Railway Ord | 8⁹⁄₁₆–8¹¹⁄₁₆ | 3 18 0 | Feb, Aug | .. | – |
| 10 | 5% | Do. 5 per Cent. Pref. | 9¾–10¼ | 4 15 8 | Feb, Aug | .. | .. |
| St. | 4% | Do. 4 per Cent. Deb. | 99 –102 | 3 19 8 | Jan, July | .. | .. |
| 10 | 5/0 | London United Trams. 5% Cum. Pref. | 9½–10 | 5 0 0 | – | 9¹³⁄₁₆ | 9⅝ |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock | 95 –98 | 4 2 6 | – | 97¾ | 97 |
| St. | .. | Mersey Con. Ord. Stock | 4 –6 | – | – | .. | .. |
| St. | .. | Do. 3 per Cent. Perp. Pref. | 8 –11 | – | – | .. | .. |
| 1 | .. | Metropolitan Elec. Trams Def. | ⁵⁄₃₂–⁷⁄₃₂ | .. | – | ³⁄₁₆ | .. |
| 1 | 0/6 | Do. 5% Cum. Pref. | ⅞–1 | 5 0 0 | – | ³¹⁄₃₂ | ²⁹⁄₃₂ |
| St. | 4½% | Do. 4½% Deb. Stock | 104 –106 | 4 5 0 | – | .. | .. |
| 5 | .. | New Gen. Tract. 6 per Cent. Cum. Pref. | ½–1½ | .. | May | .. | .. |
| 10 | 10/0 | Potteries Electric Traction Ord. | 8 –9 | 5 15 0 | .. | – | .. |
| 10 | 5/0 | Do. 5 per Cent. Cum. Pref. | 9 –9½ | 5 5 0 | Feb, Aug | – | – |
| St. | 4½% | Do. 4½ per Cent. Deb. Stock | 103 –106 | 4 5 0 | – | .. | .. |
| 100 | 5% | Sunderland Dst. Elc. Trms. 5% 1st Mt. Db. | 92 –95 | 5 5 0 | – | 92½ | .. |
| | 5% | Underground Elec. Rys. Co. of London | 98 –100 | 5 0 0 | – | 99 | 98 |
| St. | 3½% | Waterloo and City Ord. | 101 –104 | 3 2 6 | June, Dec | 102½ | .. |
| St. | 4½% | Yorkshire W.R. El. Trs. Co. 4½% 1st Debs. | 95 –97 | 4 13 0 | .. | – | .. |

| Shre. | Last Divi-dend | Name. | Price Tues., April 10. | Rate % Yield-ed. | Dividend Due. |
|---|---|---|---|---|---|
| | | **ELECTRIC MANUFACTURING, &c.** | | £ s. d. | |
| 1 | 6d. | Alliance Elec. Co. 5% Cum. Pref. | ⅝–⅞ | 5 6 6 | – |
| 1 | 10½d. | Aron El. Met. 6% Cm. Pf. | [illegible] | .. | – |
| 1 | 1/7½ | Babcock & Wilcox Ord. | 3⅞–4⅛ | 4 17 9 | .. |
| 1 | 7½d. | Do. Pref | 1⁷⁄₁₆–1⁹⁄₁₆ | 3 16 10 | .. |
| 5 | 4/0 | †British Insulated & Helsby Cables Ord. | 6½–7 | 5 14 0 | July, Feb |
| 5 | 8/0 | Do. 6 per Cent. Pref. | 5¾–6¼ | 4 16 0 | Jan, July |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 108 –116 | 4 4 11 | .. |
| St. | 4½% | British Thoms'n-Houst'n 4½% 1st Mt. Db. | 96 –98 | 4 12 0 | .. |
| 5 | .. | British Westinghouse 6% Pref. | 1⅞–2⅛ | .. | .. |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock | 80 –85 | 4 14 0 | .. |
| 2 | – | Brush Electrical Engineering | ¾–1 | .. | March |
| 2 | 2/4½ | Do. 6 per Cent. Pref. Non-Cum. | 1½–2 | 6 0 0 | Mar, Sept |
| St. | 4½% | Do. ~~4½ per Cent. Perp. 1st Deb. Stock~~ | 97 –99 | 4 11 0 | Mar, Sept |
| St. | 4½% | Do. Perpetual 2nd Deb. Stock | 84 –86 | 5 4 6 | Jan, July |
| 5 | 5/0 | Callender's Cable Con. Ord. | 10½–11½ | 4 7 0 | Jan, July |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5¾–6 | 4 8 4 | Jan, July |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Debs. (rd.) | 108½–110½ | .. | Nov, May |
| 1 | 4½d. | Castner-Kellner Alkali Co. | 1 –1⅛ | 5 6 6 | .. |
| St. | 4½% | Do. 4½% 1st Mort. Deb. (red.) | 95 –100 | 4 10 0 | – |
| 1 | 9⅜d. | Chadburn's (Ship) Telegraph Ord. | 1³⁄₁₆–1⁵⁄₁₆ | 7 10 0 | – |
| 1 | 7½d. | † Do 6% Cum. Pref. | 1¹⁄₁₆–1³⁄₁₆ | 5 8 0 | .. |
| 8 | 1/6 | Crompton and Co. (Nos. 1 to 54,000) | 2 –2¼ | 3 9 0 | Jan, July |
| 100 | 5% | * Do. 5 per Cent. 1st Mort. Debs. (red.) | 98%–99% | 5 2 0 | Jan, July |
| 5 | 10/0 | Dick, Kerr & Co. Ord. | – | 5 8 0 | Sept |
| 5 | 8/0 | † Do. 6% Cum. Pref. | – | 4 14 0 | Sept |
| St. | 4½% | Do. 4½% Deb. Stock | 104 –106 | 4 5 0 | .. |
| 5 | 1/6 | Edison & Swan United ("A" Sh.) (£3 pd.) | 1⅝–1⅞ | – | Feb, Aug |
| 5 | 2/6 | Do. (£5 paid) | 2½–3 | – | Feb, Aug |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stock (rd.) | 86 –88 | 4 11 0 | June, Dec |
| St. | 5% | † Do. 5 per Cent. 2nd Deb. Stock | 90 –95 | 5 5 0 | – |
| 5 | 2/6 | Edmundson's Elec. Corp. Ord. | 3¾– 4¼ | 8 4 6 | H'lf-yearly |
| 5 | 8/0 | Do. 6 per Cent. Cum. Pref. | 5 – 5½ | 5 9 0 | .. |
| St. | 4½% | Do. 4½ per Cent. 1st Mort. Deb. (red.) | 108 –106 | 4 5 0 | – |
| 2 | 1/7½ | Electric Construction Co. | ⁹⁄₁₆– 1⅛ | 9 6 0 | July |
| 2 | 2/9⅜ | Do. 7 per Cent. Cum. Pref | 2 –2½ | 5 12 0 | July |
| St. | 4% | Do. 4 per Cent. 1st Mort. Deb. (red.) | 89 –92 | 4 7 0 | Jan, July |
| 10 | 5/0 | General Electric (1900) 5% Cum. Pref. | 9⅜– 9⅞ | 5 8 0 | .. |
| St. | 4% | † Do. 4 per Cent. 1st Mort. Debs. | 94 – 98 | 4 1 6 | – |
| 5 | 10/0 | Henley's Telegraph Works Ord. | 12½–13½ | 5 11 0 | Feb, Aug |
| 5 | 2/8 | Do. 4½ per Cent. Pref. | 5⅜–5⅝ | 4 1 6 | Feb, Aug |
| St. | .. | Do. 4½ per Cent. 1st Mt. Db. St. | 108½–110½ | .. | .. |
| St. | .. | Do. Do. Scrip (50% paid) | 57½–59½ | .. | .. |
| 10 | 15/0 | India Rubber, Gutta Percha, &c., Wrks. | 17½–18½ | 2 14 6 | Feb, Aug |
| 10 | 5/0 | Mather & Platt 5 per Cent. Cum. Pref. | 11¾–12¼ | 4 1 8 | Mar, Sept |
| 1 | 1/2⅞ | Richardsons, Westgarth & Co., Ltd. Ord. | ²⁹⁄₃₂–³¹⁄₃₂ | 6 4 0 | .. |
| 1 | 7½d. | Do. 6% Cum. Pref. | ¹⁵⁄₁₆–1¹⁄₁₆ | 5 15 0 | .. |
| St. | 4½% | Do. 4½% Perp. Deb. Stock | 98 –101 | 4 10 0 | .. |
| 12 | 24/0 | Telegraph Construction & Mainten'ce. | 83 –85 | 5 2 6 | Mar, July |
| 100 | 4% | Do. 4 per Cent. Deb. Bonds, 1909 | 100 –102 | 3 18 6 | Jan, July |
| 1 | 2/0 | †Vickers, Sons & Maxim, Ltd., Ord. | 2⁷⁄₁₆–2⁹⁄₁₆ | 5 13 0 | .. |
| 1 | 6d. | † Do. 5% Non-Cum. Preference | 1⅜–1½ | 4 0 0 | .. |
| St. | 5% | † Do. 5% Non-Cum. Preferred | 119 –121 | 4 2 8 | – |
| St. | 4% | Do. 4% 1st Mort. Deb. Stock Red. | 105 –107 | 3 14 8 | .. |
| 100 | 4½% | Do. 4½% 2nd Mort. Debs., Red. | 106 –108 | 4 3 8 | .. |
| 5 | – | Willans and Robinson Ord. | 1¾–2¼ | – | Apr, Oct |
| 5 | – | Do. 6 per Cent. Cum. Pref. | 3½–4 | – | Apr, Oct |
| | 4% | Do. 4 per Cent. 1st Mort. Debs. | 80 –85 | 4 14 0 | May Nov |
| | | **TELEGRAPHS.** | | | |
| 100 | 4% | *African Direct Tel. 4% Mrt. Deb. (red.) | 98½–101½ | 3 18 6 | Jan, July |
| 10 | – | Amazon Telegraph | 3¾–4¼ | .. | Jn, Dec |
| 100 | 5% | Do. 5% Debs. (red.) | 83 –88 | .. | .. |
| St. | 21/0 | Anglo-American | 65 –67 | 4 17 0 | F, My, Ag, N |
| St. | 32/0 | Do. Preferred | 112½–113½ | 5 6 0 | F, My, Ag, N |
| St. | 10/0 | Do. Deferred | 19⅜–19⅞ | .. | F, My Ag, N |
| St. | 4% | †Commercial Cable 4 per Cent. Deb. Stk | 97 –99 | 4 1 0 | Jn. Ap, Jy, O |
| 10 | 5/0 | Cuba Submarine Ord. | 8½–9 | 5 11 0 | Feb, Aug |
| 10 | 10/0 | Do. Preference 10 per Cent. | 17 –18 | 5 11 2 | Feb, Aug |
| 5 | 2/0 | †Direct Spanish Ord | 3⅜–3⅝ | 5 11 9 | April, Oct |
| 5 | 5/0 | † Do. 10 per Cent. Cum. Pref. | 8½–9 | 5 11 0 | April, Oct |
| 50 | 4½% | Do. 4½ per Cent. Deb. | 100%–103% | 4 7 8 | Jan, July |
| 20 | 4/0 | †Direct United States Cable. | 15¼–15¾ | 4 5 0 | Ja, Ap, Jy, O |
| 100 | 4½% | Direct West India Cable 4½% Rg. Db. (rd.) | 100 –102 | 4 8 0 | Jn, Dec |
| St. | 25/0 | Eastern Ordinary | 145 –148 | 4 15 0 | Ja, Ap, Jy, O |
| St. | 17/6 | Do. 3½ per Cent. Pref. Stock | 90 –92 | 3 16 6 | Ja, Ap, Jy, O |
| St. | 4% | Do. 4 per Cent. Mort. Deb. Stk. (rd.) | 107 –109 | 3 13 8 | May, Nov |
| 10 | 2/6 | Eastern Extension | 14¾–15¼ | 4 11 8 | Ja, Ap, Jy, O |
| St. | 4% | Do. 4 per Cent. Deb. Stock | 105 –107 | 3 14 8 | Feb, Aug |
| 100 | 4% | Eastern & S. African 4% Mrt. Deb. 1909 | 99 –101 | 3 19 3 | Feb, Aug |
| 25 | 4% | Do. 4% Mauritius Sub. Debs. (red.) | 101%–103% | 3 18 8 | May, Nov |
| 10 | 5/0 | G. N. (of Copenhagen) with coupon 66 | 39½–41½ | 5 16 0 | Jan, July |
| 100 | 4½% | Halifax & Bermuda 4½% 1st Mt. Db. (red.) | 100 –102 | 4 8 0 | June, Dec |
| 25 | 12/6 | Indo-European | 58 –60 | 5 8 0 | May, Nov |
| 100 | $1 | Mackay Companies Common | 64⅛ | 3 8 8 | Jan, July |
| 100 | 4% | Do. Preference | 75⁷⁄₁₆ | 5 6 2 | Ja, Ap, Jy, O |
| 1 | .. | Marconi's Wireless Teleg. Co. | 1⅛–1⅜ | .. | .. |
| 100 | 4% | Pacific & Europe'n Tel. 4% Guar. Dbs. (rd.) | 99 –102 | 3 18 6 | June, Dec |
| 10 | 4/0 | West African Telegraph Shares | 9¾–10¼ | 4 17 6 | .. |
| 2½ | – | West Coast of America | ⅝–¾ | .. | – |
| 100 | 4% | Do. 4 per Cent. Debs. | 100 –102 | 3 18 3 | Jan, July |
| 10 | – | West India and Panama | ⅜–⅝ | .. | May, Nov |
| 10 | 6/0 | Do. 6% 1st Pref. | 8¼–8¾ | 6 6 8 | May, Nov |
| 10 | – | Do. 6 per Cent. 2nd Pref. | 6 –7 | .. | May, Nov |
| 100 | 5% | * Do. 5 per Cent. Debs. | 101 –104 | 4 16 0 | Jan, July |
| 10 | 8/0 | Western Telegraph | 14 –14½ | 4 17 6 | Mr, Jn, O, D |
| 100 | 5% | * Do. 5% Debs. (2nd Series, 1906) | 101 –103 | 4 17 0 | June, Dec |
| St. | 4% | Do. 4% Deb. Stock (red.) | 105 –108 | 3 18 6 | .. |
| | | **TELEPHONES** | | | |
| – | .. | Amer. Telephn. & Telegh. Coll. Trust $1,000 4% Bonds | 96 –98 | .. | .. |
| St. | 5% | Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk. | 101 –103 | 4 17 0 | August |
| 5 | 8/0 | Chili Telephone (fully paid) | 8 –8½ | 4 17 0 | – |
| 1 | 0/9⅜ | Monte Video Telephone Ord. | ¹⁵⁄₁₆–1¹⁄₁₆ | 3 15 3 | – |
| 1 | 1/0 | Do. 5% Pref. | ⅞–1 | 5 0 0 | .. |
| St. | 6% | National Co. Pref. Stock | 109 –111 | 5 8 0 | – |
| St. | 5% | Do. Def. Stock | 111 –113 | 4 8 6 | – |
| 10 | 6/0 | Do. 6 per Cent. Cum. 1st Pref. | 12 –14 | 4 5 6 | Feb, Aug |
| 10 | 6/0 | Do. 6 per Cent. Cum. 2nd Pref. | 10½–12½ | 4 16 0 | Feb, Aug |
| 5 | 2/6 | Do. 5 per Cent. Non-Cum. 3rd Pref. | 5¼–5½ | 4 11 0 | Feb, Aug |
| St. | 3½% | * Do. Deb. Stock 3½ per Cent. (red.) | 99 –101 | 3 9 8 | June, Dec |
| St. | 4% | Do. 4 per Cent. Deb. Stock (red.) | 103 –105 | 3 16 8 | – |
| 1 | 0/7½ | Oriental | 1⁵⁄₁₆–1⁷⁄₁₆ | 4 7 8 | April, Oct |
| 1 | 0/7½ | Do. 6 per Cent. Cum. Pref. | 1¼–1⅜ | 4 7 0 | – |
| St. | 24/7⅜ | Do. 4% Red. Deb. Stock | 98 –100 | 4 0 0 | .. |
| St. | 4½% | Telephone Co. of Egypt 4½% Db. Stk. Rd. | 103 –106 | 4 4 9 | .. |
| 5 | 8/0 | United River Plate | 7 –7½ | 5 6 8 | July |
| 5 | 2/6 | Do. 5 per Cent. Cum. Pref. | 5½–5¾ | 4 7 0 | June, Dec |
| St. | 5% | * Do. 5 per Cent. Deb. Stock (red.) | 110 –112 | 4 9 8 | June, Dec |
| | | **FINANCIAL, INVESTMENT, &c.** | | | |
| 5 | 8/0 | Elec. & Gen. Investment 6% Cum. Pref. | 4¾– 5¼ | 5 14 0 | – |
| 10 | 2/0 | Globe Telegraph and Trust | 10⅞–11⅜ | 4 16 6 | Ja, Ap, Jy, O |
| 10 | 3/0 | Do. 6 per Cent. Pref | 14⅛–14⅝ | 4 0 6 | Ja, Ap, Jy, O |
| 10 | 6% | Submarine Cables Trust (Cert.) | 129 –132 | 4 12 6 | April, Oct |

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend. ‡ The London Stock Exchange Committee have declined to quote these.



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28, 34 and 36, Southwark Street,
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Phone: 737 or 740 HOP.

**CYLINDER OILS** for High and Low Pressures, also for Superheated Steam.

**CRANK CHAMBER OILS** for Splash System and Forced Lubrication.

**DYNAMO OILS** for High-speed Bearings.

**GAS ENGINE and GENERAL MACHINERY OILS for all purposes.**

Our Oils are specially adopted and recommended by the makers of high-speed engines. They are specially refined and fulfil the requirements of electrical engineers in regard to suitable specific gravity, flash-point, &c. We shall be pleased to quote for lubricants for particular purposes.

STORES and SUPPLIES for
ENGINEERS and
ELECTRIC INSTALLATIONS.
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**ELECTRIC MOTORS** CONTINUOUS ALTERNATING.

**LANGDON-DAVIES MOTOR CO.,**
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SOUTHWARK WORKS, DEVERELL STREET, LONDON, S.E.
Telegrams:— "Damaphon, London." Telephone:— No. 277 Hop

**THE UNITED ELECTRIC CAR CO., Ltd., PRESTON, LANCS.**

Manufacturers of **RAILWAY CARRIAGES, TRAMCARS** for Electric Traction, AND ALL KINDS OF **ROLLING STOCK** for Light Railways.

Registered Office and Works:
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BRANCH WORKS:
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GENERAL INDIARUBBER AND GUTTA-PERCHA MANUFACTURERS.

**ELECTRIC WIRES AND CABLES OF EVERY DESCRIPTION.**

**PHOSPHOR BRONZE CO., Ltd.,**

87, Sumner Street, Southwark, LONDON, S.E.

*Specialists in Metallic Alloys.* *Contractors to the War Office, Admiralty, India Office, &c.*

SOLE MAKERS OF

**"PHOSPHOR BRONZE"** (Cog Wheel and Vulcan Brands) **INGOTS, CASTINGS, STRIP, SHEET, &c.**

**"WHITE ANT" METAL,** a Cheap and Efficient **ANTI-FRICTION WHITE METAL** equal to Magnolia.

"COG WHEEL" Brand PLASTIC METAL. "VULCAN" Brand BABBITTS, in 7 grades, from £45 per Ton.

**CASTINGS in Bronze, Brass, Gun Metal & Aluminium Alloys.**

# HELIOS ENCLOSED ARC LAMPS

Type 632.

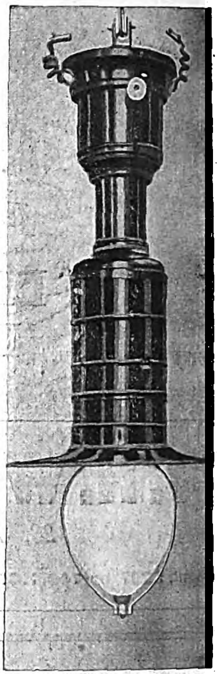
In consequence of the decision of Mr. Justice Joyce, whereby the Original Manufacturers of the STEWART ENCLOSED-ARC LAMP have been restrained from selling their lamps by that name for the future, the original

## Enclosed-Arc Lamps

manufactured for and during the existence of the STEWART ELECTRICAL SYNDICATE, LTD., by the HELIOS MANUFACTURING COMPANY, and then sold in England as STEWART ENCLOSED-ARC LAMPS, will henceforth be known as

## Helios Enclosed-Arc Lamps

No change whatever will be made in the construction of the lamps or of any of their repair or spare parts.



Type 652.
*(Single Enclosed.)*

**Repairs, Spare Parts, Glass, and Special Carbons for Stewart Arc Lamps will continue to be Undertaken and Supplied as before.**

*SOLE LICENSEES AND AGENTS FOR HELIOS ENCLOSED-ARC LAMPS*

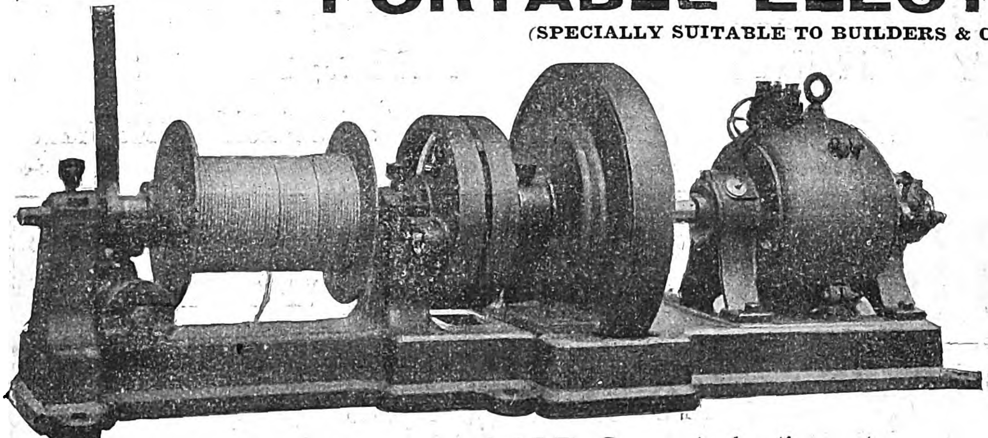
**J. DEFRIES & SONS, LIMITED, LONDON.**

◆◆◆

*ON ADMIRALTY LIST.*

## PORTABLE ELECTRIC HOIST

(SPECIALLY SUITABLE TO BUILDERS & CONTRACTORS).



OPERATED ENTIRELY WITH ONE ROPE.
MOTOR NEVER STOPS NOR REVERSES.

SIZE.

**No. 1 lifts 1 to 1½ cwt. at 100ft. per min**
**No. 2 „ 2 to 3 cwt. „ „**

Supplied with Motor or fitted to Customer's Motor if of suitable size.

*For full particulars apply to—*

**HUMPAGE, JACQUES and PEDERSEN, Ltd.,**
ASHTON GATE, BRISTOL.

For **SPEED REDUCING GEAR**—*See next advertisement.*

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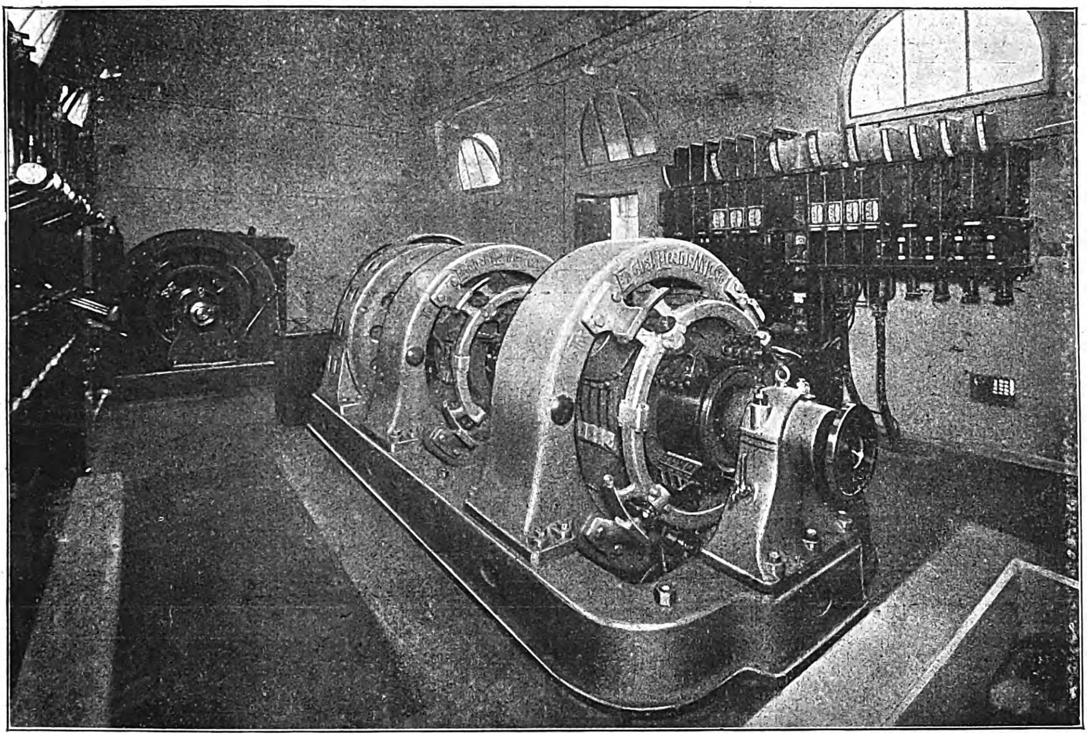
Telegrams: Electric London.
Offices & Warehouse: PLAYHOUSE YARD, GOLDEN LANE, LONDON, E.C. Works: LEYTON, E.
Telephone: No. 105 Bank

*MANUFACTURERS:*—CABLES of Light, Medium and High Insulation.
COVERED WIRES, STRIPS, CABLES, &c., for Dynamo Machines
SILK COVERED WIRES for Instruments.
LINE WIRES, CABLES AND CORDS for Telephones, Bells, &c.
FLEXIBLE CORDS AND CABLES.
PLATINOID, EUREKA and other RESISTANCE WIRES.
GAUZE BRUSHES and Sundry Appliances.

**PRICE LIST ON APPLICATION**

*Engineers' Specifications Carefully Worked to.*

DICK, KERR & CO., Ltd.



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ESTABLISHED 1800.

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List Prices from £2 10 0

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List Prices from £6 0 0

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Century Works, LEWISHAM, LONDON, S.E.

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VULCANIZED WIRES.

Manufactured in THREE STANDARD GRADES—
300, 600 and 2,500 megohms.

SUITABLE FOR
House Wiring, Cable Feeders, &c.

Ask for Catalogue "A W 2."

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LIMITED,
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AND 14, UNION COURT, LONDON, E.C.

ANCHOR
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LTD.,
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Works:
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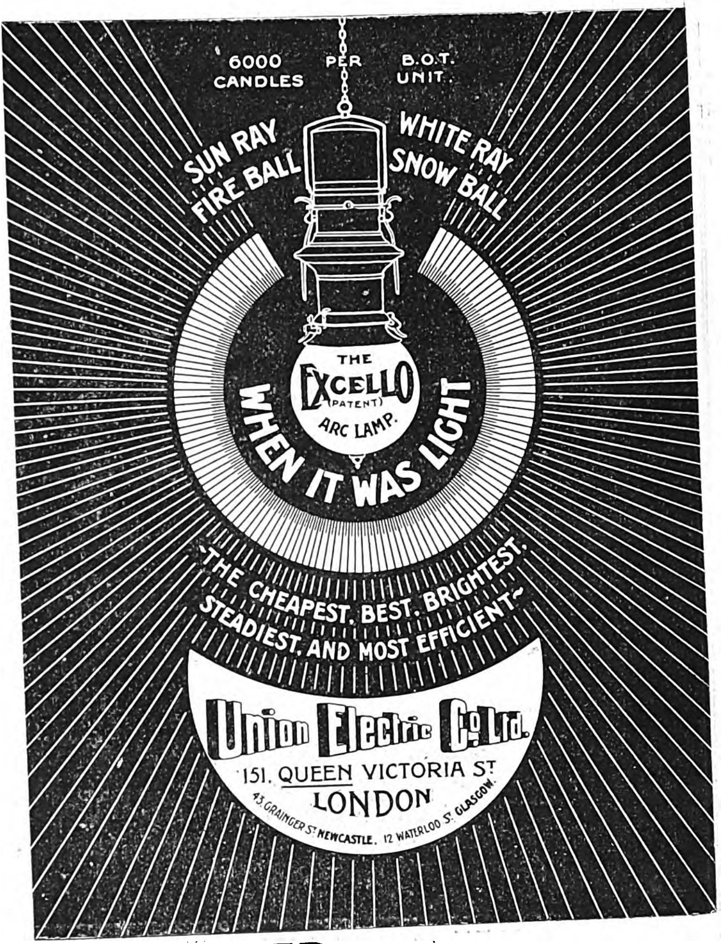
INSULATED SPANNERS,
JOINTERS' GLOVES, &c., &c.


6000 CANDLES PER B.O.T. UNIT.
SUN RAY FIRE BALL
WHITE RAY SNOW BALL
THE EXCELLO (PATENT) ARC LAMP.
WHEN IT WAS LIGHT
"THE CHEAPEST, BEST, BRIGHTEST, STEADIEST, AND MOST EFFICIENT"
Union Electric Co. Ltd.
151, QUEEN VICTORIA ST
LONDON
43 GRAINGER ST NEWCASTLE. 12 WATERLOO ST GLASGOW.

GUARANTEED
(1) For Workmanship, Material and Design.
(2) Against actions for infringement of Patents.

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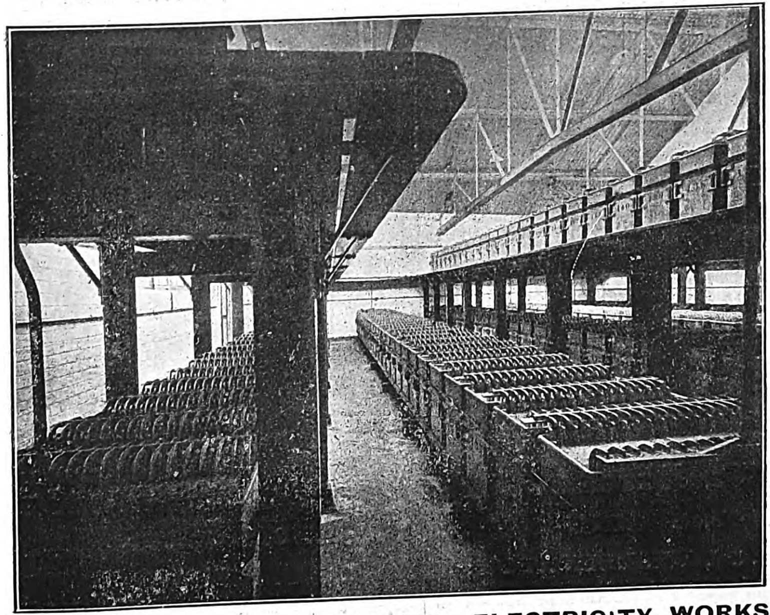
STRATFORD, LONDON, E.

STORAGE BATTERIES
FOR
CENTRAL STATIONS,
PRIVATE INSTALLATIONS.

200,000
Cells in use.


TRACTION BATTERY, BRADFORD ELECTRICITY WORKS.

STORAGE BATTERIES
FOR
MOTOR CARS,
LAUNCHES,
'BUS LIGHTING,
PORTABLE and TESTING WORK.

SEND FOR LATEST LIST.

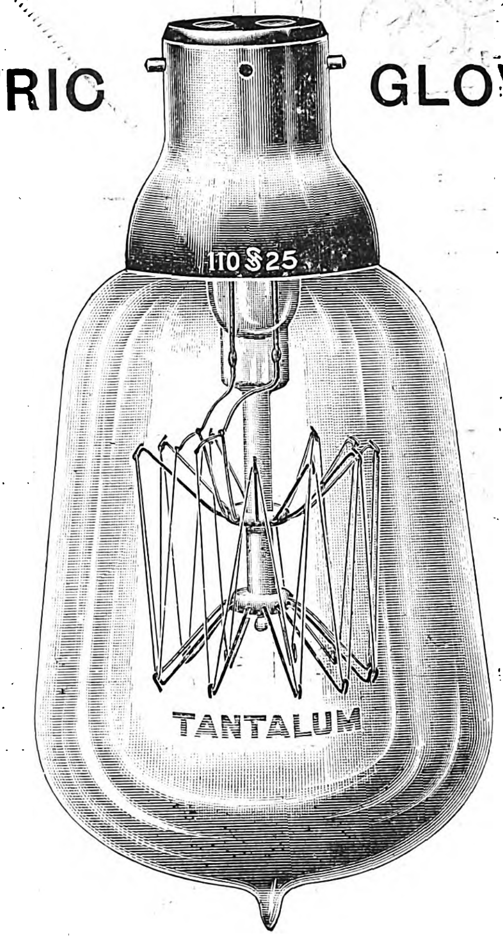
THE

TANTALUM

ELECTRIC GLOW LAMP.

SPECIAL
QUOTATIONS
GIVEN
FOR
QUANTITIES.

TERMS
FOR
CONTRACTS
SENT ON
APPLICATION.



Full size of the 23-c.p. 110-volt Lamp.

TANTALUM LAMPS. Instead of the usual Carbon Filament a fine wire of Tantalum is substituted, with the result that under similar conditions as to life, reliability and constancy of candle-power, the same amount of light is yielded with a reduction of 40 to 50 per cent. in the current bill.

In Country Houses the use of these Lamps will prolong the life of the Accumulator, and save fuel. Many thousands of Carbon Filament Lamps have already been replaced by Tantalum Lamps

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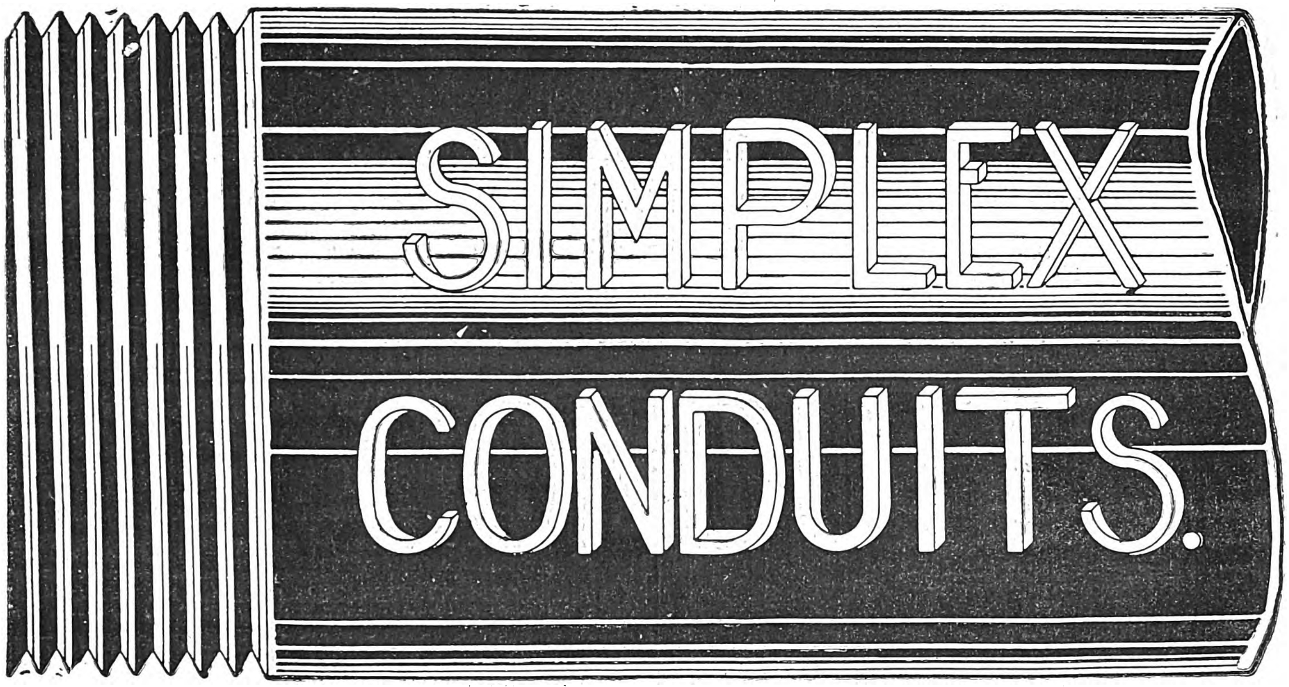
50, WELLINGTON STREET, GLASGOW.

TELEGRAMS.
"ACCUMULATOR,"
London, Manchester or Glasgow.

On all your Wiring Contracts
use Simplex Conduits and
Accessories.



Sole Manufacturers:
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**KAYE'S**
LATEST PATENT SERRATED STEEL
**SEAMLESS OIL CAN,**
**Fitted with New Patent Thumb Button, Seamless Spout, and Slide Feed Hole.**
When the Lid of the Oil Can is raised it mechanically opens the Slide Feed Hole.)
**Also in COPPER or BRASS for ELECTRICAL PURPOSES.**

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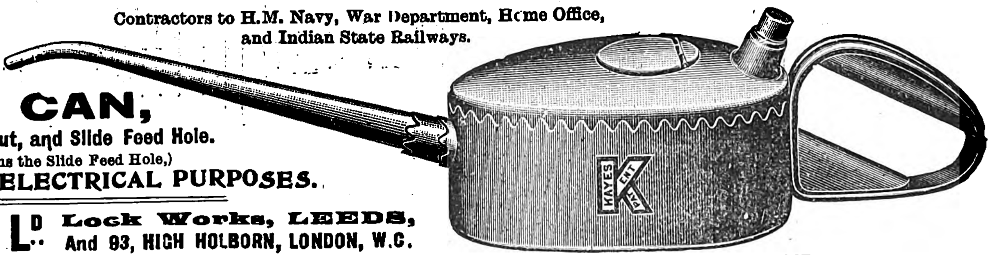
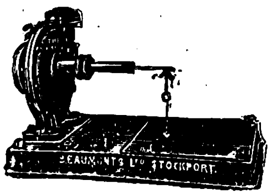
Sole Makers: **JOSEPH KAYE & SONS, L^D** Lock Works, LEEDS, And 93, HIGH HOLBORN, LONDON, W.C.
Telegrams: WEDGE, LEEDS. KAYE, HIGH HOLBORN, LONDON. Telephones: LEEDS 506. LONDON, HOLBORN 1847.



**BEAUMONT'S "RAPID" CENTRIFUGAL PUMPS.**

CONTRACTORS to the ADMIRALTY.


BEAUMONTS L^D STOCKPORT.

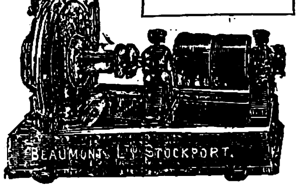
| Size of Suction & Delivery of Pump in inches. | Capacity in gallons per minute. | Maximum of Vertical Suction advisable in feet. | Price, complete £ s. d. |
|---|---|---|---|
| ¾ | 10 | 12 | 5 15 0 |
| 1 | 25 | 13 | 7 5 0 |
| 1¼ | 30 | 13 | 7 15 0 |
| 1½ | 40 | 14 | 8 10 0 |
| 2 | 80 | 15 | 11 0 0 |
| 2½ | 140 | 16 | 12 0 0 |
| 3 | 240 | 16 | 14 0 0 |

Please give voltage, speed of motor, height of centre and measurement of motor base when ordering or enquiring. First three sizes have Screwed Suction; all sizes from 2½in. have Circular Outlet Flanges.

Will pump any thick, hot, heavy or sedimentary liquid.
Will pump twice as much as the best Centrifugal Pump of other makes, size for size, the pumps running at the same speed.
**See Catalogue for Larger Pumps for all Purposes.**

| No. of Pump ......... | 1 | 1½ | 1¾ | 2 | 2½ | 3 | 4 |
|---|---|---|---|---|---|---|---|
| Capacity in Gallons | 2,000 | 5,000 | 8,000 | 14,000 | 20,000 | 30,000 | 50,000 |
| Price | £ s. | £ s. | £ s. | £ s. | £ s. | £ s. | £ s. |
| Iron Pump, 2 pulleys | 5 10 | 7 10 | 9 0 | 13 0 | 16 0 | 18 0 | 25 0 |
| Brass Pump ,, | 7 0 | 10 0 | 12 0 | 17 6 | 23 10 | 27 0 | 40 0 |

**BEAUMONTS LIMITED,**
Pump Works, STOCKPORT, ENGLAND. Telegrams: PUMPS STOCKPORT.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**WESTERN ELECTRIC COMPANY**

Manufacture and Lay **CABLES** For TRAMWAYS, ELECTRIC LIGHT AND TELEPHONES.

JUNCTION BOXES AND ALL ACCESSORIES.

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Telephone No. 418 BANK and 2389 CENTRAL.

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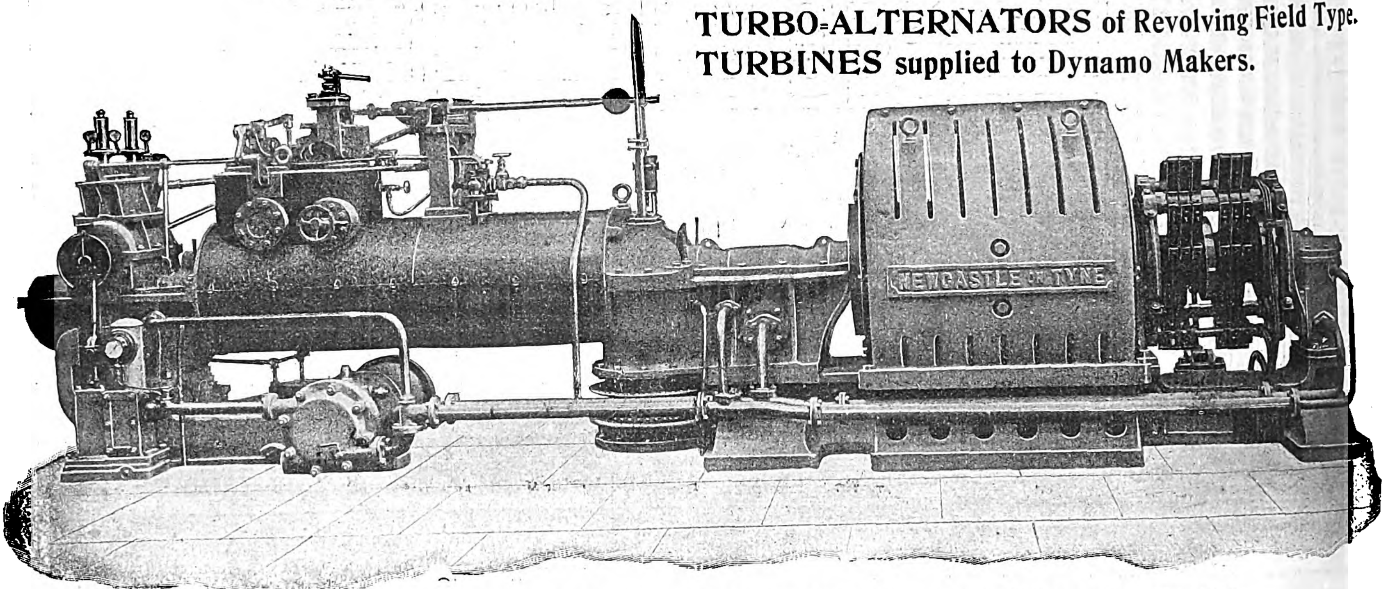
**STEAM TURBO-DYNAMOS** FOR CONTINUOUS CURRENT.

SPARKLESS COMMUTATION GUARANTEED.

TURBO-ALTERNATORS of Revolving Field Type.
TURBINES supplied to Dynamo Makers.



300 kw. C. C. TURBO-DYNAMO supplied to DERBY CORPORATION for TRAMWAYS.

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BRASS and COPPER TUBES, SHEETS, WIRE RODS, BOTTOMS, PANS, FIRE-BOX PLATES, ALUMINIUM, TIN, LEAD, ZINC, IRON, &c.

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Every Description of BRASS, COPPER, ZINC, LEAD, BATTERY PLATES, ASHES, BORINGS, and REFUSES containing Metals of any kind, also OLD CABLES, BOILERS, DYNAMOS, &c., &c. Also any Description of PLANT for DISMANTLING.

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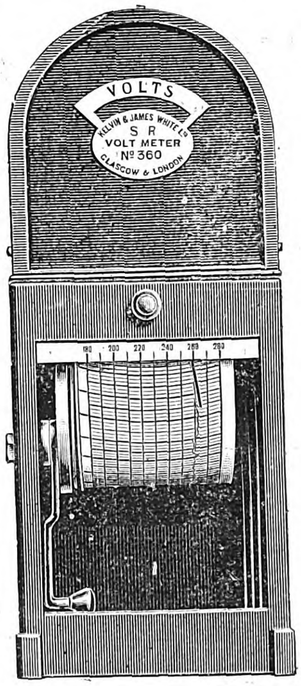

**Ammeters, Voltmeters, Wattmeters**
For Direct or Alternating Circuits,
**TRACTION AND LIGHTING**

APPROVED by the BOARD of TRADE

*DEAD-BEAT,*
*LARGE OPEN SCALES,*
*ACCURATE.*

Movement to Change Record also Winds Clock.

PEN CLOCK CANNOT BE DAMAGED. OVERWOUND.

Sole Makers—
**KELVIN & JAMES WHITE, Ltd.,**
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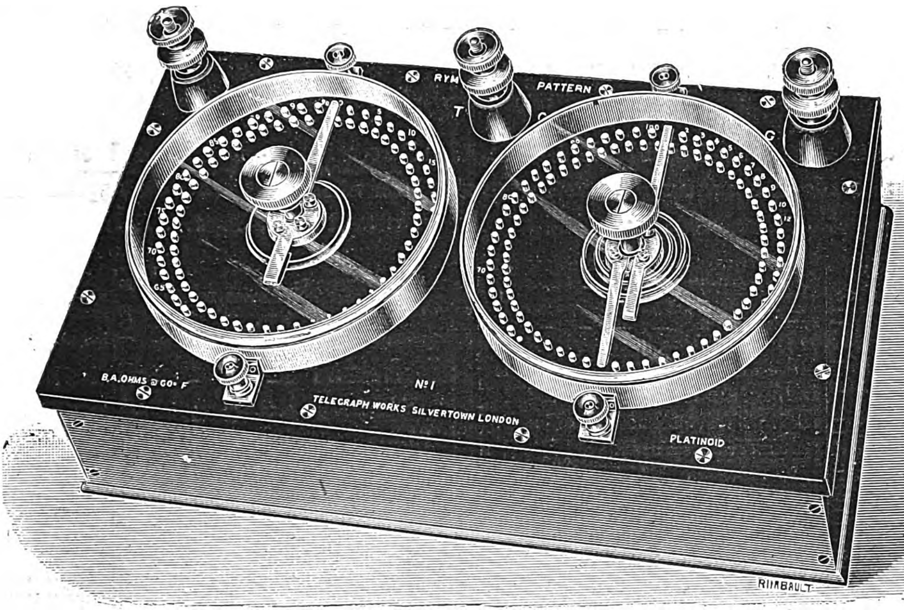
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B.A. OHMS
Nº 1
TELEGRAPH WORKS SILVERTOWN LONDON
PLATINOID
RIMBAULT

**UNIVERSAL SHUNT. RYMER-JONES PATTERN.**

CAN BE USED FOR ALL THE TESTS FOR WHICH THE KELVIN AND VARLEY SLIDES ARE SUITABLE

DESCRIPTIVE PAMPHLET ON APPLICATION.

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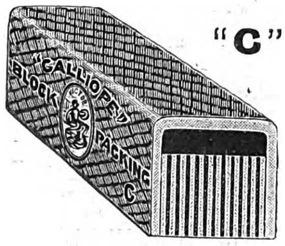
**"CALLIOPE"** (REGD.)

**PACKINGS.**


"C"
CALLIOPE BLOCK PACKING C

AN EXCELLENT WIRE GAUZE AND ASBESTOS BLOCK PACKING.

"A" Quality 1/- lb. "B" Quality 1/1½ lb.

**"C" Quality 1/3 per lb.** BEST VALUE EVER OFFERED.

The UNITED ASBESTOS CO., Ltd., Dock House, Billiter St., LONDON, E.C.

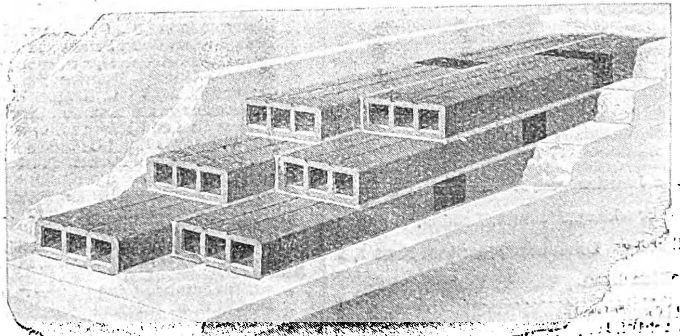
**Doulton Conduits**

*For* **TRACTION**

*Minimum Space*

*Sound Construction*

**DOULTON & CO. Limited**



*For* **LIGHTING**

*Minimum Labour*

*Depreciation Nil*

**LAMBETH**
**LONDON S.E.**

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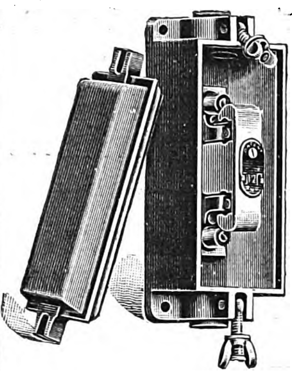
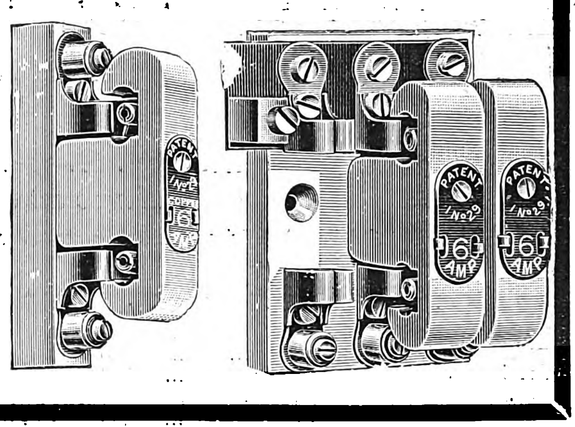

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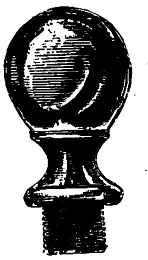
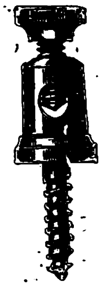

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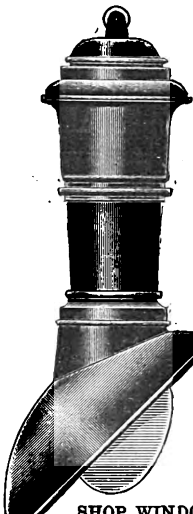
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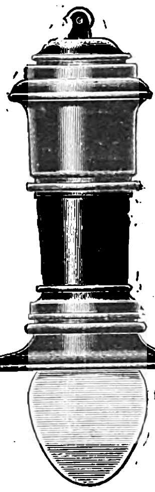
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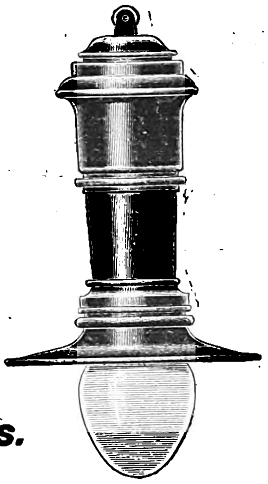
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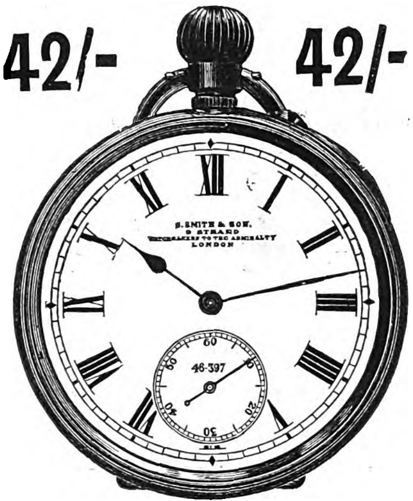
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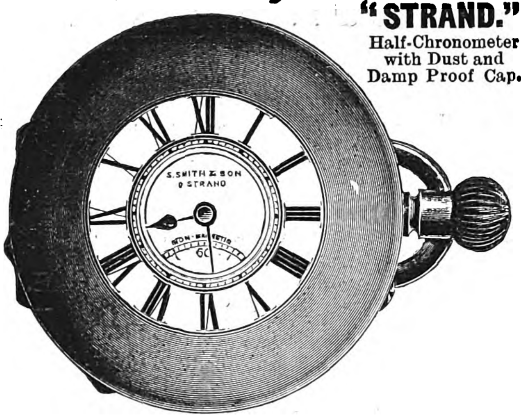
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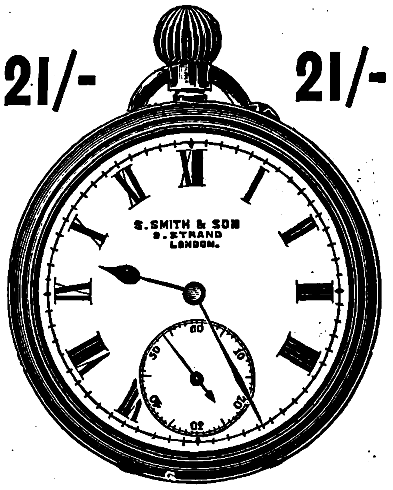
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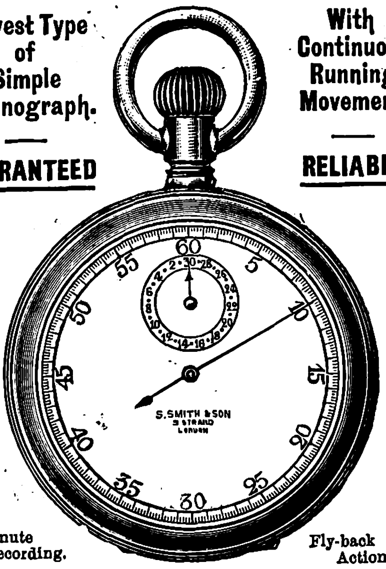
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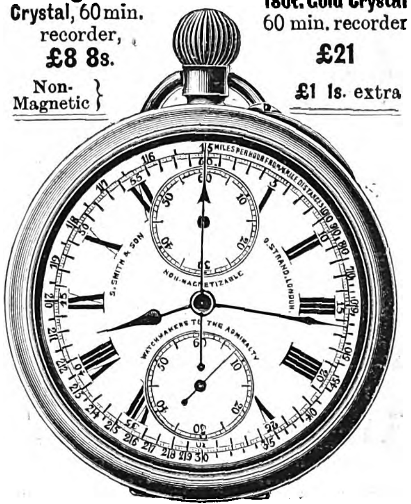
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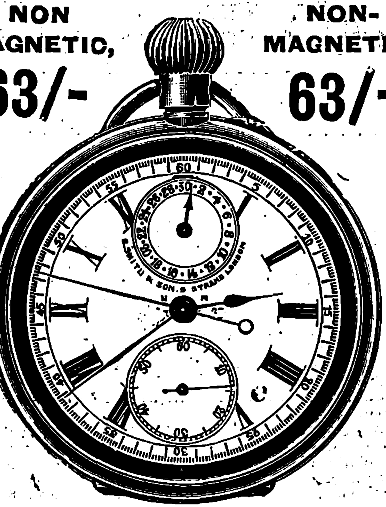
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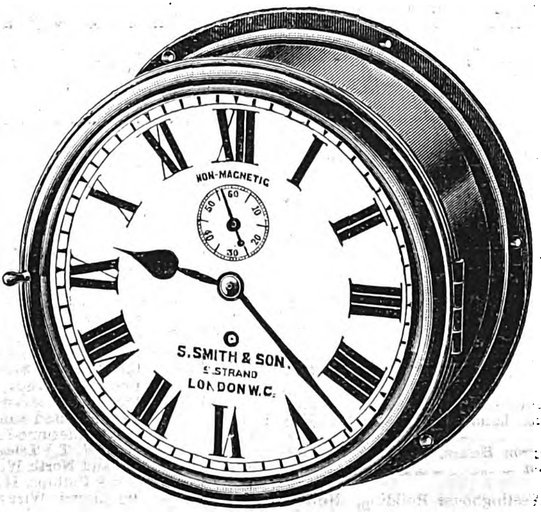
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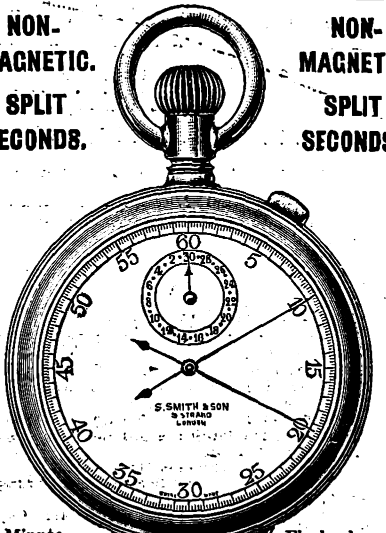
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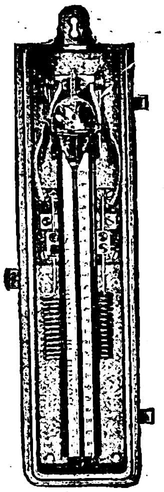

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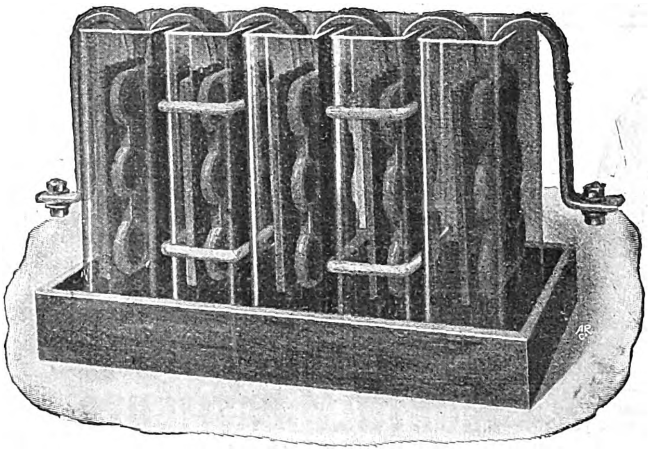

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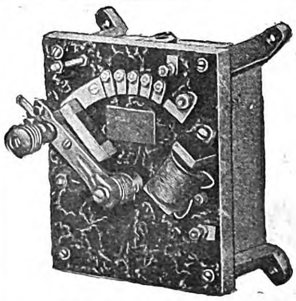

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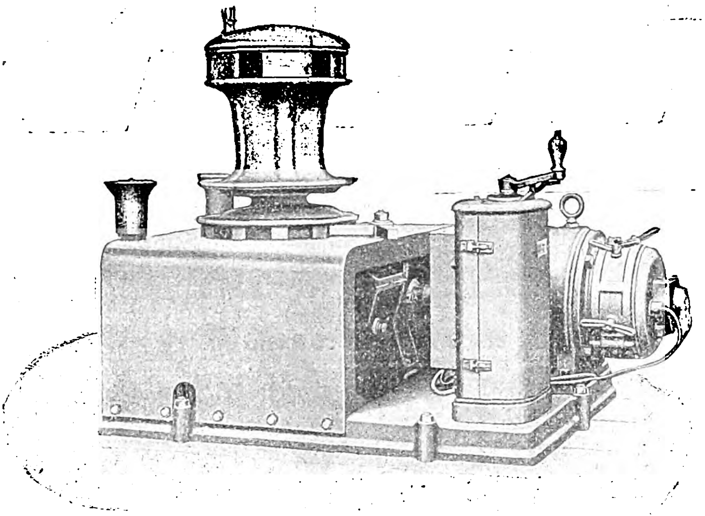

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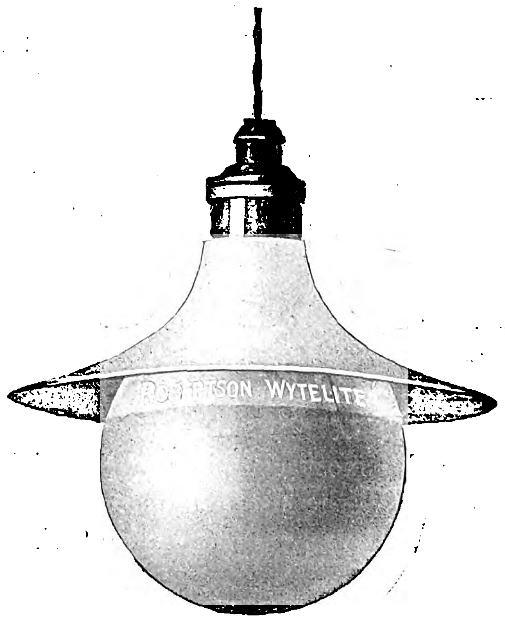

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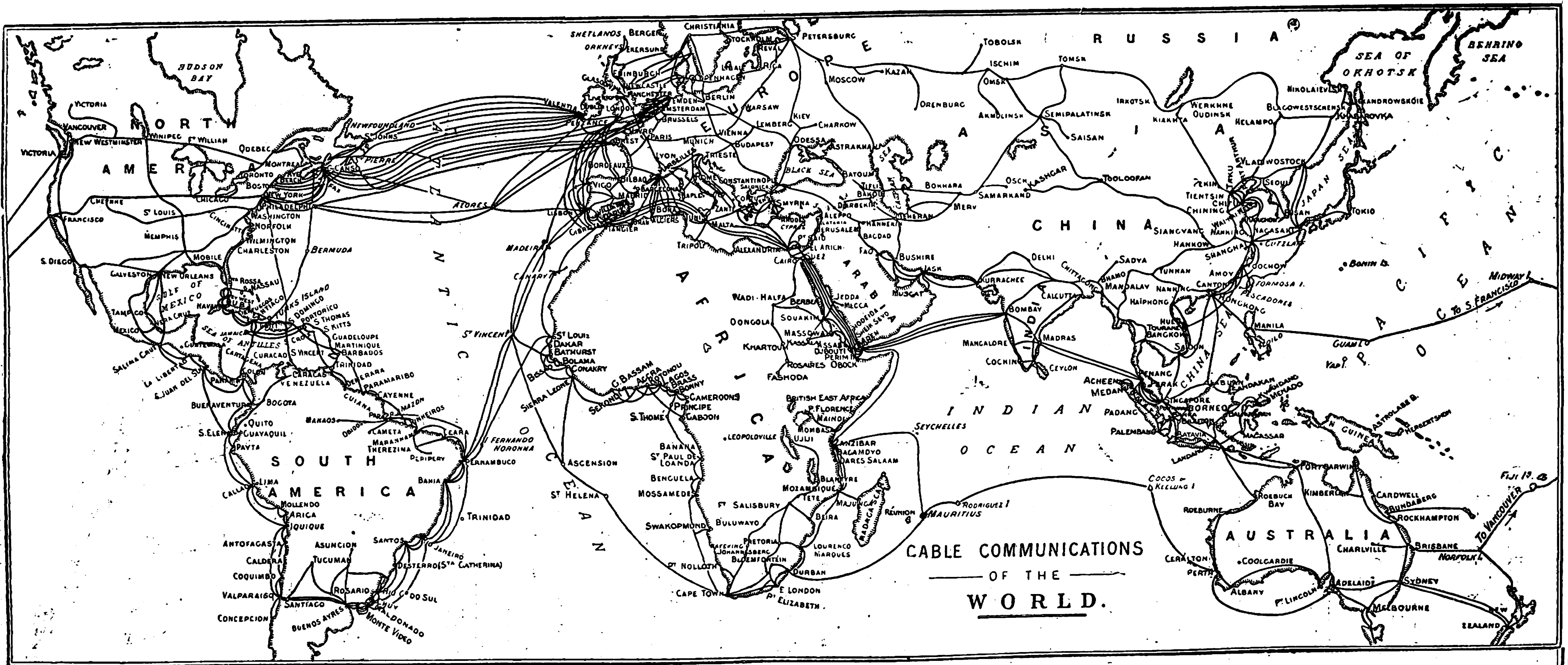
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| TUNIS | 0 | 9½ |
| **Red Sea Ports, &c.—** | | |
| ABYSSINIA | 2 | 3 |
| ADEN | 2 | 0 |
| DJIBOUTI | 2 | 3 |
| ITALIAN EAST AFRICA— | | |
| ASSAB | 2 | 1 |
| MASSOWAH AND OTHER PLACES | 2 | 2 |
| JEDDAH AND OTHER STATIONS IN HEDJAZ, via JEDDAH | 3 | 1 |
| OBOCK | 2 | 1 |
| PERIM | 2 | 0 |
| SUAKIM | 1 | 4 |
| YEMEN, via SHEIK SEYD | 2 | 7 |
| **East Coast and Adjacent Islands—** | | |
| BRITISH EAST AFRICA PROTECTORATE— | | |
| MOMBASA | 2 | 6 |
| OTHER PLACES | 2 | 10 |
| GERMAN EAST AFRICA— | | |
| BISMARCKBURG AND UJIJI, via SOUTH AFRICA | 3 | 1 |
| OTHER PLACES | 2 | 8 |
| MADAGASCAR | 3 | 2 |
| MAURITIUS, SEYCHELLES AND RODRIGUES | 2 | 6 |
| PORTUGUESE EAST AFRICA— | | |
| MOZAMBIQUE, LOURENCO MARQUES | 2 | 7 |
| GOVT. STATIONS MOZAMBIQUE PROVINCE | 2 | 7 |
| BEIRA RAILWAY COMPANY'S STATIONS | 2 | 9 |
| DISTRICT OF THE ZAMBESI | 3 | 0 |
| ZANZIBAR | 2 | 6 |

### To AFRICA *(continued)*.

| | s. | d. |
|---|---|---|
| **South—** | | |
| BRITISH CENTRAL AFRICA PROTECTORATE (NYASSALAND) | 2 | 11 |
| CAPE COLONY | 2 | 6 |
| NATAL | 2 | 6 |
| ORANGE RIVER COLONY AND TRANSVAAL | 2 | 6 |
| SOUTHERN RHODESIA | 2 | 8 |
| NORTHERN „ | 2 | 11 |
| **West Coast and Adjacent Islands—** | | |
| ANGOLA— | | |
| BENGUELLA | 10 | 0 |
| „ GOVERNMENT STATIONS | 10 | 1 |
| LOANDA | 8 | 8 |
| „ GOVERNMENT STATIONS | 8 | 9 |
| MOSSAMEDES | 10 | 11 |
| „ GOVERNMENT STATIONS | 11 | 0 |
| BATHURST | 3 | 6 |
| BISSAO AND BOLAMA | 4 | 8 |
| BONNY | 5 | 0 |
| „ GOVERNMENT STATIONS | 5 | 2 |
| BRASS | 5 | 0 |
| CAMEROONS | 5 | 2 |
| CANARIES, via CADIZ | 0 | 9 |
| „ via ST. VINCENT | 4 | 11 |
| DAHOMEY—KOTONOU, &c. | 5 | 0 |
| FRENCH CONGO—LIBREVILLE, &c. | 5 | 5 |
| „ GUINEA—CONAKRY | 3 | 6 |
| „ „ OTHER PLACES | 3 | 7 |
| „ SOUDAN (*see SENEGAL*). | | |
| GERMAN SOUTH WEST AFRICA— | | |
| SWAKOPMUND, &c. | 2 | 8 |
| GOLD COAST— | | |
| ACCRA AND SEKONDI | 4 | 8 |
| OTHER STATIONS | 4 | 10 |
| IVORY COAST—GRAND BASSAM | 4 | 6 |
| „ „ OTHER STATIONS | 4 | 8 |
| LAGOS | 5 | 0 |
| „ GOVERNMENT STATIONS | 5 | 2 |
| MADEIRA, via DIRECT | 1 | 0 |
| „ via CADIZ | 4 | 7 |
| PRINCIPE | 7 | 3 |
| ST. JAGO, via DIRECT | 3 | 1 |
| „ „ via CADIZ | 3 | 11 |
| ST. THOMÉ | 6 | 8 |
| ST. VINCENT, via DIRECT | 2 | 2 |
| „ „ via CADIZ | 3 | 4 |
| SENEGAL AND FRENCH SOUDAN | 1 | 5 |
| „ via ST. VINCENT | 4 | 3 |
| SIERRA LEONE & WATER STREET & CLINE TOWN RAILWAY OFFICES | 3 | 6 |
| „ OTHER RAILWAY OFFICES | 3 | 7 |
| TOGOLAND | 5 | 0 |
| ASCENSION AND ST. HELENA | 2 | 6 |

### To ASIA.

| | s. | d. |
|---|---|---|
| ANNAM | 4 | 5 |
| BRITISH NORTH BORNEO— | | |
| LABUAN | 3 | 6 |
| OTHER PLACES | 3 | 8 |
| CHINA—HONG-KONG | 4 | 5 |
| „ MACAO | 4 | 7 |
| „ OTHER PLACES | 4 | 5 |
| COCHIN CHINA | 3 | 10 |
| COCOS-KEELING ISLANDS | 2 | 6 |
| COREA—ALL STATIONS, via JAPAN | 4 | 10 |
| DUTCH BORNEO | 4 | 5 |

### To ASIA *(continued)*.

| | s. | d |
|---|---|---|
| DUTCH INDIES—JAVA | 4 | 0 |
| „ OTHER ISLANDS | 4 | 5 |
| FORMOSA | 4 | 10 |
| INDIA—INDIA | 2 | 0 |
| „ BURMAH | 2 | 0 |
| „ CEYLON | 2 | 1 |
| JAPAN | 4 | 10 |
| PENINSULA OF KWANTOUNG—PORT ARTHUR, DALNY AND TALIENVAN | 4 | 5 |
| PERSIA, via MALTA | 2 | 0 |
| „ via BOMBAY | 3 | 3 |
| PERSIAN GULF STATIONS— | | |
| via MALTA | 2 | 0 |
| via BOMBAY | 3 | 1 |
| PHILIPPINES—ISLAND OF LUZON | 4 | 5 |
| „ OTHER ISLANDS (VISAYAS) | 4 | 10 |
| RUSSIA IN ASIA AND BOKHARA, via SINGAPORE | 6 | 0 |
| SIAM, via SINGAPORE | 4 | 3 |
| „ „ MOULMEIN | 3 | 3 |
| STRAITS SETTLEMENTS—PENANG, SINGAPORE, MALACCA AND NATIVE STATES | 3 | 6 |
| TONQUIN | 4 | 5 |
| TURKEY IN ASIA, via DIRECT | 0 | 6½ |
| „ „ via EL ARICH | 2 | 3 |
| „ „ via BOMBAY | 3 | 11 |
| YAP (CAROLINE ISLANDS) | 4 | 11 |

### To AUSTRALASIA.

| | s. | d |
|---|---|---|
| FANNING ISLAND | 4 | 7 |
| FIJI | 3 | 7 |
| NEW CALEDONIA | 3 | 8 |
| NEW SOUTH WALES | 3 | 0 |
| NEW ZEALAND | 3 | 0 |
| NORFOLK ISLAND | 3 | 2 |
| QUEENSLAND | 3 | 0 |
| SOUTH AND WEST AUSTRALIA | 3 | 0 |
| TASMANIA | 3 | 0 |
| VICTORIA | 3 | 0 |

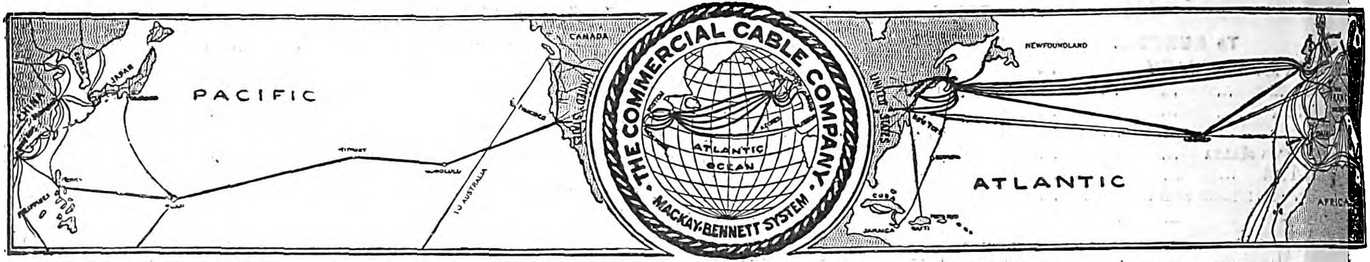
### To SOUTH AMERICA.

| | s. | d |
|---|---|---|
| ARGENTINE REPUBLIC | 4 | 2 |
| BOLIVIA | 5 | 9 |
| BRAZIL— | | |
| PERNAMBUCO | 3 | 0 |
| AMAZON STATIONS—BREVES, CAMETA, CHAVES, GURUPÁ, MACAPA, MONTE ALEGRE, MOSQUEIRO, PINHEIROS, SANTAREM, SOURÉ | 5 | 2 |
| ALEMQUER, ITACOATIARA, MANAOS, OBIDOS, PARINTINS | 6 | 5 |
| ALL OTHER PLACES | 4 | 0 |
| BRITISH GUIANA, via ST. VINCENT | 14 | 1 |
| CHILI—PUNTA ARENAS | 4 | 2 |
| „ OTHER PLACES | 5 | 9 |
| COLUMBIA | 7 | 10 |
| DUTCH GUIANA | 6 | 9 |
| ECUADOR— | | |
| GUAYAQUIL, via ST. VINCENT | 7 | 8 |
| OTHER PLACES „ | 7 | 10 |
| FRENCH GUIANA | 6 | 9 |
| PARAGUAY | 4 | 2 |
| PERU | 5 | 9 |
| URUGUAY | 4 | 2 |

TELEGRAMS

"Via Eastern"

# COMMERCIAL CABLE COMPANY.



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| „ | 1, Shorters Court, E.C. | Avenue 1146 |
| „ | The Baltic, E.C. | Central 7486 |
| „ | 16, Mark Lane, E.C. | Avenue 2164 |
| „ | 1, Northumberland Avenue, Charing Cross, W.C. | Gerrard 5145 |
| „ | 11, Duke Street, London Bridge, S.E. | Hop 878 |
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| MANCHESTER: | 18, Moult Street, Cross Street | 1608 |
| LEITH: | 5, Bernard Street | 589 |

| | | Telephone |
|---|---|---|
| LIVERPOOL: | F7, Exchange Buildings | Central 484 |
| „ | Cotton Exchange, Brown's Buildings | – |
| BRADFORD: | 8, Foster Square | 778 |
| BRISTOL: | Carlton Chambers, Baldwin Street | 61 |
| WESTON-SUPER-MARE: | 12, Richmond Street | – |
| NEWCASTLE-ON-TYNE: | 29, Sandhill | 1856 |
| GLASGOW: | 28, Gordon Street | 3849 |
| EDINBURGH: | 18c, George Street | 384 |
| DUNDEE: | 37, Albert Square | 554 |

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◆ ◆ ◆

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HAYS WHARF, TOOLEY STREET, LONDON, S.E.
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1, PANMURE STREET, DUNDEE.
50, FREDERICK STREET, EDINBURGH.
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31, BROWN STREET, MANCHESTER.
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|---|---|---|---|---|---|
| | 32 | 727 | Motherwell | 46 | 494 |
| Glasgow | 40 | 75 | Morecambe | 35 | 752 |
| | 42 | 496 | Morley | 41 | 312 |
| | 45 | 765, 805, 849 | Newbury | 52 | 593 |
| | 56 | 218 | Newcastle and District Co. | 49 | 824 |
| Govan | 44 | 498 | Oxford | 29 | 195, 254 |
| Grantham (Urban Electric Supply Co.) | 51 | 1031 | Partick | 48 | 892 |
| Guernsey | 45 | 693 | Portsmouth | 33 | 123 |
| Handsworth (Staffs.) | 55 | 969 | Rathmines | 45 | 631 |
| Hartlepool (Northern Counties Co.) | 52 | 513 | | 51 | 589 |
| Hastings | 25 | 386 | Ryde | 52 | 10 |
| | 38 | 87 | Salisbury | 42 | 356 |
| | 50 | 379 | Sheffield | 35 | 45 |
| Hereford | 44 | 254 | | 53 | 465 |
| Heston & Isleworth | 54 | 165 | Stamford | 49 | 1,022 |
| Hornsey | 50 | 797 | Stirling | 44 | 807 |
| | 51 | 398 | Torquay | 40 | 684 |
| Hull | 42 | 34 | Tunbridge Wells | 50 | 299 |
| Ilfracombe | 52 | 195 | Twickenham and Teddington | 53 | 860 |
| Ingleton | 44 | 578 | Ventnor | 44 | 503 |
| Kendal | 49 | 777 | Wakefield | 41 | 241 |
| Kilmacolm | 52 | 429 | Walker | 50 | 357, 382 |
| Kilmarnock | 54 | 368 | Watford | 43 | 184 |
| King's Lynn | 43 | 722 | Wycombe | 42 | 640 |
| Leeds | 50 | 51 | | | |
| Leicester | 35 | 14 | | | |
| Llandudno | 42 | 11 | | | |

## "THE ELECTRICIAN"

## TABLES OF ELECTRIC SUPPLY AND TRACTION UNDERTAKINGS of the UNITED KINGDOM, 1906.

***Uniform with the present Sheet.***

**Tables Ia.** and **II.**—In one Sheet, to be published with *The Electrician* for January 19th.

Table Ia.—**Towns taking Electricity Supply "in Bulk."**

Table II.—**Electricity Works supplying both Lighting and Tramways.**

**Table III.**—" **Electric Power Companies,** "to be published with *The Electrician* for January 26th.

**Tables IV., V.** and **VI.**—In one Sheet, to be published with *The Electrician* for February 2nd.

Table IV.—**Tramways and Light Railways supplied from Combined Lighting and Traction Power Houses.**

Table V.—**Tramways and Light Railways with Power Houses for Traction only.**

Table VI.—**Electric Railways in Operation and in Progress.**

*These Sheet Tables can also be purchased printed on one side of the paper and mounted in various styles Full particulars free by post.*

**Printed and Published for the Proprietors by GEO. TUCKER,**
**1, 2 and 3, Salisbury Court, Fleet Street, London.**

SUPPLEMENT TO "THE ELECTRICIAN," JANUARY 26, 1906.

*Extra Copies of this Sheet can be obtained, as this, price 1s. 6d.*

# "THE ELECTRICIAN"

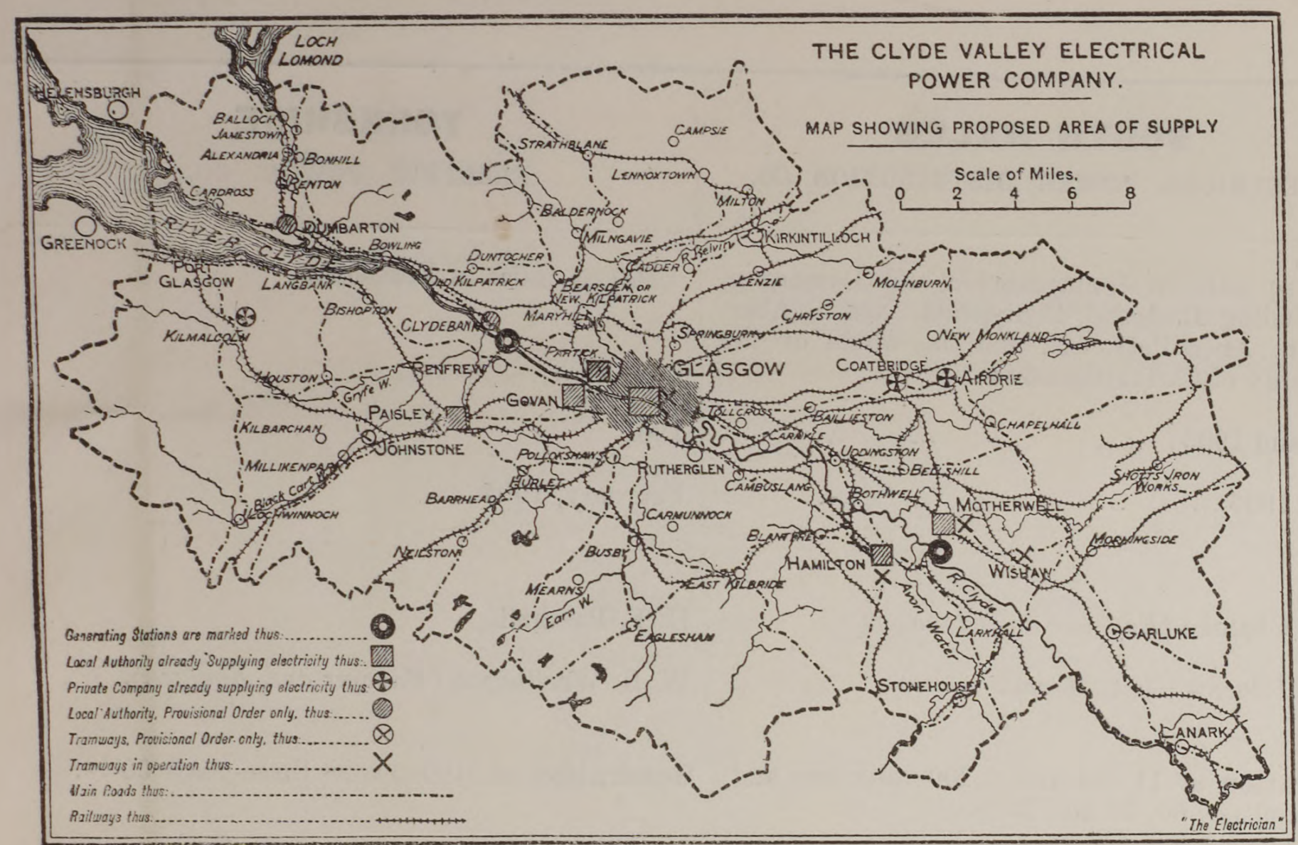
## TABLES OF ELECTRIC SUPPLY AND TRACTION UNDERTAKINGS OF THE UNITED KINGDOM.—JAN., 1906.

**Copyright.**

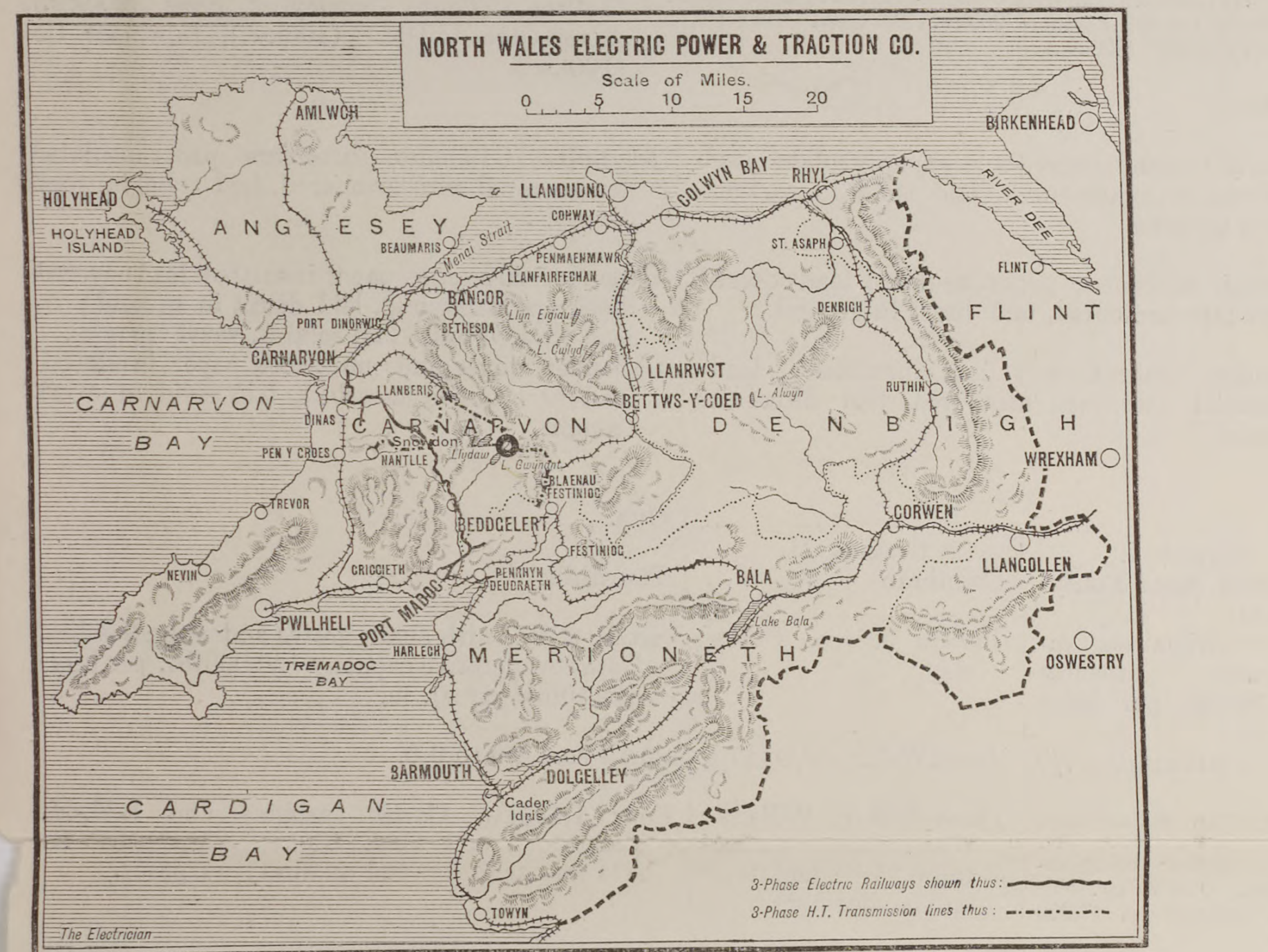
## TABLE III. ELECTRIC POWER COMPANIES.—MAPS OF AREAS.

**Copyright.**

### CLYDE VALLEY ELECTRICAL POWER CO.


THE CLYDE VALLEY ELECTRICAL POWER COMPANY.
MAP SHOWING PROPOSED AREA OF SUPPLY

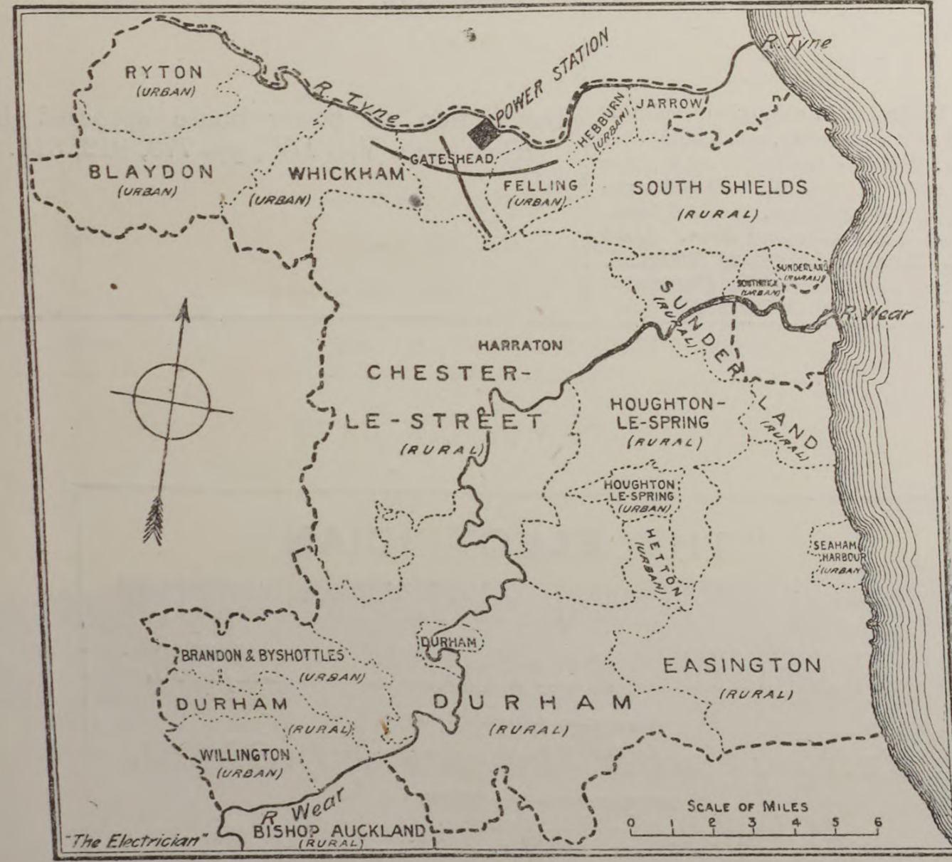
### NORTH WALES ELECTRIC POWER AND TRACTION CO.


NORTH WALES ELECTRIC POWER & TRACTION CO.

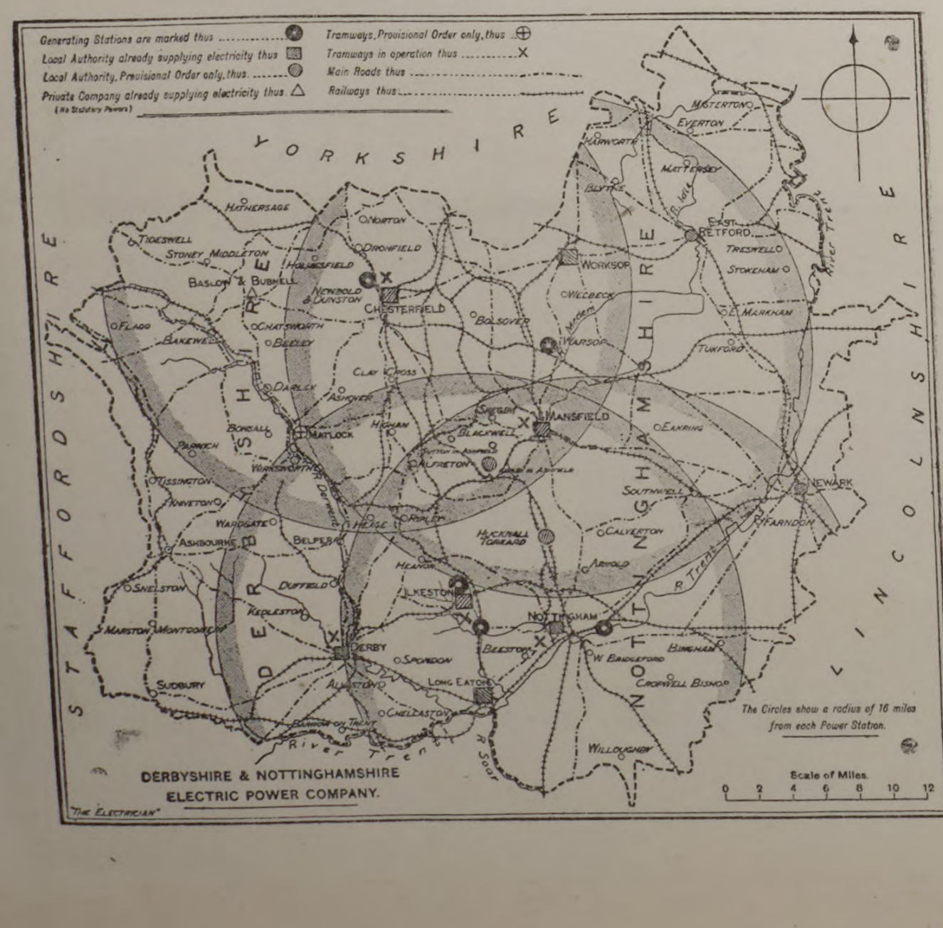
Generating station shown thus : ◉.

Local Authorities have electricity works in operation at *Bangor*, *Llandudno*, *Colwyn Bay* and *Rhyl*; Companies at *Carnarvon*, *Holyhead*, *Llangollen* and *Llanrwst*. Provisional Orders have also been granted to the Local Authorities in the following towns : *Pwllheli*, *Penmaenmawr* and *Conway*.

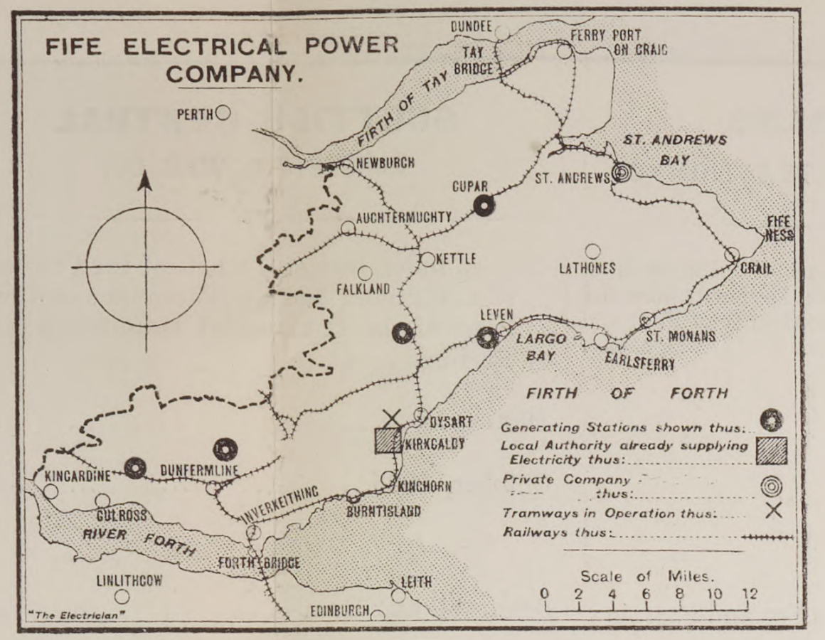
### COUNTY OF DURHAM ELECTRIC POWER SUPPLY COMPANY.



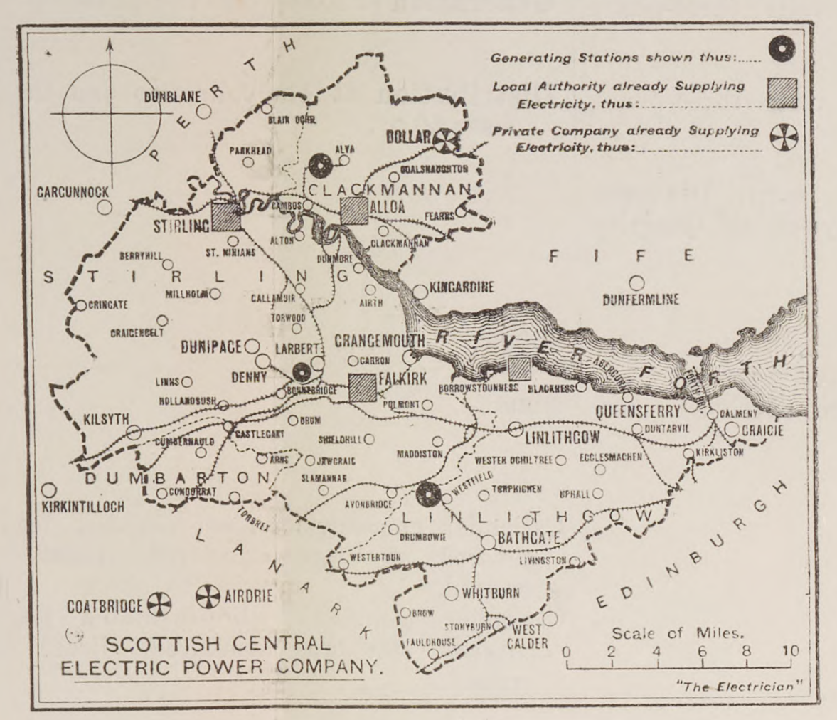
### DERBYSHIRE AND NOTTINGHAMSHIRE ELECTRIC POWER CO.


DERBYSHIRE & NOTTINGHAMSHIRE ELECTRIC POWER COMPANY.

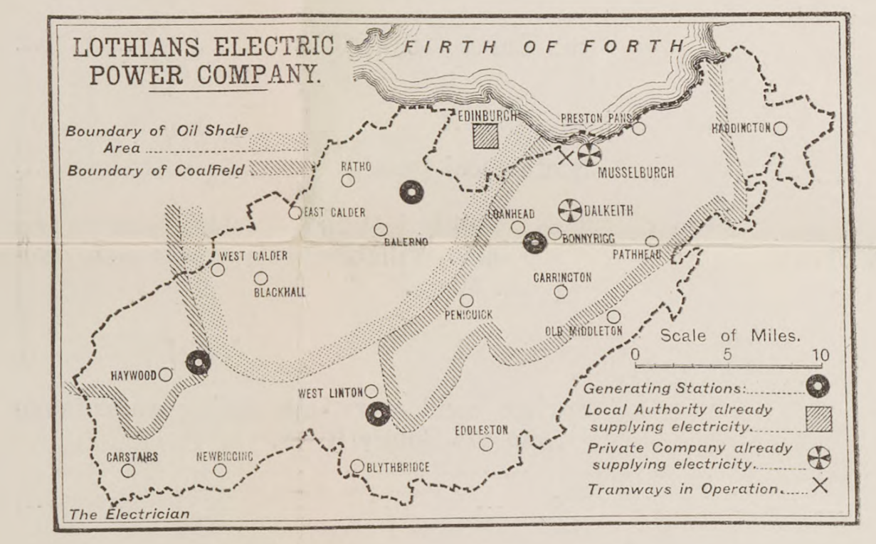
### FIFE ELECTRIC POWER CO.


FIFE ELECTRICAL POWER COMPANY.

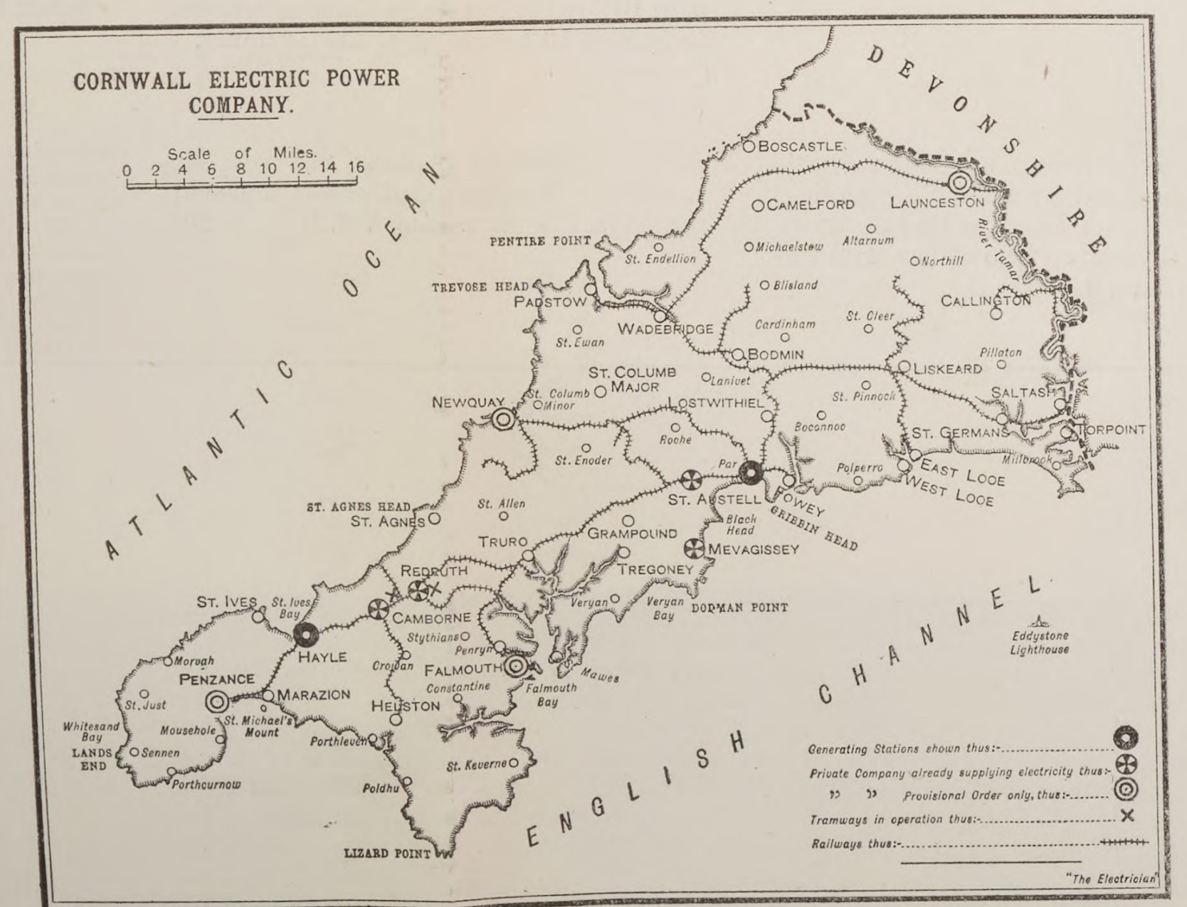
### SCOTTISH CENTRAL ELECTRIC POWER CO.


SCOTTISH CENTRAL ELECTRIC POWER COMPANY.

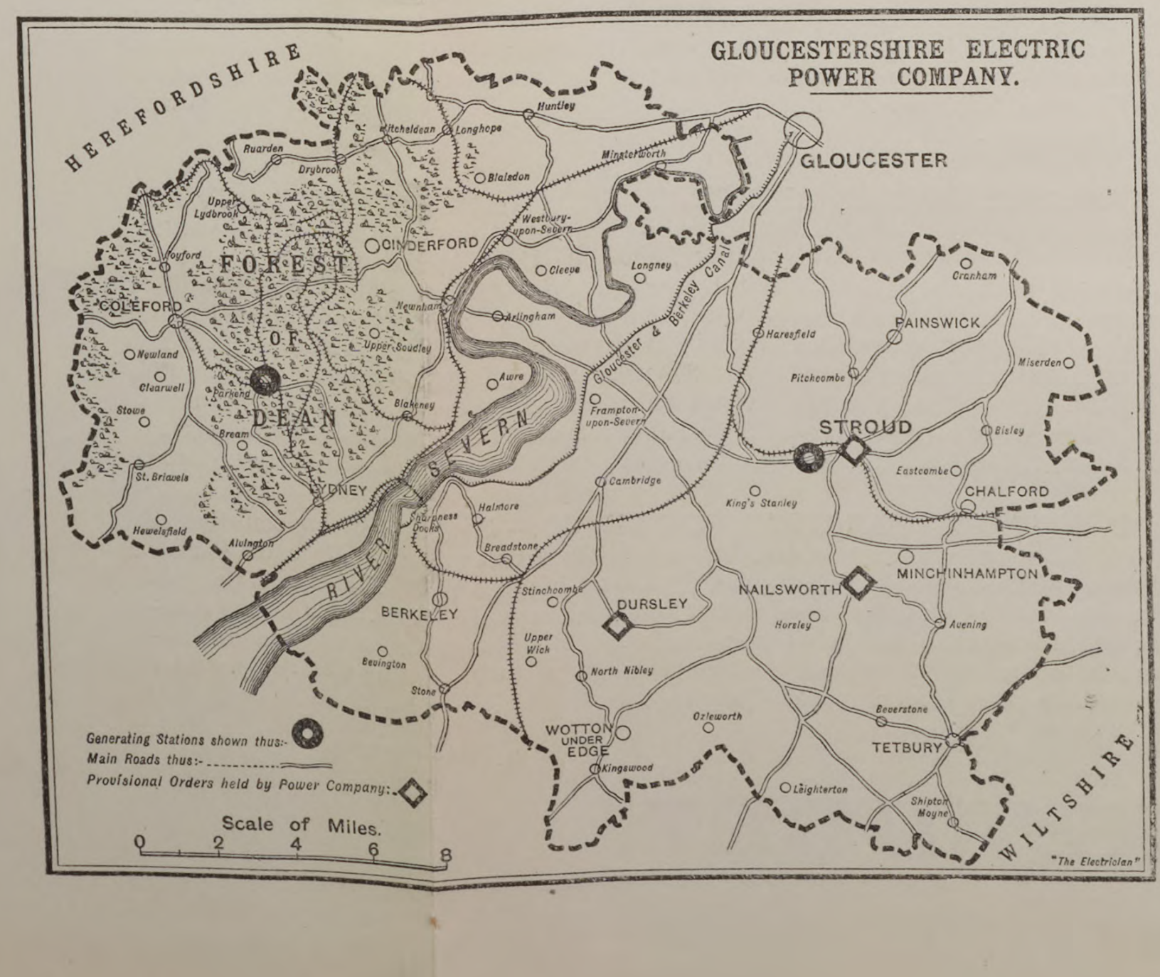
### LOTHIANS ELECTRIC POWER CO.


LOTHIANS ELECTRIC POWER CO.

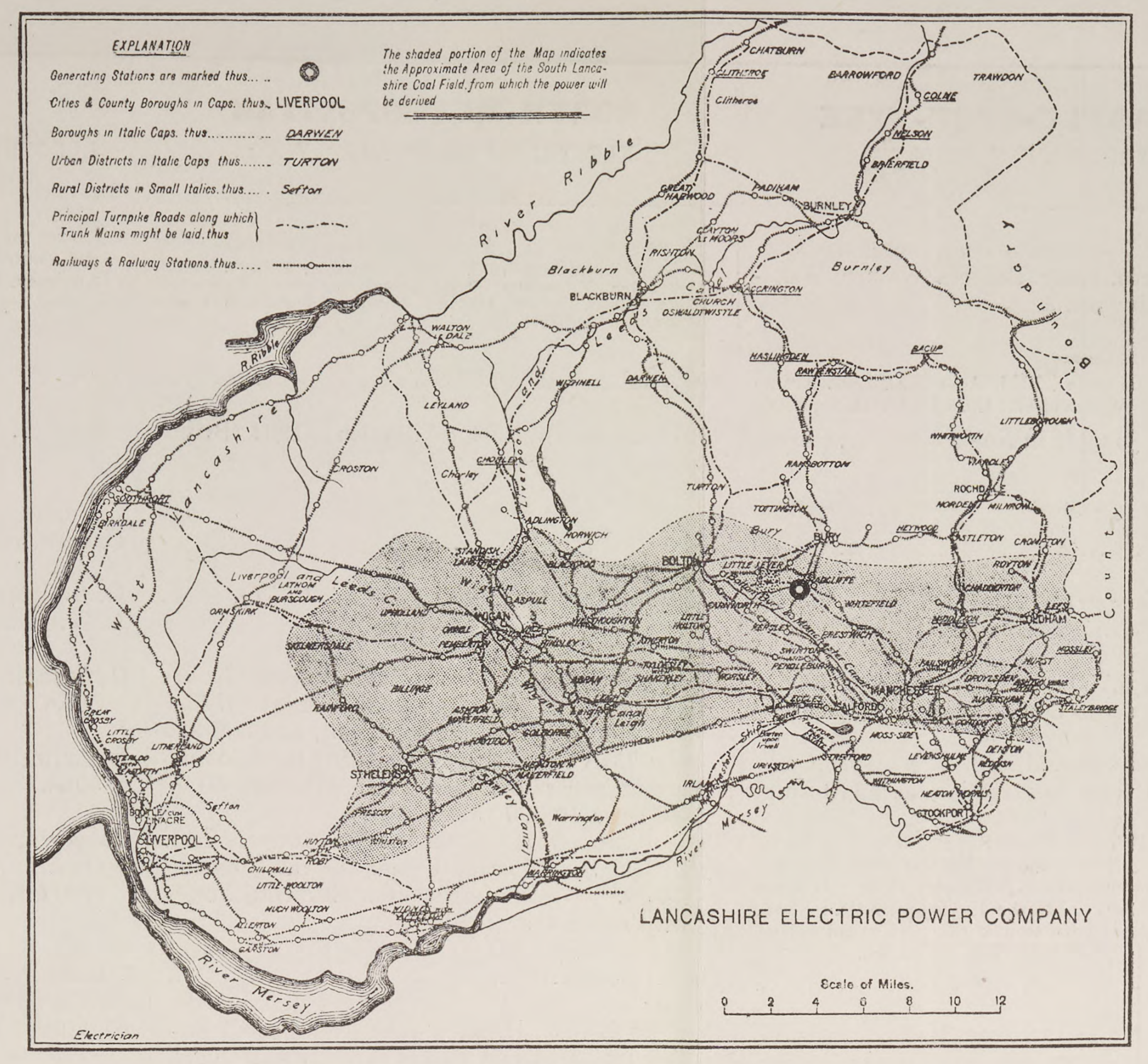
### CORNWALL ELECTRIC POWER CO.


CORNWALL ELECTRIC POWER COMPANY

### GLOUCESTERSHIRE ELECTRIC POWER CO.


GLOUCESTERSHIRE ELECTRIC POWER COMPANY.

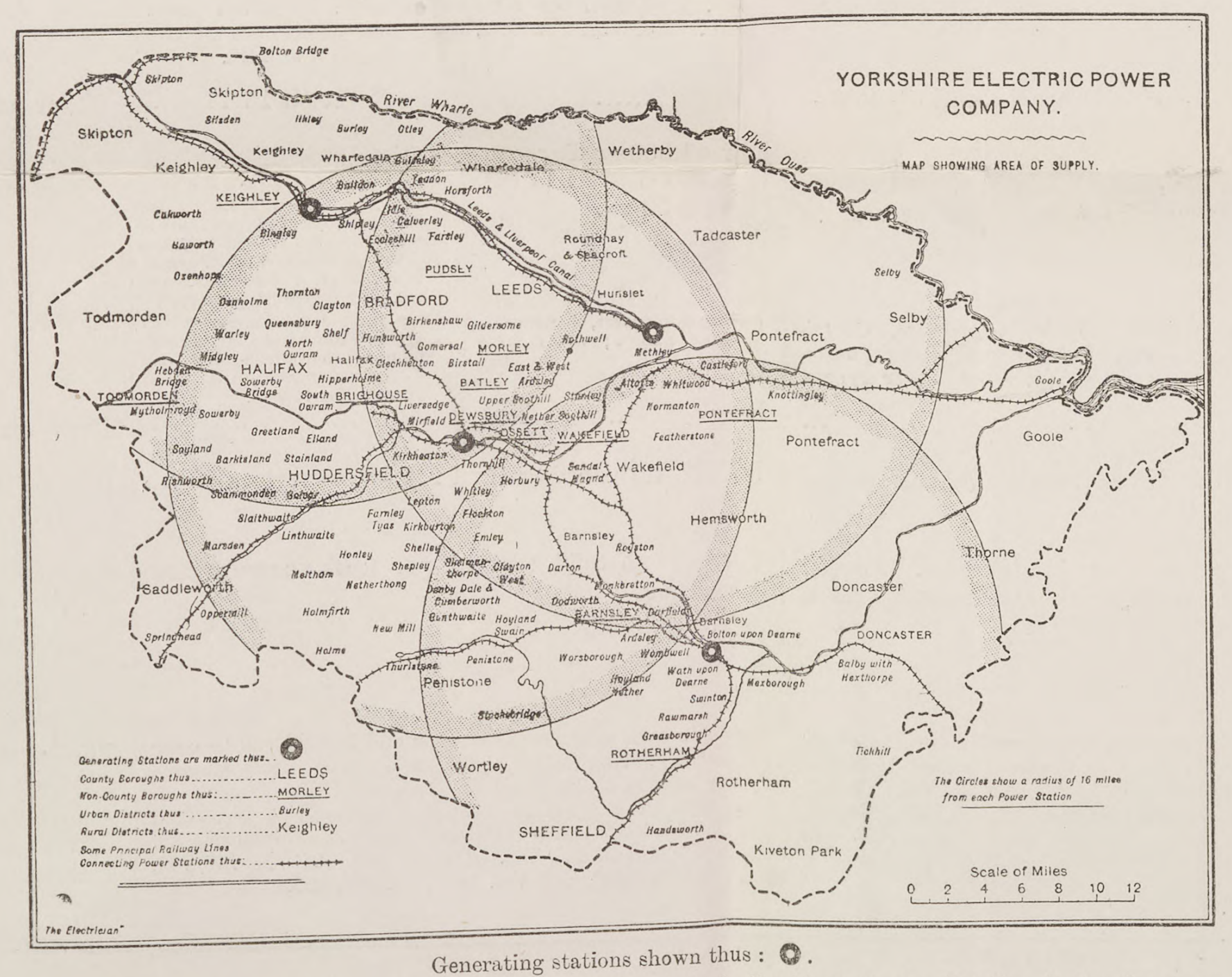
### LANCASHIRE ELECTRIC POWER CO.


LANCASHIRE ELECTRIC POWER COMPANY

Generating stations shown thus : ◉

Local Authorities have generating stations in operation at the following places :—*Bootle*, *Liverpool*, *Warrington*, *Southport*, *Wigan*, *St. Helens*, *Blackburn*, *Accrington*, *Burnley*, *Darwen*, *Bolton*, *Radcliffe*, *Atherton*, *Leigh*, *Farnworth*, *Eccles*, *Salford*, *Manchester*, *Stretford*, *Stockport*, *Oldham*, *Heywood*, *Rochdale*, *Nelson*, *Middleton*, *Colne*, *Ashton-under-Lyne*; Companies at *Great Crosby*, *Waterloo-with-Seaforth*, *Birkdale*, *Prescot*. Provisional Orders have also been granted to Local Authorities in the following towns :—*Litherland*, *Ormskirk*, *Walton-le-Dale*, *Leyland*, *Chorley*, *Ashton-in-Makerfield*, *Aspull*, *Abram*, *Hindley*, *Westhoughton*, *Golborne*, *Newton-in-Makerfield*, *Orrell*, *Little Lever*, *Worsley*, *Whitefield*, *Royton*, *Crompton*, *Rishton*, *Haslingden*, *Rawtenstall*, *Swinton* and *Pendlebury*, *Bacup*, *Tyldesley*, *Whitworth* and *Littleborough*, and to a Company in *Widnes*.

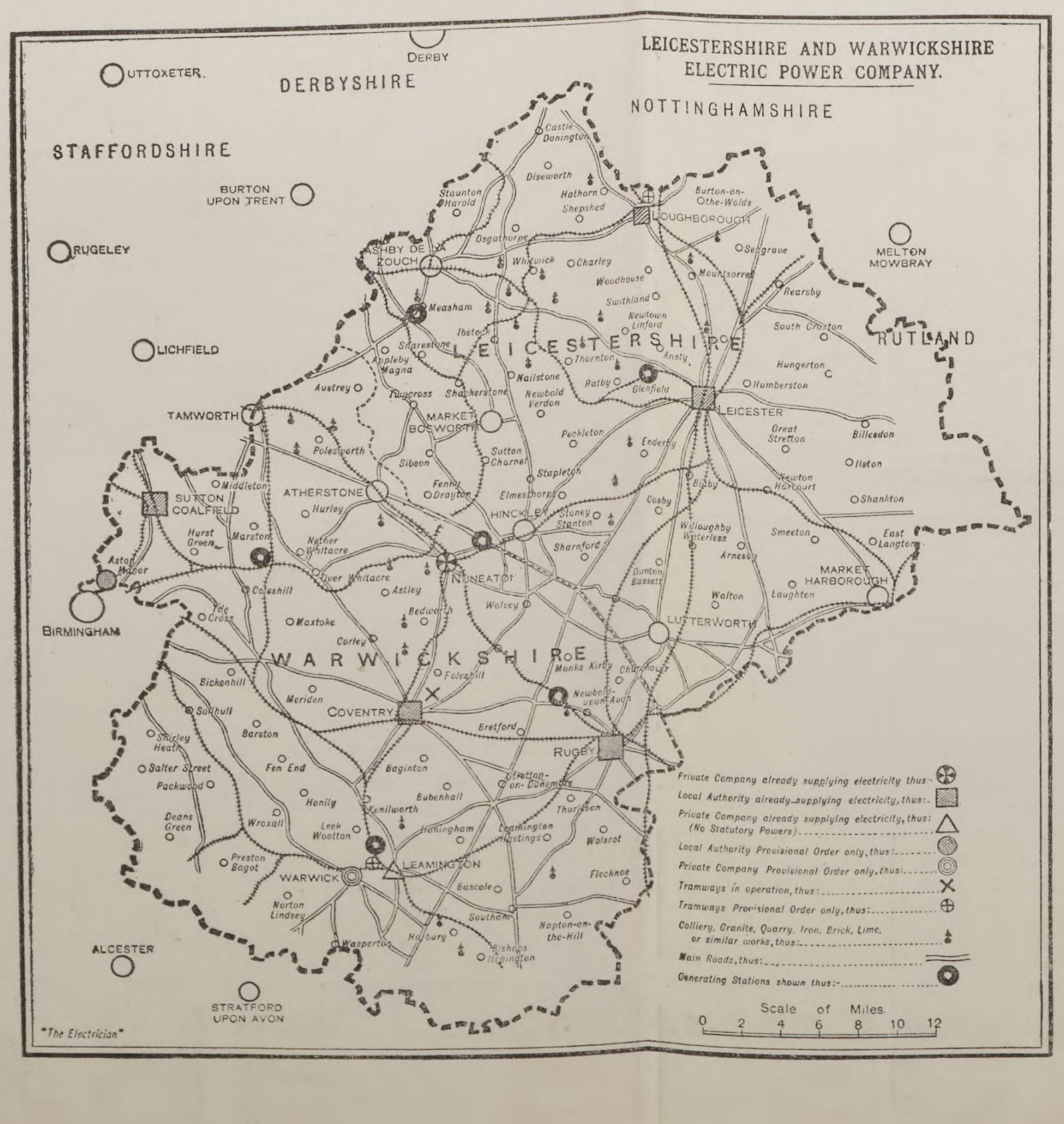
### YORKSHIRE ELECTRIC POWER CO.


YORKSHIRE ELECTRIC POWER COMPANY.

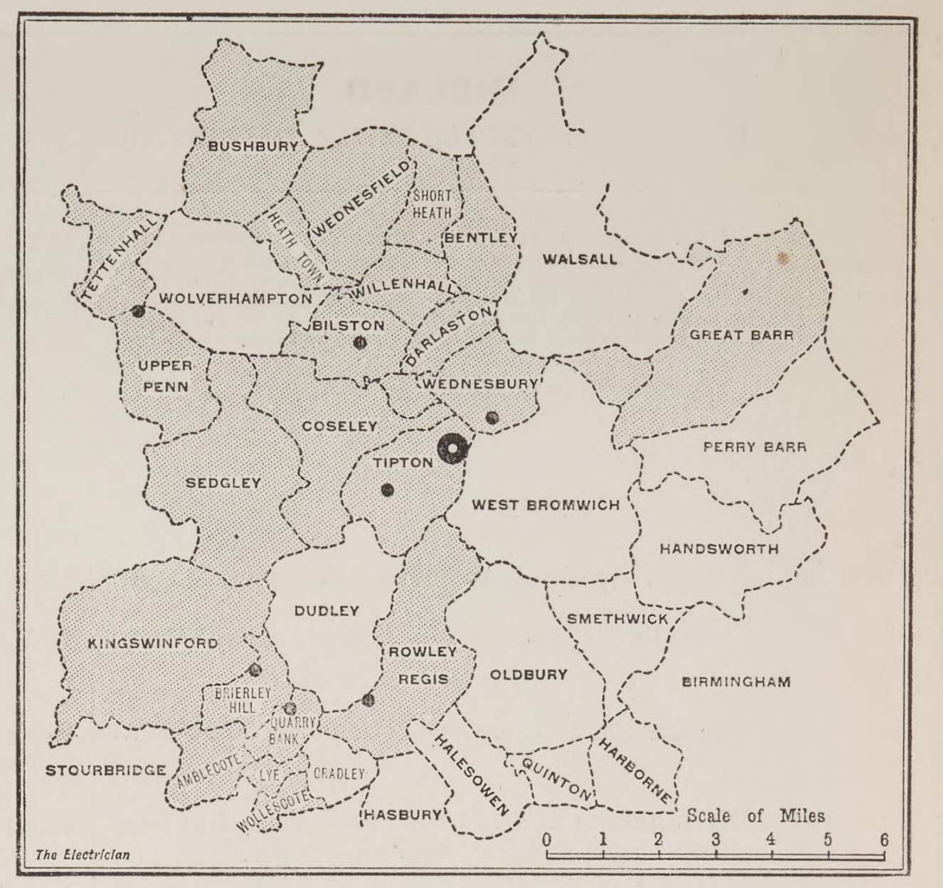
Generating stations shown thus : ◉.

Local Authorities have generating stations in operation at *Leeds*, *Bradford*, *Morley*, *Keighley*, *Batley*, *Dewsbury* *Wakefield*, *Brighouse*, *Halifax*, *Huddersfield*, *Doncaster*, *Rotherham*, *Barnsley*, *Todmorden*, *Hebden Bridge*, *Elland* *Cleckheaton*, *Honley*; Companies at *Roundhay* and *Tadcaster*. Provisional Orders have also been granted to Local Authorities in the following places : *Sowerby Bridge*, *Mytholmroyd*, *Linthwaite*, *Hipperholme*, *Horsforth*, *Gomersal* *Wath-upon-Dearne*, *Ilkley*, *Horbury*, *Whitwood*, *Ravensthorpe*, *Ardsley East and West*, *Goole*, *Liversedge*, and to Companies in *Hemsworth*, *Rawmarsh*, *Mexborough*, *Swinton*, *Pontefract*, *Knottingley* *Castleford* and *Saddleworth*.

### LEICESTERSHIRE AND WARWICKSHIRE ELECTRIC POWER CO.


LEICESTERSHIRE AND WARWICKSHIRE ELECTRIC POWER COMPANY.

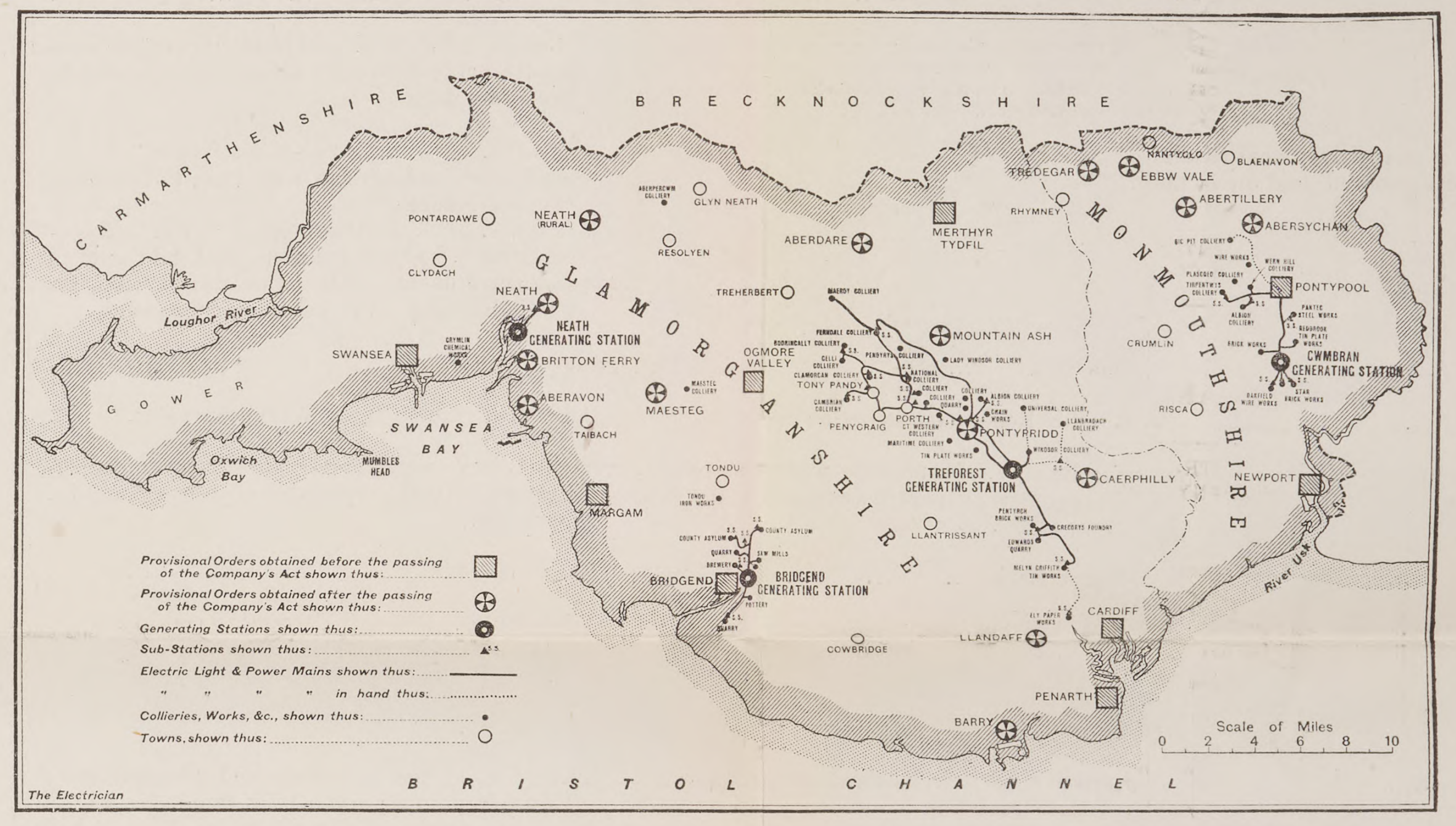
### MIDLAND ELECTRIC CORPORATION FOR POWER DISTRIBUTION.



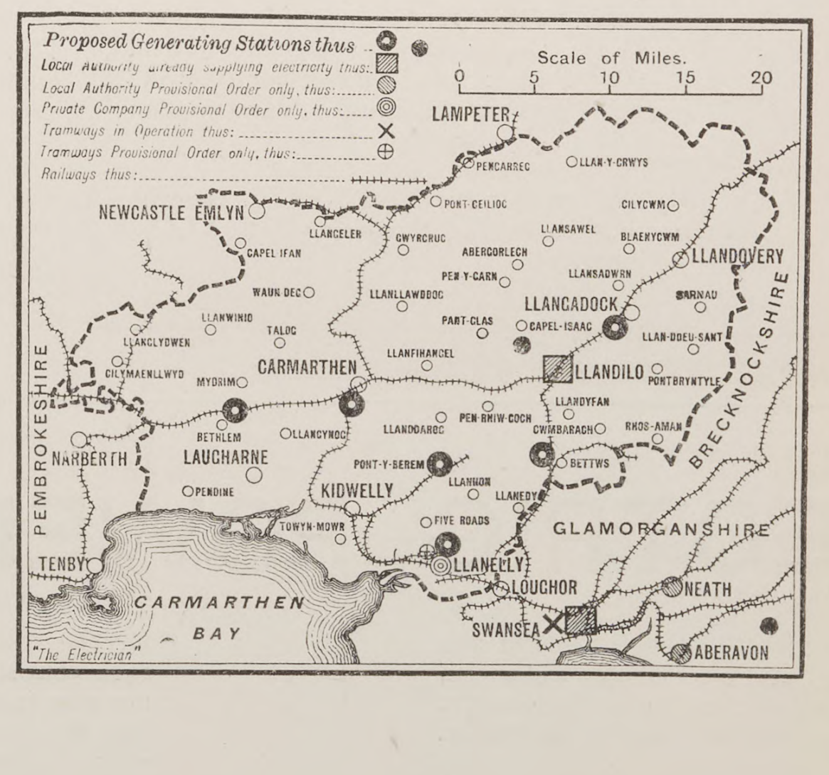
Generating station shown thus : ☾.

Sub-stations at *Tipton*, *Wednesbury*, *Bilston*, *Wolverhampton*, *Darlaston*, *Old Hill (Rowley Regis)*, *Quarry Bank*, *Willenhall* and *Brierley Hill* shown thus : ●

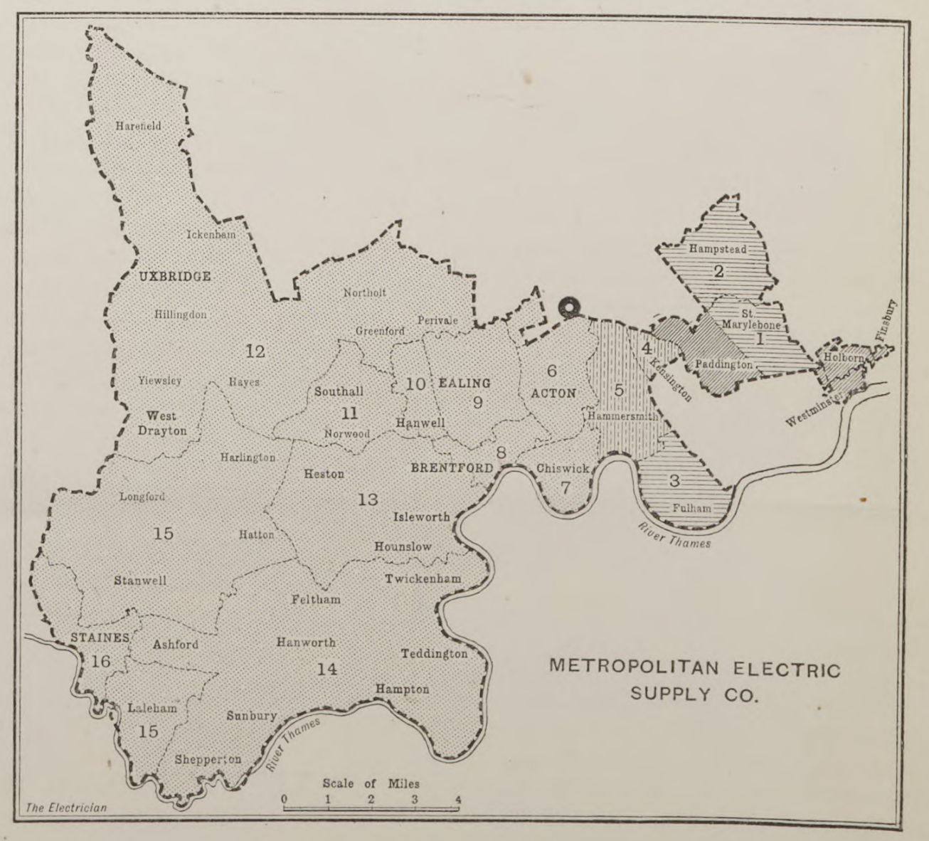
### SOUTH WALES ELECTRICAL POWER DISTRIBUTION CO. (SOUTHERN AREA).



### CARMARTHENSHIRE AREA OF THE SOUTH WALES ELECTRICAL POWER DISTRIBUTION CO.



### METROPOLITAN ELECTRIC SUPPLY CO.


METROPOLITAN ELECTRIC SUPPLY CO.

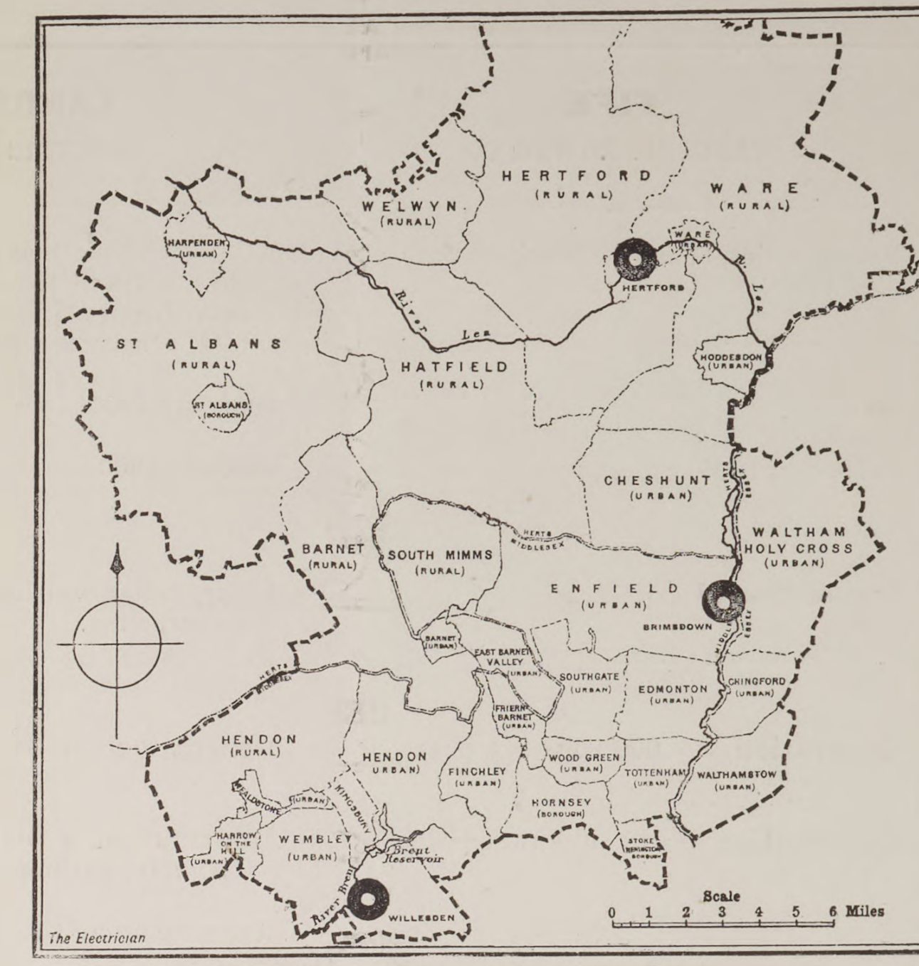
Generating Station shown thus : ◉

Companies' Provisional Order areas are : *City of Westminster* (part), and *Boroughs of Holborn*, *Finsbury* (part) and *Paddington*, shown thus : ▨

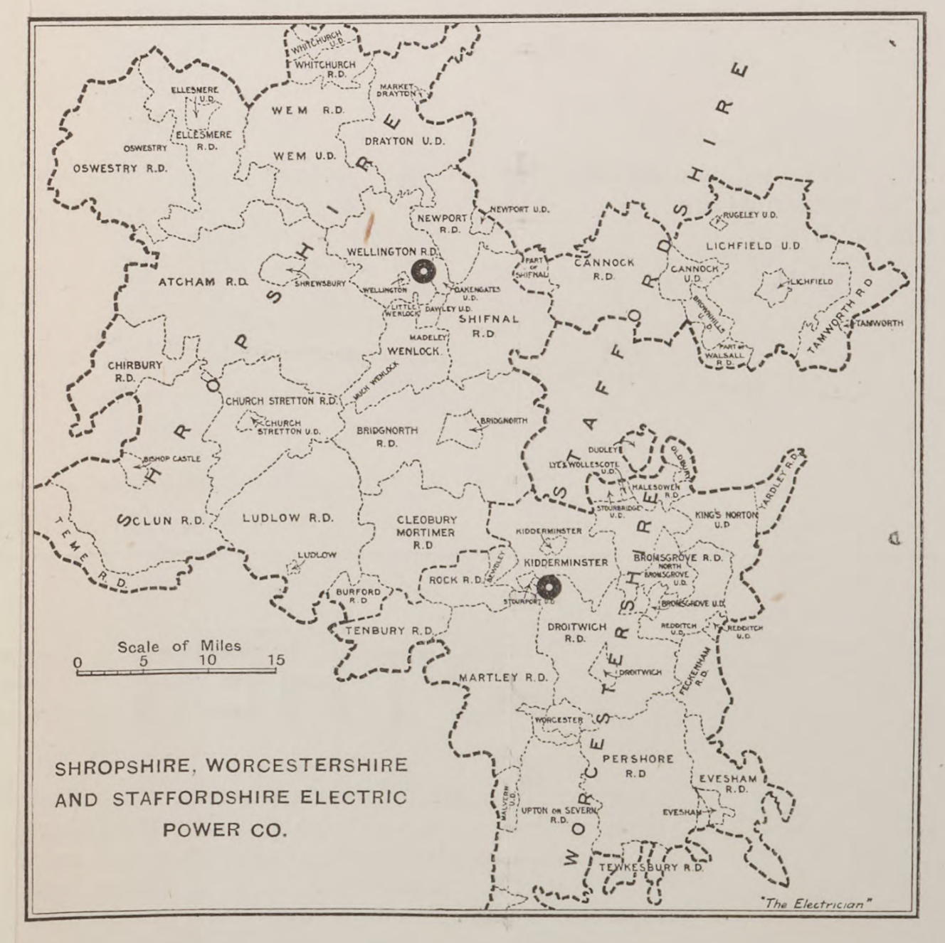
Trunk mains only may be laid in *Boroughs of Kensington* (part) and *Hammersmith*, shown thus : ▦

Local Authorities have electricity works in operation at *St. Marylebone*, *Hampstead*, *Fulham*, *Ealing*, *Heston* and *Isleworth*; Companies at *Chiswick*, *Uxbridge*, *Twickenham* and *Teddington*. Power Company supplies in bulk to the *Acton* Urban District Council. Provisional Orders have been granted to the Local Authorities in *Hanwell*, *Southall-Norwood*, and to a Company in *Brentford*.

### NORTH METROPOLITAN ELECTRIC POWER SUPPLY COMPANY.



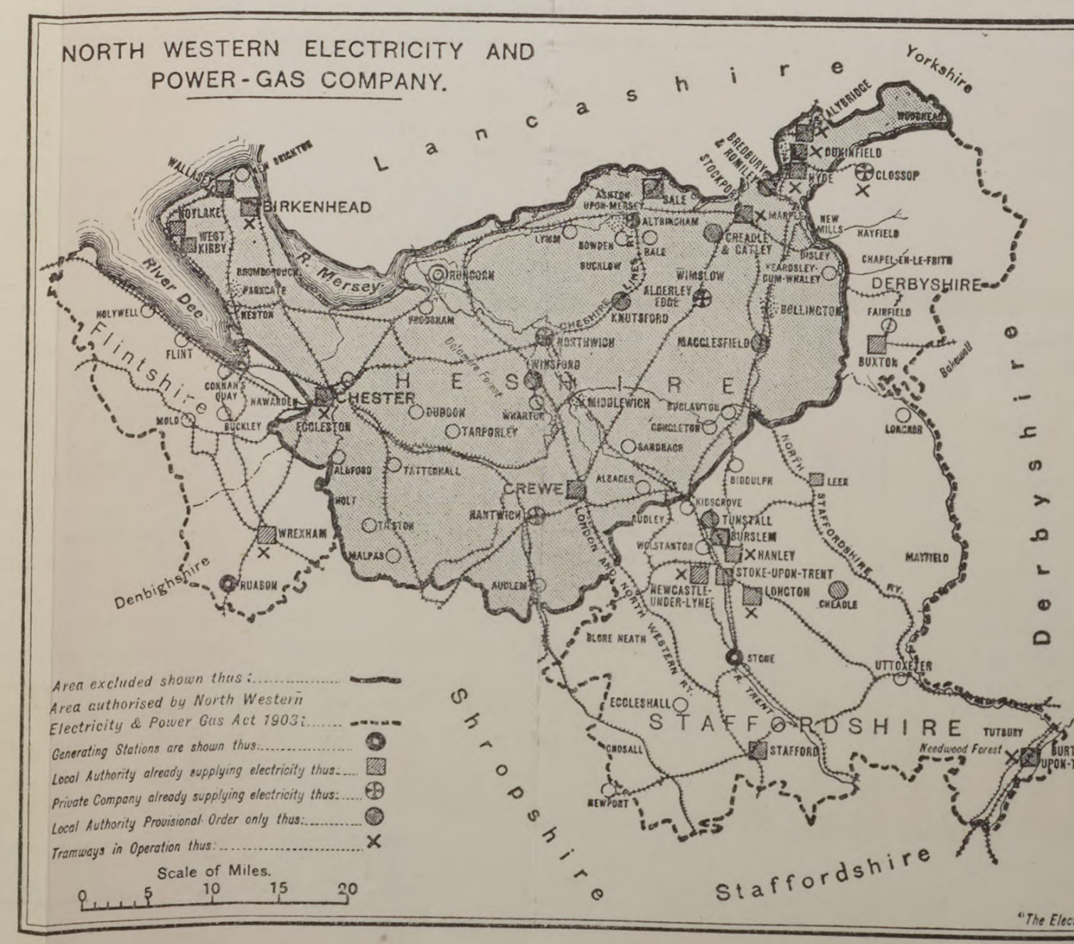
Power stations marked thus : ◉.


SHROPSHIRE, WORCESTERSHIRE AND STAFFORDSHIRE ELECTRIC POWER CO.

Proposed generating stations are shown thus : ◉.

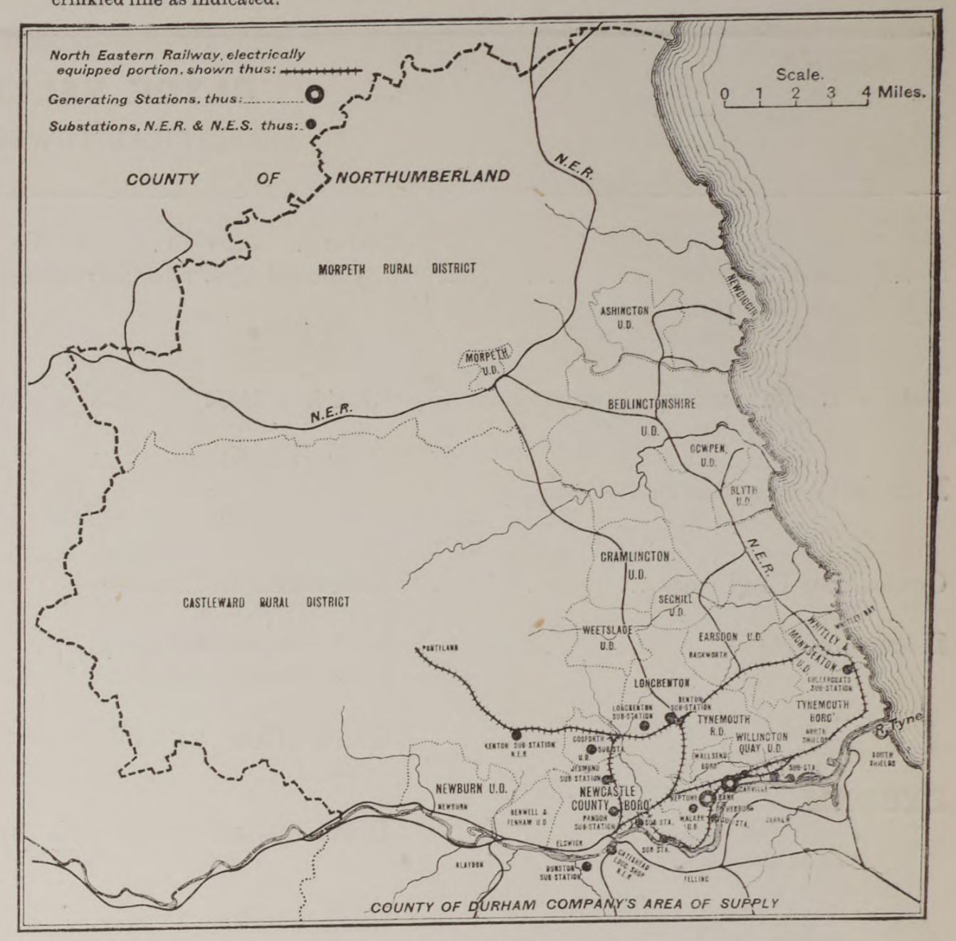
Local Authorities have electricity works in operation at *Worcester*, *Shrewsbury*, *Ludlow*, *Redditch* and *Dudley*; Companies at *Kidderminster*, *Oswestry* and *Church Stretton*. Power Company owns Provisional Order for *Bromsgrove*. Provisional Orders have also been granted to the Local Authorities in the following towns :—*Wellington*, *Stourbridge*, *Halesowen*, *Oldbury*, *King's Norton*, *Lichfield* and *Cannock*.

### NORTH-WESTERN ELECTRICITY AND POWER-GAS CO.

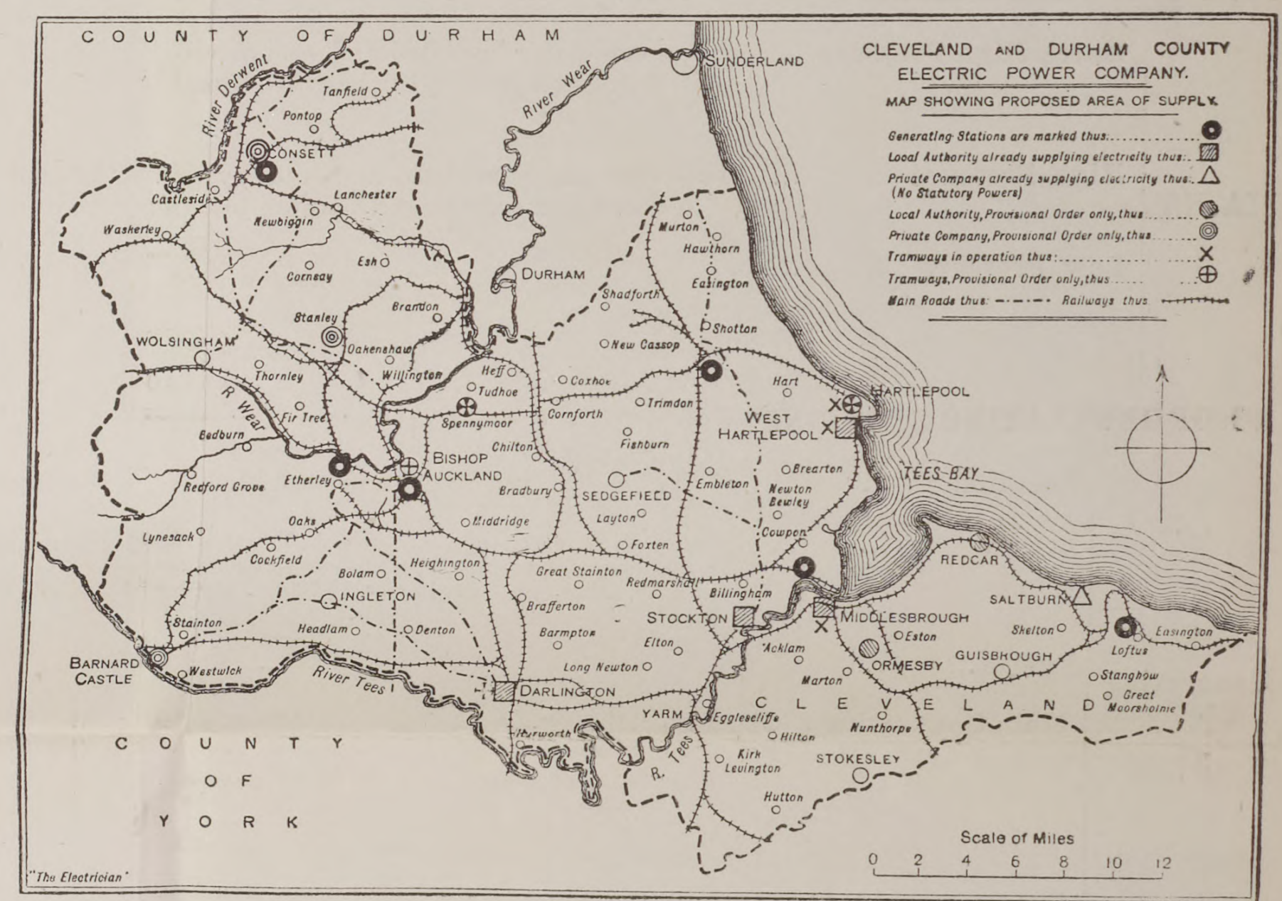

NORTH WESTERN ELECTRICITY AND POWER-GAS COMPANY.

### NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY CO.

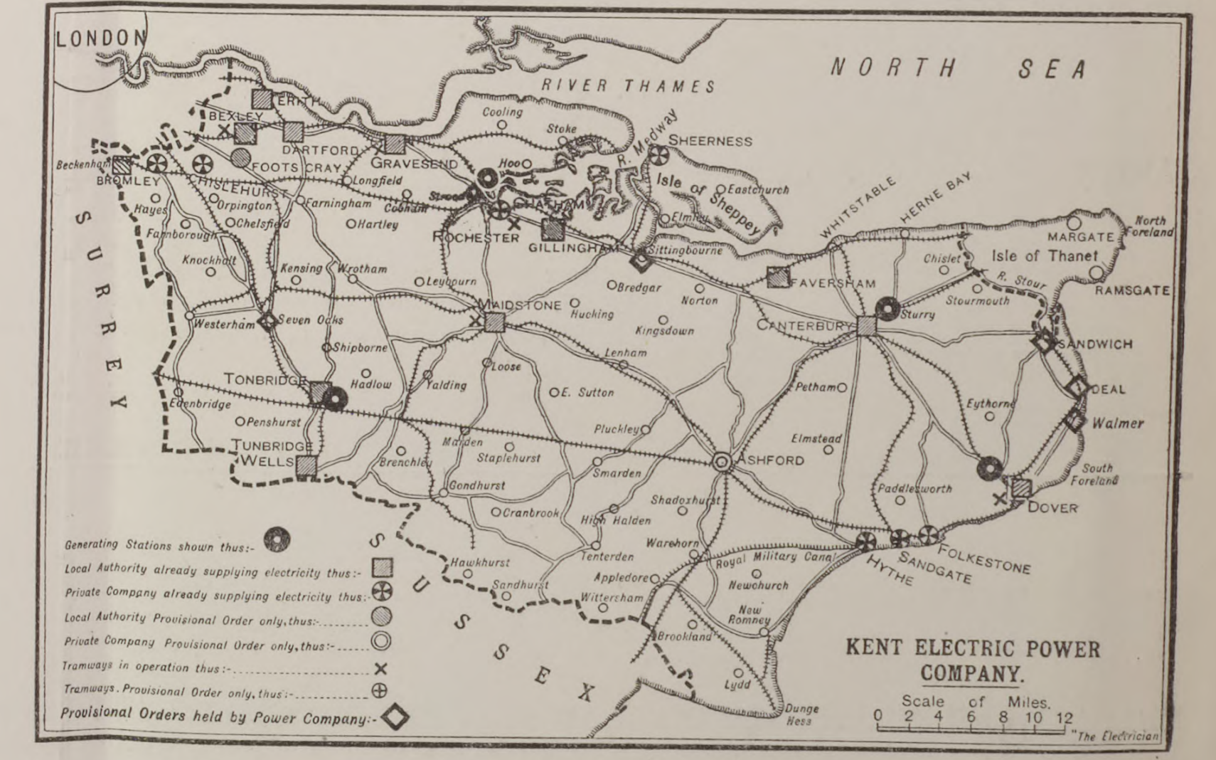
The boundaries of the area of supply of this Company's undertaking is delimitated on the South and East by the River Tyne and the North Sea, and on the North and West by the crinkled line as indicated.


COUNTY OF NORTHUMBERLAND
COUNTY OF DURHAM COMPANY'S AREA OF SUPPLY

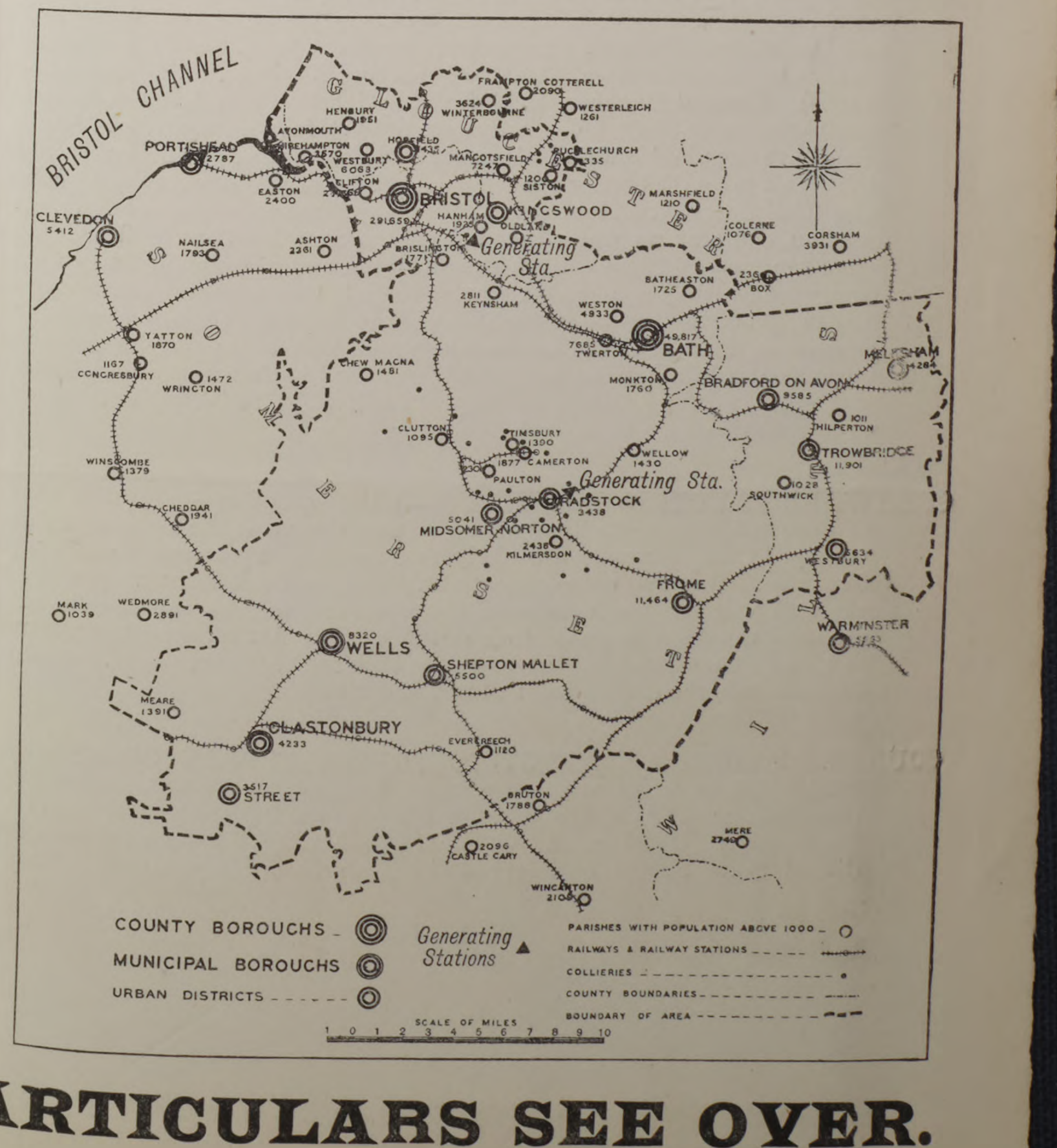
### CLEVELAND AND DURHAM COUNTY ELECTRIC POWER CO.


CLEVELAND AND DURHAM COUNTY ELECTRIC POWER COMPANY.

### KENT ELECTRIC POWER CO.


KENT ELECTRIC POWER COMPANY.

### SOMERSET ELECTRIC POWER CO.



**FOR OTHER PARTICULARS SEE OVER.**

SUPPLEMENT TO "THE ELECTRICIAN." JANUARY 26, 1906.

*Extra Copies of this Sheet can be obtained, as this, price 1s. 6d.*

# "THE ELECTRICIAN"

# TABLES OF ELECTRIC SUPPLY AND TRACTION UNDERTAKINGS OF THE UNITED KINGDOM.—JAN., 1906.

**Copyright.**

## TABLE III. ELECTRIC POWER COMPANIES.

**Copyright.**

| — | **CLYDE VALLEY**<br>ELECTRICAL POWER CO. | **FIFE**<br>ELECTRIC POWER CO. | **LANCASHIRE**<br>ELECTRIC POWER CO. | **MIDLAND**<br>ELEC. CORPORATION FOR POWER DISTRIBUTION. |
|---|---|---|---|---|
| Definition of District | 730 sq. miles in the Clyde Valley. Provisional Order for Clydebank. | 504 sq. miles, being the whole of the County of Fife | 1,100 sq. miles, being the whole of Lancashire south of the River Ribble, excepting only Liverpool, Bootle, Manchester, Salford, Stockport and part of Bolton. | 70 sq. miles in Worcestershire and Staffordshire, including light and power in Wednesbury, Darlaston, Tipton, Tettenhall, Bushbury, Bilston, Willenhall, Bentley, Heath Town, Sedgley, Coseley, Kingswinford, Amblecote, Lye and Wollescote, Rowley Regis, Quarry Bank, Brierley Hill, Upper Penn, Great Barr, Wednesfield, Short Heath, Cradley, Old Hill. |
| Date of Parliamentary Powers | 1901 and 1904 | 1903 | 1900 and 1904 | 1898, 1901 and 1902 |
| Date of Commencement of Supply | August, 1905 | February, 1905 | October, 1905 | July, 1902 |
| Consulting Engineers | Strain and Robertson | Bramwell and Harris | Lacey, Sillar and Leigh; H. F. Parshall for construction. | Kincaid, Waller, Manville and Dawson |
| Head Officials | D. A. Starr (*Manager*)<br>H. A. Barnett (*Resident Engineer*) | J. S. Thomson (*Manager*) | R. L. Gamlen (*Engineer and Manager*) | J. Hardie McLean (*General Manager and Engineer*) |
| **SYSTEM** | **Generation** at 10,000 volts three-phase 25 ∽.<br>**Distribution** at 440 volts three-phase | **Generation** at 3,000 volts two-phase 50 ∽.<br>**Distribution** at 440 volts two-phase 50 ∽. | **Generation** at 10,000 volts three-phase 50 ∽.<br>**Distribution** at 400 volts three-phase and 500 volts continuous | **Generation** at 7,000 volts two-phase 50 ∽.<br>**Distribution** at 2,700 volts two-phase, 200 volts two-phase, and 500 volts continuous. |
| **Largest Consumers** ("Authorised Distributors," supplied in bulk, marked with an asterisk) | Steel Works, Collieries and Engineering Works, Burghs of Wishaw* and Clydebank | ...... | Acme Spinning Co., Ltd., (600kw.) | Wolverhampton and District Tramways and Wednesbury Urban District Council.* Dudley, Stourbridge and District Tramways (Kinver Section). Birmingham and District Tramways (Old Hill Section). |
| **Total Connections to Mains** | 3,000kw. | ...... | ...... | 2,900kw. |
| **MAINS** — **Extra High Pressure** | Three-core paper-insulated and lead-covered, in ducts, and solid in earthenware troughs | ...... | 20 route miles Callender three-core paper-insulated, lead-covered, wire-armoured, laid in bitumen in wood troughs. 5 route miles overhead bare wires on creosoted wood poles. | 45·4 miles. B.I. & H. two-phase "twin" (three-conductor) lead-covered and juted, laid solid in stoneware ducts. |
| **MAINS** — **High Pressure** | Three-core paper-insulated and lead-covered, in ducts, and solid in earthenware troughs | Callender concentric paper-insulated lead-covered steel-tape armoured, laid direct in ground | ...... | 46·9 miles. B.I. & H. two-phase "twin" (three-conductor) lead-covered and juted, laid solid in stoneware ducts. |
| **MAINS** — **Low Pressure** | ...... | ...... | ...... | 41·1 miles. B.I. & H. two-phase "twin" (three-conductor) lead-covered and juted, laid solid in stoneware ducts. Ditto simple twin cable for public lighting. 14½ miles telephone cable. |
| **NO. OF GENERATING STATIONS** | Two | ...... | One | One |
| Generating Stations — Location | STATION I. Yoker<br>STATION II. Motherwell | Dunfermline | Ringley Road, near Radcliffe | Ocker Hill, Tipton (near Wednesbury) |
| Generating Stations — Boilers | STATION I. Four B. & W. water-tube, with Roney stokers (capacity 17,000lbs. per hour each)<br>STATION II. Four B. & W. water-tube, with Roney stokers (capacity 17,000lbs. per hour each) | Four Lancs. 30′ × 8′ 6″ | Six B. & W. chain grate with superheaters (aggregate evaporative capacity, 120,000lbs. per hour). | Eight B. & W. with chain-grate stokers and superheaters. Total evaporative capacity 96,000lbs. per hour. |
| Generating Stations — Fuel | STATION I. ...<br>STATION II. ... | ...... | Rough slack | Local slack |
| Generating Stations — Main Generating Sets | STATION I. Two 2,000kw. Westinghouse - Parsons turbo alternators.<br>STATION II. Two 2,000kw. Westinghouse - Parsons turbo alternators. | Two 500 H.P. Willans-Peebles and one 1,500 Willans-Peebles sets | Four 1,500kw. Curtis—B.T.-H. turbine sets | Two 800kw. Ferranti-Ferranti. One 1,500kw. Yates & Thom—Ferranti. |
| Generating Stations — Condensing Plant | STATION I. Surface condensers. Water from River Clyde.<br>STATION II. Barometric condenser. Cooling tower. Make up water from River Clyde. | ...... | Surface condenser, Edwards air pump, centrifugal circulating pump. | Surface condensers, electric and steam-driven; Edwards pumps; water from canal. |
| **NUMBER OF SUB-STATIONS** | Three completed, ten under construction | ...... | ...... | Eight |
| **Sub-Station Equipment** | Westinghouse transformers and H. and L.T. switch gear | ...... | ..... | Ferranti, British Electric Transformer Co. and Westinghouse transformers, Westinghouse rotaries. |
| **TARIFF** | 3d. to ¾d., according to quantity and load-factor. | 1½d. to ¾d., according to quantity with 10% reduction for continuous running, *i.e.*, above 16 hours out of 24. | 0·45d. per unit, plus the following charges per kw. per year: 1 to 100kw., £6; 101 to 200kw., £5; 201 to 300kw., £4. 10s.; 301 to 500kw., £3. 10s.; 501 to 2,000kw., £3. | *Lighting:* 4d., with ½d. discount for payment within 21 days; or on maximum demand system, 6d.(1)—3d. *Power:* 1½d., with discounts up to ¾d. per B.T.U.; or on maximum demand system, 3d.(1)—0·825d. |
| ***REMARKS*** | Motherwell generating station started Nov. 1, 1905. Description of power house appeared in *The Electrician*, Vol. LV., p. 368. | ...... | Description of power house appeared in *The Electrician*, Vol. LV., p. 1033. | Company works under Provisional Orders. Description published in *The Electrician*, Vol. XLIX., pp. 936 and 986. |

| — | **NEWCASTLE-UPON-TYNE**<br>ELECTRIC SUPPLY CO., LTD. | **NORTH METROPOLITAN**<br>ELECTRIC POWER SUPPLY CO. |
|---|---|---|
| Definition of District | 375 sq. miles in Northumberland, including Newcastle, Gosforth, Long Benton, Walker, Wallsend and Willington, &c. | 325 sq. miles in Middlesex, Hertfordshire and Essex, including Hertford, St. Albans, Hatfield, Welwyn, Barnet, Hoddesdon, Tottenham, Wood Green, Southgate, Edmonton, Ware, Enfield, Hendon, Finchley, Harrow, Chingford, Walthamstow and Willesden. |
| Date of Parliamentary Powers | Newcastle Provisional Order, 1893. Acts 1900, 1902. Transfer of Walker and Wallsend Gas Co.'s Undertaking, 1903. | 1900, 1902, 1903 and 1905 |
| Date of Commencement of Supply | January, 1900. (Supply in Newcastle only, started 1889) | 1901 (Hertford), 1904 (Willesden), 1904 (Brimsdown). |
| Consulting Engineers | Charles H. Merz | ...... |
| Head Officials | R. P. Sloan (*Manager*)<br>J. S. Watson (*Technical Manager*) | E. T. Ruthven-Murray (*Engineer-in-Chief*) |
| **SYSTEM** | **Generation** at 5,750 volts three-phase, 40 ∼. Transmission up to 30,000 volts three-phase.<br>**Distribution** at 480 and 240 volts continuous, 500 and 600 volts for traction, and 440 volts three-phase. | *Brimsdown* — 10,500 volts three-phase 50 ∽. *Hertford*—460-500 volts, direct current. *Willesden*—500-550 volts direct current, and 300-330 volts 25 ∽ three-phase alternating from double-current generators (see Table Ia), and 50 ∽ 3,000 and 10,500 volts. |
| **Largest Consumers** ("Authorised Distributors," supplied in bulk, marked with an asterisk) | County of Durham Electric Power Supply Co.; Armstrong, Whitworth & Co.; North Eastern Railway Co.; Tyneside Tramways & Tramroads Co.; Walker Urban District Council; North Eastern Marine Engineering Co.; Swan, Hunter & Wigham, Richardson & Co.; Northumberland Shipbuilding Co.; Tynemouth Corporation, &c. | The Metropolitan Electric Tramways, Ltd. (1,500kw.); Willesden Urban District Council* (850kw.); North Metropolitan Electrical Power Distribution Co.* (350kw.) |
| **Total Connections to Mains** | About 32,000kw. | About 3,000kw. |
| **MAINS** — **Extra High Pressure** | Callender and B.I. & H. three-core lead-covered and wire-armoured, drawn into earthenware pipes, and laid solid in cast-iron troughs and earthenware troughs. | 45 miles B.I. & H. three-core lead-covered and paper-insulated, laid solid in earthernware ducts. |
| **MAINS** — **High Pressure** | ...... | ...... |
| **MAINS** — **Low Pressure** | Callender single conductor V.B. cables, and B.I. & H. Co. three-core and four-core lead-covered, laid solid in earthenware troughs. | ...... |
| **NO. OF GENERATING STATIONS** | Two | Three |
| Generating Stations — Location | STATION I. Neptune Bank, Wallsend<br>STATION II. Carville | STATION I. Brimsdown<br>STATION II. Willesden |
| Generating Stations — Boilers | STATION I. Eight B. & W. (each 13,000lbs. per hour) with chain grate stokers.<br>STATION II. Ten B. & W. (Marine), each 20,000lbs. per hour. Chain grate stokers. | STATION I. Six B.&W. Evaporative capacity, 15,000lbs. per hour each. Mechanical stokers.<br>STATION II. Six B. & W. Evaporative capacity, 12,500lbs. each. Four hand fired, two mechanical stokers. |
| Generating Stations — Fuel | STATION I. Rough small coal at 5/- to 6/-<br>STATION II. Rough small 5/- to 6/- | STATION I. ......<br>STATION II. Small Welsh 15/11 |
| Generating Stations — Main Generating Sets | STATION I. One Brown-Boveri turbo-alternator, 1,500kw.; three Wigham Richardson—B.T.-H., 750kw. each; one Wallsend Slipway-B.T.-H., 750kw. (all condensing).<br>STATION II. Two 2,000kw. and two 3,500kw. Parsons turbo-alternators. | STATION I. Three 1,000kw. Parsons-Brown-Boveri 11,000 volts 50 ∽.<br>STATION II. 2 300kw., 1 600kw. Ferranti-Westinghouse and 1 750kw. Brush, double-current sets; 300 v. 25∽ 500 v. d.c. Step-up transf'rs, 300: 2,700 v. 2 Brush 1,200kw. turbo-alt'ntrs., 3,000 v. 50∽. 1 300kw. Westngh'se revers. mot. gen'r., 50∽ 3,000 v. 3-phase 500-550 v. d.c. Step-up transf 3,000: 10,500v |
| Generating Stations — Condensing Plant | STATION I. Surface condensers. One cooling pond and 2 cooling towers.<br>STATION II. Surface condensers. Centrifugal circulating pumps. Water from River Tyne. | STATION I. Surface condensers, electrically-driven pumps; water from River Lea.<br>STATION II. Four surface condensers, elec.-driven air and circulating pumps, one steam and one Körting spray cooling plant, also cooling towers. |
| **NUMBER OF SUB-STATIONS** | Thirty | Four |
| **Sub-Station Equipment** | Brown-Boveri, B.T.-H., &c., motor generators and rotary converters | B.T.-H. transformers and rotary converters |
| **TARIFF** | *Lighting:* 3¾d. per unit less 5% discount. *Power:* 1½d. to ¾d. per unit, with discounts for large quantities. | Varies from 3·5d. to 0·4d. per unit according to load factor. |
| ***REMARKS*** | Current is also obtained from the generating station of the Priestman Power Co. Estimated maximum load, 15,000kw. Description published in *The Electrician*, Vol. XLVII., pp. 319, 359, 397, Vol. XLIX., pp. 701, 736, Vol. L., pp. 357, 382, Vol. LI., p. 237, and Vol. LIII., pp. 424, 470, 513. | Supply in bulk to Stoke Newington and Enfield will be commenced during the year. For particulars of third generating station at Hertford, *see* Table I. of *The Electrician*, Tables of Electricity Supply Undertakings, published Jan. 12, 1906. Descriptions of stations, sub-stations &c. in *The Electrician*, Vol. LIII., pp. 591, 665, 702, 742, 784, 900, 940, 1021, and Vol. LIV., pp. 257, 266. |

| — | **NORTH WALES**<br>ELECTRIC POWER & TRACTION CO. | **SCOTTISH CENTRAL**<br>ELECTRIC POWER CO. | **SOUTH WALES**<br>ELECTRICAL POWER DISTRIBUTION CO. | **YORKSHIRE**<br>ELECTRIC POWER CO. |
|---|---|---|---|---|
| Definition of District | 2,100 sq. miles in North Wales including the whole of the Counties of Carnarvonshire, Merionethshire and Anglesey, a small portion of the County of Flint and a considerable portion of the County of Denbighshire. | 400 sq. miles, being the whole of the Counties of Linlithgow and Clackmannan, and portions of the Counties of Dumbarton and Stirling. | 1,034 sq. miles in Monmouthshire and Glamorgan, including Bridgend, Pontypridd, Neath, Aberavon, Abertillery, &c., and the whole of the County of Carmarthenshire. | 1,800 sq. miles in Yorkshire. |
| Date of Parliamentary Powers | 1904 | 1903 | 1900 and 1903 | 1901. |
| Date of Commencement of Supply | 1906 | October, 1905 | April, 1903 | February, 1905. |
| Consulting Engineers | Harper Bros. and Sir Douglas Fox and Partners | Bramwell and Harris | W. A. Chamen (*Engineer and Manager*) | H. F. Parshall. |
| Head Officials | G. C. Aitchison (*General Manager*)<br>A. W. Beuttell (*Chief Engineer*) | E. C. Churchward (*Gen. Man.*); James Walker, C.A. (*Sec.*); W. D. Morgan (*Chief Engineer*). | C. A. Holbrow (*Asst. Manager*) | W. B. Woodhouse (*Manager and Engineer*). |
| **SYSTEM** | **Generation** at 10,000 volts three-phase 50 ∽.<br>**Distribution** at 10,000 volts three-phase 50 ∽. | **Generation** at 3,000 volts two-phase 50 ∼<br>**Distribution** at 440 volts two and three-phase 50 ∼. | **Generation** at 11,000 and 2,200 volts two and three-phase, 60, 50 and 25 ∼.<br>**Distribution** at 2,200 and 440 volts two and three-phase. | **Generation** at 10,000 volts three-phase 50 ∽.<br>**Distribution** at 500 volts continuous and 400 volts three-phase. |
| **Largest Consumers** ("Authorised Distributors," supplied in bulk, marked with an asterisk) | Oakeley Quarries (2,000 H.P.), Dinorwic Quarries (700 H.P.), Pen-yr-orsedd Quarries (720 H.P.). | ...... | D. Davis & Sons (1,500kw.), United National Collieries (800kw.), Albion Collieries (400kw.), Oakfield Steel Wire Works (350kw.), Cambrian Collieries (350kw.), Glamorgan County Council Asylums (200kw.), Bridgend Urban District Council* (200kw.) | Pudsey Corporation* (100kw.), Mirfield Urban District Council* (100kw.), Mirfield Coal Co. (150kw.), Thos. Burnley & Sons (200kw.), Liversedge U.D.C.* (100kw.), Lowmoor Co. (100kw.) |
| **Total Connections to Mains** | 6,000kw. | 800kw. | 7,000kw. | ...... |
| **MAINS** — **Extra High Pressure** | 20 miles. Bare copper wires overhead. | None | 90 miles Callender three-core paper-insulated lead-covered wire-armoured, laid solid in earthenware troughs. | 34 miles Callender three-core paper-insulated lead-covered wire armoured, laid solid in wood troughs. |
| **MAINS** — **High Pressure** | ...... | Callender concentric paper-insulated lead-covered steel-tape armoured, direct in ground. | Callender concentric paper-insulated lead-covered steel-tape armoured, laid direct in ground. | Callender three-core paper-insulated lead-covered steel-tape armoured, laid direct in ground; or lead-covered only, laid solid in wood troughs. |
| **MAINS** — **Low Pressure** | ...... | Callender concentric fibre-insulated lead-covered steel-tape armoured, direct in ground. | Callender concentric fibre-insulated lead-sheathed steel-tape armoured, laid direct in ground. | Callender single and multi-core paper insulated, lead or bitumen sheathed, laid solid in wood troughs. |
| **NO. OF GENERATING STATIONS** | One | One | Four | One. |
| Generating Stations — Location | Cwm Dyli (near Beddgelert) | Bonnybridge (near Larbert) | STATION I. Treforest (near Pontypridd).<br>STATION II. Cwmbran | Thornhill. |
| Generating Stations — Boilers | ...... | Six Lancs., 30′ × 8′ 6″ | STATION I. Fourteen Niclausse (evaporative capacity 14,000lbs. per hour each).<br>STATION II. Twelve 30′ × 8′ Galloway. | Six B. & W., with chain grates and superheaters. Total evaporative capacity 120,000lbs. per hour at 150lbs. per sq. in. |
| Generating Stations — Fuel | Water power | Scotch coal (small) | STATION I. Small Welsh at 6/0 to 7/0<br>STATION II. Small Welsh at 6/0 to 7/0 | Small coal 4/6 to 6/0. |
| Generating Stations — Main Generating Sets | Four Ganz (Pelton)-Peebles sets. 1,500kw. three-phase 10,000 volts 50 ∽. | Two 400kw. Willans-Peebles sets; two 1,000kw. Willans-Peebles turbo-sets, two-phase 50 ∼. | STATION I. Three 2,000kw. Willans-Ganz three-phase (11,000 volts, 25 ∽), another being installed. One 300kw. Willans-Westinghouse (2,200 volts).<br>STATION II. Three 300kw. Willans-Westinghouse (2,200 volts, 25 ∽), and step-up transformers. | Four 1,500kw. Curtis turbines and B.T.-H. generators, and three 150kw. Allen—B.T.-H. sets for excitation and auxiliary purposes. |
| Generating Stations — Condensing Plant | ...... | Surface condensers, circulating water taken from the Bonny River. | STATION I. Surface condensers; electrically-driven pumps; water from River Taff.<br>STATION II. Non-condensing at present, condensers being installed. | Surface condensers, motor driven. Edwards air-pumps. Water from river. |
| **NUMBER OF SUB-STATIONS** | Three quarry sub-stations | Six | Thirty-two | Eight. |
| **Sub-Station Equipment** | Peebles three-phase transformers | Westinghouse transformers and Cowans switch gear. | Westinghouse and Berry stationary transformers. | B.T.-H. transformers and motor-generators. |
| **TARIFF** | ...... | 1¾d. to ¾d. per unit according to quantity, with 10% reduction for continuous running, *i.e.*, above 16 hours out of the 24 hours. | 1⅜d. to $\frac{9}{16}$d., according to quantity and load-factor for power or bulk supply. | £4 per annum per kw. of demand, plus 0·83d. per unit (small consumers) to 0·4d. per unit (large consumers). |
| ***REMARKS*** | The generators are driven by Pelton wheels which are supplied by a double pipe line, with pipes 27 in. diameter, leading the water from Lake Llydaw on Snowdon. Head of water at turbines 1,150 ft. | Alva and Westfield stations not yet constructed. Description of power house appeared in *The Electrician*, Vol. LIV., p. 263. | Generating Station III. at Bridgend, in operation, contains three 30′ × 8′ Lancs. Galloway boilers (evap. cap. 8,500lb. per hour each) and two 200kw. Willans-Westinghouse 2-phase 3,000 volt 60 ∽ generating sets. Station IV., at Neath, contains four similar boilers, and two 200kw. Willans-Westinghouse generating sets, at 2,200 volts and 50 ∽. Load factor at Bridgend, 31·9%. Total works costs at Bridgend, 0·71d. Description of system appeared in *The Electrician* of Dec. 2 & 9, 1904, and Vol. LIV., pp. 247 & 300. | Description of power house appeared in *The Electrician*, Vol. LV., pp. 773, 812, 848. |

## OTHER ELECTRIC POWER COMPANIES.

**BELFAST AND NORTH-EAST IRELAND ELECTRICITY AND POWER GAS CO.**—Company's area includes portions of the counties of Londonderry, Antrim, Down and Armagh, but excludes the City of Belfast. Act granted in 1904; no works yet commenced, but a start is shortly to be made.

**CLEVELAND AND DURHAM COUNTY ELECTRIC POWER CO.**—820 sq. miles in Cleveland (Yorks.) and the County of Durham, including Bishop Auckland, Consett, Crook, and, under certain conditions, Stockton, Middlesbrough, West Hartlepool, Thornaby and Darlington. Date of Parliamentary powers, 1901. Supply commenced under temporary conditions in March, 1904. Consulting Engineer, H. Graham Harris (Bramwell & Harris). General Manager, E. E. Soden. Generation at 2,200 volts two-phase 50 ∽ and 2,200 volts three-phase 25 ∼. System not yet fully at work, but 16 miles of 11,000-volt cable have been laid (Callender's paper lead-sheathed and armoured laid solid), 25 miles of 2,200-volt cable (Callender's paper lead-sheathed, laid direct), and 4 miles 500-volt three-wire (Callender's V.B., laid solid). Main generating station at Grangetown, in course of erection, contains six water-tube boilers and four 1,000kw. Willans-Westinghouse turbo-generating sets. There will be 10 sub-stations equipped with Berry transformers. Temporary generating stations at Auckland and Consett, each containing three Lancashire boilers (8,500 lb. per hour each) and two 300kw. Willans-Westinghouse three-phase generators. Mains: Callender three-core and concentric paper-insulated lead-covered steel-tape armoured, laid direct in ground. Public lighting in Auckland and Consett; supply also given to the Adelaide Colliery. Tariff: 1¼d. to ¾d. per unit, according to quantity of current taken for power or bulk supply

**CORNWALL ELECTRIC POWER CO.**—1,100 sq. miles—being the whole of the county of Cornwall except the Scilly Islands and the rural districts of Stratton and Houldsworthy. Chief demands are likely to arise from Penzance, Falmouth and Truro; and from the mining and china clay works. Date of Parliamentary powers, 1902. 3d. to 1d. per unit will be the maximum charges according to the length of demand. It is proposed to erect two generating stations. The Act gives authorisation to supply energy to private consumers for all purposes, and not for power only. Nothing has yet been done towards the development of this undertaking.

**COUNTY OF DURHAM ELECTRIC POWER SUPPLY CO.**—Special Act granted in 1900. 250 sq. miles in the county of Durham, including Gateshead, Jarrow, Durham, Chester-le-Street, Whickham, South Shields [Rural], Sunderland [Rural], &c. Consulting Engineers, C. H. Merz and W. McLellan. A. S. Esslemont (Manager), N. H. Firmin (Secretary). Supply commenced in Gateshead, July, 1902. The Company owns a generating station at Gateshead from which a supply is given to the Gateshead and District Tramways, and also the County of Durham Electrical Power Distribution Co., which has an electric lighting provisional order for Gateshead, and also for Jarrow. This station contains eight B. & W. boilers, with chain grate stokers, and three 300kw. and two 200kw. Brush engines and dynamos; two 500kw. Belliss-Siemens & Halske sets, and one 250kw. and one 500kw. Brown-Boveri sets. An agreement has been entered into between the Newcastle-on-Tyne Electric Supply Co. and the County of Durham Electrical Power Distribution Co. (which is closely identified with the Supply Co., holding practically all its shares), for the operation of the undertaking of the company. At present, all additional current to that generated at Gateshead is purchased from the Newcastle-on-Tyne Electric Supply Co.

**DERBYSHIRE AND NOTTINGHAMSHIRE ELECTRIC POWER CO.**—1,570 sq. miles in Derbyshire and Nottinghamshire, including Worksop, Retford, Matlock, Ilkeston and Newark (Provisional Order). Date of Parliamentary powers, 1901. Supply commenced from temporary (500-volt continuous-current) plant at Ilkeston, May, 1903. Consulting Engineers, Bramwell & Harris. Engineer-in-Chief, A. E. Loos. System will eventually be high-pressure polyphase with sub-stations. Present consumers: Ilkeston Corporation (lighting and traction) and the Manners Colliery Co. Mains: Callender vulcanised bitumen laid solid in earthenware troughs, and three-core fibre-insulated lead-sheathed and armoured with steel tape. The Ilkeston power house contains three "Economic" boilers (each evaporating 8,500lb. per hour); two Davey-Paxman cross-compound horizontal 500 I.H.P., coupled to E.C.C. generators; one 160 I.H.P. Peache engine coupled to Westinghouse dynamo. There are also two 80kw. E.C.C. motor generators for converting direct current to three-phase 500-600 volts 25 ∼. Tariff: 1½d. to 1d. according to quantity for power or bulk supply.

**DURHAM COLLIERIES ELECTRIC POWER CO.**—This company has, as yet, no statutory powers, but a power station is being erected at Philadelphia, Co. Durham, and the supply of electrical energy to neighbouring collieries, works, &c., is contemplated. Messrs. Harper Bros. are the Consulting Engineers, Mr. C. W. Nicholl the Engineer-in-Chief, and Mr. W. J. S. Jones, Resident Engineer. Current will be generated at 6,600 volts three-phase 50 ∼, and distributed to consumers' sub-stations at 6,600 volts and 11,000 volts. The high-pressure mains laid consist of 37 miles of Callender, Glover and St. Helens three-core paper-insulated cable, some laid solid and the remainder armoured and laid direct in the ground. Overhead mains will be erected shortly. The power station contains five B. & W. boilers of a total evaporative capacity of 105,000 lb. per hour, and three Parsons-Peebles and two Willans-Peebles turbo-generating sets, each of 1,000kw. capacity. Cole, Marchent & Morley condensing plant is installed. Small slack is used for fuel. Water for the station is pumped from a river about 2 miles away. Two direct-current sets, each consisting of a 180kw. generator, which supplies the auxiliaries, and a 60kw. exciter are also installed, driven by Willans engines. A supply will be available very shortly. The Sunderland & District Tramways Co., which is at present supplied by a gas plant, will eventually take the whole of its supply from the Company.

**GLOUCESTER ELECTRIC POWER CO.**—329 sq. miles, including Stroud, Forest of Dean, Dursley, Lydney and Coleford. Date of Parliamentary powers, 1902. Company also holds Provisional Orders for Stroud [Rural], Nailsworth and Dursley. Consulting Engineer, G. L. Addenbrooke. There will be two generating stations, one in the Forest of Dean and one near Stroud.

**KENT ELECTRIC POWER CO.**—1,485 sq. miles in Kent, being the whole of the county with the exception of the Isle of Thanet. Date of Parliamentary powers, 1902. Land for four generating stations is scheduled. The Company has taken over the present undertaking of the Chatham, Rochester and District Electric Lighting Co., but the works were burnt down recently, and a supply for Chatham is now being obtained in bulk from the Gillingham Corporation. A new station is under construction at Frindsham, near Chatham, which will contain B. & W. boilers and two Parsons 1,500kw. 11,000 volt three-phase 50 ∼ turbo-generators. There will be 15 sub-stations. Present tariff: Lighting, 4d. per unit or 7d.(1)—2d. Power: By agreement, according to circumstances. Joint Consulting Engineers, G. L. Addenbrooke and A. A. C. Swinton. H. E. M. Kensit (General Manager), C. T. Linney (Resident Engineer). Company also holds Provisional Orders for Sevenoaks, Sittingbourne, Milton, Strood and Parishes of Stone and Swanscombe in Dartford [Rural District], Sandwich, Deal, Walmer, and Bromley [Rural District].

**LEICESTERSHIRE AND WARWICKSHIRE ELECTRIC POWER CO.**—1,340 sq. miles in Leicestershire and Warwickshire, including Leicester, Loughborough, Market Bosworth, Ashby-de-la-Zouche, Lutterworth, Atherstone, Nuneaton, Sutton Coldfield, Coventry, Rugby and Leamington. Date of Parliamentary powers, 1902. Consulting Engineers, Bramwell & Harris. High-tension polyphase with sub-stations. Land for six generating stations scheduled, and one power house in course of erection at Hinckley. General Manager, E. M. Robinson.

**LOTHIANS ELECTRIC POWER CO.**—500 sq. miles in the counties of Edinburgh and Haddington, including Haddington, Dalkeith, Bonnyrigg, Lasswade, &c. Date of Parliamentary powers, 1904. Sites for three generating stations have been scheduled at Kingsknowe, West Linton and Auchengray. Consulting Engineers, Bramwell & Harris. E. C. Churchward (General Manager), W. D. Morgan (Chief Engineer). Maximum prices, 3d. per unit for first 400 hours of maximum demand, and 2d. per unit afterwards.

**METROPOLITAN ELECTRIC SUPPLY CO.**—Special Act granted in 1905 for a large area to the West of London, including St. Marylebone, Hampstead, Fulham, Acton, Chiswick, Brentford, Ealing, Hanwell, Southall-Norwood, Uxbridge, Heston and Isleworth, Twickenham, Teddington and Staines. Powers to lay mains through Kensington and Hammersmith were also granted. No detail supply is permissible under the Act, supply in bulk only to local authorities, authorised distributors, railway companies, &c., being stipulated. Under another Act of 1905 the Company already supplies in bulk to the Acton Urban District Council. J. Conacher (General Manager), E. Cunliffe Owen (Secretary), J. S. Highfield (Engineer-in-Chief). For particulars of equipment of generating stations, &c., which give supply to the Company's Provisional Order areas in Westminster, Holborn, Finsbury and Paddington, see Table I.

**NORTH-WESTERN ELECTRICITY AND POWER GAS CO.**—Portions of Staffordshire, Derbyshire, Flintshire and Denbighshire. Originally the area of the Company's operations was 2,000 sq. miles, but the whole of the county of Cheshire was struck out by the Parliamentary Committee. Supply of Mond gas for power purposes, in addition to electricity. Gas will be led to sub-stations equipped with gas engines driving dynamos. Date of Parliamentary powers, 1903. Works to be commenced within four years. Consulting Electrical Engineers, Lacey, Sillar & Leigh. Capacity of proposed power stations 7,000 H.P. each.

**SHROPSHIRE, WORCESTERSHIRE AND STAFFORDSHIRE ELECTRIC POWER CO.**—The whole of the counties of Shropshire and Worcestershire, and part of the county of Staffordshire. Date of Parliamentary powers, 1903 and 1905. Land for two generating stations scheduled at Hadley (Salop) and Upper Mitton (Worcestershire). Substantial commencement to be made with works within three years from date of original Act. Powers to lapse if supply not available within five years. Consulting Engineer, G. L. Addenbrooke. Maximum charges under Act 3d. per unit for first 200 hours of maximum demand, and 2d. per unit afterwards. The company also holds a Provisional Order for Bromsgrove. The Company are arranging with a large number of local authorities to take over their orders, and a Bill seeking additional area is being promoted this session.

**SOMERSET AND DISTRICT ELECTRIC POWER CO.**—Portions of the counties of Somerset, Wiltshire and Gloucestershire, including Bristol and Bath. Date of Parliamentary powers, 1903. Consulting Engineers, Pressland & Fippard and Kirkland & Capper. Land for two generating stations scheduled at Radstock and Hanham. No works commenced yet, but plans are in course of preparation. This was the first scheme in connection with which Parliament refused to exclude the large towns owning electricity works from the operations of an electric power Company.

"THE ELECTRICIAN"
TABLES OF ELECTRIC SUPPLY AND TRACTION UNDERTAKINGS of the UNITED KINGDOM, 1906.

***Uniform with the present Sheet.***

Table I.—**Electricity Supply Undertakings with no Tramway Load.** In one Sheet. Published with *The Electrician* for January 12th.
Tables **Ia.** and **II.**—In one Sheet. Published with *The Electrician* for January 19th.
Table Ia.—**Towns taking Electricity Supply "in Bulk."**
Table II.—**Electricity Works supplying both Lighting and Tramways.**
Tables **IV., V.** and **VI.**—In one Sheet, to be published with *The Electrician* for February 2nd.
Table IV.—**Tramways and Light Railways supplied from Combined Lighting and Traction Power Houses.**
Table V.—**Tramways and Light Railways with Power Houses for Traction only.**
Table VI.—**Electric Railways in Operation and in Progress.**

*These Sheet Tables can also be purchased printed on one side of the paper and mounted in various styles Full particulars free by post.*

Printed and Published for the Proprietors by GEO. TUCKER,
1, 2 and 3, Salisbury Court, Fleet Street, London.

## FOR MAPS OF AREAS SEE OTHER SIDE OF THIS SHEET.

PUBLISHED ANNUALLY SINCE 1889.

# KINGDOM.—JAN., 1906.

## IWAY LOAD.

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| Capacity in Ampere Hours. | METERS. | PRICE PER UNIT. If Wright system, $^{(1)}$ = first hour, $^{(2)}$ first two hours, &c. Lighting. | Power. | Price of Gas in District. | Gasworks owned by. L.A. = Local Auth. Co. = Company. | — | REMARKS. |
|---|---|---|---|---|---|---|---|
| 240 | Thomson and Bastian; Vulcan and Reason prepay't | 6d. | 6d. & 3d. | 3/8 | Co. | 1 | Steam draught. Hand stoking. Worthington feed pump; town water. Changed over entirely from alternating to 3-wire low-tension system. |
| 750 | Ferranti generally | 4d. with discounts | 3d.$^{(1)}$–1d. with discounts | 2/6½ & 2/9 | L.A. | 2 | Refuse destructor worked in conjunction with the boiler house plant. Motors, &c., on hire. Free wiring. |
| 585 | Hookham; Watson and Reason prepayment | 7d.$^{(1)}$—4d. | 2½d. | 3/0 | Co. | 3 | Berryman feed water heater. Worthington feed pumps. Hand stoking. 2s. per quarter charged for consumers' meters, &c. Free wiring by company. Motors on hire. |
| 300 | Hookham; Reason prepayment | 6d.$^{(1)}$—4d. or 5d. | 3d.$^{(1)}$–2d. | 2/8 | Co. | 4 | 144-tube Green economiser. Natural draught. Hand firing. Worthington feed pumps. No free wiring. |
| 250 | Bastian, Hookham & Rochdale prepayment | 5½d. & 4d. | 2½d. & 1¼d. | 3/3 | Co. | 5 | 72-tube Green economiser. Natural draught. B. & W. chain grates. Electric and steam feed pumps. |
| ... | Hookham, Shallenberger, Thomson and Westinghouse | 6d. | 3d. | 2/10 to 3/4 | Co. | 6 | 488-tube economiser. |
| 440 at 11 hrs. | Reason ...... | 7d.$^{(1)}$—2½d. | 1½d. | 3/9 to 2/8 | Co. | 7 | Two Empire Weir feed pumps. |
| 500 at 10 hrs. | Bastian, Ferranti, Hookham; B.T.H. and Reason prepayment | 5d. | 2½d. | 3/6 | L.A. | 8 | Meldrum forced draught. Hand stoking. Duplicat Weir feed-pumps working through Berryman exhaust steam heaters, and 96-tube Green economiser. Meldrum refuse destructor. Free wiring by company. |
| 1,000 at 5 hrs | Hookham and Reason | 4½d. | 2d. & 1½d. | 2/9 | Co. | 9 | No economisers. Superheaters. Natural draught. Hand firing. Webster feed heater. Weir direct-acting feed pumps. River water. Batteries for night load. No free wiring. Extensions in progress. |
| 420 | Hookham, B.T.H., O.K. and Reason electrolytic: Reason prepayment | 5d. | 2d., 2½d. & 3d. | 3/6 | Co. | 10 | B. & W. superheaters. Green economiser. Hand stoking. Hall feed pumps. Holden & Brooke injectors. |
| 1,560 at 10 hrs. | Shallenberger, Vulcan, Hookham, Reason, Stanley & Eclipse | 5d. | 1¾d. | 2/1 | Co. | 11 | Nat. draught. 1 Sturtevant ind. draught fan (mot. driven). Hand stoking. B. & W. superhtr. and econ. with marine boiler. Doulton water softener. 2 Blake, 2 Edwards 3-throw air, 1 Hayward-Tyler 3-throw feed pumps. |
| ... | B.T.H. and Westinghouse | 5d. | 2d. to 1½d. | 2/6 | Co. | 12 | The station is in conjunction with a Horsfall 3-cell dust destructor. 96-tube Green economiser. Natural draught, but motor fan for destructor. Hand stoking. Weir & Worthington ram pumps. Town water and artesian well. Boby heater and detartarisers. Free wiring. |
| ... | Aron, Hookham, Shallenberger, Westinghouse, Ferranti, B.T.H.; B.T.H. prepayt | 5½d. less ½d. dis. | 1⅓d. net | 2/9 net | Co. | 13 | Green econs. Nat. and Davidson ind. draught. Vicars stokers. Worthington, Hall & Weir feed pumps. River water. Street inc. lamps from separate L.T. network fed from separate transformers & H.T. feeders. |
| 400 at 10 hrs. | Hookham and Reason | 6d.$^{(1)}$—3d. | 4d.$^{(1)}$—1½d. | 3/7 less 15 p. c. large cusmrs. | Co. | 14 | No econrs. Boby heater. Sugden's superheaters. Underfeed stokers. Hall's compound feed pumps. Free wiring at 4½d. per lamp per quarter. 7d. per unit through prepayment meters. Motors hired out at 10 per cent. on cost. |
| 500 at 10 hrs. | Hookham & Reason electrolytic; Reason prepayment | 7d.$^{(1)}$ & 2d. & 1½d. | 2d. | 4/6 | Co. | 15 | No economiser. Natural draught. Hand firing Two Smith and Vaile pumps. Two feed mains. Town water. Superheaters. Exhaust steam feed water heater. Well sunk at station for feed and condensing purposes. Further extensions to plant in hand. |
| 840<br>630 | Ferranti and Hookham | 6d.$^{(1)}$–3d.$^{(2)}$–1½d.<br>5d. flat rate. | 2½d. to 1¼d. | 2/6 | L.A. | 16 | 324-tube Green economiser. Natural draught. Vicars stokers. Worthington feed pumps and injector. |
| 2,400 | Hookham, Ferranti & Bastian | 6d. to 4d. | 3d. to 1½d. | 2/6 to 1/10 | L.A. | 17 | Bennis stokers. New station for traction and lighting in hand. |
| 300 | Hookham, Bastian & Rochdale | 5½d. to 4d. | 2½d. to 1¼d. | 3/0 | Co. | 18 | 96-pipe Green economiser. Hand stoking and B. & W. chain grate stokers. Free wiring. Motors on hire. Rates with prepayment meters: 1d. each 8 c.p. lamp for 5½ hours. |
| 400 at 5 hrs. | Reason and Hookham | 5d. | 2½d. | 3/4 | Co. | 19 | Green 96-tube econ. Nat. draught. Hand-firing. Weir feed pumps. Na Elec. Construction Co. pay charges on capital borrowed by Burgh Commissioners. |
| ... | Hookham, Shallenberger and B.T.H.<br>Bastian | 6d.$^{(1½)}$—3½d. | 6d.$^{(1½)}$–3½d. | 3/10 | Co. | 20 | Alternators run on separate circuits. Hand stoking. Green economisers. Natural draught.<br>destructor. |

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# TAN UGDOM.—JAN., 1906.

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## KS AYS.—Continued.

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| — | Name o (Figures estin | otalCon-nections nclud. traction) Kilowatts. | Charge per Street Lamp per annum. | UNIT. t hour, (2) first c. Power. | Trams. | Price of Gas in District. | Gasworks owned by. L.A. = LocalAuth. Co. = Company. | Purchaser of Current for Traction. | — | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|
| 54 | GREAT [63,1 | 1,945 | £20 | h h | 1½d. to 1¼d. | 2/5 | Co. | Great Grimsby Street Trams.Co. | 54 | Economiser (1,000 gal.). Underfeed automatic stokers, with forced draught. Motor-driven fans. |
| 55 | GREEN | 4,262 | £16 | | 1½d. to | 2/9 | L.A. | Greenock & Port | 55 | 256-tube Green econ. Natural and induced draught. Six B. & W. super- |
| | [68,1 [48, | 1,408 | Arcs £2 16 c.p. in equiv. £7 per annu | | 2d.—1d. | 3/4 | Co. | B.E.T. Co. ... | 108 | Natural draught. |
| 108 | TAUN [21, | 2,294 | Arcs £ open, £ enc.Inc.1 per 8 c. | d. | 1½d. to 1d. | 2/2 less disc'nts | Co. | Tynemouth Trams. Co. & Tyneside Trams. Co. | 109 | 352-tube Green econr. Proctor stokers. Weir steam pumps. Rented wiring by company from 5d. per lamp per qr. 5d. (200)—2d. winter; 5d. (100)—2d. summer. |
| 109 | TYNE [51, | 1,725 | £20 | | 1⅝d. | 2/9 | L.A. | U.D.C.Trams. | 110 | Free wiring. Meldrum's forced draught. Second price after 2 units per quarter per 8 c.p. lamp wired. Worthington feed pumps. Economisers. |
| 110 | WALL [60, | 1,727 | Arcs £25 1 Inc. 16 c. £2 10s | qr. er | 1½d. | 2/6 light 2/3 power | L.A. | Corpn.Trams. | 111 | Hand firing. Green economiser. Induced draught. 2 B. & W. superheaters. |
| 111 | WAL [86 | 2,971 | N. £4 3s. Arcs £17 & £11 2 Incs. 2 | d. | 2d. | 3/6 | Co. | U.D.C.Trams. | 112 | Motors on hire system. Dowson gas producers. |
| 112 | WALI [11 | 3,130 | per uni £20 includ ing inc | 0 r., | 2d. per unit for first 100,000, 1½d. after per annum. | 2/7 | L.A. | Corpn.Trams. | 113 | 360-tube Green economiser. Weir feed pumps. Bell water softening plant. |
| 113 | WAR [68 | 493 | ... | | 2d. | 3/0 | Co. | Leamington and Warwick Elec. Co. (B.E.T.) | 114 | B. & W. superheaters. Natural draught. |
| 114 | WAR (11 | 1,655 | 2 arcs a 2 inc. 1 pole £ | d. | 2d. per 400,000 units 1½d. after | 2/9 to 1/5 | L.A. | B'ham & Midland Joint Trams. Committee | 115 | No economisers. Natural draught. Bennis stokers and furnaces. Hire-purchase wiring. 4 B. & W. chain grate stokers and superheaters. Motors, arc and Nernst lamps on hire. |
| 115 | WES [65 | 6,990 | Arcs £ Inc. £ | | 1d. | 2/10 | Co. | Corpn.Trams. | 116 | Harris-Anderson Purifier. Motors on hire and hire purchase. Machine and hand firing. Induced draught. Power charged also £1 per kw per quarter and 0·7d. per unit. |
| 116 | WES [30 | 1,000 | Non | d. at | ... | 3/0 | Co. | Weston-super-Mare Tram. Co. | 117 | No econ's. Nat. draught. Hand firing. Tariff with free wiring 8d. (1)—2d. Motors on hire or hire-purchase. 3 B. & W. superheaters. 2 steam 2 motor feed-pumps. Free wiring without add. charge for current. |
| 117 | WES [19 | 5,442 | 3d. per un | | 1½d. | 2/9 | L.A. | Wigan Corpn. Trams. | 118 | 590-tube Green econo. B. and W. stokers. Natural draught. Weir feed pumps. Motors on hire. |
| 118 | WIG [82 | 1,490 | | | | 3/0 | L.A. | | | 192-tube Green econ. Natural draught. Hand stoking. Pump and injectors. |
| | | 4,000 | Arcs £ Inc. £2 15 | d. at | 1¼d. | light'g 2/6 power 1/6 & 2/3 | Co. | Corpn.Trams. | 119 | 448-tube Green econ. Steam-driven Weir feed pumps. Dupl. feed-pipes. Induced draught. Motors on hire-purchase system. Superheaters. Stanhope water softener. Feed water heater. Hand firing. |
| 119 | WOL [9 | 2,125 | Arcs £27 & £16 1 Inc. 2 16 | d. | 200,000 at 2d. 200,000 at 1¾d. | 3/5 | Co. | B.E.T. Co. ... | 120 | Two separate stations, continuous for lighting and traction. Water-power auxiliary. Corporation free wiring. Economisers. Natural draught. Mechanical stoking. Motors on hire. 75kw. motor alternator in continuous current station |
| 120 | WOR [4 | 675 | £3 10s Arc £ Enc. a £7 10s | | 1·3d. | 2/9 | Co. | B.E.T. Co. ... | 121 | Lancs. boiler in connection with dust destructor. No economiser. Nat draught. B. & W. chain grates. Water from wells on works. Duplicate Hall feed pumps & inj'rs. 100 amp. bal'r set, also 75 amp. motor gen'r. |
| 121 | WRE [14 | 2,648 | Inc. £3 Arc £ | | 2½d. | 3/8 | Co. | Corpn.Trams. | 122 | Boilers with auxiliary oil burning apparatus 196-tube Green economiser. Natural draught. Hand-stoking. Worthington feed pumps. Two B. & W. superheaters. |
| 122 | YAR [5 | | | | | | | | | |

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"THE ELECTRICIAN"

upply and Traction Undertakings of the United Kingdom, 1906.

UNIFORM WITH THE PRESENT SHEET.

Undertakings with no Tramway Load. Published with *The Electrician* for January 12th.

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**PUBLISHED ANNUALLY SINCE 1889.**

SUPPLE

# TA KINGDOM.—JAN., 1906.

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owns, arrangements for taking a supply of electrical energy in bulk are either in PROGRESS or PROJECTED:—

visional Order, 1902. Urban District Council. Consult-
H. Gibbings. The Council is at present negotiating for
1 for distribution by itself.

2 **AND WEST** [7,856]. — Provisional Order, 1902.
ouncil. Negotiations have been proceeding for some time
3 re Electric Power Co. for a supply in bulk, but no definite
t been come to.

4 Provisional Order, 1901. Urban District Council. Con-
J. E. Ellis. An application has been made to the
5 t Board for sanction to borrow £2,000 for the provision
., but no decision has yet been given. Supply will be
6 Yorkshire Electric Power Co., and the Board of Trade
proposed system. Gas by company at 2/10.

7 7,000].—Provisional Order, 1901. Urban District Council.
eers, Lewis and Fletcher. The question of taking a
8 om the South Wales Electrical Power Distribution Co. has

9

0].—Provisional Order, 1901. Urban District Council.
10 eer, R. P. Wilson. An agreement has been entered into
ale Iron and Coal Co. Distribution will be at 200 and
11 are overhead mains. Public lighting will be carried out
16 c.p. incandescent lamps. Gas by company at 4/9.

12 43].—Provisional Order, 1899. Urban District Council.
eers, Lacey, Sillar and Leigh. Negotiations have been
13 the Lancashire Electric Power Co. for a supply in
mpany at 3/7.

14 00].—Provisional Order, 1900. Urban District Council.
eers, C. Gott and Sons. A supply in bulk from the
15 ic Power Co. has been suggested, but the actual details
worked out. Gas by company at 2/6.

16 32,000].—Provisional Order, 1899. Corporation. Con-
17 s, Lacey, Sillar and Leigh. An agreement with the
ic Power Co. is contemplated, and in connection with this
18 0 has been granted. Gas by company at 2/9.

19

**SWINTON AND PENDLEBURY** [28,500].—Provisional Order, 1899. Urban District Council. Consulting engineers, Messrs. T. L. Miller and Wilson. A Provisional Agreement has been entered into with the Lancashire Electric Power Co. for a supply of three-phase current at extra high pressure to be brought to sub-station in town, from which continuous current will be supplied to the distributing network. The price to be paid by the Council is upon a sliding scale, from £6 per kilowatt demand per annum plus ½d. per unit. An application has been made to the Local Government Board by the Council for a loan, but the necessary permission has not been granted, there being some question as to the legality of the agreement. Gas by company at 2/8.

**TYLDESLEY** [16,000].—Provisional Order, 1902. Urban District Council. Consulting engineers, T. L. Miller and Wilson. Negotiations are at present in progress with the Lancashire Electric Power Co. for a supply of electrical energy in bulk. Gas by company at 3/-

**WHITWORTH** [9,578].—Provisional Order, 1905. Urban District Council. Consulting engineers, J. and J. S. Enright. Negotiations are pending for a supply in bulk. Gas by company at 3/10.

### DESCRIPTIONS OF ELECTRICITY WORKS IN TABLE IA.

Descriptions of some of the works mentioned in Table IA. have appeared in "THE ELECTRICIAN." Reference is given below to the volume and page:—

| STATION. | VOL. | PAGE. | STATION. | VOL. | PAGE. |
|---|---|---|---|---|---|
| Acton | 55 | 905 | Wednesbury | 56 | 149 |
| Alloa | 48 | 619 | Willesden | 53 | 900, 940, 1021 |
| Chislehurst | 44 | 462 | | | |

# TRAMWAYS.

| S. ] | PRICE PER UNIT. If Wright system, (1)=first hour, (2) first two hours, &c. Lighting. | Power. Private. | Power. Trams. | Price of Gas in District. | Gasworks owned by. L.A = Local Auth. Co. = Company. | Purchaser of Current for Traction. | — | REMARKS. |
|---|---|---|---|---|---|---|---|---|
| T.H. ook- a | 6d.(1)—2d. | 3d.(1)—1d. &3d.(4)-1d. | For Corpn. Trams cost price; for Suburban Co. 2½d. | 2/9 | L.A. | Corpn. Trams. & Aberdeen Sub. Trams. Co. | 1 | 2 Green economisers: B. & W. chain grate stokers. Weir and Hayward-Tyler feed pumps. Condensing water from River Dee. B. & W.-Hunt coal and ash convey for dealing with 20 tons per hour, and bunkers of 800 tons capacity; boilers fitte with 1cwt. Avery auto. weighing machine. Motors, &c, on hire, and lamps sold. Natural draugh |
| 0 ... | 3½d. to 2½d. less 5% dis. | 1½d. to 0·9d. | 1½d. to 1d. | 2/4 | Co. | B.E.T. Co. & Corpn. Trams. | 2 | Refuse destructors in addition. 320-tube Green economiser. Holden and Brooke injecto Hand stoking. Motor-driven three-throw pump and steam pump. Jackson 75-kilowatt motor-generator, for small lighting a traction loads. |
| e. Co., Sert; | 3¾d. to 2½d. flat | 2d. with dis. | 1½d. | 1/7 to 2/7 | L.A. | B'ham Corpn. Trams. and B.E.T. Co. | 3 | Two 96-tube Green econ. Nat. draught. Vicars stokers. Well water Motor and steam feed pumps. Boby water heaters and detartarisers Hunt coal conveyor. Free wiring. |
| | 5d. | 2d. | 1½d. first 200,000, | 3/4 | 2 Cos. | Corpn. Trams. | 4 | 96-tube Green economiser. Natural draught. Vicars, chain grate and two B. & W. stokers. Worthington and Weir feed pumps. River water Municipal wiring. |

1
2
3

| | | | | | |
|---|---|---|---|---|---|
| | inghouse - Parsons turbo alternators. | inghouse - Par turbo alternato | ; one 50kw. | 3,500kw. Parsons turbo-alternators. | . |
| Condensing Plant ... | Surface condensers. Water from River Clyde. | Barometric condenser. C tower. Make up wate River Clyde. | cool- vers. | Surface condensers. Centrifugal circulating pumps. Water from River Tyne. | Su ds air- d F |
| NUMBER OF SUB-STATIONS ... | Three completed, ten under construction | | | ... ... ... ... | Fo |
| Sub-Station Equipment ... ... | Westinghouse transformers and H. and I switch gear | | | H., &c., motor generators and | B. |
| TARIFF ... ... ... ... | 3d. to ¾d., according to quantity and l factor. | | | nit less 5% discount. *Power:* nit, with discounts for large | Va d. per (large |
| REMARKS... ... ... | Motherwell generating station started No 1905. Description of power house appe in *The Electrician*, Vol. LV., p. 368. | | | from the generating station of the stimated maximum load, 15,000kw. in *The Electrician*, Vol. XLVII., ol. XLIX., pp. 701, 736, Vol. L., p. 237, and Vol. LIII., pp. 424, 470, | Su n *The* |

# OMPANI

**BELFAST AND NORTH-EAST IRELAND ELECTRICITY AND POWE**
Company's area includes portions of the counties of Londonderry, Antri
Armagh, but excludes the City of Belfast. Act granted in 1904; no works y
but a start is shortly to be made.

**CLEVELAND AND DURHAM COUNTY ELECTRIC POWER CO.**—8
Cleveland (Yorks.) and the County of Durham, including Bishop Auck
Crook, and, under certain conditions, Stockton, Middlesbrough, West Hartle
and Darlington. Date of Parliamentary powers, 1901. Supply commenc
porary conditions in March, 1904. Consulting Engineer, H. Graham Harr
Harris). General Manager, E. E. Soden. Generation at 2,200 volts two-p
2,200 volts three-phase 25 ∾. System not yet fully at work, but 16 miles
cable have been laid (Callender's paper lead-sheathed and armoured laid sol
2,200-volt cable (Callender's paper lead-sheathed, laid direct), and 4 miles
wire (Callender's V.B., laid solid). Main generating station at Grangetow
erection, contains six water-tube boilers and four 1,000kw. Willans-Westi
generating sets. There will be 10 sub-stations equipped with Berry transf
porary generating stations at Auckland and Consett, each containing th
boilers (8,500 lb. per hour each) and two 300kw. Willans-Westinghou
generators. Mains: Callender three-core and concentric paper-insulated lea
tape armoured, laid direct in ground. Public lighting in Auckland and C
also given to the Adelaide Colliery. Tariff: 1¼d. to ¾d. per unit, accordi
of current taken for power or bulk supply

**CORNWALL ELECTRIC POWER CO.**—1,100 sq. miles—being the whole
of Cornwall except the Scilly Islands and the rural districts of Stratto
worthy. Chief demands are likely to arise from Penzance, Falmouth a
from the mining and china clay works. Date of Parliamentary powers, 1
per unit will be the maximum charges according to the length of d
proposed to erect two generating stations. The Act gives authorisation t
to private consumers for all purposes, and not for power only. Nothin
done towards the development of this undertaking.

**COUNTY OF DURHAM ELECTRIC POWER SUPPLY CO.**—Special
1900. 250 sq. miles in the county of Durham, including Gateshead, Ja
Chester-le-Street, Whickham, South Shields [Rural], Sunderland [Rural],
Engineers, C. H. Merz and W. McLellan. A. S. Esslemont (Manager),
(Secretary). Supply commenced in Gateshead, July, 1902. The

from a river about 2 miles aw
w. generator, which supplies the
by Willans engines. A supply
ct Tramways Co., which is at p
hole of its supply from the Comp

**POWER CO.**—329 sq. miles, incl
ord. Date of Parliamentary pow
troud [Rural], Nailsworth and D
e will be two generating statio

**CO.**—1,485 sq. miles in Kent,
Isle of Thanet. Date of Parlia
ns is scheduled. The Compan
m, Rochester and District Elect
and a supply for Chatham is no
on. A new station is under co
tain B. & W. boilers and two
erators. There will be 15 sub-sta
Power: By agreement, according
Addenbrooke and A. A. C. Swint
Resident Engineer). Company al
Milton, Strood and Parishes o
Sandwich, Deal, Walmer, and B

**RWICKSHIRE ELECTRIC**
wickshire, including Leicester, Lo
erworth, Atherstone, Nuneaton,
Date of Parliamentary powers,
-tension polyphase with sub-stat
e power house in course of e

**WER CO.**—500 sq. miles in t
addington, Dalkeith, Bonnyrig
4. Sites for three generating s
and Auchengray. Consulting
al Manager), W. D. Morgan
400 hours of maximum deman

# OTHE

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# D KINGDOM.—JAN., 1906.

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| CENTRAL<br>POWER CO. | SOUTH WALES<br>ELECTRICAL POWER DISTRIBUTION CO. | YORKSHIRE<br>ELECTRIC POWER CO. |
|---|---|---|
| e whole of the Counties Clackmannan, and por- ies of Dumbarton and lt | 1,034 sq. miles in Monmouthshire and Glamorgan, including Bridgend, Pontypridd, Neath, Aberavon, Abertillery, &c., and the whole of the County of Carmarthenshire. ... ... ... ... | 1,800 sq. miles in Yorkshire. |
| .. ... ... ... | 1900 and 1903 ... ... ... ... ... | 1901. |
| .. ... ... ... | April, 1903 ... ... ... ... ... ... | February, 1905. |
| | | H. F. Parshall. |
| P ... ... ... | W. A. Chamen (*Engineer and Manager*) ... ... | W. B. Woodhouse (*Manager and Engineer*). |
| *Man.*); James Walker, organ (*Chief Engineer*). | C. A. Holbrow (*Asst. Manager*) ... ... ... | |
| volts two-phase 50 ∿ | **Generation** at 11,000 and 2,200 volts two and three-phase, 60, 50 and 25 ∿. | **Generation** at 10,000 volts three-phase 50 ∿. |
| volts two and three- | **Distribution** at 2,200 and 440 volts two and three-phase. | **Distribution** at 500 volts continuous and 400 volts three-phase. |
| ... | D. Davis & Sons (1,500kw.), United National Collieries (800kw.), Albion Collieries (400kw.), Oakfield Steel Wire Works (350kw.), Cambrian Collieries (350kw.), Glamorgan County Council Asylums (200kw.), Bridgend Urban District Council* (200kw.) ... ... ... ... ... | Pudsey Corporation* (100kw.), Mirfield Urban District Council* (100kw.), Mirfield Coal Co. (150kw.), Thos. Burnley & Sons (200kw.), Liversedge U.D.C.* (100kw.), Lowmoor Co. (100kw.) |
| . ... ... . . | 7,000kw. ... ... ... ... ... | ...... |
| ... ... ...<br>ap. tu a | 90 miles Callender three-core paper-insulated lead-covered wire-armoured, laid solid in earthenware troughs. | 34 miles Callender three-core paper-insulated lead-covered wire armoured, laid solid in wood troughs. |
| paper-insulated lead-armoured, direct in | Callender concentric paper-insulated lead-covered steel-tape armoured, laid direct in ground. | Callender three-core paper-insulated lead-covered steel-tape armoured, laid direct in ground; or lead-covered only, laid solid in wood troughs. |
| fibre-insulated lead-armoured, direct in | Callender concentric fibre-insulated lead-sheathed steel-tape armoured, laid direct in ground. | Callender single and multi-core paper insulated, lead or bitumen sheathed, laid solid in wood troughs. |
| ... ... ... | Four ... ... ... ... ... ... | One. |
| bert) ... ... | STATION I. Treforest (near Pontypridd).<br>STATION II. Cwmbran ... ... | Thornhill. |
| u ... ... ...<br>, l | Fourteen Niclausse (evaporative capacity 14,000lbs. per hour each).<br>Twelve 30′ × 8′ Galloway. | Six B. & W., with chain grates and superheaters. Total evaporative capacity 120,000lbs. per hour at 150lbs. per sq. in. |
| ... ... ... | Small Welsh at 6/0 to 7/0<br>Small Welsh at 6/0 to 7/0 | Small coal 4/6 to 6/0. |
| rs-Pe ts; two | Three 2,000kw. Willans-Ganz<br>Three 300kw. Willans- | Four 1,500kw. Curtis turbines and B.T.-H. |

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**PUBLISHED ANNUALLY SINCE 1889.**

**IPPLEMENT**

| | | | | |
|---|---|---|---|---|
| | ways a | | ... | |
| 57 | Keighley | q. in., | 7 | 9 |
| 58 | Kirkcald | | ... | 12 |
| 59 | Lancashi | ........ | 7½ | 12 |
| 60 | Lancaste | | ... | 8 |
| 61 | Leaming trical C | ........ | 10 | 14 |
| 62 | Leith Co | two 0·5 boosted | ... | ... |
| 63 | Lincoln C | 00yds. | ... | 12 |
| 64 | Liverpool | | 7½ | 14 |
| 65 | Lowestof | ........ | 8 | 12 |
| 66 | Maidston | ders... | ... | 12 |
| 67 | Manchest | ders... | 7¼ | 16 |
| 8 | Merthyr Lightin | ı. in.... | 6 | 8 |
| 9 | Metropoli (Ltd.) | 6 sq. in. | 7½ | 16 |
| 0 | Middleton | ders ... | 7½ | 12 |
| 1 | Musselbu tric Lig | ........ | 8 | 12 |
| | Nelson Co | | ... | 10 |
| | Sunderlan | return | 7·6 | 12 |
| | Swindon | | ... | 12 |
| | Taunton a Railway | | ... | ... |
| | Trafford | er 0·25 | 6 | 12 |
| | Tynemout Traction | | 7·5 | 15 |
| | Tyneside roads C | | ... | ... |
| | Wallasey | ......... | ... | 10 |
| | Walsall C | n. ...... | 6·75 | 14 |
| | Walthams Council | tion feeders | 8 | 12 |
| | Walton-on (Coast D | | .. | .. |
| | Warringto | ......... | 8 | .. |
| | West Ham | sq. in. | 6⅔ | 1 |
| | Weston-su Electric | sq. in. | ... | 1 |
| | Wigan Co | eder ... | 4 | 1 |
| | Wolverhan | ......... | 6½ | |
| | Worcester | ......... | 8 | 1 |
| | Wrexham Tramwa | ·4 sq. in. | 6·5 | 1 |
| | Yarmouth | ......... | ... | 1 |
| | Yorkshire Electric | ·5 sq. in. | 6·6 | 1 |

Light Railway Order, 1904. 4½ miles. 3′ 6″ gauge. Consulting engineers, Pritchard, Green & Co. Arrangements are being made to construct the lines during this year.

Special Act, 1904. 2 miles. J. H. Rhodes, consulting engineer. No construction work commenced.

Special Act, 1905, authorised the construction of piers on the rivers Crouch and Blackwater in order to connect up lengths of light railway already authorised by the Board of Trade. Total length 27 miles, connecting up Southend, Rochford, Burnham, Southminster, Bradwell-on-Sea, West Mersea and Colchester.

Under its Act of 1900 the Company has power, among others, to adopt electric traction. Tenders have been asked for.

Special Act, 1903, authorising 17 miles of electric tramways and trolley omnibuses. Consulting engineers G. L. Addenbrooke and A. A. C. Swinton. No construction work yet commenced.

Omnibus Bill passed in 1902, authorised the construction of 9 miles. Overhead trolley system decided upon after negotiations as to a surface-contact system. The lines have been leased to the Swansea Tramways and Improvements Co. (*see* Table V.).

Light Railway Order, 1900. 21 miles.

Light Railway Order, 1903. Pritchard, Green & Co., consulting engineers. 4′ 8½″ gauge. 2 miles. No progress has been made with this scheme.

Special Act, 1900, but no works constructed.

Scottish Provisional Order, 1905. Powers were granted for the construction of tramways in Wemyss, which are purchasable by the Kirkcaldy Corporation at periods of five years.

A total length of some 30 miles is authorised in this Company's Act, granted in 1901, which will extend through Cleator Moor Whitehaven, Workington and Maryport to Sillothy. Consulting engineer, Sir Douglas Fox. No works have yet been constructed owing to the necessary capital not having been raised.

Special Act, 1903, for the construction of electric tramways. Agreement with Hove and Worthing Co. for running powers. No progress has yet been made with this scheme.

Special Act, 1902, for the construction of tramways and for the acquisition of the undertaking of the York Tramways Co. Scheme was abandoned after a poll of the ratepayers.

## PROJECTED

ail- Special Act, 1903. Line already worked by steam between Liverpool Overhead Railway and the Cheshire Lines Committee's extension at Sefton. Act empowers Liverpool Overhead Railway Co. to work the line electrically and to run a through service.

ght This line, which is a tunnel railway for through communication between Portsmouth and the Isle of Wight, was authorised in 1901. An extension of time was granted in 1904.

ail- Special Acts, 1903 and 1904.

In a general powers Act, passed in 1903, the use of electric traction upon any of the Company's lines was authorised.

Powers were obtained in 1900 to adopt electric traction. 26½ miles. A joint committee of the Mersey and Wirral Railway Companies is to be formed to carry out the powers of the Act. S. B. Cottrell, consulting engineer.

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y and Traction Undertakings of the United Kingdom, 1906.

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*"THE ELEC* *by post.*

SU

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# T ) KINGDOM.—JAN., 1906.

# TRACTION ONLY.

Co

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| OOSTERS. | | | | REMARKS. | |
|---|---|---|---|---|---|
| Kw. | Negative. No. | Negative. Kw. | | Power House Equipment. | General. |
| .. | 2 | 15 | 1 | Two Admiralty Wheeler condensers (14,000lb. per hour each), with combined steam-driven air and circulating pump; steam and electric feed-pumps. 240-tube Clay Cross economisers. Hand firing. Natural draught. | Numerous curves on all routes. Very hilly in places. |
| .. | None | ... | 2 | ...... | No batteries. Each motor car hauls 3 to 4 trailers. By 1900 Act Newry, Keady & Tynan Light Ry. Co. was formed to purchase the line and add new lines; but no scheme yet developed. |
| 00 | None | ... | 3 | Wheeler & Klein surface and jet condensers. Cooling towers. Blake-Knowles feed pumps. Three economisers. McDougall stokers. Washed slack, at 9s. 5d. | Lighting from separate station. |
| .. | ... | ... | 4 | A { B. & W. chain grates. Rough slack 6/3. Green economiser. Harris purifier. Weir steam and Mather & Platt electric feed pumps. Weir and Brush condensers. | Two sub-stations: Birmingham, three 200kw. B.T.H. rotaries, Oldbury, three 100kw. B.T.H. rotaries. |
| . | None | ... | 5 | B { Worthington feed pumps. Hand stoking. Fuel: Hamstead slack, Nat. draught. One 35 B.H.P. Bumsted & Chandler engine direct connected to one 23kw. 500v. shunt dynamo for night lighting. | Trolley system replaced accumulator system in May, 1901. (For **Birmingham Corporation Tramways** *see* Table overleaf.) |
| D | D 2 | 45 | 6 | D { Blake & Knowles duplex feed pumps. 192-tube Green econ. Hand stoking. Rough slack, 6s. 9d. per ton at the boilers. Nat. draught. Wheeler condenser. Motor-driven air and circulating pumps. | { Three sub-stations: Coalbournbrook (near Stourbridge), Old Hill and Bilston, receiving currrent at 2,700 volts 2-phase 50 ∽ from Midland Power Co. Dudley Corporation supplies within Dudley boundary. |
| 1. | None | ... | 7 | F { Surface condensers. Two vertical steam-driven pumps. Fuel: slack | Includes lines owned by West Bromwich, Handsworth, Tipton and Kings Norton Local Authorities, leased to the Co. Power for W. Bromwich and Handsworth lines supplied by Corpns<br>Two Chloride accumulator sub-stations, each of 180kw. hours. |
| 0 | 1 | 20 | 8 | Ledward ejector cond. Weir and Worthington pumps. Green econ. Klein 800 H.P. water coolers. Hand stoking. Natural draught. | |
| C | 5 | 30 each | 9 | Wheeler surface condensers. Electrically-driven circulating pumps. Green economiser. River water. Mechanical stokers. Natural draught. | ...... |
| I | 1 | 14½ | 10 | Wheeler surface condenser 1,600 sq. ft. Cooling ponds with Harrison spraying nozzles. 2 Pearn quadruple-acting steam-driven pumps, 2,500 galls. per hour. Lowcock econ, 288-tubes. Vicars stokers. Nat. draught | Circular route with branches. Includes lines leased from Rochester Corporation. |
| I | None | ... | 11 | Browett-Lindley surface condensers. Condensing pumps, beam-geared to small engines. Worthington feed-pumps, 240-tube Green economisers. No water coolers. Bennis automatic stokers and coal conveyor. Fuel: screened slack. Natural draught | Rails partly cast-welded and Thermit welded. |
| D | None | ... | 12 | Wheeler condensers. Green economiser. Cooling pond. Electrically driven pump. | Line exceptionally hilly, running through sparsely populated district. Three locomotives and eleven trailers also in use. Trigger life-guards. |
| | 4 | 70 | 13 | Three Wheeler surface condensers, 1,500 H.P. each. Two Blake & Knowles steam pumps. One Weir pump. Two 384-tube Green economisers. No water coolers. Vicars stokers. Fuel: nut coal. Natural draught | Direct-current transmission to all except two sections. These are worked by 3-phase transmission with stationary and rotary transformers in 3 sub-stations. Includes Dublin-Dalkey line. |
| G | None | ... | 14 | Worthington surface condensers. 2 Worthington steam pumps; 2,800 galls. per hour. Wheeler feed-water heater. 1 Harris feed-water filter; 1,400 galls. per hour. Sugden superheaters. Natural draught. | Trams go to Dundee City boundary, but running powers obtained over one route of Dundee City tramways. Dundee City cars (*see* Table IV.) run over the Co's. lines to Monifieth. |
| G | None | ... | 15 | Water power station. Power-house also charges cells for lighting the Causeway Hotel. | Track very hilly. This is the first electric tramway built. Opened in 1883, with a side iron conductor rail. Altered to the overhead system in 1899. Rolling stock includes six trailers. Train seats 74 passengers. |
| Da | 22—sub-stations only | Total 660 | 16 | Main generators 6,600 volts 25 ∽. Two rotary convertors 500kw. 6 Westinghouse 200kw. transf'rs. Surf. cond'rs., circ'g., air and feed pumps electrically driven. Econ'rs, mech. stokers, feed-water filters. | Five sub-stations, 22 Westinghouse 500kw. rotaries, 66 Westinghouse 200kw. transf'rs 30kw. negative booster coupled to each rotary. Running powers over Paisley Co.'s lines. |
| | None | | 17 | Two Wheeler condensers. Two duplex Blake & Knowles steam-driven | |

## ys, SEE OVER.

**WITH SUPPLEMENT**

"THE ELECTRICIAN," OCTOBER 20, 1905.

**(Gratis) INDEX TO VOL. LV.**

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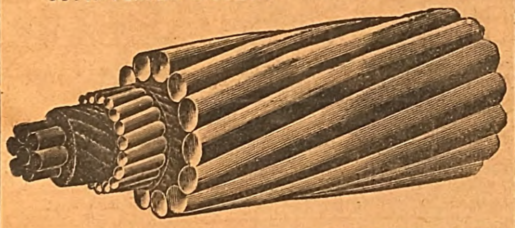

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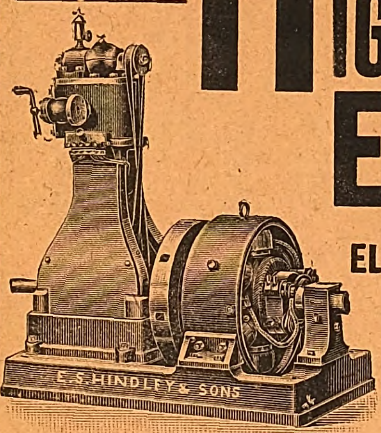

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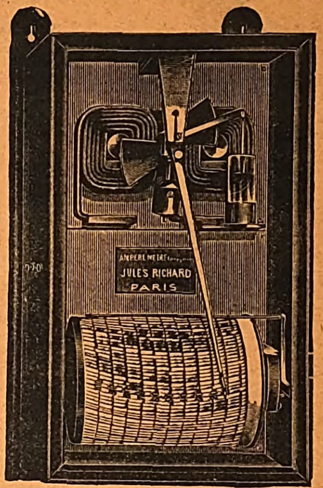

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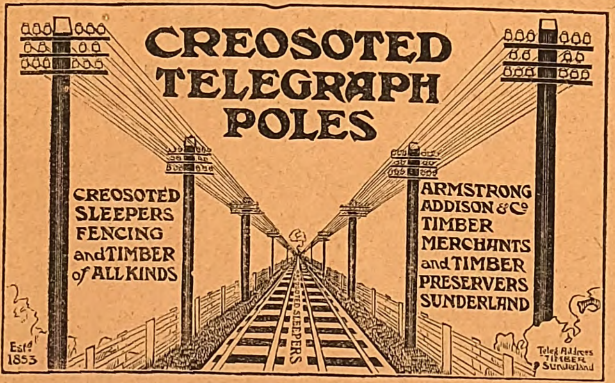
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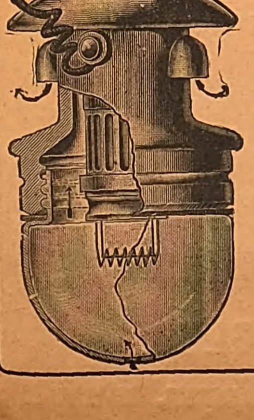

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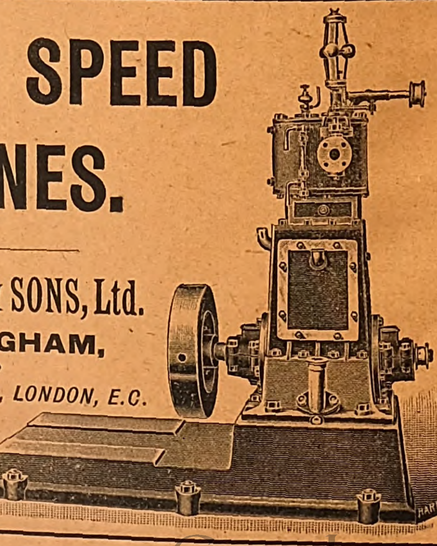

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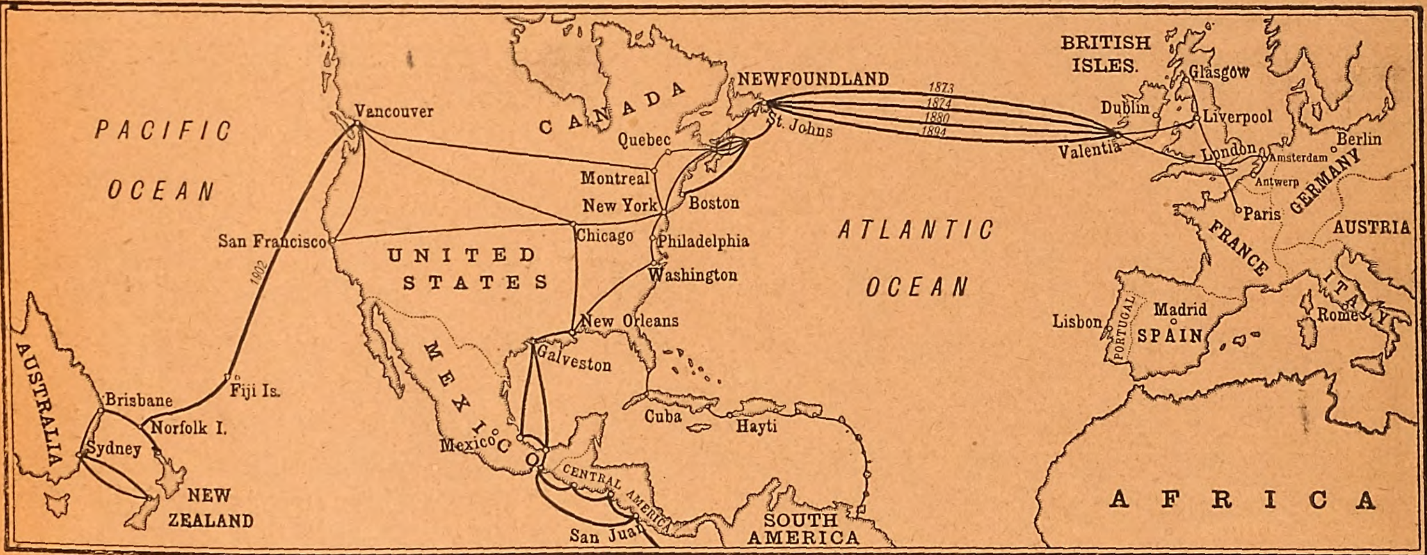

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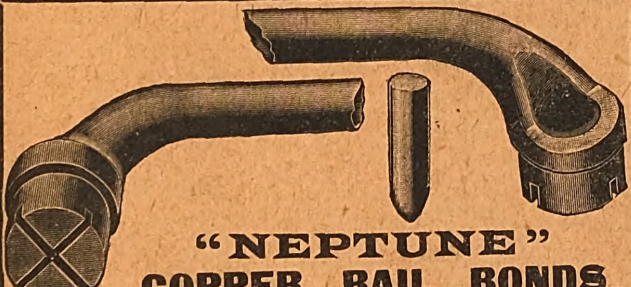

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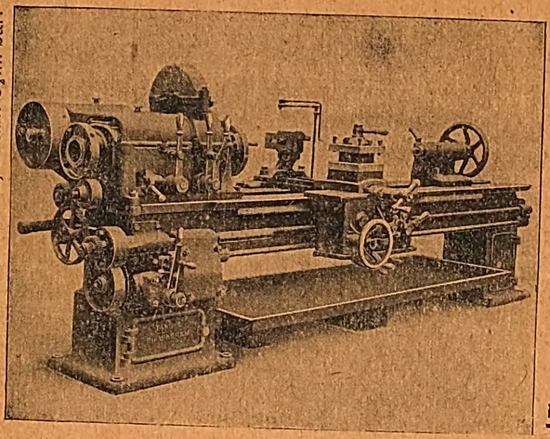

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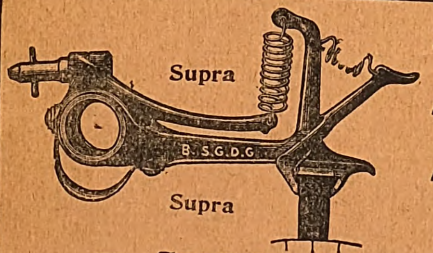

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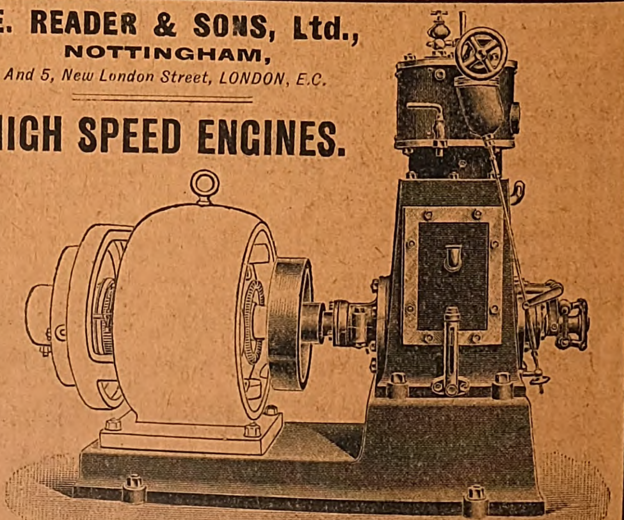
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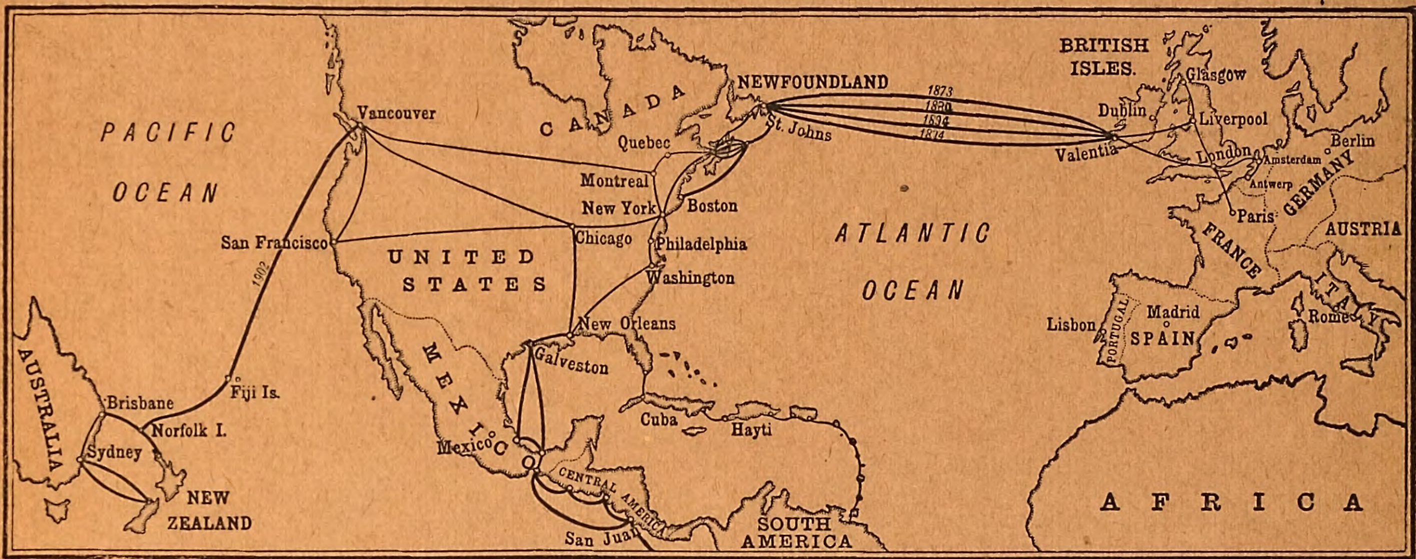
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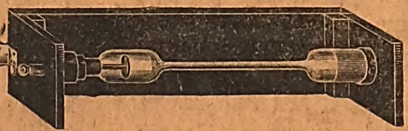

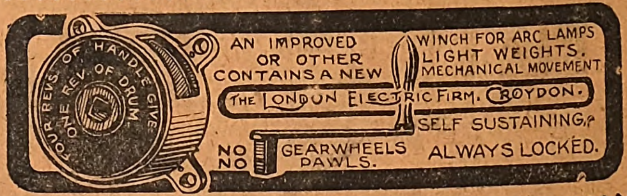
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# DUBLIN ELECTRICITY COMMITTEE

IN ***RECOMMENDING*** THE

BRITISH INSULATED & HELSBY COMPANY'S ***TENDER***

FOR A FURTHER CONTRACT SAID,

"that the Contractor for the Mains had laid £140,000 worth of Mains, "which gave the most complete satisfaction, and the guarantees which "were given were fulfilled in every case."

**BRITISH INSULATED & HELSBY CABLES, LTD**

*WORKS: PRESCOT, HELSBY AND LIVERPOOL.*

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